HANDBOOK
OF
CAST IRON PIPE

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FOR

Water, Gas, Sewerage and Industrial Service

Second Edition

Service Mark Reg.

CAST IRON PIPE RESEARCH ASSOCIATION
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Preface to Second Edition

THE first edition of the "Handbook of Cast Iron Pipe," published in 1927, has had a distribution of nearly 50,000 copies among water and gas utilities, municipal and consulting engineers, and all principal engineering schools.

The present second edition includes much new material due to important changes that have occurred in the Cast Iron Pipe industry in the past two decades; among these are new specifications for pipe; increased knowledge of stresses in underground piping; advances in foundry practice and foundry control; the development of new joints; new data on coefficient of flow in pipe; and improvements in pipe laying practice. Because of these changes new sections have been added to the Handbook and other sections rewritten in the light of present day knowledge.

Among the new sections are those dealing with new processes of manufacture; specifications for centrifugally cast pipe; submarine joints; short bodied fittings, and mechanical joint pipe. The section dealing with carrying capacity has been changed in its entirety and includes a number of flow tests on cement lined pipe. The section on pipe laying has been revised to conform with practices known to be desirable on the basis of tests at the University of Illinois and Iowa State College in connection with the preparation of the American Standards Association Specification for Cast Iron Pipe.

In general this second edition of our Handbook aims to give complete information regarding the use of cast iron pipe for service underground, above ground and underwater.

CAST IRON PIPE RESEARCH ASSOCIATION

December, 1952

America's oldest cast iron water main, laid in Philadelphia in 1821

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America's oldest cast iron gas main, laid in Baltimore in 1834

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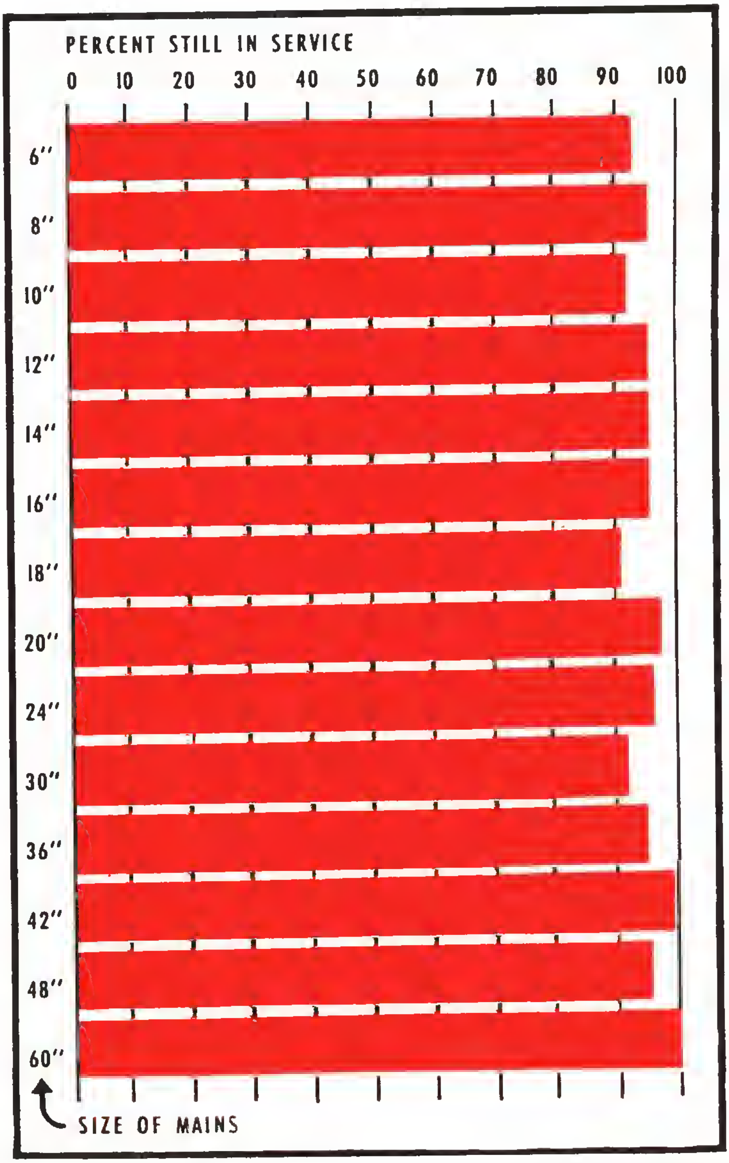
This cast iron water main installed at Versailles, France, in 1664 is still in service

SERVICE RECORDS OF CAST IRON WATER MAINS IN 25 CITIES

96% of all 6-inch and larger mains are still in service.



Based on reports of the study directed by a Joint Committee representing the American Water Works Association, New England Water Works Association, and the Institute of Water Supply Utilities. (See pages 10-11.)

SECTION 1
Evolution and History of Piping

THE first pipe used as a conduit for water was probably made of baked clay. Archeologists have unearthed in ancient Mesopotamia twin lines of baked clay tubes and a number of tees and bends, which served as part of the plumbing system of Nippur. A later and more elaborate use of clay pipe was in the drainage system of the House of Minos at Cnossus on the island of Crete, *circa* 2000 B.C.

Other forms of early conduits were pipes made of wood and lead, masonry channels, pierced stones cemented together, tunnels and aqueducts. Greatest achievements of the ancient water works engineers were the vented tunnels and the aqueducts bringing water into Grecian and Roman cities, there to be distributed to neighborhood fountains, and residences of the wealthy, by clay, wood and lead pipe. Despite the short life of wood pipe, breaks in clay lines, and imperfectly refined lead, these old Roman materials continued to be used down through the middle ages in European cities and, in fact, until 1738 when the substitution of coke for costly charcoal in the reduction of ore made cast iron pipe available to water works at a price they could afford.

FIRST LARGE-SCALE WATER DISTRIBUTION SYSTEM

The cities that sprang up in Europe during the middle ages, taking advantage of growing knowledge of the principles of mechanics and hydraulics, were ultimately able to expand distribution systems. London, typical of such cities at the beginning of the 17th Century, was in dire need of an adequate system.

Sir Hugh Myddelton, generally referred to as the "father of modern water distribution systems," built in 1609-1613 his New River Aqueduct and laid more than 400 miles of wooden mains, in addition to pipe previously installed. A water power pumping plant had been built at London Bridge in 1582, and the city no doubt considered itself equipped with an adequate water system. Yet defective piping was giving constant trouble. The wooden pipe leading from the pumps could not withstand the pressure required to force water into the upper stories of many houses and its rapid deterioration gave it an average life of only ten to fifteen years. In addition, the great fire of 1666 destroyed quantities of both lead and wood pipe at the time when it was most needed.

A REVOLUTIONARY EXPERIMENT

After the London fire, English engineers must have followed with keen interest an experiment with cast iron pipe then being made in France. King Louis XIV had ordered the construction of a cast iron main extending for 15 miles from a pumping station at Marly-on-Seine to Versailles to supply water for the fountains and town. The first authenticated installation of cast iron pipe for the purpose, it is still functioning after more than 280 years. When the line was begun (1664) the production of iron in England and Europe required the use of expensive charcoal for the reduction of the iron ore. Attempts to produce a lower-cost iron by the use of coke instead of charcoal were unsuccessful until 1738. Immediately thereafter, cast iron mains began to be installed by the more progressive cities.

INVENTION OF BELL AND SPIGOT JOINT

The joints of these early cast iron lines were of the flanged type, with lead gaskets. These joints, although unsatisfactory, were used until Sir Thomas Simpson, engineer of the Chelsea Water Company, London, invented the bell and spigot joint in 1785. It was adopted soon afterwards when that Company relaid a forty-five-year-old line whose bolted joints had "perished." Thus was developed bell and spigot cast iron pipe which has been used extensively ever since. Many of the original bell and spigot lines are still in use, apparently good for more centuries of service.

Most of the cities of this country are young enough to have built their distribution systems with pipe that is the standard material today. Some of the older cities, however, went through disagreeable experimental stages with other kinds of pipe before building cast iron systems.

CAST IRON THE STANDARD MATERIAL

Since the introduction of cast iron pipe in the United States, shortly after 1816, substitutes of various materials have been offered as suitable for water distribution mains. That none of these has proved able, throughout 130 years, to supplant cast iron pipe in the confidence and preference of water works engineers, is demonstrated by the fact that *more than 95% of all the distribution mains in our principal cities are cast iron mains.* Many of these mains have been in service from 100 to

125 years. In filtration plants also, more than 95% of all pipe installed is cast iron pipe.

A survey of survival and retirement experience with water works facilities in 25 representative cities, from Canada to Florida, disclosed that 96% *of all cast iron distribution mains, sizes 6-inch and over, ever laid in those cities, were still in service.* (See Chart on page 8.) The survey, recently completed, was directed by a committee representing three water works associations and the findings published by the American Water Works Association.

Because of such expert evidence and the cumulative experience of generations of water works engineers, cast iron pipe remains more strongly intrenched than ever in its acknowledged position as the standard material for water distribution mains.

CAST IRON PIPE FOR GAS

An Englishman, William Murdock, is usually called the "father" of the gas industry. In 1792 he succeeded in distilling coal in an iron retort and piping the gas seventy feet through tinned tubes to his residence to be used for lighting purposes. Later he lighted the foundry of Boulton, Watt & Co. with gas and introduced the "gas tip" which later came into general use.

In 1812 the London and Westminster Gas Light and Coke Company was granted a charter. The following year the Westminster Bridge was lighted and the citizens of London were dumfounded by the spectacle. The system was extended rapidly thereafter. In 1816 the gas meter and gas holder were developed.

Following its success in London, gas lighting spread quickly to other countries. In the United States, Baltimore in 1816 was the first city to light its streets with gas.

In designing early distribution systems in this country and abroad, gas engineers benefitted by the experience of water works engineers before them and constructed their mains with cast iron pipe. The Baltimore company imported cast iron pipe from England until 1834 when a pipe foundry was built at Millville, New Jersey, the forerunner of an industry destined to play an important part in the development of the gas industry in America. Indeed, from its beginning in London in 1812, the gas industry may be said to have had its roots in cast iron pipe.

GROWTH OF GAS INDUSTRY

For half a century our use of gas was confined largely to street-lighting, due to high cost of production. The great growth in gas consumption for home-lighting began at the close of the Civil War. The gas stove was introduced at the Centennial Exposition in Philadelphia in 1876. Today, the gas industry serves more than twenty million customers, and a population of ninety million people, with manufactured, natural or mixed gas for cooking, heating and industrial purposes.

DEVELOPMENT OF MECHANICAL JOINT

Until a quarter-century ago, the bell and spigot joint was used, as it is today, for mains distributing manufactured gas. It gave good service because manufactured gas contains sufficient moisture to keep the jute packing in a damp, expanded condition resulting in a tight joint.

With the advent of dry natural gas, and higher working pressures, the cast iron pipe industry developed and perfected a new type of joint to meet the changed requirements. This is called the Mechanical Joint and consists of four elements: (1) A special socket cast integral with the pipe; (2) a rubber gasket; (3) a cast iron gland or follower ring; (4) necessary cast iron bolts. It is fully described in another section (see page 237). In early tests by the American Gas Association laboratory, and subsequent performance in thousands of installations, it has been proved bottle-tight at all working pressures.

CAST IRON PIPE IN SEWERAGE SYSTEMS

Since the development of water supply systems, by the Greeks and Romans, sewage has been transported by water carriage to rivers and large bodies of water. It remains true today that without a water supply there can be no sewerage system.

The early conduits for sewage disposal and for water distribution were, as previously stated, clay, stone, lead and wood pipes. Centuries later, large cities in Europe and this country built sewers of brick, vitrified clay and concrete. Unfortunately, in the light of later developments, these were combined sewers carrying both storm water and domestic sewage.

DEVELOPMENT OF SEWAGE TREATMENT

The importance of cast iron pipe as a factor in sewage works construction began with the development of sewage treatment at about the turn of the century. Public health officials promoted sewage treatment as the only answer to the problem of sewage disposal without pollution of the air or of streams, lakes and coastal waters.

The primary purpose of a municipal treatment plant is to treat domestic sewage which is a dilute liquid rarely containing more than 1/10th of 1% of total solid matter. The volume of domestic sewage to be treated should govern the size of the plant and its investment and operating costs. To insure an influent that would be confined to domestic sewage required separate sanitary sewers that would be leak-proof and infiltration-proof. From generations of experience in the water works field, cast iron mains were known to have tight joints that would not permit leakage or infiltration. Thus was created a wide demand for cast iron pipe for influent mains and, because of its effective resistance to corrosion, in the construction of plants as well. More than 90% of the pipe in all treatment plants is cast iron pipe.

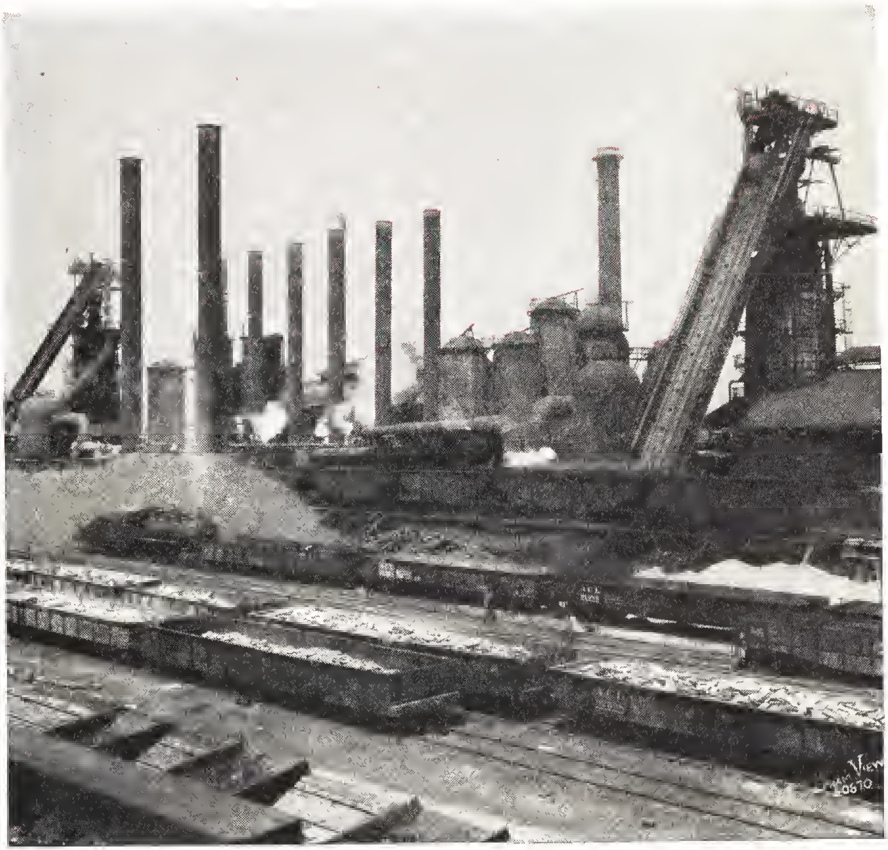
PRESSURE AND OUTFALL SEWERS

With the installation of treatment plants it usually became necessary to transport the sewage from the old point of discharge to the treatment plant. This required, in most instances, a pressure sewer. An important advantage of a pressure sewer is that it can follow the contour of the ground. Thus the initial cost of the sewer is reduced, due to the size factor as well as to the fact that a trench shallower than generally required for gravity sewers is possible. Flow tests on pressure sewers and waste sludge lines, in service for long periods, indicate that ordinary hydraulic tables can be used for calculating the capacity of cast iron pipe for such service.

Outfall sewers, discharging untreated or partially treated sewage into a body of water or stream, should be leak-proof. Since they extend for considerable distances into the water to avoid pollution of water supply, bathing beaches or fishing grounds, construction should be such as to permit no leakage. The land section of outfall sewers also may be exposed to wet and dry conditions, both internally and externally, and, therefore, must effectively resist corrosion, especially when laid in muck or when submerged in salt water at high tide. Cast iron pipe has successfully met these requirements in a large number of installations during the past fifty years.

SECTION 2

The Production of Iron



Modern Blast Furnace

SECTION 2

The Production of Iron

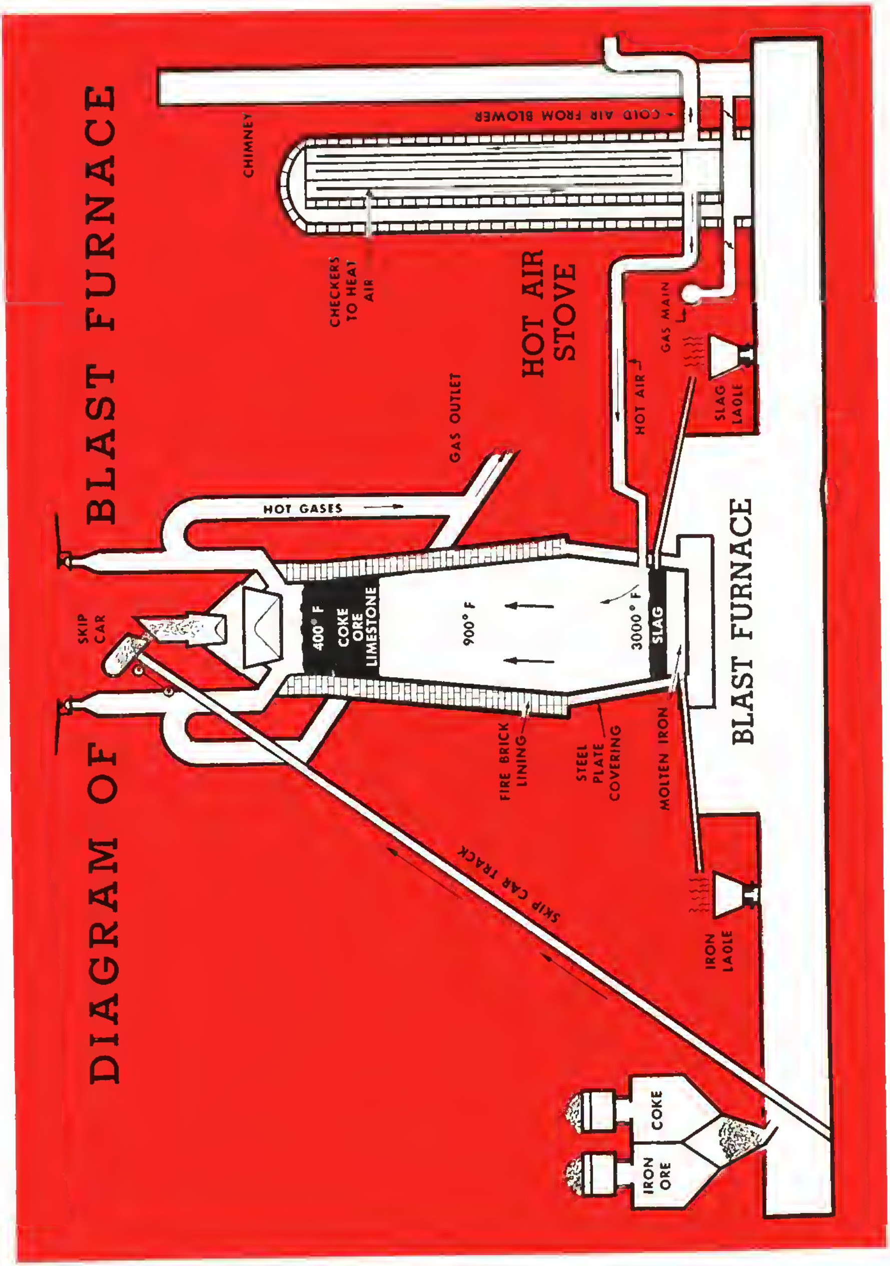
THE production of iron is one of the oldest of the arts, dating back to some unknown iron master five or six thousand years ago. Metallurgical methods in those ancient times were so wasteful of both material and labor, that the metal was not of great economic importance. Ores were reduced to a pasty metallic mass at a temperature below the melting point of the iron itself, and the clay and sand embedded in the ore were laboriously kneaded out by hammering. The science of metallurgy had its origin in about the thirteenth century A.D. when furnaces were developed in Western Europe to produce iron in a molten condition.

The modern blast furnace is a barrel-shaped shaft about a hundred feet in height and twenty-five feet at its largest diameter, with thick fire-brick walls jacketed and supported with steel plates. The bottom section, seven to ten feet high, is cylindrical. It is topped by a ring of openings for nozzles or tuyeres, as they are called, through which the blast of air is forced. Immediately above is a divergent conical section called the "Bosh." The "Bosh" is surmounted by another cylindrical section, then another cone, and finally another cylinder at the top. A bell, drawn up tight against a ring, seals the top and can be lowered at intervals to drop in fresh supplies of ore and coke. A "skip" or charging car periodically brings up fresh supplies of raw materials from the nearby stock house, which are dumped into the annular hopper around the bell.

In blast furnace practice, the raw materials are divided into three classes—ores, fuels and fluxes. The ores are the mineral sources of the metal, occurring in Nature as deposits of the oxides of iron. They are mined by open cutting or tunnelling, depending on local conditions, and are usually shipped to the furnace without other treatment than sizing.

The fuels are used to produce the temperatures and also the gases that deoxidize the ores. At present coke is the only one of commercial importance, though in the past much charcoal was used.

The fluxes are minerals which combine with the coke ash and the impurities in the ore, to form an easily fusible slag. Generally these are



Courtesy of Inland Steel Company

Diagrammatic Drawing of Blast Furnace

the carbonates of calcium or magnesium, which are charged in the furnace as raw limestone (dolomite).

The reduction of the ore is accomplished by the removal of oxygen, through the agency of two chemical reactions, accompanied by heat. When air passes through a thick bed of incandescent coke or charcoal, incomplete combustion takes place and a gas called carbon monoxide or C O is formed. This gas has very active reducing properties so that at temperatures above 600 degrees Fahrenheit, it will take up the oxygen in the ore, leaving metallic iron. There are several intermediate reactions, but the whole reducing process may be generalized as follows:

$$6\,C + 3\,O_2 = 6\,C\,O$$

$$2\,Fe_2O_3 + 6\,C\,O = 2\,Fe_2 + 6\,C\,O_2$$

The gases that pass off are high enough in heat value to be used under boilers and for heating the regenerative stoves for the blast. These stoves are steel shells about twenty feet in diameter by a hundred feet high, filled with brick checkerwork. They are alternately heated with the gas and then thrown in on the blast line. The cold air from the blowing engine for a time is heated to about 1300 degrees F. while passing through the checkerwork, but when the stove has cooled so that the blast is no longer as hot as desired, the air is passed through another stove and the cool one is again heated with the gas from the furnace. The heated blast is led through brick-lined pipe to the tuyeres where it enters the furnace. The blast pressure in the more modern plants is from 20 to 25 pounds per square inch and is developed in large blowing engines or turbo blowers.

The furnace is kept nearly full of carefully proportioned charges of coke, ore and limestones. This column travels slowly downward as the coke below is consumed, being heated as it approaches the "Bosh" by the ascending gases. The ore is also acted on by the carbon monoxide so that most of it has been reduced by the time the combustion zone in the "Bosh" is reached. Here the heat is intense and the iron and slag melt and trickle down to collect in the hearth below the tuyeres.

Their great difference in specific gravity separates the iron and slag into layers, permitting the withdrawal of iron through a hole, or notch, at the bottom, and the slag through another notch higher up. Both notches are usually plugged but as often as the slag level rises to approach the tuyeres, the cinder notch is opened and the accumulation of slag flows out into a receiving vessel. At less frequent intervals, five or six times a day, the iron notch is opened and the furnace drained of iron.

The molten iron is received in large ladles to be carried to the pig casting machine. In this country the most commonly used casting machine has a slow-moving endless chain which carries a series of parallel molds with overlapping edges. The molten iron from the ladle is carefully poured into a trough provided with a skimming device that carries it to the slowly moving metal molds which have been coated to keep the iron from sticking to the mold surface. The pigs are cooled and removed from the molds, after which the molds are again coated and poured. Previous to the use of casting machines, pig iron was cast in molds made in a sand bed and it was from this process that the name "Pig Iron" originated. The arrangement of these molds (a long channel with shorter and narrower channels opening into it on one side) suggested a litter of pigs to an Englishman who gave the terms "sow" to the main channel and "pigs" to the shorter ones. On solidifying, the pigs and sow were broken into convenient sizes for handling.

Iron has never been produced in an absolutely pure state except under the most precise laboratory conditions. At high temperatures, it has a strong tendency to alloy with many of the non-ferrous substances which are present in the fuel or ore and these naturally are retained in the cast iron. They are not to be regarded as injurious substances because each has its peculiar modifying influence on the metal. By scientific control of these constituents the foundryman produces the desired qualities in his castings.

Steel and wrought iron, the two other commercial forms of iron, are both made by reducing the non-ferrous constituents of pig iron to a desired minimum. This reduction is accomplished through treatments that cause these elements to separate from the iron and form gas or slag. In steel-making these new substances are formed in a molten bath of metal and are either burned out or, being lighter than iron, they float to the surface to be skimmed off. For wrought iron, the slag is formed while the metal is at a pasty heat, and is removed from the resulting mass by kneading. Each of these metals exhibits distinct physical characteristics which are modified greatly by the presence of such non-ferrous elements as remain.

As compared with cast iron, the most marked changes caused by these conversions are the increase in strength, ductility, and forging properties, and the loss of the original granular structure.

Cast iron, because it readily lends itself to formation into intricate shapes, has always been a metal of wide usefulness to the foundryman. The outstanding merit of the metal, however, is its effective resistance to corrosion when used for conduits in the form of cast iron pipe and fittings.

METALLURGY OF CAST IRON PIPE

Cast iron is essentially an alloy of iron and carbon containing appropriate amounts of silicon and manganese. Most cast iron is made by melting pig iron with selected scrap. In gray cast iron, which is the type used for pipe and fittings, a major part of the carbon content occurs as free carbon or graphite in the form of flakes interspersed throughout the mass of metal. The engineering properties specific to gray cast iron are principally due to the presence of these free carbon graphite flakes.

The excellent corrosion resistance of cast iron pipe in underground service is well known. Cast iron is not rust-proof, but when rust forms on cast iron it is tightly adherent and helps to protect the metal beneath. Graphite is non-corrodible and the appreciable volume of this component, together with relatively inert iron phosphides, causes gray cast iron to be more resistant to corrosion than the purer forms of iron.

In severely corrosive conditions where the metallic content of a cast iron pipe is severely reduced by corrosion, the corrosion products of cast iron form an interlocking mat of graphite, phosphides and iron oxides which is strong and dense enough to enable the pipe to continue to serve indefinitely as an effective conduit under ordinary pressures.

Machinability of any metal structure is important, particularly where it must be drilled, tapped, or cut with ordinary tools. At a given hardness level cast iron is more easily machined than most other metals because the graphite flakes break up the chips and lubricate the cutting tool.

CHEMICAL COMPOSITION OF CAST IRON PIPE

Carbon: Carbon in cast iron pipe may vary from about 3.00% to 3.75%. In gray cast iron high carbon means soft iron and low carbon means hard iron. In general the carbon content is adjusted to suit the particular method of manufacture and the cooling rate of a given size of casting.

Silicon: Silicon in cast iron normally ranges from about 1% to 2.75%. Silicon promotes graphitization, and, therefore, higher silicon will make the iron softer where other conditions are equal. Silicon is a very useful element to control the properties of iron in thick and thin sections. If the silicon is raised for casting thin sections which normally tend to be harder, and lowered for casting heavy sections which normally tend to be soft, a wide range of different castings may be made with uniform strength and hardness properties.

Manganese: The usual range of manganese content in gray iron is from about 0.20% to 1.00%. Manganese is useful in minimizing the detrimental effects of sulfur and is adjusted to suit the particular method and cooling rate used in producing cast iron pipe and fittings.

Phosphorus: Phosphorus in cast iron is usually between 0.10% and 1.00%. Phosphorus increases the fluidity of the molten iron, making it easier to pour at low temperatures and better for casting thin sections. When phosphorus is above about 0.15% it forms iron phosphides in the iron. These phosphides are hard, wear-resistant, and corrosion-resistant. Therefore a high phosphorus content is useful for certain wear services and adds corrosion-resistance. For cast iron pipe a medium-to-high phosphorus content is often preferred because the increased fluidity gives sounder casting and the phosphides add corrosion-resistance.

Sulfur: It was formerly thought that a sulfur content above about 0.10% was dangerous, but since the laws of balancing sulfur with manganese have been understood, sulfur contents up to 0.15% are found in high quality irons.

Alloys: In the normal run of cast iron pipe and fittings, special alloys are not necessary, but they may be used to advantage where special properties are required. Of the alloying elements, Chromium and Molybdenum tend to prevent graphitization while aluminum, titanium, and zirconium are graphitizers. Copper and nickel are nearly neutral but slightly graphitizing.

Molybdenum is the most effective alloy for increasing strength. Chromium is the best for increasing heat resistance. Nickel has the unusual properties of making iron very hard in the 4 to 6% range when combined with Chromium (Ni Hard), but in the 12 to 30% range making gray iron austenitic-soft, non-magnetic, corrosion-resistant (Ni Resist). Copper, up to about 2%, is alloyed with iron to add resistance to acid corrosion.

Inoculation: In addition to the effect of the specific elements mentioned above it is common practice to inoculate cast iron immediately before pouring. This is done by adding small amounts of such materials as graphite or ferrosilicon whose effect is to alter the structure by an amount out of proportion to the normal chemical action of these elements. Such a practice is very beneficial and is widely used to promote uniformity of product in the manufacture of pipe and fittings.

METALLURGICAL CONTROL

The methods of casting and the types of molds used have a profound effect on the structure and properties of cast iron.

In general, the desirable structure of cast iron for pipe and fittings shows a sound gray fracture with uniformly dispersed graphite flakes in a dense uniform matrix. Hardness should be not over 95 Rockwell B in order to allow cutting and tapping in the field. The iron should have good strength yet retain enough resilience and toughness to confer adequate impact resistance.

ASTM specification A-48 lists seven classes of gray cast iron ranging in tensile strength from 20,000 psi. to 60,000 psi. Cast iron for pipe and fittings, which must be soft and freely machinable, is usually in the 30,000 to 40,000 tensile strength range, as measured by the ASTM arbitration test bar.

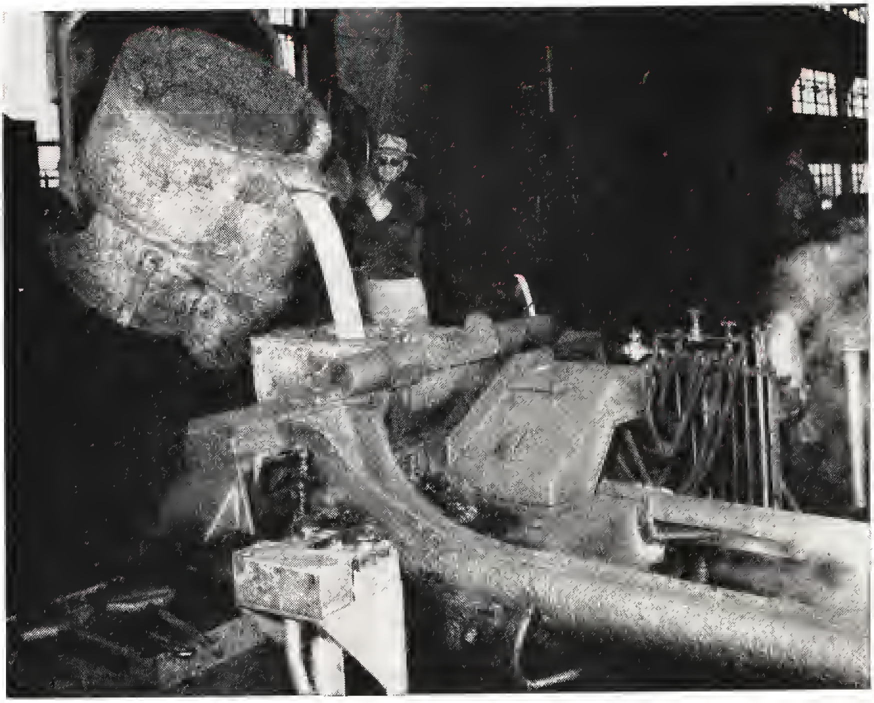
The compressive strength of gray cast iron is much higher—about three times greater—than its tensile strength. Therefore, cast iron can be used at high stresses in compression.

Since bending is a combination of tension and compression, the bending strength of cast iron—modulus of rupture—falls between the tensile and compressive strengths, usually about twice the tensile strength.

Modern metallurgical control enables the foundry to produce quality castings with the best combination of properties. The routine tests carried out as a guide to metallurgical control include: Frequent chemical analyses for each mix used in the cupola, chill tests for graphitizing tendency, test bars, Talbot strips from the pipe wall, ring tests on rings cut from the pipe, full length bursting tests of pipe, impact tests, direct tensile tests, and others. One of the routine tests of the finished product is the hydrostatic test to which every length is subjected. Correlation of the values obtained from all these tests with service performance of the castings have enabled the cast iron pressure pipe industry to produce progressively better and more reliable cast iron pipe and fittings.

SECTION 3

Manufacture of Cast Iron Pipe



Pouring ladle tilts to introduce molten iron through the trough into the spinning mold—metal mold process.

SECTION 3

Manufacture of Cast Iron Pipe

CAST iron pipe is known to have been produced as early as the 15th Century. There is an official record of its manufacture in a foundry at Siegerland, Germany in 1455 for installation at the Dillenburg Castle.

The underlying principle of the process is the same today as it was then. The molten iron was introduced into casting molds where it solidified into the desired shape. Hand labor, of course, was used exclusively and technical controls were unknown. Nowadays, the process is largely mechanized; the most efficient machines electrical and mechanical engineers can devise are utilized and production is guided by the science of metallurgy.

THE FOUR CASTING METHODS

Cast iron pipe was originally cast in horizontal molds in lengths of from four to five feet. The mold into which the molten iron was poured was formed in two boxes of damp sand. Each box contained an impression, in the sand, of half the outer circumference of the pipe. The two half-molds were then closed around a core whose diameter was that of the pipe bore. As the core was a cylinder of baked sand reinforced with iron rods, the limit of the length of molds, and therefore of pipe length, was the extreme length at which the core would support itself without bending.

The problem of increasing the length of pipe, so as to reduce the number of joints, was only partially solved until about 1850 when the method of vertical pouring, or pit casting, came into use. The length of cast iron pipe was thereby increased to twelve feet and later, to as much as 16 feet. The vertical method of casting, as well as an improved horizontal method, are both in use today; the former, chiefly for large diameter pipe; the latter, for small diameter pipe only.

The centrifugal method of machine casting, by which the majority of pipe is produced today, was developed in the early twenties. Some foundries cast pipe centrifugally in sand-lined molds; others use metal molds.

The application of the principle of centrifugal force is fundamentally the same in both processes.

Thus, there are four methods by which cast iron pipe is manufactured:

(1) improved horizontal casting;

(2) vertical, or pit casting;

(3) centrifugal casting in sand-lined molds; and

(4) centrifugal casting in metal molds.

The latter three methods, by far the most widely used, are described farther on in this section.

All these methods involve various operations common to all pipe foundries. These operations are, in order: The analysis of raw materials; the melting of the iron; analysis of the molten iron; the casting, or pouring of the pipe; and finally, the cleaning, testing, and inspection of the finished product.

THE MODERN PIPE FOUNDRY

The modern pipe foundry is so laid out that raw materials are received and stored at one side of the plant and the finished product delivered from the other side. First come the storage piles of pig iron, scrap, coke and limestone; then the nearby cupolas in which the pig iron is melted. The casting floor is next. Here the molten metal is poured into horizontal molds, the vertical molds or the centrifugal casting machines. Where the process requires the preparation of molds, a large area is provided for this purpose, adjacent to the casting floor. After the pipe is cast, it goes to the cleaning floor where it is cleaned, tested, coated and given final inspection.

The cupola is a steel shell, from 5 to 10 feet in diameter according to capacity, and forty feet high, lined with a twelve inch fire-brick wall. The bottom is sealed and a hole through the wall just above it opens into the trough for the escape of the iron as it melts. A short distance higher another hole is pierced for the removal of the slag, and still higher, about three feet above the bottom, a full circle of openings are arranged through which the blast of air is forced. At about half its height, a door in the cupola opens on the second story of the building for the charges of raw materials. Above this point, the cupola serves as a draft stack to prevent the hot gases blowing out through the door.

After a bed of coke several feet thick has been thrown in and ignited, the cupola is filled to the door with alternate charges of coke, pig iron and limestone. The blast of air is led from a low-pressure blower through the openings near the bottom, and in a short time the molten iron begins to flow out. As the coke is consumed and the iron at the bottom is removed, the column of iron and fuel is replenished through the door until a sufficient quantity has been charged. The charges are made up from weight fractions from the various piles of pig iron and are usually brought to the cupola platform one at a time, as needed. A proportion of scrap iron is mixed with the pig, originating either from "home" scrap or from outside sources. When used with a proper analysis of the metal, scrap iron improves the quality of the castings. Limestone is charged with the pig iron to render more fluid the pasty mass of slag formed from the ash in the coke and the foreign matter adhering to the iron, and to permit its easier removal at the slag hole. All pipe foundries use practically the same method of melting iron and, by metallurgical controls have precise knowledge of the physical characteristics of the iron before it is poured into the mold.

MANUFACTURE OF PIT CAST PIPE

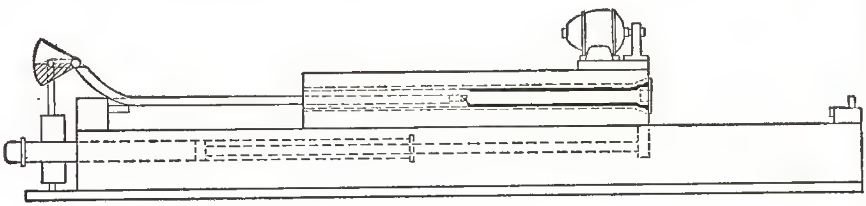
The casting floor of the pit cast department of a pipe foundry is a series of pits in which the molds are rammed and poured. The molds are made in cylindrical containers, called flasks. The barrel pattern is a metal cylinder with handling rings at one end.

Empty flasks and molding sand are brought to the pits to be rammed. Damp sand is thrown in at the top between the pattern and the flask and rammed, or compacted, to form a separating wall. For pipe to be made with bell up, a bell pattern is then placed over the barrel pattern and more sand rammed around it until the mold is full. The barrel pattern is withdrawn by the crane and the complete mold is carried to a drying oven. Hot gases bake the mold until it is thoroughly dry.

Cores are meanwhile being prepared in another department. Both barrel and head cores are made of a mixture of sand and clay and after being formed are baked. When mold and cores are dry they are ready for assembly. The barrel core is lowered through the mold and seated, and the bell core is placed over it. When a group of molds and cores are assembled, molten iron is brought from the cupola in a ladle and poured into the molds. The iron solidifies; the core bar is withdrawn; the flask lifted out of the pit and suspended horizontally over a rail runway leading to the cleaning floor; clamps are knocked off, and the pipes roll out. After cleaning, inspection, and coating, each pipe is subjected to the final hydrostatic test. In the testing press, the pipe is filled with water and must withstand a pressure considerably in excess of what it will encounter in actual service.

CENTRIFUGAL CASTING IN METAL MOLDS

By this process, the pipe is cast centrifugally in water cooled metal molds, a method that has been used commercially in this country since 1922. The machine in which the pipe is cast consists essentially of a cylindrical metal mold mounted on rollers in a water jacket so that it can be rotated at comparatively high speeds. The water jacket is mounted on wheels so that the entire assembly can be moved by means of a hydraulic cylinder in the direction of the longitudinal axis of the mold on a fixed bed inclined slightly to the horizontal. The molten iron is fed into the mold through a trough similarly inclined. The trough has a spout on its lower end which is curved toward the sidewall of the mold. Pre-analyzed molten iron is supplied to the trough by a small casting ladle of sufficient capacity to make one pipe. In casting, the ladle is tilted at a uniform rate by an electrically operated tilting mechanism thus maintaining a constant uniform pouring rate (see diagram). In making bell and spigot or me-



chanical joint pipe, it is necessary to insert a sand core into the bell end of the mold to form the inside contour of the pipe bell. This is done when the mold is at the lower end of the fixed bed. Following that operation the mold and assembly are moved to the upper portion of the fixed bed.

When the mold is at the extreme upper end of the fixed bed, it is ready for casting at which time the trough extends down the barrel of the mold for nearly its full length. After the casting ladle has been filled by a transfer ladle from the cupola, the machine operator, stationed at the upper end of the machine brings the mold up to speed and actuates the mechanism controlling the tilting of the ladle. In a few seconds the iron has filled the bell space at which time the core setter, stationed at the lower end of the machine, gives the operator a signal to start moving the revolving water jacketed mold longitudinally down the bed. The stream of iron discharged from the spout flows tangentially onto the surface of the mold, where it is held in place by centrifugal force and forms a homogeneous pipe with a perfectly cylindrical bore. The hydraulic cylinder is supplied with a regulated amount of water at a constant pressure which results in uniform longitudinal movement of the mold. Since the pouring rate of the casting ladle and the amount of water supplied to the hydraulic cylinder can be regulated easily and accurately, the wall thickness of the pipe produced is held within desired tolerances without difficulty.

After the pipe is completely cast, the mold is kept rotating at its original speed until the pipe has cooled to approximately 1500° F. The pipe is then taken from the machine, transferred to and travels through a closely regulated heat treating furnace where it reaches a maximum temperature of 1700° F. and is slowly cooled below 1200° F. before leaving the furnace.

After removal of each pipe from the casting machine, the mold is cleaned and is then ready for coating and the casting of another pipe. The entire casting operation requires from 1½ to 8 minutes depending upon the diameter and the length of the pipe.

CENTRIFUGAL CASTING IN SAND-LINED MOLDS

By this process, the pipe is also cast centrifugally but in sand-lined molds.

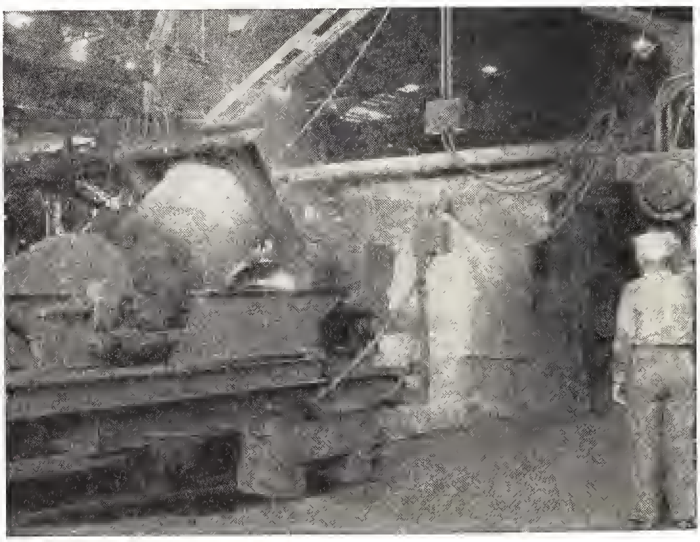
In preparing a mold, the metal flask is placed in a vertical position on a metal stool which closes the lower end of the flask and centers the metal pattern concentrically within the flask. Tempered and bonded synthetic foundry sand is fed at a uniform rate into the open upper end of the revolving flask as rammers pack the sand firmly between the pattern and the flask. When the ramming of the entire length is completed, the pattern is then withdrawn.

The bell or flange end of the mold is closed with a baked oil sand core which extends into the mold to shape the socket of the pipe. The spigot end of the mold is similarly closed with a flat ring-shaped core. In the center of either the bell or spigot end core there is a suitable opening for admission of the molten metal.

The completed and dried mold assembly is placed horizontally in the centrifugal casting machine in which the flask is spun about the horizontal axis by two sets of powered rollers. Since the process is one of continuous production, molten iron of the correct analysis and temperature is being made ready at the same time that the mold is being prepared. Continuous melting cupolas feed molten metal into large receiving and mixing ladles whence the ladles serving the casting machines obtain iron as required. The pouring ladle attached to the casting machine is filled with a carefully weighed amount of pre-analyzed iron. When the flask-mold combination is brought to the proper spinning speed the pouring ladle empties itself into the mold through a trough extending into one end of the mold. Centrifugal force holds the liquid metal on the wall of the sand mold, forming a perfectly cylindrical bore, and spinning is continued until the metal has solidified.

The proper spinning speed to quickly throw the molten metal on the mold wall is determined largely by the inside diameter, and to a lesser degree by the wall thickness, iron temperature, and method of pouring.

When the spinning metal has completely solidified the pipe is cooled in the mold to about 1200° F., then stripped from the flask by breaking loose the sand mold. Each pipe is then cleaned by chipping and grinding all roughnesses at the ends and grinding and washing the inside to remove all adhering slag. After hydrostatic testing, gaging, weighing, and coating or lining, the pipe is ready for shipment.



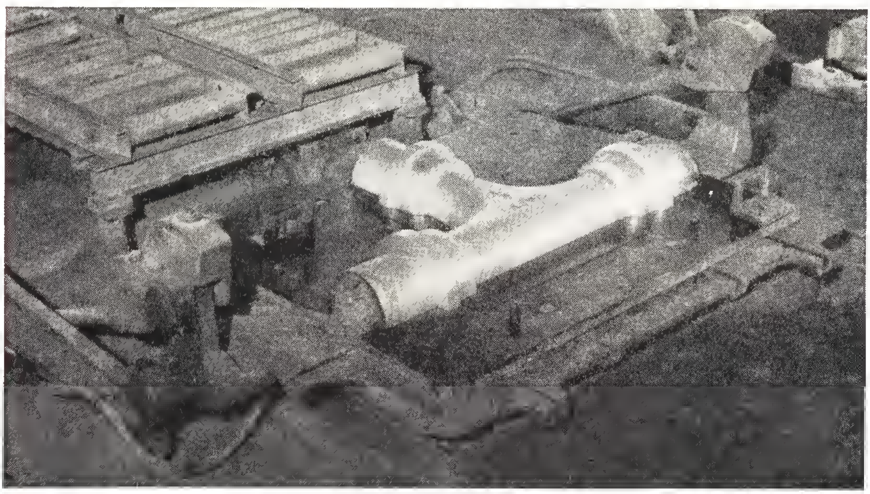
Pouring ladle tilts to introduce molten iron through the trough into the spinning mold—sand-lined mold process

MANUFACTURE OF FITTINGS

Fittings for cast iron pipe are not made in the pipe shop but in a separate department, or building, or even a separate plant devoted exclusively to the manufacture of fittings and special castings.

Most small fittings are made with solid patterns and core boxes in damp or "green" sand molds. The manner of molding is determined by the shape of the casting, as the mold must be parted so that the pattern can be removed without disturbing the sand surfaces. The flasks are conveniently shaped frames with cross bars to support the sand. Hand ramming is still practiced though molding machines and sandslingers of various kinds are used extensively. The accompanying illustration shows one type of these machines, mounted with a six-inch tee pattern. One of the flasks piled in the background is placed over the pattern shown on the left-hand side of the machine, and is filled with sand. An air cylinder underneath the pattern plate raises and drops the pattern and flask with sharp blows until the sand has packed tightly in place. Another cylinder, through arms underneath the pattern plate, swings the flask and pattern vertically to the right side of the machine, where the mold is shown in the illustration. The pattern is then withdrawn from the mold and swung back to its former position, leaving the mold ready to be carried to the pouring floor.

Just back of the machine is shown the core box. A special reinforcing rod or arbor is placed in one half of the box, and both halves are packed



with sand. The box is then closed and one half is lifted off, leaving a firm sand core shaped like the inside of the tee. It is lifted out by the exposed tips of the arbor and placed on the supporting shoulders or "prints" formed at each bell or spigot opening in the mold. The prints fit the core snugly so that when the upper half of the mold is placed over it, the core is held firmly in position and no joints are left between it and the mold through which the iron may run out. Two openings are made into the mold from the upper surface of the flask: One serves as the gate into which the iron is poured; the other serves to indicate when the mold is full and also to permit the air in the mold cavity to escape as it is replaced by the iron. Before closing the mold, both the mold and the core are covered with graphite, or some other refractory material, so that the sand will not fuse to the iron.

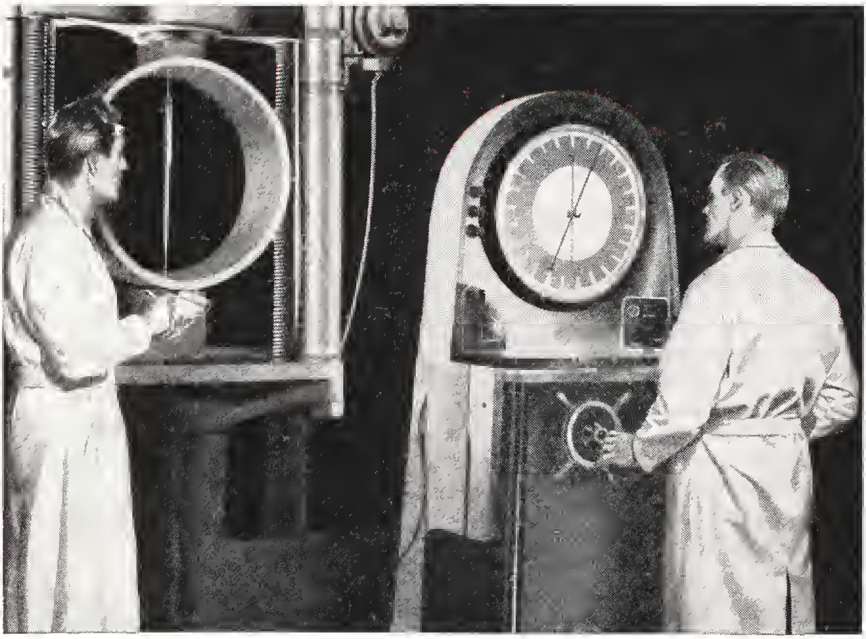
Tees, crosses, and bends up to the twelve-inch sizes are all made very much in the same manner as just described. Above these sizes it is usually more economical to use less expensive pattern equipment even though the molding cost is greater. Then, too, as the sections increase with the size of the fittings, dry sand molds must be used, and numerous variations of molding practice may be employed.

After the fittings have been poured and allowed to cool in the mold, the sand is shaken out in the foundry, and the casting is carried out to be cleaned. Most of the smaller castings are placed in a steel drum where, with slow revolving, they tumble against each other until all adhering sand has been rubbed off. Those castings not suitable for cleaning in this manner are brushed or sand-blasted. All fins and gates are chipped and ground off and the fittings are heated and given the same coating used for pipe.

When the fittings are coated and weighed, they are given a final inspection, occasionally with a representative of the purchaser collaborating with the plant inspector. They are then loaded on cars for shipment, and it is worthy of note that the precautions against rough handling in the field, which are suggested elsewhere in this book, are scrupulously observed by the manufacturer. The fittings are carefully loaded in a manner that reduces to a minimum the possibility of shifting and damage in transit.

SECTION 4

A.S.A. Method of Design



The Ring Test

SECTION 4

A.S.A. Method of Design*

THE method described here for the design of Cast Iron Pipe was developed by the American Standards Association Committee A-21, whose sponsors were the American Water Works Association, the New England Water Works Association, the American Gas Association, and the American Society for Testing Materials. The committee was composed of representatives from these sponsor bodies, pipe manufacturers, consulting engineers, and representatives of other pipe using organizations. This method of design corrects the faults of previous methods by the adoption of the following factors not previously considered in pipe design.

1. The effect of crushing load due to backfill on the strength of pipe subjected to internal pressure.
2. Variations of the crushing load transmitted to the pipe with different trench conditions.
3. Factors of safety based on the overall stresses due to internal pressure and external load.
4. Allowances for corrosion and foundry tolerance.

An extensive series of tests were carried out including bursting, crushing, beam action, impact and pull out strength of joints—separately and in some cases in combination with one another. These tests were carried out at the University of Illinois, Iowa State College, and Ohio State University. A complete report covering these tests and the method of design was presented before a meeting of the American Water Works Association in May of 1938, and published in the American Water Works Association Journal in May, 1939. The title of this paper was, "A Proposed New Method of Determining Barrel Thickness of Cast Iron Pipe," by Thomas H. Wiggin, M. L. Enger, and W. J. Schlick. Comprehensive tests determined: (1) The actual strength of the pipe by bursting full length specimens; (2) the strength of pipe in crushing by three-edge bearing tests; (3) the relation of actual crushing stresses to the three-edge

*For complete details see A.S.A. Bulletin A-21.1.

crushing tests, and (4) the magnitude of surface loads transmitted to the pipe.

COMBINED LOADS

The relationship between the internal pressure and the external load caused by the weight of the backfill and surface loads is expressed by the following equation:

$$w = \frac{W}{\sqrt{P}} \sqrt{(P-p)}$$

in which "W" is the external crushing load in pounds per lineal foot of pipe in 3-edge bearing that would cause failure independent of internal pressure; "w" and "p" will be any combination of external load and internal pressure respectively sufficient to cause pipe failure when acting together.

INTERNAL PRESSURE

The internal pressure is made up of two components. First, nominal working pressure, and second, water hammer that may be caused by rapid closing of valves, the stopping of centrifugal pumps, or other causes. The normal water pressures depend on local conditions and requirements and are known. The pressures caused by water hammer are those commonly used in the water works industry. They are as follows:

WATER HAMMER ALLOWANCE

3″ to 10″	120 lbs. per sq. in.
12″ to 14″	110 lbs. per sq. in.
16″ to 18″	100 lbs. per sq. in.
20″	90 lbs. per sq. in.
24″	85 lbs. per sq. in.
30″	80 lbs. per sq. in.
36″	75 lbs. per sq. in.
42″ to 60″	70 lbs. per sq. in.

The bursting strength of pipe, "P" is determined from the formula:

$$P = \frac{2tS}{D}$$

in which "t" is the thickness of pipe in inches, "D" is the internal diameter in inches, and "S" is the tensile strength of the metal found by bursting full lengths of pipe. The value of "S" has been determined by full-length bursting tests to be not less than 11,000 pounds per square inch for Pit Cast Pipe, and 18,000 pounds per square inch for Centrifugal Pipe. (Using certain foundry practice and controls, this latter figure may be as high as 25,000 pounds per square inch.) The stresses of 11,000 and 18,000 pounds per square inch referred to correspond to metal that when tested in a straight tension test would have values of from 18,000 to 30,000 pounds per square inch.

EXTERNAL LOAD

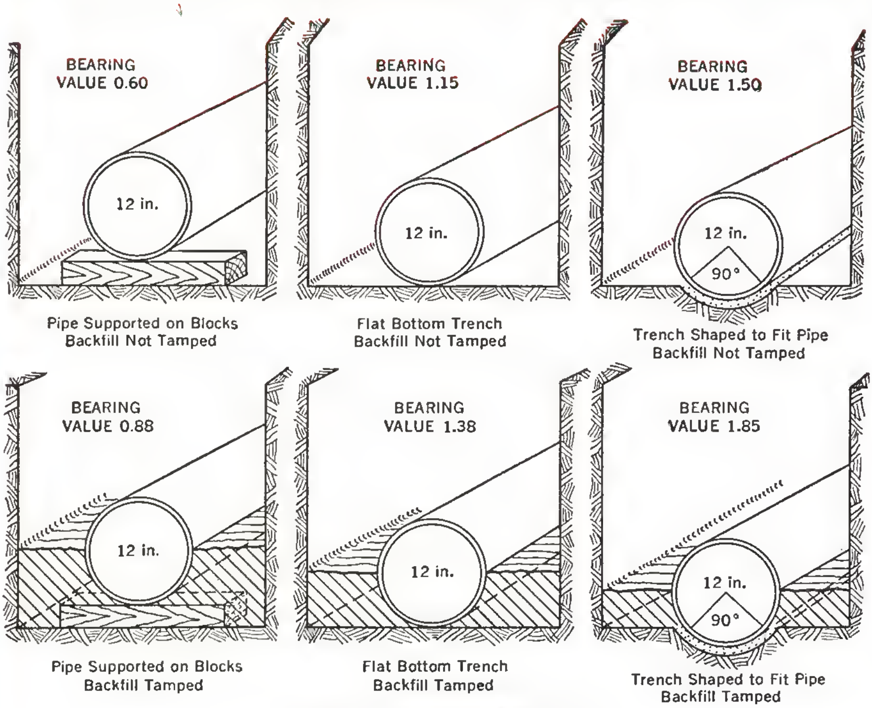
The external load on a pipe is made up of: (1) Weight of backfill; and, (2) weight of the traffic plus impact, and is influenced by the trench condition. These factors must be considered when calculating the crushing load on the pipe.

The fill loads on pipe for various depths of cover and for six methods of installing the pipe on the bottom of the trench are covered by several graphs, curves and tables in the American Standards Association Manual of Design (A.S.A. A. 21.1). The magnitude of the loads can be readily determined by use of the manual. In computing the surface traffic load, it was assumed that two 5-ton trucks are passing over the pipe at the same time. A curve shows the amount of load that is transmitted through the earth to the pipe for various depths of cover. A pipe laid with only a shallow cover will be called upon to carry a large per cent of the surface load caused by the trucks, while pipes laid deep are only slightly affected. However, they are in turn called upon to carry a heavy load caused by the earth backfill.

TRENCH CONDITIONS

The effect of these external forces and loads can be reduced by proper installation. Tests at the University of Iowa for American Standards Association Committee A-21 were made to evaluate the various methods of laying pipe and these methods and values are shown in the following diagram. The six views show the common methods of laying pipe at the bottom of the trench and the bearing values of each 12-inch pipe. These bearing coefficients change for various sizes of pipe.

The first view shows a pipe laid on blocks. This is the poorest way to lay underground pipe, since for sizes under 12 inches it produces a direct beam action, and for larger sizes concentrates crushing loads at the block. Utility operators for years have used this method of laying pipe. If it is



TYPES OF TRENCH BOTTOMS

used, the inspector should insist on the tamping of the backfill under and around the pipe. The two center views show the common method of laying water pipe—a flat bottom trench with the backfill either tamped or untamped. Tamping backfill up to the center line of the pipe is worth the added expense. The two righthand views show the sewer type of construction. This is not often used for water mains, but could be employed to advantage in special cases, such as under deep fills and locations where there is a heavy load on the pipe.

RING CRUSHING TESTS

The ability of cast iron pipe to withstand external loads is determined by crushing rings cut from the pipe and tested in the three-edge crushing test. These rings may vary in width from 1 inch to 12 inches. They are placed in a compression testing machine and loaded until failure occurs. Hundreds of specimens were tested in arriving at the values to be used for design purposes. These values are 31,000 p.s.i. for pit cast pipe, and 40,000 p.s.i. for centrifugal pipe. Since the stresses caused under actual trench conditions vary from those that occur in the three-edge bursting test, conversion factors were arrived at as a result of tests made under actual trench conditions. These conversion factors are shown in the American Standards Association Manual (A.S.A. 21.1–1939).

CORROSION ALLOWANCE AND FOUNDRY TOLERANCES

A corrosion allowance of 0.08 inches of additional metal has been agreed upon for all sizes of cast iron pipe, and foundry tolerances in accord with the following tables were adopted:

FOUNDRY TOLERANCE

Diameter	*Pit Cast Pipe*	*Centrifugal Pipe*
3″ to 8″	.07″	.05″
10″ to 12″	.08″	.06″
14″ to 24″	.08″	.08″
30″ to 60″	.10″	.10″

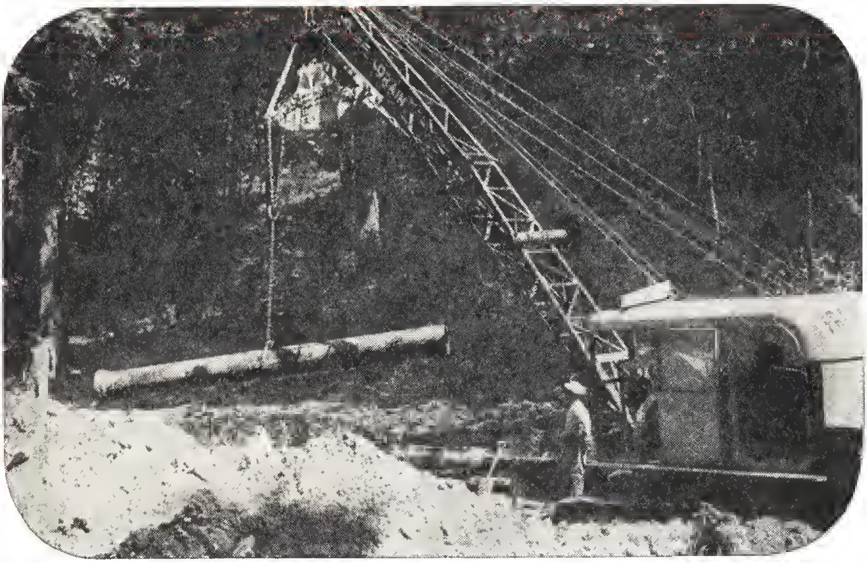
WALL THICKNESSES TO BE USED

Tables in the A.S.A. Manual A21.1 show the recommended wall thickness for cast iron pipe under various trench conditions and depths, and for various internal working pressures. The engineer can readily select from this table the proper metal thickness for pipe for conditions under which it will be called upon to serve.

THE STANDARD LAYING CONDITION ADOPTED BY COMMITTEE A-21 WAS THE FLAT BOTTOM TRENCH WITH TAMPED BACKFILL WITHOUT BLOCKS AND WITH 5 FT. OF COVER. TABLES OF WALL THICKNESSES FOR THIS STANDARD CONDITION ARE SHOWN IN AMERICAN STANDARDS ASSOCIATION SPECIFICATIONS.

SECTION 5

Laying Cast Iron Pipe



SECTION 5

Laying Cast Iron Pipe

THE installation of cast iron underground mains is often regarded as a simple task capable of being performed by almost any kind of labor. This concept has arisen for several reasons: (1) The inherent strength and corrosion-resistance of cast iron; (2) the fact that thousands of miles of cast iron mains, laid by unskilled labor, without proper engineering planning and supervision, have given excellent service, many for more than 100 years. This assumption is almost true. Laying cast iron pipe is a relatively simple job. However, experience and research show that certain elementary requirements should be observed to insure trouble-free service for generations. If a construction engineer were to build a distribution system with his own money, as a lifetime investment for himself and his descendants, he would undoubtedly observe these few simple requirements.

Good judgment suggests that it is more economical to use conscientious care in handling and installing pipe than it is to have to spend money later on for unnecessary maintenance. This is but consistent with the care taken by the manufacturer in producing the pipe and in handling it for shipment. There have been innumerable instances where the blame for a repair job was charged to the pipe only to find, by later investigation, that the fault was properly chargeable to the method of laying the pipe, or lack of reasonable care in handling or installing it.

The following review of the principal points of good practise in the handling and laying of cast iron pipe may be helpful in the promotion of better pipeline construction.

UNLOADING PIPE

From the time the pipe is taken from the molds or the centrifugal casting machine, until it is loaded by special cranes on freight cars or trucks, the manufacturers exercise utmost care to avoid damage to their product. Each length of pipe is examined, hydraulically tested, and inspected before it is loaded for shipment. Every precaution is taken to insure that the pipe will arrive at destination, as it left the foundry, in first class condition.

Damage from rough handling in transit will occasionally occur; consequently, the purchaser or contractor should inspect the pipe as it is being unloaded. A simple precaution is to "ring" each length with a hammer. Damaged pipe should be noted on the freight bill and immediately brought to the attention of the agent for his signature to insure proper adjustment with the transportation company.

In unloading, dropping pipe to the ground from trucks or cars is apt to cause damage which may not show up until after the pipe is installed in the line. Pipe being unloaded on skids should not be rolled against other pipe. Observance of these simple precautions takes little time or trouble and can save money.

DELIVERY AT TRENCH SITE

In the delivery of small diameter pipe to be laid by hand, efficiency requires that the pipe be strung along the route with the bells facing in the direction in which the work is to proceed. To avoid unnecessary handling, the pipe, as well as fittings, should also be placed as close as possible to the locations it will occupy in the finished line.

Usual procedure is to place the pipe close to the trench on the opposite side from the earth pile. Traffic conditions and type of excavation and installation equipment will effect this procedure. A desirable safety measure is to keep the pile of excavated earth between the trench and the road traffic. When travelling cranes are used for handling, the pipe should be strung so as to cause the least interference with traffic.

In the northern states, valves, fittings and hydrants should be placed, or stored, where they will not collect rain water and be damaged in freezing weather. Pipe for future use should be carefully stacked in the storage yard in even layers with 4″ x 4″ stringers between each layer and with heavy blocks at the end of each row to prevent rolling. Bottom layers should be raised on heavy timbers to prevent dirt and rubbish from entering the pipe. For convenience as well as safety, each size should be separately stacked.

EXCAVATION

The width of trench for various sizes of pipe is determined by the type of soil, the depth of laying, type of excavating equipment and the space required to allow workmen to backfill thoroughly around and under the pipe. It is conceivable to install a 36″ pipe, for instance, in a trench 48″

wide, but it would be a physical impossibility to tamp the backfill material properly around and under the pipe with such small clearance. Generally speaking, the wider the trench the greater the earth load on the pipe. However, the trench must be of sufficient width to enable the workmen to tamp the backfill around the bottom half of the pipe. Most specifications allow the trench to be from one to two feet wider than the outside diameter of the pipe.

TRENCH WIDTHS FOR VARIOUS PIPE SIZES

The following table will serve as a guide for width of trench:

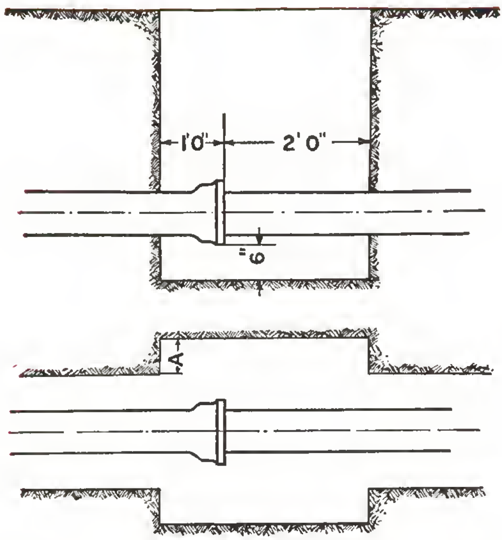
Nominal Diameter of Pipe, Inches	*2*	*3*	*4*	*6*	*8*	*10*	*12*	*14*	*16*	*18*	*20*	*24*	*30*	*36*	*42*	*48*
Minimum Width of Trench, Inches	*18*	*18*	*18*	*21*	*24*	*26*	*28*	*30*	*31*	*32*	*33*	*36*	*47*	*54*	*61*	*68*

The bottom of the trench should be cut true and even, so that the barrel of the pipe will have a bearing for its full length. When trenches are dug with a power-shovel or back-hoe, special care should be taken to make sure that the trench bottom is levelled off to provide a bed for the pipe.

The depth of the trench for water pipe must be at least sufficient to bring the pipe below maximum depth of frost. Large mains laid in heavy traffic streets, under railroad crossings, or in any location where shock might be transmitted to the pipe, should be laid deeper than the minimum requirements mentioned above. In some cases, a minimum covering of 4 to 5 feet is required for mains of even large diameters to provide a cushion to absorb shocks due to traffic. In the southern states, where there is no danger of freezing, a covering of from 2½ to 4 feet is usually sufficient.

BELL HOLES

At each joint a bell hole is dug of sufficient size to insure proper joint making. Digging bell holes so small that the calker cannot easily swing his calking hammer, or operate an air-driven hammer, is false economy. On the other hand, too large bell holes are a detriment to the pipe. Experience has shown that large bell holes dug with a ditching machine place undue stress on small diameter pipe, resulting in breaks due to extra and unnecessary beam action. The diagram following shows the general dimensions of bell holes for small diameter pipe.



Dimension "A" varies from 6 inches to 10 inches, depending on kind of soil, type of joint, calking material used and method of calking (hand or air). In smaller sizes of pipe bell holes may not extend to the surface of the ground in stiff material but may be dished out for about a foot and a half above the top of the pipe.

ROCK EXCAVATION

In rock excavations, it is necessary that the rock be removed to such an extent that at no place will it come closer than 6 inches to the finished pipe line. After the excavation is completed, a bed of sand, or earth free from stones or clods, 6 inches deep, should be made on the bottom of the trench and the pipe placed on this "cushion." Failure to do this may result in the pipe resting on a sharp point of rock, a condition which has caused many breaks in small diameter mains.

Underground mains should be carried around underground obstructions, such as sewers, conduits, piers, vaults and other construction, using special fittings where necessary. Pipe should not be allowed to rest on any unyielding structure, nor should it be called on to support another structure. Pipe should not be laid in a manner that will cause it to act as a beam. It should not be poured solid in concrete walls, footings, piers, abutments or other immovable objects, as the weight of the backfill and settlement of the trench often cause the pipe to act as a cántilever beam, with resulting failure. Sleeves or special wall castings should be used at the junction with these heavy subsurface structures.

CORROSIVE CONDITIONS

Experience has shown that in certain types of soil—some natural and some man-made, corrosion of cast iron pipe may occur. The Cast Iron Pipe Research Association has cooperated with the National Bureau of Standards in their soil corrosion test work ever since its inception, and more recently have undertaken a test program of their own. This work is being carried on in spite of the fact that places where severe corrosion of cast iron pipe occurs are comparatively rare. We know, however, that from time to time pipe must be laid through cinder fills, through garbage dumps, through salt marshes, through muck soils and places of high alkali or acid concentration. Our tests are intended to develop methods of protection for these isolated cases. These tests include trench improvement, cathodic protection, and coatings, including cement armor coating, and as other methods suggest themselves, they too will be investigated. The results of tests up to date indicate that as a general rule, trench improvement, that is, the use of sand or limestone screenings, or similar inert materials, from a point 10 in., below the pipe to 10 in. above, is usually effective and much cheaper than other methods. In the rare cases where extremely corrosive conditions exist, it may be advisable to make a complete study of the conditions surrounding the pipe and to determine a method of protection most suitable for each individual case.

BREAKS IN PIPE

The durability of cast iron pipe, as proved by service records, occasionally persuades construction superintendents and contractors to disregard some of the aforementioned elementary principles of pipe-laying practice. It is true that thousands of miles of cast iron mains, laid before the maze of underground construction beneath the streets of metropolitan cities could have been foreseen, are still in service. Moreover, many of those old mains were installed without benefit of engineering planning or supervision. It is, therefore, remarkable that the percentage of breaks per year in cast iron pipe compared to lengths in service, is negligible.

Surveys made by staff members of the Cast Iron Pipe Research Association and studies of annual reports of water supply systems, show that "breaks per mile per year" amount to less than one one-thousandth of one per cent of the lengths of cast iron pipe in service.

Breaks in water distribution mains are "front page news" for the very reason that they occur infrequently. Newspaper reporters are seldom informed before press-time that the broken length of pipe was resting on a sewer line, supporting a conduit, or was serving under conditions unforeseen at the time it was installed.

Cast iron pipe is designed and produced to have wide margins of safety in beam strength, bursting strength and compressive strength. With reasonable care in handling and installation, and due regard to the hazards of other underground installations, breaks in cast iron pipe will continue to be, as they have in the past, a rare occurrence.

METHODS OF INSTALLING PIPE

There are several types of trench bottom used in laying pipe. These include laying pipe on blocks placed on the bottom of the trench; laying pipe on a flat bottom trench; or on a trench bottom rounded out to fit the shape of the pipe. Some foremen have tamped the backfill around and under the pipe; others have thought it a waste of time, and many have their own particular methods of construction. The American Standards Association has carried on research studies through its Committee, A-21, at Iowa State College and the University of Illinois. These studies of pipe-laying conditions have developed actual relative strength values for various methods of installing pipe in the bottom of the trench. Diagram on page 35 gives relative bearing values for 12″ pipe for different trench conditions.

Six methods of installing pipe were studied by this committee:

A. Flat bottom trench, backfill not tamped.
B. Flat bottom trench, backfill tamped.
C. Pipe supported on blocks, backfill not tamped.
D. Pipe supported on blocks, backfill tamped.
E. Bottom of trench shaped to fit the bottom of the pipe for about 90 degrees, unevenness filled in with sand as required, backfill not tamped.
F. Same as E, except that the backfill is tamped.

Method "C" produces the greatest loads that tend to crush the pipe, and method "F" produces the smallest crushing loads. Type "B" method is the one adopted as standard by Committee A-21 of the American Standards Association.

When blocks are used for aligning and supporting the pipe, they should be placed at two points in the length of the pipe. Especially is this important for sizes under 16″ in diameter. The blocks should be laid on undisturbed earth and set in slots in the bottom of the trench so that they project about 1″ above the trench bottom. They should be so set as to have a bearing over the entire surface. The primary purpose of blocking is to support and level the pipe during construction. The backfill material should be carefully tamped around and under the pipe so that the blocks will carry only a small per cent of the finished load. The use of blocks for installing water mains is becoming less common and the practice may soon be discarded altogether.

HANDLING PIPE

Pipe should be handled by mechanical equipment if possible and not just rolled or pushed into the trench from the bank. Pipe up to 12″ in diameter may be lowered into the trench by taking a turn of rope around each end of the pipe, while standing on the other end of the rope, and then playing it out until the pipe rests on the bottom of the trench. Large sizes are best handled by means of power equipment.

Before the pipe is lowered into the trench, it should be swabbed or brushed out to insure that no dirt or foreign material gets into the finished line. Where pipe has been allowed to remain along the right-of-way for a considerable time, it may become fouled with surface pollution and should be swabbed out or otherwise disinfected with a chlorine solution. Trench waters should be kept out of the pipe and the pipe kept closed by means of test plugs whenever work is not in progress.

YARNING

Before entering the spigot of the pipe into the bell of the preceding length, strands of yarn are held in place around the spigot so that both enter the bell at the same time. The yarn serves to center the spigot in the bell and to keep it at the proper distance from the bottom. This is important, and if by chance, after the crane slacks off on the pipe, it is found that the joint space on the bottom is smaller than on top, the pipe should be raised by the crane, ropes or wedges, and additional yarn driven into the lower part of the bell.

Strands of yarn, or braided hemp if used, are cut somewhat longer than the circumference of the pipe so that the ends will overlap, and the overlapping ends of successive strands should be staggered. The separate strands should be driven home with a yarning tool and hammered, and when the last one is in place all strands should be thoroughly compacted. This is essential to the making of a good joint as the yarn forms a compressible gasket that helps assure water tightness. Sufficient yarn should be used to fill the bell up to within 2 to 2½ inches of the face. There are several grades of yarn for various types of work. The yarns that are used by plumbers or boat makers are not suitable for water works construction, as they are impregnated with tar or oil and will impart a definite phenol taste and odor to the water. If sterilized yarn is used it should be kept in substantial containers with tight-fitting covers so that it will not be contaminated during construction. Sanitary aspects of water works construction are receiving more care and thought than in the past.

Yarn has been used as a calking material for over 100 years, but recently several alternative products have been developed: A specially prepared paper calking material, a braided cotton material and various types of rubber products. The rubber gasket material is prepared in a round form which can be cut off in suitable lengths for the various sizes of pipe, and also ready-formed in diameters for various sizes of pipe. These materials were developed because of contamination entering water mains due to the use of yarn as calking material. Yarn has been the source of considerable criticism due to its ability to support gas forming bacteria.

JOINT MATERIALS

The most common type of joint is made with cast lead. For water lines cement and sulfur jointing compounds are also used. Recently, mechanical gland-type joints having heavy rubber gaskets have gained much favor in both the water and gas industries.

LEAD JOINTS

After the joint is yarned, the lead runner is put in place on the joint so that it fits tightly against the face of the bell and the outside of the pipe. Clay should be used whenever necessary to make a tight joint between runner and pipe. The pouring gate is built up with clay to a point at least one inch above the top of the joint space. If possible, joints should be poured from one ladleful of lead. If more than one ladleful is required, no considerable time should elapse between pouring successive ladles. In the case of joints on pipe above 48 inches in diameter, in extremely cold weather, it is sometimes necessary to pour the joints in halves. The runner is placed around the bottom halfway up on the pipe. Lead is then poured into both gates until it has reached a point just below the midpoint on the pipe. The bottom of the runner remains in place and the upper ends are then placed over the top half of the pipe and a pouring gate built up at the extreme top as in pouring ordinary joints. The remainder of the joint is then poured in the usual manner. As soon as the joint has cooled, the runner is removed and the joint is ready for calking.

In extreme cold weather it occasionally becomes necessary to heat the joints of large size pipe to avoid "misses."

Good calking practise requires that each calking tool be used, from the smallest to the largest, that will fit in the joint space and that the joint be calked completely around with each tool. This method calls for more work than would be necessary if only the larger tools were used but the joint that results is worth the additional effort. Pneumatic calking hammers are recommended even for small diameter pipe. Their use produces a much better job of calking, with less effort by the workmen and at a lower cost. Excessive calking should be avoided to prevent splitting bells. The depth to which calking is effective has been found to be about ¾ of an inch when calking is properly done. Lead wool may be used for repairing joints. It comes in a loosely shredded rope form and is calked into the defective joint one strand at a time.

LEAD ALLOYS

Where extremely high pressures are to be used, alloys are added to the commercial lead, the object being to produce a material that is harder and consequently less apt to "flow" or flatten out when pressure tends to push the lead out of the joint. The City of Boston after experimenting with different alloys for use in its high pressure fire-fighting system, adopted one consisting of 96% lead, 2% tin and 2% antimony; a mixture of 95% lead and 5% tin was also used with good results.

LEAD SUBSTITUTES

Several kinds of self-calking substitutes for lead have been developed. These materials are usually a mixture of iron, sulfur, slag and other ingredients which, when melted and cooled, forms a hard slag-like mass. They are furnished in either a powdered form or in small pigs. Less heat is required for melting than in the case of lead. The best results are obtained with a gasoline-fired furnace as temperatures can be accurately controlled. Overheating of the material is a common fault and results in a poor joint.

In yarning the joint, it is important that a dry yarn be used and that the inside of the bell and outside of the spigot be thoroughly cleaned. Braided hemp is better than ordinary yarn for this type of joint. The jointing operation is usually kept four lengths back of the pipe-laying crew.

The runner is placed in the usual manner and the pouring gate built up 6 or 8 inches above the top of the bell. The manufacturers furnish cone-shaped metallic runner-heads that are used in place of clay for a high pouring gate. The joint is now ready for pouring. The compound is at the proper temperature when it flows freely, reflects one's image as in a mirror, and is free from foam or bubbles. If too hot or too cold it will be somewhat thicker than the required consistency, and it should be either reheated or cooled before pouring. The joint should be poured with one ladleful until the joint and pouring gate are full. When the jointing material has cooled, the runner should be removed, the joint inspected, and the runner-head cut off. In case of a defective joint the material should be cut out for several inches, all loose material removed, and the defective joint repoured. This joint requires no calking and is ready for use as soon as it has cooled. As it is a characteristic of this joint to sweat or seep a little at first, the final leakage test is not run until 30 days after the pouring. Since this type of material may not be adaptable under certain conditions, prudence suggests investigating installations operating under similar conditions before its use.

CEMENT JOINTS

Water systems throughout the Southwest and along the Pacific Coast have used cement joints for pressures up to 150 pounds. A number of different methods of making the joint have been developed. The method described below seems to be the most common.

First, the pipe should be properly supported before the joint is started, so as to eliminate any possibility of movement before the cement has set. The next step is to yarn the joint, just as for any other type of material, being sure to see that the yarn is driven home with hammers in the usual manner. The yarn should be free from all oil and grease. Cement for the joint itself should be about one quart of cement to ¼ pint of water, and thoroughly mixed by workmen, usually in wheelbarrow so that mixing can keep pace with joint making. Experience shows that neat cement mixed with a sufficient quantity of water, and thoroughly kneaded by hand to such a consistency that no moisture will show when squeezed tightly in the hand, will give proper results. The cement should be dry enough to give a metallic sound while being calked. Cement mortar should be made up in small batches so that no mortar shall stand longer than 30 minutes before using. A wooden or iron tool with a broad face is used for ramming the mortar into the joint. The joint should be calked when half-filled with cement, and again when filled, using lighter blows than for a lead joint.

MECHANICAL JOINTS

The mechanical joint, developed about 25 years ago, is based upon the well-known engineering principle of the stuffing box. It has four parts: A flange cast integral with the socket, or bell, of the pipe; a rubber gasket fitting a recess in the socket; a gland, or follower ring, to compress the gasket, and the bolts and nuts for tightening the gland. A complete description of this joint with instructions for assembling will be found in Section 12.

The assembly of this joint is simplicity itself, requiring but one tool, an ordinary ratchet wrench. It is quick and easy for even untrained men. A wet trench presents little or no difficulty because the pipe can be jointed above the trench and lowered.

One of the problems in the operation of gas systems distributing dry or mixed gas has been "unaccounted-for leakage." The mechanical joint proved to be the answer. It is bottle-tight at high pressure for both gas and water lines. It permits a high degree of deflection as well as longitudinal expansion and contraction.

Mechanical joint cast iron pipe can be laid faster with less equipment and smaller crews, more than offsetting the higher cost per foot compared with bell and spigot pipe. Moreover, it is now completely standardized so that fittings and accessories made by one manufacturer will fit the pipe produced by any other manufacturer.

COUPLED JOINTS

For connecting plain end pipe several types of couplings are available, the best known being the Dresser Coupling. This coupling consists of two flanges, two gaskets, a middle ring and the necessary bolts. The gaskets are usually of rubber, but various types are available for the specific duty of the pipe line. To insure uniform compression of the gasket, bolts opposite each other are drawn up a little at a time until all are drawn up to the limit. The best joint is obtained when two men work on opposite bolts, each drawing his up an equal amount. On small size pipe several lengths may be joined together on the bank before lowering into the trench. For large size pipe, the joint must be made in the ditch.

Victaulic Coupling: This type of coupling for cast iron pipe has two malleable iron half housings, an endless rubber ring and malleable iron bolts. The couplings for large pipe are made up of several segmental housings bolted together. Cast iron pipe for use with victaulic couplings is furnished with shouldered ends for high pressure and with grooved ends for medium or low pressure.

SUBMARINE PIPE LAYING

There are several methods of installing cast iron pipe across rivers or other bodies of water. The most common practise is to use mechanical gland type pipe, either the standardized mechanical joint that deflects up to 8 degrees, or the ball and socket joint that deflects up to 15 degrees. Large pipe, 24 inches or over, is usually made up in sections of three or four lengths either on shore or on the deck of a barge, and then attached to a "strongback" and the assembly lowered to the bed of the stream where the sections are progressively connected by divers. Submarine lines under 24 inches in diameter are usually laid with joints provided with positive locking devices so that the pipes cannot be pulled apart. This type of pipe can be assembled on a barge and lowered from the rear of the barge as the line progresses across the river or lake. These joints have a wide angle of deflection and readily follow the contour of the bottom of the river.

In shallow water it is often economy to construct cofferdams and after pumping them out, to lay the pipe as on dry land. If the body of water is navigable the cofferdam should be constructed in sections, to provide a channel for boats. In still water the line may be joined together on shore along the bank and floated by means of barrels or rafts attached to the pipe. When the entire length of line has been assembled, one end is towed out until the pipe occupies the desired position. It is then lowered by releasing the barrels, care being taken during the sinking process so that the joints do not become distorted. If lead joints are used, the entire line should be lowered as one unit. Cofferdams are then constructed at the shore ends and pipe connected up in the usual manner.

A somewhat similar method is to lay the pipe on the shore and as each length is connected up to push it down skids into the water where barrels are attached to it. As each successive length is laid, the line extends further into the water. The finished line is sunk in the manner described above.

Another method is to drive piling in pairs along the proposed line and to rest the pipe on timbers supported between piles. When the entire line is connected up, sills are laid across the top of the piles and pipe supported from the sills by means of rope, blocks, or chain hoists. The pipe is then raised enough to release the timbers upon which it was resting, and after their removal the line is lowered gradually to the bottom of the water. It is not necessary that the entire line be lowered as a whole. It should be lowered beginning at one end and proceeding to the other so that the total deflection of the joints is not excessive.

Submarine lines laid in navigable streams should be placed in trenches and covered over so that the pipe will not be injured or pulled up by boats dragging their anchors.

TESTING WATER MAINS

Good engineering practice requires that all pipe lines be tested before placing in service, and usually before backfilling. In city streets with heavy traffic, backfilling is done as soon as two or three lengths of pipe have been laid. This applies to both water and gas mains. In the case of water mains the test pressure should equal the pressure under which the line will operate plus 50 per cent over the working pressure. Care should be taken to see that air is expelled and all caps and plugs are properly braced before the test pressure is applied and that all piers and masonry supports at bends and tees are in place.

Air is expelled by opening a fire hydrant near the high point of the line, or by opening a corporation cock that has previously been inserted. When the air has been expelled, the valve or valves between the old part of the system and the line under test are closed. Pressure is then applied to the portion under test either by means of a hand pump for small lines, or small sections of large lines, or by use of a gasoline pump or fire engine for large lines. After the main has been brought up to the test pressure it should be held at this pressure for at least 30 minutes and the make up water carefully measured by the use of a displacement meter or by pumping the water from a vessel of known volume. The American Water Works Association Specification for Installation of Cast Iron Water Mains (C600-49T) requires that the leakage shall not exceed 70 gallons per 24 hours per inch of diameter per mile for 12-foot lengths and correspondingly varied for other lengths of pipe when the test pressure is 150 lbs. A table in the specification shows allowable leakage per 100 joints for other test pressures. While the pipe is under test it should be thoroughly inspected from one end to the other, especially the joints, to be sure that they have been properly calked. Any leaking or sweating joints should be redriven and the line made tight.

In the case of sulfur compound joints the line should be left full of water for 30 to 40 days before making the final measured leakage test.

However, initial hydrostatic tests may be run at any time after the joints have been poured and before backfilling. Pipe joints made with cement should not be subjected to the hydrostatic test until after 36 hours from the making of the last joint in the line. The measured leakage test should not be made until 14 days have elapsed. After any leaks or other defects have been repaired the ditch should be backfilled.

TESTING GAS MAINS

In testing gas pipe, air pressure is used and leaks are detected either by applying soapsuds to each joint, or by placing a water-filled canvas bag around the joint. In the case of leaks, bubbles will appear and the joints can be recalked, if of lead, or the bolts tightened if of the mechanical joint type. As a rule the actual leakage in gas lines is not measured by a displacement meter, but the tightness of the line is determined by the fact that the pressure, when built up to the test point remains stationary for a 24-hour period. Recording pressure charts and recording thermometers are used for making the check. Temperature is a very important factor in the test and must be given due consideration.

SUPPORTS FOR FITTINGS

Supports should be constructed behind all bends, tees, caps, and plugs. They should be designed to carry the load that will be imposed upon them with the pipe working under its maximum head, and with a reasonable allowance for water hammer. They should bear against undisturbed earth and in case this is not possible, they should be made correspondingly larger due to poor bearing capacity of newly filled ground. The use of supports behind fittings refers to fittings in the vertical plane as well as those used in the horizontal plane. These should be so designed that they will not interfere with recalking joints should such work become necessary.

BACKFILLING

One phase of pipe line construction that is apt to receive casual attention is backfilling. The old fashioned idea of shovelling the dirt into the trench and letting nature take its course is a prolific source of trouble. The proper method is to replace the excavated earth in such a way that future settlement will be reduced to a minimum. When a trench is carelessly backfilled the pipe may be called upon to act as a beam in supporting material directly over it. In the case of excavation in sand, backfilling can be done efficiently by the proper use of flooding, although even in this case some care is necessary to see that no open spaces are left under the pipe.

CUTTING PIPE

There are two general methods used for cutting cast iron pipe: A cutting machine, or by the use of diamond points, chisels, hammers, etc. The ordinary wheel type of cutter is used for pipe up to about 16 inches in diameter. The operation of this type of cutter requires no particular explanation, nor is a great amount of skill required.

A certain degree of skill and care is necessary when cutting pipe with cold chisels, diamond points, and hardys. When cutting pipe in the trench, or when cutting larger pipe on the bank, it is advisable to use a chisel with a diamond-shape point. This tool actually removes the iron in small chips instead of merely deforming it. After a groove has been cut completely around the pipe with the diamond point, a cold cut or hardy is used for finishing the cut. It is possible, by striking hard blows with heavy hammers, to cause small cracks in pipe that is being cut, which may not show for some time. Care is needed if pipe is not to be damaged in the cutting process.

CHLORINATION OF MAINS

All new water distribution systems, or extensions to existing systems should be thoroughly flushed and sterilized before being placed in service. The contractor or construction superintendent should see that the pipe is clean when installed, and should give the new mains a complete flushing before turning them over for operation.

Chlorination or sterilization of mains should be done by men who have had experience with chlorine or other sterilizing agents. Prior to chlorination all dirt and foreign matter should be removed by a high velocity flushing through fire hydrants or other approved blow-offs. A good flushing is a very important factor in sterilization. Chlorine can be used in several forms, as a gas with direct feed as the water is let into the new main, as a dry powder such as Hypochlorite placed in each length of pipe as the line is laid, and as a mixture of chlorinated lime and water. The dry powder is the easiest to use, especially when the work is being done by the contractor, although, some sanitary engineers rate it as the least effective method. The important point in the chlorination of a main is to have it entirely filled with a chlorine solution of at least 40 to 50 parts per million of chlorine and to retain it in the pipe for at least three hours.

After this period the chlorine residual at the pipe extremities should be at least 5 parts per million.

The dosage for sterilizing new mains when using Calcium Hypochloride (comparable to commercial products known as H.T.H. Perchloron, and Maxochlar which contains about 70 per cent available Chlorine Maxochlar), shall be one pound for each 1,680 gallons of water pipe capacity treated. This dosage is equivalent to a treatment of 50 p.p. million available chlorine. In like manner, one pound of Calcium Hypochlorite powder will treat 2,100 gallons of water to 40 p.p. million chlorine. Following chlorination, all treated water should be thoroughly flushed from the newly laid pipe line at its extremities until the replacement water throughout its length shall equal in quality, both chemically and bacteriologically, the water served to the public by the water supply system. (See A.W.W.A. specification for disinfecting water mains.)

For detailed information on chlorination of water mains see A.W.W.A. Document C601–48 (or the most recent revision), "The Procedure for Disinfecting Water Mains." Reprints of this publication can be secured from the American Water Works Association, 521 Fifth Avenue, New York 17, New York—Price 15c.

SECTION 6

Flow of Water in Cast Iron Pipe with Flow Tables

SECTION 6

Flow of Water in Cast Iron Pipe

IN SOME areas of the United States, water mains have lost an appreciable part of their original carrying capacity after years of service, and for this reason consideration of the causes of this trouble and the remedies should be of interest. This loss in carrying capacity results in increased costs either because of extra pumping expense or additional capital charges if larger mains are required. There are many reasons for a reduction in the flow capacity of a pipe line—reduced flow does not necessarily indicate that the trouble is caused by tuberculation. Increased friction may be due to any of the following:

1. Sedimentation; mud, silt or sand.
2. Obstruction of the pipe due to debris; sticks, boards, stones, tools and other things that may have gotten into the pipe during construction.
3. Partly closed valves.
4. Accumulation of air at summits.
5. Mineral deposits.
6. Slime growths on walls of pipe.
7. Tuberculation.

All of these difficulties can be taken care of by proper design and operation.

SEDIMENTATION

Transmission mains that carry raw water from rivers or lakes are subject to heavy deposits of silt and sand whenever the rivers are at flood stage, or the lakes turbulent. Many of the older distribution systems were supplied with raw water for years before the construction of treatment plants. During the low consumption periods at night, these waters settled out a layer of mud along the bottom of the pipe. Sand may enter the raw water lines at most any time and it may enter the distribution lines whenever the filters become defective or when the beds are abused by inexpert operation. If sedimentation has occurred, the remedy is either to flush the mains or when this is not effective, to carry on a pipe cleaning operation.

OBSTRUCTIONS IN PIPE

Modern pipe laying specifications require that each length of pipe be cleaned out before installation in the line. They also require that the end of the pipe be closed with a plug after each day's work. In spite of these provisions it is a fact that at times stones thrown into the pipe by children, or pieces of wood, tools, boots, and other things placed in the last pipe by workmen, who expect to remove them before the work continues, are sometimes left in the pipe. Good laying practice should eliminate this difficulty.

PARTLY CLOSED VALVES

In the ordinary operation of a water works system, it becomes necessary from time to time to close valves to carry on maintenance and extension work and in many of the systems, valves are throttled for pressure control purposes. Care should be taken to the end that closed valves be opened after the construction work is completed and the location of throttle valves properly recorded so that in the event that future operation requires a full opening, these valves may be opened. The opening and closing of valves is an important part of distribution system operation and records should be kept in such a fashion that no valves are accidentally left closed or partly closed.

ACCUMULATION OF AIR AT SUMMITS

In supply lines in hilly country, there is occasionally an opportunity for air to accumulate at a summit to the point where the water occupies only a portion of the total area of the pipe. In extreme cases, water may even be shut off completely by the accumulation of air. The remedy for this difficulty is to provide air valves at summits in installations of this nature.

MINERAL DEPOSITS

In rare cases, waters are highly mineralized. These minerals are picked up from the rock formations through which the water seeps in its underground passage. Some waters are super-saturated and the minerals only loosely held in solution. A small amount of air mixed with water in the pumping operation may cause the mineral to deposit out, or the water may change temperature and in this manner cause precipitation. Natural lime waters usually form a hard, smooth deposit on the entire wall of the pipe and do not increase the friction loss to an appreciable extent until the diameter of the pipe is materially reduced. Mineral deposits in mains are difficult to remove, usually requiring special cleaning tools. Lime deposits that result from softening and filtration processes are sometimes carried out into the mains. As a rule, these deposits are relatively soft and may be removed by ordinary pipe cleaning operations.

SLIME GROWTHS

Some water supplies are troubled with organic growths in the mains. Many of the growths may be due to the use of surface water containing microscopic organisms. Some of these may cause tastes and odors, and others, while having little effect on the quality of the water, cling to the walls of the pipe reducing the rate of flow in the line. These growths may be removed by the use of chlorine, a combination of chlorine and ammonia, or copper sulfate. The nature of the treatment depends on each individual case and the application of chemicals should usually be started by the use of small dosages with gradual increase until the required effect results. A sudden change in chemical dosage is liable to cause complaints of tastes or odors.

TUBERCULATION

In certain parts of the United States, uncoated or unlined cast iron water mains may develop a nodular growth on the interior of the pipe. These growths are called tubercules and their accumulation will materially affect the capacity of the pipe line. These growths can only occur where the water comes in contact with the metal of the pipe and the remedy for the difficulty is the use of cement linings wherever "active" waters are to be transported. The details on cement lining processes and advantages can be found on page 59 of this book.

Williams-Hazen Flow Tables and typical examples of flow computations will be found in the section following.

Williams-Hazen Flow Tables

THE following friction flow tables (pages 63 through 71) are based on the Williams and Hazen formula, $V = Cr^{0.63} s^{0.54} 0.001^{-0.04}$. The formula makes use of a coefficient "C" which varies with the condition of the interior surface of the pipe—the smoother the surface of the pipe wall the larger the value of "C" and, consequently, the greater the carrying capacity; the rougher the surface, the smaller will be the value of "C". Field tests of modern cast iron pipe shows the value of "C" to range from 140 to 150 for new pipe. Many tests conducted in the field on long working lines suggests the following values of "C" for design purposes.

Use C = 140 for transmission mains and supply lines. If the water is tuberculating and forms nodules on the inside surface of the pipe, cement lined cast iron pipe should be used in order to maintain the original carrying capacity of the line.

Use C = 130 for secondary mains of shorter length and smaller diameter.

Use C = 100 for city distribution work involving a large number of fittings, hydrants, services, short runs of pipe and for old unlined pipe lines. The tables that follow have been prepared to show capacities and friction losses for these three conditions. The following are examples of how the flow tables may be used:

EXAMPLE NO. 1—Find the friction loss in five miles of 24-inch cement lined cast iron pipe supply line, delivering 6,000,000 gallons per 24 hours. A coefficient of C = 140 should be used for a pipe line of this character, and by referring to the table for 24-inch pipe we find that the friction loss per 1,000 ft. of main is 1.06 ft. (reading across the table from the 6,000,000 gallon rate of flow and in the column under C = 140). Then the friction loss in the pipe line will be $5 \times \frac{5280}{1000} \times 1.06 = 28$ ft., which is equivalent to 12.1 pounds.

EXAMPLE NO. 2—Find the friction loss in 500 ft. of unlined 8-inch cast iron distribution main laid twenty years ago, delivering 400,000 gallons per 24 hours. A coefficient of C = 100 should be used for a condition of this kind. By referring to the table for 8-inch pipe and by reading across from the 400,000 gallon per day rate of flow and in the column under C = 100, we find a loss of 2.76 ft. per thousand feet of pipe. Then the friction loss will be $\frac{500}{1000}$ x 2.76 = 1.38 ft., which is less than one pound loss.

EXAMPLE NO. 3—How much water will a 16-inch lined cast iron pipe, 6,000 ft. long, deliver when the head (or pressure) at the supply end is 120 feet and a residual head of 100 feet is desired at the delivery end of the line. By subtracting the desired residual pressure from the initial pressure we find that 20 feet is available for overcoming the friction loss. As the water main is 6,000 feet long, the head that can be expended for each 1,000 feet of pipe is 20 divided by 6, or 3.33 ft. By referring to the table on 16-inch pipe in the column head C = 140, we find that with a friction loss of 3.33 feet per thousand feet of pipe, the pipe in question will deliver 3,825,000 gallons per 24 hours.

CEMENT LININGS FOR CAST IRON PIPE

Cement linings for cast iron pipe have been in use for approximately 30 years, and cement linings in other metal pipe have been in use for over 80 years. For the majority of water supply systems, tuberculation presents no problem; however, in certain parts of the United States, uncoated or unlined cast iron water mains had lost an appreciable part of their original carrying capacity after many years of service. In these relatively limited areas, reduced carrying capacity was generally caused by tuberculation, a nodulose growth on the inside of the pipe caused by tuberculating water. It is now known, and has been conclusively demonstrated, that the use of cement linings prevents tuberculation by keeping the "active" water from coming into contact with the iron.

DEVELOPMENT OF CEMENT-LINED CAST IRON PIPE

The first attempt to solve the problem of tuberculation was the application of a tar coating to the inside of the pipe. The tar-coated pipe resisted tuberculation to a greater degree than the uncoated pipe. However, it became apparent, with time, that "active" water penetrated pinholes in the tar coating and tuberculation ensued. The need of an effective pipe lining to combat tuberculation led to experiments with cement mortar.

In 1921, the first cement-lined cast iron pipe was installed in the water distribution system of Charleston, South Carolina. Tests made over a period of 23 years showed virtually no loss in carrying capacity in spite of the fact that highly tuberculative water was carried. Subsequent experience in many installations, during more than a quarter-century, has demonstrated that cement-lined cast iron pipe is tuberculation-proof, insuring high carrying capacity for the life of the pipe.

ECONOMICS OF CEMENT LININGS

The advantages of cement-lined cast iron pipe go beyond the prevention of tuberculation and are clearly applicable to installations in territories where tuberculating waters.do not exist. In order fully to understand the financial advantages of using cement linings it is necessary to have some knowledge of certain hydraulic phenomena.

When water moves through pipe, friction is developed between the water and the inside of the pipe. The result is that, as the water travels through the pipe, some of the energy imparted to it by the pump is consumed by the friction, resulting in a loss of pressure. The amount of friction so developed is the criterion by which the size of pipe, and the amount of power required for pumping, are determined. When a given amount of water is to be transported, the total amount of friction developed depends on the diameter and length of the pipe and the condition of its interior.

THE WILLIAMS-HAZEN FORMULA

For nearly a half century, engineers have been guided in determining pipe capacity by the Williams-Hazen formula.

$$V = Cr^{0.63} s^{0.54} 0.001^{-0.04}$$

This formula was developed empirically from results of tests on a number of water lines throughout the United States. The coefficient "C" in this formula is intended to reflect the condition of the pipe interior. The other values in the formula have to do with length, loss of head and size of pipe.

The tests on which this formula was based indicated that new tar-coated cast iron pipe had a coefficient of 130, and that, as time went on, with certain waters, it fell off to less than 100. For design purposes it became the custom to use a coefficient of 100 as the value of "C" in the formula.

Since most waters do not cause serious tuberculation, the practice of using a value of 100 produced results definitely on the safe side. Pipe lines designed according to that value performed above par; that is, either pumping costs were lower than contemplated, or capacities exceeded those assumed in the original design. The reverse was true where growths developed in the pipe restricting the flow to the point where higher pressures were needed at the pumping station, pipe cleaning was resorted to, or even new lines required.

FINANCIAL ADVANTAGES

The principal advantage of cement linings is increased carrying capacity when the pipe is new and maintained carrying capacity as the pipe grows older. The economy resulting from the prevention of tuberculation is obvious, but experience has shown that less friction results when cement linings are used even where non-tuberculating waters are transported.

For example, a test made on a new 36-inch *tar-coated* cast iron supply line showed a coefficient of approximately 135. A test on a new 36-inch *cement lined* cast iron line showed a coefficient of 145. Since new pipe was tested in both cases, the difference in values was due to the different conditions of the pipe interiors.

As a demonstration of the financial advantages accruing from the use of cement linings, consider a typical instance based on flow conditions that prevailed at the time flow tests were made on the 36-inch cement lined pipe referred to above, and project them into the future.

A 36-inch (nominal diameter) cement-lined pipe under test was carrying 8,290,000 gpd. in a line 74,400 feet long. The Williams-Hazen coefficient determined by the tests was 145 and the loss of head was 16.8 feet.

Also tested was a 20-inch tar-coated line that had been in service 29 years which was found to have a coefficient of 102. (It is safe to assume that at the end of another year this coefficient would have been 100.) Assuming no increase in demand and a pumping cost of 5¢ per mil. gal., 1 ft. high, the annual cost of pumping against friction head only, if tar-coated pipe were used (actual inside diameter 36.8 in.), would have ranged from $3,140.00 per year when new (C = 130) to $5,160.00 per year when the pipe had reached an age of 30 years (C = 100).

In the case of cement-lined pipe, the pumping cost of the first year (C = 140) would have been $2,540.00 and would remain at that figure throughout the 30-year period. The actual saving for this period resulting from the use of a cement lining would, therefore, be $48,300.00.

SMALL DISTRIBUTION PIPING

In the case of smaller diameter pipe used in distribution systems, sizes are usually determined by fire protection requirements. The additional pressure available when cement linings are used may stop a fire in its early stages that would otherwise become a conflagration.

Where tuberculating waters are carried, the falling-off in capacity of smaller tar-coated mains occurs at a faster rate than is the case with larger mains. This can mean that in a relatively short time the capacity of tar-coated pipe is so reduced that replacement becomes advisable. The cost of cement lining, which insures high carrying capacity for the life of the pipe, is much less than the cost of replacement, even though it be delayed for as long as 45 years.

THE CEMENT LINING PROCESS

The extrusion method of applying cement-mortar lining through a hollow shaft is modern practice. In this process the pipe is mounted horizontally on rollers. A hollow shaft is inserted to the far end of the pipe and the mortar extruded as the shaft is withdrawn. By this method, sufficient mortar for lining a predetermined number of lengths of pipe can be prepared and placed in the hopper of the machine, and linings applied at a rate permitting mass production. After the mortar is applied, the pipe is spun at a high speed to compact the mortar and remove excess water.

After the pipes are lined, they are either stored in a moist atmosphere during the curing period, or given a bituminous seal-coating to prevent too rapid loss of moisture. Applied in this manner, the cement lining adheres to the wall of the pipe so closely that pipe may be cut and tapped without damage to the lining.

To summarize: (1) Cement lined cast iron pipe prevents tuberculation. (2) In supply lines, the high Williams-Hazen "C" values result in economy due to lower pumping cost. (3) Cement linings make it possible to use smaller diameter pipe since the flow coefficient remains constant as compared to reduced capacity where tar-coated pipe is used. (4) With certain types of water, cement lining mitigates tastes, odors and red water troubles. (5) Modern cement linings adhere to the wall of the pipe and are not damaged by cutting or tapping.

Flow Capacity of Cast Iron Water Pipe

Williams-Hazen Formula

Loss of Head Per 1,000 Feet of Pipe

Flow in Gallons Per 24 Hours	2-Inch Pipe				3-Inch Pipe			
	Velocity in Feet Per Second	Loss of Head in Feet			Velocity in Feet Per Second	Loss of Head in Feet		
		C=120	C=100	C=80		C=120	C=100	C=80
8,640	0.61	1.4	2.0	2.9				
14,400	1.02	3.6	5.0	7.6	0.45	0.50	0.7	1.0
28,800	2.04	12.9	18.2	27.5	0.91	1.80	2.5	3.8
36,000	2.55	19.6	27.3	41.6	1.13	2.71	3.8	5.8
43,200	3.06	27.3	38.4	58.0	1.36	3.81	5.4	8.1
50,400	3.57	36.6	51.0	78.0	1.59	5.10	7.1	10.7
57,600	4.08	46.8	66.0	99.0	1.82	6.50	9.1	13.8
72,000	5.11	71.0	99.0	150.0	2.27	9.80	13.8	20.8
86,400	6.13	99.0	139.0	210.0	2.72	13.70	19.2	29.1
100,800	7.15	132.0	184.0	280.0	3.18	18.30	25.7	38.8
108,000	7.66	149.0	209.0	318.0	3.41	20.70	29.0	43.8
115,200	8.17	169.0	237.0	358.0	3.63	23.40	32.8	49.6
129,600	9.19	210.0	294.0	447.0	4.09	29.10	40.8	62.0
144,000	10.21	256.0	358.0	540.0	4.54	35.20	49.6	75.0
172,800	12.25	360.0	500.0	760.0	5.45	49.70	70.0	106.0
201,600	14.30	479.0	670.0		6.35	66.00	92.0	139.0
230,400	16.34	610.0	860.0		7.26	84.00	118.0	179.0
259,200					8.17	106.00	148.0	223.0
288,000					9.08	128.00	178.0	271.0
316,800					9.99	153.00	213.0	323.0
345,600					10.89	179.00	251.0	380.0

Flow Capacity of Cast Iron Water Pipe

Williams-Hazen Formula

Loss of Head Per 1,000 Feet of Pipe

Flow in Gallons Per 24 Hours	4-Inch Pipe				6-Inch Pipe			
	Velocity in Feet Per Second	Loss of Head in Feet			Velocity in Feet Per Second	Loss of Head in Feet		
		C = 140	C = 130	C = 100		C = 140	C = 130	C = 100
20,000	0.36	0.17	0.19	0.32				
30,000	0.53	0.36	0.41	0.67				
40,000	0.71	0.61	0.70	1.13				
50,000	0.89	0.92	1.05	1.71	0.39	0.13	0.15	0.24
60,000	1.07	1.29	1.47	2.40	0.47	0.18	0.20	0.33
70,000	1.24	1.72	1.96	3.20	0.55	0.24	0.27	0.44
80,000	1.42	2.20	2.52	4.10	0.63	0.30	0.35	0.57
90,000	1.60	2.72	3.12	5.04	0.71	0.38	0.43	0.71
100,000	1.78	3.30	3.81	6.19	0.79	0.46	0.53	0.86
110,000	1.95	3.95	4.55	7.40	0.87	0.55	0.63	1.03
120,000	2.13	4.63	5.17	8.65	0.95	0.65	0.74	1.21
140,000	2.49	6.20	7.10	11.60	1.10	0.87	0.99	1.62
160,000	2.84	7.90	9.10	14.70	1.26	1.10	1.26	2.06
180,000	3.19	9.80	11.30	18.30	1.42	1.37	1.57	2.56
200,000	3.56	12.00	13.80	22.20	1.58	1.67	1.91	3.10
220,000	3.91	14.20	16.40	26.70	1.73	1.99	2.29	3.71
240,000	4.27	16.70	19.30	31.20	1.89	2.33	2.69	4.35
260,000	4.63	19.40	22.40	36.10	2.05	2.71	3.10	5.00
280,000	4.99	22.30	25.50	41.60	2.21	3.11	3.58	5.80
300,000	5.34	25.30	29.10	47.10	2.36	3.54	4.06	6.60
400,000	7.12	43.20	49.50		3.15	6.00	6.90	11.30
500,000					3.94	9.10	10.40	16.90
600,000					4.73	12.80	14.60	23.80
700,000					5.52	17.00	19.50	31.60
800,000					6.30	21.60	24.90	40.40
900,000					7.09	26.90	30.90	50.00
1,000,000					7.88	32.90	37.80	61.00

Flow Capacity of Cast Iron Water Pipe

Williams-Hazen Formula

Loss of Head Per 1,000 Feet of Pipe

Flow in Gallons Per 24 Hours	8-Inch Pipe				10-Inch Pipe			
	Velocity in Feet Per Second	Loss of Head in Feet			Velocity in Feet Per Second	Loss of Head in Feet		
		C=140	C=130	C=100		C=140	C=130	C=100
200,000	0.89	0.41	0.47	0.77				
220,000	0.98	0.49	0.56	0.92				
240,000	1.06	0.58	0.66	1.07				
260,000	1.15	0.67	0.77	1.25				
280,000	1.24	0.77	0.88	1.43				
300,000	1.33	0.87	1.00	1.62	0.85	0.29	0.34	0.55
320,000	1.42	0.98	1.13	1.84	0.91	0.33	0.38	0.62
340,000	1.51	1.10	1.26	2.05	0.96	0.37	0.42	0.69
360,000	1.60	1.22	1.40	2.28	1.02	0.41	0.47	0.77
380,000	1.68	1.35	1.55	2.51	1.08	0.45	0.52	0.85
400,000	1.77	1.48	1.70	2.76	1.13	0.50	0.57	0.93
450,000	1.99	1.85	2.11	3.43	1.28	0.62	0.71	1.16
500,000	2.22	2.25	2.58	4.18	1.42	0.76	0.87	1.41
550,000	2.44	2.68	3.07	5.00	1.56	0.90	1.03	1.68
600,000	2.66	3.14	3.61	5.90	1.70	1.06	1.21	1.97
650,000	2.88	3.64	4.18	6.80	1.84	1.23	1.41	2.29
700,000	3.10	4.19	4.80	7.80	1.99	1.41	1.62	2.64
750,000	3.32	4.73	5.40	8.80	2.13	1.60	1.84	3.00
800,000	3.55	5.30	6.10	9.90	2.27	1.81	2.08	3.38
900,000	3.99	6.70	7.60	12.40	2.55	2.24	2.58	4.18
1,000,000	4.43	8.10	9.30	15.10	2.84	2.73	3.13	5.10
1,100,000	4.88	9.60	11.10	18.00	3.12	3.25	3.72	6.10
1,200,000	5.37	11.30	13.00	21.10	3.40	3.82	4.40	7.10
1,300,000	5.76	13.10	15.10	24.50	3.69	4.44	5.10	8.30
1,400,000	6.20	15.10	17.30	28.10	3.97	5.10	5.80	9.50
1,500,000	6.65	17.00	19.50	31.80	4.26	5.80	6.70	10.80
1,600,000	7.09	19.20	22.00	35.80	4.54	6.50	7.50	12.20
1,800,000	7.98	23.80	27.20	44.20	5.11	8.10	9.30	15.10
2,000,000	8.86	29.00	33.30	54.00	5.67	9.90	11.30	18.40
2,400,000	10.64	41.00	47.00	77.00	6.81	13.70	15.70	25.50

Flow Capacity of Cast Iron Water Pipe

Williams-Hazen Formula

Loss of Head Per 1,000 Feet of Pipe

Flow in Gallons Per 24 Hours	12-Inch Pipe				14-Inch Pipe			
	Velocity in Feet Per Second	Loss of Head in Feet			Velocity in Feet Per Second	Loss of Head in Feet		
		C=140	C=130	C=100		C=140	C=130	C=100
300,000	0.59	0.12	0.14	0.22	0.43	0.057	0.066	0.107
400,000	0.79	0.20	0.24	0.38	0.58	0.098	0.112	0.182
500,000	0.99	0.31	0.36	0.58	0.72	0.147	0.169	0.275
600,000	1.18	0.44	0.50	0.81	0.87	0.207	0.238	0.388
700,000	1.38	0.58	0.66	1.08	1.01	0.277	0.317	0.52
800,000	1.58	0.74	0.85	1.38	1.16	0.351	0.406	0.66
900,000	1.77	0.92	1.06	1.72	1.30	0.44	0.50	0.82
1,000,000	1.97	1.12	1.29	2.10	1.45	0.53	0.61	1.00
1,100,000	2.17	1.34	1.54	2.50	1.59	0.63	0.73	1.18
1,200,000	2.36	1.58	1.81	2.94	1.73	0.74	0.86	1.38
1,300,000	2.56	1.83	2.10	3.40	1.88	0.86	0.99	1.62
1,400,000	2.76	2.10	2.40	3.90	2.02	0.99	1.14	1.85
1,500,000	2.96	2.39	2.73	4.43	2.17	1.13	1.28	2.10
1,600,000	3.15	2.69	3.09	5.00	2.31	1.27	1.46	2.37
1,700,000	3.35	3.00	3.45	5.60	2.46	1.42	1.63	2.65
1,800,000	3.55	3.33	3.82	6.20	2.60	1.58	1.82	2.93
1,900,000	3.74	3.70	4.24	6.90	2.75	1.74	1.99	3.24
2,000,000	3.94	4.06	4.65	7.60	2.90	1.92	2.20	3.57
2,200,000	4.33	4.85	5.60	9.00	3.18	2.33	2.64	4.28
2,400,000	4.73	5.70	6.50	10.50	3.48	2.69	3.08	5.00
2,600,000	5.12	6.60	7.60	12.30	3.76	3.12	3.58	5.80
2,800,000	5.52	7.60	8.70	14.10	4.05	3.58	4.12	6.70
3,000,000	5.91	8.60	9.90	16.00	4.35	4.07	4.65	7.60
3,500,000	6.89	11.40	13.20	21.30	5.07	5.40	6.20	10.10
4,000,000	7.88	14.50	16.60	27.00	5.79	6.90	8.00	12.90
4,500,000	8.87	18.00	20.60	33.60	6.51	8.60	9.90	16.10
5,000,000	9.85	22.00	25.10	41.00	7.24	10.40	12.00	19.50
5,500,000	10.84	26.50	30.30	49.40	7.96	12.50	14.30	23.20
6,000,000	11.82	31.10	35.70	58.00	8.68	14.70	16.80	27.30
7,000,000	13.79	41.20	47.20	77.00	10.12	19.50	22.30	36.50

Flow Capacity of Cast Iron Water Pipe

Williams-Hazen Formula

Loss of Head Per 1,000 Feet of Pipe

Flow in Gallons Per 24 Hours	16-Inch Pipe				18-Inch Pipe			
	Velocity in Feet Per Second	Loss of Head in Feet			Velocity in Feet Per Second	Loss of Head in Feet		
		C=140	C=130	C=100		C=140	C=130	C=100
400,000	0.44	0.051	0.058	0.095	0.35	0.029	0.033	0.053
600,000	0.66	0.108	0.124	0.201	0.52	0.061	0.069	0.113
800,000	0.89	0.183	0.210	0.34	0.70	0.103	0.118	0.193
1,000,000	1.11	0.278	0.319	0.52	0.88	0.156	0.179	0.291
1,200,000	1.33	0.389	0.446	0.72	1.05	0.218	0.251	0.409
1,400,000	1.55	0.52	0.60	0.96	1.22	0.290	0.333	0.54
1,600,000	1.77	0.66	0.76	1.23	1.40	0.374	0.43	0.69
1,800,000	1.99	0.82	0.95	1.53	1.57	0.461	0.53	0.86
2,000,000	2.22	1.00	1.15	1.87	1.75	0.56	0.65	1.05
2,200,000	2.44	1.19	1.37	2.22	1.93	0.67	0.77	1.25
2,400,000	2.66	1.41	1.62	2.62	2.10	0.79	0.90	1.47
2,600,000	2.88	1.63	1.87	3.03	2.28	0.92	1.06	1.71
2,800,000	3.10	1.87	2.15	3.49	2.45	1.05	1.21	1.96
3,000,000	3.32	2.12	2.43	3.98	2.63	1.19	1.37	2.23
3,500,000	3.87	2.81	3.21	5.10	3.07	1.58	1.83	2.96
4,000,000	4.43	3.61	4.15	6.80	3.50	2.02	2.34	3.79
4,500,000	4.99	4.50	5.20	8.40	3.94	2.53	2.92	4.71
5,000,000	5.54	5.50	6.30	10.20	4.38	3.07	3.53	5.70
5,500,000	6.09	6.60	7.50	12.20	4.83	3.68	4.20	6.80
6,000,000	6.65	7.70	8.80	14.30	5.25	4.31	4.95	8.00
6,500,000	7.20	8.90	10.20	16.60	5.70	4.98	5.70	9.30
7,000,000	7.76	10.20	11.70	19.00	6.13	5.80	6.60	10.70
7,500,000	8.31	11.60	13.30	21.70	6.57	6.50	7.50	12.20
8,000,000	8.86	13.10	14.90	24.20	7.01	7.40	8.40	13.60
8,500,000	9.42	14.50	16.60	27.00	7.45	8.20	9.40	15.30
9,000,000	9.97	16.30	18.60	30.20	7.90	9.10	10.50	17.00
9,500,000	10.53	17.80	20.50	33.20	8.33	10.10	11.60	18.80
10,000,000	11.08	19.80	22.60	36.80	8.76	11.10	12.70	20.80
11,000,000	12.19	23.60	27.00	44.00	9.65	13.30	15.20	24.60
12,000,000	13.30	27.80	31.80	52.00	10.50	15.60	17.80	29.00

Flow Capacity of Cast Iron Water Pipe

Williams-Hazen Formula

Loss of Head Per 1,000 Feet of Pipe

Flow in Gallons Per 24 Hours	20-Inch Pipe				24-Inch Pipe			
	Velocity in Feet Per Second	Loss of Head in Feet			Velocity in Feet Per Second	Loss of Head in Feet		
		C=140	C=130	C=100		C=140	C=130	C=100
600,000	0.43	0.037	0.049	0.068				
800,000	0.57	0.062	0.071	0.115				
1,000,000	0.71	0.094	0.107	0.174	0.49	0.038	0.044	0.072
1,200,000	0.85	0.131	0.150	0.243	0.59	0.054	0.062	0.100
1,400,000	0.99	0.174	0.200	0.326	0.69	0.071	0.082	0.133
1,600,000	1.13	0.223	0.257	0.416	0.79	0.092	0.105	0.170
1,800,000	1.28	0.278	0.319	0.52	0.89	0.113	0.130	0.212
2,000,000	1.42	0.339	0.389	0.63	0.98	0.138	0.159	0.259
2,500,000	1.77	0.51	0.58	0.95	1.23	0.210	0.240	0.39
3,000,000	2.13	0.72	0.82	1.33	1.48	0.293	0.338	0.55
3,500,000	2.48	0.95	1.09	1.78	1.72	0.391	0.449	0.73
4,000,000	2.84	1.22	1.39	2.28	1.97	0.50	0.58	0.93
4,500,000	3.19	1.52	1.74	2.83	2.22	0.62	0.72	1.16
5,000,000	3.55	1.84	2.11	3.43	2.46	0.76	0.87	1.41
5,500,000	3.90	2.20	2.52	4.09	2.71	0.90	1.03	1.68
6,000,000	4.26	2.59	2.97	4.81	2.96	1.06	1.22	1.97
6,500,000	4.61	3.00	3.43	5.60	3.20	1.23	1.41	2.29
7,000,000	4.96	3.43	3.95	6.40	3.45	1.41	1.62	2.63
7,500,000	5.32	3.90	4.48	7.30	3.69	1.61	1.84	2.98
8,000,000	5.67	4.39	5.10	8.20	3.94	1.81	2.07	3.38
8,500,000	6.03	4.91	5.60	9.20	4.19	2.02	2.32	3.77
9,000,000	6.38	5.50	6.30	10.20	4.43	2.26	2.58	4.20
9,500,000	6.74	6.00	6.90	11.30	4.68	2.48	2.85	4.62
10,000,000	7.09	6.60	7.60	12.40	4.92	2.73	3.12	5.10
11,000,000	7.80	7.90	9.10	14.80	5.42	3.26	3.74	6.10
12,000,000	8.51	9.40	10.70	17.40	5.91	3.82	4.39	7.10
13,000,000	9.22	10.80	12.40	20.10	6.40	4.45	5.10	8.30
14,000,000	9.93	12.40	14.20	23.10	6.89	5.10	5.80	9.50
15,000,000	10.64	14.10	16.20	26.20	7.39	5.80	6.60	10.80
16,000,000	11.35	15.80	18.20	29.60	7.88	6.60	7.50	12.20

Flow Capacity of Cast Iron Water Pipe

Williams-Hazen Formula

Loss of Head Per 1,000 Feet of Pipe

Flow in Gallons Per 24 Hours	30-Inch Pipe				36-Inch Pipe			
	Velocity in Feet Per Second	Loss of Head in Feet			Velocity in Feet Per Second	Loss of Head in Feet		
		C=140	C=130	C=100		C=140	C=130	C=100
1,500,000	0.47	0.028	0.032	0.052	0.33	0.011	0.013	0.021
2,000,000	0.63	0.047	0.054	0.087	0.44	0.019	0.022	0.036
2,500,000	0.79	0.071	0.081	0.132	0.55	0.029	0.033	0.054
3,000,000	0.95	0.099	0.113	0.184	0.66	0.041	0.047	0.076
3,500,000	1.10	0.132	0.151	0.247	0.77	0.054	0.062	0.102
4,000,000	1.26	0.168	0.194	0.315	0.88	0.070	0.080	0.129
4,500,000	1.42	0.210	0.241	0.391	0.98	0.086	0.099	0.160
5,000,000	1.58	0.256	0.292	0.476	1.09	0.105	0.121	0.196
5,500,000	1.73	0.304	0.349	0.57	1.20	0.125	0.143	0.232
6,000,000	1.89	0.357	0.410	0.67	1.31	0.147	0.168	0.274
6,500,000	2.05	0.414	0.475	0.78	1.42	0.170	0.195	0.316
7,000,000	2.21	0.474	0.55	0.89	1.53	0.196	0.224	0.365
7,500,000	2.36	0.54	0.62	1.01	1.64	0.221	0.253	0.411
8,000,000	2.52	0.61	0.70	1.13	1.75	0.250	0.288	0.467
8,500,000	2.68	0.68	0.78	1.27	1.86	0.280	0.320	0.52
9,000,000	2.84	0.76	0.87	1.42	1.97	0.311	0.358	0.58
10,000,000	3.15	0.92	1.06	1.72	2.19	0.379	0.434	0.71
11,000,000	3.47	1.09	1.26	2.06	2.41	0.451	0.52	0.84
12,000,000	3.78	1.28	1.47	2.41	2.63	0.53	0.61	0.99
13,000,000	4.10	1.50	1.72	2.79	2.85	0.62	0.71	1.15
14,000,000	4.41	1.72	1.97	3.20	3.06	0.71	0.81	1.32
15,000,000	4.73	1.95	2.24	3.64	3.28	0.80	0.92	1.49
16,000,000	5.04	2.20	2.52	4.10	3.50	0.90	1.03	1.68
17,000,000	5.36	2.46	2.82	4.59	3.72	1.02	1.16	1.88
18,000,000	5.67	2.74	3.14	5.10	3.94	1.12	1.29	2.10
19,000,000	5.99	3.02	3.47	5.60	4.16	1.24	1.43	2.32
20,000,000	6.30	3.33	3.81	6.20	4.38	1.37	1.57	2.55
22,000,000	6.93	3.96	4.55	7.40	4.82	1.63	1.87	3.04
24,000,000	7.56	4.65	5.40	8.70	5.25	1.92	2.20	3.58
26,000,000	8.20	5.40	6.20	10.10	5.69	2.22	2.55	4.14

Flow Capacity of Cast Iron Water Pipe

Williams-Hazen Formula

Loss of Head Per 1,000 Feet of Pipe

Flow in Gallons Per 24 Hours	42-Inch Pipe				48-Inch Pipe			
	Velocity in Feet Per Second	Loss of Head in Feet			Velocity in Feet Per Second	Loss of Head in Feet		
		C=140	C=130	C=100		C=140	C=130	C=100
3,000,000	0.48	0.019	0.022	0.036	0.37	0.010	0.012	0.019
4,000,000	0.64	0.033	0.038	0.061	0.49	0.017	0.020	0.032
5,000,000	0.80	0.050	0.057	0.092	0.62	0.026	0.030	0.048
6,000,000	0.96	0.070	0.080	0.129	0.74	0.036	0.042	0.068
7,000,000	1.13	0.092	0.106	0.172	0.86	0.048	0.055	0.090
8,000,000	1.29	0.118	0.136	0.220	0.98	0.062	0.071	0.115
9,000,000	1.45	0.147	0.168	0.273	1.11	0.077	0.088	0.143
10,000,000	1.61	0.178	0.207	0.332	1.23	0.094	0.107	0.174
12,000,000	1.93	0.251	0.288	0.468	1.48	0.131	0.150	0.243
14,000,000	2.25	0.333	0.382	0.62	1.72	0.174	0.199	0.324
16,000,000	2.57	0.428	0.49	0.80	1.97	0.222	0.256	0.417
18,000,000	2.89	0.53	0.61	0.99	2.22	0.277	0.319	0.52
20,000,000	3.22	0.64	0.74	1.21	2.46	0.338	0.387	0.63
22,000,000	3.53	0.77	0.88	1.44	2.71	0.401	0.46	0.75
24,000,000	3.86	0.90	1.04	1.68	2.96	0.472	0.54	0.88
26,000,000	4.18	1.05	1.21	1.96	3.20	0.55	0.63	1.02
28,000,000	4.50	1.21	1.38	2.25	3.45	0.63	0.72	1.17
30,000,000	4.82	1.37	1.57	2.56	3.69	0.72	0.82	1.33
32,000,000	5.15	1.54	1.77	2.88	3.94	0.80	0.92	1.50
34,000,000	5.47	1.73	1.98	3.21	4.19	0.90	1.03	1.68
36,000,000	5.79	1.92	2.20	3.58	4.43	1.00	1.15	1.87
38,000,000	6.11	2.12	2.43	3.95	4.68	1.11	1.27	2.07
40,000,000	6.45	2.33	2.68	4.35	4.92	1.22	1.39	2.28
42,000,000	6.75	2.56	2.92	4.76	5.17	1.33	1.53	2.49
44,000,000	7.08	2.78	3.19	5.20	5.42	1.45	1.67	2.71
46,000,000	7.40	3.02	3.48	5.60	5.66	1.58	1.81	2.94
48,000,000	7.72	3.28	3.76	6.10	5.91	1.71	1.96	3.19
50,000,000	8.04	3.52	4.05	6.60	6.16	1.84	2.12	3.44
55,000,000	8.84	4.21	4.82	7.80	6.77	2.19	2.52	4.09
60,000,000	9.65	4.94	5.70	9.20	7.39	2.58	2.97	4.80

Flow Capacity of Cast Iron Water Pipe

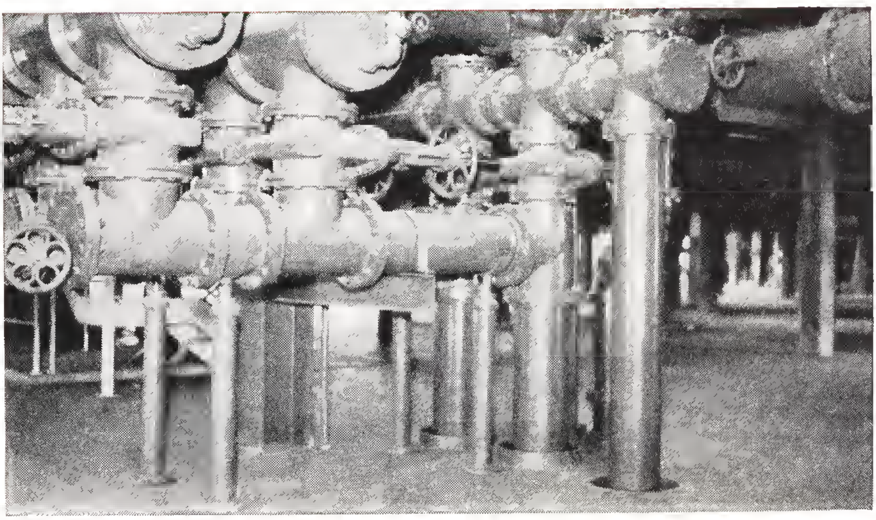
Williams-Hazen Formula

Loss of Head Per 1,000 Feet of Pipe

Flow in Gallons Per 24 Hours	54-Inch Pipe: Velocity in Feet Per Second	54-Inch Pipe: Loss of Head in Feet			60-Inch Pipe: Velocity in Feet Per Second	60-Inch Pipe: Loss of Head in Feet		
		C=140	C=130	C=100		C=140	C=130	C=100
6,000,000	0.58	0.020	0.023	0.038	0.47	0.012	0.014	0.023
8,000,000	0.78	0.035	0.040	0.065	0.63	0.021	0.024	0.039
10,000,000	0.97	0.053	0.060	0.098	0.79	0.032	0.036	0.059
12,000,000	1.17	0.074	0.085	0.137	0.95	0.044	0.051	0.082
14,000,000	1.36	0.098	0.113	0.183	1.10	0.059	0.068	0.109
16,000,000	1.56	0.126	0.144	0.235	1.26	0.075	0.086	0.140
18,000,000	1.75	0.157	0.179	0.291	1.42	0.094	0.107	0.174
20,000,000	1.95	0.190	0.218	0.354	1.58	0.113	0.131	0.212
22,000,000	2.14	0.227	0.260	0.422	1.73	0.136	0.156	0.253
24,000,000	2.33	0.267	0.306	0.496	1.89	0.159	0.183	0.298
26,000,000	2.53	0.309	0.354	0.58	2.05	0.185	0.212	0.346
28,000,000	2.72	0.353	0.406	0.66	2.21	0.212	0.243	0.395
30,000,000	2.92	0.402	0.461	0.75	2.36	0.241	0.277	0.449
32,000,000	3.11	0.453	0.52	0.85	2.52	0.271	0.310	0.51
34,000,000	3.31	0.51	0.58	0.95	2.68	0.303	0.349	0.57
36,000,000	3.50	0.56	0.65	1.05	2.84	0.338	0.388	0.63
38,000,000	3.70	0.62	0.72	1.17	2.99	0.372	0.428	0.70
40,000,000	3.89	0.68	0.79	1.28	3.15	0.41	0.47	0.76
45,000,000	4.37	0.85	0.97	1.59	3.55	0.51	0.59	0.95
50,000,000	4.86	1.04	1.19	1.94	3.94	0.62	0.71	1.16
55,000,000	5.35	1.24	1.42	2.30	4.33	0.74	0.85	1.38
60,000,000	5.84	1.46	1.67	2.71	4.73	0.87	1.00	1.62
65,000,000	6.32	1.68	1.93	3.14	5.12	1.02	1.16	1.88
70,000,000	6.81	1.93	2.22	3.61	5.52	1.16	1.33	2.17
75,000,000	7.30	2.20	2.52	4.10	5.91	1.32	1.51	2.46
80,000,000	7.78	2.48	2.84	4.61	6.30	1.48	1.70	2.78
85,000,000	8.27	2.78	3.18	5.20	6.70	1.66	1.90	3.09
90,000,000	8.76	3.08	3.52	5.80	7.09	1.84	2.12	3.44
95,000,000	9.24	3.41	3.91	6.40	7.49	2.03	2.34	3.80
100,000,000	9.73	3.75	4.30	7.00	7.88	2.24	2.57	4.19

SECTION 7

Cast Iron Pipe for Sewerage Systems and Sewage Treatment Works



SECTION 7

Cast Iron Pipe for Sewerage Systems and Sewage Treatment Works

SEWAGE disposal has been defined as "the collection, transportation, treatment and ultimate disposal of domestic and industrial wastes finding their way into the sewer system."

Nearly all of our urban population is served by sewer systems, and about one-half by sewage treatment plants. Considerable progress has also been made in the treatment of industrial wastes.

Needless to say, the prime function of a municipal treatment plant is to treat domestic sewage. The size of the plant, required investment and operating cost are governed by the volume of domestic sewage to be treated. To insure that the influent will be confined to sewage alone requires separate storm and sanitary sewers.

Many cities, particularly in their older districts, are served by *combined* sewers carrying both storm water and domestic sewage. Unfortunately, the sewer mains in combined systems were frequently constructed of materials that permitted infiltration of water to increase the load on both sewers and sewage treatment plants.

Thus, one important factor in solving the problem of sewage disposal—the construction of treatment plants—brought in its wake an attendant problem of efficient sewage transportation. The problem has been met in many cases by separate sanitary sewers constructed of infiltration-proof cast iron pipe with permanently tight joints.

SANITARY SEWERS

One of the chief requirements of a sanitary sewer is that it shall be *permanently* tight to prevent leakage and infiltration.

Leakage permits polluted water to saturate surrounding soil, creating unsanitary conditions and possible odor nuisance and, if located close to a source of water supply, to contaminate the water.

Infiltration decreases the capacity of the sewer as a conveyor of sanitary sewage and, if the sewage is to be treated, the treatment plant must be larger than otherwise necessary to handle the increased flow.

Cast iron pipe provides a permanently tight sewer because it is impermeable; because its joints are tight and stay tight; and because it effectively resists corrosion.

Frequently, sanitary sewers must be built in deep excavations and are therefore required to withstand high external pressures; or they may be built in shallow cuts and must withstand external pressures due to heavy traffic loads.

The known ability of cast iron pipe to meet such service stresses is due to wide margins of safety in beam-strength, compressive-strength and impact-resistance. This structural strength, plus effective resistance to corrosion, keeps maintenance cost down to a negligible minimum.

OUTFALL SEWERS

Any sewer discharging raw sewage, treatment plant effluent, or storm water into a body of water or stream, is commonly known as an outfall sewer. To avoid pollution of water supply, bathing beaches, shellfish areas, or fishing grounds, as well as for better diffusion of the sewage or effluent in the diluting water, outfall sewers often extend for considerable distances into the body of water in which they discharge. As a prime requirement of such installations is that they shall permit no leakage, cast iron pipe is widely used in their construction.

The land sections of outfall sewers may be exposed to wet and dry conditions, both internally and externally, and, therefore, must resist corrosion, especially when laid in muck soil or when submerged in salt water at high tide. Indeed, one of the most rigorous tests a pipe line material is called upon to meet is in subaqueous service where the line is alternately submerged and exposed to sun and air with the changing tides.

About 40 years ago, the City of Pensacola, Florida, installed two cast iron subaqueous outfall sewers. One sewer was 20-inch and the other, 24-inch cast iron pipe. These outfalls carried raw sewage for 3,000 feet into Pensacola Bay where there is a tidal variation of between one and two feet, causing a portion of the pipe to submerge for part of each day when not exposed to air and sun. Upon inspection after 30 years' service, it was found that a scale had formed over the pipe which, when removed, revealed a metallic surface like that of newly cast pipe and some of the original coating was intact.

Cast iron pipe, with either ball and socket or mechanical joints has successfully met the arduous requirements of outfall sewers in a great number of installations over the past fifty years.

PRESSURE SEWERS

The growing use of cast iron pressure sewers stems from the advent of sewage treatment. Transporting the sewage from the point of origin to the treatment plant frequently requires a pressure sewer. Gravity sewers in many cases, were not constructed of materials that could withstand pressures.

An important feature of a pressure sewer is that it can follow the contour of the ground surface. Thus the initial cost of the sewer is reduced due to the smaller diameter required and to the fact that a trench shallower than generally needed for gravity sewers is possible.

Flow tests on pressure sewers and waste sludge lines, in service for long periods, indicate that ordinary hydraulic tables can be used for calculating the capacity of cast iron pipe in such service. The following test results on a sludge line in Chicago provide a typical example:

Twenty years ago, a 14-inch cast iron pipe sludge line was placed in operation for the Sanitary District of Chicago. The sludge from the activated sludge process at the North Side Sewage Treatment Plant was pumped at a pressure of 90 lbs. per sq. in. for some 90,000 feet to the West Side Treatment Works for disposal. The line was tested for leakage at a pressure of 175 lbs. per sq. in. The allowable leakage was 2400 gallons per 24 hours per mile of pipe; the actual leakage was less than half of the allowable amount. Friction tests, made on the line immediately after being put in operation, indicated a value of "C" in the Williams-Hazen formula of 141.

Sewage and sludge pumping and the use of pressure sewers to force sewage to treatment plants have greatly contributed to economical sewage treatment and disposal. The development of highly efficient sewage pumps and the use of cast iron pipe for pressure sewers have been important factors in reducing total sewage treatment costs.

ACTIVATED SLUDGE TREATMENT PLANTS

The activated sludge process of sewage treatment is designed for communities requiring a high degree of purification the year around. This process provides complete treatment with effluents purified 90% or more, in terms of oxygen demand. Purification is effected quickly and without nuisances. The sludge resulting from the process may be disposed of by various accepted methods, and, if properly dried, is a fertilizer of commercial value.

Cast iron pipe is used extensively in the activated sludge process for influent, effluent and distribution conduits, air mains and leaders, sludge draw-off lines and drains. A substantial amount of the piping is placed underground or in concrete and is not easily accessible for repairs. Conduits, mains and lines must be permanently tight to insure against leaks which would result in power losses or nuisances.

CHEMICAL PRECIPITATION PLANTS

The chemical precipitation process is generally used by communities which do not require a high degree of purification the year around, but which require efficiencies higher than that afforded by plain primary settling. Most of the chemicals used in the process are highly corrosive. Standard and rubber-lined cast iron pipe are used for all piping in connection with the handling of chemicals and solutions; also for piping for mixing tanks, flocculation tanks and for air conduits.

IMHOFF TANKS

Imhoff tanks have been used for about 40 years and will no doubt continue to be used in localities where only partial treatment of sewage is required, or where such units precede secondary treatment processes. From 30 to 40% of the B.O.D. and from 50 to 75% of the suspended solids are usually removed by Imhoff tanks and at low operating costs. The treatment is usually preceded by screening and grit removal. Gases and sludge resulting from Imhoff tank operation are corrosive, requiring a piping material with effective resistance to corrosion, such as cast iron pipe.

TRICKLING FILTERS

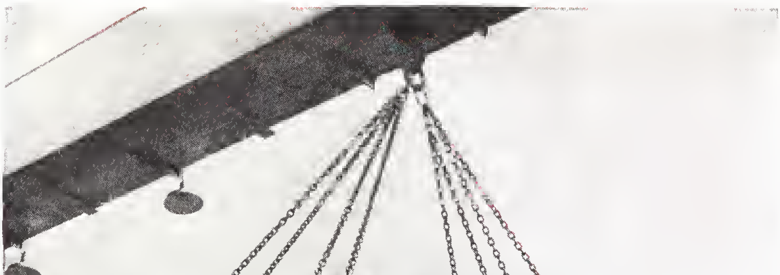
Trickling filters have been popular due to their simplicity of operation and ability to meet wide and sudden fluctuations in sewage strength. With efficient screening and settling preceding the filters, and with final settling tanks, the overall purification ranges from 70 to 90 per cent, in terms of removal of B.O.D. (biochemical oxygen demand).

Cast iron pipe, because of its tight joints and corrosion-resistance is widely used in the construction of trickling filters.

SECTION 8

2-INCH CAST IRON PIPE

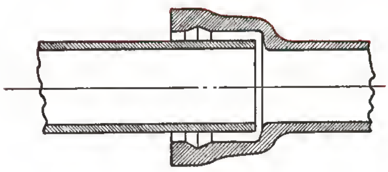
and other sizes under 3 inches



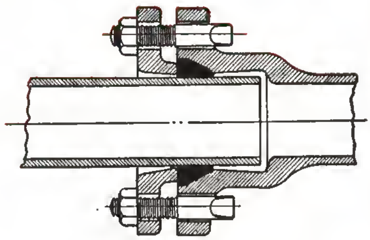
SECTION 8

2-INCH CAST IRON PIPE

and other sizes under 3 inches



BELL & SPIGOT JOINT



MECHANICAL JOINT

While the smallest pipe included in standard Cast Iron Pipe specifications is 3-inch in diameter, smaller sizes have been made for over twenty-five years. These small diameter pipe are made to a manufacturer's specifications that in all essential parts is identical with the specifications under which larger diameter pipe are produced. Small diameter pipe are regularly furnished with Bell and Spigot and Mechanical Joints, and may be furnished with plain ends, screw joints, or roll-on joints.

The fact that over 7,000,000 feet of small diameter pipe are produced each year indicates the acceptance of this pipe by pipe users. The principal uses are:

(1) Water mains where fire protection is available from larger mains.
(2) The development of new subdivisions.
(3) Gas mains—low and high pressure.
(4) Services for both water and gas.
(5) The secondary main in two-main systems.
(6) Irrigation for golf courses, parks, cemeteries, and private estates.
(7) Filter drains.
(8) Industrial uses.

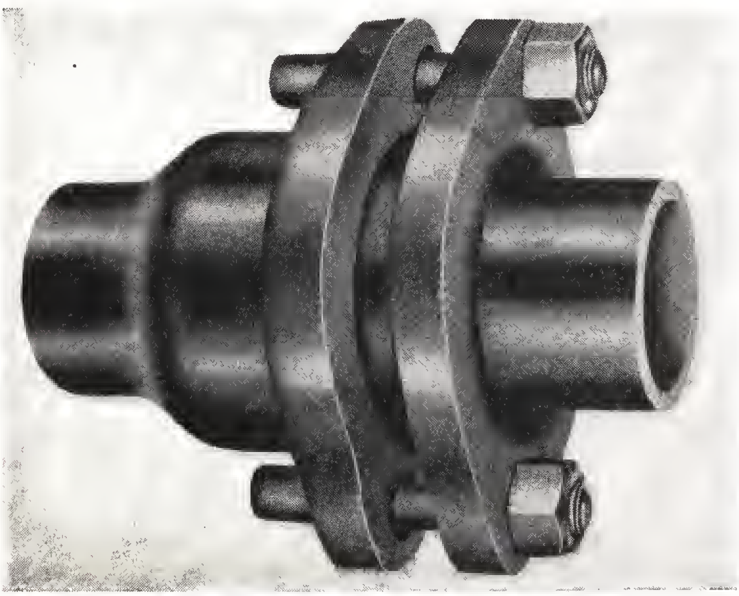
The pipe are made of first quality iron and each length ls subjected to a test pressure of 500 P.S.I. at the foundry. The lengths produced by different manufacturers vary from 5 feet to 12 feet—short lengths may be factory assembled into longer lengths to reduce the number of field joints.

For water use, when required, small diameter pipe can be furnished with a cement lining. Connections may be made either by tapping into tapping collars, by the use of tapping saddles, or by the use of standard fittings.

As an instance of importance of small diameter pipe in gas distribution systems, the footage of various sizes used in a new system constructed in an area adjacent to a large southern city is of interest.

6-inch	—11,100 feet
4-inch	—21,850 feet
2¼-inch	—48,100 feet
2-inch	—66,600 feet

The use of small diameter Cast Iron Pipe in distribution system makes it possible to have the same long life and resistance to external stress in these lines as in the larger mains in the system.



2″ Mechanical Joint

SECTION 9

A.S.A. Specifications

ASA
A 21.2

American Standard

SPECIFICATIONS

for

CAST IRON PIT CAST PIPE FOR WATER OR OTHER LIQUIDS

Users of this document should make reference to "American Recommended Practice Manual for the Computation of Strength and Thickness of Cast Iron Pipe (A.S.A., A21.1)" for complete information concerning the conditions which various thicknesses of pipe are designed to meet. The foreword of the Manual also contains a statement regarding the history of the specifications and references to other related documents.

SPONSORS

AMERICAN GAS ASSOCIATION

AMERICAN SOCIETY FOR TESTING MATERIALS

AMERICAN WATER WORKS ASSOCIATION

NEW ENGLAND WATER WORKS ASSOCIATION

ASA
A 21.2

AMERICAN STANDARD SPECIFICATIONS
for
CAST IRON PIT CAST PIPE FOR WATER OR OTHER LIQUIDS

This specification covers cast iron pit cast pipe for water or other liquids. Pit cast pipe are pipe cast vertically with dry sand molds and cores.

Sect. 2-1. Description of Pipe. The pipe shall be made with bell and spigot ends, plain ends or such other type of ends as may be agreed upon at the time of purchase. Pipe with bell and spigot ends shall conform accurately to the dimensions given in Table 1. Pipe with other types of ends shall comply with the dimensions agreed upon but in all other respects shall fulfill the specifications hereinafter given. Pipe shall be straight and shall be true circles in section, with their inner and outer surfaces concentric. They shall be at least 12 ft. in nominal laying length, except as provided for cut pipe in Sect. 2-10.

Sect. 2-2. Casting of Pipe. The pipe shall be cast in dry sand molds in a vertical position. Pipe 16 inches or less in diameter shall be cast with the bell end up or down as specified in the proposals. Pipe 18 inches or more in diameter shall be cast with the bell end down. The pipe shall not be stripped or taken from the pit while showing color of heat, but shall be left in the flasks for a sufficient length of time to prevent unequal contraction by subsequent exposure.

Sect. 2-3. Quality of Iron.

(a) All pipes shall be made of cast iron of good quality, and of such character and so adapted in chemical composition to the thickness of the pipe to be cast, that the iron in the pipe shall be strong, tough, resilient, of even grain and soft enough for satisfactory drilling and cutting and it shall comply with the physical specifications given in Sect. 2-16, 2-17 and 2-18. The metal shall be remelted in a cupola or other suitable furnace.

(b) The iron in the pipe shall not contain more than 0.90 per cent of phosphorus nor more than 0.12 per cent of sulphur. Samples for chemical analysis shall be taken by drilling completely through from skin to skin each of the acceptance test specimens; but not to exceed three specimens per heat.

Sect. 2-4. Quality of Castings. The pipe shall be smooth, free from scales, lumps, blisters, sand holes and defects of every nature which unfit them for the use for which they are intended. No plugging, filling, burning-in or welding will be allowed except as permitted by the purchaser.

Sect. 2-5. Foundry Records. A record of the following tests shall be made and retained for at least one year. Upon request, such record will be available to the purchaser at the foundry. If written transcripts of any of these tests are desired, this fact shall be noted in the order for pipe, naming the tests of which transcripts are desired.

(a) *Chemical Analyses.* Chemical analyses of each iron mixture used directly in pouring of pipe, obtained as in Sect. 2–3(b), shall be made for silicon, sulphur, manganese, phosphorus and total carbon during the first hour and at intervals not to exceed three hours throughout the heat. If pipe is poured directly from the cupola, chemical analyses shall be made of iron from the first and from the last ladle. If the mixture is changed one or more times during a heat in order to produce a different iron, the time of taking samples shall be varied in such a way as to obtain representative tests of iron at least at the beginning and end of each period during which the iron is intended to be constant in quality.

(b) *Pouring Temperature.* The pouring temperature of the iron shall be taken at the casting ladle for each size of pipe at least once each hour.

(c) *Test Bar Tests.* See Sect. 2–17.

(d) *Ring Tests and Talbot Strip Tests.* See Sections 2–17(d) and 2–18.

(e) *Full-Length Bursting Tests.* See Sect. 2–19.

Sect. 2-6. Marking Pipe. Every pipe shall have distinctly cast upon it the initials of the maker's name. When cast especially to order, each pipe larger than 4-inch may also have cast upon it figures showing the year in which it was cast and a number signifying the order in point of time in which it was cast, the figures denoting the year being above and the number below, thus:

1950	1950	1950
1	2	3

etc., also any initials, not exceeding four, which may be required by the purchaser. The letters and figures shall be cast on the outside and shall have dimensions as indicated below.

Diameters of Pipe, Inches, Inclusive	Height of Letter, Inches	Relief, Inch
3 to 10	$\frac{3}{4}$	$\frac{3}{32}$
12 to 20	$1\frac{1}{4}$	$\frac{3}{32}$
24 & larger	$1\frac{3}{4}$	$\frac{1}{8}$

The weight and the class shall be conspicuously painted in white in the inside or outside of each pipe after the coating has become hard.

Sect. 2-7. Inspection by Purchaser.

(a) *Definition of Word "Purchaser."* Wherever the word "Purchaser" is used herein it shall be understood to mean the actual purchaser of the pipe or his authorized agents acting within the scope of the duties entrusted to them.

(b) *Power of Purchaser to Inspect.* The purchaser shall have free access at all times to all parts of any manufacturing plant which concern the manufacture of articles to be made for him. He may inspect the material, the pattern work, molding, casting, coating and lining of the pipe. The forms, sizes, uniformity and conditions of all pipe herein referred to shall be subject to his inspection and approval, and he may reject, without subjection to hydrostatic test, any pipe which is not in conformity with the specifications or drawings. Any pipe rejected shall be marked "rejected" and any marks pertaining to the purchaser shall be chipped or erased from such pipe.

(c) *Manufacturer to Furnish Men and Material.* The manufacturer shall provide all tools, testing equipment, materials, labor and facilities necessary for the required testing, inspection and weighing of the pipe at the foundry.

(d) *Report of Purchaser's Inspection.* The purchaser shall make written report daily at the foundry office of all pipe rejected, noting causes for rejection.

Sect. 2-8. Inspection and Certification by Manufacturer. Should the purchaser have no inspector at the works, the manufacturer shall, if required by the purchaser, furnish a sworn statement that the inspection and all of the tests have been made as specified, this statement to contain the results of all specified tests.

Sect. 2-9. Pipe to be Delivered Sound. All the pipe must be delivered in all respects sound and comformable to these specifications. The inspection shall not relieve the manufacturer of any of his obligations in this respect, and any defective pipe which may have passed the purchaser at the works or elsewhere shall be at all times liable to rejection when discovered, until the final completion and adjustment of the contract; provided, however, that the manufacturer shall not be held liable for pipe found to be cracked after they have been accepted at the agreed point of delivery, unless there shall be unmistakable evidence that the casting was originally defective or damaged before acceptance. Care shall be taken in handling the pipe not to injure the coating or lining and no pipe or other material of any kind shall be placed in the pipe during transportation or at any other time after they have received the coating or lining.

Sect. 2-10. Cut Pipe. Defective spigot ends on pipe may be cut off in a manner which will produce a square end. Cut pipe shall be shipped with plain ends or shall have an iron or steel band shrunk into a groove or welded securely on the pipe, as may be agreed upon at time of purchase. Not more than 8 per cent of the total number of pipe of each size shall be cut, and no cut pipe shall be furnished which is less than 11 ft. 0 in. in laying length, unless it has been used by purchaser's order for strip and ring tests in which case a length of not less than 10 ft. 0 in. shall be accepted.

Sect. 2-11. Tolerances or Maximum Permitted Variations from Standard.

(a) *Tolerances in Diameter of Pipe and Sockets.* Outside diameters of pipe barrels and spigot beads and diameters of sockets shall be kept as nearly as practicable to the specified dimensions. They shall be tested with circular gauges. Tolerances or maximum permitted variations from standard dimensions are listed below:

Nominal Diameter in Inches	Tolerance, Plus or Minus, in Inches
3 to 16	.06
18, 20 & 24	.08
30, 36 & 42	.10
48	.12
54	.15
60	.15

(b) *Tolerances in Thickness.* The tolerances, or maximum permitted variations from standard in thickness of pipe and in dimensions of bells are listed below:

Nominal Diameter in Inches, inclusive	Tolerance, Plus or Minus, in Inches
3 to 8	.07
10 to 24	.08
30 to 60	.10

NOTE: In pipe barrel thickness, tolerances .02 inch greater than those listed above shall be permissible over areas not exceeding 8 inches in length in any direction.

(c) *Allowable Percentage of Variation in Weight.* The weight of no single pipe shall be less than the nominal tabulated weight by more than 5% for pipe 16 inches or less in diameter, and 4% for pipe more than 16 inches in diameter. The total excess weight to be paid for on orders of 25 tons or more shall not exceed 2% of the nominal weight, and on orders less than 25 tons shall not exceed 5% of the nominal weight. An order is hereby defined as including all the pipe ordered under the terms of a specific contract or purchase order or a single order placed under the terms of a standing contract.

Sect. 2-12. Cleaning and Inspecting. All pipe shall have gates, fins and other roughnesses chipped or ground off and shall be thoroughly cleaned, checked as to dimensions and also subjected to a careful surface inspection, a hammer test, and a rolling test, before being coated or lined.

Sect. 2-13. Hydrostatic Test. Each pipe shall be subjected to a hydrostatic proof test. This test may be made either before or after the tar dip or the priming coat for bituminous enamel has been applied but shall be made before the cement mortar lining, bituminous enamel lining, or any other special lining has been applied to pipe for which such a lining is specified.

The pipe shall be under the test pressure for at least one-half minute, and while under pressure shall be subjected to a hammer or shock test. Any pipe showing defects by leaking, sweating, or otherwise, shall be rejected. The test pressures shall be in accordance with the table on the following page.

Sect. 2-14. Weighing. Each length of pipe shall be weighed and the weight and class plainly marked on the outside or inside of the bell or spigot end. Pipe which is to be lined with cement mortar or coated on the inside or outside, or both, with bituminous enamel or other special material shall be weighed before the application of such

TABLE OF PRESSURES FOR HYDROSTATIC TESTS

Nominal Diameter of Pipe, Inches	Barrel Thickness, Inches From	Barrel Thickness, Inches To	Test Pressures, Lb. per sq.in.
3 to 12	All Thicknesses		400
14	.50	.70	300
14	.71	.85	350
14	.86	1.20	450
16	.55	.75	300
16	.76	.95	350
16	.96	1.25	450
18	.60	.80	300
18	.81	1.00	350
18	1.01	1.35	450
20	.65	.85	250
20	.86	1.05	350
20	1.06	1.45	450
24	.70	.90	200
24	.91	1.00	300
24	1.01	1.60	400
30	.85	1.05	200
30	1.06	1.30	300
30	1.31	1.75	400
36	.95	1.15	200
36	1.16	1.45	300
36	1.46	1.95	350
42	1.05	1.35	200
42	1.36	1.60	300
42	1.61	1.75	350
48	1.15	1.50	200
48	1.51	1.90	300
48	1.91	2.05	350
54	1.30	1.55	200
54	1.56	1.80	250
54	1.81	2.05	300
54	2.06	2.25	350
60	1.35	1.75	200
60	1.76	2.05	250
60	2.06	2.30	300
60	2.31	2.40	350

Note: Unless otherwise arranged between the manufacturer and the purchaser, pipe thicker than those listed in the above table shall be tested at the highest pressures listed for the given diameter.

a lining or coating. If desired by the purchaser, pipe not lined or coated with cement mortar, bituminous enamel or other special material shall be weighed after delivery and the weights so ascertained shall be used in the final settlement, provided such weighing is done by a legalized weigh master. Unless otherwise stated in the contract, a ton shall be 2,000 lb. avoirdupois.

Sect. 2-15. Linings and Exterior Coatings. Any particular lining or coating which is to be applied to the pipe shall be specified in the agreement made at the time of purchase. Separate specifications for a cement-mortar lining have been provided in connection with these specifications for pipe. (See specification ASA A21.4–1952.)

No pipe or specials for waterworks service shall be furnished without protective coating unless specifically ordered by the purchaser.

Sect. 2-16. Tests of Material. The acceptability of iron used in the cast iron pipe herein specified as regards physical characteristics shall be determined by the testing of bars cast from the same iron as the pipe, or, if specified by the purchaser, by the testing of Talbot strips and/or rings cut from the pipe as described in Sect. 2–18, or by full-length bursting tests (see Sect. 2–19) in addition to Talbot strips and rings. Such strip tests, ring tests and full-length bursting tests shall be paid for by the purchaser at prices to be agreed upon. In any case the test bars shall be made and tested and results given to the purchaser if requested. The smallest pipe on which ring tests may be required is the 6-inch. The observations and the computed results hereinafter required shall be recorded and if requested reported to the purchaser.

Sect. 2-17. Test Bars.

(a) *Dimensions.* Test bars shall be 2 inches wide, 1 inch thick, and not less than 26 inches long. Individual test bars may vary as much as 2 per cent from standard width, or standard thickness, or both, but the patterns and molding practice shall be such that the errors shall in general not exceed 1 per cent.

(b) *Methods of Casting.* The bars shall be cast vertically in well-faced, dry sand molds provided with suitable pouring basin and mounted on a suitable refractory foundation. Metal for the bars shall be obtained by using a small heated ladle taking its metal from the main ladle from which the pipe is to be poured and after all alloys and other additional metal, except cast iron pipe for cooling, have been added to the main ladle and become melted. The bars shall not be removed from the mold before they have cooled to 500°F.

(c) *When Cast and to What Pipe Applicable.* Except as hereinafter provided for special cases, one pair of test bars of the metal used shall be cast with iron from the first ladle, another pair with iron from the approximately middle ladle, and a third pair with iron from the last ladle of iron taken during a day's run or heat from the cupola in which the iron for the pipe is melted. If the heat lasts for more than 6 hours, then additional pairs of bars shall be cast at approximately uniform intervals so as to give an extra pair of bars for each 3 hours during which the heat lasts in excess of 6 hours. In case the charging of the cupola is to be changed one or more times during the day's run or heat in order to produce a different iron, the time of taking test bars shall be varied in such a way as to obtain representative tests of the iron at least at the beginning and end of each period during which the iron is intended to be constant in quality; and in case such period exceeds four hours additional pairs of bars shall be taken at such times as will provide a pair of bars for each two hours during which this special mixture is used. At least one bar from each pair shall be broken, but the manufacturer shall have the right to break both bars in which case the better bar shall be taken as representative. Bars showing flaws in fracture may be disregarded.

(d) *Test Bar Requirements to Indicate Acceptable Iron; Retests may be made at Contractor's Option using Talbot Strips and/or Rings.* In order that the iron shall be acceptable the average results from the single bars representing the respective pairs of bars cast during the heat or period shall comply with the requirements hereinafter specified and, in addition, no representative bar shall be more than 5 percent below the minimum requirements in either corrected breaking load or corrected deflection. In case the test bars do not measure up to these requirements the manufacturer may make one or more Talbot strip tests and/or ring tests of specimens cut from such of the pipe as may be agreed upon as best representing the iron at the time when the deficient test bars were cast. In the absence of the purchaser the manufacturer may select the pipe from which rings and/or strips shall be cut. The results from these rings and/or strips shall be kept as a foundry record available to any purchaser who requires a report of tests on the 2-inch by 1-inch bars. Any Talbot strip tests or ring tests made under this provision shall be at the expense of the manufacturer. If these supplementary Talbot strip tests and/or ring tests do not meet the requirements, the pipe cast in that heat or period, or such a part thereof as may be agreed to by the purchaser, shall be rejected.

(e) *Method of Testing.* The bars shall be broken as beams by placing them flatwise on supports 24 inches apart and applying the load at the center of the span. The breaking load and the corresponding deflection shall be observed and recorded.

(f) *Correcting Observed Breaking Loads and Deflections.* The bars shall be measured at the point of application of the load and the results corrected to standard 2 inch by 1 inch cross section by the conventional beam formula as follows:

Corrected breaking load = observed breaking load multiplied by $\frac{2}{bd^2}$

Corrected deflection at breaking = observed deflection at breaking multiplied by d

where b = measured width and
d = measured depth
of the bar at point of application of load

In the formulae above the deflection and all dimensions are in inches.

(g) *Requirements as to Strength and Deflection of 2 inch by 1 inch Bars.* In order to indicate acceptable metal, the corrected breaking loads and deflections of the representative 2 inch by 1 inch test bars for a given heat or period interpreted as provided in paragraph (d) above, shall comply with such of the following tabulated requirements as pertain to the thickness range within which fall the particular pipes which are under consideration.

Table of Minimum Corrected Breaking Loads & Deflections

Metal Thickness of Pipe, Inch	Minimum Center Breaking Load, Pounds	Minimum Center Deflection at Breaking, Inch
Below .61	1900	.30 + .0001 (Breaking Load − 1900)
.61 to .90	2000	.30 + .0001 (Breaking Load − 2000)
.91 to 1.60	2200	.30 + .0001 (Breaking Load − 2200)
1.61 to 2.50	2300	.30 + .0001 (Breaking Load − 2300)

Note: For thicknesses exceeding 2.50 inches the form of test specimen and the test requirements shall be as agreed upon in the purchase contract.

Sect. 2-18. Talbot Strip Tests and Ring Tests.

(a) *Dimensions.* Rings shall have a length equal to half the nominal diameter of the pipe unless the diameter exceeds 24 inches, in which case the length of ring shall be 12 inches. Strips shall be not less than 11 inches long and for 24-inch and larger pipe may be cut from the least stressed portions of rings (see Sect. 2-18 (d) after the rings have been broken. The end 2 inches of the pipe shall not be included in ring or strip.

Note: To make both ring and strip tests on a pipe will therefore require at the least (on 6 inch pipe) 16 inches of pipe, at the most (on 20 inch pipe) 23 inches of pipe, and on pipe larger than 20 inches, 14 inches of pipe.

(b) *Method of Sampling.* The purchaser who has expressly specified Talbot strip tests and/or ring tests as acceptance tests of the pipe may select at random from each run, or heat, one or more pipe from which test specimens are to be cut. In the absence of the purchaser or his representative, the pipe from which test specimens are to be taken may be selected by the manufacturer. If the purchaser should wish to test the uniformity of a run or heat, he may divide it into two or more periods and have a separate set of acceptance tests for pipe in each period.

(c) *Defective Specimens; Retests.* If any test specimen shows defective machining or obvious lack of continuity of metal, it shall be discarded and replaced by another specimen selected by the purchaser. If the test specimens first selected fail to meet the require-

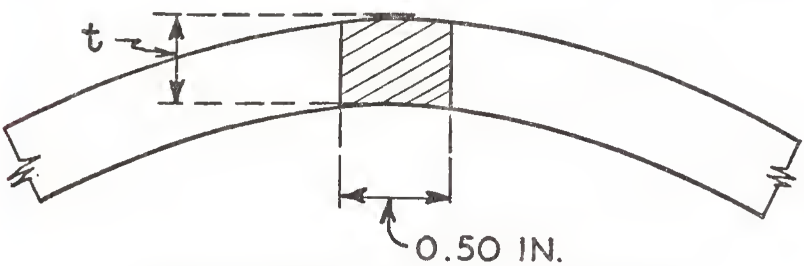


Fig. 1. Position from which Talbot Strip Is Cut

ments specified hereinafter and the purchaser permits a retest, at least twice the number of specimens that failed shall be selected by the purchaser for retest from a pipe cast in the same run or period. In case a ring from a pipe 24 inches in diameter or larger fails to meet specifications, the purchaser may accept strip tests, two specimens to be cut from the failed ring at points of low stress as described in Sect. 2-18 (d). In any case of retest the pipe cast during the run or period shall be acceptable only when all retest specimens meet the requirements. All retests shall be made at the expense of the manufacturer.

(d) *Talbot Strip Tests.* Two Talbot strips shall be machined longitudinally from each pipe selected by the purchaser for testing by this method. If ring tests are also made and the pipe are 24 inches or larger these Talbot strips may be cut from a part of the ring little stressed in the ring test, i.e., near one of the elements marked (a) in Fig. 2. (See Sect. 2-18 (e).) The strips in any case will be in cross section as indicated in Fig. 1, i.e., will have for their width the thickness of the pipe and for their thickness 0.50 inch. Their length will be the length of the ring, 12 inches; or, if not cut from a ring, at least 11 inches. These strips shall be tested as a beam on supports 10 inches apart with loads applied perpendicularly to the machined faces at two points $3\frac{1}{3}$ inches from the supports. The breaking load and the corresponding deflection shall be observed and recorded.

The strip shall be accurately calipered at point of rupture and the modulus of rupture, R, shall be calculated by the usual beam formula which for this case reduces to the expression:

$$R = \frac{10W}{td^2}$$

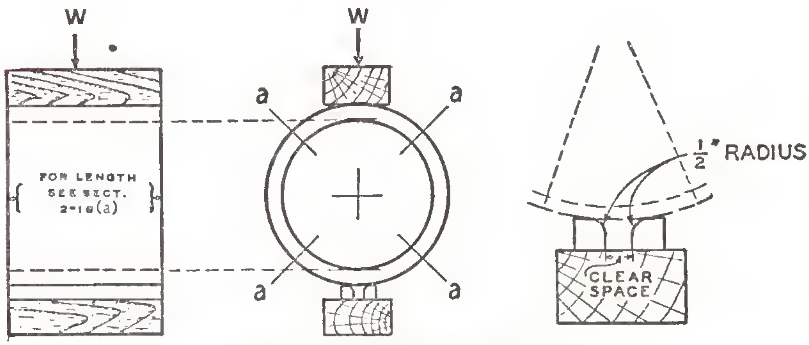


FIG. 2. Assembly for Ring Test

The secant modulus of elasticity E_s, in lb. per sq.in. shall be computed by the formula:

$$E_s = \frac{213W}{td^3y} = \frac{21.3R}{dy}$$

where R = modulus of rupture, lb. per sq.in.
E_s = secant modulus of elasticity, lb. per sq.in.
W = breaking load, lb.
d = depth of strip in inches (intended to be 0.50 in.)
t = width of strip, inches (pipe thickness)
y = deflection of strip at center at breaking load, inches.

To be acceptable a Talbot strip shall have the modulus of rupture, R, not less than 30,000 lb. per sq.in. and the secant modulus of elasticity, E_s, not more than 10,000,000 lb. per sq.in. If the results from either strip are up to the specifications the test shall be regarded as satisfactory.

(e) *Ring Tests.* Each ring shall be tested by the three-edge-bearing method as indicated in Fig. 2. The lower bearing for the ring shall consist of two strips with vertical sides having their interior top corners rounded to a radius of approximately $\frac{1}{2}$ inch. The strips shall be of hard wood or of metal. If of metal a piece of leather belting about $\frac{3}{16}$ inch thick shall be laid over them. They shall be straight and shall be securely fastened to a rigid block with their interior vertical faces spaced at a distance apart as given in the following table:

Diam. of Pipe	Clear Space
12-inch and smaller	$\frac{1}{2}$ inch
14-inch to 24-inch inclusive	1 inch
30-inch and larger	2 inch

The upper bearing shall be a rigid wooden block, straight and true from end to end. The upper and lower bearings shall extend the full length of the outside of the ring. The ring shall be placed symmetrically between the two bearings, and the center of application of the load shall be so placed that the vertical deformations at the two ends of the ring shall be equal. If the ring is not uniform in thickness, it shall be so placed that the thick and thin portions are near the ends of the horizontal diameter. A record of the breaking load and the corresponding vertical deformation of each ring tested shall be made. In order to be acceptable the modulus of rupture computed from the formula

$$R = 0.954\,\frac{W(d + t)}{bt^2}$$

shall be not less than 31,000 lb. per sq.in., and the secant modulus of elasticity computed from the formula

$$E_s = \frac{0.225\,W(d + t)^3}{bt^3y} = \frac{0.236\,R(d + t)^2}{ty}$$

shall not exceed 15,000,000 lb. per sq.in.

b = length of ring, inches
d = average inside diameter of ring, inches
t = average thickness of metal along line of fracture, inches
y = maximum vertical deflection of ring, inches
W = breaking load, in lb.
R = modulus of rupture, lb. per sq.in.
E = secant modulus of elasticity, lb. per sq.in.

The modulus of elasticity shall not be determined in rings from pipe less than 12 inches in diameter.

Sect. 2-19. Full-Length Bursting Tests. The bursting tensile strength shall be determined by testing full-length pipe (less the amount cut off for ring and strip test specimens) to destruction by hydraulic pressure. Bells may be removed to facilitate testing. A suitable means for holding the end thrust shall be used which will not subject the pipe to endwise tension or compression, or other parasitic stresses. A calibrated pressure gage shall be used for determining the bursting pressure. This gage shall be connected to the interior of the test pipe by a separate connection from that which supplies water for the test. The unit tensile strength in bursting shall be obtained by the use of the formula:

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

in which S is the bursting tensile strength (psi.) of the iron, P is the internal pressure (psi.) at bursting, d is the average inside diameter (in.) of the pipe and t is the minimum average thickness (in.) of the pipe along the principal line of break.

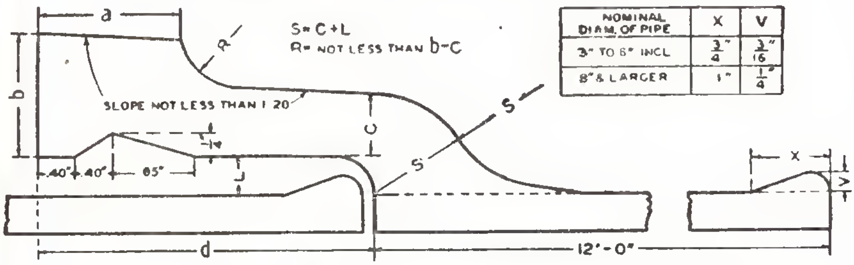
Measurements of thickness shall be taken along the principal line of break at 1-ft. intervals.

The minimum average thickness along the principal line of break shall be obtained by averaging the measurements at the thinnest section at a weight of two and at the adjacent sections on each side at a weight of one each; or, if the thinnest section is at the end of the break, by averaging this thinnest-section measurement at a weight of two and the measurements of the adjacent section and the next section at a weight of one each.

In order to be acceptable, the bursting tensile strength shall not be less than 11,000 psi.

Table No. 1

STANDARD DIMENSIONS OF BELLS, SOCKETS, SPIGOT BEADS and OUTSIDE DIAMETERS of PIT CAST PIPE also WEIGHTS OF BELLS AND OF SPIGOT BEADS



NOMINAL DIAM. OF PIPE	X	V
3" TO 6" INCL	3/4"	3/16"
8" & LARGER	1"	1/4"

Nominal Diam.	Thickness of pipe: From	Thickness of pipe: To	Out-Side Diam. of Pipe	DIMENSIONS OF BELLS: Diam. of Socket	Thickness of Joint L	Depth of Socket d	a	b	c	Wt. of Bell	Wt. of Spigot Bead
3	.37	45	3 80	4 60	40	3 50	1 25	1 30	65	19	3
	46	53	3 96	4.76	40	3.50	1 25	1 30	65	20	.3
4	40	.45	4 80	5.60	.40	3 50	1.50	1 30	.65	23	.3
	.46	.55	5.00	5.80	.40	3.50	1.50	1.30	65	24	.4
6	.43	50	6 90	7.70	40	3.50	1.50	1 40	70	33	.5
	51	.60	7.10	7.90	.40	3.50	1.50	1 40	70	34	.5
	61	.66	7.22	8.02	.40	4.00	1.50	1 75	75	56	.9
	67	74	7.38	8.18	40	4.00	1.50	1.85	.85	62	.9
8	.46	.57	9.05	9.85	.40	4.00	1.50	1.50	75	48	1.1
	58	.70	9.30	10.10	40	4.00	1 50	1.50	.75	49	1.2
	.71	.76	9 42	10.22	40	4.00	1.50	1.85	.85	75	1.2
	.77	.85	9.60	10.40	40	4.00	1 50	1.95	95	84	1.2
10	.50	.60	11.10	11.90	40	4.00	1.50	1 50	75	58	1.4
	61	.75	11.40	12.20	40	4.00	1.50	1.60	.80	64	1.4
	.76	.85	11.60	12.40	40	4 50	1.75	1.95	.95	99	1.4
	.86	.97	11.84	12.64	.40	4.50	1.75	2.05	1.05	110	1.5
12	54	.65	13.20	14.00	.40	4.00	1 50	1 60	.80	72	1.6
	66	80	13.50	14.30	.40	4.00	1.50	1 70	85	78	1.7
	.81	94	13 78	14.58	.40	4.50	1.75	2.05	1.05	125	1.7
	95	1.09	14.08	14.88	.40	4.50	1 75	2.20	1.20	144	1.7
14	54	.62	15 30	16.10	.40	4.00	1.50	1.70	85	88	1.9
	.63	.87	15.65	16.45	.40	4.00	1.50	1.80	90	96	1.9
	.88	1.04	15.98	16.78	.40	4.50	2.00	2.15	1 15	148	2.0
	1.05	1.21	16.32	17.12	.40	4.50	2.00	2.35	1.35	183	2.0
16	.58	.67	17.40	18.40	50	4.00	1.75	1.80	90	114	2.1
	.68	.95	17.80	18.80	50	4.00	1.75	1.90	1 00	128	2.2
	96	1.13	18.16	18 96	40	4.50	2.00	2 30	1.25	180	2.2
	1.14	1.32	18.54	19.34	40	4.50	2.00	2 55	1 45	224	2.3
18	63	.72	19.50	20.50	.50	4.00	1 75	1 90	95	133	2.4
	73	1.01	19.92	20.92	.50	4 00	1 75	2.10	1 05	154	2.4
	1 02	1 22	20.34	21.14	.40	4.50	2.25	2 45	1 40	222	2.5
	1 23	1.44	20.78	21.58	.40	4.50	2.25	2.75	1.65	283	2.5

All dimensions given in inches. All weights given in pounds.

Table No. 1 (continued)

STANDARD DIMENSIONS OF BELLS, SOCKETS, SPIGOT BEADS and OUTSIDE DIAMETERS of PIT CAST PIPE also WEIGHTS OF BELLS AND OF SPIGOT BEADS

Nominal Diam.	Thickness of pipe		Out-Side Diam. of Pipe	DIMENSIONS OF BELLS						Wt. of Bell	Wt. of Spigot Bead
	From	To		Diam. of Socket	Thickness of Joint L	Depth of Socket d	a	b	c		
20	.66	.82	21.60	22.60	.50	4.00	1.75	2.00	1.00	156	2.6
	.83	1.08	22.06	23.06	.50	4.00	1.75	2.30	1.15	189	2.7
	1.09	1.32	22.54	23.34	.40	4.50	2.25	2.55	1.50	260	2.8
	1.33	1.56	23.02	23.82	.40	4.50	2.25	2.85	1.75	326	2.8
24	.74	.92	25.80	26.80	.50	4.00	2.00	2.10	1.05	199	3.2
	.93	1.21	26.32	27.32	.50	4.00	2.00	2.50	1.25	250	3.2
	1.22	1.50	26.90	27.90	.50	5.00	2.25	2.75	1.70	349	3.3
	1.51	1.93	27.76	28.56	.40	5.00	2.25	3.15	1.95	489	3.4
30	.87	.92	31.74	32.74	.50	4.50	2.00	2.30	1.15	296	3.9
	.93	1.05	32.00	33.00	.50	4.50	2.00	2.30	1.15	298	3.9
	1.06	1.18	32.40	33.40	.50	4.50	2.00	2.60	1.32	351	4.0
	1.19	1.42	32.74	33.74	.50	4.50	2.00	3.00	1.50	416	4.0
	1.43	1.60	33.10	34.10	.50	5.00	2.25	3.25	1.80	557	4.0
	1.61	1.78	33.46	34.46	.50	5.00	2.25	3.50	2.00	626	4.1
36	.97	1.03	37.96	38.96	.50	4.50	2.00	2.50	1.25	383	4.6
	1.04	1.20	38.30	39.30	.50	4.50	2.00	2.80	1.40	446	4.7
	1.21	1.40	38.70	39.70	.50	4.50	2.00	3.10	1.60	512	4.7
	1.41	1.63	39.16	40.16	.50	4.50	2.00	3.40	1.80	586	4.8
	1.64	1.85	39.60	40.60	.50	5.00	2.25	3.70	2.05	770	4.8
	1.86	2.07	40.04	41.04	.50	5.00	2.25	4.00	2.30	876	4.9
42	1.07	1.15	44.20	45.20	.50	5.00	2.00	2.80	1.40	539	5.4
	1.16	1.30	44.50	45.50	.50	5.00	2.00	3.00	1.50	586	5.4
	1.31	1.57	45.10	46.10	.50	5.00	2.00	3.40	1.75	701	5.5
	1.58	1.84	45.58	46.58	.50	5.00	2.00	3.80	1.95	805	5.8
48	1.18	1.30	50.50	51.50	.50	5.00	2.00	3.00	1.50	660	6.1
	1.31	1.45	50.80	51.80	.50	5.00	2.00	3.30	1.65	745	6.2
	1.46	1.72	51.40	52.40	.50	5.00	2.00	3.80	1.95	900	6.2
	1.73	2.04	51.98	52.98	.50	5.00	2.00	4.20	2.20	1046	6.3
54	1.30	1.38	56.66	57.66	.50	5.50	2.25	3.20	1.60	855	6.9
	1.39	1.60	57.10	58.10	.50	5.50	2.25	3.60	1.80	993	6.9
	1.61	1.89	57.80	58.80	.50	5.50	2.25	4.00	2.15	1189	7.0
	1.90	2.25	58.40	59.40	.50	5.50	2.25	4.40	2.45	1391	7.1
60	1.39	1.45	62.80	63.80	.50	5.50	2.25	3.40	1.70	1021	7.6
	1.46	1.75	63.40	64.40	.50	5.50	2.25	3.70	1.90	1145	7.7
	1.76	2.15	64.20	65.20	.50	5.50	2.25	4.20	2.25	1393	7.8
	2.16	2.46	64.82	65.82	.50	5.50	2.25	4.70	2.60	1647	7.9

All dimensions given in inches. All weights given in pounds.

NOTE: Pipe for pressures greater than 200 pounds per square inch may be supplied with double lead groove if desired.

Table 2

STANDARD THICKNESSES, DIAMETERS AND WEIGHTS OF PIT CAST PIPE

Dimensions in Inches — Weights in Pounds

Nominal Diam.	Thickness Class	Thickness	Outside Diam.	Inside Diam.	Wt. of Barrel Per Ft.	Wt. of Bell	Wt. Based on 12 Ft. Length*	
							Per Length	Avg. Per Foot
1	2	3	4	5	6	7	8	9
3	1	.37	3.80	3.06	12.4	19	170	14.2
	2	.40	3.80	3.00	13.3	19	180	15.0
	3	.43	3.80	2.94	14.2	19	190	15.8
	4	.46	3.96	3.04	15.8	20	210	17.5
	5	.50	3.96	2.96	17.0	20	225	18.8
4	1	.40	4.80	4.00	17.3	23	230	19.2
	2	.43	4.80	3.94	18.4	23	245	20.4
	3	.46	5.00	4.08	20.5	24	270	22.5
	4	.50	5.00	4.00	22.1	24	290	24.2
	5	.54	5.00	3.92	23.6	24	310	25.8
6	1	.43	6.90	6.04	27.3	33	360	30.0
	2	.46	6.90	5.98	29.0	33	380	31.7
	3	.50	6.90	5.90	31.4	33	410	34.2
	4	.54	7.10	6.02	34.7	34	450	37.5
	5	.58	7.10	5.94	37.1	34	480	40.0
	6	.63	7.22	5.96	40.7	56	545	45.4
	7	.68	7.38	6.02	44.7	62	600	50.0
	8	.73	7.38	5.92	47.6	62	635	52.9
8	1	.46	9.05	8.13	38.7	48	515	42.9
	2	.50	9.05	8.05	41.9	48	550	45.8
	3	.54	9.05	7.97	45.0	48	590	49.2
	4	.58	9.30	8.14	49.6	49	645	53.8
	5	.63	9.30	8.04	53.5	49	690	57.5
	6	.68	9.30	7.94	57.5	49	740	61.7
	7	.73	9.42	7.96	62.2	75	825	68.8
	8	.79	9.60	8.02	68.2	84	905	75.4
	9	.85	9.60	7.90	72.9	84	960	80.0
10	1	.50	11.10	10.10	52.0	58	685	57.1
	2	.54	11.10	10.02	55.9	58	730	60.8
	3	.58	11.10	9.94	59.8	58	775	64.6
	4	.63	11.40	10.14	66.5	64	865	72.1
	5	.68	11.40	10.04	71.5	64	925	77.1
	6	.73	11.40	9.94	76.4	64	980	81.7
	7	.79	11.60	10.02	83.7	99	1105	92.1
	8	.85	11.60	9.90	89.6	99	1175	97.9
	9	.92	11.84	10.00	98.5	110	1295	107.9
12	1	.54	13.20	12.12	67.0	72	880	73.3
	2	.58	13.20	12.04	71.8	72	935	77.9
	3	.63	13.20	11.94	77.6	72	1005	83.8
	4	.68	13.50	12.14	85.5	78	1105	92.1
	5	.73	13.50	12.04	91.4	78	1175	97.9
	6	.79	13.50	11.92	98.4	78	1260	105.0
	7	.85	13.78	12.08	107.7	125	1420	118.3
	8	.92	13.78	11.94	116.0	125	1520	126.7
	9	.99	14.08	12.10	127.0	144	1670	139.2
	10	1.07	14.08	11.94	136.4	144	1785	148.8
14	1	.54	15.30	14.22	78.1	88	1025	85.4
	2	.58	15.30	14.14	83.7	88	1095	91.3
	3	.63	15.65	14.39	92.8	96	1210	100.8
	4	.68	15.65	14.29	99.8	96	1295	107.9
	5	.73	15.65	14.19	106.8	96	1380	115.0
	6	.79	15.65	14.07	115.1	96	1480	123.3
	7	.85	15.65	13.95	123.3	96	1580	131.7
	8	.92	15.98	14.14	135.8	148	1780	148.3
	9	.99	15.98	14.00	145.5	148	1895	157.9

*Including Bell and Spigot Bead. Calculated weight of Pipe rounded off to nearest 5 pounds.

Table 2 (continued)

STANDARD THICKNESSES, DIAMETERS AND WEIGHTS OF PIT CAST PIPE

Dimensions in Inches — Weights in Pounds

Nominal Diam.	Thickness Class	Thickness	Outside Diam.	Inside Diam.	Wt. of Barrel Per Ft.	Wt. of Bell	Wt. Based on 12 Ft. Length*	
							Per Length	Avg. Per Foot
1	2	3	4	5	6	7	8	9
14	10	1.07	16.32	14.18	160.0	183	2105	175.4
	11	1.16	16.32	14.00	172 4	183	2255	187.9
16	1	.58	17.40	16.24	95.6	114	1265	105.4
	2	.63	17.40	16.14	103.6	114	1360	113.3
	3	.68	17.80	16.44	114.1	128	1500	125.0
	4	.73	17.80	16.34	122.1	128	1595	132.9
	5	.79	17.80	16.22	131.7	128	1710	142.5
	6	.85	17.80	16.10	141.2	128	1825	152.1
	7	.92	17.80	15.96	152.2	128	1955	162.9
	8	.99	18.16	16.18	166.6	180	2180	181.7
	9	1.07	18.16	16.02	179.2	180	2335	194.6
	10	1.16	18.54	16.22	197.6	224	2600	216.7
	11	1.25	18.54	16.04	211.8	224	2770	230.8
18	1	.63	19.50	18.24	116.5	133	1535	127.9
	2	.68	19.50	18.14	125.4	133	1640	136.7
	3	.73	19.92	18 46	137.3	154	1805	150.4
	4	.79	19.92	18.34	148.1	154	1935	161.3
	5	.85	19.92	18 22	158.9	154	2065	172.1
	6	.92	19.92	18.08	171.3	154	2210	184.2
	7	.99	19.92	17.94	183.7	154	2360	196.7
	8	1.07	20.34	18.20	202.1	222	2650	220.8
	9	1.16	20 34	18.02	218.1	222	2840	236.7
	10	1.25	20.78	18.28	239.3	283	3155	262.9
	11	1.35	20.78	18.08	257.1	283	3370	280.8
20	1	.66	21.60	20.28	135.5	156	1785	148.8
	2	.71	21.60	20.18	145.4	156	1905	158.8
	3	.77	21.60	20.06	157.2	156	2045	170.4
	4	.83	22.06	20.40	172.7	189	2265	188.8
	5	.90	22.06	20.26	186.7	189	2430	202.5
	6	.97	22.06	20.12	200.5	189	2600	216.7
	7	1.05	22.06	19.96	216.2	189	2785	232.1
	8	1.13	22.54	20.28	237.1	260	3110	259.2
	9	1.22	22.54	20.10	255.0	260	3325	277.1
	10	1.32	22.54	19.90	274.6	260	3560	296.7
	11	1.43	23.02	20.16	302.6	326	3960	330.0
24	1	.74	25.80	24.32	181.8	199	2385	198.8
	2	.80	25.80	24.20	196.0	199	2555	212.9
	3	.86	25.80	24.08	210.2	199	2725	227.1
	4	.93	26.32	24.46	231.5	250	3030	252.5
	5	1.00	26.32	24.32	248.2	250	3230	269.2
	6	1.08	26 32	24.16	267.2	250	3460	288.3
	7	1.17	26.32	23.98	288.4	250	3715	309.6
	8	1.26	26.90	24.38	316.7	349	4155	346.2
	9	1.36	26.90	24.18	340.5	349	4440	370.0
	10	1.47	26.90	23.96	366.4	349	4750	395.8
	11	1.59	27.76	24.58	407.9	489	5385	448.8
	12	1.72	27.76	24.32	439.0	489	5760	480.0
	13	1.86	27.76	24.04	472.2	489	6160	513.3
30	1	.87	31.74	30.00	263.3	296	3460	288.3
	2	.94	32.00	30.12	286.2	298	3735	311.3
	3	1.02	32.00	29.96	309.7	298	4020	335.0
	4	1.10	32.40	30.20	337.5	351	4405	367.1
	5	1.19	32.74	30.36	368.0	416	4835	402.9
	6	1.29	32.74	30.16	397.7	416	5190	432.5
	7	1.39	32.74	29.96	427.1	416	5545	462.1

*Including Bell and Spigot Bead. Calculated weight of Pipe rounded off to nearest 5 pounds.

Table 2 (continued)

STANDARD THICKNESSES, DIAMETERS AND WEIGHTS OF PIT CAST PIPE

Dimensions in Inches — Weights in Pounds

Nominal Diam.	Thickness Class	Thickness	Outside Diam.	Inside Diam.	Wt. of Barrel Per Ft.	Wt. of Bell	Wt. Based on 12 Ft. Length*	
							Per Length	Avg. Per Foot
1	2	3	4	5	6	7	8	9
30	8	1.50	33.10	30.10	464.6	557	6135	511.3
	9	1.62	33.46	30.22	505.6	626	6695	557.9
	10	1.75	33.46	29.96	543.9	626	7155	596.3
36	1	.97	37.96	36.02	351.7	383	4610	384.2
	2	1.05	38.30	36.20	383.4	446	5050	420.8
	3	1.13	38.30	36.04	411.7	446	5390	449.2
	4	1.22	38.70	36.26	448.2	512	5895	491.3
	5	1.32	38.70	36.06	483.6	512	6320	526.7
	6	1.43	39.16	36.30	528.9	586	6940	578.3
	7	1.54	39.16	36.08	567.9	586	7405	617.1
	8	1.66	39.60	36.28	617.3	770	8180	681.7
	9	1.79	39.60	36.02	663.4	770	8735	727.9
	10	1.93	40.04	36.18	720.9	876	9530	794.2
42	1	1.07	44.20	42.06	452.3	539	5970	497.5
	2	1.16	44.50	42.18	492.8	586	6505	542.1
	3	1.25	44.50	42.00	529.9	586	6950	579.2
	4	1.35	45.10	42.40	578.9	701	7655	637.9
	5	1.46	45.10	42.18	624.5	701	8200	683.3
	6	1.58	45.58	42.42	681.4	805	8990	749.2
	7	1.71	45.58	42.16	735.3	805	9635	802.9
48	1	1.18	50.50	48.14	570.4	660	7510	625.8
	2	1.27	50.50	47.96	612.8	660	8020	668.3
	3	1.37	50.80	48.06	663.8	745	8715	726.3
	4	1.48	51.40	48.44	724.2	900	9595	799.6
	5	1.60	51.40	48.20	781.0	900	10280	856.7
	6	1.73	51.98	48.52	852.1	1046	11280	940.0
	7	1.87	51.98	48.24	918.5	1046	12075	1006.3
	8	2.02	51.98	47.94	989.2	1046	12925	1077.1
54	1	1.30	56.66	54.06	705.4	855	9325	777.1
	2	1.40	57.10	54.30	764.3	993	10170	847.5
	3	1.51	57.10	54.08	822.8	993	10875	906.3
	4	1.63	57.80	54.54	897.4	1189	11965	997.1
	5	1.76	57.80	54.28	966.8	1189	12800	1066.7
	6	1.90	58.40	54.60	1052.2	1391	14025	1168.8
	7	2.05	58.40	54.30	1132.3	1391	14985	1248.8
	8	2.21	58.40	53.98	1217.2	1391	16005	1333.8
60	1	1.39	62.80	60.02	836.7	1021	11070	922.5
	2	1.50	63.40	60.40	910.1	1145	12075	1006.3
	3	1.62	63.40	60.16	981.0	1145	12925	1077.1
	4	1.75	63.40	59.90	1057.5	1145	13845	1153.8
	5	1.89	64.20	60.42	1154.3	1393	15250	1270.9
	6	2.04	64.20	60.12	1242.9	1393	16315	1359.6
	7	2.20	64.82	60.42	1350.3	1647	17860	1488.3
	8	2.38	64.82	60.06	1456.6	1647	19135	1594.6

NOTE: When pipe is to be cement lined, patterns and cores giving larger outside and inside diameter without change of thickness will be used if ordered.

*Including Bell and Spigot Bead. Calculated weight of Pipe rounded off to nearest 5 pounds.

Table No. 3

STANDARD THICKNESSES AND WEIGHTS OF CAST IRON PIT CAST PIPE

NOTE: These weights are for pipe laid without blocks, on flat bottom trench, with tamped backfill, under 5 feet of cover. For other conditions see Table 4 hereof and the Manual.

Size Inches	CLASS 50 — 50 Lb. Pressure — 115 Feet Head			CLASS 100 — 100 Lb. Pressure — 231 Feet Head			CLASS 150 — 150 Lb. Pressure — 346 Feet Head			CLASS 200 — 200 Lb. Pressure — 462 Feet Head		
	Thickness Inches	Wt Based on 12 Ft. Lgh.* Avg. Per Foot	Per Length	Thickness Inches	Wt. Based on 12 Ft. Lgh.* Avg. Per Foot	Per Length	Thickness Inches	Wt. Based on 12 Ft. Lgh.* Avg. Per Foot	Per Length	Thickness Inches	Wt. Based on 12 Ft. Lgh.* Avg. Per Foot	Per Length
3	.37	14.2	170	.37	14.2	170	.37	14.2	170	.37	14.2	170
4	.40	19.2	230	.40	19.2	230	.40	19.2	230	.40	19.2	230
6	.43	30.0	360	.43	30.0	360	.43	30.0	360	.43	30.0	360
8	.46	42.9	515	.46	42.9	515	.46	42.9	515	.46	42.9	515
10	.50	57.1	685	.50	57.1	685	.54	60.8	730	.58	64.6	775
12	.54	73.3	880	.54	73.3	880	.58	77.9	935	.63	83.8	1005
14	.54	85.4	1025	.58	91.3	1095	.63	100.8	1210	.68	107.9	1295
16	.58	105.4	1265	.63	113.3	1360	.68	125.0	1500	.79	142.5	1710
18	.63	127.9	1535	.68	136.7	1640	.79	161.3	1935	.85	172.1	2065
20	.66	148.8	1785	.71	158.8	1905	.83	188.8	2265	.90	202.5	2430
24	.74	198.8	2385	.80	212.9	2555	.93	252.5	3030	1.00	269.2	3230
30	.87	288.3	3460	.94	311.3	3735	1.10	367.1	4405	1.19	402.9	4835
36	.97	384.2	4610	1.13	449.2	5390	1.22	491.3	5895	1.43	578.3	6940
42	1.07	497.5	5970	1.16	542.1	6505	1.35	637.9	7655	1.58	749.2	8990
48	1.18	625.8	7510	1.37	726.3	8715	1.48	799.6	9595	1.73	940.0	11280
54	1.30	777.1	9325	1.51	906.3	10875	1.63	997.1	11965	1.90	1168.8	14025
60	1.39	922.5	11070	1.62	1077.1	12925	1.89	1270.9	15250	2.20	1488.3	17860

*Including Bell and Spigot Bead. Calculated weight of Pipe rounded off to nearest 5 pounds.

Table No. 3 (Continued)

STANDARD THICKNESSES AND WEIGHTS OF CAST IRON PIT CAST PIPE

NOTE: These weights are for pipe laid without blocks, on flat bottom trench, with tamped backfill, under 5 feet of cover. For other conditions see Table 4 hereof and the Manual.

	CLASS 250			CLASS 300			CLASS 350		
	250 Lb. Pressure			300 Lb. Pressure			350 Lb. Pressure		
	577 Feet Head			693 Feet Head			808 Feet Head		
		Wt. Based on 12 Ft. Lgh.*			Wt. Based on 12 Ft. Lgh.*			Wt. Based on 12 Ft. Lgh.*	
Size Inches	Thickness Inches	Avg. Per Foot	Per Length	Thickness Inches	Avg. Per Foot	Per Length	Thickness Inches	Avg. Per Foot	Per Length
3	.37	14.2	170	.37	14.2	170	.37	14.2	170
4	.40	19.2	230	.40	19.2	230	.40	19.2	230
6	.43	30.0	360	.46	31.7	380	.50	34.2	410
8	.50	45.8	550	.54	49.2	590	.58	53.8	645
10	.63	72.1	865	.68	77.1	925	.73	81.7	980
12	.68	92.1	1105	.73	97.9	1175	.79	105.0	1260
14	.79	123.3	1480	.85	131.7	1580	.92	148.3	1780
16	.85	152.1	1825	.92	162.9	1955	.99	181.7	2180
18	.92	184.2	2210	.99	196.7	2360	1.07	220.8	2650
20	.97	216.7	2600	1.05	232.1	2785	1.22	277.1	3325
24	1.17	309.6	3715	1.26	346.2	4155	1.36	370.0	4440
30	1.39	462.1	5545	1.50	511.3	6135	1.62	557.9	6695
36	1.54	617.1	7405	1.79	727.9	8735	1.93	794.2	9530
42	1.71	802.9	9635						
48	2.02	1077.1	12925						
54	2.21	1333.8	16005						
60	2.38	1594.6	19135						

*Including Bell and Spigot Bead. Calculated weight of Pipe rounded off to nearest 5 pounds.

Table No. 4

STANDARD THICKNESSES OF CAST IRON PIT CAST PIPE

Thickness in Inches. Working Pressure in Pounds per Square Inch.
Thicknesses Include Allowances for Water Hammer,
Foundry Practice and Corrosion

Laying Condition A—Flat Bottom Trench, Without Blocks, Untamped Backfill
Laying Condition B—Flat Bottom Trench, Without Blocks, Tamped Backfill
Laying Condition C—Pipe Laid on Blocks, Untamped Backfill
Laying Condition D—Pipe Laid on Blocks, Tamped Backfill

Size Inches	Working Pressure	3½ FEET OF COVER				5 FEET OF COVER				8 FEET OF COVER			
		Laying Condition				Laying Condition				Laying Condition			
		A	B	C	D	A	B	C	D	A	B	C	D
3	50	.37	.37	.37	.37	.37	.37	.37	.37	.37	.37	.43	.37
	100	.37	.37	.37	.37	.37	.37	.37	.37	.37	.37	.43	.37
	150	.37	.37	.37	.37	.37	.37	.37	.37	.37	.37	.43	.37
	200	.37	.37	.37	.37	.37	.37	.40	.37	.37	.37	.43	.37
	250	.37	.37	.37	.37	.37	.37	.40	.37	.37	.37	.46	.37
	300	.37	.37	.37	.37	.37	.37	.40	.37	.37	.37	.46	.37
	350	.37	.37	.37	.37	.37	.37	.40	.37	.37	.37	.46	.37
4	50	.40	.40	.40	.40	.40	.40	.40	.40	.40	.40	.50	.40
	100	.40	.40	.40	.40	.40	.40	.43	.40	.40	.40	.50	.40
	150	.40	.40	.40	.40	.40	.40	.43	.40	.40	.40	.50	.40
	200	.40	.40	.40	.40	.40	.40	.43	.40	.40	.40	.50	.40
	250	.40	.40	.43	.40	.40	.40	.46	.40	.40	.40	.50	.40
	300	.40	.40	.43	.40	.40	.40	.46	.40	.40	.40	.54	.40
	350	.40	.40	.43	.40	.40	.40	.46	.40	.40	.40	.54	.40
6	50	.43	.43	.46	.43	.43	.43	.50	.43	.43	.43	.58	.43
	100	.43	.43	.50	.43	.43	.43	.50	.43	.43	.43	.58	.43
	150	.43	.43	.50	.43	.43	.43	.50	.43	.43	.43	.58	.43
	200	.43	.43	.50	.43	.43	.43	.54	.43	.43	.43	.58	.43
	250	.43	.43	.50	.43	.43	.43	.54	.43	.46	.48	.63	.46
	300	.46	.43	.54	.46	.46	.48	.54	.46	.50	.48	.63	.46
	350	.50	.50	.54	.50	.50	.50	.58	.50	.50	.50	.63	.50
8	50	.46	.48	.54	.46	.46	.48	.54	.46	.46	.48	.63	.46
	100	.46	.46	.54	.46	.46	.48	.58	.46	.46	.48	.63	.50
	150	.46	.46	.54	.46	.46	.48	.58	.46	.50	.50	.68	.50
	200	.46	.48	.58	.46	.50	.48	.58	.50	.54	.50	.68	.54
	250	.50	.50	.58	.50	.54	.50	.63	.54	.54	.54	.68	.58
	300	.54	.54	.58	.54	.54	.54	.63	.58	.58	.58	.73	.58
	350	.58	.58	.63	.58	.58	.58	.68	.58	.63	.83	.73	.63
10	50	.50	.50	.58	.50	.50	.50	.58	.50	.54	.50	.68	.54
	100	.50	.50	.58	.50	.50	.50	.63	.50	.58	.54	.73	.58
	150	.50	.50	.58	.50	.54	.54	.63	.54	.58	.58	.73	.58
	200	.54	.54	.63	.58	.58	.58	.68	.58	.63	.58	.79	.63
	250	.58	.58	.63	.58	.63	.83	.68	.63	.68	.63	.79	.68
	300	.63	.63	.68	.63	.68	.88	.73	.68	.68	.88	.85	.73
	350	.68	.88	.73	.73	.73	.73	.79	.73	.73	.73	.85	.73
12	50	.54	.54	.58	.54	.54	.54	.63	.54	.58	.58	.73	.63
	100	.54	.54	.63	.54	.54	.54	.63	.58	.63	.58	.79	.63
	150	.58	.54	.63	.58	.58	.58	.68	.63	.68	.83	.79	.68
	200	.63	.58	.68	.63	.63	.83	.73	.63	.68	.88	.85	.73
	250	.68	.88	.73	.68	.68	.88	.79	.68	.73	.73	.85	.73
	300	.73	.73	.79	.73	.73	.73	.79	.79	.79	.79	.92	.79
	350	.79	.79	.85	.79	.79	.79	.85	.85	.85	.85	.92	.85
14	50	.54	.54	.63	.58	.58	.54	.68	.58	.68	.63	.79	.68
	100	.58	.54	.68	.58	.63	.58	.68	.63	.68	.88	.85	.73
	150	.63	.83	.68	.63	.68	.83	.73	.68	.73	.73	.85	.79
	200	.68	.88	.73	.68	.73	.88	.79	.73	.79	.79	.92	.79
	250	.79	.73	.79	.79	.79	.79	.85	.79	.85	.79	.92	.85
	300	.85	.85	.85	.85	.85	.85	.92	.85	.92	.85	.99	.92
	350	.92	.92	.92	.92	.92	.92	.99	.92	.99	.92	1.07	.99

Tablo No. 4—Continuod

Size Inches	Working Pressure	3½ FEET OF COVER — Laying Condition A	B	C	D	5 FEET OF COVER — Laying Condition A	B	C	D	8 FEET OF COVER — Laying Condition A	B	C	D
16	50	.58	.56	.68	.63	.63	.58	.73	.63	.73	.68	.85	.73
	100	.63	.56	.73	.63	.68	.63	.73	.68	.73	.73	.85	.79
	150	.68	.66	.73	.68	.73	.93	.79	.73	.79	.79	.92	.85
	200	73	.73	.79	.73	.79	.79	.85	.79	.85	.85	.92	.85
	250	.85	.79	.85	.85	.85	.85	.92	.85	.92	.85	.99	.92
	300	92	.92	.92	.92	.92	.92	.99	.92	.99	.92	1.07	.99
	350	99	.99	.99	.99	.99	.99	1.07	.99	1.07	1.07	1.16	1.07
18	50	.63	.63	.73	68	.68	.63	.79	.68	.79	.73	.85	.79
	100	.68	.63	.79	.68	.73	.69	.79	.73	.85	.79	.92	.85
	150	.73	.73	.79	.73	.79	.79	.85	.79	.85	.85	.99	.92
	200	.85	.79	.85	.85	.85	.85	.92	.85	.92	.92	.99	.99
	250	92	.92	.92	.02	.92	.92	.99	.92	.99	.99	1.07	1.07
	300	99	.99	.99	.99	.99	.99	1.07	1.07	1.07	1.07	1.16	1.07
	350	1.07	1.07	1.07	1.07	1.07	1.07	1.16	1.16	1.16	1.19	1.25	1.16
20	50	.71	.66	.77	.71	.71	.66	.83	.77	.83	.77	.90	.83
	100	71	.66	.83	.77	.77	.71	.83	.83	.90	.83	.97	.90
	150	.77	.77	.83	.83	.83	.83	.90	.83	.90	.90	1.05	.97
	200	.90	.83	.90	.90	.90	.90	.97	.90	.97	.97	1.05	1.05
	250	.97	.97	.97	.97	.97	.97	1.05	1.05	1.05	1.05	1.13	1.13
	300	1.05	1.05	1.13	1.05	1.13	1.05	1.13	1.13	1.13	1.13	1.22	1.13
	350	1.22	1.13	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.32	1.22
24	50	.80	.74	.86	.80	.80	.74	.93	.86	.93	.86	1.00	.93
	100	.80	.74	.93	.86	.86	.80	.93	.86	1.00	.93	1.08	1.00
	150	86	.86	.93	.86	.93	.93	1.00	1.00	1.08	1.00	1.17	1.08
	200	1.00	1.00	1.00	1.00	1.08	1.00	1.08	1.08	1.17	1.09	1.17	1.17
	250	1.08	1.06	1.17	1.08	1.17	1.17	1.17	1.17	1.26	1.17	1.26	1.26
	300	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.36	1.26	1.36	1.36
	350	1.36	1.36	1.36	1.36	1.36	1.39	1.47	1.36	1.47	1.36	1.47	1.47
30	50	.94	.87	1.02	.94	.94	.87	1.10	1.02	1.10	1.02	1.19	1.10
	100	1.02	.87	1.02	.94	1.02	.94	1.10	1.02	1.19	1.10	1.29	1.19
	150	1.10	1.02	1.10	1.10	1.19	1.10	1.19	1.19	1.29	1.19	1.29	1.29
	200	1.19	1.19	1.19	1.19	1.29	1.19	1.29	1.29	1.39	1.29	1.39	1.39
	250	1.39	1.29	1.39	1.39	1.39	1.39	1.39	1.39	1.50	1.39	1.50	1.50
	300	1.50	1.50	1.50	1.50	1.50	1.50	1.62	1.50	1.62	1.50	1.62	1.62
	350	1.62	1.92	1.62	1.62	1.75	1.92	1.75	1.75	1.75	1.75	1.75	1.75
36	50	1.05	.97	1.13	1.05	1.13	.97	1.22	1.13	1.22	1.13	1.32	1.22
	100	1.13	.97	1.22	1.13	1.22	1.13	1.22	1.13	1.32	1.22	1.43	1.32
	150	1.22	1.13	1.32	1.22	1.32	1.22	1.32	1.32	1.43	1.32	1.54	1.43
	200	1.43	1.32	1.43	1.32	1.43	1.43	1.54	1.43	1.54	1.43	1.66	1.54
	250	1.54	1.54	1.54	1.54	1.66	1.54	1.66	1.66	1.66	1.69	1.79	1.66
	300	1.79	1.79	1.79	1.79	1.79	1.79	1.79	1.79	1.93	1.79	1.93	1.79
	350	1.93	1.93	1.93	1.93	1.93	1.93	1.93	1.93	2.08	1.93	2.08	2.08
42	50	1.16	1.07	1.25	1.16	1.25	1.07	1.35	1.25	1.35	1.25	1.46	1.35
	100	1.25	1.07	1.35	1.25	1.35	1.16	1.35	1.35	1.46	1.35	1.58	1.46
	150	1.35	1.35	1.46	1.35	1.46	1.35	1.58	1.46	1.58	1.46	1.71	1.58
	200	1.58	1.46	1.58	1.58	1.58	1.59	1.71	1.58	1.71	1.59	1.85	1.71
	250	1.71	1.71	1.85	1.71	1.85	1.71	1.85	1.85	1.85	1.85	2.00	1.85
48	50	1.27	1.19	1.37	1.27	1.37	1.19	1.48	1.37	1.60	1.37	1.60	1.48
	100	1.37	1.27	1.48	1.37	1.48	1.37	1.60	1.48	1.60	1.48	1.73	1.60
	150	1.48	1.46	1.60	1.48	1.60	1.48	1.73	1.60	1.87	1.60	1.87	1.73
	200	1.73	1.73	1.73	1.73	1.87	1.73	1.87	1.87	2.02	1.87	2.02	1.87
	250	2.02	2.02	2.02	2.02	2.02	2.02	2.02	2.02	2.18	2.02	2.18	2.18
54	50	1.40	1.30	1.51	1.40	1.51	1.30	1.63	1.40	1.76	1.51	1.76	1.63
	100	1.51	1.40	1.63	1.51	1.63	1.51	1.76	1.63	1.90	1.63	1.90	1.76
	150	1.63	1.63	1.76	1.63	1.76	1.63	1.90	1.76	2.05	1.76	2.05	1.90
	200	1.90	1.90	1.90	1.90	2.05	1.90	2.05	2.05	2.21	2.05	2.21	2.21
	250	2.21	2.21	2.21	2.21	2.21	2.21	2.39	2.21	2.39	2.21	2.39	2.39
60	50	1.50	1.39	1.62	1.50	1.62	1.39	1.75	1.62	1.89	1.62	1.89	1.75
	100	1.62	1.50	1.75	1.62	1.75	1.62	1.89	1.75	2.04	1.75	2.04	1.89
	150	1.89	1.75	1.89	1.75	2.04	1.89	2.04	1.89	2.20	2.04	2.20	2.04
	200	2.20	2.04	2.20	2.04	2.20	2.20	2.20	2.20	2.38	2.20	2.38	2.38
	250	2.38	2.36	2.38	2.38	2.57	2.38	2.57	2.38	2.57	2.57	2.78	2.57

ASA
A.21.3–1952

American Standard

SPECIFICATIONS

for

CAST IRON PIT CAST PIPE FOR GAS

Users of this document should make reference to "American Recommended Practice Manual for the Computation of Strength and Thickness of Cast Iron Pipe" (ASA A21.1) for complete information concerning the conditions which various thicknesses of pipe are designed to meet. The foreword of the Manual also contains a statement regarding the history of the specifications and references to other related documents.

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AMERICAN STANDARD SPECIFICATIONS
for
CAST IRON PIT CAST PIPE FOR GAS

This specification covers cast iron pit cast pipe for gas. Pit cast pipe are pipe cast vertically with dry sand molds and cores.

Section 3-1. Description of Pipe. The pipe shall be made with bell and spigot ends, plain ends or such other type of ends as may be agreed upon at the time of purchase. Pipe with bell and spigot ends shall conform accuratcly to the dimensions given in Table 3.1. Pipe with other types of ends shall comply with the dimensions agreed upon but in all other respects shall fulfill the specifications hereinafter given. Pipe shall be straight and shall be true circles in section, with their inner and outer surfaces concentric. They shall be at least 12 ft. in nominal laying length, except as provided for cut pipe in Sect. 3-10.

Section 3-2. Casting of Pipe. The pipe shall be cast in dry sand molds in a vertical position. Pipe 16 inches or less in diameter shall be cast with the bell end up or down as specified in the proposals. Pipe 20 inches or more in diameter shall be cast with the bell end down. The pipe shall not be stripped or taken from the pit while showing color of heat, but shall be left in the flasks for a sufficient length of time to prevent unequal contraction by subsequent exposure.

Section 3-3. Quality of Iron.

(3-3.1) All pipes shall be made of cast iron of good quality, and of such character and so adapted in chemical composition to the thickness of the pipe to be cast, that the iron in the pipe shall be strong, tough, resilient, of even grain and soft enough for satisfactory drilling and cutting and it shall comply with the physical specifications given in Sect. 3-16, 3-17, and 3-18. The metal shall be remelted in a cupola or other suitable furnace.

(3-3.2) The iron in the pipe shall not contain more than 0.90 per cent of phosphorus nor more than 0.12 per cent of sulphur. Samples for chemical analysis shall be taken by drilling completely through from skin to skin each of the acceptance test specimens; but not to exceed three specimens per heat.

Section 3-4. Quality of Castings. The pipe shall be smooth, free from scales, lumps, blisters, sand holes and defects of every nature which unfit them for the use for which they are intended. No plugging, filling, burning-in or welding will be allowed except as permitted by the purchaser.

Section 3-5. Foundry Records.

(3-5.1) *Casting*—A record of the melting and pouring temperatures of the iron shall be furnished the purchaser if requested.

(3-5.2) *Chemical Analyses*—Chemical analyses shall be made by the manufacturer from each heat to determine total carbon, manganese, phosphorus, sulphur and silicon; duplicate copies of test reports shall be furnished the purchaser on request.

Section 3-6. Marking Pipe. Every pipe shall have distinctly cast upon it the initials of the maker's name. When cast especially to order, each pipe larger than 4-inch may also have cast upon it figures showing the year in which it was cast and a number signifying the order in point of time in which it was cast, the figures denoting the year being above and the number below, thus:

1950	1950	1950
1	2	3

etc., also any initials, not exceeding four, which may be required by the purchaser. The letters and figures shall be cast on the outside and shall have dimensions as indicated below.

Diameters of Pipe, Inches, Inclusive	Height of Letter, Inches	Relief, Inch
4 to 10	¾	$\frac{3}{32}$
12 to 20	1¼	$\frac{3}{32}$
24 & larger	1¾	⅛

The weight and the class shall be conspicuously painted in white in the inside or outside of each pipe after the coating (if used) has become hard.

Section 3-7 Inspection by Purchaser.

(3-7.1) *Definition of Word "Purchaser."* Wherever the word "Purchaser" is used herein it shall be understood to mean the actual purchaser of the pipe or his authorized agents acting within the scope of the duties entrusted to them.

(3-7.2) *Power of Purchaser to Inspect.* The purchaser shall have free access at all times to all parts of any manufacturing plant which concern the manufacture of articles to be made for him. He may inspect the material, the pattern work, molding, and casting of the pipe, and the coating (if used). The forms, sizes, uniformity and conditions of all pipe herein referred to shall be subject to his inspection and approval, and he may reject, without subjection to hydrostatic test, any pipe which is not in conformity with the specifications or drawings. Any pipe rejected shall be marked "rejected" and any marks pertaining to the purchaser shall be chipped or erased from such pipe.

(3-7.3) *Manufacturer to Furnish Men and Material.* The manufacturer shall provide all tools, testing equipment, materials, labor and facilities necessary for the required testing, inspection and weighing of the pipe at the foundry.

(3-7.4) *Report of Purchaser's Inspection.* The purchaser shall make written report daily at the foundry office of all pipe rejected, noting causes for rejection.

Section 3-8. Inspection and Certification by Manufacturer. Should the purchaser have no inspector at the works, the manufacturer shall, if required by the purchaser, furnish a sworn statement that the inspection and all of the tests have been made as specified, this statement to contain the results of all specified tests.

Section 3-9. Pipe to be Delivered Sound. All the pipe must be delivered in all respects sound and comformable to these specifications. The inspection shall not relieve the manufacturer of any of his obligations in this respect, and any defective pipe which may have passed the purchaser at the works or elsewhere shall be at all times liable to rejection when discovered, until the final completion and adjustment of the contract; provided, however, that the manufacturer shall not be held liable for pipe found to be cracked after they have been accepted at the agreed point of delivery, unless there shall be unmistakable evidence that the casting was originally defective or damaged before acceptance. Care shall be taken in handling the pipe not to injure the coating (if used) and no pipe or other material of any kind shall be placed in the pipe during transportation.

Section 3-10. Cut Pipe. Defective spigot ends on pipe may be cut off in a manner which will produce a square end. Cut pipe shall be shipped with plain ends or shall have an iron or steel band shrunk into a groove or welded securely on the pipe, as may be agreed upon at time of purchase. Not more than 8 per cent of the total number of pipe of each size shall be cut, and no cut pipe shall be furnished which is less than 11 ft. 0 in. in laying length, unless it has been used by purchaser's order for strip and ring tests in which case a length of not less than 10 ft. 0 in. shall be accepted.

Section 3-11. Tolerances or Maximum Permitted Variations from Standard.

(3-11.1) *Tolerances in Diameter of Pipe and Sockets.* Outside diameters of pipe barrels and spigot beads and diameters of sockets shall be kept as nearly as practicable to the specified dimensions. They shall be tested with circular gauges. Tolerances or maximum permitted variations from standard dimensions are listed below.

Nominal Diameter in Inches	Tolerance, Plus or Minus in Inches
4 to 16	.06
20 & 24	.08
30, 36 & 42	.10
48	.12
54	.15
60	.15

(3-11.2) *Tolerances in Thickness.* The tolerances, or maximum permitted variations from standard in thickness of pipe and in dimensions of bells are listed below:

Nominal Diameter in Inches, inclusive	Tolerance, Plus or Minus, in Inches
4 to 8	.07
10 to 24	.08
30 to 60	.10

NOTE: In pipe barrel thickness, tolerances .02 inch greater than those listed above shall be permissible over areas not exceeding 8 inches in length in any direction.

(3-11.3) *Allowable Percentage of Variation in Weight.* The weight of no single pipe shall be less than the nominal tabulated weight by more than 5% for pipe 16 inches or less in diameter, and 4% for pipe more than 16 inches in diameter. The total excess weight to be paid for on orders of 25 tons or more shall not exceed 2% of the nominal weight, and on orders less than 25 tons shall not exceed 5% of the nominal weight. An order is hereby defined as including all the pipe ordered under the terms of a specific contract or purchase order or a single order placed under the terms of a standing contract.

Section 3-12. Cleaning and Inspecting. All pipe shall have gates, fins and other roughnesses chipped or ground off and shall be thoroughly cleaned, checked as to dimensions and also subjected to a careful surface inspection, a hammer test, and a rolling test, before the coating (if used) is applied.

Section 3-13. Hydrostatic Test. Each pipe shall be subjected to a hydrostatic proof test.

The pipe shall be under the test pressure for at least one-half minute, and while under pressure shall be subjected to a hammer or shock test. Any pipe showing defects by leaking, sweating, or otherwise, shall be rejected. The test pressures shall be in accordance with the table on the following page.

Section 3-14. Weighing. Each length of pipe shall be weighed and the weight and class plainly marked on the outside or inside of the bell or spigot end. Unless otherwise stated in the contract, a ton shall be 2,000 lb. avoirdupois.

Section 3-15. Exterior Coatings. Coating (if used) which is to be applied to the pipe, shall be specified in the agreement made at time of purchase.

Section 3-16. Tests of Material. The acceptability of iron used in cast iron pipe as regards physical characteristics shall be determined by the testing of bars cast from the same iron as the pipe, or, if specified by the purchaser, by the testing of Talbot strips and/or rings cut from the pipe as described in Sect. 3-18. Such strip and/or ring tests shall be paid for by the purchaser at prices to be agreed upon. By special arrangement bursting tests of pipe may be made as provided in Sect. 3-19. In any case the test bars shall be made and tested and results given to the purchaser if requested. The smallest pipe on which ring tests may be required is the 6-inch. The observations and the computed results hereinafter required shall be recorded and if requested reported to the purchaser.

TABLE OF PRESSURES FOR HYDROSTATIC TESTS

Nominal Diameter of Pipe, Inches	Barrel Thickness, Inches From	To	Test Pressures, Lb. per sq.in.
4 to 12	All Thicknesses		400
16	.58	.75	300
16	.76	.95	350
20	.66	.85	250
20	.86	1.05	350
24	.74	.90	200
24	.91	1.00	300
24	1.01	1.17	400
30	.87	1.05	200
30	1.06	1.30	300
30	1.31	1.39	400
36	.97	1.15	200
36	1.16	1.45	300
36	1.46	1.54	350
42	1.07	1.35	200
42	1.36	1.60	300
42	1.61	1.71	350
48	1.18	1.50	200
48	1.51	1.90	300

Note: Unless otherwise arranged between the manufacturer and the purchaser, pipe thicker than those listed in the above table shall be tested at the highest pressures listed for the given diameter.

Section 3-17. Test Bars.

(3-17.1) *Dimensions.* Test bars shall be 2 inches wide, 1 inch thick, and not less than 26 inches long. Individual test bars may vary as much as 2 per cent from standard width, or standard thickness, or both, but the patterns and molding practice shall be such that the errors shall in general not exceed 1 per cent.

(3-17.2) *Methods of Casting.* The bars shall be cast vertically in well-faced, dry sand molds provided with suitable pouring basin and mounted on a suitable refractory foundation. Metal for the bars shall be obtained by using a small heated ladle taking its metal from the main ladle from which the pipe is to be poured and after all alloys and other additional metal, except cast iron pipe for cooling, have been added to the main ladle and become melted. The bars shall not be removed from the mold before they have cooled to 500° F.

(3-17.3) *When Cast and to What Pipe Applicable.* Except as hereinafter provided for special cases, one pair of test bars of the metal used shall be cast with iron from the first ladle, another pair with iron from the approximately middle ladle, and a third pair with iron from the last ladle of iron taken during a day's run or heat from the cupola in which the iron for the pipe is melted. If the heat lasts for more than 6 hours, then additional pairs of bars shall be cast at approximately uniform intervals so as to give an extra pair of bars for each 3 hours during which the heat lasts in excess of 6 hours. In case the charging of the cupola is to be changed one or more times during the day's run or heat in order to produce a different iron, the time of taking test bars shall be varied in such a way as to obtain representative tests of the iron at least at the beginning and end of each period during which the iron is intended to be constant in quality; and in case such period exceeds four hours additional pairs of bars shall be taken at such times as will provide a pair of bars for each two hours during which this special mixture is used. At least one bar from each pair shall be broken, but the manufacturer shall have the right to break both bars in which case the better bar shall be taken as representative. Bars showing flaws in fracture may be disregarded.

(3-17.4) *Test Bar Requirements to Indicate Acceptable Iron; Retests may be made at Contractor's Option using Talbot Strips and/or Rings.* In order that the iron shall be acceptable the average results from the single bars representing the respective pair of bars cast during the heat or period shall comply with the requirements hereinafter specified and, in addition, no representative bar shall be more than 5 percent below the minimum requirements in either corrected breaking load or corrected deflection. In case the test bars do not measure up to these requirements the manufacturer may make one or more Talbot strip tests and/or ring tests of specimens cut from such of the pipe as may be agreed upon as best representing the iron at the time when the deficient test bars were cast. In the absence of the purchaser the manufacturer may select the pipe from which rings and/or strips shall be cut. The results from these rings and/or strips shall be kept as a foundry record available to any purchaser who requires a report of tests on the 2-inch by 1-inch bars. Any Talbot strip tests or ring tests made under this provision shall be at the expense of the manufacturer. If these supplementary Talbot strip tests and/or ring tests do not meet the requirements, the pipe cast in that heat or period, or such a part thereof as may be agreed to by the purchaser, shall be rejected.

(3-17.5) *Method of Testing.* The bars shall be broken as beams by placing them flatwise on supports 24 inches apart and applying the load at the center of the span. The breaking load and the corresponding deflection shall be observed and recorded.

(3-17.6) *Correcting Observed Breaking Loads and Deflections.* The bars shall be measured at the point of application of the load and the results corrected to standard 2 inch by 1 inch cross section by the conventional beam formula as follows:

Corrected breaking load = observed breaking load multiplied by $\frac{2}{bd^2}$

Corrected deflection at breaking = observed deflection at breaking multiplied by d

where b = measured width and
d = measured depth
of the bar at point of application of load

In the formula above the deflection and all dimensions are in inches.

(3-17.7) *Requirements as to Strength and Deflection of 2 inch by 1 inch Bars.* In order to indicate acceptable metal, the corrected breaking loads and deflections of the representative 2 inch by 1 inch test bars for a given heat or period interpreted as provided in paragraph 3-17.4 above, shall comply with such of the following tabulated requirements as pertain to the thickness range within which fall the particular pipes which are under consideration.

TABLE OF MINIMUM CORRECTED BREAKING LOADS & DEFLECTIONS

Metal Thickness of Pipe, Inches	Minimum Center Breaking Load, Pounds	Minimum Center Deflection at Breaking, Inch
Below .61	1900	.30 + .0001 (Breaking Load — 1900)
.61 to .90	2000	.30 + .0001 (Breaking Load — 2000)
.91 to 1.60	2200	.30 + .0001 (Breaking Load — 2200)
1.61 to 2.50	2300	.30 + .0001 (Breaking Load — 2300)

Note: For thicknesses exceeding 2.50 inches the form of test specimen and the test requirements shall be as agreed upon in the purchase contract.

Section 3-18. Talbot Strip Tests and Ring Tests.

(3-18.1) *Dimensions.* Rings shall have a length equal to half the nominal diameter of the pipe unless the diameter exceeds 24 inches, in which case the length of ring shall be 12 inches. Strips shall be not less than 11 inches long and for 24-inch and larger pipe may be cut from the least stressed portions of rings (see Sect. 3-18.4) after the rings have been broken. The end 2 inches of the pipe shall not be included in ring or strip.

> Note: To make both ring and strip tests on a pipe will therefore require at the least (on 6 inch pipe) 16 inches of pipe, at the most (on 20 inch pipe) 23 inches of pipe, and on pipe larger than 20 inches, 14 inches of pipe.

(3-18.2) *Method of Sampling.* The purchaser who has expressly specified Talbot strip tests and/or ring tests as acceptance tests of the pipe may select at random from each run, or heat, one or more pipe from which test specimens are to be cut. In the absence of the purchaser or his representative, the pipe from which test specimens are to be taken may be selected by the manufacturer. If the purchaser should wish to test the uniformity of a run or heat, he may divide it into two or more periods and have a separate set of acceptance tests for pipe in each period.

(3-18.3) *Defective Specimens; Retests.* If any test specimen shows defective machining or obvious lack of continuity of metal, it shall be discarded and replaced by another specimen selected by the purchaser. If the test specimens first selected fail to meet the requirements specified hereinafter and the purchaser permits a retest, at least twice the number of specimens that failed shall be selected by the purchaser for retest from a pipe cast in the same run or period. In case a ring from a pipe 24 inches in diameter or larger fails to meet specifications, the purchaser may accept strip tests, two specimens to be cut from the failed ring at points of low stress as described in Sect. 3-18.4. In any case of retest the pipe cast during the run or period shall be acceptable only when all retest specimens meet the requirements. All retests shall be made at the expense of the manufacturer.

(3-18.4) *Talbot Strip Tests.* Two Talbot strips shall be machined longitudinally from each pipe selected by the purchaser for testing by this method. If ring tests are also made and the pipe are 24 inches or larger these Talbot strips may be cut from a part of the ring little stressed in the ring test, i.e., near one of the elements marked (a) in

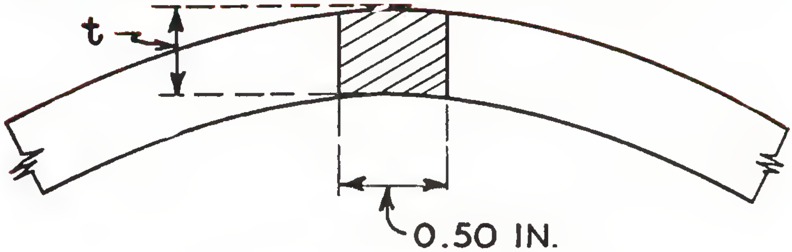


FIG. 3.1. Position from which Talbot Strip Is Cut

Fig. 3.2. (See Sect. 3-18.5.) The strips in any case will be in cross section as indicated in Fig. 3.1, i.e., will have for their width the thickness of the pipe and for their thickness 0.50 inch. Their length will be the length of the ring, 12 inches; or, if not cut from a ring, at least 11 inches. These strips shall be tested as a beam on supports 10 inches apart with loads applied perpendicularly to the machined faces at two points 3⅓ inches from the supports. The breaking load and the corresponding deflection shall be observed and recorded.

The strip shall be accurately calipered at point of rupture and the modulus of rupture, R, shall be calculated by the usual beam formula which for this case reduces to the expression:

$$R = \frac{10W}{td^2}$$

The secant modulus of elasticity, E_s, in lb. per sq.in. shall be computed by the formula:

$$E_s = \frac{213W}{td^3y} = \frac{21.3R}{dy}$$

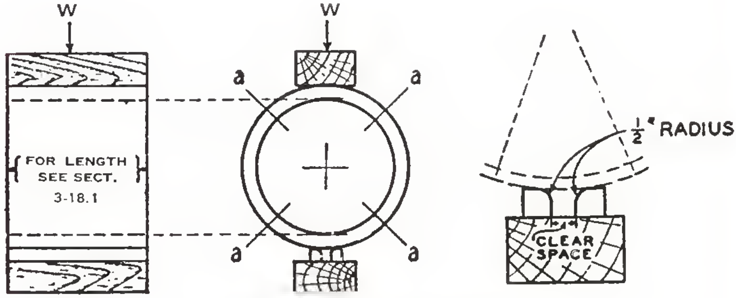


FIG. 3.2. Assembly for Ring Test

where R = modulus of rupture, lb. per sq.in.
E_s = secant modulus of elasticity, lb. per sq.in.
W = breaking load, lb.
d = depth of strip in inches (intended to be 0.50 in.)
t = width of strip, inches (pipe thickness)
y = deflection of strip at center at breaking load, inches.

To be acceptable a Talbot strip shall have the modulus of rupture, R, not less than 30,000 lb. per sq.in. and the secant modulus of elasticity, E_s, not more than 10,000,000 lb. per sq.in. If the results from either strip are up to the specifications the test shall be regarded as satisfactory.

(3-18.5) *Ring Tests.* Each ring shall be tested by the three-edge-bearing method as indicated in Fig. 3.2. The lower bearing for the ring shall consist of two strips with vertical sides having their interior top corners rounded to a radius of approximately ½ inch. The strips shall be of hard wood or of metal. If of metal a piece of leather belting about 3/16 inch thick shall be laid over them. They shall be straight and shall be securely fastened to a rigid block with their interior vertical faces spaced at a distance apart as given in the following table:

Diam. of Pipe	Clear Space
12-inch and smaller	½ inch
16-inch to 24-inch inclusive	1 inch
30-inch and larger	2 inch

The upper bearing shall be a rigid wooden block, straight and true from end to end. The upper and lower bearings shall extend the full length of the outside of the ring. The ring shall be placed symmetrically between the two bearings, and the center of application of the load shall be so placed that the vertical deformations at the two ends of the ring shall be equal. If the ring is not uniform in thickness, it shall be so placed that the thick and thin portions are near the ends of the horizontal diameter. A record of the breaking load and the corresponding vertical deformation of each ring tested shall be made. In order to be acceptable the modulus of rupture computed from the formula

$$R = 0.954 \frac{W(d + t)}{bt^2}$$

shall be not less than 31,000 lb. per sq. in., and the secant modulus of elasticity computed from the formula which follows on page 116.

$$E_s = \frac{0.225\, W(d+t)^3}{bt^3y} = \frac{0.236\, R(d+t)^2}{ty}$$

shall not exceed 15,000,000 lb. per sq.in.

b = length of ring, inches
d = average inside diameter of ring, inches
t = average thickness of metal along line of fracture, inches
y = maximum vertical deflection of ring, inches
W = breaking load, in lb.
R = modulus of rupture, lb. per sq.in.
E_s = secant modulus of elasticity, lb. per sq.in.

The modulus of elasticity shall not be determined in rings from pipe less than 12 inches in diameter.

Section 3-19. Full-Length Bursting Tests.

By special arrangement between purchaser and manufacturer, the bursting tensile strength shall be determined by testing full length pipe (less amount cut off for ring and strip test specimens, see Section 3-18.1 and 3-18.2) to destruction by hydraulic pressure. Bells may be removed to facilitate testing. A suitable means for holding the end thrust shall be used which will not subject the pipe to endwise tension or compression, or other parasitic stresses. A calibrated pressure gauge shall be used for determining the bursting pressure. This gauge shall be connected to the interior of the test pipe by a separate connection from that which supplies water for the test. Unit tensile strength in bursting shall be obtained by the use of the formula:

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

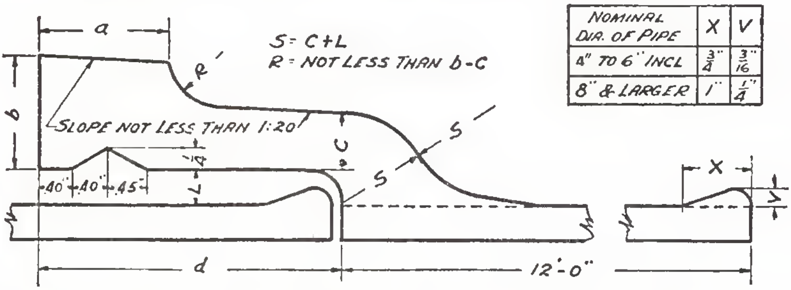
Where: S = bursting tensile strength of the iron, lbs. per sq.in.
P = internal pressure at bursting, lbs. per sq.in.
d = average inside diameter of pipe, inches
t = minimum average thickness of the pipe along the principal line of break, inches

Measurements of thickness shall be taken along the principal line of break at one foot intervals.

The minimum average thickness along the principal line of break shall be obtained by averaging the measurements at the thinnest section at a weight of two and at the adjacent sections on each side at a weight of one each or if the thinnest section is at the end of the break, by averaging this thinnest section measurement at a weight of two and the measurements of the adjacent section and the next section at a weight of one each.

Table No. 3.1

STANDARD DIMENSIONS OF BELLS, SOCKETS, SPIGOT BEADS and OUTSIDE DIAMETERS of PIT CAST PIPE FOR GAS also WEIGHTS OF BELLS AND OF SPIGOT BEADS



Nominal Diam.	Thickness of Pipe From	Thickness of Pipe To	Outside Diam. of Pipe	DIMENSIONS OF BELLS: Diam. of Socket	Thickness of Joint L	Depth of Socket d	a	b	c	Wt. of Bell	Wt. of Spigot Bead
4	.40	.50	4.80	5.80	0.50	3.50	1.50	1.30	.65	25.0	0.3
6	.43	.58	6.90	7.90	0.50	3.50	1.50	1.40	.70	35.0	0.5
8	.46	.63	9.05	10.05	0.50	4.00	1.50	1.53	.78	52.0	1.1
10	.50	.60	11.10	12.10	0.50	4.00	1.50	1.50	.69	58.0	1.4
	.61	.68	11.10	12.10	0.50	4.00	1.50	1.65	.85	69.0	1.4
12	.54	.65	13.20	14.20	0.50	4.00	1.50	1.50	.70	66.0	1.6
	.66	.79	13.20	14.20	0.50	4.00	1.50	1.75	.90	84.0	1.6
16	.58	.67	17.40	18.66	0.63	4.00	1.75	1.67	.77	106.0	2.1
	.68	.85	17.40	18.66	0.63	4.00	1.75	1.90	1.00	128.0	2.1
20	.66	.82	21.60	22.86	0.63	4.00	1.75	1.87	0.87	146.0	2.6
	.83	.97	21.60	22.86	0.63	4.00	1.75	2.30	1.15	196.0	2.6
24	.74	.85	25.80	27.06	0.63	4.00	2.00	1.97	0.92	188.0	3.2
	.86	1.00	25.80	27.06	0.63	4.00	2.00	2.50	1.25	265.0	3.2
30	.87	1.01	31.74	33.00	0.63	4.50	2.00	2.30	1.15	309.0	3.9
	1.02	1.19	31.74	33.00	0.63	4.50	2.00	2.60	1.32	376.0	3.9
36	.97	1.12	37.96	39.22	0.63	4.50	2.00	2.50	1.25	419.0	4.6
	1.13	1.32	37.96	39.22	0.63	4.50	2.00	2.80	1.44	459.0	4.6
42	1.07	1.30	44.20	45.46	0.63	5.00	2.00	2.80	1.40	538.0	5.4
	1.31	1.46	44.20	45.46	0.63	5.00	2.00	3.02	1.52	609.0	5.4
48	1.18	1.30	50.50	51.76	0.63	5.00	2.00	3.00	1.50	657.0	6.1
	1.31	1.50	50.50	51.76	0.63	5.00	2.00	3.32	1.67	774.0	6.1
	1.51	1.60	50.50	51.76	0.63	5.00	2.00	3.80	1.95	890.0	6.1

All dimensions given in inches. All weights given in pounds.

Table No. 3.2

STANDARD THICKNESSES, DIAMETERS AND WEIGHTS OF PIT CAST PIPE FOR GAS

Dimensions in Inches — Weights in Pounds

Nominal Diam.	Thickness Class	Thickness	Outside Diam.	Inside Diam.	Wt. of Barrel Per Ft.	Wt. of Bead	Wt. of Bell	Wt. Based on 12 Ft. Length* Per Length	Wt. Based on 12 Ft. Length* Avg. Per Ft.
1	2	3	4	5	6	7	8	9	10
4	1	.40	4.80	4.00	17.3	0.3	25.0	235	19.6
	2	.43	4.80	3.94	18.4	0.3	25.0	245	20.4
	3	.46	4.80	3.88	19.6	0.3	25.0	260	21.7
	4	.50	4.80	3.80	21.1	0.3	25.0	280	23.3
6	1	.43	6.90	6.04	27.3	0.5	35.0	365	30.4
	2	.46	6.90	5.98	29.0	0.5	35.0	385	32.1
	3	.50	6.90	5.90	31.4	0.5	35.0	410	34.2
	4	.54	6.90	5.82	33.7	0.5	35.0	440	36.7
	5	.58	6.90	5.74	35.9	0.5	35.0	465	38.8
8	1	.46	9.05	8.13	38.7	1.1	52.0	520	43.3
	2	.50	9.05	8.05	41.9	1.1	52.0	555	46.2
	3	.54	9.05	7.97	45.0	1.1	52.0	595	49.6
	4	.58	9.05	7.89	48.2	1.1	52.0	630	52.5
	5	.63	9.05	7.79	52.0	1.1	52.0	675	56.2
10	1	.50	11.10	10.10	52.0	1.4	58.0	685	57.1
	2	.54	11.10	10.02	55.9	1.4	58.0	730	60.8
	3	.58	11.10	9.94	59.8	1.4	58.0	775	64.6
	4	.63	11.10	9.84	64.7	1.4	69.0	845	70.4
	5	.68	11.10	9.74	69.5	1.4	69.0	905	75.4
12	1	.54	13.20	12.12	67.0	1.6	66.0	870	72.5
	2	.58	13.20	12.04	71.8	1.6	66.0	930	77.5
	3	.63	13.20	11.94	77.6	1.6	66.0	1000	83.3
	4	.68	13.20	11.84	83.4	1.6	84.0	1085	90.4
	5	.73	13.20	11.74	89.2	1.6	84.0	1155	96.2
	6	.79	13.20	11.62	96.1	1.6	84.0	1240	103.3
16	1	.58	17.40	16.24	95.6	2.1	106.0	1255	104.6
	2	.63	17.40	16.14	103.6	2.1	106.0	1350	112.5
	3	.68	17.40	16.04	111.4	2.1	128.0	1465	122.1
	4	.73	17.40	15.94	119.3	2.1	128.0	1560	130.0
	5	.79	17.40	15.82	128.6	2.1	128.0	1675	139.6
	6	.85	17.40	15.70	137.9	2.1	128.0	1785	148.8
20	1	.66	21.60	20.28	135.5	2.6	146.0	1775	147.9
	2	.71	21.60	20.18	145.4	2.6	146.0	1895	157.9
	3	.77	21.60	20.06	157.2	2.6	146.0	2035	169.6
	4	.83	21.60	19.94	169.0	2.6	196.0	2225	185.4
	5	.90	21.60	19.80	182.6	2.6	196.0	2390	199.2
	6	.97	21.60	19.66	196.1	2.6	196.0	2550	212.5
24	1	.74	25.80	24.32	181.8	3.2	188.0	2375	197.9
	2	.80	25.80	24.20	196.0	3.2	188.0	2545	212.1
	3	.86	25.80	24.08	210.2	3.2	265.0	2790	232.5
	4	.93	25.80	23.94	226.7	3.2	265.0	2990	249.2
	5	1.00	25.80	23.80	243.1	3.2	265.0	3185	265.4
30	1	.87	31.74	30.00	263.3	3.9	309.0	3470	289.2
	2	.94	31.74	29.86	283.8	3.9	309.0	3720	310.0
	3	1.02	31.74	29.70	307.1	3.9	376.0	4065	338.8
	4	1.10	31.74	29.54	330.4	3.9	376.0	4345	362.1
	5	1.19	31.74	29.36	356.3	3.9	376.0	4655	387.9
36	1	.97	37.96	36.02	351.7	4.6	419.0	4645	387.1
	2	1.05	37.96	35.86	379.9	4.6	419.0	4980	415.0
	3	1.13	37.96	35.70	407.9	4.6	459.0	5360	446.7
	4	1.22	37.96	35.52	439.3	4.6	459.0	5735	477.9
	5	1.32	37.96	35.32	474.1	4.6	459.0	6155	512.9
42	1	1.07	44.20	42.06	452.3	5.4	538.0	5970	497.5
	2	1.16	44.20	41.88	489.4	5.4	538.0	6415	534.6
	3	1.25	44.20	41.70	526.2	5.4	538.0	6860	571.7
	4	1.35	44.20	41.50	567.0	5.4	609.0	7420	618.3
	5	1.46	44.20	41.28	611.6	5.4	609.0	7955	662.9
48	1	1.18	50.50	48.14	570.4	6.1	657.0	7510	625.8
	2	1.27	50.50	47.96	612.8	6.1	657.0	8015	667.9
	5	1.37	50.50	47.76	659.7	6.1	774.0	8695	724.6
	4	1.48	50.50	47.54	711.1	6.1	774.0	9215	776.2
	5	1.60	50.50	47.30	766.9	6.1	890.0	10100	841.7

*Includes Bell and Spigot Bead. Calculated weight of pipe rounded off to nearest 5 pounds.

Table No. 3.3

STANDARD THICKNESSES AND WEIGHTS OF CAST IRON PIT CAST PIPE FOR GAS

NOTE: These weights are for pipe laid without blocks, on flat bottom trench, with tamped backfill, under 5 feet of cover. For other conditions see Table 3.2 and 3.4 hereof and the Manual.

	CLASS 10			CLASS 50			CLASS 100			CLASS 150		
	10 Lb. Pressure			50 Lb. Pressure			100 Lb. Pressure			150 Lb. Pressure		
		Wt. Based on 12 Ft. Length*			Wt. Based on 12 Ft. Length*			Wt. Based on 12 Ft. Length*			Wt. Based on 12 Ft. Length*	
Size Inches	Thickness Inches	Avg. Per Foot	Per Length	Thickness Inches	Avg. Per Foot	Per Length	Thickness Inches	Avg. Per Foot	Per Length	Thickness Inches	Avg. Per Foot	Per Length
4	.40	19.6	235	.40	19.6	235	.40	19.6	235	.40	19.6	235
6	.43	30.4	365	.43	30.4	365	.43	30.4	365	.43	30.4	365
8	.46	43.3	520	.46	43.3	520	.46	43.3	520	.46	43.3	520
10	.50	57.1	685	.50	57.1	685	.50	57.1	685	.50	57.1	685
12	.54	72.5	870	.54	72.5	870	.54	72.5	870	.54	72.5	870
16	.58	104.6	1255	.58	104.6	1255	.58	104.6	1255			
20	.66	147.9	1775	.66	147.9	1775	.71	157.9	1895			
24	.74	197.9	2375	.74	197.9	2375	.80	212.1	2545			
30	.87	289.2	3470	.87	289.2	3470						
36	.97	387.1	4645	.97	387.1	4645						
42	1.07	497.5	5970	1.07	497.5	5970						
48	1.18	625.8	7510	1.18	625.8	7510						

*Including Bell and Spigot Bead. Calculated weight of Pipe rounded off to nearest 5 pounds.

Table No. 3.4

STANDARD THICKNESSES OF CAST IRON PIT CAST PIPE FOR GAS

Thickness in Inches. Working Pressure in Pounds per Square Inch. Thicknesses Include Allowances for Foundry Practice and Corrosion

Laying Condition A—Flat Bottom Trench, Without Blocks, Untamped Backfill
Laying Condition B—Flat Bottom Trench, Without Blocks, Tamped Backfill
Laying Condition C—Pipe Laid on Blocks, Untamped Backfill
Laying Condition D—Pipe Laid on Blocks, Tamped Backfill

Size Inches	Working Pressure	3½ FEET OF COVER Laying Condition A	B	C	D	5 FEET OF COVER Laying Condition A	B	C	D	8 FEET OF COVER Laying Condition A	B	C	D
4	10	.40	.40	.40	.40	.40	.40	.40	.40	.40	.40	.46	.40
	50	.40	.40	.40	.40	.40	.40	.40	.40	.40	.40	.50	.40
	100	.40	.40	.40	.40	.40	.40	.43	.40	.40	.40	.50	.40
	150	.40	.40	.40	.40	.40	.40	.43	.40	.40	.40	.50	.40
6	10	.43	.43	.46	.43	.43	.43	.50	.43	.43	.43	.54	.43
	50	.43	.43	.46	.43	.43	.43	.50	.43	.43	.43	.54	.43
	100	.43	.43	.46	.43	.43	.43	.50	.43	.43	.43	.58	.43
	150	.43	.43	.50	.43	.43	.43	.50	.43	.43	.43	.58	.43
8	10	.46	.46	.50	.46	.46	.46	.54	.46	.46	.46	.58	.46
	50	.46	.46	.54	.46	.46	.46	.54	.46	.46	.46	.63	.46
	100	.46	.46	.54	.46	.46	.46	.58	.46	.46	.46	.63	.46
	150	.46	.46	.54	.46	.46	.46	.58	.46	.46	.46	.63	.46
10	10	.50	.50	.54	.50	.50	.50	.58	.50	.50	.50	.68	.50
	50	.50	.50	.58	.50	.50	.50	.58	.50	.50	.50	.68	.54
	100	.50	.50	.58	.50	.50	.50	.63	.50	.54	.50	.68	.54
	150	.50	.50	.58	.50	.50	.50	.63	.50	.54	.50	.68	.58
12	10	.54	.54	.58	.54	.54	.54	.63	.54	.54	.54	.68	.58
	50	.54	.54	.58	.54	.54	.54	.63	.54	.58	.54	.73	.58
	100	.54	.54	.63	.54	.54	.54	.63	.54	.58	.58	.73	.58
	150	.54	.54	.63	.58	.58	.54	.68	.58	.63	.58	.79	.63
16	10	.58	.58	.68	.58	.58	.58	.68	.63	.68	.63	.79	.68
	50	.58	.58	.68	.63	.63	.58	.73	.63	.68	.63	.79	.73
	100	.63	.58	.73	.63	.63	.58	.73	.68	.73	.68	.85	.73
20	10	.66	.66	.77	.71	.71	.66	.83	.71	.77	.71	.90	.83
	50	.71	.66	.77	.71	.71	.66	.83	.77	.77	.71	.90	.83
	100	.71	.66	.83	.77	.77	.71	.83	.77	.83	.77	.97	.83
24	10	.74	.74	.80	.74	.80	.74	.86	.80	.86	.80	.93	.86
	50	.80	.74	.86	.80	.80	.74	.93	.86	.86	.80	1.00	.93
	100	.80	.74	.93	.86	.86	.80	.93	.86	.93	.86	1.00	.93
30	10	.87	.87	.94	.87	.94	.87	1.02	.94	1.02	.87	1.10	1.02
	50	.94	.87	1.02	.94	.94	.87	1.10	1.02	1.10	.94	1.19	1.10
36	10	1.05	.97	1.05	.97	1.05	.97	1.13	1.05	1.13	.97	1.22	1.13
	50	1.05	.97	1.13	1.05	1.13	.97	1.22	1.13	1.22	1.05	1.32	1.22
42	10	1.16	1.07	1.16	1.07	1.16	1.07	1.25	1.16	1.35	1.07	1.35	1.25
	50	1.16	1.07	1.25	1.16	1.25	1.07	1.35	1.25	1.35	1.16	1.46	1.35
48	10	1.27	1.18	1.37	1.18	1.37	1.18	1.37	1.27	1.48	1.18	1.60	1.37
	50	1.27	1.18	1.37	1.27	1.37	1.18	1.48	1.37	1.48	1.27	1.60	1.48

ASA
A21.4–1952

AMERICAN STANDARD SPECIFICATIONS

for

CEMENT MORTAR LINING FOR CAST IRON PIPE AND FITTINGS

(A revision of ASA—A21.4 - 1939)

SPONSORS

American Gas Association
American Society for Testing Materials
American Water Works Association
New England Water Works Association

ASA
A21.4–1952

AMERICAN STANDARD SPECIFICATIONS
for
CEMENT MORTAR LINING
FOR CAST IRON PIPE AND FITTINGS

Sect. 4–1—Portland Cement

Portland cement shall meet all the requirements of Standard Specifications for Type-2 Portland Cement of the American Society for Testing Materials, A.S.T.M. Designation: C 150, of latest revision.

Sect. 4–2—Sand

Sand shall consist of hard, strong, durable, uncoated, silicious particles. Under the colorimetric test for organic impurities it shall not produce a color darker than the standard, unless it is shown by adequate tests that the impurities causing the color are not harmful to the strength or other specified properties of the finished lining. It shall lose not more than 3 per cent in the decantation test, and not more than 4 per cent in boiling hydrochloric acid. The sand shall be well graded from fine to coarse so as to produce a lining as nearly as practicable of maximum density and minimum water absorption consistent with the proportion of cement and the lining methods used, with workability of the mortar and with the other specified properties of the lining; provided that, when tested with standard sieves, it shall meet the following requirements:

	Per Cent
Total passing sieve having a clear opening of the size nearest to one-half the specified minimum thickness of lining	100
Passing No. 50 sieve, not more than	50
Passing No. 100 sieve, not more than	5

Sect. 4–3—Accepted Specifications

The specified tests of sand shall be made in accordance with the Standard Methods of the American Society for Testing Materials, of latest revision, as follows:

Colorimetric Test: Standard Method of Test for Organic Impurities in Sands for Concrete. A.S.T.M. Designation: C 40.

Decantation Test: Standard Method of Test for Amount of Material Finer than No. 200 Sieve in Aggregates, A.S.T.M. Designation: C 117.

Solubility in hydrochloric acid: Standard Method of Testing Bituminous Mastics, Grouts, and like Mixtures, A.S.T.M. Designation: D 147.

Sampling: Methods of Sampling Stone, Slag, Gravel, Sand and Stone Block for use as Highway Materials, A.S.T.M. Designation: D 75, Sections 14 and 15.

Sect. 4–4—Water

Water for tempering the mortar and for curing the lining shall be potable water, as defined in U. S. Treasury "Drinking Water Standards" of latest revision.

Sect. 4–5—Mortar

The mortar shall be an intimate and thorough mixture of portland cement, sand and water of the qualities specified, and shall contain no other ingredient; except that, subject to the approval of the purchaser, other hydraulic cements producing linings having lower water-solubility, less shrinkage or other advantages may be substituted for portland cement in whole or in part, or other ingredients may be incorporated in the mortar. Portland cement mortar for linings not exceeding one-quarter inch in minimum thickness shall contain not less than one part of cement to two parts of dry sand by volume. (1)*

Sect. 4–6—Preparation of Pipe and Fittings for Lining

All pipe and fittings shall be thoroughly cleaned and surfaces to be lined shall be free from harmful amounts of blacking, grease, dirt, loose sand, rust, slag, soda or other flux, and from tar or other coating, and shall be entirely free from sharp projections of iron which might reduce the thickness of the lining. Required hydrostatic tests shall be made before lining.

Sect. 4–7—Method of Applying Cement Mortar Linings

The waterway surfaces of pipe and fittings shall be completely covered with as nearly as practicable a uniform thickness of the specified mortar entirely free from holidays or visible bubbles of air and thoroughly compacted throughout. Straight pipe shall be lined by the centrifugal process, combining high speed spinning and vibration, or by some other process producing linings which are equal to such centrifugal linings in accuracy of surface contour, smoothness of surface texture, density, low water absorption, and freedom from shrinkage cracks and loose spots. The consistency of the mortar and the time and speed of spinning shall be so adjusted as to minimize the segregation of the sand from the cement, and to deliver the finished lining free from

* Numbers in parenthesis such as that above refer to notes following this standard.

laitance. Fittings shall be lined by such process as will produce linings equal, as nearly as practicable, in the above enumerated respects to the linings of straight pipe. Defective linings which have set shall not be patched but the linings on small areas damaged in handling may be completely cut out to the metal, with square edges, the adjoining lining thoroughly wet, and the bare spot recoated by hand troweling or equivalent means and the patch cured as specified in Section 4–12.

Sect. 4–8—Bell to be Cleaned

All mortar shall be removed from the joint surface of the bell.

Sect. 4–9—Work to be Protected

The work of lining the pipe and fittings shall be done in a building where the products shall be protected from the direct rays of the sun, and from extreme weather conditions, such as frost, rain, etc. The product shall not be put on the yard until the cement has set sufficiently to avoid injury or damage thereto.

Sect. 4–10—Thickness of Lining

The thickness of linings for pipe and fittings shall be nowhere less than the following for the respective diameters: 3 to 12 inches, 1/8 inch; 14 to 24 inches, 3/16 inch; 30 to 48 inches, 1/4 inch. Linings may taper at the ends. The length of taper shall be as short as practicable and shall not exceed two inches. A plus tolerance of 1/8-inch, but no more, shall be permitted on all sizes of pipe and 1/4-inch, but no more, on all sizes and patterns of fittings. Linings of greater thickness will be furnished when specified.

Sect. 4–11—Determination of Thickness

The thickness of lining may be determined by means of spear measurement, using a hardened steel point not larger than 1/16 inch in diameter or by other approved gage. If tested by spear measurement the inspector shall pierce the lining immediately after it is placed in the pipe, and before the mortar has set, at four diametrically opposite points of the pipe at bell and spigot ends, making two sets of measurements at each end. The first set shall not be more than 4 inches from the respective ends of the pipe and the second set shall be made as far into the interior of the pipe as can readily be reached without injuring the lining.

Sect. 4–12—Curing

Unless otherwise specified curing shall be effected by the application of a bituminous seal coating which shall cover and seal the cement mortar. This shall be applied while the lining is still moist. If the lining is not to be seal coated it shall be kept constantly damp for at least 24 hours after the lining is placed and as much longer as may be necessary to control separation and cracking. (2) No pipe or fittings shall be shipped until the lining is thoroughly set and hard.

Sect. 4–13—The Finished Lining

The linings of both pipe and fittings, after curing and drying shall meet the following requirements:

(a) *Surface and contour.* The lining shall have a hard, smooth surface and shall be free from noticeable ridges, corrugations, elevations and depressions. The linings of pipe shall be cylindrical; the linings of fittings shall be as nearly as practicable of uniform thickness throughout and shall afford smooth waterways.

(b) *Water absorption.* When tested for water absorption in accordance with Standard Specifications for Cement Concrete Sewer Pipe, A.S.T.M. Designation: C 14, of latest revision, the lining shall show an absorption not exceeding 12 per cent of its dry weight. Samples for this test may be from linings placed for this purpose in the bell, provided that such linings are of the same thickness and mix, placed and compacted at the same time and by the same methods, and subjected to the same curing as the linings of the waterways. Samples at time of tests shall not be more than 30 days older than the most recently placed of the linings in the shipment or order which they represent. (3)

(c) *Cracks and loose spots.* Pipe showing any loose spot measuring 12 inches or more in greatest dimension, or any crack over 9 inches in length, or any crack of any length standing open perceptibly, shall be rejected. Surface crazing shall not be cause for rejection. (4)

Sect. 4–14—Outside Coating

Any coating which is to be applied to the outside of cement-mortar-lined pipe or fittings shall be specified in the agreement made at the time of purchase.

No pipe or fittings for water works service shall be furnished without protective coating unless specifically ordered by the purchaser.

Sect. 4–15—Bituminous Seal Coat

(a) *The Bituminous Seal Coat,* after drying for 48 hours, shall have no deleterious effect upon the quality, color, taste or odor of potable water which has been standing for 48 hours in the pipe. (5) The seal coat shall adhere tenaciously to the mortar lining at all points. The seal coated pipe, when tested in accordance with Section 4–15(b) shall not impart to the water more than 25 parts per million of hardness, nor more than 25 parts per million of total alkalinity, nor any caustic alkalinity.

(b) *Method of Testing.* Except as another form of specimen and test is agreed upon by the purchaser and manufacturer, the sample shall be a 6-inch length of 6- or 8-inch pipe, lathe-cut at both ends. The specimen shall be cut from a pipe whose lining is of the same age and which has been lined, cured and seal-coated in all respects like the product which it represents, the seal-coat being applied 48 hours prior to the test. With this form of specimen the test shall be made by bedding the specimen on end in a shallow pan of melted paraffin, allowing the paraffin to cool, filling the pipe nearly to the top with distilled or demineralized water at laboratory temperature, and covering with a glass plate on a seal of vaseline. The water shall have an electrical resistivity (or resistance) exceeding 50,000 ohm-centimeters, or it shall contain not more than 10 parts per million of the bicarbonates, chlorides and sulfates of potassium, sodium, calcium and magnesium, and it shall contain not more than 3.0 parts per million of free carbon dioxide at the time of filling the test specimen. The water shall be changed and tested after 24 hours contact on each of three successive days, and on each test shall be free from objectionable color, taste and odor, and from hardness and alkalinity in excess of the limits specified in Sect. 4–15(a). Determination of hardness and alkalinity shall be made by methods prescribed in Standard Methods of Water Analysis of the American Public Health Association and the American Water Works Association, most recent edition. The purchaser shall indicate in his request for bids the number of tests and test specimens required. At the purchaser's option, this test may be made by him with the water with which the pipe is to be used.

Sect. 4–16—Frequency of Tests

A record of all specified tests shall be made and retained for at least one year. This record will be available to the purchaser at the foundry. If written transcripts of the test results or any additional tests are desired, this fact shall be noted on the order.

The several tests shall be made with at least the following frequencies:

Cement. (See Sect. 4–1) The manufacturer's analyses and physical tests of the cement of each shipment.

Sand. (See Sect. 4–2) One sieve analysis on each carload or, for sand otherwise delivered, one sieve analysis for each 50 tons.

The colorimetric, decantation and hydrochloric acid tests of sand from an established source of supply, once each 6 months; for sand from a new source not less often than once a month for period of 6 months.

Determination of Thickness. (See Sect. 4–11) One test for each 100 pipe, well distributed among the different sizes produced.

Water Absorption. (See Sect. 4–13(b)) One test a month, well distributed among the different thicknesses of lining produced.

Bituminous Seal Coat. (See Sect. 4–15) Leaching Test once a month on pipe selected at random from regular production.

NOTES

(These notes are not parts of the standard, but are given for information only.)

(1) The provision for the use of cements other than standard portland and for other modifications of the mortar, subject to the approval of the purchaser, permits taking advantage of any useful results of the development of hydraulic cements of special properties.

(2) The purchaser who is buying cement-mortar-lined pipe for use with a water that is corrosive to calcium carbonate, such as a soft water of low alkalinity and low pH, is advised, before omitting the seal coat, to satisfy himself by appropriate test that the lining to be furnished will not impart objectionable hardness or alkalinity to the water, *considering the amount of circulation in the proposed pipe line and the amount of blowing off of dead ends that he is prepared to do.* The procedure of Section 4-15(b), omitting the seal coat and substituting for distilled water the water with which the pipe is to be used, is suggested as a convenient form of test.

Another advantage of the seal coat is in prolonging the life of the lining.

(3) The water absorption of cement-mortar linings which have been exposed to the atmosphere diminishes with increasing age of the lining, hence the 30 day limit so that the sample tested shall be reasonably representative of the shipment.

(4) Whitewash may be used to protect the pipe from the heat of the sun which tends to expand the pipe away from the lining. If cement-mortar-lined pipe are to be stored for a long time along the trench or in the purchaser's yard, it is recommended that the whitewash be maintained on all sides exposed to the sun. The need for whitewashing varies with the size of the pipe, the climate and probably other conditions. Pipe 16 inches in diameter and larger are more likely to need whitewashing than smaller pipe.

(5) The following test for tendency of a seal coating material to impart color, taste, and odor to the water has been used: A 2" x 3" x 6" block of the mortar to be used in lining the pipe is dried, painted and exposed to the air for 48 hours; it is then placed in a covered vessel with a volume of the water of the purchaser's supply equal in cubic inches, to twice the area of the block in square inches (the volume-area relation of an 8-inch pipe). After 48 hours at laboratory temperature it is tested for color, taste and odor.

By changing the water and testing for hardness, total and caustic alkalinity for, say, 3 successive days, and thereafter at longer intervals, an indication of the protective value of the seal coat may be had.

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American Standard Specifications

for

CAST IRON PIPE CENTRIFUGALLY CAST IN METAL MOLDS, FOR WATER OR OTHER LIQUIDS

SPONSORS

American Gas Association
American Society for Testing Materials
American Water Works Association
New England Water Works Association

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NOTE 1—Tables showing additional thicknesses required for greater depths of cover and other conditions of laying will be found in ASA A21.1.

NOTE 2—Users of these tables are cautioned to select fittings having proper socket dimensions and thicknesses suited to the pressures. Pipe specified in these tables have outside diameters which will chamber correctly with existing standards for pipe and fittings.

Users of this document should make reference to "American Recommended Practice Manual for the Computation of Strength and Thickness of Cast Iron Pipe" (ASA A21.1) for complete information concerning the conditions which various thicknesses of pipe are designed to meet. The foreword of the Manual also contains a statement regarding the history of the specifications and references to other related documents.

ASA
A21.6–1952

American Standard Specifications for

Cast Iron Pipe Centrifugally Cast in Metal Molds, for Water or Other Liquids

This specification covers cast iron pipe centrifugally cast in metal molds.

Sec. 6–1—Definitions

Purchaser. Wherever the word "purchaser" is used herein, it shall be understood to mean the actual purchaser of the pipe or his authorized agents acting within the scope of the duties entrusted to them.

Heat. A heat is a period during which a cupola or furnace is operated continuously.

Run. A run is a period of one or more shifts during which a shop is operated continuously.

Mixture of Iron. Mixture of iron is a combination of pig iron, scrap, coke and other raw materials charged to a cupola or furnace to give a desired composition of iron; or a combination of molten iron from one or more sources, made in a forehearth or ladle to give a desired composition of iron.

Source of Iron. A source of iron is a cupola, furnace or forehearth from which iron is delivered to a transfer or pouring ladle.

Forehearth. A forehearth is a refractory-lined receptacle for the temporary storage of molten iron from one or more cupolas or furnaces.

Sec. 6–2—Description of Pipe

The pipe shall be made with bell and spigot ends, plain ends or such other type of ends as may be agreed upon at the time of purchase. Pipe with bell-and-spigot ends shall conform to the dimensions and weights shown in the tables given in this document. Pipe with other types of ends shall comply with the dimensions agreed upon, but in all other respects shall fulfill the specifications hereinafter given. Pipe shall be straight and shall be true circles in section, with the inner and outer surfaces concentric. Pipe shall be cast at least 12 ft. in nominal laying length. This type of pipe is commonly made at present (1952) in 12- and 18-ft. lengths.

Sec. 6–3—Casting of Pipe

The pipe shall be centrifugally cast in metal molds, and after withdrawal from the molds pipe shall be heat-treated to meet the requirements of this specification.

Sec. 6–4—Quality of Iron

6–4.1. All pipe shall be made of cast iron of good quality, and of such character and so adapted in chemical composition to the thickness of the pipe to be cast, that the iron in the pipe shall be strong, tough, resilient, of even grain and soft enough for satisfactory drilling and cutting, and it shall comply with the physical specifications given in Sec. 6–17 and 6–18. The metal shall be remelted in a cupola or other suitable furnace.

6–4.2. The iron in the pipe shall not contain more than 0.90 per cent of phosphorus nor more than 0.12 per cent of sulphur. Samples for chemical analyses shall be taken by drilling completely through from skin to skin either acceptance test specimens or specimens cast for this purpose, but not to exceed three specimens per heat of approximately eight hours. In case of dispute, analyses will be determined on samples taken from the pipe in question.

Sec. 6–5—Quality of Castings

The pipe shall be smooth, free from scales, lumps, blisters, sand holes, laps and defects of every nature which unfit them for the use for which they are intended. No plugging, filling, burning-in or welding will be allowed except as permitted by the purchaser.

Sec. 6–6—Foundry Records

A record of the results of the following tests shall be made and retained for at least one year. Upon request such record will be available to the purchaser at the foundry. If written transcripts of the results of any of these tests are desired this fact shall be noted in the order for pipe, naming the tests of which transcripts are desired. The methods of testing and the dimensions of all test specimens are given in the Appendix.

6–6.1. *Chemical analyses.* Chemical analyses of each iron mixture used directly in the pouring of pipe, obtained as in Sec. 6–4.2, shall be made for silicon, sulphur, manganese, phosphorus and total carbon during the first hour and at intervals not to exceed three hours throughout the heat. If pipe are poured directly from the cupola, chemical analyses shall be made of iron from the first and from the last ladle. If the mixture is changed one or more times during a heat in order to produce a different iron, the time of taking samples shall be varied in such a way as to obtain representative tests of the iron at least at the beginning and end of each period during which the iron is intended to be constant in quality.

6–6.2. *Pouring temperatures.* The pouring temperature of the iron shall be taken at the casting ladle for each size of pipe at least once each hour.

6–6.3. *Hardness tests.* See Sec. 6–17.2 and Appendix Sec. 6–A1—Talbot Strip Tests.

6–6.4. *Talbot strip tests.* See Sec. 6–17.1.

6–6.5. *Periodic ring, strip and full-length bursting tests.* See Sec. 6–17 and 6–18.

Sec. 6–7—Marking Pipe

Each pipe shall have the weight and class designation conspicuously painted on it. In addition, each bell-and-spigot pipe shall have distinctly cast or stamped on the face of the bell the manufacturer's mark and the year in which the pipe was cast. When specified by the purchaser, the manufacturer's mark, the year in which the pipe was cast and initials not exceeding four in number shall be distinctly cast on the face of the bell. The size of

PIPE CENTRIFUGALLY CAST IN METAL MOLDS

letters and figures is to be as large as practicable. Pipe with ends other than bell and spigot are to be marked as agreed upon at the time of purchase.

Sec. 6–8—Inspection by Purchaser

6–8.1. *Power of purchaser to inspect.* The purchaser shall have free access at all times to all parts of any manufacturing plant which concern the manufacture of articles to be made for him. He may inspect the material, pattern work, molding, casting, heat-treating, coating and lining of the pipe. The forms, sizes, uniformity and conditions of all pipe herein referred to shall be subject to his inspection and approval, and he may reject, without subjection to hydrostatic test, any pipe which is not in conformity with the specifications or drawings. Any pipe rejected shall be so marked and any marks pertaining to the purchaser shall be chipped or erased from such pipe.

6–8.2. *Manufacturer to furnish men and materials.* The manufacturer shall provide tools, testing equipment, materials, labor and facilities necessary for the required testing, inspection and weighing of the pipe at the foundry.

6–8.3. *Report of purchaser's inspection.* The purchaser shall make written report daily to the foundry office of all pipe rejected with the causes for rejection.

Sec. 6–9—Inspection and Certification by Manufacturer

Should the purchaser have no inspector at the works, the manufacturer shall, if required by the purchaser, furnish a sworn statement that the inspection and all of the tests have been made and met as specified. If written transcripts of any of these test results are required, including chemical tests if desired, a request specifying the tests of which transcripts are desired shall accompany the order.

Sec. 6–10—Pipe to be Delivered Sound

All the pipe shall be delivered in all respects sound and in conformity with these specifications. The inspection shall not relieve the manufacturer of any of his obligations in this respect, and any defective pipe which may have passed the purchaser at the works or elsewhere shall be at all times liable to rejection when discovered, until the final completion and adjustment of the contract; provided, however, that the manufacturer shall not be held liable for pipe found to be damaged after they have been accepted at the agreed point of delivery, unless there shall be unmistakable evidence that the casting was originally defective or damaged before acceptance. Care shall be taken in handling the pipe not to injure the coating or lining, and no pipe or other material of any kind shall be placed in the pipe during transportation or at any other time after they have received the coating or lining.

Sec. 6–11—Cut Pipe

Defective spigot ends on pipe may be cut off in a manner which will produce a square end. Not more than 10 per cent of the total number of pipe of each size of a given order may be shipped as cut pipe. Such cut pipe when cut from 12-ft. lengths shall have a nominal laying length of not less than 11 ft.; pipe originally of 16-ft. or greater length shall not be cut more than 2 ft.

Sec. 6–12—Tolerances or Maximum Permitted Variations

6–12.1. *Pipe and socket diameters.* Outside diameters of pipe barrels and spigot ends, and inside diameters of sockets, shall be kept as nearly as practicable to the specified dimensions. The inside diameters of the sockets and the outside diameters of the spigot ends shall be tested with circular gages. Tolerances or maximum permitted variations from standard dimensions are listed below:

Nom. Pipe Diam. *in.*	Tolerances *in.*
3–12	±0.06
14–24	±0.08

6–12.2. *Thickness.* The minus tolerances from standard thickness of pipe and dimensions *a, b, c* and *d* of the bell are as follows:

Nom. Pipe Diam. *in.*	Minus Tolerance *in.*
3– 8	0.05
10–12	0.06
14–24	0.08

Note: In pipe barrel thickness, tolerances 0.02 in. greater than those listed above shall be permissible over areas not exceeding 8 in. in length in any direction.

6–12.3. *Weight.* The weight of no single pipe shall be less than the nominal tabulated weight by more than 5 per cent for pipe 12 in. or smaller in diameter, nor by more than 4 per cent for pipe larger than 12 in. in diameter. The total weight of any order of 25 tons or more shall not be more than 2 per cent under the total nominal weight. The total excess weight to be paid for on orders of 25 tons or more shall not exceed 2 per cent of the nominal weight and on orders of less than 25 tons shall not exceed 5 per cent of the nominal weight. An order is hereby defined as including all the pipe ordered under the terms of a specific contract or purchase order or a single order placed under the terms of a standing contract. Unless otherwise specified in the contract, a ton shall be 2,000 lb. avoirdupois.

Sec. 6–13—Cleaning and Inspecting

All pipe shall have fins and other roughnesses chipped or ground off and shall be thoroughly cleaned, checked as to dimensions and also subjected to a careful inspection and a rolling test, before being coated or lined.

Sec. 6–14—Hydrostatic Test

Each pipe shall be subjected to a hydrostatic proof test. This test may be made either before or after a hot or cold bituminous dip or paint has been applied but shall be made before the cement mortar lining or any other special lining has been applied to pipe for which such lining is specified.

The pipe shall be under the test pressure for at least one-half minute. Any pipe showing defects by leaking, sweating or otherwise shall be rejected. The test pressures shall be in accordance with the table appearing on page 134.

Sec. 6–15—Weighing

Each length of pipe shall be weighed and the weight plainly marked on the outside or inside of the bell or spigot end. Pipe shall be weighed before the application of any lining or coating other than hot or cold bituminous dip or paint.

PIPE CENTRIFUGALLY CAST IN METAL MOLDS

Table of Hydrostatic Test Pressures

Nom. Pipe Diam. *in.*	Nom. Barrel Thickness *in.*	Test Pressure *psi.*
3–12	all thicknesses	500
14	0.57 and less	400
14	0.58 and over	500
16	0.60 and less	400
16	0.61 and over	500
18	0.65 and less	400
18	0.66 and over	500
20	0.70 and less	400
20	0.71 and over	500
24	0.75 and less	400
24	0.76 and over	500

Sec. 6–16—Linings and Exterior Coatings

Any particular lining or coating which is to be applied to the pipe shall be specified in the agreement made at the time of purchase. Separate specifications for a cement-mortar lining have been provided in connection with these specifications for pipe. *See* specification ASA A21.4

No pipe or specials for waterworks service shall be furnished without protective coating unless specifically ordered by the purchaser.

Sec. 6–17—Acceptance Tests for Physical Properties

The standard acceptance tests for the physical characteristics of the pipe shall be as follows:

Sec. 6–17.1—Talbot Strip Tests

Talbot strip tests shall be used to determine the acceptability of 3-in. to 24-in. pipe for modulus of rupture and secant modulus of elasticity.

17.1.1. *Sampling.* For sampling, every run shall be divided into periods of approximately three hours each, and at least one sample shall be taken during each three-hour period. The sample for the first period of the run shall be taken during the first hour or, if casting is direct from the cupola, from the first ladle. Samples shall be taken so that each size of pipe cast for two hours or longer during the run and each mixture or source of iron used for two hours or longer during the run shall be fairly represented.

17.1.2. *Method of testing.* The method of testing Talbot strips is given in Sec. 6–A1 of the Appendix.

17.1.3. *Acceptance values.* The acceptance values for tests on Talbot strips from 3-in. to 24-in. pipe shall be as follows:

Modulus of rupture: 40,000 psi. minimum

Secant modulus of elasticity: 12,000,-000 psi. maximum

If the modulus of elasticity exceeds 12,000,000, the modulus of rupture shall exceed 40,000 in at least the same proportion.

Sec. 6–17.2—Hardness Tests

On the outside of each pipe a hardness determination shall be made with a portable instrument. The Rockwell hardness number or its equivalent shall not exceed B–95, using a ball having a diameter of 1.59 mm. ($\frac{1}{16}$ in.) and a weight of 100 kg. (220.5 lb.). Any harder pipe may be re-heat-treated to meet this requirement. For the purpose of the foundry records (Sec. 6–6.3), hardness tests shall be made also on Talbot strips as noted in the Appendix under "Talbot Strip Tests"—viz., a Rockwell hardness test at three well distributed points each on the outside of the pipe and on one machined face shall be made and recorded.

Sec. 6–18—Periodic Ring Tests and Full-Length Bursting Tests

The manufacturer shall periodically make such bursting tests and ring tests in conjunction with strip tests that he can certify the design values of the modulus of rupture (40,000 psi.) and the tensile strength of the iron in the pipe (18,000 psi.). These tests shall be made in accordance with dimensions and methods given in the Appendix.

Pipe for these periodic ring and bursting tests shall be so selected that they will be representative of the sizes and various thicknesses of each size cast. Ring tests shall not be made on 3-in. and 4-in. pipe.

Tests of Talbot strips cut from the ring and hardness tests as provided in the Appendix shall be made in conjunction with ring and bursting tests. At least three Talbot strips shall be tested from each burst pipe and one of these strips shall come from the ring. For pipe for which rings less than 10½ in. long are used, the Talbot strip shall come from parts other than the ring.

Tests and records shall include the modulus of rupture of each strip and ring, the modulus of elasticity of each strip and of each ring 12 in. and larger, and a hardness test on all strips.

At the purchaser's request, the manufacturer shall furnish a written transcript of ring and bursting tests and tests on Talbot strips made in connection therewith for a period not exceeding one year and for such sizes as requested.

Sec. 6–19—Additional Tests Required by Purchaser

If more or other tests than those provided in these specifications are required by the purchaser, such tests shall be specified in the invitation for bids.

Sec. 6–20—Defective Specimens and Retests

If any test specimen shows defective machining or lack of continuity of metal, it may be discarded and replaced by another specimen. If any sound test specimen fails to meet the specified requirements, the purchaser may permit a retest on two additional sound specimens from pipe cast in the same period as the specimen which failed; both of the additional specimens shall meet the prescribed tests to be acceptable.

Sec. 6–21—Rejection of Pipe

If any routine chemical analysis fails to meet the chemical requirements of Sec. 6–4.2, or if any acceptance test fails to meet the requirements of Sec. 6–17.1.3, 6–17.2 and 6–20, the pipe cast in the period shall be rejected except as subject to the provisions of Sec. 6–22.

Sec. 6–22—Limiting Rejection

The manufacturer may limit the amount of rejection by making similar additional tests of pipe of the same size as that rejected until the rejected lot is bracketed in order of manufacture by two acceptable tests. If a period is rejected, the acceptability of pipe of different sizes from that rejected may be established by making the routine acceptance tests for these sizes.

ASA
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Appendix*

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Tables †

* This Appendix is a part of ASA A21.6—American Standard Specifications for Cast Iron Pipe Centrifugally Cast in Metal Molds, for Water or Other Liquids.

† Data on thicknesses required for greater depths of cover and conditions of laying other than those assumed in the following tables will be found in Appendix B of ASA A21.1—American Recommended Practice Manual for the Computation of Strength and Thickness of Cast Iron Pipe.

Users of the following tables are cautioned to select fittings having proper socket dimensions and thicknesses suited to the pressures. Pipe specified in these tables have outside diameters which will chamber correctly with existing standards for pipe and fittings.

Sec. 6–A1—Talbot Strip Tests

Talbot strips (Fig. 6.1) shall be machined longitudinally from each pipe specimen selected for testing by this method. These Talbot strips may be cut from a part of the ring little stressed in the ring test—i.e., near one of the elements marked *a* in the illustration of the ring test (Fig. 6.2). The strips in any case will be in cross section as indicated in Fig. 6.1—i.e., will have for their width the thickness of the pipe and for their depth 0.50 in. Their length shall be at least 10½ in. These strips shall be tested as beams on supports 10 in. apart with loads applied perpendicularly to the machined faces at two points 3⅓ in. from the supports. The breaking load and the deflection shall be observed and recorded. For purposes of Sec. 6–6.3—Foundry Records, a Rockwell hardness test at three well distributed points each on the outside of the pipe and on one machined face shall be made and recorded.

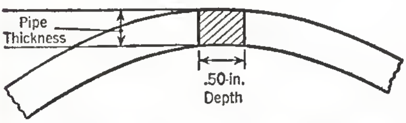

Fig. 6.1. Position From Which Talbot Strip Is Cut

The strip shall be accurately calipered at the point of rupture and the modulus of rupture, R, shall be calculated by the usual beam formula, which for this case reduces to the expression:

$$R = \frac{10W}{td^2}$$

The secant modulus of elasticity, E_s, in pounds per square inch, shall be computed by the formula:

$$E_s = \frac{21.3R}{dy}$$

In the above formulas, R is the modulus of rupture (psi.), E_s is the secant modulus of elasticity (psi.), W is the breaking load (lb.), d is the depth (in.) of the strip (intended to be 0.50 in.), t is the width (in.) of the strip (pipe thickness) and y is the deflection (in.) of the strip at the center at breaking load.

Sec. 6–A2—Ring Tests

The maximum length of any ring shall not exceed 12 in.; for pipe 14 in. and larger, the minimum length shall be 10½ in.; for pipe 12 in. and smaller, the minimum length shall be one-half the nominal diameter of the pipe. Each ring shall be tested by the three-edge bearing method as indicated in Fig. 6.2.

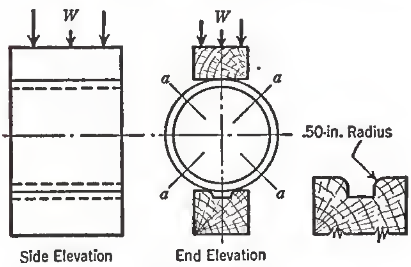

Fig. 6.2. Assembly for Ring Test

The lower bearing for the ring shall consist of two strips with vertical sides having their interior top corners rounded to a radius of approximately ½ in. The strips shall be of hard wood or of metal. If of metal, a piece of fabric or leather approximately $\frac{3}{16}$ in. thick shall be laid over them. They shall be straight and shall be securely fastened to a rigid block with their interior vertical faces the following distances apart:

Nom. Pipe Diam. *in.*	Bearing Strip Spacing *in.*
3–12	½
14–24	1

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The upper bearing shall be an oak block, straight and true from end to end. The upper and lower bearings shall extend the full length of the ring. The ring shall be placed symmetrically between the two bearings, and the center of application of the load shall be so placed that the vertical deformation at the two ends of the ring shall be approximately equal. If the ring is not uniform in thickness, it shall be so placed that the thick and thin portions are near the ends of the horizontal diameter.

A record of the breaking load and the vertical deformation of each ring tested shall be made. The modulus of rupture and modulus of elasticity are computed from the formulas:

$$R = 0.954 \frac{W(d+t)}{bt^2}$$

$$E = \frac{0.225W(d+t)^3}{bt^3y} = \frac{0.236R(d+t)^2}{ty}$$

in which R is the modulus of rupture (psi.); W is the breaking load (lb.), d is the average inside diameter (in.) of the ring, t is the average thickness (in.) of metal along the line of fracture, b is the length (in.) of the ring, E is the modulus of elasticity (psi.) and y is the vertical deformation (in.) of the ring at the center.

Sec. 6–A3—Full-Length Bursting Tests

The bursting tensile strength shall be determined by testing full-length pipe (less the amount cut off for ring and strip test specimens) to destruction by hydraulic pressure. Bells may be removed to facilitate testing. A suitable means for holding the end thrust shall be used which will not subject the pipe to endwise tension or compression, or other parasitic stresses. A calibrated pressure gage shall be used for determining the bursting pressure. This gage shall be connected to the interior of the test pipe by a separate connection from that which supplies water for the test. The unit tensile strength in bursting shall be obtained by the use of the formula:

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

in which S is the bursting tensile strength (psi.) of the iron, P is the internal pressure (psi.) at bursting, d is the average inside diameter (in.) of the pipe and t is the minimum average thickness (in.) of the pipe along the principal line of break.

Measurements of thickness shall be taken along the principal line of break at 1-ft. intervals.

The minimum average thickness along the principal line of break shall be obtained by averaging the measurements at the thinnest section at a weight of two and at the adjacent sections on each side at a weight of one each; or, if the thinnest section is at the end of the break, by averaging this thinnest-section measurement at a weight of two and the measurements of the adjacent section and the next section at a weight of one each.

Sec. 6–A4—Deflection Measurements

All deflection measurements required by these specifications shall be that of the specimen and shall not include any compression of the supports or loading blocks, or backlash or distortion of the testing machine.

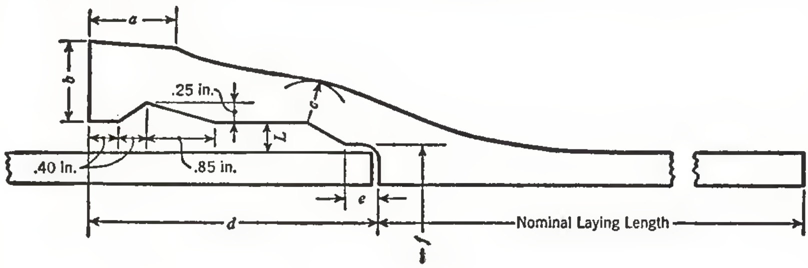

TABLE 6.1

STANDARD DIMENSIONS OF BELLS, SOCKETS AND OUTSIDE DIAMETERS—AND WEIGHTS OF BELLS—OF PIPE CENTRIFUGALLY CAST IN METAL MOLDS

Nom. Diam.	Pipe Thickness		Pipe Outside Diam.	Dimensions of Bells								Bell Weight
				Socket Diam.	Joint Thickness *L*	Socket Depth *d*	Centering Shoulder		*a*	*b*	*c*	
	From	To					Depth *e*	Inside Diam. *f*				
	in.											*lb.*
3	0.32	0.38	3.96	4.76	0.40	3.30	0.30	4.10	0.88	1.02	0.41	11
4	0.35	0.44	4.80	5.60	0.40	3.30	0.30	4.94	1.00	1.06	0.47	14
	0.35	0.44	5.00	5.80	0.40	3.30	0.30	5.14	1.00	1.06	0.47	15
6	0.38	0.48	6.90	7.70	0.40	3.88	0.38	7.06	1.13	1.10	0.55	25
	0.38	0.52	7.10	7.90	0.40	3.88	0.38	7.26	1.13	1.10	0.55	26
8	0.41	0.56	9.05	9.85	0.40	4.38	0.38	9.21	1.13	1.28	0.64	41
	0.41	0.60	9.30	10.10	0.40	4.38	0.38	9.46	1.13	1.28	0.64	42
10	0.44	0.60	11.10	11.90	0.40	4.38	0.38	11.28	1.13	1.38	0.69	54
	0.44	0.65	11.40	12.20	0.40	4.38	0.38	11.58	1.13	1.38	0.69	56
12	0.48	0.65	13.20	14.00	0.40	4.38	0.38	13.38	1.13	1.42	0.71	66
	0.48	0.60	13.50	14.30	0.40	4.38	0.38	13.68	1.13	1.42	0.71	67
	0.65	0.76	13.50	14.30	0.40	4.38	0.38	13.68	1.13	1.62	0.81	78
14	0.48	0.69	15.30	16.10	0.40	4.50	0.50	15.52	1.25	1.46	0.73	78
	0.48	0.64	15.65	16.45	0.40	4.50	0.50	15.87	1.25	1.46	0.73	80
	0.69	0.81	15.65	16.45	0.40	4.50	0.50	15.87	1.25	1.76	0.88	101
16	0.50	0.73	17.40	18.40	0.50	4.50	0.50	17.62	1.25	1.54	0.77	96
	0.50	0.68	17.80	18.80	0.50	4.50	0.50	18.02	1.25	1.54	0.77	98
	0.73	0.85	17.80	18.80	0.50	4.50	0.50	18.02	1.25	1.86	0.93	121
18	0.54	0.79	19.50	20.50	0.50	4.50	0.50	19.72	1.25	1.64	0.82	114
	0.54	0.73	19.92	20.92	0.50	4.50	0.50	20.14	1.25	1.64	0.82	116
	0.79	0.92	19.92	20.92	0.50	4.50	0.50	20.14	1.25	1.98	0.99	145
20	0.57	0.84	21.60	22.60	0.50	4.50	0.50	21.82	1.25	1.74	0.87	133
	0.57	0.78	22.06	23.06	0.50	4.50	0.50	22.28	1.25	1.74	0.87	136
	0.84	0.98	22.06	23.06	0.50	4.50	0.50	22.28	1.25	2.10	1.05	171
24	0.63	0.92	25.80	26.80	0.50	4.50	0.50	26.02	1.25	1.94	0.97	179
	0.63	0.85	26.32	27.32	0.50	4.50	0.50	26.54	1.25	1.94	0.97	182
	0.92	1.07	26.32	27.32	0.50	4.50	0.50	26.54	1.25	2.36	1.18	229

PIPE CENTRIFUGALLY CAST IN METAL MOLDS

TABLE 6.2

STANDARD THICKNESSES, DIAMETERS AND WEIGHTS OF PIPE CENTRIFUGALLY CAST IN METAL MOLDS

Nom. Diam. *in.*	Thick-ness Class	Thick-ness	Outside Diam.	Inside Diam.	Barrel Weight Per Foot	Bell Weight	Weight Based on 12-ft. Laying Length		Weight Based on 18-ft. Laying Length	
							Per Length*	Avg. Per Foot†	Per Length*	Avg. Per Foot†
		in.			*lb.*					
3	22	0.32	3.96	3.32	11.4	11	150	12.5	215	12.0
	23	0.35	3.96	3.26	12.4	11	160	13.5	235	13.0
	24	0.38	3.96	3.20	13.3	11	170	14.3	250	13.9
4	22	0.35	4.80	4.10	15.3	14	200	16.6	290	16.1
	23	0.38	4.80	4.04	16.5	14	210	17.7	310	17.3
	24	0.41	4.80	3.98	17.6	14	225	18.8	330	18.4
	25	0.44	4.80	3.92	18.8	14	240	20.0	350	19.5
	22	0.35	5.00	4.30	16.0	15	205	17.2	305	16.9
	23	0.38	5.00	4.24	17.2	15	220	18.5	325	18.0
	24	0.41	5.00	4.18	18.4	15	235	19.7	345	19.2
	25	0.44	5.00	4.12	19.7	15	250	21.0	370	20.5
6	22	0.38	6.90	6.14	24.3	25	315	26.4	460	25.6
	23	0.41	6.90	6.08	26.1	25	340	28.2	495	27.5
	24	0.44	6.90	6.02	27.9	25	360	30.0	525	29.3
	25	0.48	6.90	5.94	30.2	25	385	32.2	570	31.7
	22	0.38	7.10	6.34	25.0	26	325	27.2	475	26.4
	23	0.41	7.10	6.28	26.9	26	350	29.1	510	28.2
	24	0.44	7.10	6.22	28.7	26	370	30.9	545	30.2
	25	0.48	7.10	6.14	31.1	26	400	33.3	585	32.5
	26	0.52	7.10	6.06	33.5	26	430	35.7	630	34.9
8	22	0.41	9.05	8.23	34.7	41	455	38.1	665	36.9
	23	0.44	9.05	8.17	37.1	41	485	40.5	710	39.4
	24	0.48	9.05	8.09	40.3	41	525	43.7	765	42.6
	25	0.52	9.05	8.01	43.5	41	565	46.9	825	45.8
	26	0.56	9.05	7.93	46.6	41	600	50.0	880	48.9
	22	0.41	9.30	8.48	35.7	42	470	39.2	685	38.0
	23	0.44	9.30	8.42	38.2	42	500	41.7	730	40.5
	24	0.48	9.30	8.34	41.5	42	540	45.0	790	43.8
	25	0.52	9.30	8.26	44.8	42	580	48.3	850	47.1
	26	0.56	9.30	8.18	48.0	42	620	51.5	905	50.3
	27	0.60	9.30	8.10	51.2	42	655	54.7	965	53.5
10	22	0.44	11.10	10.22	46.0	54	605	50.5	880	49.0
	23	0.48	11.10	10.14	50.0	54	655	51.5	955	53.0
	24	0.52	11.10	10.06	53.9	54	700	58.4	1025	56.9
	25	0.56	11.10	9.98	57.9	54	750	62.4	1095	60.9
	26	0.60	11.10	9.90	61.8	54	795	66.3	1165	64.8
	22	0.44	11.40	10.52	47.3	56	625	52.0	905	50.4
	23	0.48	11.40	10.44	51.4	56	675	56.1	980	54.5
	24	0.52	11.40	10.36	55.5	56	720	60.2	1055	58.6
	25	0.56	11.40	10.28	59.5	56	770	64.2	1125	62.6
	26	0.60	11.40	10.20	63.5	56	820	68.2	1200	66.6
	27	0.65	11.40	10.10	68.5	56	880	73.2	1290	71.6
12	22	0.48	13.20	12.24	59.8	66	785	65.3	1140	63.4
	23	0.52	13.20	12.16	64.6	66	840	70.1	1230	68.3
	24	0.56	13.20	12.08	69.4	66	900	74.9	1315	73.1
	25	0.60	13.20	12.00	74.1	66	955	79.6	1400	77.8
	26	0.65	13.20	11.90	80.0	66	1025	85.5	1505	83.7
	22	0.48	13.50	12.54	61.3	67	805	66.9	1170	65.0
	23	0.52	13.50	12.46	66.2	67	860	71.8	1260	69.9
	24	0.56	13.50	12.38	71.0	67	920	76.6	1345	74.8
	25	0.60	13.50	12.30	75.9	67	980	81.5	1435	79.7
	26	0.65	13.50	12.20	81.9	78	1060	88.4	1550	86.2
	27	0.70	13.50	12.10	87.8	78	1130	91.3	1660	92.1
	28	0.76	13.50	11.98	94.9	78	1215	101.4	1785	99.2
14	21	0.48	15.30	14.34	69.7	78	915	76.2	1335	74.1
	22	0.51	15.30	14.28	73.9	78	965	80.4	1410	78.2
	23	0.55	15.30	14.20	79.5	78	1030	86.0	1510	83.8
	24	0.59	15.30	14.12	85.1	78	1100	91.6	1610	89.5
	25	0.64	15.30	14.02	92.0	78	1180	98.5	1735	96.5
	26	0.69	15.30	13.92	98.8	78	1265	105.3	1855	103.1

* Including bell. Calculated weight of pipe rounded off to nearest 5 lb.
† Average weight per foot based on calculated weight of pipe before rounding.

TABLE 6.2 (contd.)

STANDARD THICKNESSES, DIAMETERS AND WEIGHTS OF PIPE CENTRIFUGALLY CAST IN METAL MOLDS

Nom. Diam. *in.*	Thickness Class	Thickness	Outside Diam.	Inside Diam.	Barrel Weight Per Foot	Bell Weight	Weight Based on 12-ft. Laying Length		Weight Based on 18-ft. Laying Length	
							Per Length*	Avg. Per Foot†	Per Length*	Avg. Per Foot†
		in.			*lb.*					
14	21	0.48	15.65	14.69	71.4	80	935	78.1	1365	75.8
	22	0.51	15.65	14.63	75.7	80	990	82.4	1445	80.2
	23	0.55	15.65	14.55	81.4	80	1055	88.1	1545	85.8
	24	0.59	15.65	14.47	87.1	80	1125	93.8	1650	91.6
	25	0.64	15.65	14.37	94.2	80	1210	100.9	1775	98.7
	26	0.69	15.65	14.27	101.2	101	1315	109.6	1925	106.9
	27	0.75	15.65	14.15	109.5	101	1415	117.9	2070	115.1
	28	0.81	15.65	14.03	117.8	101	1515	126.2	2220	123.4
16	21	0.50	17.40	16.40	82.8	96	1090	90.8	1585	88.1
	22	0.54	17.40	16.32	89.2	96	1165	97.2	1700	94.5
	23	0.58	17.40	16.24	95.6	96	1245	103.6	1815	100.9
	24	0.63	17.40	16.14	103.6	96	1340	111.6	1960	109.0
	25	0.68	17.40	16.04	111.4	96	1435	119.4	2100	116.8
	26	0.73	17.40	15.94	119.3	96	1530	127.3	2245	124.8
	21	0.50	17.80	16.80	84.8	98	1115	93.0	1625	90.2
	22	0.54	17.80	16.72	91.4	98	1195	99.6	1745	96.9
	23	0.58	17.80	16.64	97.9	98	1275	106.1	1860	103.3
	24	0.63	17.80	16.54	106.0	98	1370	114.2	2005	111.5
	25	0.68	17.80	16.44	114.1	98	1465	122.2	2150	119.5
	26	0.73	17.80	16.34	122.1	121	1585	132.2	2320	128.8
	27	0.79	17.80	16.22	131.7	121	1700	141.8	2490	138.4
	28	0.85	17.80	16.10	141.2	121	1815	151.3	2665	148.0
18	21	0.54	19.50	18.42	100.4	114	1320	109.9	1920	106.7
	22	0.58	19.50	18.34	107.6	114	1405	117.1	2050	113.9
	23	0.63	19.50	18.24	116.5	114	1510	126.0	2210	122.8
	24	0.68	19.50	18.14	125.4	114	1620	134.9	2370	131.8
	25	0.73	19.50	18.04	134.3	114	1725	143.8	2530	140.6
	26	0.79	19.50	17.92	144.9	114	1855	154.4	2720	151.2
	21	0.54	19.92	18.84	102.6	116	1345	112.2	1965	109.1
	22	0.58	19.92	18.76	109.9	116	1435	119.6	2095	116.3
	23	0.63	19.92	18.66	119.1	116	1545	128.8	2260	125.5
	24	0.68	19.92	18.56	128.2	116	1655	137.9	2425	134.8
	25	0.73	19.92	18.46	137.3	116	1765	147.0	2585	143.7
	26	0.79	19.92	18.34	148.1	145	1920	160.2	2810	156.1
	27	0.85	19.92	18.22	158.9	145	2050	171.0	3005	166.9
	28	0.92	19.92	18.08	171.3	145	2200	183.4	3230	179.4
20	21	0.57	21.60	20.46	117.5	133	1545	128.6	2250	124.9
	22	0.62	21.60	20.36	127.5	133	1665	138.6	2430	134.9
	23	0.67	21.60	20.26	137.5	133	1785	148.6	2610	144.9
	24	0.72	21.60	20.16	147.4	133	1900	158.5	2785	154.8
	25	0.78	21.60	20.04	159.2	133	2045	170.3	3000	166.8
	26	0.84	21.60	19.92	170.9	133	2185	182.0	3210	178.4
	21	0.57	22.06	20.92	120.1	136	1575	131.4	2300	127.7
	22	0.62	22.06	20.82	130.3	136	1700	141.6	2480	137.9
	23	0.67	22.06	20.72	140.5	136	1820	151.8	2665	148.1
	24	0.72	22.06	20.62	150.6	136	1945	161.9	2845	158.1
	25	0.78	22.06	20.50	162.7	136	2090	174.0	3065	170.3
	26	0.84	22.06	20.38	174.7	171	2265	188.9	3315	184.1
	27	0.91	22.06	20.24	188.7	171	2435	203.0	3570	198.2
	28	0.98	22.06	20.10	202.5	171	2600	216.8	3815	212.0
24	21	0.63	25.80	24.54	155.4	179	2045	170.3	2975	165.3
	22	0.68	25.80	24.44	167.4	179	2190	182.3	3190	177.3
	23	0.73	25.80	24.34	179.4	179	2330	194.3	3410	189.4
	24	0.79	25.80	24.22	193.7	179	2505	208.6	3665	203.6
	25	0.85	25.80	24.10	207.9	179	2675	222.8	3920	217.8
	26	0.92	25.80	23.96	224.4	179	2870	239.3	4220	234.4
	21	0.63	26.32	25.06	158.6	182	2085	173.8	3035	168.7
	22	0.68	26.32	24.96	170.9	182	2235	186.1	3260	181.0
	23	0.73	26.32	24.86	183.1	182	2380	198.3	3480	193.2
	24	0.79	26.32	24.74	197.7	182	2555	212.9	3740	207.8
	25	0.85	26.32	24.62	212.2	182	2730	227.4	4000	222.3
	26	0.92	26.32	24.48	229.0	229	2975	248.1	4350	241.7
	27	0.99	26.32	24.34	245.8	229	3180	264.9	4655	258.5
	28	1.07	26.32	24.18	264.8	229	3405	283.9	4995	277.5

* Including bell. Calculated weight of pipe rounded off to nearest 5 lb.
† Average weight per foot based on calculated weight of pipe before rounding.

PIPE CENTRIFUGALLY CAST IN METAL MOLDS

TABLE 6.3

STANDARD THICKNESSES AND WEIGHTS OF PIPE CENTRIFUGALLY CAST IN METAL MOLDS*

Size	Thickness	Outside Diam.	Weight Based on: 12-ft. Laying Length, Avg. Per Foot†	12-ft. Laying Length, Per Length‡	18-ft. Laying Length, Avg. Per Foot†	18-ft. Laying Length, Per Length‡
	in.		*lb.*			
Class 50—50-psi. Pressure—115-ft. Head						
3	0.32	3.96	12.5	150	12.0	215
4	0.35	4.80	16.6	200	16.1	290
6	0.38	6.90	26.4	315	25.6	460
8	0.41	9.05	38.1	455	36.9	665
10	0.44	11.10	50.5	605	49.0	880
12	0.48	13.20	65.3	785	63.4	1140
14	0.48	15.30	76.2	915	74.1	1335
16	0.54	17.40	97.2	1165	94.5	1700
18	0.54	19.50	109.9	1320	106.7	1920
20	0.57	21.60	128.6	1545	124.9	2250
24	0.63	25.80	170.3	2045	165.3	2975
Class 100—100-psi. Pressure—231-ft. Head						
3	0.32	3.96	12.5	150	12.0	215
4	0.35	4.80	16.6	200	16.1	290
6	0.38	6.90	26.4	315	25.6	460
8	0.41	9.05	38.1	455	36.9	665
10	0.44	11.10	50.5	605	49.0	880
12	0.48	13.20	65.3	785	63.4	1140
14	0.51	15.30	80.4	965	78.2	1410
16	0.54	17.40	97.2	1165	94.5	1700
18	0.58	19.50	117.1	1405	113.9	2050
20	0.62	21.60	138.6	1665	134.9	2430
24	0.68	25.80	182.3	2190	177.3	3190
Class 150—150-psi. Pressure—346-ft. Head						
3	0.32	3.96	12.5	150	12.0	215
4	0.35	4.80	16.6	200	16.1	290
6	0.38	6.90	26.4	315	25.6	460
8	0.41	9.05	38.1	455	36.9	665
10	0.44	11.10	50.5	605	49.0	880
12	0.48	13.20	65.3	785	63.4	1140
14	0.51	15.65	82.4	990	80.2	1445
16	0.54	17.80	99.6	1195	96.9	1745
18	0.58	19.92	119.6	1435	116.3	2095
20	0.62	22.06	141.6	1700	137.9	2480
24	0.73	26.32	198.3	2380	193.2	3480

* These thicknesses and weights are for pipe laid without blocks, on flat-bottom trench, with tamped backfill, under 5 ft. of cover. For other conditions, see Tables 6.2 and 6.4 hereof and ASA A21.1, "Manual for the Computation of Strength and Thickness of Cast Iron Pipe."

† Average weight per foot based on calculated weight of pipe before rounding.

‡ Including bell. Calculated weight of pipe rounded off to nearest 5 lb.

TABLE 6.3 (contd.)

STANDARD THICKNESSES AND WEIGHTS OF PIPE CENTRIFUGALLY CAST IN METAL MOLDS*

Size	Thickness	Outside Diam.	Weight Based on 12-ft. Laying Length: Avg. Per Foot†	12-ft. Laying Length: Per Length‡	18-ft. Laying Length: Avg. Per Foot†	18-ft. Laying Length: Per Length‡
	in.		*lb.*			
Class 200—200-psi. Pressure—462-ft. Head						
3	0.32	3.96	12.5	150	12.0	215
4	0.35	4.80	16.6	200	16.1	290
6	0.38	6.90	26.4	315	25.6	460
8	0.41	9.05	38.1	455	36.9	665
10	0.44	11.10	50.5	605	49.0	880
12	0.48	13.20	65.3	785	63.4	1140
14	0.55	15.65	88.1	1055	85.8	1545
16	0.58	17.80	106.1	1275	103.3	1860
18	0.63	19.92	128.8	1545	125.5	2260
20	0.67	22.06	151.8	1820	148.1	2665
24	0.79	26.32	212.9	2555	207.8	3740
Class 250—250-psi. Pressure—577-ft. Head						
3	0.32	3.96	12.5	150	12.0	215
4	0.35	4.80	16.6	200	16.1	290
6	0.38	6.90	26.4	315	25.6	460
8	0.41	9.05	38.1	455	36.9	665
10	0.44	11.10	50.5	605	49.0	880
12	0.52	13.20	70.1	840	68.3	1230
14	0.59	15.65	93.8	1125	91.6	1650
16	0.63	17.80	114.2	1370	111.5	2005
18	0.68	19.92	137.9	1655	134.8	2425
20	0.72	22.06	161.9	1945	158.1	2845
24	0.79	26.32	212.9	2555	207.8	3740
Class 300—300-psi. Pressure—693-ft. Head						
3	0.32	3.96	12.5	150	12.0	215
4	0.35	4.80	16.6	200	16.1	290
6	0.38	6.90	26.4	315	25.6	460
8	0.41	9.05	38.1	455	36.9	665
10	0.48	11.10	54.5	655	53.0	955
12	0.52	13.20	70.1	840	68.3	1230
14	0.59	15.65	93.8	1125	91.6	1650
16	0.68	17.80	122.2	1465	119.5	2150
18	0.73	19.92	147.0	1765	143.7	2585
20	0.78	22.06	174.0	2090	170.3	3065
24	0.85	26.32	227.4	2730	222.3	4000

* These thicknesses and weights are for pipe laid without blocks, on flat-bottom trench, with tamped backfill, under 5 ft. of cover. For other conditions, see Tables 6.2 and 6.4 hereof and ASA A21.1, "Manual for the Computation of Strength and Thickness of Cast Iron Pipe."

† Average weight per foot based on calculated weight of pipe before rounding.

‡ Including bell. Calculated weight of pipe rounded off to nearest 5 lb.

PIPE CENTRIFUGALLY CAST IN METAL MOLDS

TABLE 6.3 (contd.)

STANDARD THICKNESSES AND WEIGHTS OF PIPE CENTRIFUGALLY CAST IN METAL MOLDS*

Size	Thickness	Outside Diam.	Weight Based on 12-ft. Laying Length: Avg. Per Foot†	Weight Based on 12-ft. Laying Length: Per Length‡	Weight Based on 18-ft. Laying Length: Avg. Per Foot†	Weight Based on 18-ft. Laying Length: Per Length‡
	in.		*lb.*			
Class 350—350-psi. Pressure—808-ft. Head						
3	0.32	3.96	12.5	150	12.0	215
4	0.35	4.80	16.6	200	16.1	290
6	0.38	6.90	26.4	315	25.6	460
8	0.41	9.05	38.1	455	36.9	665
10	0.52	11.10	58.4	700	56.9	1025
12	0.56	13.20	74.9	900	73.1	1315
14	0.64	15.65	100.9	1210	98.7	1775
16	0.68	17.80	122.2	1465	119.5	2150
18	0.79	19.92	160.2	1920	156.1	2810
20	0.84	22.06	188.9	2265	184.1	3315
24	0.92	26.32	248.1	2975	241.7	4350

* These thicknesses and weights are for pipe laid without blocks, on flat-bottom trench, with tamped backfill, under 5 ft. of cover. For other conditions, see Tables 6.2 and 6.4 hereof and ASA A21.1, "Manual for the Computation of Strength and Thickness of Cast Iron Pipe."

† Average weight per foot based on calculated weight of pipe before rounding.

‡ Including bell. Calculated weight of pipe rounded off to nearest 5 lb.

TABLE 6.4

STANDARD THICKNESSES* OF PIPE CENTRIFUGALLY CAST IN METAL MOLDS

Laying Condition A—Flat-Bottom Trench, Without Blocks, Untamped Backfill
Laying Condition B—Flat-Bottom Trench, Without Blocks, Tamped Backfill
Laying Condition C—Pipe Laid on Blocks, Untamped Backfill
Laying Condition D—Pipe Laid on Blocks, Tamped Backfill

Size *in.*	Working Pressure *psi.*	3½ ft. of Cover				5 ft. of Cover				8 ft. of Cover			
		Laying Condition				Laying Condition				Laying Condition			
		A	B	C	D	A	B	C	D	A	B	C	D
		Thickness—*in.*											
3	50	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.38	0.32
	100	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.38	0.32
	150	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.38	0.32
	200	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.38	0.32
	250	0.32	0.32	0.32	0.32	0.32	0.32	0.35	0.32	0.32	0.32	0.38	0.32
	300	0.32	0.32	0.32	0.32	0.32	0.32	0.35	0.32	0.32	0.32	0.38	0.32
	350	0.32	0.32	0.32	0.32	0.32	0.32	0.35	0.32	0.32	0.32	0.38	0.32
4	50	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.41	0.35
	100	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.41	0.35
	150	0.35	0.35	0.35	0.35	0.35	0.35	0.38	0.35	0.35	0.35	0.41	0.35
	200	0.35	0.35	0.35	0.35	0.35	0.35	0.38	0.35	0.35	0.35	0.44	0.35
	250	0.35	0.35	0.35	0.35	0.35	0.35	0.38	0.35	0.35	0.35	0.44	0.35
	300	0.35	0.35	0.35	0.35	0.35	0.35	0.38	0.35	0.35	0.35	0.44	0.35
	350	0.35	0.35	0.38	0.35	0.35	0.35	0.38	0.35	0.35	0.35	0.44	0.35
6	50	0.38	0.38	0.41	0.38	0.38	0.38	0.44	0.38	0.38	0.38	0.48	0.38
	100	0.38	0.38	0.41	0.38	0.38	0.38	0.44	0.38	0.38	0.38	0.48	0.38
	150	0.38	0.38	0.41	0.38	0.38	0.38	0.44	0.38	0.38	0.38	0.48	0.38
	200	0.38	0.38	0.41	0.38	0.38	0.38	0.44	0.38	0.38	0.38	0.52	0.38
	250	0.38	0.38	0.44	0.38	0.38	0.38	0.44	0.38	0.38	0.38	0.52	0.38
	300	0.38	0.38	0.44	0.38	0.38	0.38	0.44	0.38	0.38	0.38	0.52	0.38
	350	0.38	0.38	0.44	0.38	0.38	0.38	0.48	0.38	0.38	0.38	0.52	0.38
8	50	0.41	0.41	0.44	0.41	0.41	0.41	0.48	0.41	0.41	0.41	0.52	0.41
	100	0.41	0.41	0.48	0.41	0.41	0.41	0.48	0.41	0.41	0.41	0.56	0.41
	150	0.41	0.41	0.48	0.41	0.41	0.41	0.48	0.41	0.41	0.41	0.56	0.41
	200	0.41	0.41	0.48	0.41	0.41	0.41	0.52	0.41	0.41	0.41	0.56	0.44
	250	0.41	0.41	0.48	0.41	0.41	0.41	0.52	0.41	0.44	0.41	0.56	0.44
	300	0.41	0.41	0.48	0.41	0.41	0.41	0.52	0.41	0.44	0.44	0.60	0.44
	350	0.41	0.41	0.52	0.41	0.44	0.41	0.52	0.44	0.48	0.44	0.60	0.48
10	50	0.44	0.44	0.48	0.44	0.44	0.44	0.52	0.44	0.44	0.44	0.60	0.48
	100	0.44	0.44	0.52	0.44	0.44	0.44	0.52	0.44	0.48	0.44	0.60	0.48
	150	0.44	0.44	0.52	0.44	0.44	0.44	0.56	0.44	0.48	0.44	0.60	0.48
	200	0.44	0.44	0.52	0.44	0.44	0.44	0.56	0.44	0.48	0.48	0.60	0.52
	250	0.44	0.44	0.56	0.44	0.48	0.44	0.56	0.48	0.52	0.48	0.65	0.52
	300	0.48	0.44	0.56	0.48	0.48	0.48	0.56	0.48	0.52	0.52	0.65	0.56
	350	0.48	0.48	0.56	0.48	0.52	0.52	0.60	0.52	0.56	0.52	0.65	0.56
12	50	0.48	0.48	0.52	0.48	0.48	0.48	0.56	0.48	0.52	0.48	0.65	0.52
	100	0.48	0.48	0.56	0.48	0.48	0.48	0.56	0.48	0.52	0.48	0.65	0.52
	150	0.48	0.48	0.56	0.48	0.48	0.48	0.56	0.48	0.52	0.52	0.65	0.56
	200	0.48	0.48	0.56	0.48	0.48	0.48	0.60	0.52	0.56	0.52	0.65	0.56
	250	0.52	0.48	0.60	0.52	0.52	0.52	0.60	0.52	0.56	0.56	0.70	0.60
	300	0.52	0.52	0.60	0.52	0.56	0.52	0.60	0.56	0.60	0.56	0.70	0.60
	350	0.56	0.56	0.60	0.56	0.56	0.56	0.65	0.60	0.60	0.60	0.76	0.65

* Thicknesses include allowances for foundry practice, corrosion, and either water hammer or truck load.

PIPE CENTRIFUGALLY CAST IN METAL MOLDS

TABLE 6.4 (contd.)

STANDARD THICKNESSES* OF PIPE CENTRIFUGALLY CAST IN METAL MOLDS

Laying Condition A—Flat-Bottom Trench, Without Blocks, Untamped Backfill
Laying Condition B—Flat-Bottom Trench, Without Blocks, Tamped Backfill
Laying Condition C—Pipe Laid on Blocks, Untamped Backfill
Laying Condition D—Pipe Laid on Blocks, Tamped Backfill

Size *in.*	Working Pressure *psi.*	3½ ft. of Cover				5 ft. of Cover				8 ft. of Cover			
		Laying Condition				Laying Condition				Laying Condition			
		A	B	C	D	A	B	C	D	A	B	C	D
		Thickness—*in.*											
14	50	0.51	0.48	0.59	0.51	0.51	0.48	0.59	0.55	0.59	0.55	0.69	0.59
	100	0.51	0.48	0.59	0.55	0.55	0.51	0.64	0.55	0.59	0.55	0.69	0.64
	150	0.55	0.51	0.59	0.55	0.55	0.51	0.64	0.59	0.64	0.59	0.75	0.64
	200	0.55	0.51	0.64	0.59	0.55	0.55	0.64	0.59	0.64	0.59	0.75	0.69
	250	0.59	0.55	0.64	0.59	0.59	0.59	0.69	0.59	0.64	0.64	0.75	0.69
	300	0.59	0.59	0.69	0.59	0.64	0.59	0.69	0.64	0.69	0.64	0.81	0.69
	350	0.64	0.64	0.69	0.64	0.64	0.64	0.75	0.69	0.75	0.69	0.81	0.75
16	50	0.54	0.50	0.63	0.58	0.58	0.54	0.63	0.58	0.63	0.58	0.73	0.63
	100	0.54	0.54	0.63	0.58	0.58	0.54	0.68	0.58	0.63	0.58	0.73	0.68
	150	0.58	0.54	0.63	0.58	0.58	0.54	0.68	0.63	0.68	0.63	0.79	0.68
	200	0.58	0.58	0.68	0.63	0.63	0.58	0.68	0.63	0.68	0.63	0.79	0.73
	250	0.63	0.58	0.68	0.63	0.63	0.63	0.73	0.68	0.73	0.68	0.79	0.73
	300	0.63	0.63	0.73	0.68	0.68	0.68	0.73	0.68	0.73	0.73	0.85	0.79
	350	0.68	0.68	0.73	0.68	0.73	0.68	0.79	0.73	0.79	0.73	0.85	0.79
18	50	0.58	0.54	0.63	0.58	0.58	0.54	0.68	0.63	0.68	0.63	0.79	0.68
	100	0.58	0.54	0.68	0.63	0.63	0.58	0.73	0.63	0.68	0.63	0.79	0.73
	150	0.63	0.58	0.68	0.63	0.63	0.58	0.73	0.68	0.73	0.68	0.79	0.73
	200	0.63	0.58	0.73	0.68	0.68	0.63	0.73	0.68	0.73	0.68	0.85	0.79
	250	0.68	0.63	0.73	0.68	0.68	0.68	0.79	0.73	0.79	0.73	0.85	0.79
	300	0.68	0.68	0.79	0.73	0.73	0.73	0.79	0.79	0.79	0.79	0.92	0.85
	350	0.79	0.73	0.79	0.79	0.79	0.79	0.85	0.79	0.85	0.85	0.92	0.85
20	50	0.62	0.57	0.72	0.62	0.67	0.57	0.72	0.67	0.72	0.67	0.78	0.72
	100	0.62	0.57	0.72	0.67	0.67	0.62	0.78	0.67	0.72	0.67	0.84	0.78
	150	0.67	0.62	0.72	0.67	0.67	0.62	0.78	0.72	0.78	0.72	0.84	0.78
	200	0.67	0.62	0.78	0.72	0.72	0.67	0.78	0.72	0.78	0.72	0.91	0.84
	250	0.72	0.67	0.78	0.72	0.78	0.72	0.84	0.78	0.84	0.78	0.91	0.84
	300	0.78	0.72	0.84	0.78	0.78	0.78	0.84	0.84	0.84	0.84	0.98	0.91
	350	0.84	0.78	0.84	0.84	0.84	0.84	0.91	0.84	0.91	0.84	0.98	0.91
24	50	0.68	0.63	0.79	0.68	0.73	0.63	0.79	0.73	0.79	0.73	0.85	0.79
	100	0.73	0.63	0.79	0.73	0.73	0.68	0.85	0.79	0.85	0.73	0.92	0.85
	150	0.73	0.68	0.79	0.79	0.79	0.73	0.85	0.79	0.85	0.79	0.92	0.85
	200	0.79	0.73	0.85	0.79	0.79	0.79	0.92	0.85	0.92	0.85	0.99	0.92
	250	0.79	0.79	0.85	0.85	0.85	0.79	0.92	0.85	0.92	0.85	0.99	0.99
	300	0.85	0.85	0.92	0.85	0.92	0.85	0.99	0.92	0.99	0.92	1.07	0.99
	350	0.92	0.92	0.99	0.92	0.99	0.92	0.99	0.99	1.07	0.99	1.07	1.07

* Thicknesses include allowances for foundry practice, corrosion, and either water hammer or truck load,

ASA
A21.7–1952

American Standard

SPECIFICATIONS

for

CAST IRON PIPE CENTRIFUGALLY CAST IN METAL MOLDS FOR GAS

SPONSORS

American Gas Association
American Society for Testing Materials
American Water Works Association
New England Water Works Association

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Note 1—Tables showing additional thicknesses required for greater depths of cover and other conditions of laying will be found in ASA A21.1.

Note 2—Users of these tables are cautioned to select fittings having proper socket dimensions and thicknesses suited to the pressures. Pipe specified in these tables have outside diameters which will chamber correctly with existing standards for pipe and fittings.

Users of this document should make reference to "American Recommended Practice Manual for the Computation of Strength and Thickness of Cast Iron Pipe" (ASA A21.1) for complete information concerning the conditions which various thicknesses of pipe are designed to meet. The foreword of the Manual also contains a statement regarding the history of the specifications and references to other related documents.

ASA
A21.7–1952

AMERICAN STANDARD SPECIFICATIONS
for
CAST IRON PIPE CENTRIFUGALLY CAST IN METAL MOLDS FOR GAS

This specification covers cast iron pipe centrifugally cast in metal molds for gas.

Section 7-1—Definitions

PURCHASER. Wherever the word "Purchaser" is used herein, it shall be understood to mean the actual purchaser of the pipe or his authorized agents acting within the scope of the duties entrusted to them.

HEAT. A heat is a period during which a cupola or furnace is operated continuously.

RUN. A run is a period of one or more shifts during which a shop is operated continuously.

MIXTURE OF IRON. Mixture of iron is a combination of pig iron, scrap, coke and other raw materials charged to a cupola or furnace to give a desired composition of iron; or a combination of molten iron from one or more sources, made in a forehearth or ladle to give a desired composition of iron.

SOURCE OF IRON. A source of iron is a cupola, furnace or forehearth from which iron is delivered to a transfer or pouring ladle.

FOREHEARTH. A forehearth is a refractory-lined receptable for the temporary storage of molten iron from one or more cupolas or furnaces.

Section 7-2—Description of Pipe

The pipe shall be made with bell and spigot ends, plain ends or such other type of ends as may be agreed upon at the time of purchase. Pipe with bell and spigot ends shall conform to the dimensions and weights given in the following tables. Pipe with other types of ends shall comply with the dimensions agreed upon, but in all other respects shall fulfill the specifications hereinafter given. Pipe shall be straight and shall be true circles in section, with their inner and outer surfaces concentric. They shall be cast at least 12 feet in nominal laying length. This type of pipe is commonly made at present (1952) in 12- and 18-foot lengths.

Section 7-3—Casting of Pipe

The pipe shall be centrifugally cast in metal molds and after withdrawal from the molds, pipe shall be heat-treated to meet the requirements of this specification.

Section 7-4—Quality of Iron

(7-4.1) All pipe shall be made of cast iron of good quality, and of such character and so adapted in chemical composition to the thickness of the pipe to be cast, that the iron in the pipe shall be strong, tough, resilient, of even grain and soft enough for satisfactory drilling and cutting and it shall comply with the physical specifications given in Sect. 7-17 and 7-18. The metal shall be remelted in a cupola or other suitable furnace.

(7-4.2) The iron in the pipe shall not contain more than 0.90 per cent of phosphorus nor more than 0.12 per cent of sulphur. Samples for chemical analyses shall be taken by drilling completely through from skin to skin either acceptance test specimens or specimens cast for this purpose but not to exceed three specimens per heat of approximately eight hours. In case of dispute, analyses will be determined on samples taken from the pipe in question.

Section 7-5—Quality of Castings

The pipe shall be smooth, free from scales, lumps, blisters, sand holes, laps, and defects of every nature which unfit them for the use for which they are intended. No plugging, filling, burning-in or welding will be allowed except as permitted by the purchaser.

Section 7-6—Foundry Records

A record of the results of the following tests shall be made and retained for at least one year. Upon request such record will be available to purchaser at the foundry. If written transcripts of the results of any of these tests are desired, this fact shall be noted in the order for pipe, naming tests of which transcripts are desired. The methods of testing and the dimensions of all test specimens are given in the Appendix.

(7-6.1) *Chemical Analyses*

Chemical analyses of each iron mixture used directly in the pouring of pipe, obtained as in Sect. 7-4.2 shall be made for silicon, sulphur, manganese, phosphorus and total carbon during the first hour and at intervals not to exceed three hours throughout the heat. If pipe are poured directly from the cupola, chemical analyses shall be made of iron from the first and from the last ladle. In case the mixture is changed one or more times during a heat in order to produce a different iron, the time of taking samples shall be varied in such a way as to obtain representative tests of the iron at least at the beginning and end of each period during which the iron is intended to be constant in quality.

(7-6.2) *Pouring Temperatures*

The pouring temperature of the iron shall be taken at the casting ladle for each size of pipe at least once each hour.

(7-6.3) *Hardness Tests*

(See Sect. 7-17.2, also Appendix under "Talbot Strip Tests.")

(7-6.4) *Talbot Strip Tests*

(See Sect. 7-17.1.)

(7-6.5) *Periodic Ring, Strip and Full Length Bursting Tests*

(See Sect. 7-17 and 7-18.)

Section 7-7—Marking Pipe

Each pipe shall have the weight and class designation conspicuously painted on it. In addition, each bell and spigot pipe shall have distinctly cast or stamped on the face of the bell the manufacturer's mark and the year in which the pipe was cast. When specified by the purchaser, the manufacturer's mark, year in which pipe was cast and initials not exceeding four in number shall be distinctly cast on the face of the bell. The size of letters and figures is to be as large as practicable. Pipe with ends other than bell and spigot are to be marked as agreed upon at the time of purchase.

Section 7-8—Inspection by Purchaser

(7-8.1) *Power of Purchaser to Inspect*

The purchaser shall have free access at all times to all parts of any manufacturing plant which concern the manufacture of articles to be made for him. He may inspect the material, the pattern work, molding, casting, heat-treating and coating (if used) of the pipe. The forms, sizes, uniformity and conditions of all pipe herein referred to shall be subject to his inspection and approval, and he may reject, without subjection to hydrostatic test, any pipe which is not in conformity with the specifications or drawings. Any pipe rejected shall be marked as rejected and any marks pertaining to the purchaser shall be chipped or erased from such pipe.

(7-8.2) *Manufacturer to Furnish Men and Materials*

The manufacturer shall provide tools, testing equipment, materials, labor and facilities necessary for the required testing, inspection and weighing of the pipe at the foundry.

(7-8.3) *Report of Purchaser's Inspection*

The purchaser shall make written report daily to the foundry office of all pipe rejected with the causes of rejection.

Section 7-9—Inspection and Certification by Manufacturer

Should the purchaser have no inspector at the works, the manufacturer shall, if required by the purchaser, furnish a sworn statement that the inspection and all of the tests have been made and met as specified. If written transcripts of any of these test results are required, including chemical tests if desired, a request for same, specifying the tests of which transcripts are desired, shall accompany the order.

Section 7-10—Pipe to be Delivered Sound

All the pipe shall be delivered in all respects sound and in conformity with these specifications. The inspection shall not relieve the manufacturer of any of his obligations in this respect, and any defective pipe which may have passed the purchaser at the works or elsewhere shall be at all times liable to rejection when discovered, until the final completion and adjustment of the contract; provided, however, that the manufacturer shall not be held liable for pipe found to be damaged after they have been accepted at the agreed point of delivery, unless there shall be unmistakable evidence that the casting was originally defective or damaged before acceptance. Care shall be taken in handling the pipe not to injure the coating (if used) and no pipe or other material of any kind shall be placed in the pipe during transportation.

Section 7-11—Cut Pipe

Defective spigot ends on pipe may be cut off in a manner which will produce a square end. Not more than 10 per cent of the total number of pipe of each size of a given order may be shipped as cut pipe. Such cut pipe when cut from 12-foot lengths shall have a nominal laying length of not less than 11 feet; pipe originally of 16 feet or greater length shall not be cut more than 2 feet.

Section 7-12—Tolerances or Maximum Permitted Variations from Standard Dimensions

(7-12.1) *Tolerances in Diameter of Pipe and Sockets*

Outside diameters of pipe barrels, spigot ends and inside diameters of sockets shall be kept as nearly as practicable to the specified dimensions. The inside diameters of the sockets and the outside diameters of the spigot ends shall be tested with circular gauges. Tolerances or maximum permitted variations from standard dimensions are listed in the following table.

Nominal Pipe Diameter Inches	Tolerances, Plus or Minus Inches
4 to 12	.06
16 to 24	.08

(7-12.2) *Tolerances in Thickness*

The minus tolerances from standard thickness of pipe and dimensions a, b, c, and d of the bell are listed in the following table.

Nominal Pipe Diameter Inches	Minus Tolerances Inches
4 to 8	.05
10 to 12	.06
16 to 24	.08

NOTE: In pipe barrel thickness, tolerances .02 inch greater than those listed above shall be permissible over areas not exceeding 8 inches in length in any direction.

(7-12.3) *Allowable Percentage of Variation in Weight*

The weight of no single pipe shall be less than the nominal tabulated weight by more than 5% for pipe 12 inches or smaller in diameter, nor by more than 4% for pipe larger than 12 inches in diameter. The total weight of any order of 25 tons or more shall not be more than 2% under the total nominal weight. The total excess weight to be paid for on orders of 25 tons or more shall not exceed 2% of the nominal weight and on orders less than 25 tons shall not exceed 5% of the nominal weight. An order is hereby defined as including all the pipe ordered under the terms of a specific contract or purchase order or a single order placed under the terms of a standing contract. Unless otherwise stated in the contract, the ton shall be 2,000 pounds avoirdupois.

Section 7-13—Cleaning and Inspecting

All pipe shall have fins and other roughnesses chipped or ground off and shall be thoroughly cleaned, checked as to dimensions and also subjected to a careful inspection and a rolling test before the coating (if used) is applied.

Section 7-14—Hydrostatic Test

Each pipe shall be subjected to a hydrostatic proof test. The pipe shall be under the test pressure for at least one-half minute. Any pipe showing defects by leaking, sweating, or otherwise, shall be rejected. The test pressures shall be in accordance with the following table.

TABLE OF PRESSURES FOR HYDROSTATIC TESTS

Nominal Pipe Diameter Inches	Nominal Barrel Thickness Inches	Test Pressures, Lbs. per sq.in.
4 to 12	All Thicknesses	500
16	.60 and less	400
16	.61 and over	500
20	.70 and less	400
20	.71 and over	500
24	.75 and less	400
24	.76 and over	500

Section 7-15—Weighing

Each length of pipe shall be weighed and the weight plainly marked on the outside or inside of the bell or spigot end.

Section 7-16—Exterior Coatings

Any coating (if used) which is to be applied to the pipe, shall be specified in the agreement made at time of purchase.

Section 7-17—Acceptance Tests for Physical Properties

The standard acceptance tests for the physical characteristics of the pipe shall be as follows:

(7-17.1) *Talbot Strip Tests*

Talbot strip tests shall be used to determine acceptability of 4 inch to 24 inch pipe for modulus of rupture and secant modulus of elasticity.

(17.1.1) *Sampling.* For sampling, each run shall be divided into periods of approximately three hours each and at least one sample shall be taken during each 3-hour period. The sample for the first period of the run shall be taken during the first hour, or if casting is direct from cupola, from the first ladle. Samples shall be taken so that each size of pipe cast for two hours or longer during the run and each mixture or source of iron used for two hours or longer during the run shall be fairly represented.

(17.1.2) *Method of Testing.* The method of testing Talbot strips is given in the Appendix.

(17.1.3) *Acceptance Values.* The acceptance values for Talbot strip tests shall be as follows:

Talbot Strips from 4 Inch to 24 Inch Pipe

Modulus of rupture	40,000 lbs. per sq.in. minimum
Secant modulus of elasticity	12,000,000 lbs. per sq.in. maximum

If modulus of elasticity exceeds 12,000,000, the modulus of rupture shall exceed 40,000 in at least the same proportion.

(7-17.2) *Hardness Tests*

On the outside of each pipe a hardness determination shall be made with a portable instrument. The Rockwell hardness number or its equivalent shall not exceed B-95 using a ball having a diameter of 1.59 millimeters (1/16 inch) and a weight of 100 kilograms (220.5 lbs.). Any harder pipe may be re-heat-treated to meet this requirement. For the purpose of the foundry records, Sect. 7-6.3, hardness tests, shall be made also on Talbot strips as noted in Appendix under Talbot Strip Tests, viz., a Rockwell hardness test shall be made and recorded at three well-distributed points each on outside of pipe and on one machined face.

Section 7-18—Periodic Ring Tests and Full-Length Bursting Tests

The manufacturer shall periodically make such bursting tests and ring tests in conjunction with strip tests that he can certify the design values of modulus of rupture (40,000 lbs. per sq.in.) and tensile strength of the iron in the pipe (18,000 lbs. per sq.in.). These tests shall be made in accordance with dimensions and methods given in the Appendix.

Pipe for these periodic ring and bursting tests shall be so selected that they will be representative of the sizes and various thicknesses of each size cast. Ring tests shall not be made on 4-inch pipe.

Tests of Talbot strips cut from the ring and hardness tests as provided in the Appendix shall be made in conjunction with ring and bursting tests. At least three Talbot strips shall be tested from each burst pipe and one of these strips shall come from the ring. For pipe for which rings less than 10½ inches long are used, the Talbot strip shall come from parts other than the ring.

Tests and records shall include modulus of rupture of each strip and ring, modulus of elasticity of each strip and of each ring of 12 inches and larger and hardness test on all strips.

At purchaser's request, manufacturer shall furnish a written transcript of ring and bursting tests and tests on Talbot strips made in connection therewith for a period not exceeding one year and for such sizes as requested.

Section 7-19—Additional Tests Required by Purchaser

If more or other tests than provided in these specifications are required by the purchaser, such tests shall be specified in the invitation for bids.

Section 7-20—Defective Specimens and Retests

If any test specimen shows defective machining or lack of continuity of metal, it may be discarded and replaced by another specimen. If any sound test specimen fails to meet the specified requirements, the purchaser may permit a retest on two additional sound specimens from pipe cast in the same period as the specimen which failed, in which case both specimens shall meet the prescribed tests to be acceptable.

Section 7-21—Rejection Due to Failure to Meet the Routine Acceptance Test Requirements

If any routine chemical analysis fails to meet the chemical requirements of Sect. 7-4.2 or if any acceptance test fails to meet the requirements of Sect. 7-17.1.3, 7-17.2 and 7-20, the pipe cast in the period shall be rejected subject to the provisions of Sect. 7-22.

Section 7-22—Limiting the Rejection Due to Failure to Meet the Routine Acceptance Test Requirements

The manufacturer may limit the amount of rejection by making similar additional tests on pipe of the same size as that rejected until the rejected lot is bracketed in order of manufacture by two acceptable tests. If a period is rejected, the acceptability of pipe of different sizes from that rejected may be established by making the routine acceptance tests for these sizes.

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APPENDIX*

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TABLES†

Section 7-A1—Talbot Strip Tests

Talbot strips (Fig. 7.1) shall be machined longitudinally from each pipe specimen selected for testing by this method. These Talbot strips may be cut from a part of the ring little stressed in the ring test—i.e., near one of the elements marked *a* in the illustration of the ring test (Fig. 7.2). The strips in any case will be in cross section as indicated in Fig. 7.1—i.e., will have for their width the thickness of the pipe and for their depth 0.50 in. Their length shall be at least 10½ in. These strips shall be tested as beams on supports 10 in. apart with loads applied perpendicularly to the machined faces at two points 3⅓ in. from

* This Appendix is a part of ASA A21.7—American Standard Specifications for Cast Iron Pipe Centrifugally Cast in Metal Molds, for Gas.

† Data on thicknesses required for greater depths of cover and conditions of laying other than those assumed in the following tables will be found in Appendix B of ASA A21.1—American Recommended Practice Manual for the Computation of Strength and Thickness of Cast Iron Pipe.

Users of the following tables are cautioned to select fittings having proper socket dimensions and thicknesses suited to the pressures. Pipe specified in these tables have outside diameters which will chamber correctly with existing standards for pipe and fittings.

the supports. The breaking load and the deflection shall be observed and recorded. For purposes of Sec. 7-6.3—Foundry Records, a Rockwell hardness test at three well distributed points each on the outside of the pipe and on one machined face shall be made and recorded.

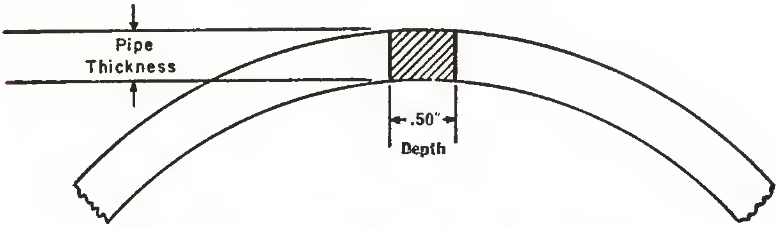


FIG. 7.1. Postion From Which Talbot Strip Is Cut

The strip shall be accurately calipered at the point of rupture and the modulus of rupture, R, shall be calculated by the usual beam formula, which for this case reduces to the expression:

$$R = \frac{10W}{td^2}$$

The secant modulus of elasticity, E_s, in pounds per square inch, shall be computed by the formula:

$$E_s = \frac{21.3R}{dy}$$

In the above formulas, R is the modulus of rupture lbs. per sq. in., E_s is the secant modulus of elasticity lbs. per sq. in., W is the breaking load (lb.), d is the depth (in.) of the strip (intended to be 0.50 in), t is the width (in.) of the strip (pipe thickness) and y is the deflection (in.) of the strip at the center at breaking load.

Section 7-A2—Ring Tests

The maximum length of any ring shall not exceed 12 in.; for pipe 16 in. and larger, the minimum length shall be 10½ in.; for pipe 12 in. and smaller, the minimum length shall be one-half the nominal diameter of the pipe. Each ring shall be tested by the three-edge bearing method as indicated in Fig. 7.2. The lower bearing for the ring shall consist of two strips with vertical sides having their interior top corners rounded to a radius of approximately ½ in. The strips shall be of hard wood or of metal. If of metal, a piece of fabric or leather approximately

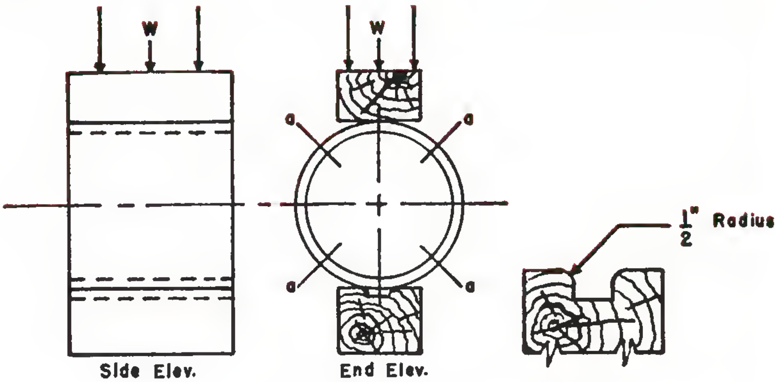


FIG. 7.2. Assembly for Ring Test

3/16 in. thick shall be laid over them. They shall be straight and shall be securely fastened to a rigid block with their interior vertical faces the following distances apart:

Nom. Pipe Diam. *in.*	Bearing Strip Spacing *in.*
4—12	½
16—24	1

The upper bearing shall be an oak block, straight and true from end to end. The upper and lower bearings shall extend the full length of the ring. The ring shall be placed symmetrically between the two bearings, and the center of application of the load shall be so placed that the vertical deformation at the two ends of the ring shall be approximately equal. If the ring is not uniform in thickness, it shall be so placed that the thick and thin portions are near the ends of the horizontal diameter.

A record of the breaking load and the vertical deformation of each ring tested shall be made. The modulus of rupture and modulus of elasticity are computed from the formulas:

$$R = 0.954\frac{W(d+t)}{bt^2}$$

$$E = \frac{0.225W(d+t)^3}{bt^3y} = \frac{0.236R(d+t)^2}{ty}$$

in which R is the modulus of rupture lbs. per sq. in., W is the breaking load (lb.), d is the average inside diameter (in.) of the ring, t is the average thickness (in.) of metal along the line of fracture, b is the length (in.) of the ring, E is the modulus of elasticity lbs. per sq. in. and y is the vertical deformation (in.) of the ring at the center.

Section 7-A3—Full-Length Bursting Tests

The bursting tensile strength shall be determined by testing full-length pipe (less the amount cut off for ring and strip test specimens) to destruction by hydraulic pressure. Bells may be removed to facilitate testing. A suitable means for holding the end thrust shall be used which will not subject the pipe to endwise tension or compression, or other parasitic stresses. A calibrated pressure gage shall be used for determining the bursting pressure. This gage shall be connected to the interior of the test pipe by a separate connection from that which supplies water for the test. The unit tensile strength in bursting shall be obtained by the use of the formula:

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

in which S is the bursting tensile strength lbs. per sq. in. of the iron, P is the internal pressure lbs. per sq. in. at bursting, d is the average inside diameter (in.) of the pipe and t is the minimum average thickness (in.) of the pipe along the principal line of break.

Measurements of thickness shall be taken along the principal line of break at 1-ft. intervals.

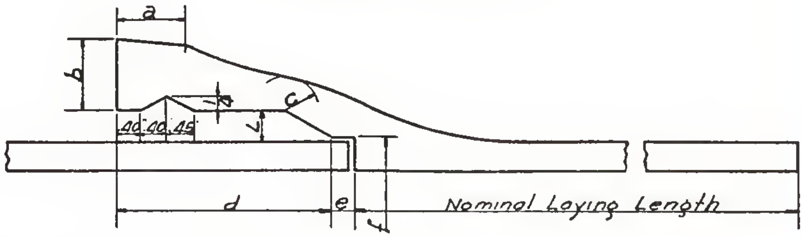
The minimum average thickness along the principal line of break shall be obtained by averaging the measurements at the thinnest section at a weight of two and at the adjacent sections on each side at a weight of one each; or, if the thinnest section is at the end of the break, by averaging this thinnest-section measurement at a weight of two and the measurements of the adjacent section and the next section at a weight of one each.

Section 7-A4—Deflection Measurements

All deflection measurements required by these specifications shall be that of the specimen and shall not include any compression of the supports or loading blocks, or backlash or distortion of the testing machine.

Table No. 7.1

STANDARD DIMENSIONS OF BELLS, SOCKETS and OUTSIDE DIAMETERS FOR GAS PIPE CENTRIFUGALLY CAST IN METAL MOLDS, also WEIGHTS OF BELLS



Nominal Diam.	Thickness of Pipe From	Thickness of Pipe To	Out-Side Diam. of Pipe	Dimensions of Bells: Diam. of Socket	Thickness of Joint L	Depth of Socket d	Depth of Centering Shoulder e	Inside Diam. of Centering Shoulder f	a	b	c	Wt. of Bell
4	.35	.41	4.80	5.80	.50	3.50	.30	4.94	1.00	1.06	0.48	17
6	.38	.48	6.90	7.90	.50	3.50	.38	7.06	1.12	1.13	0.52	25
8	.41	.56	9.05	10.05	.50	4.00	.38	9.21	1.12	1.28	0.64	42
10	.44	.60	11.10	12.10	.50	4.00	.38	11.28	1.12	1.38	0.69	55
12	.48	.65	13.20	14.20	.50	4.00	.38	13.38	1.12	1.42	0.71	68
16	.50	.63	17.40	18.66	.63	4.00	.50	17.62	1.25	1.50	0.75	96
	.68	.73	17.40	18.66	.63	4.00	.50	17.62	1.25	1.80	0.90	116
20	.57	.72	21.60	22.86	.63	4.00	.50	21.82	1.25	1.74	0.87	137
	.78	.84	21.60	22.86	.63	4.00	.50	21.82	1.25	1.94	0.97	154
24	.63	.79	25.80	27.06	.63	4.00	.50	26.02	1.25	1.88	0.94	174
	.85	.92	25.80	27.06	.63	4.00	.50	26.02	1.25	2.06	1.03	182

All dimensions given in inches. All weights given in pounds.

Table No. 7.2

STANDARD THICKNESSES, DIAMETERS AND WEIGHTS FOR GAS PIPE CENTRIFUGALLY CAST IN METAL MOLDS

Dimensions in Inches — Weights in Pounds

Nominal Diam.	Thickness Class	Thickness	Outside Diam.	Inside Diam.	Wt. of Barrel Per Ft.	Wt. of Bell	Wt. Based On 12 Ft. Length		Wt. Based On 18 Ft. Length	
							Per Length*	Avg. Per Ft.†	Per Length*	Avg. Per Ft.†
4	22	.35	4.80	4.10	15.3	17	200	16.7	290	16.2
	23	.38	4.80	4.04	16.5	17	215	17.9	315	17.4
	24	.41	4.80	3.98	17.6	17	230	19.1	335	18.6
6	22	.38	6.90	6.14	24.3	25	315	26.4	460	25.6
	23	.41	6.90	6.08	26.1	25	340	28.2	495	27.5
	24	.44	6.90	6.02	27.9	25	360	30.0	525	29.3
	25	.48	6.90	5.94	30.2	25	385	32.2	570	31.7
8	22	.41	9.05	8.23	34.7	42	460.	38.2	665	37.0
	23	.44	9.05	8.17	37.1	42	485	40.6	710	39.4
	24	.48	9.05	8.09	40.3	42	525	43.8	765	42.6
	25	.52	9.05	8.01	43.5	42	565	47.0	825	45.8
	26	.56	9 05	7.93	46.6	42	600	50.1	880	48.9
10	22	.44	11.10	10.22	46.0	55	605	50.6	885	49.1
	23	.48	11.10	10.14	50.0	55	655	54.6	955	53.0
	24	.52	11.10	10.06	53.9	55	700	58.5	1025	57.0
	25	.56	11.10	9.98	57.9	55	750	62.5	1095	60.9
	26	.60	11.10	9.90	61.8	55	795	66.4	1165	64.8
12	22	.48	13.20	12.24	59.8	68	785	65.5	1145	63.6
	23	.52	13.20	12.16	64.6	68	845	70.3	1230	68.4
	24	.56	13.20	12.08	69.4	68	900	75.1	1315	73.1
	25	.60	13.20	12.00	74.1	68	955	79.7	1400	77.9
	26	.65	13.20	11.90	80.0	68	1030	85.7	1510	83.9
16	21	.50	17.40	16.40	82.8	96	1090	90.8	1585	88.1
	22	.54	17.40	16.32	89.2	96	1165	97.2	1700	94.5
	23	.58	17.40	16.24	95.6	96	1245	103.6	1815	100.9
	24	.63	17.40	16.14	103.6	96	1340	111.6	1960	109.0
	25	.68	17.40	16.04	111.4	116	1455	121.1	2120	117.8
	26	.73	17.40	15.94	119.3	116	1550	129.0	2265	125.7
20	21	.57	21.60	20.46	117.5	137	1545	128.9	2250	125.1
	22	.62	21.60	20.36	127.5	137	1665	138.9	2430	135.1
	23	.67	21.60	20.26	137.5	137	1785	148.9	2610	145.1
	24	.72	21.60	20.16	147.4	137	1905	158.8	2790	155.0
	25	.78	21.60	20.04	159.2	154	2065	172.0	3020	167.8
	26	.84	21.60	19.92	170.9	154	2205	183.7	3230	179.5
24	21	.63	25.80	24.54	155.4	174	2040	169.9	2970	165.1
	22	.68	25.80	24.44	167.4	174	2185	181.9	3185	177.0
	23	.73	25.80	24.34	179.4	174	2325	193.9	3405	189.1
	24	.79	25.80	24.22	193.7	174	2500	208.2	3660	203.4
	25	.85	25.80	24.10	207.9	182	2675	223.1	3925	218.0
	26	.92	25.80	23.96	224.4	182	2875	239.6	4220	234.5

*Including Bell. Calculated weight of Pipe rounded off to nearest 5 pounds.
†Average weight per foot based on calculated weight of pipe before rounding.

Table No. 7.3

STANDARD THICKNESSES AND WEIGHTS FOR CAST IRON GAS PIPE CENTRIFUGALLY CAST IN METAL MOLDS

NOTE: These thicknesses and weights are for pipe laid without blocks, on flat bottom trench, with tamped backfill, under 5 feet of cover. For other conditions see Tables 7.2 and 7.4 hereof and the Manual.

Size Inches	CLASS 10 — 10 Lb. Pressure						CLASS 50 — 50 Lb. Pressure					
	Thickness Inches	Outside Diam. Inches	Wt. Based on 12 Foot Length: Avg. Per Foot†	Wt. Based on 12 Foot Length: Per Length*	Wt. Based on 18 Foot Length: Avg. Per Foot†	Wt. Based on 18 Foot Length: Per Length*	Thickness Inches	Outside Diam. Inches	Wt. Based on 12 Foot Length: Avg. Per Foot†	Wt. Based on 12 Foot Length: Per Length*	Wt. Based on 18 Foot Length: Avg. Per Foot†	Wt. Based on 18 Foot Length: Per Length*
4	.35[1]	4.80	16.7	200	16.2	290	.35[1]	4.80	16.7	200	16.2	290
	or .38[2]	4.80	17.9	215	17.4	315	or .38[2]	4.80	17.9	215	17.4	315
6	.38[1]	6.90	26.4	315	25.6	460	.38[1]	6.90	26.4	315	25.6	460
	or .41[2]	6.90	28.2	340	27.5	495	or .41[2]	6.90	28.2	340	27.5	495
8	.41	9.05	38.2	460	37.0	665	.41	9.05	38.2	460	37.0	665
10	.44	11.10	50.6	605	49.1	885	.44	11.10	50.6	605	49.1	885
12	.48	13.20	65.5	785	63.6	1145	.48	13.20	65.5	785	63.6	1145
16	.50	17.40	90.8	1090	88.1	1585	.50	17.40	90.8	1090	88.1	1585
20	.57	21.60	128.9	1545	125.1	2250	.57	21.60	128.9	1545	125.1	2250
24	.63	25.80	169.9	2040	165.1	2970	.63	25.80	169.9	2040	165.1	2970

*Including Bell. Calculated weight of Pipe rounded off to nearest 5 pounds.
†Average weight per foot based on calculated weight of pipe before rounding.
[1]Class 22 thickness.
[2]Class 23 thickness offers increased factor of safety and is recommended for use in areas of dense population and heavy traffic.

Table No. 7.3 (Continued)

STANDARD THICKNESSES AND WEIGHTS FOR CAST IRON GAS PIPE CENTRIFUGALLY CAST IN METAL MOLDS

NOTE: These thicknesses and weights are for pipe laid without blocks, on flat bottom trench, with tamped backfill, under 5 feet of cover. For other conditions see Tables 7.2 and 7.4 hereof and the Manual.

Size Inches	CLASS 100 — 100 Lb. Pressure						CLASS 150 — 150 Lb. Pressure					
	Thickness Inches	Outside Diam. Inches	Wt. Based on 12 Foot Length: Avg. Per Foot†	Wt. Based on 12 Foot Length: Per Length*	Wt. Based on 18 Foot Length: Avg. Per Foot†	Wt. Based on 18 Foot Length: Per Length*	Thickness Inches	Outside Diam. Inches	Wt. Based on 12 Foot Length: Avg. Per Foot†	Wt. Based on 12 Foot Length: Per Length*	Wt. Based on 18 Foot Length: Avg. Per Foot†	Wt. Based on 18 Foot Length: Per Length*
4	.35[1]	4.80	16.7	200	16.2	290	.35[1]	4.80	16.7	200	16.2	290
	or .38[2]	4.80	17.9	215	17.4	315	or .38[2]	4.80	17.9	215	17.4	315
6	.38[1]	6.90	26.4	315	25.6	460	.38[1]	6.90	26.4	315	25.6	460
	or .41[2]	6.90	28.2	340	27.5	495	or .41[2]	6.90	28.2	340	27.5	495
8	.41	9.05	38.2	460	37.0	665	.41	9.05	38.2	460	37.0	665
10	.44	11.10	50.6	605	49.1	885	.44	11.10	50.6	605	49.1	885
12	.48	13.20	65.5	785	63.6	1145	.48	13.20	65.5	785	63.6	1145
16	.54	17.40	97.2	1165	94.5	1700						
20	.62	21.60	138.9	1665	135.1	2430						
24	.68	25.80	181.9	2185	177.0	3185						

*Including Bell. Calculated weight of Pipe rounded off to nearest 5 pounds.
†Average weight per foot based on calculated weight of pipe before rounding.
[1]Class 22 thickness.
[2]Class 23 thickness offers increased factor of safety and is recommended for use in areas of dense population and heavy traffic.

Table No. 7.4

STANDARD THICKNESSES FOR CAST IRON GAS PIPE CENTRIFUGALLY CAST IN METAL MOLDS

Thickness in Inches. Working Pressure in Pounds per Square Inch.
Thicknesses Include Allowances for Foundry Practice and Corrosion

Laying Condition A—Flat Bottom Trench, Without Blocks, Untamped Backfill
Laying Condition B—Flat Bottom Trench, Without Blocks, Tamped Backfill
Laying Condition C—Pipe Laid on Blocks, Untamped Backfill
Laying Condition D—Pipe Laid on Blocks, Tamped Backfill

Size Inches	Working Pressure	3½ FEET OF COVER Laying Condition A	B	C	D	5 FEET OF COVER Laying Condition A	B	C	D	8 FEET OF COVER Laying Condition A	B	C	D
4	10	[1].35	.35	.35	.35	.35	.35	.35	.35	.35	.35	.41	.35
		[2].38	.38	.38	.38	.38	.38	.38	.38	.38	.38	.41	.38
	50	[1].35	.35	.35	.35	.35	.35	.35	.35	.35	.35	.41	.35
		[2].38	.38	.38	.38	.38	.38	.38	.38	.38	.38	.41	.38
	100	[1].35	.35	.35	.35	.35	.35	.35	.35	.35	.35	.41	.35
		[2].38	.38	.38	.38	.38	.38	.38	.38	.38	.38	.41	.38
	150	[1].35	.35	.35	.35	.35	.35	.38	.35	.35	.35	.41	.35
		[2].38	.38	.38	.38	.38	.38	.38	.38	.38	.38	.41	.38
6	10	[1].38	.38	.41	.38	.38	.38	.41	.38	.38	.38	.48	.38
		[2].41	.41	.41	.41	.41	.41	.41	.41	.41	.41	.48	.41
	50	[1].38	.38	.41	.38	.38	.38	.41	.38	.38	.38	.48	.38
		[2].41	.41	.41	.41	.41	.41	.41	.41	.41	.41	.48	.41
	100	[1].38	.38	.41	.38	.38	.38	.44	.38	.38	.38	.48	.38
		[2].41	.41	.41	.41	.41	.41	.44	.41	.41	.41	.48	.41
	150	[1].38	.38	.41	.38	.38	.38	.44	.38	.38	.38	.48	.38
		[2].41	.41	.41	.41	.41	.41	.44	.41	.41	.41	.48	.41
8	10	.41	.41	.44	.41	.41	.41	.48	.41	.41	.41	.52	.41
	50	.41	.41	.44	.41	.41	.41	.48	.41	.41	.41	.52	.41
	100	.41	.41	.48	.41	.41	.41	.48	.41	.41	.41	.56	.41
	150	.41	.41	.48	.41	.41	.41	.48	.41	.41	.41	.56	.41
10	10	.44	.44	.48	.44	.44	.44	.52	.44	.44	.44	.60	.44
	50	.44	.44	.48	.44	.44	.44	.52	.44	.44	.44	.60	.44
	100	.44	.44	.52	.44	.44	.44	.52	.44	.44	.44	.60	.48
	150	.44	.44	.52	.44	.44	.44	.56	.44	.48	.44	.60	.48
12	10	.48	.48	.52	.48	.48	.48	.56	.48	.48	.48	.60	.52
	50	.48	.48	.52	.48	.48	.48	.56	.48	.48	.48	.60	.52
	100	.48	.48	.56	.48	.48	.48	.56	.48	.52	.48	.65	.52
	150	.48	.48	.56	.48	.48	.48	.56	.48	.52	.48	.65	.52
16	10	.54	.50	.58	.54	.54	.50	.63	.58	.58	.54	.73	.63
	50	.54	.50	.63	.54	.54	.50	.63	.58	.63	.58	.73	.63
	100	.54	.54	.63	.58	.58	.54	.68	.58	.63	.58	.73	.68
20	10	.62	.57	.67	.62	.62	.57	.72	.67	.67	.62	.78	.72
	50	.62	.57	.72	.62	.67	.57	.72	.67	.72	.62	.78	.72
	100	.62	.57	.72	.67	.67	.62	.78	.67	.72	.67	.84	.78
24	10	.63	.63	.73	.68	.73	.63	.79	.73	.79	.68	.85	.79
	50	.68	.63	.79	.68	.73	.63	.79	.73	.79	.73	.85	.79
	100	.73	.63	.79	.73	.73	.68	.85	.79	.79	.73	.92	.85

[1]Class 22 thickness.
[2]Class 23 thickness offers increased factor of safety and is recommended for use in areas of dense population and heavy traffic.

ASA
A21.8–1952

American Standard Specifications

for

CAST IRON PIPE CENTRIFUGALLY CAST IN SAND-LINED MOLDS, FOR WATER OR OTHER LIQUIDS

SPONSORS

American Gas Association
American Society for Testing Materials
American Water Works Association
New England Water Works Association

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Note 1—Tables showing additional thicknesses required for greater depths of cover and other conditions of laying will be found in ASA A21.1.

Note 2—Users of these tables are cautioned to select fittings having proper socket dimensions and thicknesses suited to the pressures. Pipe specified in these tables have outside diameters which will chamber correctly with existing standards for pipe and fittings.

Users of this document should make reference to "American Recommended Practice Manual for the Computation of Strength and Thickness of Cast Iron Pipe" (ASA A21.1) for complete information concerning the conditions which various thicknesses of pipe are designed to meet. The foreword of the Manual also contains a statement regarding the history of the specifications and references to other related documents.

ASA
A21.8–1952

American Standard Specifications for

Cast Iron Pipe Centrifugally Cast in Sand-lined Molds, for Water or Other Liquids

This specification covers cast iron pipe centrifugally cast in sand-lined molds.

Sec. 8–1—Definitions

Purchaser. Wherever the word "purchaser" is used herein, it shall be understood to mean the actual purchaser of the pipe or his authorized agents acting within the scope of the duties entrusted to them.

Heat. A heat is a period during which a cupola or furnace is operated continuously.

Run. A run is a period of one or more shifts during which a shop is operated continuously.

Mixture of Iron. Mixture of iron is a combination of pig iron, scrap, coke and other raw materials charged to a cupola or furnace to give a desired composition of iron; or a combination of molten iron from one or more sources, made in a forehearth or ladle to give a desired composition of iron.

Source of Iron. A source of iron is a cupola, furnace or forehearth from which iron is delivered to a transfer or pouring ladle.

Forehearth. A forehearth is a refractory-lined receptacle for the temporary storage of molten iron from one or more cupolas or furnaces.

Sec. 8–2—Description of Pipe

The pipe shall be made with bell and spigot ends with beads cast on, or with plain ends or such other type of ends as may be agreed upon at the time of purchase. Pipe with bell-and-spigot ends shall conform to the dimensions and weights shown in the tables given in this document. Pipe with other types of ends shall comply with the dimensions agreed upon, but in all other respects shall fulfill the specifications hereinafter given. Pipe shall be straight and shall be true circles in sections, with the inner and outer surfaces concentric. Pipe shall be cast at least 12 ft. in nominal laying length. This type of pipe is commonly made at present (1952) in 16-, 16½- and 20-ft. lengths.

Sec. 8–3—Casting of Pipe

The pipe shall be centrifugally cast in sand-lined molds and shall remain in the sand for a sufficient length of time to prevent unequal contraction during cooling.

Sec. 8–4—Quality of Iron

8–4.1. All pipe shall be made of cast iron of good quality, and of such character and so adapted in chemical composition to the thickness of the pipe to be cast, that the iron in the pipe shall be strong, tough, resilient, of even grain and soft enough for satisfactory drilling and cutting, and it shall comply with the physical specifications given in Sec. 8–17 and 8–18. The metal shall be remelted in a cupola or other suitable furnace.

8–4.2. The iron in the pipe shall not contain more than 0.90 per cent of phosphorus nor more than 0.12 per cent of sulphur. Samples for chemical analyses shall be taken by drilling completely through from skin to skin either acceptance test specimens or specimens cast for this purpose, but not to exceed three specimens per heat of approximately eight hours. In case of dispute, analyses will be determined on samples taken from the pipe in question.

Sec. 8–5—Quality of Castings

Pipe shall be smooth, free from scales, lumps, blisters, sand holes, laps and defects of every nature which unfit them for the use for which they are intended. No plugging, filling, burning-in or welding will be allowed except as permitted by the purchaser.

Sec. 8–6—Foundry Records

A record of the results of the following tests shall be made and retained for at least one year. Upon request such record will be available to the purchaser at the foundry. If written transcripts of the results of any of these tests are desired this fact shall be noted in the order for pipe, naming the tests of which transcripts are desired. The methods of testing and the dimensions of all test specimens are given in the Appendix.

8–6.1. *Chemical analyses.* Chemical analyses of each iron mixture used directly in the pouring of pipe, obtained as in Sec. 8–4.2, shall be made for silicon, sulphur, manganese, phosphorus and total carbon during the first hour and at intervals not to exceed three hours throughout the heat. If pipe are poured directly from the cupola, chemical analyses shall be made of iron from the first and from the last ladle. If the mixture is changed one or more times during a heat in order to produce a different iron, the time of taking samples shall be varied in such a way as to obtain representative tests of the iron at least at the beginning and end of each period during which the iron is intended to be constant in quality.

8–6.2. *Pouring temperatures.* The pouring temperature of the iron shall be taken at the casting ladle for each size of pipe at least once each hour.

8–6.3. *Talbot strip tests.* See Sec. 8–17.1.

8–6.4. *Test bar tests.* See Sec. 8–17.2.

8–6.5. *Periodic ring, strip and full-length bursting tests.* See Sec. 8–17 and 8–18.

Sec. 8–7—Marking Pipe

Each pipe shall have the weight and class designation conspicuously painted on it. In addition, each pipe shall have cast on it the manufacturer's mark, the year in which the pipe was cast and, when specified by the purchaser, initials not exceeding four in number. The letters and figures shall be on the outside surface of the pipe, and cast marks shall have dimensions not less than those indicated in the following table:

PIPE CENTRIFUGALLY CAST IN SAND-LINED MOLDS

Nom. Pipe Diam. *in.*	Height of Letter *in.*	Relief of Letter *in.*
3–4	$\frac{1}{2}$	$\frac{1}{16}$
6–12	$\frac{3}{4}$	$\frac{3}{32}$
14–20	$1\frac{1}{2}$	$\frac{1}{8}$
24–48	2	$\frac{1}{8}$

Sec. 8–8—Inspection by Purchaser

8–8.1. *Power of purchaser to inspect.* The purchaser shall have free access at all times to all parts of any manufacturing plant which concern the manufacture of articles to be made for him. He may inspect the material, pattern work, molding, casting, coating and lining of the pipe. The forms, sizes, uniformity and conditions of all pipe herein referred to shall be subject to his inspection and approval, and he may reject, without subjection to hydrostatic test, any pipe which is not in conformity with the specifications or drawings. Any pipe rejected shall be so marked and any marks pertaining to the purchaser shall be chipped or erased from such pipe.

8–8.2. *Manufacturer to furnish men and materials.* The manufacturer shall provide tools, testing equipment, materials, labor and facilities necessary for the required testing, inspection and weighing of the pipe at the foundry.

8–8.3. *Report of purchaser's inspection.* The purchaser shall make written report daily to the foundry office of all pipe rejected with the causes for rejection.

Sec. 8–9—Inspection and Certification by Manufacturer

Should the purchaser have no inspector at the works, the manufacturer shall, if required by the purchaser, furnish a sworn statement that the inspection and all the tests have been made and met as specified. If written transcripts of any of these test results are required, including chemical tests if desired, a request specifying the tests of which transcripts are desired shall accompany the order.

Sec. 8–10—Pipe to be Delivered Sound

All the pipe shall be delivered in all respects sound and in conformity with these specifications. The inspection shall not relieve the manufacturer of any of his obligations in this respect, and any defective pipe which may have passed the purchaser at the works or elsewhere shall be at all times liable to rejection when discovered, until the final completion and adjustment of the contract; provided, however, that the manufacturer shall not be held liable for pipe found to be damaged after they have been accepted at the agreed point of delivery, unless there shall be unmistakable evidence that the casting was originally defective or damaged before acceptance. Care shall be taken in handling the pipe not to injure the coating or lining, and no pipe or other material of any kind shall be placed in the pipe during transportation or at any other time after they have received the coating or lining.

Sec. 8–11—Cut Pipe

Defective spigot ends on pipe may be cut off in a manner which will produce a square end. Not more than 10 per cent of the total number of pipe of each size of a given order may be shipped as cut pipe. Such cut pipe when cut from 12-ft. lengths shall have a nominal laying length of not less than 11 ft.; pipe originally of 16-ft. or greater length shall not be cut more than 2 ft.

Sec. 8–12—Tolerances or Maximum Permitted Variations

8–12.1. *Pipe and socket diameters.* Outside diameters of pipe barrels and spigot ends, and inside diameters of sockets, shall be kept as nearly as practicable to the specified dimensions. The inside diameters of the sockets and the outside diameters of the spigot ends shall be tested with circular gages. Tolerances or maximum permitted variations from standard dimensions are listed below:

Nom. Pipe Diam. *in.*	Tolerances *in.*
3–12	±0.06
14–24	±0.08
30–36	±0.10
42–48	±0.12

8–12.2. *Thickness.* The minus tolerances from standard thickness of pipe and dimensions *a, b, c* and *d* of the bells are as follows:

Nom. Pipe Diam. *in.*	Minus Tolerance *in.*
3–8	0.05
10–12	0.06
14–24	0.08
30–48	0.10

Note: In pipe barrel thickness, tolerances 0.02 in. greater than those listed above shall be permissible over areas not exceeding 8 in. in length in any direction.

8–12.3. *Weight.* The weight of no single pipe shall be less than the nominal tabulated weight by more than 5 per cent for pipe 12 in. or smaller in diameter, nor by more than 4 per cent for pipe larger than 12 in. in diameter. The total weight of any order of 25 tons or more shall not be more than 2 per cent under the total nominal weight. The total excess weight to be paid for on orders of 25 tons or more shall not exceed 2 per cent of the nominal weight, and on orders of less than 25 tons shall not exceed 5 per cent of the nominal weight. An order is hereby defined as including all the pipe ordered under the terms of a specific contract or purchase order or a single order placed under the terms of a standing contract. Unless otherwise specified in the contract, a ton shall be 2,000 lb. avoirdupois.

Sec. 8–13—Cleaning and Inspecting

All pipe shall have fins and other roughnesses chipped or ground off and shall be thoroughly cleaned, checked as to dimensions and also subjected to a careful inspection and a rolling test, before being coated or lined.

Sec. 8–14—Hydrostatic Test

Each pipe shall be subjected to a hydrostatic proof test. This test may be made either before or after a hot or cold bituminous dip or paint has been applied but shall be made before the cement mortar lining or any other special lining has been applied to pipe for which such lining is specified.

The pipe shall be under the test pressure for at least one-half minute. Any pipe showing defects by leaking, sweating or otherwise shall be rejected. The test pressures shall be in accordance with the table appearing on page 5.

Sec. 8–15—Weighing

Each length of pipe shall be weighed and the weight plainly marked on the outside or inside of the bell or spigot end. Pipe shall be weighed before the application of any lining or coating other than hot or cold bituminous dip or paint.

PIPE CENTRIFUGALLY CAST IN SAND-LINED MOLDS

Table of Hydrostatic Test Pressures

Nom. Pipe Diam. *in.*	Nom. Barrel Thickness *in.*	Test Pressure *psi.*
3–12	all thicknesses	500
14	0.57 and less	400
14	0.58 and over	500
16	0.60 and less	400
16	0.61 and over	500
18	0.65 and less	400
18	0.66 and over	500
20	0.70 and less	400
20	0.71 and over	500
24	0.75 and less	400
24	0.76 and over	500
30	0.88 and less	400
30	0.89 and over	500
36	0.98 and less	400
36	0.99 and over	500
42	1.09 and less	400
42	1.10 and over	500
48	1.18 and less	400
48	1.19 and over	500

Sec. 8–16—Linings and Exterior Coatings

Any particular lining or coating which is to be applied to the pipe shall be specified in the agreement made at the time of purchase. Separate specifications for a cement-mortar lining have been provided in connection with these specifications for pipe. *See* specification ASA A21.4

No pipe or specials for waterworks service shall be furnished without protective coating unless specifically ordered by the purchaser.

Sec. 8–17—Acceptance Tests for Physical Properties

The standard acceptance tests for the physical characteristics of the pipe shall be as follows:

Sec. 8–17.1—Talbot Strip Tests

Talbot strip tests shall be used to determine the acceptability of 3-in. to 24-in. pipe for modulus of rupture and secant modulus of elasticity.

17.1.1. *Sampling.* For sampling, every run shall be divided into periods of approximately three hours each, and at least one sample shall be taken during each three-hour period. The sample for the first period of the run shall be taken during the first hour or, if casting is direct from the cupola, from the first ladle. Samples shall be taken so that each size of pipe cast for two hours or longer during the run and each mixture or source of iron used for two hours or longer during the run shall be fairly represented.

17.1.2. *Method of testing.* The method of testing Talbot strips is given in Sec. 8–A1 of the Appendix.

17.1.3. *Acceptance values.* The acceptance values for tests on Talbot strips from 3-in. to 24-in. pipe shall be as follows:

Modulus of rupture: 40,000 psi. minimum.

Secant modulus of elasticity: 10,000,000 psi. maximum.

If the modulus of elasticity exceeds 10,000,000, the modulus of rupture shall exceed 40,000 in at least the same proportion.

Sec. 8–17.2—Two-Inch Test Bar Tests

A.S.T.M. standard (A48 Bar C) 2-in. diameter by 27-in. test bar tests shall be used to determine the acceptability of 30-in. to 48-in. pipe.

From each mixture of iron used to cast pipe of 30-in. to 48-in. sizes, 2-in. diameter test bars shall be cast and tested from the first ladle of iron, and at intervals not to exceed three hours during the heat.

For the record, from every 200 lengths, but from at least one pipe of each size each week, one Talbot strip shall be cut and tested, and shall meet the requirements of Sec. 8–17.1.3.

At the manufacturer's option, Talbot strips may be tested instead of test bars. If Talbot strips are tested, they shall meet the requirements of Sec. 8–17.1.3.

Test bars shall have a minimum breaking load of 6,000 lb. and a deflection of 0.15 in. plus 0.01 in. for each 500 lb. that the breaking load exceeds 6,000 lb.

These test bar values apply only to thickness classes 21 to 25 in pipe designed with an 18,000-psi. tensile strength in bursting and a 40,000-psi. modulus of rupture of the ring.

Sec. 8–18—Periodic Ring Tests and Full-Length Bursting Tests

The manufacturer shall periodically make such bursting tests and ring tests in conjunction with strip tests that he can certify the design values of the modulus of rupture (40,000 psi.) and the tensile strength of the iron in the pipe (18,000 psi.). These tests shall be made in accordance with dimensions and methods given in the Appendix.

Pipe for these periodic ring and bursting tests shall be so selected that they will be representative of the sizes and various thicknesses of each size cast. Ring tests shall not be made on 3-in. and 4-in. pipe.

Tests of Talbot strips cut from the ring, as provided in the Appendix, shall be made in conjunction with ring and bursting tests. At least three Talbot strips shall be tested from each burst pipe and one of these strips shall come from the ring. For pipe for which rings less than $10\frac{1}{2}$ in. long are used, the Talbot strip shall come from parts other than the ring.

Tests and records shall include the modulus of rupture of each strip and ring and also the modulus of elasticity of each strip and of each ring 12 in. and larger; the breaking load and deflection of each test bar shall also be included.

At the purchaser's request, the manufacturer shall furnish a written transcript of ring and bursting tests and tests on Talbot strips made in connection therewith for a period not exceeding one year and for such sizes as requested.

Unless there is a record of satisfactory tests equivalent to those hereinafter described, extending to within three months or less of the time to begin manufacture of an order for pipe of any size from 30 in. to 48 in., the producer shall test three pipe from the first day's production and one each succeeding day for the next four days. If all the tests meet the specifications, he shall test one pipe every five days for the next three weeks, and if all those meet the specifications, he shall test one pipe each month. In the case of a failure of any test, the same series of tests as above specified shall be repeated. If there is a lapse of more than one month in the manufacture of such pipe, the monthly test shall be made on a pipe from the first day's run. If the tests are all satisfactory, the number of pipe tested shall not exceed 3 per cent of the order.

Sec. 8–19—Additional Tests Required by Purchaser

If more or other tests than those provided in these specifications are required by the purchaser, such tests shall be specified in the invitation for bids.

Sec. 8–20—Defective Specimens and Retests

8–20.1. If any test specimen shows defective machining or lack of continuity of metal, it may be discarded and replaced by another specimen. If any sound test specimen fails to meet the specified requirements, the purchaser may permit a retest on two additional sound specimens from pipe cast in the same period as the specimen which failed; both of the additional specimens shall meet the prescribed tests to be acceptable.

8–20.2. Test bars may be cast in pairs and at least one bar from each pair shall be tested, but the manufacturer shall have the right to test both bars, in which case the better bar shall be taken as representative.

8–20.3. If a routine test bar test fails to meet the requirements, the manufacturer shall have the right to substitute two Talbot strips cut from a pipe cast with iron represented by the failed test bar test. If both strip tests meet the requirements, the pipe for that period shall be acceptable.

Sec. 8–21—Rejection of Pipe

If any routine chemical analysis fails to meet the chemical requirements of Sec. 8–4.2, or if any acceptance test fails to meet the requirements of Sec. 8–17.1.3, 8–17.2 and 8–20, the pipe cast in the period shall be rejected except as subject to the provisions of Sec. 8–22.

Sec. 8–22—Limiting Rejection

The manufacturer may limit the amount of rejection by making similar additional tests of pipe of the same size as that rejected until the rejected lot is bracketed in order of manufacture by two acceptable tests. If a period is rejected, the acceptability of pipe of different sizes from that rejected may be established by making the routine acceptance tests for these sizes.

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Appendix*

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Tables †

* This Appendix is a part of ASA A21.8—American Standard Specifications for Cast Iron Pipe Centrifugally Cast in Sand-lined Molds, for Water or Other Liquids.

† Data on thicknesses required for greater depths of cover and conditions of laying other than those assumed in the following tables will be found in Appendix B of ASA A21.1—American Recommended Practice Manual for the Computation of Strength and Thickness of Cast Iron Pipe.

Users of the following tables are cautioned to select fittings having proper socket dimensions and thicknesses suited to the pressures. Pipe specified in these tables have outside diameters which will chamber correctly with existing standards for pipe and fittings.

PIPE CENTRIFUGALLY CAST IN SAND-LINED MOLDS

Sec. 8–A1—Talbot Strip Tests

Talbot strips (Fig. 8.1) shall be machined longitudinally from each pipe specimen selected for testing by this method. These Talbot strips may be cut from a part of the ring little stressed in the ring test—i.e., near one of the elements marked *a* in the illustration of the ring test (Fig. 8.2). The strips in any case will be in cross section as indicated in Fig. 8.1—i.e., will have for their width the thickness of the pipe and for their depth, 0.50 in. Their length shall be at least $10\frac{1}{2}$ in. These strips shall be tested as beams on supports 10 in. apart with loads applied perpendicularly to the machined faces at two points $3\frac{1}{3}$ in. from the supports. The breaking load and

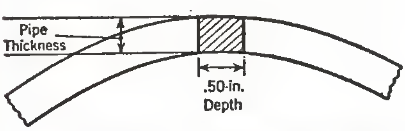

Fig. 8.1. Position From Which Talbot Strip Is Cut

the deflection shall be observed and recorded.

The strip shall be accurately calipered at the point of rupture and the modulus of rupture, *R*, shall be calculated by the usual beam formula, which for this case reduces to the expression:

$$R = \frac{10\,W}{td^2}$$

The secant modulus of elasticity, E_s, in pounds per square inch, shall be computed by the formula:

$$E_s = \frac{21.3R}{dy}$$

In the above formulas, *R* is the modulus of rupture (psi.), E_s is the secant modulus of elasticity (psi.), *W* is the breaking load (lb.), *d* is the depth (in.) of the strip (intended to be 0.50 in.), *t* is the width (in.) of the strip (pipe thickness) and *y* is the deflection (in.) of the strip at the center at breaking load.

Sec. 8–A2—Ring Tests

The maximum length of any ring shall not exceed 12 in.; for pipe 14 in. and larger, the minimum length shall be $10\frac{1}{2}$ in.; for pipe 12 in. and smaller, the minimum length shall be one-half the nominal diameter of the pipe. Each ring shall be tested by the three-edge bearing method as indicated in Fig. 8.2.

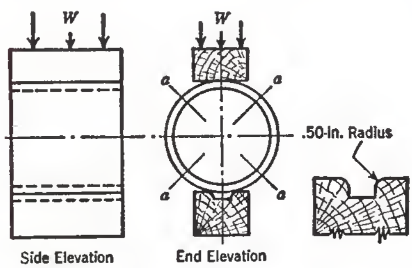

Fig. 8.2. Assembly for Ring Test

The lower bearing for the ring shall consist of two strips with vertical sides having their interior top corners rounded to a radius of approximately $\frac{1}{2}$ in. The strips shall be of hard wood or of metal. If of metal, a piece of fabric or leather approximately $\frac{3}{16}$ in. thick shall be laid over them. They shall be straight and shall be securely fastened to a rigid block, with their interior vertical faces the following distances apart:

Nom. Pipe Diam. *in.*	Bearing Strip Spacing *in.*
3–12	$\frac{1}{2}$
14–24	1
30–48	2

The upper bearing shall be an oak block, straight and true from end to end. The upper and lower bearings shall extend the full length of the ring. The ring shall be placed symmetrically between the two bearings, and the center of application of the load shall be so placed that the vertical deformation at the two ends of the ring shall be approximately equal. If the ring is not uniform in thickness, it shall be so placed that the thick and thin portions are near the ends of the horizontal diameter.

A record of the breaking load and the vertical deformation of each ring tested shall be made. The modulus of rupture and modulus of elasticity are computed from the formulas:

$$R = 0.954 \frac{W(d + t)}{bt^2}$$

$$E = \frac{0.225W(d + t)^3}{bt^3y} = \frac{0.236R(d + t)^2}{ty}$$

in which R is the modulus of rupture (psi.), W is the breaking load (lb.), d is the average inside diameter (in.) of the ring, t is the average thickness (in.) of metal along the line of fracture, b is the length (in.) of the ring, E is the modulus of elasticity (psi.) and y is the vertical deformation (in.) of the ring at the center.

Sec. 8–A3—Full-Length Bursting Tests

The bursting tensile strength shall be determined by testing full-length pipe (less the amount cut off for ring and strip test specimens) to destruction by hydraulic pressure. Bells may be removed to facilitate testing. A suitable means for holding the end thrust shall be used which will not subject the pipe to endwise tension or compression, or other parasitic stresses. A calibrated pressure gage shall be used for determining the bursting pressure. This gage shall be connected to the interior of the test pipe by a separate connection from that which supplies water for the test. The unit tensile strength in bursting shall be obtained by the use of the formula:

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

in which S is the bursting tensile strength (psi.) of the iron, P is the internal pressure (psi.) at bursting, d is the average inside diameter (in.) of the pipe and t is the minimum average thickness (in.) of the pipe along the principal line of break.

Measurements of thickness shall be taken along the principal line of break at 1-ft. intervals.

The minimum average thickness along the principal line of break shall be obtained by averaging the measurements at the thinnest section at a weight of two and at the adjacent sections on each side at a weight of one each; or, if the thinnest section is at the end of the break, by averaging this thinnest-section measurement at a weight of two and the measurements of the adjacent section and the next section at a weight of one each.

Sec. 8–A4—Test Bars

8–A4.1. *Dimensions.* Test bars for pipe of 30-in. to 48-in. diameter shall be 2 in. in diameter and not less than 26 in. long. Individual test bars may vary as much as 3 per cent from the standard diameter.

8–A4.2. *Method of casting.* The bars shall be cast vertically in well faced, dry sand molds provided with a suitable pouring basin and mounted on a suitable refractory foundation. Metal for the bars shall be obtained by using a small heated ladle taking its metal from the main ladle from which the pipe is to be poured. The metal shall be taken after all alloys and other additional metal, except cast-iron pipe scrap for cooling, have been added to the main ladle and become melted. The bars shall not be removed from the mold before they have cooled to 500°F.

8–A4.3. *Method of testing.* The bars shall be broken as beams by placing them on supports 24 in. apart and applying the load at the center of the span. The breaking load and the corresponding deflection shall be observed and recorded.

8–A4.4. *Correcting observed breaking loads and deflections.* The bars shall be measured at the point of application of the load and the results corrected to standard dimensions by the conventional beam formula (for bars of 2-in. diameter):

$$\text{Corrected } W = \text{Observed } W \times \frac{8}{d_h d_v^2}$$

$$\text{Corrected } y = \text{Observed } y \times \frac{d_v}{2}$$

in which W is the breaking load (lb.), d_h is the measured horizontal diameter (in.), d_v is the measured vertical diameter (in.) and y is the deflection (in.) at breaking.

Sec. 8–A5—Deflection Measurements

All deflection measurements required by these specifications shall be that of the specimen and shall not include any compression of the supports or loading blocks, or backlash or distortion of the testing machine.

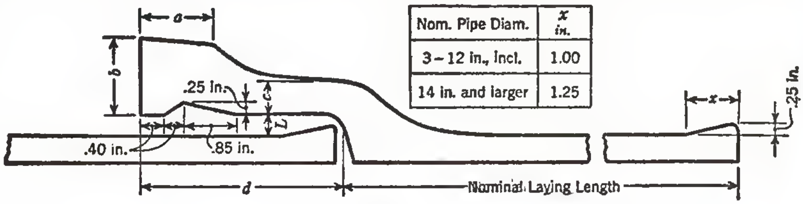

TABLE 8.1

STANDARD DIMENSIONS OF BELLS, SOCKETS, SPIGOT BEADS AND OUTSIDE DIAMETERS—AND WEIGHTS OF BELLS AND SPIGOT BEADS—OF PIPE CENTRIFUGALLY CAST IN SAND-LINED MOLDS

Nom. Diam.	Pipe Thickness		Pipe Outside Diam.	Dimensions of Bells						Weight of Bell and Spigot Bead
	From	To		Socket Diam.	Thickness of Joint L	Socket Depth d	a	b	c	
	in.									*lb.*
3	0.32	0.38	3.96	4.76	0.40	3.50	1.25	1.25	0.52	15
4	0.35	0.44	4.80	5.60	0.40	3.50	1.25	1.30	0.55	19
	0.35	0.44	5.00	5.80	0.40	3.50	1.25	1.30	0.55	20
6	0.38	0.41	6.90	7.70	0.40	3.50	1.38	1.35	0.48	26
	0.44	0.48	6.90	7.70	0.40	3.50	1.38	1.35	0.64	29
	0.38	0.41	7.10	7.90	0.40	3.50	1.38	1.35	0.48	27
	0.44	0.52	7.10	7.90	0.40	3.50	1.38	1.35	0.64	30
8	0.41	0.44	9.05	9.85	0.40	4.00	1.38	1.45	0.52	37
	0.48	0.56	9.05	9.85	0.40	4.00	1.38	1.45	0.68	43
	0.41	0.44	9.30	10.10	0.40	4.00	1.38	1.45	0.52	38
	0.48	0.60	9.30	10.10	0.40	4.00	1.38	1.45	0.68	44
10	0.44	0.48	11.10	11.90	0.40	4.00	1.50	1.55	0.56	50
	0.52	0.60	11.10	11.90	0.40	4.00	1.50	1.55	0.73	56
	0.44	0.48	11.40	12.20	0.40	4.00	1.50	1.55	0.56	51
	0.52	0.65	11.40	12.20	0.40	4.00	1.50	1.55	0.73	58
12	0.48	0.52	13.20	14.00	0.40	4.00	1.50	1.60	0.60	63
	0.56	0.65	13.20	14.00	0.40	4.00	1.50	1.60	0.79	71
	0.48	0.52	13.50	14.30	0.40	4.00	1.50	1.60	0.60	64
	0.56	0.70	13.50	14.30	0.40	4.00	1.50	1.60	0.79	73
	0.76		13.50	14.30	0.40	4.00	1.50	1.60	0.95	81
14	0.48	0.55	15.30	16.10	0.40	4.00	1.50	1.70	0.64	79
	0.59	0.69	15.30	16.10	0.40	4.00	1.50	1.70	0.85	88
	0.48	0.55	15.65	16.45	0.40	4.00	1.50	1.70	0.64	80
	0.59	0.75	15.65	16.45	0.40	4.00	1.50	1.70	0.85	90
	0.81		15.65	16.45	0.40	4.00	1.50	1.70	1.01	99

PIPE CENTRIFUGALLY CAST IN SAND-LINED MOLDS

TABLE 8.I (contd.)

STANDARD DIMENSIONS OF BELLS, SOCKETS, SPIGOT BEADS AND OUTSIDE DIAMETERS—AND WEIGHTS OF BELLS AND SPIGOT BEADS—OF PIPE CENTRIFUGALLY CAST IN SAND-LINED MOLDS

Nom. Diam.	Pipe Thickness		Pipe Outside Diam.	Dimensions of Bells						Weight of Bell and Spigot Bead
	From	To		Socket Diam.	Thickness of Joint L	Socket Depth d	a	b	c	
	in.									lb.
16	0.50	0.58	17.40	18.40	0.50	4.00	1.75	1.75	0.67	96
	0.63	0.73	17.40	18.40	0.50	4.00	1.75	1.75	0.89	108
	0.50	0.58	17.80	18.80	0.50	4.00	1.75	1.75	0.67	98
	0.63	0.79	17.80	18.80	0.50	4.00	1.75	1.75	0.89	110
	0.85		17.80	18.80	0.50	4.00	1.75	1.75	1.06	122
18	0.54	0.63	19.50	20.50	0.50	4.00	1.75	1.80	0.72	115
	0.68	0.79	19.50	20.50	0.50	4.00	1.75	1.80	0.95	128
	0.54	0.63	19.92	20.92	0.50	4.00	1.75	1.80	0.72	117
	0.68	0.85	19.92	20.92	0.50	4.00	1.75	1.80	0.95	130
	0.92		19.92	20.92	0.50	4.00	1.75	1.80	1.14	145
20	0.57	0.67	21.60	22.60	0.50	4.00	1.75	1.90	0.76	135
	0.72	0.84	21.60	22.60	0.50	4.00	1.75	1.90	1.01	149
	0.57	0.67	22.06	23.06	0.50	4.00	1.75	1.90	0.76	137
	0.72	0.91	22.06	23.06	0.50	4.00	1.75	1.90	1.01	152
	0.98		22.06	23.06	0.50	4.00	1.75	1.90	1.21	171
24	0.63	0.73	25.80	26.80	0.50	4.00	2.00	2.05	0.85	171
	0.79	0.92	25.80	26.80	0.50	4.00	2.00	2.05	1.04	191
	0.63	0.73	26.32	27.32	0.50	4.00	2.00	2.05	0.85	174
	0.79	0.92	26.32	27.32	0.50	4.00	2.00	2.05	1.04	194
	0.99	1.07	26.32	27.32	0.50	4.00	2.00	2.05	1.29	221
30	0.73	0.85	32.00	33.00	0.50	4.50	2.00	2.25	0.97	254
	0.92	1.07	32.00	33.00	0.50	4.50	2.00	2.25	1.20	280
	1.16		32.00	33.00	0.50	4.50	2.00	2.25	1.49	318
36	0.81	0.94	38.30	39.30	0.50	4.50	2.00	2.45	1.09	347
	1.02	1.19	38.30	39.30	0.50	4.50	2.00	2.45	1.35	390
	1.29	1.39	38.30	39.30	0.50	4.50	2.00	2.45	1.67	445
42	0.90	1.05	44.50	45.50	0.50	5.00	2.00	2.65	1.20	450
	1.13	1.32	44.50	45.50	0.50	5.00	2.00	2.65	1.48	510
	1.43	1.54	44.50	45.50	0.50	5.00	2.00	2.65	1.83	585
48	0.98	1.14	50.80	51.80	0.50	5.00	2.00	2.85	1.29	556
	1.23	1.44	50.80	51.80	0.50	5.00	2.00	2.85	1.61	634
	1.56	1.68	50.80	51.80	0.50	5.00	2.00	2.85	1.99	735

TABLE 8.2

STANDARD THICKNESSES, DIAMETERS AND WEIGHTS OF PIPE CENTRIFUGALLY CAST IN SAND-LINED MOLDS

Nom. Diam. *in.*	Thickness Class	Thickness *in.*	Outside Diam. *in.*	Inside Diam. *in.*	Weight of Barrel per Foot *lb.*	Weight of Bell and Spigot Bead *lb.*	Weight (*lb.*) Based on					
							16-ft. Laying Length		16½-ft. Laying Length		20-ft. Laying Length	
							Per Length*	Avg. per Foot†	Per Length*	Avg. per Foot†	Per Length*	Avg. per Foot†
3	22	0.32	3.96	3.32	11.4	15	195	12.4	205	12.3		
	23	0.35	3.96	3.26	12.4	15	215	13.4	220	13.3		
	24	0.38	3.96	3.20	13.3	15	230	14.3	235	14.2		
4	22	0.35	4.80	4.10	15.3	19	265	16.5	270	16.4		
	23	0.38	4.80	4.04	16.5	19	285	17.7	290	17.6		
	24	0.41	4.80	3.98	17.6	19	300	18.8	310	18.7		
	25	0.44	4.80	3.92	18.8	19	320	20.0	330	19.9		
	22	0.35	5.00	4.30	16.0	20	275	17.2	285	17.1		
	23	0.38	5.00	4.24	17.2	20	295	18.5	305	18.4		
	24	0.41	5.00	4.18	18.4	20	315	19.7	325	19.6		
	25	0.44	5.00	4.12	19.7	20	335	21.0	345	20.9		
6	22	0.38	6.90	6.14	24.3	26	415	25.9	425	25.8		
	23	0.41	6.90	6.08	26.1	26	445	27.7	455	27.6		
	24	0.44	6.90	6.02	27.9	29	475	29.7	490	29.6		
	25	0.48	6.90	5.94	30.2	29	510	32.0	525	31.9		
	22	0.38	7.10	6.34	25.0	27	425	26.7	440	26.6		
	23	0.41	7.10	6.28	26.9	27	455	28.5	470	28.4		
	24	0.44	7.10	6.22	28.7	30	490	30.6	505	30.5		
	25	0.48	7.10	6.14	31.1	30	530	33.0	545	32.9		
	26	0.52	7.10	6.06	33.5	30	565	35.4	585	35.3		
8	22	0.41	9.05	8.23	34.7	37	590	37.0	610	36.9		
	23	0.44	9.05	8.17	37.1	37	630	39.5	650	39.4		
	24	0.48	9.05	8.09	40.3	43	690	43.0	710	42.9		
	25	0.52	9.05	8.01	43.5	43	740	46.2	760	46.1		
	26	0.56	9.05	7.93	46.6	43	790	49.3	810	49.2		
	22	0.41	9.30	8.48	35.7	38	610	38.1	625	38.0		
	23	0.44	9.30	8.42	38.2	38	650	40.6	670	40.5		
	24	0.48	9.30	8.34	41.5	44	710	44.3	730	44.2		
	25	0.52	9.30	8.26	44.8	44	760	47.6	785	47.5		
	26	0.56	9.30	8.18	48.0	44	810	50.7	835	50.6		
	27	0.60	9.30	8.10	51.2	44	865	54.0	890	53.9		

* Including bell and spigot bead. Calculated weight of pipe rounded off to nearest 5 lb.
† Average weight per foot based on calculated weight of pipe before rounding.

TABLE 8.2 (contd.)

STANDARD THICKNESSES, DIAMETERS AND WEIGHTS OF PIPE CENTRIFUGALLY CAST IN SAND-LINED MOLDS

Nom. Diam. *in.*	Thickness Class	Thickness *in.*	Outside Diam. *in.*	Inside Diam. *in.*	Weight of Barrel per Foot *lb.*	Weight of Bell and Spigot Bead *lb.*	Weight (*lb.*) Based on 16-ft. Laying Length: Per Length*	16-ft. Laying Length: Avg. per Foot†	16½-ft. Laying Length: Per Length*	16½-ft. Laying Length: Avg. per Foot†	20-ft. Laying Length: Per Length*	20-ft. Laying Length: Avg. per Foot†
10	22	0.44	11.10	10.22	46.0	50	785	49.1	810	49.0		
	23	0.48	11.10	10.14	50.0	50	850	53.1	875	53.0		
	24	0.52	11.10	10.06	53.9	56	920	57.4	945	57.3		
	25	0.56	11.10	9.98	57.9	56	980	61.4	1,010	61.3		
	26	0.60	11.10	9.90	61.8	56	1,045	65.3	1,075	65.2		
	22	0.44	11.40	10.52	47.3	51	810	50.5	830	50.4		
	23	0.48	11.40	10.44	51.4	51	875	54.6	900	54.5		
	24	0.52	11.40	10.36	55.5	58	945	59.1	975	59.0		
	25	0.56	11.40	10.28	59.5	58	1,010	63.1	1,040	63.0		
	26	0.60	11.40	10.20	63.5	58	1,075	67.1	1,105	67.0		
	27	0.65	11.40	10.10	68.5	58	1,155	72.1	1,190	72.0		
12	22	0.48	13.20	12.24	59.8	63	1,020	63.7	1,050	63.6	1,260	63.0
	23	0.52	13.20	12.16	64.6	63	1,095	68.5	1,130	68.4	1,355	67.8
	24	0.56	13.20	12.08	69.4	71	1,180	73.8	1,215	73.7	1,460	73.0
	25	0.60	13.20	12.00	74.1	71	1,255	78.5	1,295	78.4	1,555	77.7
	26	0.65	13.20	11.90	80.0	71	1,350	84.4	1,390	84.3	1,670	83.6
	22	0.48	13.50	12.54	61.3	64	1,045	65.3	1,075	65.2	1,290	64.5
	23	0.52	13.50	12.46	66.2	64	1,125	70.2	1,155	70.1	1,390	69.4
	24	0.56	13.50	12.38	71.0	73	1,210	75.6	1,245	75.4	1,495	74.7
	25	0.60	13.50	12.30	75.9	73	1,285	80.4	1,325	80.3	1,590	79.6
	26	0.65	13.50	12.20	81.9	73	1,385	86.5	1,425	86.3	1,710	85.6
	27	0.70	13.50	12.10	87.8	73	1,480	92.4	1,520	92.2	1,830	91.4
	28	0.76	13.50	11.98	94.9	81	1,600	100.0	1,645	99.8	1,980	99.0
14	21	0.48	15.30	14.34	69.7	79	1,195	74.6	1,230	74.5	1,475	73.7
	22	0.51	15.30	14.28	73.9	79	1,260	78.8	1,300	78.7	1,555	77.8
	23	0.55	15.30	14.20	79.5	79	1,350	84.4	1,390	84.3	1,670	83.4
	24	0.59	15.30	14.12	85.1	88	1,450	90.6	1,490	90.4	1,790	89.4
	25	0.64	15.30	14.02	92.0	88	1,560	97.5	1,605	97.3	1,930	96.4
	26	0.69	15.30	13.92	98.8	88	1,670	104.3	1,720	104.1	2,065	103.2
	21	0.48	15.65	14.69	71.4	80	1,220	76.4	1,260	76.3	1,510	75.4
	22	0.51	15.65	14.63	75.7	80	1,290	80.7	1,330	80.5	1,595	79.7
	23	0.55	15.65	14.55	81.4	80	1,380	86.4	1,425	86.3	1,710	85.4
	24	0.59	15.65	14.47	87.1	90	1,485	92.7	1,525	92.5	1,830	91.5
	25	0.64	15.65	14.37	94.2	90	1,595	99.8	1,645	99.7	1,975	98.7
	26	0.69	15.65	14.27	101.2	90	1,710	106.8	1,760	106.7	2,115	105.7
	27	0.75	15.65	14.15	109.5	90	1,840	115.1	1,895	114.9	2,280	114.0
	28	0.81	15.65	14.03	117.8	99	1,985	124.0	2,045	123.8	2,455	122.8

* Including bell and spigot bead. Calculated weight of pipe rounded off to nearest 5 lb.
† Average weight per foot based on calculated weight of pipe before rounding.

TABLE 8.2 (contd.)

STANDARD THICKNESSES, DIAMETERS AND WEIGHTS OF PIPE CENTRIFUGALLY CAST IN SAND-LINED MOLDS

Nom. Diam. *in.*	Thickness Class	Thickness *in.*	Outside Diam. *in.*	Inside Diam. *in.*	Weight of Barrel per Foot *lb.*	Weight of Bell and Spigot Bead *lb.*	Weight (*lb.*) Based on 16-ft. Laying Length: Per Length*	16-ft. Laying Length: Avg. per Foot†	16½-ft. Laying Length: Per Length*	16½-ft. Laying Length: Avg. per Foot†	20-ft. Laying Length: Per Length*	20-ft. Laying Length: Avg. per Foot†
16	21	0.50	17.40	16.40	82.8	96	1,420	88.8	1,460	88.6	1.750	87.6
	22	0.54	17.40	16.32	89.2	96	1.525	95.2	1.570	95.0	1.880	94.0
	23	0.58	17.40	16.24	95.6	96	1.625	101.6	1.675	101.4	2,010	100.4
	24	0.63	17.40	16.14	103.6	108	1.765	110.4	1.815	110.1	2.180	108.9
	25	0.68	17.40	16.04	111.4	108	1,890	118.2	1,945	117.9	2.335	116.7
	26	0.73	17.40	15.94	119.3	108	2.015	126.0	2,075	125.8	2.495	124.7
	21	0.50	17.80	16.80	84.8	98	1.455	90.9	1.495	90.7	1,795	89.7
	22	0.54	17.80	16.72	91.4	98	1.560	97.5	1.605	97.3	1,925	96.3
	23	0.58	17.80	16.64	97.9	98	1,665	104.0	1,715	103.8	2,055	102.8
	24	0.63	17.80	16.54	106.0	110	1.805	112.9	1,860	112.7	2.230	111.4
	25	0.68	17.80	16.44	114.1	110	1.935	121.0	1,995	120.8	2,390	119.4
	26	0.73	17.80	16.34	122.1	110	2,065	129.0	2.125	128.8	2,550	127.6
	27	0.79	17.80	16.22	131.7	110	2,215	138.5	2,285	138,4	2.745	137,2
	28	0.85	17.80	16.10	141.2	122	2,380	148.8	2.450	148.6	2.945	147.3
18	21	0.54	19.50	18.42	100.4	115	1,720	107.6	1.770	107.4	2,125	106.2
	22	0.58	19.50	18.34	107.6	115	1,835	114.8	1,890	114.6	2.265	113.3
	23	0.63	19.50	18.24	116.5	115	1,980	123.7	2.035	123.4	2,445	122.2
	24	0.68	19.50	18.14	125.4	128	2.135	133.4	2.195	133.1	2.635	131.7
	25	0.73	19.50	18.04	134.3	128	2,275	142.3	2,345	142.1	2.815	140.7
	26	0.79	19.50	17.92	144.9	128	2.445	152.9	2,520	152.7	3.025	151.3
	21	0.54	19.92	18.84	102.6	117	1.760	109.9	1.810	109.7	2.170	108.4
	22	0.58	19.92	18.76	109.9	117	1.875	117.2	1.930	117.0	2.315	115.8
	23	0.63	19.92	18.66	119.1	117	2,025	126.5	2,080	126.2	2,500	125.0
	24	0.68	19.92	18.56	128.2	130	2.180	136.3	2,245	136.1	2,695	134.7
	25	0.73	19.92	18.46	137.3	130	2.325	145.4	2.395	145.2	2,875	143.7
	26	0.79	19.92	18.34	148.1	130	2.500	156.2	2.575	156.1	3,090	154.6
	27	0.85	19.92	18.22	158.9	130	2,670	167.0	2.750	166.8	3.310	165.4
	28	0.92	19.92	18.08	171.3	145	2,885	180.4	2.970	180.1	3.570	178.6
20	21	0.57	21.60	20.46	117.5	135	2,015	125.9	2.075	125.7	2.485	124.2
	22	0.62	21.60	20.36	127.5	135	2,175	135.9	2.240	135.7	2,685	134.2
	23	0.67	21.60	20.26	137.5	135	2,335	145.9	2.405	145.7	2,885	144.2
	24	0.72	21.60	20.16	147.4	149	2,505	156.7	2.580	156.4	3,095	154.7
	25	0.78	21.60	20.04	159.2	149	2,695	168.5	2.775	168.2	3,335	166.7
	26	0.84	21.60	19.92	170.9	149	2,885	180.2	2,970	179.9	3,565	178.3

* Including bell and spigot bead. Calculated weight of pipe rounded off to nearest 5 lb.
† Average weight per foot based on calculated weight of pipe before rounding.

TABLE 8.2 (contd.)

STANDARD THICKNESSES, DIAMETERS AND WEIGHTS OF PIPE CENTRIFUGALLY CAST IN SAND-LINED MOLDS

Nom. Diam. *in.*	Thickness Class	Thickness *in.*	Outside Diam. *in.*	Inside Diam. *in.*	Weight of Barrel per Foot *lb.*	Weight of Bell and Spigot Bead *lb.*	Weight (*lb.*) Based on 16-ft. Laying Length: Per Length*	16-ft. Laying Length: Avg. per Foot†	16½-ft. Laying Length: Per Length*	16½-ft. Laying Length: Avg. per Foot†	20-ft. Laying Length: Per Length*	20-ft. Laying Length: Avg. per Foot†
20	21	0.57	22.06	20.92	120.1	137	2,060	128.7	2,120	128.4	2,540	127.0
	22	0.62	22.06	20.82	130.3	137	2,220	138.9	2,285	138.6	2,745	137.2
	23	0.67	22.06	20.72	140.5	137	2,385	149.1	2,455	148.8	2,945	147.3
	24	0.72	22.06	20.62	150.6	152	2,560	160.1	2,635	159.8	3,165	158.2
	25	0.78	22.06	20.50	162.7	152	2,755	172.2	2,835	171.9	3,405	170.3
	26	0.84	22.06	20.38	174.7	152	2,945	184.2	3,035	184.0	3,645	182.3
	27	0.91	22.06	20.24	188.7	152	3,170	198.2	3,265	198.0	3,925	196.3
	28	0.98	22.06	20.10	202.5	171	3,410	213.2	3,510	212.8	4,220	211.0
24	21	0.63	25.80	24.54	155.4	171	2,655	166.0	2,735	165.8	3,280	164.0
	22	0.68	25.80	24.44	167.4	171	2,850	178.1	2,935	177.8	3,520	176.0
	23	0.73	25.80	24.34	179.4	171	3,040	190.1	3,130	189.8	3,760	188.0
	24	0.79	25.80	24.22	193.7	191	3,290	205.6	3,385	205.3	4,065	203.2
	25	0.85	25.80	24.10	207.9	191	3,515	219.8	3,620	219.5	4,350	217.4
	26	0.92	25.80	23.96	224.4	191	3,780	236.3	3,895	236.0	4,680	234.0
	21	0.63	26.32	25.06	158.6	174	2,710	169.5	2,790	169.1	3,345	167.3
	22	0.68	26.32	24.96	170.9	174	2,910	181.8	2,995	181.4	3,590	179.6
	23	0.73	26.32	24.86	183.1	174	3,105	194.0	3,195	193.6	3,835	191.8
	24	0.79	26.32	24.74	197.7	194	3,355	209.8	3,455	209.5	4,150	207.4
	25	0.85	26.32	24.62	212.2	194	3,590	224.3	3,695	224.0	4,440	221.9
	26	0.92	26.32	24.48	229.0	194	3,860	241.1	3,970	240.7	4,775	238.7
	27	0.99	26.32	24.34	245.8	221	4,155	259.6	4,275	259.2	5,135	256.8
	28	1.07	26.32	24.18	264.8	221	4,460	278.6	4,590	278.2	5,515	275.8
30	21	0.73	32.00	30.54	223.7	254	3,835	239.6	3,945	239.1	4,730	236.4
	22	0.79	32.00	30.42	241.7	254	4,120	257.6	4,240	257.1	5,090	254.4
	23	0.85	32.00	30.30	259.5	254	4,405	275.4	4,535	274.9	5,445	272.2
	24	0.92	32.00	30.16	280.3	280	4,765	297.8	4,905	297.3	5,885	294.3
	25	0.99	32.00	30.02	300.9	280	5,095	318.4	5,245	317.9	6,300	314.9
	26	1.07	32.00	29.86	324.4	280	5,470	341.9	5,635	341.4	6,770	338.4
	27	1.16	32.00	29.68	350.7	318	5,930	370.6	6,105	370.0	7,330	366.6

* Including bell and spigot bead. Calculated weight of pipe rounded off to nearest 5 lb.
† Average weight per foot based on calculated weight of pipe before rounding.

TABLE 8.2 (contd.)

STANDARD THICKNESSES, DIAMETERS AND WEIGHTS OF PIPE CENTRIFUGALLY CAST IN SAND-LINED MOLDS

Nom. Diam. *in.*	Thickness Class	Thickness *in.*	Outside Diam. *in.*	Inside Diam. *in.*	Weight of Barrel per Foot *lb.*	Weight of Bell and Spigot Bead *lb.*	Weight (*lb.*) Based on					
							16-ft. Laying Length		16½-ft. Laying Length		20-ft. Laying Length	
							Per Length*	Avg. per Foot†	Per Length*	Avg. per Foot†	Per Length*	Avg. per Foot†
36	21	0.81	38.30	36.68	297.7	347	5,110	319.4				
	22	0.87	38.30	36.56	319.2	347	5,455	340.9				
	23	0.94	38.30	36.42	344.2	347	5,855	365.9				
	24	1.02	38.30	36.26	372.7	390	6,355	397.1				
	25	1.10	38.30	36.10	401.1	390	6,810	425.5				
	26	1.19	38.30	35.92	432.9	390	7,315	457.3				
	27	1.29	38.30	35.72	468.0	445	7,935	495.8				
	28	1.39	38.30	35.52	502.9	445	8,490	530.7				
42	21	0.90	44.50	42.70	384.6	450	6,605	412.7				
	22	0.97	44.50	42.56	413.9	450	7,070	442.0				
	23	1.05	44.50	42.40	447.2	450	7,605	475.3				
	24	1.13	44.50	42.24	480.4	510	8,195	512.3				
	25	1.22	44.50	42.06	517.6	510	8,790	549.5				
	26	1.32	44.50	41.86	558.7	510	9,450	590.6				
	27	1.43	44.50	41.64	603.7	585	10,245	640.3				
	28	1.54	44.50	41.42	648.5	585	10,960	685.1				
48	21	0.98	50.80	48.84	478.6	556	8,215	513.4				
	22	1.06	50.80	48.68	516.8	556	8,825	551.6				
	23	1.14	50.80	48.52	554.9	556	9,435	589.6				
	24	1.23	50.80	48.34	597.6	634	10,195	637.2				
	25	1.33	50.80	48.14	644.9	634	10,950	684.5				
	26	1.44	50.80	47.92	696.7	634	11,780	736.3				
	27	1.56	50.80	47.68	752.9	735	12,780	798.8				
	28	1.68	50.80	47.44	808.9	735	13,675	854.8				

* Including bell and spigot bead. Calculated weight of pipe rounded off to nearest 5 lb.
† Average weight per foot based on calculated weight of pipe before rounding.

PIPE CENTRIFUGALLY CAST IN SAND-LINED MOLDS

TABLE 8.3.

STANDARD THICKNESSES AND WEIGHTS OF PIPE CENTRIFUGALLY CAST IN SAND-LINED MOLDS*

Size *in.*	Thickness *in.*	Outside Diam. *in.*	Weight (*lb.*) Based on 16-ft. Laying Length: Avg. per Foot†	16-ft. Laying Length: Per Length‡	16½-ft. Laying Length: Avg. per Foot†	16½-ft. Laying Length: Per Length‡	20-ft. Laying Length: Avg. per Foot†	20-ft. Laying Length: Per Length‡
Class 50—50-psi. Pressure—115-ft. Head								
3	0.32	3.96	12.4	195	12.3	205		
4	0.35	4.80	16.5	265	16.4	270		
6	0.38	6.90	25.9	415	25.8	425		
8	0.41	9.05	37.0	590	36.9	610		
10	0.44	11.10	49.1	785	49.0	810		
12	0.48	13.20	63.7	1,020	63.6	1,050	63.0	1,260
14	0.48	15.30	74.6	1,195	74.5	1,230	73.7	1,475
16	0.54	17.40	95.2	1,525	95.0	1,570	94.0	1,880
18	0.54	19.50	107.6	1,720	107.4	1,770	106.2	2,125
20	0.57	21.60	125.9	2,015	125.7	2,075	124.2	2,485
24	0.63	25.80	166.0	2,655	165.8	2,735	164.0	3,280
30	0.79	32.00	257.6	4,120	257.1	4,240	254.4	5,090
36	0.87	38.30	340.9	5,455				
42	0.97	44.50	442.0	7,070				
48	1.06	50.80	551.6	8,825				
Class 100—100-psi. Pressure—231-ft. Head								
3	0.32	3.96	12.4	195	12.3	205		
4	0.35	4.80	16.5	265	16.4	270		
6	0.38	6.90	25.9	415	25.8	425		
8	0.41	9.05	37.0	590	36.9	610		
10	0.44	11.10	49.1	785	49.0	810		
12	0.48	13.20	63.7	1,020	63.6	1,050	63.0	1,260
14	0.51	15.30	78.8	1,260	78.7	1,300	77.8	1,555
16	0.54	17.40	95.2	1,525	95.0	1,570	94.0	1,880
18	0.58	19.50	114.8	1,835	114.6	1,890	113.3	2,265
20	0.62	21.60	135.9	2,175	135.7	2,240	134.2	2,685
24	0.68	25.80	178.1	2,850	177.8	2,935	176.0	3,520
30	0.79	32.00	257.6	4,120	257.1	4,240	254.4	5,090
36	0.87	38.30	340.9	5,455				
42	0.97	44.50	442.0	7,070				
48	1.06	50.80	551.6	8,825				
Class 150—150-psi. Pressure—346-ft. Head								
3	0.32	3.96	12.4	195	12.3	205		
4	0.35	4.80	16.5	265	16.4	270		
6	0.38	6.90	25.9	415	25.8	425		
8	0.41	9.05	37.0	590	36.9	610		
10	0.44	11.10	49.1	785	49.0	810		
12	0.48	13.20	63.7	1,020	63.6	1,050	63.0	1,260
14	0.51	15.65	80.7	1,290	80.5	1,330	79.7	1,595
16	0.54	17.80	97.5	1,560	97.3	1,605	96.3	1,925
18	0.58	19.92	117.2	1,875	117.0	1,930	115.8	2,315
20	0.62	22.06	138.9	2,220	138.6	2,285	137.2	2,745
24	0.73	26.32	194.0	3,105	193.6	3,195	191.8	3,835
30	0.85	32.00	275.4	4,405	274.9	4,535	272.2	5,445
36	0.94	38.30	365.9	5,855				
42	1.05	44.50	475.3	7,605				
48	1.14	50.80	589.6	9,435				

* These thicknesses and weights are for pipe laid without blocks, on flat-bottom trench, with tamped backfill, under 5 ft. of cover. For other conditions see Tables *8.2* and *8.4* hereof and ASA *A21.1*, "Manual for the Computation of Strength and Thickness of Cast Iron Pipe."

† Average weight per foot based on calculated weight of pipe before rounding.

‡ Including bell and spigot bead. Calculated weight of pipe rounded off to nearest 5 lb.

TABLE 8.3 (contd.)—STANDARD THICKNESSES AND WEIGHTS*

Size *in.*	Thickness *in.*	Outside Diam. *in.*	Weight (*lb.*) Based on					
			16-ft. Laying Length		16½-ft. Laying Length		20-ft. Laying Length	
			Avg. per Foot†	Per Length‡	Avg. per Foot†	Per Length‡	Avg. per Foot†	Per Length‡
Class 200—200-psi. Pressure—462-ft. Head								
3	0.32	3.96	12.4	195	12.3	205		
4	0.35	4.80	16.5	265	16.4	270		
6	0.38	6.90	25.9	415	25.8	425		
8	0.41	9.05	37.0	590	36.9	610		
10	0.44	11.10	49.1	785	49.0	810		
12	0.48	13.20	63.7	1,020	63.6	1,050	63.0	1,260
14	0.55	15.65	86.4	1,380	86.3	1,425	85.4	1,710
16	0.58	17.80	104.0	1,665	103.8	1,715	102.8	2,055
18	0.63	19.92	126.5	2,025	126.2	2,080	125.0	2,500
20	0.67	22.06	149.1	2,385	148.8	2,455	147.3	2,945
24	0.79	26.32	209.8	3,355	209.5	3,455	207.4	4,150
30	0.92	32.00	297.8	4,765	297.3	4,905	294.3	5,885
36	1.02	38.30	397.1	6,355				
42	1.13	44.50	512.3	8,195				
48	1.23	50.80	637.2	10,195				
Class 250—250-psi. Pressure—577-ft. Head								
3	0.32	3.96	12.4	195	12.3	205		
4	0.35	4.80	16.5	265	16.4	270		
6	0.38	6.90	25.9	415	25.8	425		
8	0.41	9.05	37.0	590	36.9	610		
10	0.44	11.10	49.1	785	49.0	810		
12	0.52	13.20	68.5	1,095	68.4	1,130	67.8	1,355
14	0.59	15.65	92.7	1,485	92.5	1,525	91.5	1,830
16	0.63	17.80	112.9	1,805	112.7	1,860	111.4	2,230
18	0.68	19.92	136.3	2,180	136.1	2,245	134.7	2,695
20	0.72	22.06	160.1	2,560	159.8	2,635	158.2	3,165
24	0.79	26.32	209.8	3,355	209.5	3,455	207.4	4,150
30	0.99	32.00	318.4	5,095	317.9	5,245	314.9	6,300
36	1.10	38.30	425.5	6,810				
42	1.22	44.50	549.5	8,790				
48	1.33	50.80	684.5	10,950				
Class 300—300-psi. Pressure—693-ft. Head								
3	0.32	3.96	12.4	195	12.3	205		
4	0.35	4.80	16.5	265	16.4	270		
6	0.38	6.90	25.9	415	25.8	425		
8	0.41	9.05	37.0	590	36.9	610		
10	0.48	11.10	53.1	850	53.0	875		
12	0.52	13.20	68.5	1,095	68.4	1,130	67.8	1,355
14	0.59	15.65	92.7	1,485	92.5	1,525	91.5	1,830
16	0.68	17.80	121.0	1,935	120.8	1,995	119.4	2,390
18	0.73	19.92	145.4	2,325	145.2	2,395	143.7	2,875
20	0.78	22.06	172.2	2,755	171.9	2,835	170.3	3,405
24	0.85	26.32	224.3	3,590	224.0	3,695	221.9	4,440
Class 350—350-psi. Pressure—808-ft. Head								
3	0.32	3.96	12.4	195	12.3	205		
4	0.35	4.80	16.5	265	16.4	270		
6	0.38	6.90	25.9	415	25.8	425		
8	0.41	9.05	37.0	590	36.9	610		
10	0.52	11.10	57.4	920	57.3	945		
12	0.56	13.20	73.8	1,180	73.7	1,215	73.0	1,460
14	0.64	15.65	99.8	1,595	99.7	1,645	98.7	1,975
16	0.68	17.80	121.0	1,935	120.8	1,995	119.4	2,390
18	0.79	19.92	156.2	2,500	156.1	2,575	154.6	3,090
20	0.84	22.06	184.2	2,945	184.0	3,035	182.3	3,645
24	0.92	26.32	241.1	3,860	240.7	3,970	238.7	4,775

*†‡ See footnotes on preceding page.

PIPE CENTRIFUGALLY CAST IN SAND-LINED MOLDS

TABLE 8.4

STANDARD THICKNESSES* OF PIPE CENTRIFUGALLY CAST IN SAND-LINED MOLDS

Laying Condition A—Flat-bottom trench, without blocks, untamped backfill
Laying Condition B—Flat-bottom trench, without blocks, tamped backfill
Laying Condition C—Pipe laid on blocks, untamped backfill
Laying Condition D—Pipe laid on blocks, tamped backfill

Size *in.*	Working Pressure *psi.*	3½-ft. Cover				5-ft. Cover				8-ft. Cover			
		Laying Condition				Laying Condition				Laying Condition			
		A	B	C	D	A	B	C	D	A	B	C	D
		Thickness—*in.*											
3	50	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.38	0.32
	100	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.38	0.32
	150	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.38	0.32
	200	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.38	0.32
	250	0.32	0.32	0.32	0.32	0.32	0.32	0.35	0.32	0.32	0.32	0.38	0.32
	300	0.32	0.32	0.32	0.32	0.32	0.32	0.35	0.32	0.32	0.32	0.38	0.32
	350	0.32	0.32	0.32	0.32	0.32	0.32	0.35	0.32	0.32	0.32	0.38	0.32
4	50	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.41	0.35
	100	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.41	0.35
	150	0.35	0.35	0.35	0.35	0.35	0.35	0.38	0.35	0.35	0.35	0.41	0.35
	200	0.35	0.35	0.35	0.35	0.35	0.35	0.38	0.35	0.35	0.35	0.44	0.35
	250	0.35	0.35	0.35	0.35	0.35	0.35	0.38	0.35	0.35	0.35	0.44	0.35
	300	0.35	0.35	0.35	0.35	0.35	0.35	0.38	0.35	0.35	0.35	0.44	0.35
	350	0.35	0.35	0.38	0.35	0.35	0.35	0.38	0.35	0.35	0.35	0.44	0.35
6	50	0.38	0.38	0.41	0.38	0.38	0.38	0.44	0.38	0.38	0.38	0.48	0.38
	100	0.38	0.38	0.41	0.38	0.38	0.38	0.44	0.38	0.38	0.38	0.48	0.38
	150	0.38	0.38	0.41	0.38	0.38	0.38	0.44	0.38	0.38	0.38	0.48	0.38
	200	0.38	0.38	0.41	0.38	0.38	0.38	0.44	0.38	0.38	0.38	0.52	0.38
	250	0.38	0.38	0.44	0.38	0.38	0.38	0.44	0.38	0.38	0.38	0.52	0.38
	300	0.38	0.38	0.44	0.38	0.38	0.38	0.44	0.38	0.38	0.38	0.52	0.38
	350	0.38	0.38	0.44	0.38	0.38	0.38	0.48	0.38	0.38	0.38	0.52	0.38
8	50	0.41	0.41	0.44	0.41	0.41	0.41	0.48	0.41	0.41	0.41	0.52	0.41
	100	0.41	0.41	0.48	0.41	0.41	0.41	0.48	0.41	0.41	0.41	0.56	0.41
	150	0.41	0.41	0.48	0.41	0.41	0.41	0.48	0.41	0.41	0.41	0.56	0.41
	200	0.41	0.41	0.48	0.41	0.41	0.41	0.52	0.41	0.41	0.41	0.56	0.44
	250	0.41	0.41	0.48	0.41	0.41	0.41	0.52	0.41	0.44	0.41	0.56	0.44
	300	0.41	0.41	0.48	0.41	0.41	0.41	0.52	0.41	0.44	0.44	0.60	0.44
	350	0.41	0.41	0.52	0.41	0.44	0.41	0.52	0.44	0.48	0.44	0.60	0.48
10	50	0.44	0.44	0.48	0.44	0.44	0.44	0.52	0.44	0.44	0.44	0.60	0.48
	100	0.44	0.44	0.52	0.44	0.44	0.44	0.52	0.44	0.48	0.44	0.60	0.48
	150	0.44	0.44	0.52	0.44	0.44	0.44	0.56	0.44	0.48	0.44	0.60	0.48
	200	0.44	0.44	0.52	0.44	0.44	0.44	0.56	0.44	0.48	0.48	0.60	0.52
	250	0.44	0.44	0.56	0.44	0.48	0.44	0.56	0.48	0.52	0.48	0.65	0.52
	300	0.48	0.44	0.56	0.48	0.48	0.48	0.56	0.48	0.52	0.52	0.65	0.56
	350	0.48	0.48	0.56	0.48	0.52	0.52	0.60	0.52	0.56	0.52	0.65	0.56
12	50	0.48	0.48	0.52	0.48	0.48	0.48	0.56	0.48	0.52	0.48	0.65	0.52
	100	0.48	0.48	0.56	0.48	0.48	0.48	0.56	0.48	0.52	0.48	0.65	0.52
	150	0.48	0.48	0.56	0.48	0.48	0.48	0.56	0.48	0.52	0.52	0.65	0.56
	200	0.48	0.48	0.56	0.48	0.48	0.48	0.60	0.52	0.56	0.52	0.65	0.56
	250	0.52	0.48	0.60	0.52	0.52	0.52	0.60	0.52	0.56	0.56	0.70	0.60
	300	0.52	0.52	0.60	0.52	0.56	0.52	0.60	0.56	0.60	0.56	0.70	0.60
	350	0.56	0.56	0.60	0.56	0.56	0.56	0.65	0.60	0.60	0.60	0.76	0.65
14	50	0.51	0.48	0.59	0.51	0.51	0.48	0.59	0.55	0.59	0.55	0.69	0.59
	100	0.51	0.48	0.59	0.55	0.55	0.51	0.64	0.55	0.59	0.55	0.69	0.64
	150	0.55	0.51	0.59	0.55	0.55	0.51	0.64	0.59	0.64	0.59	0.75	0.64
	200	0.55	0.51	0.64	0.59	0.55	0.55	0.64	0.59	0.64	0.59	0.75	0.69
	250	0.59	0.55	0.64	0.59	0.59	0.59	0.69	0.59	0.64	0.64	0.75	0.69
	300	0.59	0.59	0.69	0.59	0.64	0.59	0.69	0.64	0.69	0.64	0.81	0.69
	350	0.64	0.64	0.69	0.64	0.64	0.64	0.75	0.69	0.75	0.69	0.81	0.75

* Thicknesses include allowances for foundry practice, corrosion, and either water hammer or truck load.

TABLE 8.4 (contd.)

STANDARD THICKNESSES* OF PIPE CENTRIFUGALLY CAST IN SAND-LINED MOLDS

Laying Condition A—Flat-bottom trench, without blocks, untamped backfill
Laying Condition B—Flat-bottom trench, without blocks, tamped backfill
Laying Condition C—Pipe laid on blocks, untamped backfill
Laying Condition D—Pipe laid on blocks, tamped backfill

Size *in.*	Working Pressure *psi.*	3½-ft. Cover				5-ft. Cover				8-ft. Cover			
		Laying Condition				Laying Condition				Laying Condition			
		A	B	C	D	A	B	C	D	A	B	C	D
		Thickness—*in.*											
16	50	0.54	0.50	0.63	0.58	0.58	0.54	0.63	0.58	0.63	0.58	0.73	0.63
	100	0.54	0.54	0.63	0.58	0.58	0.54	0.68	0.58	0.63	0.58	0.73	0.68
	150	0.58	0.54	0.63	0.58	0.58	0.54	0.68	0.63	0.68	0.63	0.79	0.68
	200	0.58	0.58	0.68	0.63	0.63	0.58	0.68	0.63	0.68	0.63	0.79	0.73
	250	0.63	0.58	0.68	0.63	0.63	0.63	0.73	0.68	0.73	0.68	0.79	0.73
	300	0.63	0.63	0.73	0.68	0.68	0.68	0.73	0.68	0.73	0.73	0.85	0.79
	350	0.68	0.68	0.73	0.68	0.73	0.68	0.79	0.73	0.79	0.73	0.85	0.79
18	50	0.58	0.54	0.63	0.58	0.58	0.54	0.68	0.63	0.68	0.63	0.79	0.68
	100	0.58	0.54	0.68	0.63	0.63	0.58	0.73	0.63	0.68	0.63	0.79	0.73
	150	0.63	0.58	0.68	0.63	0.63	0.58	0.73	0.68	0.73	0.68	0.79	0.73
	200	0.63	0.58	0.73	0.68	0.68	0.63	0.73	0.68	0.73	0.68	0.85	0.79
	250	0.68	0.63	0.73	0.68	0.68	0.68	0.79	0.73	0.79	0.73	0.85	0.79
	300	0.68	0.68	0.79	0.73	0.73	0.73	0.79	0.79	0.79	0.79	0.92	0.85
	350	0.79	0.73	0.79	0.79	0.79	0.79	0.85	0.79	0.85	0.85	0.92	0.85
20	50	0.62	0.57	0.72	0.62	0.67	0.57	0.72	0.67	0.72	0.67	0.78	0.72
	100	0.62	0.57	0.72	0.67	0.67	0.62	0.78	0.67	0.72	0.67	0.84	0.78
	150	0.67	0.62	0.72	0.67	0.67	0.62	0.78	0.72	0.78	0.72	0.84	0.78
	200	0.67	0.62	0.78	0.72	0.72	0.67	0.78	0.72	0.78	0.72	0.91	0.84
	250	0.72	0.67	0.78	0.72	0.78	0.72	0.84	0.78	0.84	0.78	0.91	0.84
	300	0.78	0.72	0.84	0.78	0.78	0.78	0.84	0.84	0.84	0.84	0.98	0.91
	350	0.84	0.78	0.84	0.84	0.84	0.84	0.91	0.84	0.91	0.84	0.98	0.91
24	50	0.68	0.63	0.79	0.68	0.73	0.63	0.79	0.73	0.79	0.73	0.85	0.79
	100	0.73	0.63	0.79	0.73	0.73	0.68	0.85	0.79	0.85	0.73	0.92	0.85
	150	0.73	0.68	0.79	0.79	0.79	0.73	0.85	0.79	0.85	0.79	0.92	0.85
	200	0.79	0.73	0.85	0.79	0.79	0.79	0.92	0.85	0.92	0.85	0.99	0.92
	250	0.79	0.79	0.85	0.85	0.85	0.79	0.92	0.85	0.92	0.85	0.99	0.99
	300	0.85	0.85	0.92	0.85	0.92	0.85	0.99	0.92	0.99	0.92	1.07	0.99
	350	0.92	0.92	0.99	0.92	0.99	0.92	0.99	0.99	1.07	0.99	1.07	1.07
30	50	0.85	0.73	0.85	0.85	0.85	0.79	0.92	0.85	0.92	0.85	0.99	0.92
	100	0.85	0.79	0.92	0.85	0.92	0.79	0.99	0.92	0.99	0.85	1.07	0.99
	150	0.92	0.79	0.92	0.92	0.92	0.85	0.99	0.92	0.99	0.92	1.07	0.99
	200	0.92	0.85	0.99	0.92	0.99	0.92	1.07	0.99	1.07	0.99	1.16	1.07
	250	0.99	0.92	1.07	0.99	1.07	0.99	1.07	1.07	1.16	1.07	1.16	1.16
36	50	0.94	0.81	1.02	0.94	1.02	0.87	1.10	0.94	1.10	0.94	1.19	1.02
	100	0.94	0.87	1.02	0.94	1.02	0.87	1.10	1.02	1.10	1.02	1.19	1.10
	150	1.02	0.87	1.10	1.02	1.10	0.94	1.10	1.02	1.19	1.02	1.19	1.19
	200	1.10	0.94	1.10	1.02	1.10	1.02	1.19	1.10	1.19	1.10	1.29	1.19
	250	1.10	1.02	1.19	1.10	1.19	1.10	1.29	1.19	1.29	1.19	1.39	1.29
42	50	1.05	0.90	1.13	1.05	1.13	0.97	1.13	1.05	1.22	1.05	1.32	1.13
	100	1.05	0.97	1.13	1.05	1.13	0.97	1.22	1.13	1.22	1.13	1.32	1.22
	150	1.13	0.97	1.22	1.13	1.22	1.05	1.22	1.13	1.32	1.13	1.32	1.32
	200	1.22	1.05	1.22	1.13	1.22	1.13	1.32	1.22	1.32	1.22	1.43	1.32
	250	1.32	1.13	1.32	1.22	1.32	1.22	1.43	1.32	1.43	1.32	1.54	1.43
48	50	1.14	0.98	1.23	1.14	1.23	1.06	1.33	1.14	1.33	1.14	1.44	1.33
	100	1.23	1.06	1.23	1.14	1.23	1.06	1.33	1.23	1.33	1.23	1.44	1.33
	150	1.23	1.14	1.33	1.23	1.33	1.14	1.44	1.33	1.44	1.33	1.56	1.44
	200	1.33	1.14	1.44	1.33	1.44	1.23	1.44	1.33	1.56	1.33	1.56	1.44
	250	1.44	1.33	1.44	1.33	1.44	1.33	1.56	1.44	1.56	1.44	1.68	1.56

* Thicknesses include allowances for foundry practice, corrosion, and either water hammer or truck load.

ASA
A21.9–1952

American Standard

SPECIFICATIONS

for

CAST IRON PIPE CENTRIFUGALLY CAST IN SAND LINED MOLDS FOR GAS

SPONSORS

American Gas Association
American Society for Testing Materials
American Water Works Association
New England Water Works Association

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Note 1—Tables showing additional thicknesses required for greater depths of cover and other conditions of laying will be found in ASA A21.1.

Note 2—Users of these tables are cautioned to select fittings having proper socket dimensions and thicknesses suited to the pressures. Pipe specified in these tables have outside diameters which will chamber correctly with existing standards for pipe and fittings.

Users of this document should make reference to "American Recommended Practice Manual for the Computation of Strength and Thickness of Cast Iron Pipe" (ASA A21.1) for complete information concerning the conditions which various thicknesses of pipe are designed to meet. The foreword of the Manual also contains a statement regarding the history of the specifications and references to other related documents.

ASA
A21.9–1952

AMERICAN STANDARD SPECIFICATIONS
for
CAST IRON PIPE CENTRIFUGALLY CAST IN SAND LINED MOLDS FOR GAS

This specification covers cast iron pipe centrifugally cast in sand lined molds.

Section 9-1—Definitions

PURCHASER. Wherever the word "Purchaser" is used herein, it shall be understood to mean the actual purchaser of the pipe or his authorized agents acting within the scope of the duties entrusted to them.

HEAT. A heat is a period during which a cupola or furnace is operated continuously.

RUN. A run is a period of one or more shifts during which a shop is operated continuously.

MIXTURE OF IRON. Mixture of iron is a combination of pig iron, scrap, coke and other raw materials charged to a cupola or furnace to give a desired composition of iron; or a combination of molten iron from one or more sources, made in a forehearth or ladle to give a desired composition of iron.

SOURCE OF IRON. A source of iron is a cupola, furnace or forehearth from which iron is delivered to a transfer or pouring ladle.

FOREHEARTH. A forehearth is a refractory-lined receptacle for the temporary storage of molten iron from one or more cupolas or furnaces.

Section 9-2—Description of Pipe

The pipe shall be made with bell and spigot ends with beads cast on, plain ends or such other type of ends as may be agreed upon at the time of purchase. Pipe with bell and spigot ends shall conform to the dimensions and weights given in the following tables. Pipe with other types of ends shall comply with the dimensions agreed upon, but in all other respects shall fulfill the specifications hereinafter given. Pipe shall be straight and shall be true circles in section, with their inner and outer surfaces concentric. They shall be cast at least 12 feet in nominal laying length. This type of pipe is commonly made at present (1952) in 16-, 16½- and 20-foot lengths.

Section 9-3—Casting of Pipe

The pipe shall be centrifugally cast in sand lined molds and shall remain in the sand for a sufficient length of time to prevent unequal contraction during cooling.

Section 9-4—Quality of Iron

(9-4.1) All pipe shall be made of cast iron of good quality, and of such character and so adapted in chemical composition to the thickness of the pipe to be cast, that the iron in the pipe shall be strong, tough, resilient, of even grain and soft enough for satisfactory drilling and cutting and it shall comply with the physical specifications given in Sections 9-17 and 9-18. The metal shall be remelted in a cupola or other suitable furnace.

(9-4.2) The iron in the pipe shall not contain more than 0.90 per cent of phosphorus nor more than 0.12 per cent of sulphur. Samples for chemical analyses shall be taken by drilling completely through from skin to skin either acceptance test specimens or specimens cast for this purpose but not to exceed three specimens per heat of approximately eight hours. In case of dispute, analyses will be determined on samples taken from the pipe in question.

Section 9-5—Quality of Castings

The pipe shall be smooth, free from scales, lumps, blisters, sand holes, laps, and defects of every nature which unfit them for the use for which they are intended. No plugging, filling, burning-in or welding will be allowed except as permitted by the purchaser.

Section 9-6—Foundry Records

A record of the results of the following tests shall be made and retained for at least one year. Upon request such record will be available to purchaser at the foundry. If written transcripts of the results of any of these tests are desired, this fact shall be noted in the order for pipe, naming tests of which transcripts are desired. The methods of testing and the dimensions of all test specimens are given in the Appendix.

(9-6.1) *Chemical Analyses*—Chemical analyses of each iron mixture used directly in the pouring of pipe, obtained as in Section 9-4.2 shall be made for silicon, sulphur, manganese, phosphorus and total carbon during the first hour and at intervals not to exceed three hours throughout the heat. If pipe are poured directly from the cupola, chemical analyses shall be made of iron from the first and from the last ladle. In case the mixture is changed one or more times during a heat in order to produce a different iron, the time of taking samples shall be varied in such a way as to obtain representative tests of the iron at least at the beginning and end of each period during which the iron is intended to be constant in quality.

(9-6.2) *Pouring Temperatures*—The pouring temperature of the iron shall be taken at the casting ladle for each size of pipe at least once each hour.

(9-6.3) *Talbot Strip Tests*
(See Section 9-17.1.)

(9-6.4) *Test Bar Tests*
(See Section 9-17.2.)

(9-6.5) *Periodic Ring, Strip, and Full-Length Bursting Tests*
(See Sections 9-17 and 9-18.)

Section 9-7—Marking Pipe

Each pipe shall have the weight and class designation conspicuously painted on it. In addition each pipe shall have cast on it the manufacturer's mark the year in which the pipe was cast and, when specified by the purchaser, initials not exceeding four in number. The letters and figures shall be on the outside surface of the pipe and cast marks shall have dimensions not less than those indicated below:

Nominal Pipe Diameter, Inches	Height of Letter, Inches	Relief of Letter, Inches
4	½	$\frac{1}{16}$
6-12	¾	$\frac{3}{32}$
16-20	1½	⅛
24-48	2	⅛

Section 9-8—Inspection by Purchaser

(9-8.1) *Power of Purchaser to Inspect*

The purchaser shall have free access at all times to all parts of any manufacturing plant which concern the manufacture of articles to be made for him. He may inspect the material, the pattern work, molding, casting and coating (if used) of the pipe. The forms, sizes, uniformity and conditions of all pipe herein referred to shall be subject to his inspection and approval, and he may reject, without subjection to hydrostatic test, any pipe which is not in conformity with the specifications or drawings. Any pipe rejected shall be marked as rejected and any marks pertaining to the purchaser shall be chipped or erased from such pipe.

(9-8.2) *Manufacturer to Furnish Men and Materials*

The manufacturer shall provide tools, testing equipment, materials, labor and facilities necessary for the required testing, inspection and weighing of the pipe at the foundry.

(9-8.3) *Report of Purchaser's Inspection*

The purchaser shall make written report daily to the foundry office of all pipe rejected with the causes for rejection.

Section 9-9—Inspection and Certification by Manufacturer

Should the purchaser have no inspector at the works, the manufacturer shall, if required by the purchaser, furnish a sworn statement that the inspection and all of the tests have been made and met as specified. If written transcripts of any of these test results are required, including chemical tests if desired, a request for same, specifying the tests of which transcripts are desired, shall accompany the order.

Section 9-10—Pipe to be Delivered Sound

All the pipe shall be delivered in all respects sound and in conformity with these specifications. The inspection shall not relieve the manufacturer of any of his obligations in this respect, and any defective pipe which may have passed the purchaser at the works or elsewhere shall be at all times liable to rejection when discovered, until the final completion and adjustment of the contract; provided, however, that the manufacturer shall not be held liable for pipe found to be damaged after they have been accepted at the agreed point of delivery, unless there shall be unmistakable evidence that the casting was originally defective or damaged before acceptance. Care shall be taken in handling the pipe not to injure the coating (if used) and no pipe or other material of any kind shall be placed in the pipe during transportation.

Section 9-11—Cut Pipe

Defective spigot ends on pipe may be cut off in a manner which will produce a square end. Not more than 10 per cent of the total number of pipe of each size of a given order may be shipped as cut pipe. Such cut pipe when cut from 12-foot lengths shall have a nominal laying length of not less than 11 feet; pipe originally of 16 feet or greater length shall not be cut more than 2 feet.

Section 9-12—Tolerances or Maximum Permitted Variations from Standard Dimensions

(9-12.1) *Tolerances in Diameter of Pipe and Sockets*

Outside diameters of pipe barrels, spigot ends and inside diameters of sockets shall be kept as nearly as practicable to the specified dimensions. The inside diameters of the sockets and the outside diameters of the spigot ends shall be tested with circular gauges. Tolerances or maximum permitted variations from standard dimensions are listed in the following table.

Nominal Pipe Diameter, Inches	Tolerances, Plus or Minus, Inches
4 to 12	.06
16 to 24	.08
30 to 36	.10
42 to 48	.12

(9-12.2) *Tolerances in Thickness*

The minus tolerances from standard thickness of pipe and dimensions a, b, c, and d of the bell are listed in the following table.

Nominal Pipe Diameter, Inches	Minus Tolerance, Inches
4 to 8	.05
10 to 12	.06
16 to 24	.08
30 to 48	.10

NOTE: In pipe barrel thickness, tolerances .02 inch greater than those listed above shall be permissible over areas not exceeding 8 inches in length in any direction.

(9-12.3) *Allowable Percentage of Variation in Weight*

The weight of no single pipe shall be less than the nominal tabulated weight by more than 5% for pipe 12 inches or smaller in diameter, nor by more than 4% for pipe larger than 12 inches in diameter. The total weight of any order of 25 tons or more shall not be more than 2% under the total nominal weight. The total excess weight to be paid for on orders of 25 tons or more shall not exceed 2% of the nominal weight and on orders less than 25 tons shall not exceed 5% of the nominal weight. An order is hereby defined as including all the pipe ordered under the terms of a specific contract or purchase order or a single order placed under the terms of a standing contract. Unless otherwise stated in the contract, the ton shall be 2,000 pounds avoirdupois.

Section 9-13—Cleaning and Inspecting

All pipe shall have fins and other roughnesses chipped or ground off and shall be thoroughly cleaned, checked as to dimensions and also subjected to a careful inspection and a rolling test before the coating (if used) is applied.

Section 9-14—Hydrostatic Test

Each pipe shall be subjected to a hydrostatic proof test as follows:

TABLE OF PRESSURES FOR HYDROSTATIC TESTS

Nominal Diameter of Pipe, Inches	Nominal Barrel Thickness, Inches	Test Pressures, Lbs. per sq. in.
4 to 12	All Thicknesses	500
16	.60 and less	400
16	.61 and over	500
20	.70 and less	400
20	.71 and over	500
24	.75 and less	400
24	.76 and over	500
30	.88 and less	400
30	.89 and over	500
36	.98 and less	400
36	.99 and over	500
42	1.09 and less	400
42	1.10 and over	500
48	1.18 and less	400
48	1.19 and over	500

The pipe shall be under the test pressure for at least one-half minute. Any pipe showing defects by leaking, sweating or otherwise shall be rejected.

Section 9-15—Weighing

Each length of pipe shall be weighed and the weight plainly marked on the outside or inside of the bell or spigot end.

Section 9-16—Exterior Coatings

Any coating (if used) which is to be applied to the pipe, shall be specified in the agreement made at time of purchase.

Section 9-17—Acceptance Tests for Physical Properties

The standard acceptance tests for the physical characteristics of the pipe shall be as follows:

(9-17.1) *Talbot Strip Tests*

Talbot strip tests shall be used to determine acceptability of 4 inch to 24 inch pipe for modulus of rupture and secant modulus of elasticity.

(17.1.1) *Sampling.* For sampling, each run shall be divided into periods of approximately three hours each and at least one sample shall be taken during each 3-hour period. The sample for the first period of the run shall be taken during the first hour, or if casting is direct from cupola, from the first ladle. Samples shall be taken so that each size of pipe cast for two hours or longer during the run and each mixture or source of iron used for two hours or longer during the run shall be fairly represented.

(17.1.2) *Method of Testing.* The method of testing Talbot strips is given in the Appendix.

(17.1.3) *Acceptance Values.* The acceptance values for Talbot strip tests shall be as follows:

Talbot Strips from 4-inch to 24-inch Pipe

Modulus of rupture	40,000 lbs. per sq.in. minimum
Secant modulus of elasticity	10,000,000 lbs. per sq.in. maximum

If the modulus of elasticity exceeds 10,000,000, the modulus of rupture shall exceed 40,000 in at least the same proportion.

(9-17.2) *2-inch Diameter Test Bar Tests*

A.S.T.M. standard (A-48 Bar C) 2-inch diameter × 27 inch test bar tests shall be used to determine the acceptability of 30-inch to 48-inch pipe.

From each mixture of iron used to cast pipe of 30-inch to 48-inch sizes, 2-inch diameter test bars shall be cast and tested from the first ladle of iron and at intervals not to exceed three hours during the heat.

For the record, from every 200 lengths, but not less than one pipe of each size each week, one Talbot strip shall be cut and tested and shall meet the requirements of Section 9-17.1.3.

At the manufacturer's option, Talbot strips may be tested instead of test bars. If Talbot strips are tested, they shall meet the requirements of Section 9-17.1.3.

Test bars shall have the following properties:

Breaking Load	6000 lbs., minimum
Deflection	0.15 inch plus 0.01 inch for each 500 lbs. that the breaking load exceeds 6000 lbs.

These test bar values apply only to pipe of thickness classes 21 to 25 in pipe designed using 18,000 lbs. per sq.in. tensile strength in bursting and 40,000 lbs. per sq.in. in modulus of rupture of the ring.

Section 9-18—Periodic Ring Tests and Full Length Bursting Tests

The manufacturer shall periodically make such bursting tests and ring tests in conjunction with strip tests that he can certify the design values of modulus of rupture (40,000 lbs. per sq.in.) and tensile strength of the iron in the pipe (18,000 lbs. per sq.in.). These tests shall be made in accordance with dimensions and methods given in the Appendix.

Pipe for these periodic ring and bursting tests shall be so selected that they will be representative of the sizes and various thicknesses of each size cast. Ring tests shall not be made on 4-inch pipe.

Tests of Talbot strips cut from the ring, as provided in the Appendix, shall be made in conjunction with ring and bursting tests. At least three Talbot strips shall be tested from each burst pipe and one of these strips shall come from the ring. For pipe for which rings less than 10½ inches long are used, the Talbot strip shall come from parts other than the ring.

Tests and records shall include modulus of rupture of each strip and ring, modulus of elasticity of each strip and of each ring 12-inches and larger: also, breaking load and deflection of each test bar.

At purchaser's request, manufacturer shall furnish a written transcript of ring and bursting tests and tests on Talbot strips made in connection therewith for a period not exceeding one year and for such sizes as requested.

Unless there is a record of satisfactory tests equivalent to those hereinafter described, extending to within three months or less of the time to begin manufacture of an order for pipe of any size 30-inch to 48-inch, the producer shall test three pipe from the first day's production, and one each succeeding day for the next 4 days. If all the tests meet the specifications, test one pipe every 5 days for the next 3 weeks and if all those meet the specifications, test one pipe each month. In the case of a failurc of any test, repeat the same series of tests as above specified. In the case of a lapse of more than one month in the manufacture of such pipe, the monthly test shall be made on a pipe from the first day's run. If the tests are all satisfactory, the number of pipe tested shall not exceed 3% of the order.

Section 9-19—Additional Tests Required by the Purchaser

If more or other tests than provided in these specifications are required by the purchaser, such tests shall be specified in the invitation for bids.

Section 9-20—Defective Specimens and Retests

(9-20.1) If any test specimen shows defective machining or lack of continuity of metal it may be discarded and replaced by another specimen. If any sound test specimen fails to meet the specified requirements, the purchaser may permit a retest on two additional sound specimens from pipe cast in the same period as the specimen which failed, in which case both specimens shall meet the prescribed tests to be acceptable.

(9-20.2) Test bars may be cast in pairs and at least one bar from each pair shall be tested, but the manufacturer shall have the right to test both bars in which case the better bar shall be taken as representative.

(9-20.3) If a routine test bar test fails to meet the requirements the manufacturer shall have the right to substitute two Talbot strips cut from a pipe cast with iron represented by the failed test bar test. If both strip tests meet the requirements, the pipe for that period shall be acceptable.

Section 9-21—Rejection Due to Failure to Meet the Routine Acceptance Test Requirements

If any routine chemical analysis fails to meet the chemical requirements of Section 9-4.2 or if any acceptance test fails to meet the requirements of Sections 9-17.1.3, 9-17.2 and 9-20, the pipe cast in the period shall be rejected except subject to the provisions of Section 9-22.

Section 9-22—Limiting the Rejection Due to Failure to Meet the Routine Acceptance Test Requirements

The manufacturer may limit the amount of rejection by making similar additional tests of pipe of the same size as that rejected until the rejected lot is bracketed in order of manufacture by two acceptable tests. If a period is rejected, the acceptability of pipe of different sizes from that rejected may be established by making the routine acceptance tests for these sizes.

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APPENDIX*

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Tables †

Section 9-A1—Talbot Strip Tests

Talbot strips (Fig. 9.1) shall be machined longitudinally from each pipe specimen selected for testing by this method. These Talbot strips may be cut from a part of the ring little stressed in the ring test —i.e., near one of the elements marked *a* in the illustration of the ring test (Fig. 9.2). The strips in any case will be in cross section as indicated in Fig. 9.1—i.e., will have for their width the thickness of the pipe and for their depth, 0.50 in. Their length shall be at least 10½ in. These strips shall be tested as beams on supports 10 in. apart with loads applied perpendicularly to the machined faces at two points

* This Appendix is a part of ASA A21.9—American Standard Specifications for Cast Iron Pipe Centrifugal Cast in Sand-lined Molds, for Gas.

† Data on thicknesses required for greater depths of cover and conditions of laying other than those assumed in the following tables will be found in Appendix B of ASA A21.1—American Recommended Practice Manual for the Computation of Strength and Thickness of Cast Iron Pipe.

Users of the following tables are cautioned to select fittings having proper socket dimensions and thicknesses suited to the pressures. Pipe specified in these tables have outside diameters which will chamber correctly with existing standards for pipe and fittings.

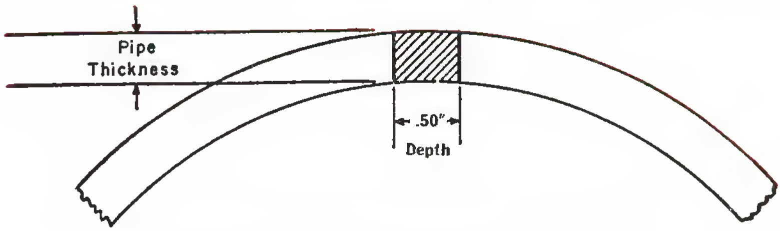


FIG. 9.1 Position From Which Talbot Strip Is Cut

3⅓ in. from the supports. The breaking load and the deflection shall be observed and recorded.

The strip shall be accurately calipered at the point of rupture and the modulus of rupture, R, shall be calculated by the usual beam formula, which for this case reduces to the expression:

$$R = \frac{10W}{td^2}$$

The secant modulus of elasticity, E_s in pounds per square inch, shall be computed by the formula:

$$E_s = \frac{21.3R}{dy}$$

In the above formulas, R is the modulus of rupture (lbs. per sq. in.), E_s is the secant modulus of elasticity (lbs. per sq.in.), W is the breaking load (lb.), d is the depth (in.) of the strip (intended to be 0.50 in.), t is the width (in.) of the strip (pipe thickness) and y is the deflection (in.) of the strip at the center at breaking load.

Section 9-A2—Ring Tests

The maximum length of any ring shall not exceed 12 in.; for pipe 16 in. and larger, the minimum length shall be 10½ in.; for pipe 12 in. and smaller, the minimum length shall be one-half the nominal diameter of the pipe. Each ring shall be tested by the three-edge bearing method as indicated in Fig. 9.2. The lower bearing for the ring shall consist of two strips with vertical sides having their interior top corners rounded to a radius of approximately ½ in. The strips shall be of hard wood or of metal. If of metal, a piece of fabric or leather approximately $\frac{3}{16}$ in. thick shall be laid over them. They shall be

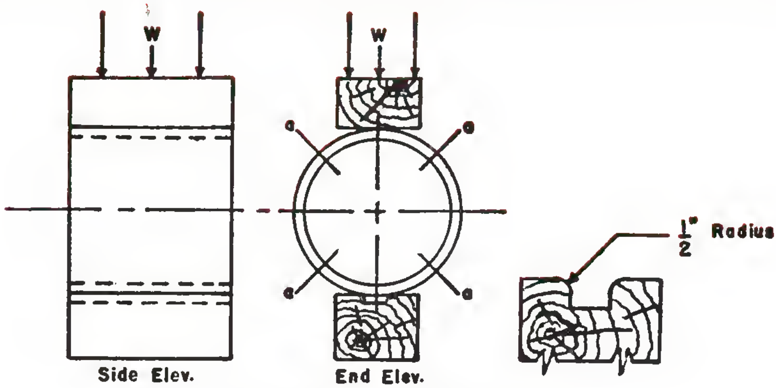


Fig. 9.2 Assembly for Ring Test

straight and shall be securely fastened to a rigid block, with their interior vertical faces the following distances apart:

Nom. Pipe Diam. *in.*	Bearing Strip Spacing *in.*
4–12	½
16–24	1
30–48	2

The upper bearing shall be an oak block, straight and true from end to end. The upper and lower bearings shall extend the full length of the ring. The ring shall be placed symmetrically between the two bearings, and the center of application of the load shall be so placed that the vertical deformation at the two ends of the ring shall be approximately equal. If the ring is not uniform in thickness, it shall be so placed that the thick and thin portions are near the ends of the horizontal diameter.

A record of the breaking load and the vertical deformation of each ring tested shall be made. The modulus of rupture and modulus of elasticity are computed from the formulas:

$$R = 0.954 \frac{W(d+t)}{bt^2}$$

$$E = \frac{0.225W(d+t)^3}{bt^3y} = \frac{0.236R(d+t)^2}{ty}$$

in which R is the modulus of rupture (lbs. per sq.in.), W is the breaking load (lb.), d is the average inside diameter (in.) of the ring, t is the average thickness (in.) of metal along the line of fracture, b is the length (in.) of the ring, E is the modulus of elasticity (lbs. per sq.in.) and y is the vertical deformation (in.) of the ring at the center.

Section 9-A3—Full-Length Bursting Tests

The bursting tensile strength shall be determined by testing full-length pipe (less the amount cut off for ring and strip test specimens) to destruction by hydraulic pressure. Bells may be removed to facilitate testing. A suitable means for holding the end thrust shall be used which will not subject the pipe to endwise tension or compression, or other parasitic stresses. A calibrated pressure gage shall be used for determining the bursting pressure. This gage shall be connected to the interior of the test pipe by a separate connection from that which supplies water for the test. The unit tensile strength in bursting shall be obtained by the use of the formula:

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

in which S is the bursting tensile strength (lbs. per sq.in.) of the iron, P is the internal pressure (lbs. per sq.in.) at bursting, d is the average inside diameter (in.) of the pipe and t is the minimum average thickness (in.) of the pipe along the principal line of break.

Measurements of thickness shall be taken along the principal line of break at 1-ft. intervals.

The minimum average thickness along the principal line of break shall be obtained by averaging the measurements at the thinnest section at a weight of two and at the adjacent sections on each side at a weight of one each; or, if the thinnest section is at the end of the break, by averaging this thinnest-section measurement at a weight of two and the measurements of the adjacent section and the next section at a weight of one each.

Section 9-A4—Test Bars

9-A4.1. *Dimensions.* Test bars for pipe of 30-in. to 48-in. diameter shall be 2 in. in diameter and not less than 26 in. long. Individual test bars may vary as much as 3 per cent from the standard diameter.

9-A4.2. *Method of casting.* The bars shall be east vertically in well faced, dry sand molds provided with a suitable pouring basin and mounted on a suitable refractory foundation. Metal for the bars shall be obtained by using a small heated ladle taking its metal from the main ladle from which the pipe is to be poured. The metal shall be taken after all alloys and other additional metal, except cast-iron pipe scrap for cooling, have been added to the main ladle and become melted. The bars shall not be removed from the mold before they have cooled to 500°F.

9-A4.3. *Method of testing.* The bars shall be broken as beams by placing them on supports 24 in. apart and applying the load at the center of the span. The breaking load and the corresponding deflection shall be observed and recorded.

9-A4.4. *Correcting observed breaking loads and deflections.* The bars shall be measured at the point of application of the load and the results corrected to standard dimensions by the conventional beam formula (for bars of 2-in. diameter):

$$\text{Corrected } W = \text{Observed } W \times \frac{8}{d_h d_v^2}$$

$$\text{Corrected } y = \text{Observed } y \times \frac{d_v}{2}$$

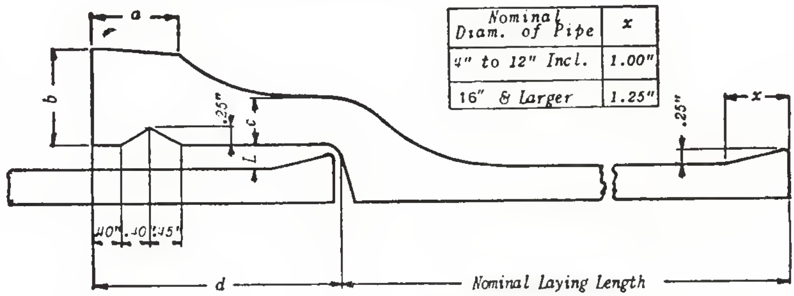
in which W is the breaking load (lb.), d_h is the measured horizontal diameter (in.), d_v is the measured vertical diameter (in.) and y is the deflection (in.) at breaking.

Section 9-A5—Deflection Measurements

All deflection measurements required by these specifications shall be that of the specimen and shall not include any compression of the supports or loading blocks, or backlash or distortion of the testing machine.

Table No. 9.1

STANDARD DIMENSIONS OF BELLS, SOCKETS, SPIGOT BEADS and OUTSIDE DIAMETERS OF GAS PIPE CENTRIFUGALLY CAST IN SAND LINED MOLDS also WEIGHTS OF BELLS AND SPIGOT BEADS



Nominal Diam.	Thickness of Pipe From	Thickness of Pipe To	Outside Diam. of Pipe	Dimensions of Bells: Diam. of Socket	Dimensions of Bells: Thickness of Joint L	Dimensions of Bells: Depth of Socket d	Dimensions of Bells: a	Dimensions of Bells: b	Dimensions of Bells: c	Wt. of Bell and Spigot Bead
4	.35	.38	4.80	5.80	.50	3.50	1.25	1.20	.45	18
	.41		4.80	5.80	.50	3.50	1.25	1.20	.60	20
6	.38	.44	6.90	7.90	.50	3.50	1.38	1.25	.54	27
	.48		6.90	7.90	.50	3.50	1.38	1.25	.66	30
8	.41	.48	9.05	10.05	.50	4.00	1.38	1.35	.58	40
	.52	.56	9.05	10.05	.50	4.00	1.38	1.35	.72	45
10	.44	.52	11.10	12.10	.50	4.00	1.50	1.45	.63	52
	.56	.60	11.10	12.10	.50	4.00	1.50	1.45	.78	59
12	.48	.56	13.20	14.20	.50	4.00	1.50	1.50	.69	67
	.60	.65	13.20	14.20	.50	4.00	1.50	1.50	.85	75
16	.50	.63	17.40	18.66	.63	4.00	1.75	1.62	.76	101
	.68	.73	17.40	18.66	.63	4.00	1.75	1.62	.93	113
20	.57	.72	21.60	22.86	.63	4.00	1.75	1.77	.88	140
	.78	.84	21.60	22.86	.63	4.00	1.75	1.77	1.08	159
24	.63	.79	25.80	27.06	.63	4.00	2.00	1.92	.91	180
	.85	.92	25.80	27.06	.63	4.00	2.00	1.92	1.16	207
30	.73	.92	32.00	33.26	.63	4.50	2.00	2.12	1.07	264
	.99		32.00	33.26	.63	4.50	2.00	2.12	1.36	302
36	.81	1.02	38.30	39.56	.63	4.50	2.00	2.32	1.22	371
	1.10	1.19	38.30	39.56	.63	4.50	2.00	2.32	1.54	426
42	.90	1.13	44.50	45.76	.63	5.00	2.00	2.52	1.35	486
	1.22	1.32	44.50	45.76	.63	5.00	2.00	2.52	1.70	561
48	.98	1.23	50.80	52.06	.63	5.00	2.00	2.72	1.48	607
	1.33	1.44	50.80	52.06	.63	5.00	2.00	2.72	1.86	708

All dimensions given in inches. All weights given in pounds.

Table No. 9.2

STANDARD THICKNESSES, DIAMETERS AND WEIGHTS OF GAS PIPE CENTRIFUGALLY CAST IN SAND LINED MOLDS

Dimensions in Inches — Weights in Pounds

Nominal Diam.	Thickness Class	Thickness	Outside Diam.	Inside Diam.	Wt. of Barrel Per Foot	Wt. of Bell and Bead	Wt. Based On 16 Foot Length		Wt. Based On 16½ Foot Length		Wt. Based On 20 Foot Length	
							Per Length*	†Average Per Foot	Per Length*	†Average Per Foot	Per Length*	†Average Per Foot
4	22	.35	4.80	4.10	15.3	18	265	16.5	270	16.4		
	23	.38	4.80	4.04	16.5	18	280	17.6	290	17.5		
	24	.41	4.80	3.98	17.6	20	300	18.9	310	18.8		
6	22	.38	6.90	6.14	24.3	27	415	26.0	430	25.9		
	23	.41	6.90	6.08	26.1	27	445	27.9	460	27.8		
	24	.44	6.90	6.02	27.9	27	475	29.6	485	29.5		
	25	.48	6.90	5.94	30.2	30	515	32.1	530	32.0		
8	22	.41	9.05	8.23	34.7	40	595	37.3	615	37.2		
	23	.44	9.05	8.17	37.1	40	635	39.6	650	39.5		
	24	.48	9.05	8.09	40.3	40	685	42.8	705	42.7		
	25	.52	9.05	8.01	43.5	45	740	46.4	765	46.3		
	26	.56	9.05	7.93	46.6	45	790	49.4	815	49.3		
10	22	.44	11.10	10.22	46.0	52	790	49.3	810	49.2		
	23	.48	11.10	10.14	50.0	52	850	53.2	875	53.1		
	24	.52	11.10	10.06	53.9	52	915	57.2	940	57.1		
	25	.56	11.10	9.98	57.9	59	985	61.6	1015	61.5		
	26	.60	11.10	9.90	61.8	59	1050	65.5	1080	65.4		
12	22	.48	13.20	12.24	59.8	67	1025	64.0	1055	63.9	1265	63.2
	23	.52	13.20	12.16	64.6	67	1100	68.8	1135	68.7	1360	68.0
	24	.56	13.20	12.08	69.4	67	1175	73.5	1210	73.4	1455	72.8
	25	.60	13 20	12 00	74 1	75	1260	78.8	1300	78.7	1555	77.8
	26	.65	13 20	11.90	80.0	75	1355	84.7	1395	84.5	1675	83.8
16	21	.50	17.40	16.40	82.8	101	1425	89.1	1465	88.9	1755	87.8
	22	.54	17.40	16.32	89.2	101	1530	95.5	1575	95.4	1885	94.2
	23	.58	17.40	16.24	95.6	101	1630	101.9	1680	101.7	2015	100.7
	24	.63	17.40	16 14	103.6	101	1760	109.9	1810	109.7	2175	108.7
	25	.68	17.40	16.04	111.4	113	1895	118.5	1950	118.2	2340	117.0
	26	.73	17.40	15.94	119.3	113	2020	126.4	2080	126.1	2500	125.0

*Including Bell and Spigot Bead. Calculated weight of pipe rounded off to nearest 5 pounds.
†Average weight per foot based on calculated weight of pipe before rounding.

Table No. 9.2 (continued)

STANDARD THICKNESSES, DIAMETERS AND WEIGHTS OF GAS PIPE CENTRIFUGALLY CAST IN SAND LINED MOLDS

Dimensions in Inches — Weights in Pounds

Nominal Diam.	Thickness Class	Thickness	Outside Diam.	Inside Diam.	Wt. of Barrel Per Foot	Wt. of Bell and Bead	Wt. Based On 16 Foot Length		Wt. Based On 16½ Foot Length		Wt. Based On 20 Foot Length	
							Per Length*	†Average Per Foot	Per Length*	†Average Per Foot	Per Length*	†Average Per Foot
20	21	.57	21.60	20.46	117.5	140	2020	126.2	2080	126.0	2490	124.5
	22	.62	21.60	20.36	127.5	140	2180	136.2	2245	136.0	2690	134.5
	23	.67	21.60	20.26	137.5	140	2340	146.2	2410	146.0	2890	144.5
	24	.72	21.60	20.16	147.4	140	2500	156.2	2570	155.9	3090	154.4
	25	.78	21.60	20.04	159.2	159	2705	169.1	2785	168.8	3345	167.2
	26	.84	21.60	19.92	170.9	159	2895	180.8	2980	180.5	3575	178.8
24	21	.63	25.80	24.54	155.4	180	2665	166.6	2745	166.3	3290	164.4
	22	.68	25.80	24.44	167.4	180	2860	178.6	2940	178.3	3530	176.4
	23	.73	25.80	24.34	179.4	180	3050	190.6	3140	190.3	3770	188.4
	24	.79	25.80	24.22	193.7	180	3280	205.0	3375	204.6	4055	202.7
	25	.85	25.80	24.10	207.9	207	3535	220.8	3635	220.4	4365	218.2
	26	.92	25.80	23.96	224.4	207	3795	237.3	3910	236.9	4695	234.8
30	21	.73	32.00	30.54	223.7	264	3845	240.2	3955	239.7	4740	236.9
	22	.79	32.00	30.42	241.7	264	4130	258.2	4250	257.7	5100	254.9
	23	.85	32.00	30.30	259.5	264	4415	276.0	4545	275.5	5455	272.7
	24	.92	32.00	30.16	280.3	264	4750	296.8	4890	296.3	5870	293.5
	25	.99	32.00	30.02	300.9	302	5115	319.8	5265	319.2	6320	316.0
36	21	.81	38.30	36.68	297.7	371	5135	320.9				
	22	.87	38.30	36.56	319.2	371	5480	342.4				
	23	.94	38.30	36.42	344.2	371	5880	367.4				
	24	1.02	38.30	36.26	372.7	371	6335	395.9				
	25	1.10	38.30	36.10	401.1	426	6845	427.7				
	26	1.19	38.30	35.92	432.9	426	7350	459.5				
42	21	.90	44.50	42.70	384.6	486	6640	415.0				
	22	.97	44.50	42.56	413.9	486	7110	444.3				
	23	1.05	44.50	42.40	447.2	486	7640	477.6				
	24	1.13	44.50	42.24	480.4	486	8170	510.7				
	25	1.22	44.50	42.06	517.6	561	8845	552.7				
	26	1.32	44.50	41.86	558.7	561	9500	593.8				
48	21	.98	50.80	48.84	478.6	607	8265	516.5				
	22	1.06	50.80	48.68	516.8	607	8875	554.7				
	23	1.14	50.80	48.52	554.9	607	9485	592.8				
	24	1.23	50.80	48.34	597.6	607	10170	635.5				
	25	1.33	50.80	48.14	644.9	708	11025	689.2				
	26	1.44	50.80	47.92	696.7	708	11855	741.0				

*Including Bell and Spigot Bead. Calculated weight of pipe rounded off to nearest 5 pounds.
†Average weight per foot based on calculated weight of pipe before rounding.

Table No. 9.3

STANDARD THICKNESSES AND WEIGHTS OF CAST IRON GAS PIPE CENTRIFUGALLY CAST IN SAND LINED MOLDS

NOTE: These thicknesses and weights are for pipe laid without blocks, on flat bottom trench with tamped backfill, under 5 feet of cover. For other conditions see tables 9.2 and 9.4 hereof and the Manual.

Size Inches	CLASS 10 — 10 Lb. Pressure — Thickness Inches	Outside Dia. Inches	Weight Based On 16 Ft. Length — Avg. Per Foot†	16 Ft. Length — Per Length*	16½ Ft. Length — Avg. Per Foot†	16½ Ft. Length — Per Length*	20 Ft. Length — Avg. Per Foot†	20 Ft. Length — Per Length*	CLASS 50 — 50 Lb. Pressure — Thickness Inches	Outside Dia. Inches	Weight Based On 16 Ft. Length — Avg. Per Foot†	16 Ft. Length — Per Length*	16½ Ft. Length — Avg. Per Foot†	16½ Ft. Length — Per Length*	20 Ft. Length — Avg. Per Foot†	20 Ft. Length — Per Length*
4	.35[1]	4.80	16.5	265	16.4	270			.35[1]	4.80	16.5	265	16.4	270		
	or .38[2]	4.80	17.6	280	17.5	290			or .38[2]	4.80	17 6	280	17.5	290		
6	.38[1]	6.90	26.0	415	25.9	430			.38[1]	6.90	26 0	415	25.9	430		
	or .41[2]	6.90	27.9	445	27.8	460			or .41[2]	6.90	27.9	445	27.8	460		
8	.41	9.05	37.3	595	37.2	615			.41	9.05	37.3	595	37.2	615		
10	.44	11.10	49.3	790	49.2	810			.44	11.10	49.3	790	49.2	810		
12	.48	13.20	64.0	1025	63.9	1055	63.2	1265	.48	13.20	64.0	1025	63.9	1055	63.2	1265
16	.50	17.40	89.1	1425	88.9	1465	87.8	1755	.50	17.40	89.1	1425	88.9	1465	87.8	1755
20	.57	21 60	126.2	2020	126.0	2080	124.5	2490	.57	21.60	126.2	2020	126.0	2080	124.5	2490
24	.63	25.80	166 6	2665	166.3	2745	164.4	3290	.63	25.80	166.6	2665	166.3	2745	164.4	3290
30	.73	32.00	240.2	3845	239.7	3955	236.9	4740	.79	32.00	258.2	4130	257.7	4250	254.9	5100
36	.81	38.30	320.9	5135					.87	38.30	342.4	5480				
42	.90	44.50	415.0	6640					.97	44.50	444.3	7110				
48	.98	50.80	516.5	8265					1.06	50.80	554.7	8875				

*Including Bell and Spigot Bead. Calculated weight of pipe rounded off to nearest 5 pounds.
†Average weight per foot based on calculated weight of pipe before rounding
[1]Class 22 thickness.
[2]Class 23 thickness offers increased factor of safety and is recommended for use in areas of dense population and heavy traffic.

Table No. 9.3 (continued)

STANDARD THICKNESSES AND WEIGHTS OF CAST IRON GAS PIPE CENTRIFUGALLY CAST IN SAND LINED MOLDS

NOTE: These thicknesses and weights are for pipe loid without blocks, on flat bottom trench with tamped bockfill, under 5 feet of cover. For other conditians see tables 9.2 and 9.4 hereof and the Manual.

	CLASS 100								CLASS 150							
	100 Lb. Pressure								150 Lb. Pressure							
			Weight Based On								Weight Based On					
			16 Ft. Length		16½ Ft. Length		20 Ft. Length				16 Ft. Length		16½ Ft. Length		20 Ft. Length	
Size Inches	Thickness Inches	Outside Dia. Inches	Avg. Per Foot†	Per Length*	Avg. Per Foot†	Per Length*	Avg. Per Foot†	Per Length*	Thickness Inches	Outside Dia. Inches	Avg. Per Foot†	Per Length*	Avg. Per Foot†	Per Length*	Avg. Per Foot†	Per Length*
4	.35[1]	4.80	16.5	265	16 4	270			.35[1]	4.80	16.5	265	16.4	270		
	or .38[2]	4.80	17.6	280	17.5	290			or. .38[2]	4.80	17.6	280	17.5	290		
6	.38[1]	6.90	26.0	415	25.9	430			.38[1]	6.90	26.0	415	25.9	430		
	or .41[2]	6.90	27.9	445	27.8	460			or .41[2]	6.90	27.9	445	27.8	460		
8	.41	9.05	37.3	595	37.2	615			.41	9.05	37.3	595	37.2	615		
10	.44	11.10	49.3	790	49.2	810			.44	11.10	49.3	790	49.2	810		
12	.48	13.20	64.0	1025	63.9	1055	63.2	1265	.48	13.20	64.0	1025	63.9	1055	63.2	1265
16	.54	17.40	95.5	1530	95.4	1575	94.2	1885								
20	.62	21.60	136.2	2180	136.0	2245	134.5	2690								
24	.68	25.80	178.6	2860	178.3	2940	176.4	3530								

*Including Bell and Spigot Bead. Calculated weight of pipe rounded off to nearest 5 pounds.
†Average weight per foot based on calculated weight of pipe before rounding.
[1]Class 22 thickness.
[2]Class 23 thickness offers increased factor of safety and is recommended for use in areas of dense population and heavy traffic.

Table No. 9.4

STANDARD THICKNESSES OF CAST IRON GAS PIPE CENTRIFUGALLY CAST IN SAND LINED MOLDS

Thickness in Inches. Working Pressure in Pounds per Square Inch. Thicknesses Include Allowances for Foundry Practice and Corrosion

Laying Condition A—Flat Bottom Trench, Without Blocks, Untamped Backfill
Laying Condition B—Flat Bottom Trench, Without Blocks, Tamped Backfill
Laying Condition C—Pipe Laid on Blocks, Untamped Backfill
Laying Condition D—Pipe Laid on Blocks, Tamped Backfill

Size Inches	Working Pressure	3½ FEET OF COVER Laying Condition				5 FEET OF COVER Laying Condition				8 FEET OF COVER Laying Condition			
		A	B	C	D	A	B	C	D	A	B	C	D
4	10	[1].35	.35	.35	.35	.35	.35	.35	.35	.35	.35	.41	.35
		[2].38	.38	.38	.38	.38	.38	.38	.38	.38	.38	.41	.38
	50	[1].35	.35	.35	.35	.35	.35	.35	.35	.35	.35	.41	.35
		[2].38	.38	.38	.38	.38	.38	.38	.38	.38	.38	.41	.38
	100	[1].35	.35	.35	.35	.35	.35	.35	.35	.35	.35	.41	.35
		[2].38	.38	.38	.38	.38	.38	.38	.38	.38	.38	.41	.38
	150	[1].35	.35	.35	.35	.35	.35	.38	.35	.35	.35	.41	.35
		[2].38	.38	.38	.38	.38	.38	.38	.38	.38	.38	.41	.38
6	10	[1].38	.38	.41	.38	.38	.38	.41	.38	.38	.38	.48	.38
		[2].41	.41	.41	.41	.41	.41	.41	.41	.41	.41	.48	.41
	50	[1].38	.38	.41	.38	.38	.38	.41	.38	.38	.38	.48	.38
		[2].41	.41	.41	.41	.41	.41	.41	.41	.41	.41	.48	.41
	100	[1].38	.38	.41	.38	.38	.38	.44	.38	.38	.38	.48	.38
		[2].41	.41	.41	.41	.41	.41	.44	.41	.41	.41	.48	.41
	150	[1].38	.38	.41	.38	.38	.38	.44	.38	.38	.38	.48	.38
		[2].41	.41	.41	.41	.41	.41	.44	.41	.41	.41	.48	.41
8	10	.41	.41	.44	.41	.41	.41	.48	.41	.41	.41	.52	.41
	50	.41	.41	.44	.41	.41	.41	.48	.41	.41	.41	.52	.41
	100	.41	.41	.48	.41	.41	.41	.48	.41	.41	.41	.56	.41
	150	.41	.41	.48	.41	.41	.41	.48	.41	.41	.41	.56	.41
10	10	.44	.44	.48	.44	.44	.44	.52	.44	.44	.44	.60	.44
	50	.44	.44	.48	.44	.44	.44	.52	.44	.44	.44	.60	.44
	100	.44	.44	.52	.44	.44	.44	.52	.44	.44	.44	.60	.48
	150	.44	.44	.52	.44	.44	.44	.56	.44	.48	.44	.60	.48
12	10	.48	.48	.52	.48	.48	.48	.56	.48	.48	.48	.60	.52
	50	.48	.48	.52	.48	.48	.48	.56	.48	.48	.48	.60	.52
	100	.48	.48	.56	.48	.48	.48	.56	.48	.52	.48	.65	.52
	150	.48	.48	.56	.48	.48	.48	.56	.48	.52	.48	.65	.52
16	10	.54	.50	.58	.54	.54	.50	.63	.58	.58	.54	.73	.63
	50	.54	.50	.63	.54	.54	.50	.63	.58	.63	.58	.73	.63
	100	.54	.54	.63	.58	.58	.54	.68	.58	.63	.58	.73	.68
20	10	.62	.57	.67	.62	.62	.57	.72	.67	.67	.62	.78	.72
	50	.62	.57	.72	.62	.67	.57	.72	.67	.72	.62	.78	.72
	100	.62	.57	.72	.67	.67	.62	.78	.67	.72	.67	.84	.78
24	10	.68	.63	.73	.68	.73	.63	.79	.73	.79	.68	.85	.79
	50	.68	.63	.79	.68	.73	.63	.79	.73	.79	.73	.85	.79
	100	.73	.63	.79	.73	.73	.68	.85	.79	.79	.73	.92	.85
30	10	.79	.73	.85	.79	.85	.73	.92	.85	.92	.79	.99	.92
	50	.85	.73	.85	.85	.85	.79	.92	.85	.92	.85	.99	.92
36	10	.87	.81	.94	.87	.94	.81	1.02	.94	1.02	.87	1.10	1.02
	50	.94	.81	1.02	.94	1.02	.87	1.10	.94	1.10	.94	1.19	1.02
42	10	1.05	.90	1.05	.97	1.05	.90	1.13	1.05	1.13	.97	1.22	1.13
	50	1.05	.90	1.13	1.05	1.13	.97	1.13	1.05	1.22	1.05	1.32	1.13
48	10	1.14	.98	1.14	1.06	1.14	.98	1.23	1.14	1.33	1.06	1.33	1.23
	50	1.14	.98	1.23	1.14	1.23	1.06	1.33	1.14	1.33	1.14	1.44	1.33

[1]Class 22 Thickness.
[2]Class 23 Thickness offers increased factor of safety and is recommended for use in areas of dense population and heavy traffic.

ASA
A21.10–1951

American Standard Specifications
for
SHORT-BODY CAST-IRON FITTINGS, 3 INCH TO 12 INCH, FOR 250-PSI. WATER PRESSURE PLUS WATER HAMMER

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American Society for Testing Materials
American Water Works Association
New England Water Works Association

Foreword

For a brief history of the development of standard specications for cast-iron pipe and fittings for water, for the organization and program of the Sectional Committee (A21) on Specifications for Cast Iron Pipe and Fittings which developed the specifications contained herein, and for a description of the other specifications issued or in preparation by this sectional committee, reference should be made to the Foreword of the "American Recommended Practice Manual for the Computation of Strength and Thickness of Cast Iron Pipe (ASA A21.1)."

The short-body fittings described in the specifications which follow were developed to meet a growing demand for lighter, cheaper and more compact fittings than those of earlier standard specifications for bell-and-spigot fittings for water, fittings better adapted to use in distribution work in city streets congested with other utility structures. This need for more compact fittings had led to a variety of special designs by different municipalities and manufacturers.

The radical change in design raised questions of strength and hydraulic properties which were studied exhaustively by Committee A21. Strength was investigated, with numerous bursting tests in each case, by Dean M. L. Enger and Prof. W. M. Lansford of the Dept. of Theoretical and Applied Mechanics, University of Illinois (unpublished), and by the American Cast Iron Pipe Co. representing the Cast Iron Pressure Pipe Institute of the manufacturers (unpublished). Hydraulic losses, in comparison with losses in fittings of the current A.W.W.A. long-body patterns, were measured at the Cornell University Engineering Experiment Station by Prof. Ernest W. Schoder and Prof. Arthur N. Vanderlip; and an economic comparison of the short-body and the A.W.W.A. types, as they would be used in a typical distribution system, was made by Allen T. Ricketts and Thomas H. Wiggin. Both of these studies of hydraulic losses were published in Cornell University Engineering Experiment Station Bulletin No. 20, September 1935 (102 pages, $1.25). These studies, for 12-in. and smaller fittings, demonstrated not only the strength of the short-body designs, but also that these short fittings are slightly superior economically in distribution systems, considering friction losses, the cost of power for pumping, and installation costs. Longer-radius bends show somewhat smaller losses of head, but the difference is so small for usual distribution velocities, and the use of bends in distribution systems, except where space is limited, is so infrequent, that this difference may be disregarded.

Since cast iron tees and crosses, especially those with equal outlets, defy accurate stress analysis, the designs were developed on the basis of numerous bursting tests, with allowances for water hammer, for foundry tolerance and for a loss in thickness of 0.08 in. by corrosion. These fittings are of one class only, for a static working water pressure of 250 psi. plus water hammer, with or without ordinary earth loads, and with a factor of safety of about 2½.

The designs contemplate all bell fittings. The spigots shown in Fig. 1 (*see* p. 6) will be substituted for one or more bells as ordered. Fittings of the same body dimensions and laying lengths, with flange ends or ends for mechanical joints, may also be ordered under these specifications.

ASA
A21.10–1951

American Standard Specifications for

Short-Body Cast-Iron Fittings, 3 Inch to 12 Inch, for 250-psi. Water Pressure Plus Water Hammer

This specification covers 3-in. to 12-in. short-body cast-iron fittings for water pressure of 250 psi. plus water hammer as specified in the "American Recommended Practice Manual for the Computation of Strength and Thickness of Cast Iron Pipe" (ASA A21.1).

Sec. 10–1—Description of Fittings

Fittings shall be made with all bell ends or such other type of ends as may be agreed upon at the time of purchase. Fittings with all bell ends or with spigot ends shall accurately conform to the dimensions given in the tables accompanying and forming a part of these specifications. Fittings with other types of ends shall comply with the dimensions agreed upon but in all other respects shall fulfill the specifications hereinafter given.

Sec. 10–2—Casting of Fittings

Fittings shall be molded from accurate patterns. They shall not be stripped while sufficiently hot to be injured by subsequent cooling.

Sec. 10–3—Quality of Iron

10–3.1. All fittings shall be made of cast iron of good quality, and of such character and so adapted in chemical composition to the thickness of the fittings to be cast that the iron in the fittings shall be strong, tough, resilient, of even grain and soft enough for satisfactory drilling and cutting and it shall comply with the physical specifications given in Sec. 10–14 and 10–15. The metal shall be remelted in a cupola or other suitable furnace.

10–3.2. The iron in the fittings shall not contain more than 0.90 per cent of phosphorus nor more than 0.12 per cent of sulfur. Samples for chemical analysis shall be taken by drilling completely through from skin to skin each of the acceptance test specimens; but not to exceed three specimens per heat.

Sec. 10–4—Quality of Castings

The fittings shall be smooth and free from scales, lumps, blisters, sand holes and defects of every nature which unfit them for the use for which they are intended. No plugging, filling, burning-in or welding will be allowed except as permitted by the purchaser.

Sec. 10–5—Foundry Records

10–5.1. *Casting.* A record of the melting and pouring temperatures of the iron shall be furnished the purchaser if requested.

10–5.2. *Chemical analyses.* Chemical analyses shall be made by the manufacturer from each heat to determine total carbon, manganese, phosphorus, sulfur and silicon; duplicate copies of test reports shall be furnished the purchaser on request.

Sec. 10–6—Marking of Fittings

Every fitting shall have distinctly cast upon it the initials of the maker's name, and, if requested by the purchaser, figures showing the year in which it was cast. Nominal diameters of openings shall be cast on all fittings and the fraction of the circle on all bends; also any initials, not exceeding four, which may be required by the purchaser. The letters and figures shall be cast on the outside and have dimensions not less than those indicated below:

Fitting Diam. *in.*	Height of Letters *in.*	Relief *in.*
3–10	$\frac{3}{4}$	$\frac{3}{32}$
12	$1\frac{1}{4}$	$\frac{3}{32}$

The weight and the class shall be conspicuously painted in white on the inside or outside of each fitting after the coating has become hard.

Sec. 10–7—Inspection by Purchaser

10–7.1. *Definition of "Purchaser."* Wherever the word "Purchaser" is used herein it shall be understood to mean the actual purchaser of the fittings or his authorized agents acting within the scope of the duties entrusted to them.

10–7.2. *Power of purchaser to inspect.* The purchaser shall have free access at all times to all parts of any manufacturing plant which concern the manufacture of articles to be made for him. He may inspect the material, pattern work, molding, casting, coating and lining of the fittings. The forms, sizes, uniformity and conditions of all fittings herein referred to shall be subject to his inspection and approval, and he may reject any fitting which is not in conformity with the specifications or drawings. Any fitting rejected shall be marked "rejected," and any marks pertaining to the purchaser shall be chipped or erased from such fitting.

10–7.3. *Manufacturer to furnish men and materials.* The manufacturer shall provide all tools, testing equipment, materials, labor and facilities necessary for the required testing, inspection and weighing of the fittings at the foundry.

10–7.4. *Report of purchaser's inspection.* The purchaser shall make written report daily at the foundry office of all fittings rejected, noting causes for rejection.

Sec. 10–8—Inspection and Certification by Manufacturer

Should the purchaser have no inspector at the works, the manufacturer shall, if required by the purchaser, furnish a sworn statement that the inspection and all of the tests have been made as specified, this statement to contain the results of all specified tests.

Sec. 10–9—Fittings to Be Delivered Sound

All the fittings must be delivered in all respects sound and conformable to these specifications. The inspection shall not relieve the manufacturer of any of his obligations in this regard, and any defective fitting which may have passed the purchaser at the works or elsewhere shall be at all times liable to rejection when discovered, until the final completion and adjustment of the contract; provided, however, that the manufacturer shall not be held liable for fittings found to be cracked after they have been accepted at the agreed point of delivery, unless there shall be unmistakable evidence that the casting was originally defective or damaged before acceptance. Care shall be taken in handling the fittings not to injure the coating or lining, and no material of any kind shall be placed in the fittings during transportation or at any other time after they have received the coating or lining.

Sec. 10–10—Tolerances or Maximum Permitted Variations From Standard

10–10.1. *Tolerances in diameter.* All sockets and spigots shall be tested by circular gages. All fittings shall be rejected which are defective in joint room, or which vary more than 0.12 in. from standard dimensions in the diameters of the sockets and the outside diameters of spigots.

10–10.2. *Tolerances in thickness.* No variations below the standard thickness shall be permitted for 10-in. by 10-in., 12-in. by 12-in. and 12-in. by 10-in. tees and crosses. For other fittings, variations below the standard thickness shall not be greater than those shown in the following table and note:

Nom. Diameter *in.*	Minus Tolerance *in.*
3, 4 and 6	0.10
8, 10 and 12	0.12

Note: Variations from the standard thickness of 0.02 in. in excess of the allowances above given shall be permitted for spaces not exceeding 8 in. in length in any direction.

10–10.3. *Allowable percentage of variation in weight.* No fitting shall be accepted the weight of which shall be less than the standard weight by more than 10 per cent, and no excess above the standard weight of more than 10 per cent will be paid for.

Sec. 10–11—Cleaning and Inspecting

All fittings shall have gates, fins and other roughnesses chipped or ground off and shall be thoroughly cleaned, checked as to dimensions and also subjected to a careful surface inspection and a hammer test before being coated or lined.

Sec. 10–12—Weighing

Each fitting shall be weighed and the weight and class conspicuously painted on the outside or inside of the bell or spigot end. Fittings which are to be lined with cement mortar or coated on the inside or outside, or both, with bituminous enamel or other special material shall be weighed before the application of such a lining or coating. If desired by the purchaser, fittings not lined or coated with cement mortar, bituminous enamel or other special material shall be weighed after delivery and the weights so ascertained shall be used in the final settlement, provided such weighing is done by a legalized weighmaster. Unless otherwise stated in the contract, a ton shall be 2,000 lb. avoirdupois.

Sec. 10–13—Linings and Exterior Coatings

Any particular lining or coating which is to be applied to the fittings shall be specified in the agreement made at the time of purchase. Separate specifications for a cement-mortar lining have been provided in connection with these specifications for fittings. (*See* specification ASA A21.4–1952.)

No pipe or specials for waterworks service shall be furnished without protective coating unless specifically ordered by the purchaser.

Sec. 10–14—Test of Material

The acceptability of the iron used in the fittings shall be determined by testing bars cast from the same iron as the fittings. The observations and the computed results hereinafter required shall be recorded, and, if requested, reported to the purchaser.

Sec. 10-15—Test Bars

10-15.1. *Dimensions.* Test bars shall be 2 in. wide, 1 in. thick and not less than 26 in. long. Individual test bars may vary as much as 2 per cent from the standard width or standard thickness, or both, but the patterns and molding practice shall be such that the errors shall in general not exceed 1 per cent.

10-15.2. *Methods of casting.* The bars shall be cast vertically in well faced, dry sand molds provided with a suitable pouring basin and mounted on a suitable refractory foundation. Metal for the bars shall be obtained by using a small, heated ladle taking its metal from the main ladle from which the fittings are to be poured and after all alloys and other additional metal, except cast iron for cooling, have been added to the main ladle and become melted. The bars shall not be removed from the mold before they have cooled to 500°F.

10-15.3. *When cast and to what fittings applicable.* Except as hereinafter provided for special cases, one pair of test bars of the metal used shall be cast with iron from the first ladle, another pair with iron from the approximately middle ladle and a third pair with iron from the last ladle of iron taken during a day's run or heat, from the cupola in which the iron for the fittings is melted. If the heat lasts for more than six hours, then additional pairs of bars shall be cast at approximately uniform intervals so as to give an extra pair of bars for each three hours during which the heat lasts in excess of six hours. In case the charging of the cupola is to be changed for one or more times during the day's run or heat in order to produce a different iron, the time of taking test bars shall be varied in such a way as to obtain representative tests of the iron at least at the beginning and end of each period during which the iron is intended to be constant in quality; and in case such period exceeds four hours, additional pairs of bars shall be taken at such times as will provide a pair of bars for each two hours during which this special mixture is used. At least one bar from each pair shall be broken, but the manufacturer shall have the right to break both bars, in which case the better bar shall be taken as representative. Bars showing flaws in fracture may be disregarded.

10-15.4. *Test bar requirements to indicate acceptable iron.* In order that the iron shall be acceptable, the average results from the single bars representing the respective pairs of bars cast during the heat or period shall comply with the requirements hereinafter specified, and, in addition, no representative bar shall be more than 5 per cent below the minimum requirements in either corrected breaking load or corrected deflection.

10-15.5. *Method of testing.* The bars shall be broken as beams by placing them flatwise on supports 24 in. apart and applying the load at the center of the span. The breaking load and the corresponding deflection shall be observed and recorded.

10-15.6. *Correcting observed breaking loads and deflections.* The bars shall be measured at the point of application of the load and the results corrected to standard 2-in. by 1-in. cross section by the conventional beam formula as follows:

SHORT-BODY CAST-IRON FITTINGS

Corrected breaking load

$$= \text{Observed breaking load} \times \frac{2}{bd^2}$$

Corrected deflection at breaking

$$= \text{Observed deflection at breaking} \times d$$

where b is the measured width and d is the measured depth of the bar at the point of application of the load. In the formulas above, the deflection and all dimensions are in inches.

10–15.7. *Requirements on strength and deflection of 2-in. by 1-in. bars.* In order to indicate acceptable metal, the corrected breaking loads and deflections of the representative 2-in. by 1-in. test bars for a given heat or period, interpreted as provided in Sec. 10–15.4 above, shall comply with the following requirements:

Minimum center breaking load:

2,300 lb.

Minimum center deflection at breaking:

$$0.30 + 0.0001 \text{ (breaking load} - 2{,}300\text{) in.}$$

TABLE 1

Weights of Short-Body Fittings

Tees and Crosses

Nom. Diam. *in.*		Weight *lb.*	
Run	Branch	Tee	Cross
3	3	80	105
4	3	100	125
4	4	105	140
6	3	140	165
6	4	150	180
6	6	160	210
8	3	200	225
8	4	210	240
8	6	220	265
8	8	240	305
10	3	280	305
10	4	290	320
10	6	300	350
10	8	320	390
10	10	370	465
12	3	365	390
12	4	375	405
12	6	385	435
12	8	405	475
12	10	460	555
12	12	485	600

Bends

Nom. Diam. *in.*	Weight—*lb.*			
	90°	45°	22½°	11¼°
3	55	50	50	50
4	70	65	65	65
6	110	100	100	100
8	165	145	145	145
10	230	200	200	200
12	305	270	270	270

Reducers

Nom. Diam.—*in.*		Weight *lb.*
Large	Small	
4	3	55
6	3	75
6	4	80
8	3	100
8	4	110
8	6	125
10	3	125
10	4	135
10	6	150
10	8	170
12	3	160
12	4	165
12	6	185
12	8	210
12	10	235

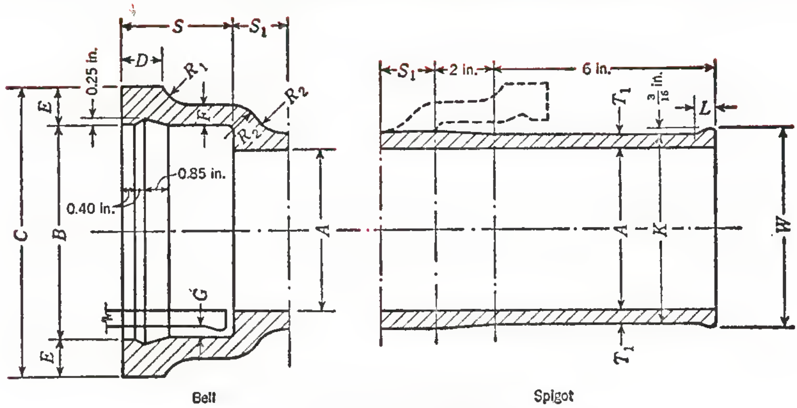


FIG. 1. Bells and Spigots

Bell and Spigot Dimensions

Nom. Diam. *in.*	A	B	C	D	E	F	G	S_1	K	L	R_1*	R_2†	S	T_1	W‡
3	3.00	4.66	7.26	1.25	1.30	0.65	0.35	1.50	3.96	0.75	0.98	1.00	3.50	0.48	4.34
4	3.96	5.70	8.30	1.50	1.30	0.65	0.40	2.00	4.90	0.75	0.98	1.05	4.00	0.47	5.28
6	6.00	7.80	10.60	1.50	1.40	0.70	0.40	2.00	7.00	0.75	1.05	1.10	4.00	0.50	7.38
8	8.10	10.00	13.00	1.50	1.50	0.75	0.41	2.00	9.18	1.00	1.12	1.16	4.00	0.54	9.56
10	10.04	12.10	15.30	1.50	1.60	0.80	0.42	2.00	11.25	1.00	1.20	1.22	4.00	0.60	11.63
12	12.00	14.20	17.60	1.50	1.70	0.85	0.42	2.00	13.35	1.00	1.28	1.27	4.00	0.68	13.73

* $R_1 = 1.5(E - F)$. † $R_2 = F + G$. ‡ $W = K + 0.38$.

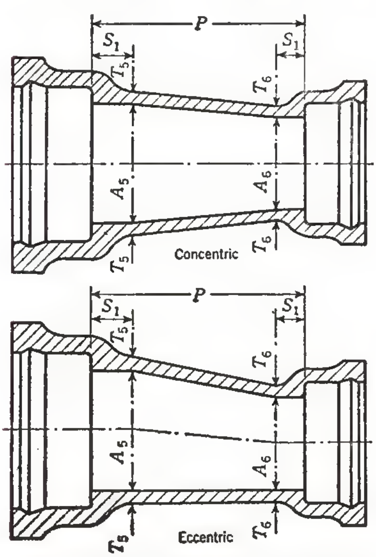


FIG. 2. Concentric and Eccentric Reducers

*Standard Short-Body Reducers**

Size *in.*	A_5	A_6	T_5	T_6	P
4×3	3.96	3.00	0.52	0.48	7.00
6×3	6.00	3.00	0.55	0.48	9.00
6×4	6.00	3.96	0.55	0.52	9.00
8×3	8.10	3.00	0.60	0.48	11.00
8×4	8.10	3.96	0.60	0.52	11.00
8×6	8.10	6.00	0.60	0.55	11.00
10×3	10.04	3.00	0.68	0.48	12.00
10×4	10.04	3.96	0.68	0.52	12.00
10×6	10.04	6.00	0.68	0.55	12.00
10×8	10.04	8.10	0.68	0.60	12.00
12×3	12.00	3.00	0.75	0.48	14.00
12×4	12.00	3.96	0.75	0.52	14.00
12×6	12.00	6.00	0.75	0.55	14.00
12×8	12.00	8.10	0.75	0.60	14.00
12×10	12.00	10.04	0.75	0.68	14.00

* S_1 equals 1.5 in. for 3-in. size; S_1 equals 2.0 in. for 4-in. through 12-in. size. For bell and spigot dimensions, see Fig. 1.

SHORT-BODY CAST-IRON FITTINGS

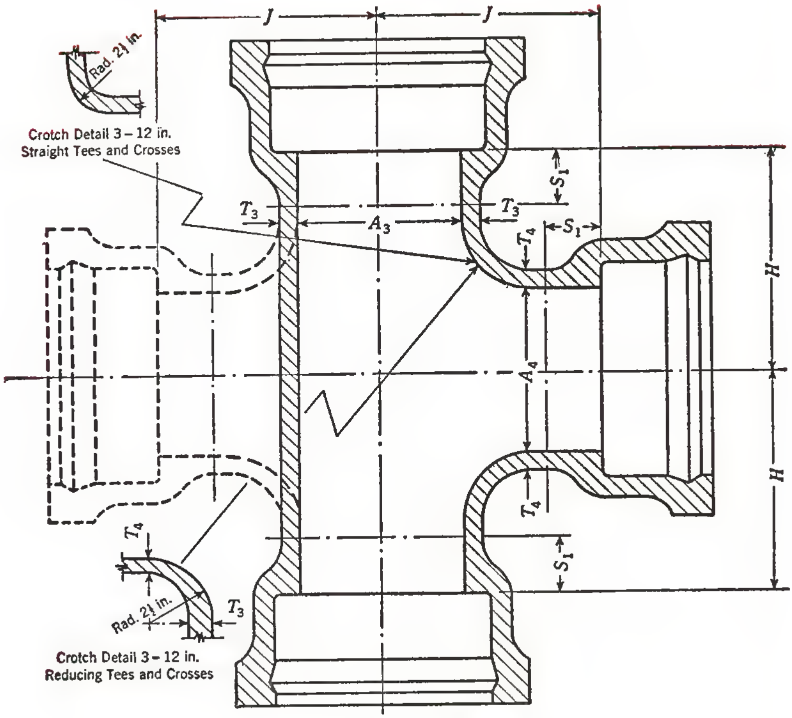


FIG. 3. Tees and Crosses

*Standard Short-Body Tees and Crosses**

Size *in.*	A_3	A_4	H	J	T_3	T_4	Size *in.*	A_3	A_4	H	J	T_3	T_4
3×3	3.00	3.00	5.5	5.5	0.48	0.48	10×4	10.04	3.96	11.00	11.00	0.68	0.52
4×3	3.96	3.00	6.5	6.5	0.52	0.48	10×6	10.04	6.00	11.00	11.00	0.68	0.55
4×4	3.96	3.96	6.5	6.5	0.52	0.52	10×8	10.04	8.10	11.00	11.00	0.68	0.60
6×3	6.00	3.00	8.0	8.0	0.55	0.48	10×10	10.04	10.04	11.00	11.00	0.80	0.80
6×4	6.00	3.96	8.0	8.0	0.55	0.52	12×3	12.00	3.00	12.00	12.00	0.75	0.48
6×6	6.00	6.00	8.0	8.0	0.55	0.55	12×4	12.00	3.96	12.00	12.00	0.75	0.52
8×3	8.10	3.00	9.0	9.0	0.60	0.48	12×6	12.00	6.00	12.00	12.00	0.75	0.55
8×4	8.10	3.96	9.0	9.0	0.60	0.52	12×8	12.00	8.10	12.00	12.00	0.75	0.60
8×6	8.10	6.00	9.0	9.0	0.60	0.55	12×10	12.00	10.04	12.00	12.00	0.87	0.80
8×8	8.10	8.10	9.0	9.0	0.60	0.60	12×12	12.00	12.00	12.00	12.00	0.87	0.87
10×3	10.04	3.00	11.00	11.00	0.68	0.48							

* S_1 equals 1.5 in. for 3-in. size; S_1 equals 2.0 in. for 4-in. through 12-in. size. For bell and spigot dimensions, see Fig. 1.

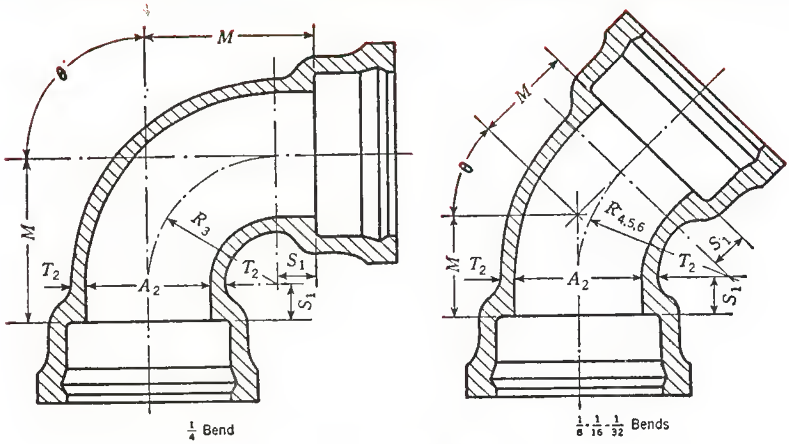


FIG. 4. Short-Body Bends

*Standard Short-Body Bends**

Size in.	All Bends		¼ Bend $\theta=90°$		⅛ Bend $\theta=45°$		1/16 Bend $\theta=22\frac{1}{2}°$		1/32 Bend $\theta=11\frac{1}{4}°$	
	A_2	T_2	M	R_3	M	R_4	M	R_5	M	R_6
3	3.00	0.48	5.50	4.00	3.00	3.62	3.00	7.56	3.00	15.25
4	3.96	0.52	6.50	4.50	4.00	4.81	4.00	10.06	4.00	20.31
6	6.00	0.55	8.00	6.00	5.00	7.25	5.00	15.06	5.00	30.50
8	8.10	0.60	9.00	7.00	5.50	8.44	5.50	17.63	5.50	35.50
10	10.04	0.68	11.00	9.00	6.50	10.88	6.50	22.62	6.50	45.69
12	12.00	0.75	12.00	10.00	7.50	13.25	7.50	27.62	7.50	55.81

* S_1 equals 1.5 in. for 3-in. size; S_1 equals 2.0 in. for 4-in. through 12-in. size. For bell and spigot dimensions see Fig. 1.

Installing mechanical joint cast iron pipe for gas distribution main.

Laying mechanical joint cast iron pipe for a water feeder main.

Mechanical joint cast iron pipe being installed for a deep sewer line.

ASA
A21.11–1952

AMERICAN STANDARD SPECIFICATIONS

for

A MECHANICAL JOINT

for

CAST IRON PRESSURE PIPE AND FITTINGS

SPONSORS

American Gas Association
American Society for Testing Materials
American Water Works Association
New England Water Works Association

ASA
A21.11–1952

AMERICAN STANDARD SPECIFICATIONS

for

A MECHANICAL JOINT

for

CAST IRON PRESSURE PIPE AND FITTINGS

These specifications cover a mechanical joint, in sizes 3-inch to 48-inch, for cast iron pressure pipe made by pit cast or by centrifugal methods and cast iron pressure fittings, for gas, water, and other liquids.

Sec. 11–1—Definitions

Purchaser. Wherever the word "purchaser" is used herein, it shall be understood to mean the actual purchaser of the pipe or his authorized agents acting within the scope of the duties entrusted to them.

Manufacturer. The word "manufacturer" means the producer who is making the pipe or fittings and who assumes the responsibility for the fulfillment of these specifications. Accessories, including glands and bolts, may be sublet to other manufacturers. Gaskets will in general be made by other manufacturers who are not expected to permit inspection of manufacturing processes without special arrangements.

Sec. 11–2—Description of Joint

The mechanical joint is a bolted joint of the stuffing box type, as shown in Section 11–4A. Each joint shall consist of (1) a bell cast integrally with the pipe or fitting and provided with an exterior flange having cored or drilled bolt holes and interior annular recesses for the sealing gasket and the spigot of the pipe or fitting; (2) a pipe or fitting spigot; (3) a sealing gasket; (4) a separate cast iron follower gland having cored or drilled bolt holes; and (5) cast iron tee-head bolts and hexagon nuts.

The joint is designed to permit normal expansion, contraction, and deflection of the pipe line.

Sec. 11–3—Pipe and Fittings to Which Mechanical Joint Is Applicable

The mechanical joint made under these specifications is intended for use on cast iron pressure pipe and fittings made in accordance with the following

Standard ASA Specifications and shall be suitable for leakproof assembly therewith.

ASA A21.2	Specifications for Cast Iron Pit Cast Pipe for Water and Other Liquids
ASA A21.3	Specifications for Cast Iron Pit Cast Pipe for Gas
ASA A21.6	Specifications for Cast Iron Pipe Centrifugally Cast in Metal Molds for Water or Other Liquids
ASA A21.7	Specifications for Cast Iron Pipe Centrifugally Cast in Metal Molds for Gas
ASA A21.8	Specifications for Cast Iron Pipe Centrifugally Cast in Sand Lined Molds for Water or Other Liquids
ASA A21.9	Specifications for Cast Iron Pipe Centrifugally Cast in Sand Lined Molds for Gas
ASA A21.10	Specifications for Cast Iron Short-Body Pressure Fittings

The mechanical joint shall meet all applicable requirements of the above listed specifications and shall have the same pressure rating as the pipe or fitting of which it is a part.

Mechanical joints for pipe or fittings beyond the scope of such standard specifications shall be subject to agreement between the manufacturer and the purchaser.

Sec. 11–4—Dimensions and Tolerances

The joint and accessories shall meet the following dimensions and the tolerances shown above them.

Sec. 11–5—Bell and Socket

The bell shall be cast integrally with the pipe or fitting and shall meet the applicable requirements of the specification under which the pipe or fitting is produced.

The surfaces of the bell and socket shall be smooth, free from holes, laps and defects of every nature which unfit them for the use for which they are intended. The bell and socket shall be subject to suitable joint tests for leakage. Such tests shall be made at sufficiently frequent intervals to assure that the joints shall be tight when properly assembled.

The annular recesses of the socket, the bolt circle, and the bell flange shall be concentric within the tolerances of Section 11–4A. The dimensions of the bell and socket, the bolt circle and the spacing of the bolt holes shall be gaged in accordance with Section 11–4A, at sufficiently frequent intervals to assure dimensional control.

Sec. 11–6—Glands

The iron in the glands shall meet the requirements of Class 25 of the Standard Specification for Gray Iron Castings ASA G25.1 (ASTM A48). The preferred acceptance test under this specification shall be the transverse test, although the tension test may be used for qualification. The minimum strengths under this specification are shown in the following table.

	1.2 in. dia. bar 18 in. supports Load at center	2 in. dia. bar 24 in. supports Load at center
Minimum Transverse Breaking Loads	2000 pounds	6800 pounds
Minimum Tensile Strength	25,000 p.s.i.	

The annular surfaces of the gland lip and the bolt circle shall be concentric. Their accuracy within the tolerances of Section 11–4A shall be checked by gaging at sufficiently frequent intervals to assure dimensional control.

The surfaces of the gland shall be smooth and free from defects of every nature which would unfit them for the use intended.

Glands shall be coated with a bituminous dip or paint unless otherwise specified.

Sec. 11–7—Bolt Holes

Bolt holes for pipe and fittings may be drilled or cored. All bolt holes shall be free of sand or projections of iron that would interfere with the fit of the bolts. Drilled holes shall be gaged as to location, at sufficiently frequent intervals to assure dimensional control. All cored holes shall be gaged for diameter of bolt circle, location and size of holes and concentricity with the socket or gland lip.

Sec. 11–8—Gaskets

Manufacture

The gaskets shall be made of a vulcanized crude rubber compound and unless otherwise specified the rubber shall be first grade plantation rubber. All surfaces of the gaskets shall be smooth except for the specified marking, and free from imperfections and the gaskets shall be free from any porosity. Tips or backs, if specified for special conditions shall be applied as shown in Section 11–4B and shall be well bonded to the rubber.

Service

Plain rubber gaskets are standard for joints in water service or other service where the gas or liquid being conveyed or the temperature is not deteriorating to the gaskets. Tips of duck, Thiokol impregnated duck, synthetic rubber of various kinds, lead and other materials can be applied for special services. Duck or other reinforcing material also may be applied to the back of the gaskets. Gaskets other than plain rubber shall be specified on the purchase order.

Physical Properties and Tests

The following tests shall be made by the gasket manufacturer in accordance with Federal Specification ZZ–R–601a or the equivalent ASTM specification.

> The test specimen for all tests except hardness shall be die-cut from routine production gaskets. It shall have a gage length of 2″ with a width of 0.25″ and a thickness of 0.10″. The gaskets selected for testing shall be such as to represent the full range of quality of the lot from which the order is to be filled. For each 5000 gaskets produced or for any week's production of less than 5000 gaskets, at least one set of tests shall be made.

1. Ultimate tensile strength.
2. Ultimate elongation.
3. Elongation at 1000 p.s.i. stress—Limits: 110% to 190%.

4. Permanent Set. The sample shall be clamped for 10 minutes at the elongation produced by 1000 p.s.i. stress, relieved of load and measured after 10 minutes' rest. The permanent set expressed as percentage of the original gage length shall not exceed 5%.
5. Hardness. Hardness tests shall be made on each batch of production gaskets. This test shall be made with a type A durometer. The preferred hardness is 70 to 75 durometer.

Sec. 11–9—Bolts and Nuts

High strength, heat-treated cast iron tee-head bolts with hexagon nuts shall be the standard bolts; they shall be in accordance with Section 11–4C and meet the requirements hereinafter specified. If special types of bolts are required by the purchaser, agreement as to such shall be made at time of placing the order.

Standard bolts and nuts shall be manufactured under close metallurgical control and the finished bolt and nut assemblies shall be subject to proof testing with the load applied between the head and the nut in a suitable test machine. Proof tests shall be made at sufficiently frequent intervals to assure conformance with the proof test loads. The following proof test loads shall be applicable and shall not permanently stretch the bolt.

Size, Inches	Proof Test Load, Pounds
5/8	10,000
3/4	15,000
1	24,500
1 1/4	40,000

The bearing surface of the cast nut shall be smooth and the nut shall be tapped at right angles to this surface to insure axial loading.

Bolts and nuts shall be coated with a rust-preventing lubricant after threading or tapping. They shall be packed in suitable containers, which shall be marked with the number of bolts, the size and type of bolts, and the net weight.

Sec. 11–10—Foundry Records

A record of the specified tests, including those of glands, bolts, and gaskets, shall be made and retained for at least one year. Upon request, such records will be available to the purchaser at the foundry. If written transcripts of the results of any tests are desired, this fact shall be noted in the order for the material.

Sec. 11–11—Inspection by Purchaser

(a) The purchaser shall have access at all times to those parts of the manufacturer's plant which concern the manufacture of articles being made for him. If the purchaser desires to inspect the manufacture of glands, bolts and gaskets which may be made by sub-contractors, special arrangements must be made therefor at the time of placing the order. He may inspect the joint materials and may reject any of the material which is not in conformity with the specification.

(b) The manufacturer shall provide all tools, testing equipment, materials, labor, and facilities necessary for the required testing and inspection of the joint at the foundry.

(c) The purchaser shall make written report daily to the foundry office of all material rejected, with the causes for rejection.

Sec. 11–12—Inspection and Certification by Manufacturer

Should the purchaser have no inspector at the works, the manufacturer shall, if required by the purchaser, furnish a sworn statement that the inspection and all of the tests have been made and met as specified.

NOTES ON METHOD OF INSTALLATION

(These notes are not parts of the Standard, but are given for information only.)

The successful operation of the mechanical joint specified requires that the spigot be centrally located in the bell and that adequate anchorage shall be provided where abrupt changes in direction and dead ends occur.

The rubber gasket seals most effectively (particularly when sealing gas) if the surfaces with which it comes in contact are brushed thoroughly with a wire brush just prior to assembly. This thorough brushing removes all loose rust or foreign material which may be present and provides clean surfaces which should be brushed with soapy water just prior to slipping the gasket over the spigot end and into the bell. Soapy water brushed over the gasket prior to installation also removes loose dirt and lubricates the gasket as it is forced into its retaining space.

For water and gas service, the normal range of bolt torques to be applied to Standard Cast Iron Bolts in a joint are:

Size, Inches	Range of Torque, Ft. Pounds
⅝	40– 60
¾	60– 90
1	70–100
1¼	90–120

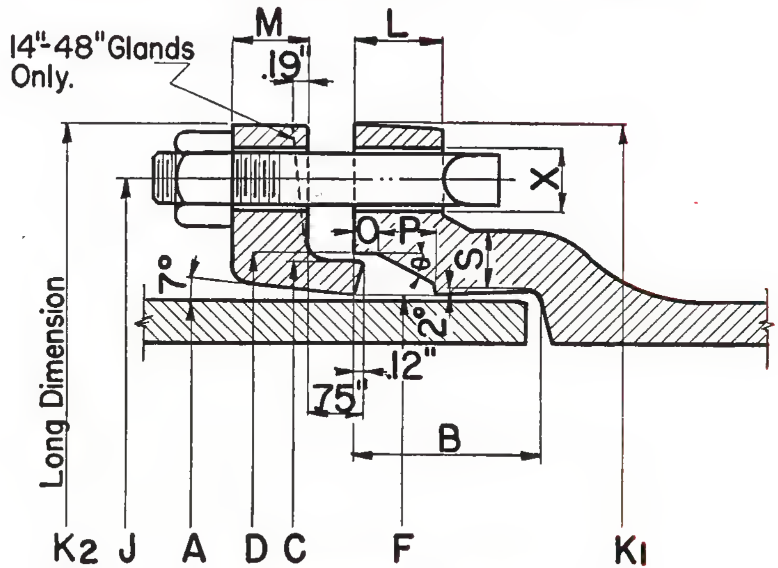
The above torque loads may be applied with torque measuring or indicating wrenches. Torque wrenches may be used to check the application of approximate torque loads applied by men trained to give an average pull on a definite length of regular socket wrench. The following lengths of wrenches should satisfactorily produce the above ranges of torques when used by the average man:

Size, Inches	Length of Wrench, Inches
⅝	8
¾	10
1	12
1¼	14

When tightening bolts, it is essential that the gland be brought up toward the pipe flange evenly, maintaining approximately the same distance between the gland and the face of the flange at all points around the socket. This may be done by partially tightening the bottom bolt first, then the top bolt, next the bolts at either side, and last, the remaining bolts. Repeat this cycle until all bolts are within the above range of torques. If effective sealing is not attained at the maximum torque indicated above, the joint should be disassembled and reassembled after thorough cleaning. Overstressing of bolts to compensate for poor installation practice is to be avoided.

SECTION 11–4A

3″–48″ STD. MECHANICAL JOINT DIMENSIONS



DIMENSIONS IN INCHES

NOTES:

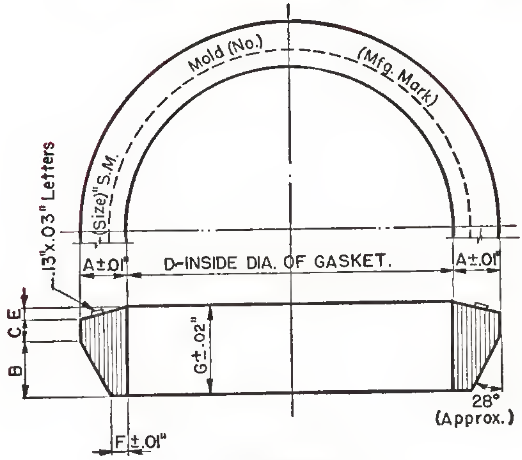
1. The thickness of the bell, S, shall in all cases be equal to and generally exceeds by at least 10% the nominal wall thickness of the pipe or fitting of which it is a part.
2. Cored holes may be tapered an additional 0.06″ in diameter.
3. In case of ovalness of the spigot O.D., the mean diameter measured by a circumferential tape shall not be less than the minimum diameter shown in the table. The minor axis shall not be less than the above minimum diameter plus an additional minus tolerance of .04″ for sizes 8″ through 12″, and .07″ for sizes 14″ through 24″.
4. K_2 is O.D. of glands across bolt holes, outside of gland may be polygon shape.
5. Dimensions of 30″—48″ sizes are tentative.

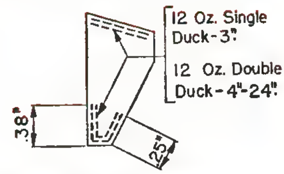
DIMENSIONS IN INCHES

SIZE	A	B	C	D	F	φ	X	J	K₁ Cent. Pipe	K₁ Pit Cast Pipe and Fittings	K_2	L	M	O	P	S Cent. Pipe	S Pit Cast Pipe and Fittings	BOLTS No.	BOLTS Size	BOLTS Lgth.
3	±.06 3.96	2.50	±.04 4.84	+.06 −.04 4.94	+.07 −.03 4.06	28°	+.06 −.0 ¾	±.06 6.19	−.06 7.62	−.12 7.69	−.12 7.69	−.06 .94	−.06 .62	.31	.63	−.05 .47	−.10 .52	4	⅝	3
4	±.06 4.80	2.50	±.04 5.92	+.06 −.04 6.02	+.07 −.03 4.90	28°	+.06 −.0 ⅞	±.06 7.50	−.06 9.06	−.12 9.12	−.12 9.12	−.06 1.00	−.06 .75	.31	.75	−.05 .55	−.10 .65	4	¾	3½
6	±.06 6.90	2.50	±.04 8.02	+.06 −.04 8.12	+.07 −.03 7.00	28°	+.06 −.0 ⅞	±.06 9.50	−.06 11.06	−.12 11.12	−.12 11.12	−.06 1.06	−.06 .88	.31	.75	−.05 .60	−.10 .70	6	¾	3½
8	±.06 9.05	2.50	±.04 10.17	+.06 −.04 10.27	+.07 −.03 9.15	28°	+.06 −.0 ⅞	±.06 11.75	−.06 13.31	−.12 13.37	−.12 13.37	−.08 1.12	−.08 1.00	.31	.75	−.05 .66	−.12 .75	6	¾	4
10	±.06 11.10	2.50	+.06 −.04 12.22	+.06 −.04 12.34	+.07 −.03 11.20	28°	+.06 −.0 ⅞	±.06 14.00	−.06 15.62	−.12 15.69	−.12 15.62	−.08 1.19	−.08 1.00	.31	.75	−.06 .72	−.12 .80	8	¾	4
12	±.06 13.20	2.50	+.06 −.04 14.32	+.06 −.04 14.44	+.07 −.03 13.30	28°	+.06 −.0 ⅞	±.06 16.25	−.06 17.88	−.12 17.94	−.12 17.88	−.08 1.25	−.08 1.00	.31	.75	−.06 .79	−.12 .85	8	¾	4
14	+.05 −.08 15.30	3.50	+.07 −.05 16.40	+.07 −.05 16.54	+.06 −.07 15.44	28°	+.06 −.0 ⅞	±.06 18.75	−.08 20.25	−.12 20.31	−.12 20.25	−.12 1.31	−.12 1.25	.31	.75	−.08 .85	−.12 .89	10	¾	4
16	+.05 −.08 17.40	3.50	+.07 −.05 18.50	+.07 −.05 18.64	+.06 −.07 17.54	28°	+.06 −.0 ⅞	±.06 21.00	−.08 22.50	−.12 22.56	−.12 22.50	−.12 1.38	−.12 1.31	.31	.75	−.08 .91	−.12 .97	12	¾	4½
18	+.05 −.08 19.50	3.50	+.07 −.05 20.60	+.07 −.05 20.74	+.06 −.07 19.64	28°	+.06 −.0 ⅞	±.06 23.25	−.08 24.75	−.15 24.83	−.15 24.75	−.12 1.44	−.12 1.38	.31	.75	−.08 .97	−.15 1.05	12	¾	4½
20	+.05 −.08 21.60	3.50	+.07 −.05 22.70	+.07 −.05 22.84	+.06 −.07 21.74	28°	+.06 −.0 ⅞	±.06 25.50	−.08 27.00	−.15 27.08	−.15 27.00	−.12 1.50	−.12 1.44	.31	.75	−.08 1.03	−.15 1.12	14	¾	4½
24	+.05 −.08 25.80	3.50	+.07 −.05 26.90	+.07 −.05 27.04	+.06 −.07 25.94	28°	+.06 −.0 ⅞	±.06 30.00	−.08 31.50	−.15 31.58	−.15 31.50	−.12 1.62	−.12 1.56	.31	.75	−.08 1.08	−.15 1.22	16	¾	5
30	32.00	4.00	33.29	33.46	32.17	20°	1⅛	36.88	39.12	39.12	39.12	1.81	2.00	.38	1.00	1.20	1.50	20	1	5½
36	38.30	4.00	39.59	39.76	38.47	20°	1⅛	43.75	46.00	46.00	46.00	2.00	2.00	.38	1.00	1.35	1.80	24	1	5½
42	44.50	4.00	45.79	45.96	44.67	20°	1⅜	50.62	53.12	53.12	53.12	2.00	2.00	.38	1.00	1.48	1.95	28	1¼	6
48	50.80	4.00	52.09	52.26	50.97	20°	1⅜	57.50	60.00	60.00	60.00	2.00	2.00	.38	1.00	1.61	2.20	32	1¼	6

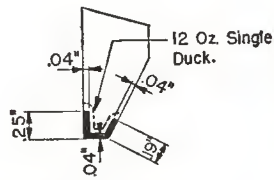
SECTION 11–4B

3″–24″ MECHANICAL JOINT GASKETS

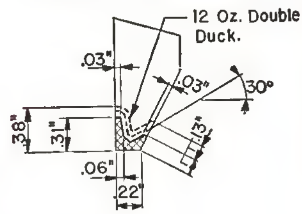




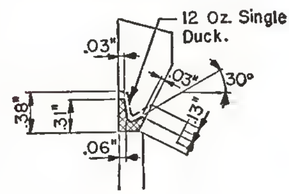
DUCK BACK or TIP-ALL SIZES



THIOKOL TIP-ALL SIZES



4"-24"-LEAD TIP



3"-LEAD TIP

3"-24" GASKETS

CHART OF SIZES (in Inches)

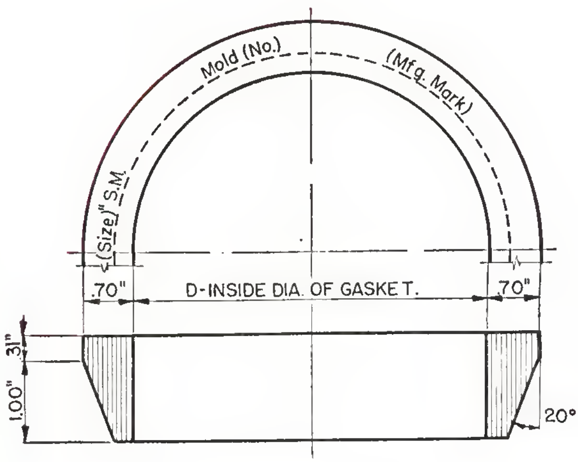
Pipe Size	O.D. of Pipe	Dimensions of Plain Rubber Gaskets						
		A ±.01″	B	C	D +0−1%	E	F ±.01″	G ±.02″
3	3.96	.48	.62	.31	3.90	.12	.15	1.05
4	4.80	.62	.75	.31	4.73	.16	.22	1.22
6	6.90	.62	.75	.31	6.80	.16	.22	1.22
8	9.05	.62	.75	.31	8.91	.16	.22	1.22
10	11.10	.62	.75	.31	10.93	.16	.22	1.22
12	13.20	.62	.75	.31	13.00	.16	.22	1.22
14	15.30	.62	.75	.31	15.07	.16	.22	1.22
16	17.40	.62	.75	.31	17.14	.16	.22	1.22
18	19.50	.62	.75	.31	19.21	.16	.22	1.22
20	21.60	.62	.75	.31	21.28	.16	.22	1.22
24	25.80	.62	.75	.31	25.41	.16	.22	1.22

NOTE:

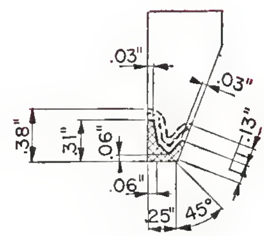
Duck backing can be omitted from lead tipped gaskets provided sufficient bonding of the lead to the rubber is obtained.

Tipped or backed gaskets may be made in the same mold as plain rubber gaskets but the inside diameter of such reinforced portions shall not exceed the "O.D. of Pipe."

SECTION 11–4B
30″–48″ STD. MECHANICAL JOINT GASKETS



30"-48" GASKETS



LEAD TIP

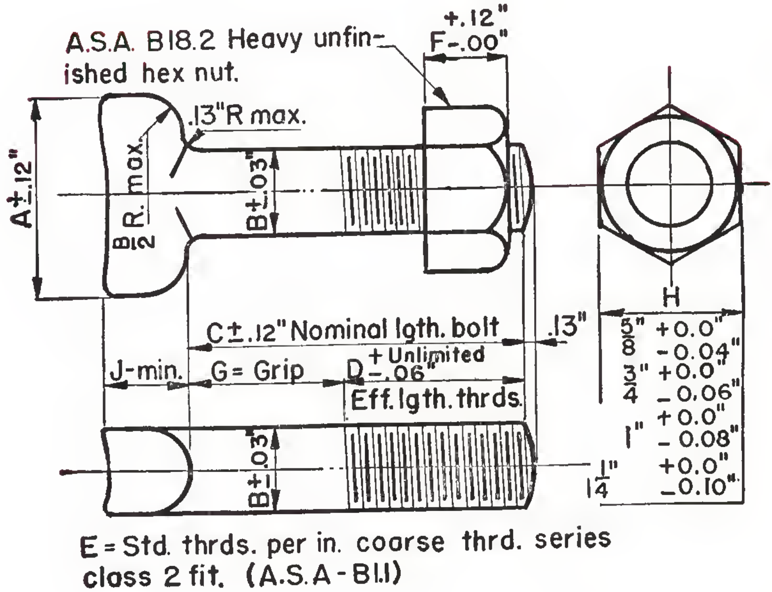
DIMENSIONS
IN INCHES

Pipe Size	Pipe O.D.	D
30	32.00	31.50
36	38.30	37.62
42	44.50	43.67
48	50.80	49.80

NOTE: Dimensions of 30″–48″ sizes are tentative.

SECTION 11–4C

MECHANICAL JOINT BOLTS AND NUTS



Nom. Size	A	B	C	D	E	F	G	H	J	Wt.-Lbs./ 100 Bolts & Nuts
5/8 x 3	1.50	.625	3.00	1.50	11	.625	1.50	1.062	.625	47
3/4 x 3 1/2	1.75	.75	3.50	2.00	10	.75	1.50	1.25	.75	77
3/4 x 4	1.75	.75	4.00	2.00	10	.75	2.00	1.25	.75	82
3/4 x 4 1/2	1.75	.75	4.50	2.00	10	.75	2.50	1.25	.75	87
3/4 x 5	1.75	.75	5.00	2.00	10	.75	3.00	1.25	.75	93
1 x 5 1/2	2.25	1.00	5.50	2.50	8	1.00	3.00	1.625	1.00	192
1 1/4 x 6	2.50	1.25	6.00	2.50	7	1.25	3.50	2.00	1.25	334

SECTION 10

Mechanical Joint Cast Iron Pipe and Fittings for Gas and Water Service

SECTION 10

Mechanical Joint Cast Iron Pipe and Fittings for Gas and Water Service

MECHANICAL joint cast iron pipe was developed in the early 1920's primarily to meet the needs of the Gas Industry occasioned by the growing use of dry, natural and mixed gas distributed under low, intermediate, or high pressures. However, it soon commended itself to water works engineers because of its tight joints and time-saving advantages in installation.

A TIME-TRIED PRINCIPLE

The mechanical joint is an adaption of the stuffing-box principle. It consists of a *socket,* or special bell, provided with a flange cast integral with it; a cast iron *gland,* or follower ring; a rubber gasket, and necessary bolts and nuts. (See cross-sectional drawing.)

The stuffing-box principle is long-established and well known to the engineering profession. Its invention is credited to an Englishman, Samuel Moreland, who obtained in 1675 a patent on a plunger pump incorporating a gland and stuffing-box through which the plunger operated.

The rubber gasket also has a successful history. Rubber ring joints have been used in Europe for upwards of a century. Thorough-going tests by an English engineer proved the utility and durability of rubber as a jointing material for underground mains. These tests demonstrated that, when a rubber ring is sealed in a joint, its life is rendered indefinitely long because the rubber is compressed in a space free from air, not exposed to light, and relatively cool, and consequently, not subject to deterioration. Present-day mechanical joints are so designed as to expose little or none of the rubber gasket to the gas or water being carried in the line.

ADVANTAGES ARE MANY

Mechanical joint cast iron pipe offers many advantages in addition to providing a bottle-tight joint for all working pressures. It permits considerable deflection as well as longitudinal expansion and contraction in line without causing leakage. It is a time-saver: The joint assembly is simple, rapid and practically fool-proof. It does not require a skilled crew. An ordinary ratchet wrench is the only tool required.

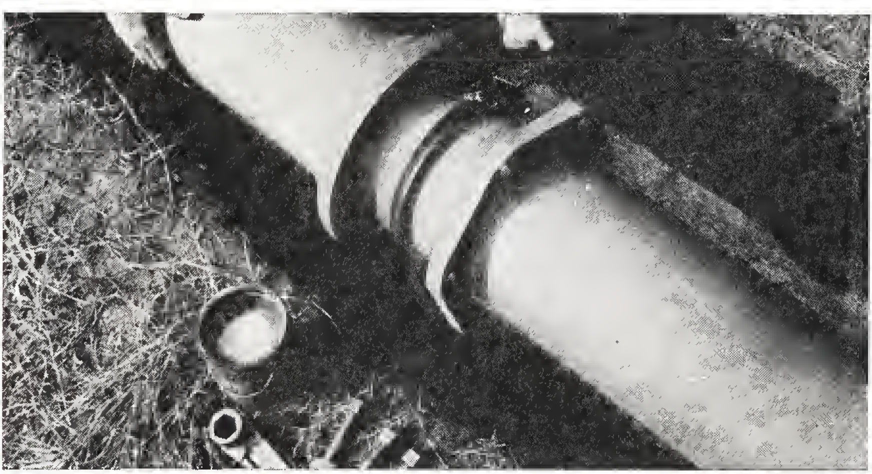
In the event of a flooded trench, an important advantage of the mechanical joint is that the pipe can be jointed on the bank in sections and lowered into the trench, saving costly delays.

HOW TO ASSEMBLE THE JOINT

Assembling the mechanical joint is simplicity itself (see cuts). The gland, followed by the rubber gasket, is placed over the plain end of the pipe which is inserted into the socket. The gasket is then pushed into position so that it is evenly seated in the socket. The gland is moved into position against the face of the gasket. Bolts are inserted and made finger-tight. Then, with an ordinary ratchet wrench, the bolts are tightened up, and the joint is completed.

STANDARDIZATION AND INTERCHANGEABILITY

Standardization added the final touch of convenience, economy and simplicity to mechanical joint cast iron pipe. Its chief advantage is *complete interchangeability* with respect to pipe, fittings, glands, gaskets and bolts furnished by all manufacturers of mechanical joint cast iron pipe. This makes it unnecessary to stock parts for each make of pipe purchased, and removes the risk of delays on jobs through delivery of wrong parts. The standardized mechanical joint incorporates the best features of the various designs previously made by members of the Cast Iron Pipe Research Association. (See A.S.A. A21.11 for complete specifications for mechanical joint.)

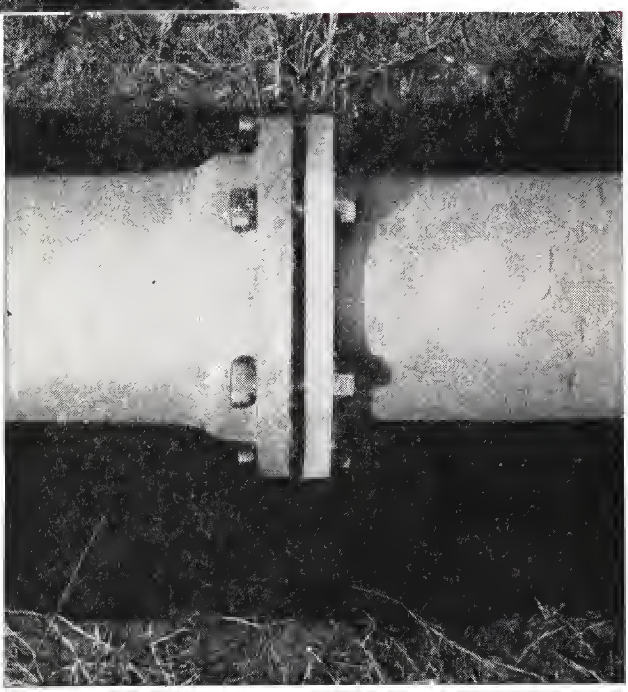


Wash socket and plain end with soapy water, then slip gland and gasket over plain end. Small side of gasket and lip side of gland, face the socket. Paint gasket with soapy water.

Insert ploin end into socket. Push gasket into position with fingers, making sure it is evenly seated.

Slide glond into position, insert bolts ond tighten nuts by hand.

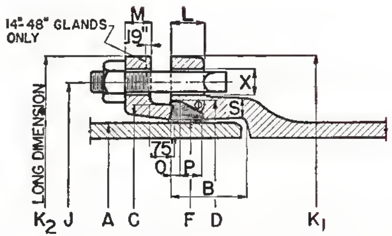
With ordinary ratchet wrench, tighten up bolts alternately (bottom, then top, and so on, all around).



The completed standardized mechanical joint — bottle-tight under all working pressures, flexible, time-saving.

Dimensions

of mechanical joint cast iron pipe and fittings



DIMENSIONS IN INCHES

Size	A	B	C	D	F	φ	X	J	K1 Cent. Pipe	K1 Pit Cast Pipe and Fittings	K2	L	M	O	P	S Cent. Pipe	S Pit Cast Pipe and Fittings	Bolts No.	Bolts Size	Bolts Lgth.	★ Weight of Bell, lb. Cent. Pipe	★ Weight of Bell, lb. Pit Cast Pipe and Fittings	★ Weight of Gland, Bolts and Gasket, lbs.
3	±.06 3.96	2.50	±.04 4.84	+.06 −.04 4.94	+.07 −.03 4.06	28°	+.06 −.0 ¾	±.06 6.19	−.06 7.62	−.12 7.69	−.12 7.69	−.06 .94	−.06 .62	.31	.63	−.05 .47	−.10 .52	4	⅝	3	11	11	7
4	±.06 4.80	2.50	±.04 5.92	+.06 −.04 6.02	+.07 −.03 4.90	28°	+.06 −.0 ⅞	±.06 7.50	−.06 9.06	−.12 9.12	−.12 9.12	−.06 1.00	−.06 .75	.31	.75	−.05 .55	−.10 .65	4	¾	3½	16	16	10
6	±.06 6.90	2.50	±.04 8.02	+.06 −.04 8.12	+.07 −.03 7.00	28°	+.06 −.0 ⅞	±.06 9.50	−.06 11.06	−.12 11.12	−.12 11.12	−.06 1.06	−.06 .88	.31	.75	−.05 .60	−.10 .70	6	¾	3½	22	23	16
8	±.06 9.05	2.50	±.04 10.17	+.06 −.04 10.27	+.07 −.03 9.15	28°	+.06 −.0 ⅞	±.06 11.75	−.06 13.31	−.12 13.37	−.12 13.37	−.08 1.12	−.08 1.00	.31	.75	−.05 .66	−.12 .75	6	¾	4	30	31	25
10	±.06 11.10	2.50	+.06 −.04 12.22	+.06 −.04 12.34	+.07 −.03 11.20	28°	+.06 −.0 ⅞	±.06 14.00	−.06 15.62	−.12 15.69	−.12 15.62	−.08 1.19	−.08 1.00	.31	.75	−.06 .72	−.12 .80	8	¾	4	40	41	30
12	±.06 13.20	2.50	+.06 −.04 14.32	+.06 −.04 14.44	+.07 −.03 13.30	28°	+.06 −.0 ⅞	±.06 16.25	−.06 17.88	−.12 17.94	−.12 17.88	−.08 1.25	−.08 1.00	.31	.75	−.06 .79	−.12 .85	8	¾	4	50	51	40
14	+.05 −.08 15.30	3.50	+.07 −.05 16.40	+.07 −.05 16.54	+.06 −.07 15.44	28°	+.06 −.0 ⅞	±.06 18.75	−.08 20.25	−.12 20.31	−.12 20.25	−.12 1.31	−.12 1.25	.31	.75	−.08 .85	−.12 .89	10	¾	4	78	79	45
16	+.05 −.08 17.40	3.50	+.07 −.05 18.50	+.07 −.05 18.64	+.06 −.07 17.54	28°	+.06 −.0 ⅞	±.06 21.00	−.08 22.50	−.12 22.56	−.12 22.50	−.12 1.38	−.12 1.31	.31	.75	−.08 .91	−.12 .97	12	¾	4½	95	97	55
18	+.05 −.08 19.50	3.50	+.07 −.05 20.60	+.07 −.05 20.74	+.06 −.07 19.64	28°	+.06 −.0 ⅞	±.06 23.25	−.08 24.75	−.15 24.83	−.15 24.75	−.12 1.44	−.12 1.38	.31	.75	−.08 .97	−.15 1.05	12	¾	4½	113	117	65
20	+.05 −.08 21.60	3.50	+.07 −.05 22.70	+.07 −.05 22.84	+.06 −.07 21.74	28°	+.06 −.0 ⅞	±.06 25.50	−.08 27.00	−.15 27.08	−.15 27.00	−.12 1.50	−.12 1.44	.31	.75	−.08 1.03	−.15 1.12	14	¾	4½	134	140	85
24	+.05 −.08 25.80	3.50	+.07 −.05 26.90	+.07 −.05 27.04	+.06 −.07 25.94	28°	+.06 −.0 ⅞	±.06 30.00	−.08 31.50	−.15 31.58	−.15 31.50	−.12 1.62	−.12 1.56	.31	.75	−.08 1.08	−.15 1.22	16	¾	5	177	185	105
30	32.00	4.00	33.29	33.46	32.17	20°	1⅛	36.88	39.12	39.12	39.12	1.81	2.00	.38	1.00	1.20	1.50	20	1	5½	285	315	220
36	38.30	4.00	39.59	39.76	38.47	20°	1⅛	43.75	46.00	46.00	46.00	2.00	2.00	.38	1.00	1.35	1.80	24	1	5½	395	445	285
42	44.50	4.00	45.79	45.96	44.67	20°	1⅜	50.62	53.12	53.12	53.12	2.00	2.00	.38	1.00	1.48	1.95	28	1¼	6	510	570	400
48	50.80	4.00	52.09	52.26	50.97	20°	1⅜	57.50	60.00	60.00	60.00	2.00	2.00	.38	1.00	1.61	2.20	32	1¼	6	645	725	475

NOTES: 1. Cored holes may be tapered an additional 0.06" in diameter. . . . 2. In case of ovalness of the spigot O. D., the mean diameter measured by a circumferential tape shall not be less than the minimum diameter shown in the table. The minor axis shall not be less than the above minimum diameter plus an additional minus tolerance of .04" for sizes 8" through 12", and .07" for sizes 14" through 24". . . . 3. K2 is O. D. of glands across bolt holes, outside of gland may be polygon shape. . . . 4. Dimensions of 30"—48" sizes are tentative, consult the manufacturer. . . . 5. This joint conforms to A.S.A. Specification A–21.11.

★ **Weights not part of specifications—for information only.**

WEIGHTS OF MECHANICAL JOINT PIPE FOR WATER

STANDARD THICKNESSES AND WEIGHTS OF CAST IRON MECHANICAL JOINT PIPE CENTRIFUGALLY CAST IN METAL AND SAND LINED MOLDS FOR WATER AND OTHER LIQUIDS

Note: Thicknesses in accordance with A.S.A. Specifications, 18,000 psi full length bursting tensile, 40,000 psi ring modulus of rupture. For pipe laid without blocks on flat bottom trench with tamped backfill under 5 feet of cover. For other conditions consult the manufacturer.

Size ins.	Thick-ness ins.	Out-side Diam. ins.	Weight Based On 12 ft. Lgth.* Avg. per ft.	12 ft. Lgth.* per Lgth.	16 ft. Lgth.* Avg. per ft.	16 ft. Lgth.* per Lgth.	16½ ft. Lgth.* Avg. per ft.	16½ ft. Lgth.* per Lgth.	18 ft. Lgth.* Avg. per ft.	18 ft. Lgth.* per Lgth.	20 ft. Lgth.* Avg. per ft.	20 ft. Lgth.* per Lgth.
			Class 50—50 Lb. Pressure—115 Foot Head									
3	.32	3.96	12.3	150	12.2	195	12.1	200	12.0	215		
4	.35	4.80	16.6	200	16.4	260	16.3	270	16.2	290		
6	.38	6.90	26.1	315	25.7	410	25.6	420	25.5	460		
8	.41	9.05	37.2	445	36.7	585	36.6	605	36.4	655		
10	.44	11.10	49.3	590	48.5	775	48.4	800	48.2	870		
12	.48	13.20	64.0	770	62.9	1005	62.8	1035	62.6	1125	62.3	1245
14	.48	15.30	76.2	915	74.6	1195	74.4	1230	74.1	1335	73.6	1470
16	.54	17.40	97.1	1165	95.0	1520	94.9	1565	94.5	1700	94.0	1880
18	.54	19.50	109.8	1320	107.5	1720	107.2	1770	106.7	1920	106.0	2120
20	.57	21.60	128.7	1545	125.9	2015	125.7	2075	124.9	2250	124.2	2485
24	.63	25.80	170.2	2040	166.5	2665	166.1	2740	165.2	2975	164.2	3285
30	.79	32.00			259.5	4150	259.0	4275			256.0	5120
36	.87	38.30			343.9	5500						
42	.97	44.50			445.7	7130						
48	1.06	50.80			557.1	8915						
			Class 100—100 Lb. Pressure—231 Foot Head									
3	.32	3.96	12.3	150	12.2	195	12.1	200	12.0	215		
4	.35	4.80	16.6	200	16.4	260	16.3	270	16.2	290		
6	.38	6.90	26.1	315	25.7	410	25.6	420	25.5	460		
8	.41	9.05	37.2	445	36.7	585	36.6	605	36.4	655		
10	.44	11.10	49.3	590	48.5	775	48.4	800	48.2	870		
12	.48	13.20	64.0	770	62.9	1005	62.8	1035	62.6	1125	62.3	1245
14	.51	15.30	80.4	965	78.8	1260	78.6	1295	78.2	1410	77.8	1555
16	.54	17.40	97.1	1165	95.0	1520	94.9	1565	94.5	1700	94.0	1880
18	.58	19.50	117.0	1405	114.7	1835	114.4	1890	113.9	2050	113.2	2265
20	.62	21.60	138.7	1665	135.9	2175	135.7	2240	134.9	2430	134.2	2685
24	.68	25.80	182.2	2185	178.5	2855	178.1	2940	177.2	3190	176.2	3525
30	.79	32.00			259.5	4150	259.0	4275			256.0	5120
36	.87	38.30			343.9	5500						
42	.97	44.50			445.7	7130						
48	1.06	50.80			557.1	8915						
			Class 150—150 Lb. Pressure—346 Foot Head									
3	.32	3.96	12.3	150	12.2	195	12.1	200	12.0	215		
4	.35	4.80	16.6	200	16.4	260	16.3	270	16.2	290		
6	.38	6.90	26.1	315	25.7	410	25.6	420	25.5	460		
8	.41	9.05	37.2	445	36.7	585	36.6	605	36.4	655		
10	.44	11.10	49.3	590	48.5	775	48.4	800	48.2	870		
12	.48	13.20	64.0	770	62.9	1005	62.8	1035	62.6	1125	62.3	1245
14	.51	15.30	80.4	965	78.8	1260	78.6	1295	78.2	1410	77.8	1555
16	.54	17.40	97.1	1165	95.0	1520	94.9	1565	94.5	1700	94.0	1880
18	.58	19.50	117.0	1405	114.7	1835	114.4	1890	113.9	2050	113.2	2265
20	.62	21.60	138.7	1665	135.9	2175	135.7	2240	134.9	2430	134.2	2685
24	.73	25.80	194.2	2330	190.4	3045	190.1	3135	189.2	3405	188.2	3765
30	.85	32.00			277.3	4435	276.8	4565			273.8	5475
36	.94	38.30			368.9	5900						
42	1.05	44.50			479.1	7665						
48	1.14	50.80			595.2	9525						

* Including Bell. Calculated weight of pipe rounded off to nearest 5 pounds.

References: A.S.A.—A-21.6—pipes cast in metal molds. A.S.A.—A-21.8—pipe cast in sand lined molds. A.S.A.—21.11—mechanical joints.

WEIGHTS OF MECHANICAL JOINT PIPE FOR WATER (Continued)

			Weight Based On									
		Out	12 ft. Lgth.*		16 ft. Lgth.*		16½ ft. Lgth.*		18 ft. Lgth.*		20 ft. Lgth.*	
Size ins.	Thick-ness ins.	side Diam. ins.	Avg. per ft.	per Lgth.	Avg. per ft.	per Lgth.	Avg. per ft.	per Lgth.	Avg. per ft.	per Lgth.	Avg. per ft.	per Lgth.
Class 200—200 Lb. Pressure—462 Foot Head												
3	.32	3.96	12.3	150	12.2	195	12.1	200	12.0	215		
4	.35	4.80	16.6	200	16.4	260	16.3	270	16.2	290		
6	.38	6.90	26.1	315	25.7	410	25.6	420	25.5	460		
8	.41	9.05	37.2	445	36.7	585	36.6	605	36.4	655		
10	.44	11.10	49.3	590	48.5	775	48.4	800	48.2	870		
12	.48	13.20	64.0	770	62.9	1005	62.8	1035	62.6	1125	62.3	1245
14	.55	15.30	86.0	1030	84.4	1350	84.2	1390	83.8	1510	83.4	1670
16	.58	17.40	103.5	1240	101.5	1625	101.3	1670	100.9	1815	100.3	2005
18	.63	19.50	125.9	1510	123.5	1975	123.3	2035	122.8	2210	122.2	2445
20	.67	21.60	148.7	1785	145.9	2335	145.7	2405	144.9	2610	144.2	2885
24	.79	25.80	208.4	2500	204.8	3275	204.4	3375	203.5	3665	202.6	4050
30	.92	32.00			298.1	4770	297.6	4910			294.6	5890
36	1.02	38.30			397.4	6360						
42	1.13	44.50			512.3	8195						
48	1.23	50.80			637.9	10205						
Class 250—250 Lb. Pressure—577 Foot Head												
3	.32	3.96	12.3	150	12.2	195	12.1	200	12.0	215		
4	.35	4.80	16.6	200	16.4	260	16.3	270	16.2	290		
6	.38	6.90	26.1	315	25.7	410	25.6	420	25.5	460		
8	.41	9.05	37.2	445	36.7	585	36.6	605	36.4	655		
10	.44	11.10	49.3	590	48.5	775	48.4	800	48.2	870		
12	.52	13.20	68.8	825	67.7	1085	67.6	1115	67.4	1215	67.1	1340
14	.59	15.30	91.6	1100	90.0	1440	89.8	1480	89.4	1610	89.0	1780
16	.63	17.40	111.5	1340	109.6	1755	109.4	1805	108.9	1960	108.3	2165
18	.68	19.50	134.8	1620	132.5	2120	132.2	2180	131.7	2370	131.0	2620
20	.72	21.60	158.6	1905	155.7	2490	155.5	2565	154.8	2785	154.1	3080
24	.79	25.80	208.4	2500	204.8	3275	204.4	3375	203.5	3665	202.6	4050
30	.99	32.00			318.7	5100	318.2	5250			315.2	6305
36	1.10	38.30			425.8	6815						
42	1.22	44.50			549.5	8790						
48	1.33	50.80			685.2	10965						
Class 300—300 Lb. Pressure—693 Foot Head												
3	.32	3.96	12.3	150	12.2	195	12.1	200	12.0	215		
4	.35	4.80	16.6	200	16.4	260	16.3	270	16.2	290		
6	.38	6.90	26.1	315	25.7	410	25.6	420	25.5	460		
8	.41	9.05	37.2	445	36.7	585	36.6	605	36.4	655		
10	.48	11.10	53.3	640	52.5	840	52.4	865	52.2	940		
12	.52	13.20	68.8	825	67.7	1085	67.6	1115	67.4	1215	67.1	1340
14	.59	15.30	91.6	1100	90.0	1440	89.8	1480	89.4	1610	89.0	1780
16	.68	17.40	119.3	1430	117.3	1875	117.2	1935	116.7	2100	116.2	2325
18	.73	19.50	143.7	1725	141.4	2260	141.1	2330	140.6	2530	140.0	2800
20	.78	21.60	170.4	2045	167.6	2680	167.3	2760	166.6	3000	165.9	3320
24	.85	25.80	222.6	2670	219.0	3505	218.6	3605	217.7	3920	216.8	4335
Class 350—350 Lb. Pressure—808 Foot Head												
3	.32	3.96	12.3	150	12.2	195	12.1	200	12.0	215		
4	.35	4.80	16.6	200	16.4	260	16.3	270	16.2	290		
6	.38	6.90	26.1	315	25.7	410	25.6	420	25.5	460		
8	.41	9.05	37.2	445	36.7	585	36.6	605	36.4	655		
10	.52	11.10	57.2	685	56.4	900	56.3	930	56.1	1010		
12	.56	13.20	73.6	885	72.5	1160	72.4	1195	72.2	1300	71.9	1440
14	.64	15.30	98.5	1180	96.9	1550	96.7	1595	96.3	1735	95.9	1920
16	.68	17.40	119.3	1430	117.3	1875	117.2	1935	116.7	2100	116.2	2325
18	.79	19.50	154.3	1850	152.0	2430	151.7	2505	151.2	2720	150.6	3010
20	.84	21.60	182.1	2185	179.3	2870	179.0	2955	178.3	3210	177.6	3550
24	.92	25.80	239.2	2870	235.4	3765	235.1	3880	234.2	4215	233.2	4665

*Including Bell. Calculated weight of pipe rounded off to nearest 5 pounds.

WEIGHTS OF MECHANICAL JOINT PIPE FOR GAS

STANDARD THICKNESSES AND WEIGHTS OF CAST IRON MECHANICAL JOINT PIPE CENTRIFUGALLY CAST IN METAL AND SAND LINED MOLDS FOR GAS

Note: Thicknesses in accordance with A.S.A. Specifications, 18,000 psi full length bursting tensile, 40,000 psi ring modulus of rupture. For pipe laid without blocks on flat bottom trench with tamped backfill under 5 feet of cover. For other conditions consult the manufacturer.

Size ins.	Thickness ins.	Outside Diam. ins.	Weight Based On: 12 ft. Lgth.* Avg. per ft.	12 ft. Lgth.* per Lgth.	16 ft. Lgth.* Avg. per ft.	16 ft. Lgth.* per Lgth.	16½ ft. Lgth.* Avg. per ft.	16½ ft. Lgth.* per Lgth.	18 ft. Lgth.* Avg. per ft.	18 ft. Lgth.* per Lgth.	20 ft. Lgth.* Avg. per ft.	20 ft. Lgth.* per Lgth.
			Class 10—10 Lb. Pressure									
4	.35(1)	4.80	16.6	200	16.4	260	16.3	270	16.2	290		
	or .38(2)	4.80	17.8	215	17.6	280	17.5	290	17.4	315		
6	.38(1)	6.90	26.1	315	25.7	410	25.6	420	25.5	460		
	or .41(2)	6.90	27.9	335	27.6	440	27.5	455	27.3	490		
8	.41	9.05	37.2	445	36.7	585	36.6	605	36.4	655		
10	.44	11.10	49.3	590	48.5	775	48.4	800	48.2	870		
12	.48	13.20	64.0	770	62.9	1005	62.8	1035	62.6	1125	62.3	1245
16	.50	17.40	90.7	1090	88.7	1420	88.6	1460	88.1	1585	87.6	1750
20	.57	21.60	128.7	1545	125.9	2015	125.7	2075	124.9	2250	124.2	2485
24	.63	25.80	170.2	2040	166.5	2665	166.1	2740	165.2	2975	164.2	3285
30	.73	32.00			241.5	3865	241.0	3975			238.0	4760
36	.81	38.30			322.4	5160						
42	.90	44.50			416.5	6665						
48	.98	50.80			519.0	8305						
			Class 50—50 Lb. Pressure									
4	.35(1)	4.80	16.6	200	16.4	260	16.3	270	16.2	290		
	or .38(2)	4.80	17.8	215	17.6	280	17.5	290	17.4	315		
6	.38(1)	6.90	26.1	315	25.7	410	25.6	420	25.5	460		
	or .41(2)	6.90	27.9	335	27.6	440	27.5	455	27.3	490		
8	.41	9.05	37.2	445	36.7	585	36.6	605	36.4	655		
10	.44	11.10	49.3	590	48.5	775	48.4	800	48.2	870		
12	.48	13.20	64.0	770	62.9	1005	62.8	1035	62.6	1125	62.3	1245
16	.50	17.40	90.7	1090	88.7	1420	88.6	1460	88.1	1585	87.6	1750
20	.57	21.60	128.7	1545	125.9	2015	125.7	2075	124.9	2250	124.2	2485
24	.63	25.80	170.2	2040	166.5	2665	166.1	2740	165.2	2975	164.2	3285
30	.79	32.00			259.5	4150	259.0	4275			256.0	5120
36	.87	38.30			343.9	5500						
42	.97	44.50			445.7	7130						
48	1.06	50.80			557.1	8915						
			Class 100—100 Lb. Pressure									
4	.35(1)	4.80	16.6	200	16.4	260	16.3	270	16.2	290		
	or .38(2)	4.80	17.8	215	17.6	280	17.5	290	17.4	315		
6	.38(1)	6.90	26.1	315	25.7	410	25.6	420	25.5	460		
	or .41(2)	6.90	27.9	335	27.6	440	27.5	455	27.3	490		
8	.41	9.05	37.2	445	36.7	585	36.6	605	36.4	655		
10	.44	11.10	49.3	590	48.5	775	48.4	800	48.2	870		
12	.48	13.20	64.0	770	62.9	1005	62.8	1035	62.6	1125	62.3	1245
16	.54	17.40	97.1	1165	95.0	1520	94.9	1565	94.5	1700	94.0	1880
20	.62	21.60	138.7	1665	135.9	2175	135.7	2240	134.9	2430	134.2	2685
24	.68	25.80	182.2	2185	178.5	2855	178.1	2940	177.2	3190	176.2	3525
			Class 150—150 Lb. Pressure									
4	.35(1)	4.80	16.6	200	16.4	260	16.3	270	16.2	290		
	or .38(2)	4.80	17.8	215	17.6	280	17.5	290	17.4	315		
6	.38(1)	6.90	26.1	315	25.7	410	25.6	420	25.5	460		
	or .41(2)	6.90	27.9	335	27.6	440	27.5	455	27.3	490		
8	.41	9.05	37.2	445	36.7	585	36.6	605	36.4	655		
10	.44	11.10	49.3	590	48.5	775	48.4	800	48.2	870		
12	.48	13.20	64.0	770	62.9	1005	62.8	1035	62.6	1125	62.3	1245

* Including Bell. Calculated weight of pipe rounded off to nearest 5 pounds.

(1) Class 22 thickness.

(2) Class 23 thickness offers increased factor of safety and is recommended for use in areas of dense population and heavy traffic.

References: A.S.A.—A-21.7—pipe cast in metal molds. A.S.A.—A-21.9—pipe cast in sand lined molds. A.S.A.—A-21.11—mechanical joints.

WEIGHTS OF MECHANICAL JOINT PIPE FOR WATER

STANDARD THICKNESSES AND WEIGHTS OF CAST IRON MECHANICAL JOINT PIT CAST PIPE FOR WATER AND OTHER LIQUIDS

Note: Thicknesses in accordance with A.S.A. Specifications, 11,000 psi full length bursting tensile, 31,000 psi ring modulus of rupture. For pipe laid without blocks on flat bottom trench with tampered backfill under 5 feet of cover. For other conditions consult the manufacturer.

		Class 50 50 lb. Pressure 115 ft. Head			Class 100 100 lb. Pressure 231 ft. Head			Class 150 150 lb. Pressure 346 ft. Head			Class 200 200 lb. Pressure 462 ft. Head		
			Weight Based on 12 ft. Length*			Weight Based on 12 ft. Length*			Weight Based on 12 ft. Length*			Weight Based on 12 ft. Length*	
Size ins.	Out-side Diam. ins.	Thick-ness ins.	Avg. per ft.	per Length	Thick-ness ins.	Avg. per ft.	per Length	Thick-ness ins.	Avg. per ft.	per Length	Thick-ness ins.	Avg. per ft.	per Length
3	3.96	.37	13.9	165	.37	13.9	165	.37	13.9	165	.37	13.9	165
4	4.80	.40	18.6	225	.40	18.6	225	.40	18.6	225	.40	18.6	225
6	6.90	.43	29.2	350	.43	29.2	350	.43	29.2	350	.43	29.2	350
8	9.05	.46	41.3	495	.46	41.3	495	.46	41.3	495	.46	41.3	495
10	11.10	.50	55.4	665	.50	55.4	665	.54	59.3	710	.58	63.2	760
12	13.20	.54	71.2	855	.54	71.2	855	.58	76.0	910	.63	81.8	980
14	15.30	.54	84.7	1015	.58	90.3	1085	.63	97.2	1165	.68	104.0	1250
16	17.40	.58	103.7	1245	.63	111.7	1340	.68	119.5	1435	.79	136.7	1640
18	19.50	.63	126.2	1515	.68	135.2	1620	.79	154.6	1855	.85	165.2	1980
20	21.60	.66	147.2	1765	.71	157.1	1885	.83	180.7	2170	.90	194.3	2330
24	25.80	.74	197.2	2365	.80	211.4	2535	.93	242.1	2905	1.00	258.5	3100
30	32.00	.87	291.8	3500	.94	312.4	3750	1.10	359.4	4315	1.19	385.7	4630
36	38.30	.97	392.0	4705	1.13	448.8	5385	1.22	480.5	5765	1.43	553.9	6645
42	44.50	1.07	503.0	6035	1.16	540.3	6485	1.35	618.5	7420	1.58	712.2	8545
48	50.80	1.18	634.3	7610	1.37	724.2	8690	1.48	775.9	9310	1.73	892.5	10710

		Class 250 250 lb. Pressure 577 ft. Head			Class 300 300 lb. Pressure 693 ft. Head			Class 350 350 lb. Pressure 808 ft. Head		
			Weight Based on 12 ft. Length*			Weight based on 12 ft. Length*			Weight Based on 12 ft. Length*	
Size ins.	Out-side Diam. ins.	Thick-ness ins.	Avg. per ft.	per Length	Thick-ness ins.	Avg. per ft.	per Length	Thick-ness ins.	Avg. per ft.	per Length
3	3.96	.37	13.9	165	.37	13.9	165	.37	13.9	165
4	4.80	.40	18.6	225	.40	18.6	225	.40	18.6	225
6	6.90	.43	29.2	350	.46	30.9	370	.50	33.3	400
8	9.05	.50	44.5	535	.54	47.6	570	.58	50.8	610
10	11.10	.63	68.1	815	.68	72.9	875	.73	77.6	930
12	13.20	.68	87.6	1050	.73	93.4	1120	.79	100.4	1205
14	15.30	.79	119.0	1430	.85	127.0	1525	.92	136.3	1635
16	17.40	.85	146.0	1750	.92	156.7	1880	.99	167.2	2005
18	19.50	.92	177.2	2125	.99	189.3	2270	1.07	203.0	2435
20	21.60	.97	207.8	2495	1.05	223.2	2680	1.22	255.4	3065
24	25.80	1.17	297.9	3575	1.26	318.5	3820	1.36	341.2	4095
30	32.00	1.39	443.2	5320	1.50	474.6	5695	1.62	508.6	6105
36	38.30	1.54	592.0	7105	1.79	677.7	8130	1.93	725.1	8700
42	44.50	1.71	764.7	9175						
48	50.80	2.02	1026.2	12315						

* Including Bell. Calculated weight of pipe rounded off to nearest 5 pounds.
References: Thicknesses—A.S.A.—A-21.2. Mechanical joint A.S.A.—A-21.11.

WEIGHTS OF MECHANICAL JOINT PIPE FOR GAS

STANDARD THICKNESSES AND WEIGHTS OF CAST IRON MECHANICAL JOINT PIT CAST PIPE FOR GAS

Note: Thicknesses in accordance with A.S.A. Specifications, 11,000 psi full length bursting tensile, 31,000 psi ring modulus of rupture. For pipe laid without blocks on flat bottom trench with tamped backfill under 5 feet of cover. For other conditions consult the manufacturer.

		Class 10 10 lb. Pressure			Class 50 50 lb. Pressure			Class 100 100 lb. Pressure			Class 150 150 lb. Pressure		
			Weight Based on 12 ft. Lgth.*			Weight Based on 12 ft. Lgth.*			Weight Based on 12 ft. Lgth.*			Weight Based on 12 ft. Lgth.*	
Size ins.	Outside Diam. ins.	Thickness ins.	Avg. per ft.	per Lgth.	Thickness ins.	Avg. per ft.	per Lgth.	Thickness ins.	Avg. per ft.	per Lgth.	Thickness ins.	Avg. per ft.	per Lgth.
4	4.80	.40	18.6	225	.40	18.6	225	.40	18.6	225	.40	18.6	225
6	6.90	.43	29.2	350	.43	29.2	350	.43	29.2	350	.43	29.2	350
8	9.05	.46	41.3	495	.46	41.3	495	.46	41.3	495	.46	41.3	495
10	11.10	.50	55.4	665	.50	55.4	665	.50	55.4	665	.50	55.4	665
12	13.20	.54	71.2	855	.54	71.2	855	.54	71.2	855	.54	71.2	855
16	17.40	.58	103.7	1245	.58	103.7	1245	.58	103.7	1245			
20	21.60	.66	147.2	1765	.66	147.2	1765	.71	157.1	1885			
24	25.80	.74	197.2	2365	.74	197.2	2365	.80	211.4	2535			
30	32.00	.87	291.8	3500	.87	291.8	3500						
36	38.30	.97	392.0	4705	.97	392.0	4705						
42	44.50	1.07	503.0	6035	1.07	503.0	6035						
48	50.80	1.18	634.3	7610	1.18	634.3	7610						

* Including Bell. Calculated weight of pipe rounded off to nearest 5 pounds.
References: Thicknesses—A.S.A.—A-21.3—pit cast for gas. Mechanical joint—A.S.A.—A-21.11.

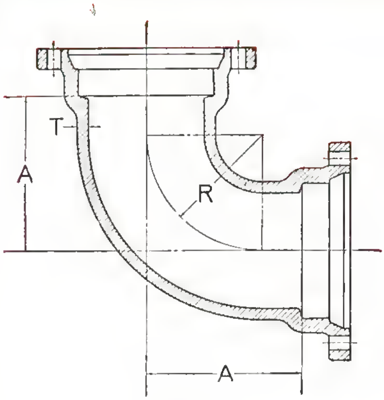
Thicknesses and Weights of Cast Iron Mechanical Joint Pipe Based on Federal Specifications, WW-P-421

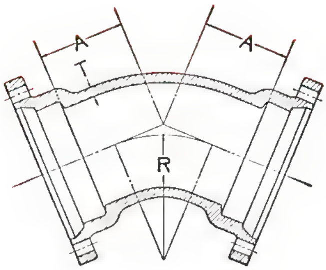
Size	O.D.	Thick-ness	Class or Work-ing Pres-sure in Psi.	Weights in Pounds									
				12 Ft. Length		16 Ft. Length		16½ Ft. Length		18 Ft. Length		20 Ft. Length	
				Per Foot Incl. Bell	Per 12 Ft. Lgth.	Per Foot Incl. Bell	Per 16 Ft. Lgth.	Per Foot Incl. Bell	Per 16½ Ft. Lgth.	Per Foot Incl. Bell	Per 18 Ft. Lgth.	Per Foot Incl. Bell	Per 20 Ft. Lgth.
4	4.80	0.34	150	16.2	195	15.9	255	15.9	260	15.8	285	.....	.....
4	4.80	0.38	250	17.8	215	17.6	280	17.5	290	17.4	315	.....	.....
6	6.90	0.37	150	25.5	305	25.1	400	25.0	415	24.9	450	.....	.....
6	6.90	0.43	250	29.1	350	28.7	460	28.6	470	28.5	515	.....	.....
8	9.05	0.42	150	38.0	460	37.4	600	37.3	615	37.2	670	.....	.....
8	9.05	0.46	200	41.2	495	40.6	650	40.5	670	40.4	725	.....	.....
8	9.05	0.50	250	44.4	530	43.8	700	43.7	720	43.6	785	.....	.....
10	11.10	0.47	150	52.3	630	51.5	825	51.4	850	51.2	920	.....	.....
10	11.10	0.52	200	57.2	685	56.4	900	56.3	930	56.1	1010	.....	.....
10	11.10	0.57	250	62.1	745	61.3	980	61.2	1010	61.0	1100	.....	.....
12	13.20	0.50	150	66.4	795	65.3	1045	65.2	1075	65.0	1170	64.7	1295
12	13.20	0.57	200	74.8	895	73.7	1180	73.6	1215	73.4	1320	73.1	1460
12	13.20	0.62	250	80.7	970	79.6	1275	79.5	1310	79.3	1430	79.0	1580
14	15.30	0.48	100	76.2	915	74.6	1195	.....	.....	74.0	1335	.....	.....
14	15.30	0.55	150	86.0	1030	84.4	1350	.....	.....	83.8	1510	.....	.....
14	15.30	0.62	200	95.7	1150	94.1	1505	.....	.....	93.5	1685	.....	.....
14	15.30	0.69	250	105.3	1265	103.7	1660	.....	.....	103.1	1855	.....	.....
16	17.40	0.52	100	93.9	1125	91.9	1470	91.8	1515	91.3	1645	90.8	1815
16	17.40	0.60	150	106.7	1280	104.7	1675	104.5	1725	104.1	1875	103.6	2070
16	17.40	0.68	200	119.3	1430	117.3	1875	117.2	1935	116.7	2100	116.2	2325
16	17.40	0.75	250	130.3	1565	128.3	2055	128.2	2115	127.7	2300	127.2	2545
18	19.50	0.56	100	113.4	1360	111.0	1775	.....	.....	110.3	1985	.....	.....
18	19.50	0.65	150	129.5	1555	127.2	2035	.....	.....	126.4	2280	.....	.....
18	19.50	0.74	200	145.5	1745	143.2	2290	.....	.....	142.4	2565	.....	.....
18	19.50	0.83	250	161.3	1935	159.0	2545	.....	.....	158.2	2845	.....	.....
20	21.60	0.58	100	130.7	1570	127.9	2045	127.6	2105	126.9	2285	126.2	2525
20	21.60	0.68	150	150.6	1805	147.8	2365	147.5	2435	146.8	2640	146.1	2920
20	21.60	0.78	200	170.4	2045	167.6	2680	167.3	2760	166.6	3000	165.9	3320
20	21.60	0.88	250	189.9	2280	187.1	2995	186.8	3085	186.1	3350	185.4	3710
24	25.80	0.64	100	172.6	2070	168.9	2700	168.5	2780	167.6	3015	166.7	3335
24	25.80	0.76	150	201.3	2415	197.6	3160	197.2	3255	196.3	3535	195.4	3905
24	25.80	0.88	200	229.7	2755	226.0	3615	225.6	3725	224.7	4045	223.8	4475
24	25.80	1.00	250	257.9	3095	254.2	4065	253.8	4190	252.9	4555	252.0	5040

Note: Thicknesses for sizes and classes of pipe not included in the WW-P-421 specifications are calculated by the Revised Fairchild Formula which is the formula used to calculate the federal specification thicknesses for Class 150 and Class 250.

Dimensions in inches.

For dimensions of Mechanical Joint, see page 242.





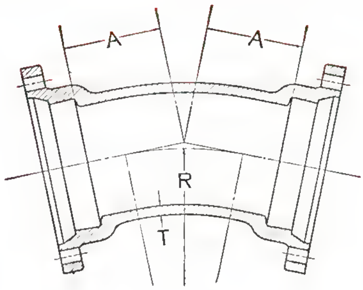
Bends

TABLE OF DIMENSIONS										
Nominal Diam.	Outside Diam.	90° Bends				45° Bends			Max. Working Pressure
		T	A	R	Weights	A	R	Weights	
3	3.96	.48	5.5	4.0	35	3.0	3.62	30	250
4	5.00	.52	6.5	4.5	55	4.0	4.81	50	250
6	7.10	.55	8.0	6.0	85	5.0	7.25	75	250
8	9.30	.60	9.0	7.0	125	5.5	8.44	110	250
10	11.40	.68	11.0	9.0	190	6.5	10.88	155	250
12	13.50	.75	12.0	10.0	255	7.5	13.25	215	250
14	15.30	.66	14.0	11.5	340	7.5	12.06	270	150
16	17.40	.70	15.0	12.5	430	8.0	13.25	340	150
18	19.50	.75	16.5	14.0	545	8.5	14.50	420	150
20	21.60	.80	18.0	15.5	680	9.5	16.88	530	150
24	25.80	.89	22.0	18.5	1025	11.0	18.12	755	150
30	32.00	1.03	36.0	32.5	2145	15.0	27.75	1380	150
36	38.30	1.15	48.0	44.5	3575	18.0	35.00	2095	150
42	44.50	1.28	48.0	44.5	4615	21.0	42.25	2955	150
48	50.80	1.42	54.0	50.5	6395	24.0	49.50	4080	150

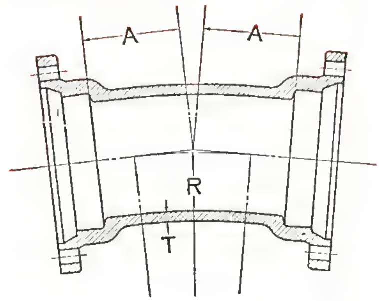
All weights are approximate and do not include joint accessories.

See page 242 for joint dimensions and weight of joint accessories.

Three to twelve-inch fittings conform to A.S.A. Specification—A-21.10—for short body fittings.



22½°



11¼°

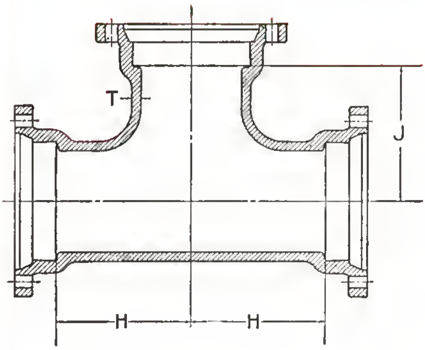
Bends

TABLE OF DIMENSIONS										
Nominal Diam.	Outside Diam.	22½° Bends				11¼° Bends			Max. Working Pressure
		T	A	R	Weights	A	R	Weights	
3	3.96	.48	3.0	7.56	30	3.0	15.25	30	250
4	5.00	.52	4.0	10.06	50	4.0	20.31	50	250
6	7.10	.55	5.0	15.06	75	5.0	30.50	75	250
8	9.30	.60	5.5	17.62	110	5.5	35.50	110	250
10	11.40	.68	6.5	22.62	160	6.5	45.69	160	250
12	13.50	.75	7.5	27.62	220	7.5	55.81	220	250
14	15.30	.66	7.5	25.12	275	7.5	50.75	275	150
16	17.40	.70	8.0	27.62	345	8.0	55.81	345	150
18	19.50	.75	8.5	30.19	430	8.5	60.94	430	150
20	21.60	.80	9.5	35.19	535	9.5	71.06	540	150
24	25.80	.89	11.0	37.69	765	11.0	76.12	770	150
30	32.00	1.03	15.0	57.81	1400	15.0	116.75	1410	150
36	38.30	1.15	18.0	72.88	2135	18.0	147.25	2145	150
42	44.50	1.28	21.0	88.00	3020	21.0	177.69	3035	150
48	50.80	1.42	24.0	103.06	4170	24.0	208.12	4190	150

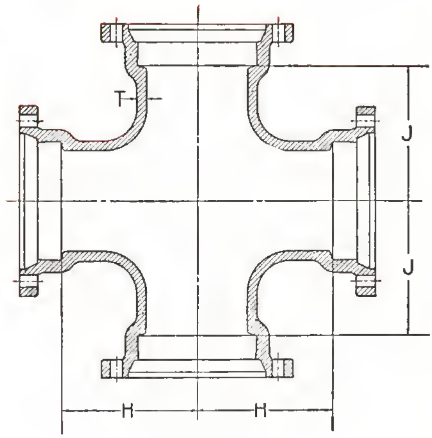
All weights are approximate and do not include joint accessories.

See page 242 for joint dimensions and weight of joint accessories.

Three to twelve-inch fittings conform to A.S.A. Specification—A-21.10—for short body fittings.



TEE



CROSS

Tees and Crosses

TABLE OF DIMENSIONS

Nominal Diam.		Outside Diam.		T				Tee	Cross	Max. Working Pressure
Run	Branch	Run	Branch	Run	Branch	H	J	Weight	Weight	
3	3	3.96	3.96	.48	.48	5.5	5.5	55	70	250
4	3	5.00	3.96	.52	.48	6.5	6.5	75	90	250
4	4	5.00	5.00	.52	.52	6.5	6.5	80	105	250
6	3	7.10	3.96	.55	.48	8.0	8.0	110	125	250
6	4	7.10	5.00	.55	.52	8.0	8.0	115	140	250
6	6	7.10	7.10	.55	.55	8.0	8.0	125	160	250
8	4	9.30	5.00	.60	.52	9.0	9.0	165	185	250
8	6	9.30	7.10	.60	.55	9.0	9.0	175	205	250
8	8	9.30	9.30	.60	.60	9.0	9.0	185	235	250
10	4	11.40	5.00	.68	.52	11.0	11.0	235	260	250
10	6	11.40	7.10	.68	.55	11.0	11.0	250	285	250
10	8	11.40	9.30	.68	.60	11.0	11.0	260	310	250
10	10	11.64	11.64	.80	.80	11.0	11.0	310	380	250
12	4	13.50	5.00	.75	.52	12.0	12.0	315	340	250
12	6	13.50	7.10	.75	.55	12.0	12.0	325	360	250
12	8	13.50	9.30	.75	.60	12.0	12.0	340	385	250
12	10	13.74	11.64	.87	.80	12.0	12.0	390	460	250
12	12	13.74	13.74	.87	.87	12.0	12.0	410	495	250
14	6	15.30	7.10	.66	.55	14.0	14.0	435	475	150
14	8	15.30	9.30	.66	.60	14.0	14.0	450	500	150
14	10	15.30	11.40	.66	.68	14.0	14.0	465	540	150
14	12	15.65	13.50	.82	.75	14.0	14.0	540	630	150
14	14	15.65	15.65	.82	.82	14.0	14.0	585	710	150
16	6	17.40	7.10	.70	.55	15.0	15.0	540	575	150
16	8	17.40	9.30	.70	.60	15.0	15.0	550	605	150
16	10	17.40	11.40	.70	.68	15.0	15.0	570	645	150
16	12	17.40	13.50	.70	.75	15.0	15.0	590	685	150
16	14	17.80	15.65	.89	.82	15.0	15.0	710	830	150
16	16	17.80	17.80	.89	.89	15.0	15.0	740	895	150

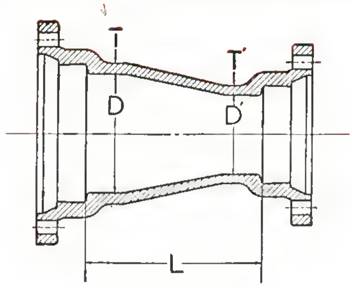
All weights are approximate and do not include joint accessories.
See page 242 for joint dimensions and weight of joint accessories.
Three to twelve-inch fittings conform to A.S.A. Specification—A-21.10—for short body fittings.

Tees and Crosses
Continued

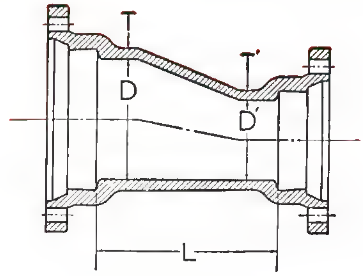
TABLE OF DIMENSIONS

Nominal Diam.		Outside Diam.		T				Tee	Cross	Max. Working Pressure
Run	Branch	Run	Branch	Run	Branch	H	J	Weight	Weight	
18	6	19.50	7.10	.75	.55	13.0	15.5	590	625	150
18	8	19.50	9.30	.75	.60	13.0	15.5	605	655	150
18	10	19.50	11.40	.75	.68	13.0	15.5	620	685	150
18	12	19.50	13.50	.75	.75	13.0	15.5	640	725	150
18	14	19.50	15.30	.75	.66	16.5	16.5	755	870	150
18	16	19.92	17.80	.96	.89	16.5	16.5	905	1060	150
18	18	19.92	19.92	.96	.96	16.5	16.5	945	1130	150
20	6	21.60	7.10	.80	.55	14.0	17.0	725	760	150
20	8	21.60	9.30	.80	.60	14.0	17.0	735	790	150
20	10	21.60	11.40	.80	.68	14.0	17.0	755	820	150
20	12	21.60	13.50	.80	.75	14.0	17.0	775	860	150
20	14	21.60	15.30	.80	.66	14.0	17.0	795	905	150
20	16	21.60	17.40	.80	.70	18.0	18.0	945	1085	150
20	18	22.06	19.92	1.03	.96	18.0	18.0	1140	1330	150
20	20	22.06	22.06	1.03	1.03	18.0	18.0	1185	1415	150
24	6	25.80	7.10	.89	.55	15.0	19.0	985	1025	150
24	8	25.80	9.30	.89	.60	15.0	19.0	1000	1045	150
24	10	25.80	11.40	.89	.68	15.0	19.0	1020	1085	150
24	12	25.80	13.50	.89	.75	15.0	19.0	1030	1110	150
24	14	25.80	15.30	.89	.66	15.0	19.0	1055	1155	150
24	16	25.80	17.40	.89	.70	15.0	19.0	1075	1200	150
24	18	25.80	19.50	.89	.75	22.0	22.0	1400	1590	150
24	20	26.32	22.06	1.16	1.03	22.0	22.0	1720	1965	150
24	24	26.32	26.32	1.16	1.16	22.0	22.0	1815	2155	150
30	6	32.00	7.10	1.03	.55	18.0	23.0	1730	1770	150
30	8	32.00	9.30	1.03	.60	18.0	23.0	1745	1795	150
30	10	32.00	11.40	1.03	.68	18.0	23.0	1760	1830	150
30	12	32.00	13.50	1.03	.75	18.0	23.0	1780	1865	150
30	14	32.00	15.30	1.03	.66	18.0	23.0	1800	1905	150
30	16	32.00	17.40	1.03	.70	18.0	23.0	1820	1950	150
30	18	32.00	19.50	1.03	.75	18.0	23.0	1845	2000	150
30	20	32.00	21.60	1.03	.80	18.0	23.0	1875	2060	150
30	24	32.74	26.32	1.37	1.16	25.0	25.0	2880	3180	150
30	30	32.74	32.74	1.37	1.37	25.0	25.0	3105	3640	150
36	8	38.30	9.30	1.15	.60	20.0	26.0	2520	2565	150
36	10	38.30	11.40	1.15	.68	20.0	26.0	2535	2600	150
36	12	38.30	13.50	1.15	.75	20.0	26.0	2550	2630	150
36	14	38.30	15.30	1.15	.66	20.0	26.0	2570	2665	150
36	16	38.30	17.40	1.15	.70	20.0	26.0	2585	2705	150
36	18	38.30	19.50	1.15	.75	20.0	26.0	2610	2750	150
36	20	38.30	21.60	1.15	.80	20.0	26.0	2635	2805	150
36	24	38.30	25.80	1.15	.89	20.0	26.0	2690	2910	150
36	30	39.16	32.74	1.58	1.37	28.0	28.0	4345	4790	150
36	36	39.16	39.16	1.58	1.58	28.0	28.0	4590	5280	150
42	12	44.50	13.50	1.28	.75	23.0	30.0	3555	3640	150
42	14	44.50	15.30	1.28	.66	23.0	30.0	3575	3675	150
42	16	44.50	17.40	1.28	.70	23.0	30.0	3595	3715	150
42	18	44.50	19.50	1.28	.75	23.0	30.0	3615	3755	150
42	20	44.50	21.60	1.28	.80	23.0	30.0	3640	3810	150
42	24	44.50	25.80	1.28	.89	23.0	30.0	3690	3910	150
42	30	44.50	32.00	1.28	1.03	31.0	31.0	4650	5040	150
42	36	45.58	39.16	1.78	1.58	31.0	31.0	6075	6655	150
42	42	45.58	45.58	1.78	1.78	31.0	31.0	6320	7145	150
48	12	50.80	13.50	1.42	.75	26.0	34.0	4870	4955	150
48	14	50.80	15.30	1.42	.66	26.0	34.0	4885	4985	150
48	16	50.80	17.40	1.42	.70	26.0	34.0	4905	5025	150
48	18	50.80	19.50	1.42	.75	26.0	34.0	4925	5065	150
48	20	50.80	21.60	1.42	.80	26.0	34.0	4950	5115	150
48	24	50.80	25.80	1.42	.89	26.0	34.0	4995	5210	150
48	30	50.80	32.00	1.42	1.03	26.0	34.0	5140	5495	150
48	36	50.80	38.30	1.42	1.15	34.0	34.0	6280	6790	150
48	42	51.98	45.58	1.96	1.78	34.0	34.0	8130	8815	150
48	48	51.98	51.98	1.96	1.96	34.0	34.0	8420	9380	150

All weights are approximate and do not include joint accessories.
See page 242 for joint dimensions and weight of joint accessories.



CONCENTRIC



ECCENTRIC

Reducers

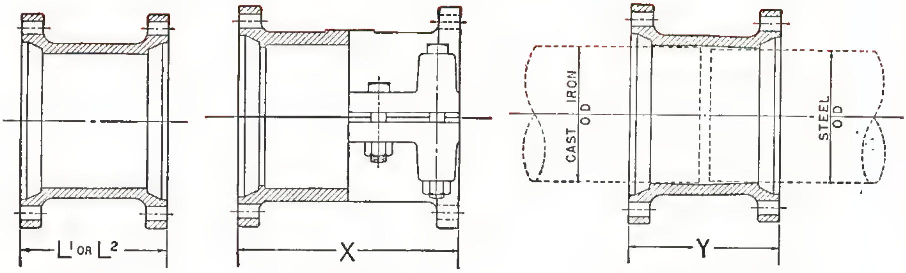
TABLE OF DIMENSIONS

Nominal Diam.		Outside Diam.		Metal Thickness		Bell & Bell		Large End Bell		Small End Bell		Max. Working Pressure
D	D'	Large	Small	T	T'	L	Weight	L	Weight	L	Weight	
4	3	5.00	3.96	.52	.48	7	40	15	40	15	35	250
6	3	7.10	3.96	.55	.48	9	55	17	55	17	50	250
6	4	7.10	5.00	.55	.52	9	60	17	60	17	60	250
8	4	9.30	5.00	.60	.52	11	80	19	80	19	80	250
8	6	9.30	7.10	.60	.55	11	95	19	90	19	90	250
10	4	11.40	5.00	.68	.52	12	105	20	100	20	100	250
10	6	11.40	7.10	.68	.55	12	115	20	115	20	115	250
10	8	11.40	9.30	.68	.60	12	135	20	130	20	130	250
12	4	13.50	5.00	.75	.52	14	135	22	130	22	130	250
12	6	13.50	7.10	.75	.55	14	150	22	145	22	150	250
12	8	13.50	9.30	.75	.60	14	165	22	165	22	165	250
12	10	13.50	11.40	.75	.68	14	190	22	185	22	190	250
14	6	15.30	7.10	.66	.55	16	190	24	185	24	175	150
14	8	15.30	9.30	.66	.60	16	210	24	205	24	190	150
14	10	15.30	11.40	.66	.68	16	230	24	230	24	215	150
14	12	15.30	13.50	.66	.75	16	255	24	255	24	240	150
16	6	17.40	7.10	.70	.55	18	230	26	230	26	210	150
16	8	17.40	9.30	.70	.60	18	250	26	250	26	230	150
16	10	17.40	11.40	.70	.68	18	280	26	275	26	255	150
16	12	17.40	13.50	.70	.75	18	305	26	305	26	285	150
16	14	17.40	15.30	.70	.66	18	335	26	315	26	310	150
18	8	19.50	9.30	.75	.60	19	295	27	295	27	270	150
18	10	19.50	11.40	.75	.68	19	325	27	320	27	300	150
18	12	19.50	13.50	.75	.75	19	350	27	350	27	325	150
18	14	19.50	15.30	.75	.66	19	380	27	365	27	355	150
18	16	19.50	17.40	.75	.70	19	415	27	395	27	390	150
20	10	21.60	11.40	.80	.68	20	375	28	375	28	345	150
20	12	21.60	13.50	.80	.75	20	405	28	405	28	375	150
20	14	21.60	15.30	.80	.66	20	430	28	415	28	400	150
20	16	21.60	17.40	.80	.70	20	470	28	445	28	435	150
20	18	21.60	19.50	.80	.75	20	510	28	485	28	475	150
24	12	25.80	13.50	.89	.75	24	550	32	550	32	510	150
24	14	25.80	15.30	.89	.66	24	575	32	560	32	535	150
24	16	25.80	17.40	.89	.70	24	615	32	595	32	575	150
24	18	25.80	19.50	.89	.75	24	660	32	635	32	620	150
24	20	25.80	21.60	.89	.80	24	705	32	675	32	665	150
30	18	32.00	19.50	1.03	.75	30	990	38	965	38	885	150
30	20	32.00	21.60	1.03	.80	30	1050	38	1020	38	945	150
30	24	32.00	25.80	1.03	.89	30	1165	38	1125	38	1060	150
36	20	38.30	21.60	1.15	.80	36	1450	44	1420	44	1285	150
36	24	38.30	25.80	1.15	.89	36	1580	44	1535	44	1410	150
36	30	38.30	32.00	1.15	1.03	36	1855	44	1750	44	1690	150
42	20	44.50	21.60	1.28	.80	42	1915	50	1880	50	1705	150
42	24	44.50	25.80	1.28	.89	42	2060	50	2020	50	1855	150
42	30	44.50	32.00	1.28	1.03	42	2370	50	2265	50	2165	150
42	36	44.50	38.30	1.28	1.15	42	2695	50	2530	50	2485	150
48	30	50.80	32.00	1.42	1.03	48	3005	56	2900	56	2740	150
48	36	50.80	38.30	1.42	1.15	48	3370	56	3205	56	3100	150
48	42	50.80	44.50	1.42	1.28	48	3750	56	3540	56	3480	150

All weights are approximate and do not include joint accessories.

See page 242 for joint dimensions and weight of joint accessories.

Three to twelve-inch fittings conform to A.S.A. Specification—A-21.10—for short body fittings.



SOLID SLEEVE

SPLIT SLEEVE*

TRANSITION SLEEVE**

Sleeves

TABLE OF DIMENSIONS											
			Solid Sleeves				Split Sleeves	Transition Sleeves			
Nominal Diam.	T	Fits O. D. C. I. Pipe	L¹	Weight	L²	Weight	X Min.	Fits O. D. Steel Pipe	Y	Weight	Max. Working Pressure
3	.48	3.96	7.5	25	12	30	10	3.50	7.50	25	250
4	.52	4.80	7.5	35	12	45	10	4.50	7.50	35	250
6	.55	6.90	7.5	45	12	65	10	6.62	7.50	45	250
8	.60	9.05	7.5	65	12	85	10	8.62	7.50	65	250
10	.68	11.10	7.5	85	12	115	10	10.75	7.50	85	250
12	.75	13.20	7.5	110	12	145	10	12.75	7.50	110	250
14	.82	15.30	9.5	165	15	225	11				150
16	.89	17.40	9.5	200	15	275	11				150
18	.96	19.50	9.5	240	15	330	11				150
20	1.03	21.60	9.5	275	15	380	11				150
24	1.16	25.80	9.5	360	15	505	11				150
30	1.37	32.00	15.0	745	24	1085	15				150
36	1.58	38.30	15.0	1030	24	1495	15				150
42	1.78	44.50	15.0	1330	24	1940	15				150.
48	1.96	50.80	15.0	1645	24	2405	15				150

* This split sleeve can be furnished with boss and tap for service connection.

** Transition sleeves are furnished with one end designed for standard steel outside diameter pipe and the other to fit mechanical joint cast iron pipe.

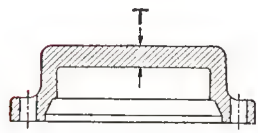
All weights are approximate and do not include joint accessories.

See page 242 for joint dimensions and weight of joint accessories.

GLAND

PLUG

SPLIT GLAND



CAP

Glands, Plugs and Caps

TABLE OF DIMENSIONS							
Weights					Weights		Max. Working Pressure
Nominal Diam.	Solid Glands	Split Glands	Design	T	Plugs	Caps	
3	5	9	Flat	.75	14	13	250
4	6	14	Flat	.75	20	20	250
6	11	18	Flat	.75	30	30	250
8	18	20	Flat	.75	50	45	250
10	20	30	Flat	.75	65	55	250
12	30	35	Flat	.75	85	75	250
14	35	60	Dished	.82	115	120	150
16	45	70	Dished	.89	150	155	150
18	55	85	Dished	.96	195	190	150
20	70	100	Dished	1.03	225	240	150
24	90	130	Dished	1.16	330	345	150
30	180	205	Dished & Ribbed	1.37	590	660	150
36	235	265	Dished & Ribbed	1.58	880	960	150
42	300	330	Dished & Ribbed	1.78	1250	1355	150
48	365	400	Dished & Ribbed	1.96	1670	1830	150

All weights are approximate.
See page 242 for joint dimensions and weight of joint accessories.

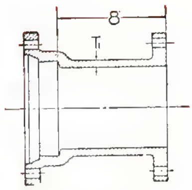


Figure A

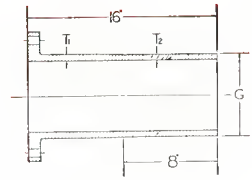


Figure B

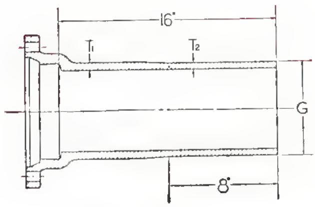


Figure C

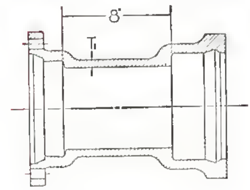


Figure D

All flanges are American 125 standard unless otherwise specified.

Connecting Pieces

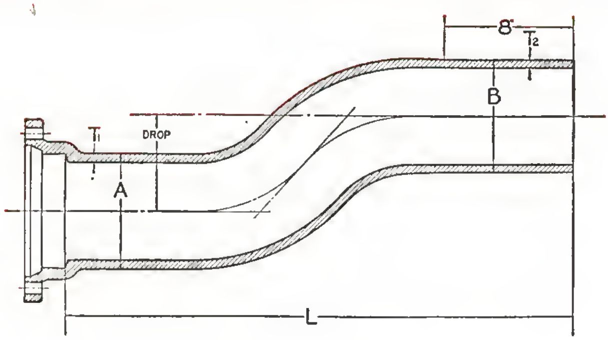
TABLE OF DIMENSIONS										
					A	B	C	D	E*	
					MJ & Flg	Flg. & PE	MJ & PE	MJ & B	MJ & MJ	Max. Working Pressure
Nominal Diam.	Body O. D.	T_1	P. E. Diam. "G"	T_2	Weight	Weight	Weight	Weight	Weight	
3	3.96	.48	3.96	.48	30	30	35	40	35	250
4	5.00	.52	4.80	.45	40	40	45	55	45	250
6	7.10	.55	6.90	.48	60	55	65	80	70	250
8	9.30	.60	9.05	.51	85	85	95	115	95	250
10	11.40	.68	11.10	.57	115	115	125	150	130	250
12	13.50	.75	13.20	.62	155	155	165	190	165	250
14	15.30	.66	15.30	.66	195	180	205	230	220	150
16	17.40	.70	17.40	.70	240	220	250	290	270	150
18	19.50	.75	19.50	.75	280	255	300	340	325	150
20	21.60	.80	21.60	.80	340	305	360	405	390	150
24	25.80	.89	25.80	.89	455	415	475	530	515	150
30	32.00	1.03	32.00	1.03	710	600	730	820	840	150
36	38.30	1.15	38.30	1.15	1000	830	1005	1170	1170	150
42	44.50	1.28	44.50	1.28	1325	1115	1295	1515	1500	150
48	50.80	1.42	50.80	1.42	1655	1390	1640	1930	1910	150

Fittings shown in Fig. B and C may be furnished from centrifugally cast pipe.

*Figure E is a mechanical joint-to-mechanical joint connecting piece having laying length of 8".

All weights are approximate.

See page 242 for joint dimensions and weight of joint accessories.

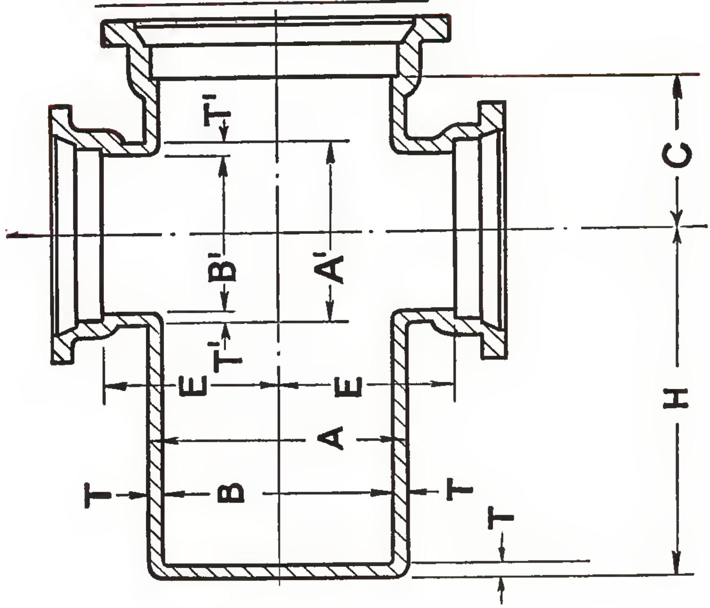


Offsets

TABLE OF DIMENSIONS								
Nominal Diam.	Plain End Diam.	Outside Diam. A	Drop	L	T_1	T_2	Weight	Max. Working Pressure
3	3.96	3.96	6	27	.48	.48	50	250
3	3.96	3.96	12	30	.48	.48	60	250
3	3.96	3.96	18	38	.48	.48	75	250
4	4.80	5.00	6	27	.52	.45	70	250
4	4.80	5.00	12	30	.52	.45	80	250
4	4.80	5.00	18	38	.52	.45	100	250
6	6.90	7.10	6	28	.55	.48	105	250
6	6.90	7.10	12	34	.55	.48	130	250
6	6.90	7.10	18	41	.55	.48	160	250
8	9.05	9.30	6	29	.60	.51	155	250
8	9.05	9.30	12	36	.60	.51	195	250
8	9.05	9.30	18	43	.60	.51	240	250
10	11.10	11.40	6	30	.68	.57	220	250
10	11.10	11.40	12	38	.68	.57	280	250
10	11.10	11.40	18	46	.68	.57	340	250
12	13.20	13.50	6	34	.75	.62	320	250
12	13.20	13.50	12	45	.75	.62	420	250
12	13.20	13.50	18	56	.75	.62	520	250

All weights are approximate.
See page 242 for joint dimensions and weight of joint accessories.

3"- 24" DRIP POTS



Drip Pots

DIMENSIONS IN INCHES											
Size	A'	A	B'	B	C	E	H	T'	T	Plug Size	Cap., qts.	Wts., lbs.
4	5.00	15.30	3.96	13.98	6.00	10.75	14.75 26.75	.52	.66	14	32 64	435 530
6	7.10	15.30	6.00	13.98	7.12	10.75	15.75 27.75	.55	.66	14	32 64	465 560
8	9.30	15.30	8.10	13.98	8.25	10.75	28.75 40.88	.60	.66	14	64 96	595 695
10	11.40	15.30	10.04	13.98	9.25	10.75	29.75 41.88	.68	.66	14	64 96	645 740
12	13.50	17.40	12.00	16.00	10.25	11.75	30.88 42.88	.75	.70	16	84 126	815 930
16	17.40	21.60	16.00	20.00	12.25	14.38	34.12 45.88	.70	.80	20	138 208	1285 1460
20	21.60	25.80	20.00	24.02	15.38	16.50	36.75 49.62	.80	.89	24	203 304	1875 2110
24	25.80	32.00	24.02	29.94	17.50	20.50	36.12 47.62	.89	1.03	30	280 420	2895 3195

All weights are approximate and do not include joint accessories.
See page 242 for joint dimensions and weight of joint accessories.
Three to twelve-inch fittings conform to A.S.A. Specification—A-21.10—for short body fittings.

SECTION 11

Federal Specifications—WW-P-421

Federal Specification WW-P-421, July 21, 1931
(with Amendment 3, April 1940)
for
Pipe; Water, Cast Iron (Bell and Spigot)*

> **For details of the above Specification, see Section IV (Part 5) of Federal Standard Stock Catalogue, available for sale by the Superintendent of Documents, Washington, D. C.**
>
> **The WW-P-421 Specification has been in general use for centrifugally Cast Cast-Iron Pressure Pipe for Water or Other Liquids, not only by the departments and independent establishments of the Government but also by most other consumers and manufacturers, prior to the issuance of A.S.A. Specifications A.S.A. A21.6 and A.S.A. A21.8.**
>
> **For the convenience of the users of the Handbook, listed below are the more important requirements, dimensions and weights.**

E. DETAIL REQUIREMENTS.

E-1. Tolerances in thickness.—

E-1a. The tolerances in thickness of pipe, plus or minus, shall not exceed those listed below.

Nominal diameter in inches:	Tolerance, plus or minus (inch)
4	0.04
6	0.045
8	0.05
10	0.055
12	0.06
14, 16, 18, 20, 24	0.08

E-1b. For all sizes of pipe, tolerances not exceeding 0.02 inch additional to above will be allowed for spaces not exceeding 8 inches in length in any direction.

E-2. Tolerance in weight.—The weight of no single pipe shall be less than the nominal tabulated weight by more than 5 per cent. The total weight of any order shall be not more than 2 per cent under nominal weight.

*For weights of Federal Specification Pipe (WW-P-421) see pages 262 to 269.

E-3. Type I—Centrifugally cast in metal contact molds in 12-foot and 18-foot lengths.

E-3a. Type I pipe shall be of the bell and spigot type, centrifugally cast in metal contact molds with plain spigot end, and with lead groove and self-centering shoulder in the bell.

E-3b. Annealing.—Type I pipe, after withdrawing from machines, shall be annealed to meet the hardness limits specified in paragraph F-6.

E-3c. Physical requirements.—Type I pipe shall have a secant modulus of elasticity (see par. F-4b) not to exceed 12,000,000 pounds per square inch with a corresponding modulus of rupture not less than 40,000 pounds per square inch.

E-3d. Tolerances in diameter.—The inside diameters of the bells and the outside diameters of the spigot ends of Type I pipe shall not vary plus or minus from the tabulated dimensions by more than 0.06 inch for pipe 12 inches and less in nominal diameter and 0.08 inch for pipe 14 inches and larger.

E-3e. Dimensions and weights.—Type I pipe shall conform to the dimensions and weights given in Figure 1 and Tables I and II for the respective classes and subject to the tolerances given in paragraphs E-1a, E-1b, E-2, and E-3d.

E-4. Type II.—Centrifugally cast in sand-lined molds in 16-foot, 16½-foot, and 20-foot lengths.

E-4a. Type II pipe shall be of the bell and spigot type, centrifugally cast in sand-lined molds; with bead cast on spigot end; and with lead groove in the bell.

E-4b. Physical Requirements.—Type II pipe shall have a secant modulus of elasticity (see par. F-4b) not to exceed 10,000,000 pounds per square inch, with a corresponding modulus of rupture not less than 40,000 pounds per square inch. Where the modulus of elasticity exceeds 10,000,000 pounds the modulus of rupture shall exceed 40,000 pounds by at least the same percentage.

E-4c. Tolerances in diameter.—The inside diameters of the bells and the outside diameters of the spigot ends (exclusive of bead) of type II pipe shall not vary plus or minus from the tabulated dimensions by more than 0.06 inch for pipe 12 inches and less in nominal diameter, and 0.08 inch for pipe 14 inches and larger.

E-4d. Dimensions and weights.—Type II pipe shall conform to the dimensions and weights given in Figure 2 and Tables III and IV for the respective classes and subject to the tolerances given in paragraphs E-1a, E-1b, E-2, and E-4c.

Dimensions of Type I Pipe (inches)

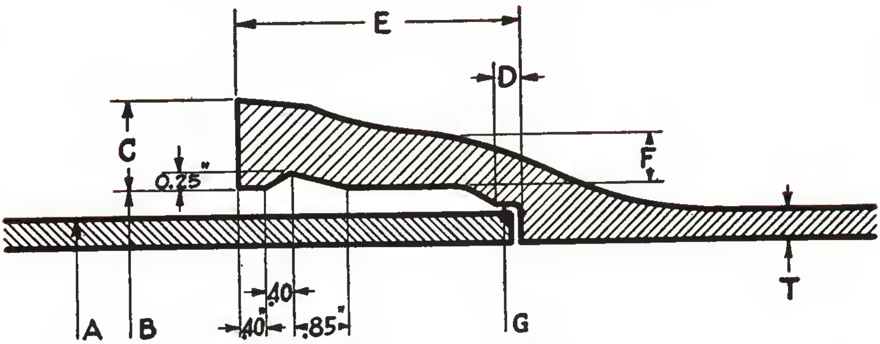


FIGURE 1—TYPE I PIPE, END DETAILS

TABLE I

Nominal Inside Diameter	Outside Diameter of Pipe	Inside Diameter of Bells	Total Depth of Bells	Depth of Centering Shoulder	Inside Diameter of Centering Shoulder	Class 150, 150 Pounds Working Pressure, 346-Foot Head			Class 250, 250 Pounds Working Pressure, 576-Foot Head		
						Thickness of Pipe	Thickness of Bells At End	Thickness of Bells At Shoulder	Thickness of Pipe	Thickness of Bells At End	Thickness of Bells At Shoulder
	A	B	E	D	G	T	C	F	T	C	F
4	4.80	5.60	3.30	0.30	4.94	0.34	1.06	0.48	0.38	1.06	0.48
6	6.90	7.70	3.88	0.38	7.06	0.37	1.13	0.52	0.43	1.13	0.52
8	9.05	9.85	4.38	0.38	9.21	0.42	1.18	0.57	0.50	1.18	0.57
10	11.10	11.90	4.38	0.38	11.28	0.47	1.23	0.63	0.57	1.23	0.63
12	13.20	14.00	4.38	0.38	13.38	0.50	1.28	0.69	0.62	1.28	0.69
14	15.65	16.45	4.50	0.50	15.87	0.55	1.35	0.73	0.69	1.56	0.93
16	17.80	18.80	4.50	0.50	18.02	0.60	1.43	0.77	0.75	1.63	1.00
18	19.92	20.92	4.50	0.50	20.14	0.65	1.53	0.82	0.83	1.68	1.09
20	22.06	23.06	4.50	0.50	22.28	0.68	1.63	0.87	0.88	1.75	1.18
24	26.32	27.32	4.50	0.50	26.54	0.76	1.83	1.03	1.00	2.00	1.38

Nominal weights of Type 1 pipe (pounds)

TABLE II

Nominal Inside Diameter	Class 150, 150 Pounds Working Pressure, 346-Foot Head				Class 250, 250 Pounds Working Pressure, 576-Foot Head			
	12-Foot Nominal Laying Length		18-Foot Nominal Laying Length		12-Foot Nominal Laying Length		18-Foot Nominal Laying Length	
	Weight of Pipe	Weight per Foot with Bell	Weight of Pipe	Weight per Foot with Bell	Weight of Pipe	Weight per Foot with Bell	Weight of Pipe	Weight per Foot with Bell
4	195	16.4	285	15.9	220	18.4	325	17.9
6	315	26.3	460	25.5	350	29.3	515	28.5
8	475	39.4	690	38.3	545	45.5	800	44.3
10	640	53.3	935	51.8	760	63.3	1,115	61.9
12	810	67.4	1,180	65.6	990	82.5	1,450	80.7
14	1,060	88.5	1,555	86.3	1,320	110.0	1,930	107.3
16	1,320	110.2	1,935	107.4	1,635	136.1	2,390	132.7
18	1,595	132.8	2,330	129.6	2,015	168.0	2,950	163.9
20	1,860	155.0	2,720	151.0	2,365	197.1	3,465	192.4
24	2,480	206.8	3,630	201.6	3,200	266.8	4,690	260.6

NOTE: Calculated weight of pipe has been rounded off to nearest 5 pounds. Weight per foot is based on weight of pipe computed to nearest pound.

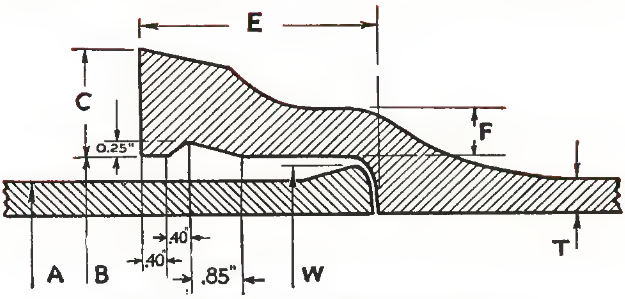


FIGURE 2 —TYPE II PIPE, END DETAILS

Dimensions of Type II pipe (inches)

TABLE III

Nominal Inside Diameter	Outside Diameter of Pipe	Outside Diameter of Spigot End, Maximum	Inside Diameter of Bells	Depth of Bells	Class 150, 150 Pounds Working Pressure, 346-Foot Head: Thickness of Pipe	Class 150: Thickness of Bells, At End, Minimum	Class 150: Thickness of Bells, At Shoulder, Minimum	Class 250, 250 Pounds Working Pressure, 576-Foot Head: Thickness of Pipe	Class 250: Thickness of Bells, At End, Minimum	Class 250: Thickness of Bells, At Shoulder, Minimum
	A	W	B	E	T	C	F	T	C	F
4	4.80	5.36	5.60	3.50	0.34	1.28	0.44	0.38	1.28	0.44
6	6.90	7.46	7.70	3.50	0.37	1.39	0.48	0.43	1.39	0.48
8	9.05	9.61	9.85	4.00	0.42	1.47	0.52	0.50	1.47	0.62
10	11.10	11.66	11.90	4.00	0.47	1.59	0.57	0.57	1.59	0.69
12	13.20	13.76	14.00	4.00	0.50	1.75	0.62	0.62	1.75	0.74
14	15.65	16.23	16.45	4.00	0.55	1.47	0.62	0.69	1.62	0.77
16	17.80	18.38	18.80	4.00	0.60	1.52	0.67	0.75	1.72	0.82
18	19.92	20.50	20.92	4.00	0.65	1.62	0.72	0.83	1.82	0.87
20	22.06	22.64	23.06	4.00	0.68	1.77	0.77	0.88	1.92	0.92
24	26.32	26.90	27.32	4.00	0.76	1.92	0.82	1.00	2.02	0.97

Nominal weights of Type II pipe (pounds)

TABLE IV

Nominal inside Diameter	Class 150, 150 Pounds Working Pressure, 346-Foot Head						Class 250, 250 Pounds Working Pressure, 576-Foot Head					
	16-Foot Nominal Laying Length		16½-Foot Nominal Laying Length		20-Foot Nominal Laying Length		16-Foot Nominal Laying Length		16½-Foot Nominal Laying Length		20-Foot Nominal Laying Length	
	Weight of Pipe	Weight per Foot with Bell	Weight of Pipe	Weight per Foot with Bell	Weight of Pipe	Weight per Foot with Bell	Weight of Pipe	Weight per Foot with Bell	Weight of Pipe	Weight per Foot with Bell	Weight of Pipe	Weight per Foot with Bell
4	255	16.1	265	16.0	......	......	290	18.1	300	18.0	......	......
6	410	25.7	425	25.6	......	......	460	28.7	475	28.6	......	......
8	615	38.6	635	38.5	......	......	715	44.6	735	44.5	......	......
10	835	52.2	860	52.1	......	......	995	62.3	1,025	62.2	......	......
12	1,055	66.1	1,090	65.9	......	......	1,300	81.1	1,335	81.0	......	......
14	1,390	86.9	1,430	86.7	......	......	1,730	108.0	1,780	107.8	......	......
16	1,730	108.1	1,780	107.9	2,140	106.9	2,135	133.6	2,200	133.3	2,640	132.1
18	2,085	130.4	2,150	130.2	2,580	128.9	2,640	164.9	2,715	164.7	3,265	163.2
20	2,430	152.0	2,505	151.7	3,005	150.2	3,095	193.6	3,190	193.2	3,830	191.5
24	3,245	202.9	3,340	202.5	4,010	200.5	4,195	262.1	4,320	261.7	5,185	259.3

NOTE: Calculated weight of pipe has been rounded off to nearest 5 pounds. Weight per foot is based on weight of pipe computed to nearest pound.

Class 100 pipe and Class 200 pipe shown in the following tables are not included in the WW-P-421 Specification, however they are manufactured to meet all the requirements of WW-P-421. The thicknesses are calculated by the Revised Fairchild Formula which is the same formula used to calculate the Federal Specification thicknesses for Class 150 and Class 250.

TYPE I PIPE—Class 100, 100 Pounds Working Pressure, 231-Foot Head

Nominal Inside Diameter	Dimensions in Inches						Weights in Pounds			
	Outside Diameter of Pipe	Inside Diameter of Bells	Total Depth of Bells	Depth of Centering Shoulder	Inside Diameter of Centering Shoulder	Thickness of Pipe	12-Foot Nominal Laying Length		18-Foot Nominal Laying Length	
	A	B	E	D	G	T	Weight of Pipe	Weight per Foot with Bell	Weight of Pipe	Weight per Foot with Bell
14	15.30	16.10	4.50	0.50	15.52	0.48	920	76.5	1340	74.3
16	17.40	18.40	4.50	0.50	17.62	0.52	1130	94.2	1645	91.4
18	19.50	20.50	4.50	0.50	19.72	0.56	1365	113.8	1990	110.6
20	21.60	22.60	4.50	0.50	21.82	0.58	1585	132.0	2305	128.0
24	25.80	26.80	4.50	0.50	26.02	0.64	2085	173.8	3035	168.6

TYPE I PIPE—Class 200, 200 Pounds Working Pressure, 462-Foot Head

8	9.05	9.85	4.38	0.38	9.21	0.46	510	42.4	745	41.3
10	11.10	11.90	4.38	0.38	11.28	0.52	700	58.3	1025	56.8
12	13.20	14.00	4.38	0.38	13.38	0.57	905	75.4	1325	73.7
14	15.65	16.45	4.50	0.50	15.87	0.62	1190	99.0	1735	96.3
16	17.80	18.80	4.50	0.50	18.02	0.68	1490	124.1	2175	120.7
18	19.92	20.92	4.50	0.50	20.14	0.74	1810	150.9	2645	146.9
20	22.06	23.06	4.50	0.50	22.28	0.78	2125	177.1	3105	172.4
24	26.32	27.32	4.50	0.50	26.54	0.88	2855	237.8	4170	231.6

In diameters 14″–24″ Class 100 pipe are made for use with A.W.W.A. Class "B" fittings.

Class 200 pipe are made for use with A.W.W.A. Class "D" fittings.

Standard WW-P-421 pipe Classes 150 and 250 are made for use with A.W.W.A. Class "D" fittings.

Special Class 150 pipe shown in the following table is made for use with Class "B" fittings to meet the requirements of those who desire to use a pipe having Standard Class 150 thickness and still use A.W.W.A. Class "B" fittings.

TYPE I PIPE—Special Class 150, 150 Pounds Working Pressure, 346-Foot Head

Dimensions in Inches							Weights in Pounds			
							12-Foot Nominal Laying Length		18-Foot Nominal Laying Length	
Nominal Inside Diameter	Outside Diameter of Pipe	Inside Diameter of Bells	Total Depth of Bells	Depth of Centering Shoulder	Inside Diameter of Centering Shoulder	Thickness of Pipe	Weight of Pipe	Weight per Foot with Bell	Weight of Pipe	Weight per Foot with Bell
	A	B	E	D	G	T				
14	15.30	16.10	4.50	0.50	15.52	0.55	1040	86.5	1520	84.3
16	17.40	18.40	4.50	0.50	17.62	0.60	1285	107.2	1880	104.4
18	19.50	20.50	4.50	0.50	19.72	0.65	1560	129.8	2280	126.6
20	21.60	22.60	4.50	0.50	21.82	0.68	1810	151.0	2645	147.0
24	25.80	26.80	4.50	0.50	26.02	0.76	2435	202.8	3555	197.6

Class 100 pipe and Class 200 pipe shown in the following tables are not included in the WW-P-421 Specification, however they are manufactured to meet all the requirements of WW-P-421. The thicknesses are calculated by the Revised Fairchild Formula which is the same formula used to calculate the Federal Specification thicknesses for Class 150 and Class 250.

TYPE II PIPE—Class 100, 100 Pounds Working Pressure, 231-Foot Head

Dimensions in Inches						Weights in Pounds					
						16-Foot Nominal Laying Length		16½-Foot Nominal Laying Length		20-Foot Nominal Laying Length	
Nominal Inside Diameter	Outside Diameter of Pipe A	Outside Diameter of Spigot End, Max. W	Inside Diameter of Bells B	Depth of Bells E	Thickness of Pipe T	Weight of Pipe	Weight per Foot with Bell	Weight of Pipe	Weight per Foot with Bell	Weight of Pipe	Weight per Foot with Bell
14	15.30	15.88	16.10	4.00	0.48	1195	74.6	1230	74.5	1475	73.7
16	17.40	17.98	18.40	4.00	0.52	1470	92.0	1515	91.8	1815	90.8
18	19.50	20.08	20.50	4.00	0.56	1780	111.2	1830	111.0	2195	109.8
20	21.60	22.18	22.60	4.00	0.58	2045	127.9	2105	127.7	2525	126.2
24	25.80	26.38	26.80	4.00	0.64	2695	168.5	2775	168.2	3325	166.4

TYPE II PIPE—Class 200, 200 Pounds Working Pressure, 462-Foot Head

Nominal Inside Diameter	A	W	B	E	T	16-Foot Weight of Pipe	16-Foot Weight per Foot with Bell	16½-Foot Weight of Pipe	16½-Foot Weight per Foot with Bell	20-Foot Weight of Pipe	20-Foot Weight per Foot with Bell
8	9.05	9.61	9.85	4.00	0.46	655	41.0	675	40.9	......	......
10	11.10	11.66	11.90	4.00	0.52	920	57.4	945	57.3	......	......
12	13.20	13.76	14.00	4.00	0.57	1200	75.0	1235	74.9	1485	74.2
14	15.65	16.23	16.45	4.00	0.62	1550	96.9	1595	96.8	1915	95.8
16	17.80	18.38	18.80	4.00	0.68	1935	121.0	1995	120.8	2390	119.4
18	19.92	20.50	20.92	4.00	0.74	2355	147.2	2425	147.0	2910	145.6
20	22.06	22.64	23.06	4.00	0.78	2755	172.2	2835	171.9	3405	170.3
24	26.32	26.90	27.32	4.00	0.88	3705	231.5	3815	231.2	4580	229.1

In diameters 14″–24″ Class 100 pipe are made for use with A.W.W.A. Class "B" fittings.

Class 200 pipe are made for use with A.W.W.A. Class "D" fittings.

Standard WW-P-421 pipe Classes 150 and 250 are made for use with A.W.W.A. Class "D" fittings.

Special Class 150 pipe shown in the following table is made for use with Class "B" fittings to meet the requirements of those who desire to use a pipe having Standard Class 150 thickness and still use A.W.W.A. Class "B" fittings.

TYPE II PIPE—Special Class 150, 150 Pounds Working Pressure, 346-Foot Head

Dimensions in Inches						Weights in Pounds					
Nominal Inside Diameter	Outside Diameter of Pipe	Outside Diameter of Spigot End, Max.	Inside Diameter of Bells	Depth of Bells	Thickness of Pipe	16-Foot Nominal Laying Length		16½-Foot Nominal Laying Length		20-Foot Nominal Laying Length	
	A	W	B	E	T	Weight of Pipe	Weight per Foot with Bell	Weight of Pipe	Weight per Foot with Bell	Weight of Pipe	Weight per Foot with Bell
14	15.30	15.88	16.10	4.00	0.55	1350	84.4	1390	84.3	1670	83.4
16	17.40	17.98	18.40	4.00	0.60	1675	104.8	1725	104.6	2070	103.6
18	19.50	20.08	20.50	4.00	0.65	2035	127.3	2095	127.1	2515	125.8
20	21.60	22.18	22.60	4.00	0.68	2365	147.8	2435	147.6	2925	146.2
24	25.80	26.38	26.80	4.00	0.76	3155	197.2	3250	196.9	3900	195.0

SECTION 12

A.W.W.A. Fittings Specifications

These Specifications include ALL of the fittings shown in American Water Works Association Specification C100-08. They also include 3-inch fittings and certain sizes of other fittings NOT shown in C100-08.

American Water Works Association

Standard Specifications

For Cast Iron Pressure Fittings

WITH TABLES OF DIMENSIONS, THICKNESSES AND WEIGHTS

(In referring to the fittings tables in this specification, the data below will clarify class designations.)

Class	Head in feet	Pounds pressure per sq. in.
A	100	43
B	200	86
C	300	130
D	400	173

Standard Specifications

for

Cast Iron Pressure Fittings

DESCRIPTION OF FITTINGS

Section 1. The fittings shall be made with bell and spigot joints and shall conform, within the specified tolerances, to the dimensions given in the tables forming a part of these specifications.

For pipe 4″–12″, one class of fittings shall be furnished, made from Class D patterns. Spigot ends shall have reduced outside diameters as shown by Table 1 and shall taper back for a distance of 6″.

For pipe 14″–24″, two classes of fittings shall be furnished; Class B, and Class D; the former shall have cast on them the letter "B" and the latter "D". For pipe 30″–60″, four classes of fittings shall be furnished; Classes A, B, C and D; and they shall have cast on them the letter of the class to which they belong.

The flanges on all manhole castings and manhole covers shall be faced and drilled as shown in the tables. The manufacturer shall furnish mild steel bolts with square heads, hexagon nuts and gaskets.

ALLOWABLE VARIATION IN DIAMETER OF SOCKETS AND SPIGOTS

Section 2. Sockets and spigots shall be tested with circular gages. Tolerances of fittings made from standard patterns are:

Size, Inches	*Tolerance plus or minus, Inches*
4–16	0.12
18–24	0.15
30–42	0.20
48–60	0.24

ALLOWABLE VARIATION IN THICKNESS

Section 3.

	Tolerance, Minus, Inches
Fittings with standard wall thickness less than 1″	0.12
Fittings with standard wall thickness 1″ or more	0.15

0.03″ additional tolerance is permitted for spaces not exceeding 8″ in length in any direction.

ALLOWABLE PERCENTAGE OF VARIATION IN WEIGHT

Section 4.

Size, Inches	*Standard Weight Tolerance ±, Per cent*
4–12 standard fittings	10
14–60 standard fittings	8
Bends and Wyes	12

No weight shall be paid for that is in excess of the amount allowed by maximum tolerance. No fitting shall be accepted that weighs less than the amount allowed by minimum tolerance.

MARKING

Section 5. Each fitting shall have cast on the outside the initials of the maker's name and the class. As many as four special initials and the year may also be cast on when required by the customer. The weight shall be painted conspicuously on each fitting.

QUALITY OF IRON

Section 6. All fittings shall be made of cast iron of good quality. The metal of the castings shall be strong, tough, of even grain, and soft enough to satisfactorily drill and cut. The manufacturer shall have the right to make and break three bars from each heat and report the average results of the three tests.

TESTS OF MATERIAL

Section 7. At least one test bar of the metal used, twenty-six inches long by two inches wide and one inch thick, shall be made and tested from each heat. The bars when placed flatwise upon supports twenty-four inches apart, and loaded in the center, shall support a load of 2,000 pounds, and show a deflection of not less than 0.30 of an inch before breaking. If preferred, tensile bars shall be made which will show a breaking point of not less than 20,000 p.s.i.

QUALITY OF CASTINGS

Section 8. The fittings shall be smooth and free from defects of every nature which unfit them for the use for which they are intended. No plugging or filling will be allowed.

CLEANING AND INSPECTION

Section 9. All fittings shall be thoroughly cleaned and subjected to a careful inspection.

LININGS AND EXTERIOR COATINGS

Section 10. Any particular lining or coating which is to be applied to the fittings shall be specified in the agreement made at the time of purchase. Separate specifications for a cement-mortar lining have been provided in connection with these specifications for fittings. (*See* specification ASA A21.4.)

No pipe or specials for waterworks service shall be furnished without protective coating unless specifically ordered by the purchaser.

WEIGHING

Section 11. The fittings shall be weighed under the supervision of the engineer before the application of any lining or coating other than hot or cold bituminous dip or paint. If desired by the engineer, the fittings shall be weighed after their delivery, and the weights so ascertained shall be used in the final settlement, provided such weighing is done by a legalized weighmaster. Bids shall be submitted and a final settlement made upon the basis of a ton of 2,000 pounds.

MANUFACTURER TO FURNISH MEN AND MATERIAL

Section 12. The manufacturer shall provide all tools, testing machines, and labor necessary for the required testing, inspection and weighing at the foundry. If specified on the order, the manufacturer shall furnish the test results and a sworn statement that all of the tests have been made as specified.

POWER OF ENGINEER TO INSPECT

Section 13. The engineer shall be at liberty at all times to inspect the material at the foundry, and the molding, casting, and coating of the fittings. All castings shall be subject to his inspection and approval, and he may reject any casting which is not in conformity with the specifications or drawings.

INSPECTOR TO REPORT

Section 14. The inspector at the foundry shall report daily to the foundry office all fittings rejected, with the causes for rejection.

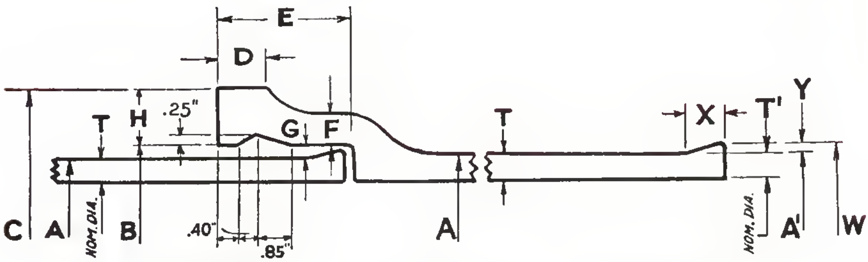
FITTINGS TO BE DELIVERED SOUND

Section 15. All the fittings must be delivered in all respects sound and conformable to these specifications. The inspection shall not relieve the manufacturer of his obligations in this respect, and any defective fittings which may have passed the engineer at the works or elsewhere shall be at all times liable to rejection when discovered, until the final completion and adjustment of the contract; provided, however, that the manufacturer shall not be held liable for fittings found to be cracked after they have been accepted at the agreed point of delivery. Care shall be taken in handling the fittings not to injure the coating, and no material of any kind shall be placed in the fittings at any time after they have been coated.

DEFINITION OF THE WORD "ENGINEER"

Section 16. Wherever the word "engineer" is used herein it shall be understood to refer to the engineer or inspector acting for the purchaser and to his properly authorized agents, limited by the particular duties intrusted to them.

Standard Dimensions of Bells and Spigots for Fittings



3" & 14" TO 60" SPIGOTS

X & Y COMMON TO ALL SIZES

4" TO 12" SPIGOTS

X = ¾" ON 4"- 6"
Y = 3/16" ON 4"-12"

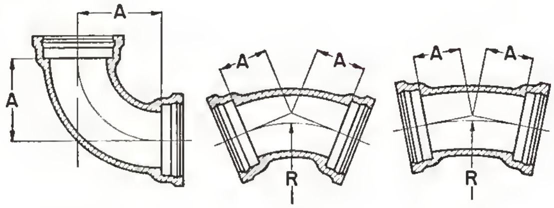
X = 1" ON 8"-60"
Y = ¼" ON 14"-60"

Size	Class	A	A1*	B	C	D	E	F	G	H	T	T1*	W
		Dimensions, Inches											
3	D	3.96		4.66	7.26	1.25	3.50	0.65	0.35	1.30	0.48		4.34
4	D	5.00	4.90	5.70	8.30	1.50	4.00	0.65	0.40	1.30	0.52	0.47	5.28
6	D	7.10	7.00	7.80	10.60	1.50	4.00	0.70	0.40	1.40	0.55	0.50	7.38
8	D	9.30	9.18	10.00	13.00	1.50	4.00	0.75	0.41	1.50	0.60	0.54	9.56
10	D	11.40	11.25	12.10	15.30	1.50	4.00	0.80	0.42	1.60	0.68	0.60	11.63
12	D	13.50	13.35	14.20	17.60	1.50	4.00	0.85	0.42	1.70	0.75	0.68	13.73
14	B	15.30		16.10	19.50	1.50	4.00	0.85	0.40	1.70	0.66		15.80
14	D	15.65		16.45	20.05	1.50	4.00	0.90	0.40	1.80	0.82		16.15
16	B	17.40		18.40	22.00	1.75	4.00	0.90	0.50	1.80	0.70		17.90
16	D	17.80		18.80	22.60	1.75	4.00	1.00	0.50	1.90	0.89		18.30
18	B	19.50		20.50	24.30	1.75	4.00	0.95	0.50	1.90	0.75		20.00
18	D	19.92		20.92	25.12	1.75	4.00	1.05	0.50	2.10	0.96		20.42
20	B	21.60		22.60	26.60	1.75	4.00	1.00	0.50	2.00	0.80		22.10
20	D	22.06		23.06	27.66	1.75	4.00	1.15	0.50	2.30	1.03		22.56
24	B	25.80		26.80	31.00	2.00	4.00	1.05	0.50	2.10	0.89		26.30
24	D	26.32		27.32	32.32	2.00	4.00	1.25	0.50	2.50	1.16		26.82
30	A	31.74		32.74	37.34	2.00	4.50	1.15	0.50	2.30	0.88		32.24
30	B	32.00		33.00	37.60	2.00	4.50	1.15	0.50	2.30	1.03		32.50
30	C	32.40		33.40	38.60	2.00	4.50	1.32	0.50	2.60	1.20		32.90
30	D	32.74		33.74	39.74	2.00	4.50	1.50	0.50	3.00	1.37		33.24
36	A	37.96		38.96	43.96	2.00	4.50	1.25	0.50	2.50	0.99		38.46
36	B	38.30		39.30	44.90	2.00	4.50	1.40	0.50	2.80	1.15		38.80
36	C	38.70		39.70	45.90	2.00	4.50	1.60	0.50	3.10	1.36		39.20
36	D	39.16		40.16	46.96	2.00	4.50	1.80	0.50	3.40	1.58		39.66
42	A	44.20		45.20	50.80	2.00	5.00	1.40	0.50	2.80	1.10		44.70
42	B	44.50		45.50	51.50	2.00	5.00	1.50	0.50	3.00	1.28		45.00
42	C	45.10		46.10	52.90	2.00	5.00	1.75	0.50	3.40	1.54		45.60
42	D	45.58		46.58	54.18	2.00	5.00	1.95	0.50	3.80	1.78		46.08
48	A	50.50		51.50	57.50	2.00	5.00	1.50	0.50	3.00	1.26		51.00
48	B	50.80		51.80	58.40	2.00	5.00	1.65	0.50	3.30	1.42		51.30
48	C	51.40		52.40	60.00	2.00	5.00	1.95	0.50	3.80	1.71		51.90
48	D	51.98		52.98	61.38	2.00	5.00	2.20	0.50	4.20	1.96		52.48
54	A	56.66		57.66	64.06	2.25	5.50	1.60	0.50	3.20	1.35		57.16
54	B	57.10		58.10	65.30	2.25	5.50	1.80	0.50	3.60	1.55		57.60
54	C	57.80		58.80	66.80	2.25	5.50	2.15	0.50	4.00	1.90		58.30
54	D	58.40		59.40	68.20	2.25	5.50	2.45	0.50	4.40	2.23		58.90
60	A	62.80		63.80	70.60	2.25	5.50	1.70	0.50	3.40	1.39		63.30
60	B	63.40		64.40	71.80	2.25	5.50	1.90	0.50	3.70	1.67		63.90
60	C	64.20		65.20	73.60	2.25	5.50	2.25	0.50	4.20	2.00		64.70
60	D	64.82		65.82	75.22	2.25	5.50	2.60	0.50	4.70	2.38		65.32

*For sizes 3" and 14"-60", A1 = A and T1 = T.

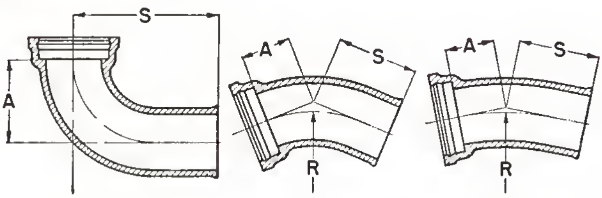
Dimensions and Weights of A.W.W.A.—N.E.W.W.A. Standard Bell and Spigot Bends

Bell and Bell Bends



90° 45° 22½°

Bell and Spigot Bends



90° 45° 22½°

Size	Class	90° Bend (¼)				45° Bend (⅛)					22½° Bend (1/16)				
		Dimensions		Weights		Dimensions			Weights		Dimensions			Weights	
		A	S	Bell and Spigot	Bell and Bell	A	S	R	Bell and Spigot	Bell and Bell	A	S	R	Bell and Spigot	Bell and Bell
3	D	16	24	65	75	9.94	15.94	24	55	65	9.55	15.55	48	55	65
4	D	16	24	90	100	9.94	15.94	24	75	90	9.55	15.55	48	75	90
6	D	16	24	135	145	9.94	15.94	24	110	125	9.55	15.55	48	110	125
8	D	16	26	200	200	9.94	15.94	24	155	180	9.55	15.55	48	155	180
10	D	16	28	285	275	9.94	15.94	24	210	240	9.55	15.55	48	210	240
12	D	16	28	365	350	9.94	15.94	24	270	305	9.55	15.55	48	270	305
14	B	18	30	410	400	14.91	20.91	36	365	400	14.32	14.32	72	315	400
14	D	18	30	495	470	14.91	20.91	36	440	475	14.32	14.32	72	380	475
16	B	24	36	590	590	14.91	20.91	36	445	500	14.32	14.32	72	385	500
16	D	24	36	740	720	14.91	20.91	36	550	605	14.32	14.32	72	480	605
18	B	24	36	705	700	14.91	20.91	36	555	590	14.32	14.32	72	460	590
18	D	24	36	895	870	14.91	20.91	36	665	730	14.32	14.32	72	580	730

Dimensions in inches.

For bell and spigot dimensions, see page 276.

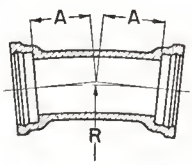
Dimensions and Weights of A.W.W.A.—N.E.W.W.A. Standard Bell and Spigot Bends

Size	Class	90° Bend (1/4)				45° Bend (1/8)					22½° Bend (1/16)				
		Dimensions		Weights		Dimensions			Weights		Dimensions			Weights	
		A	S	Bell and Spigot	Bell and Bell	A	S	R	Bell and Spigot	Bell and Bell	A	S	R	Bell and Spigot	Bell and Bell
20	B	24	36	835	825	19.88	25.88	48	755	825	19.10	19.10	96	670	825
20	D	24	36	1070	1045	19.88	25.88	48	965	1045	19.10	19.10	96	860	1045
24	B	30	42	1275	1255	24.85	30.85	60	1165	1255	23.87	23.87	120	1055	1255
24	D	30	42	1665	1625	24.85	30.85	60	1520	1625	23.87	23.87	120	1375	1625
30	A	36	48	1820	1850	24.85	30.85	60	1480	1645	23.87	23.87	120	1345	1645
30	B	36	48	2090	2075	24.85	30.85	60	1690	1830	23.87	23.87	120	1530	1830
30	C	36	48	2450	2430	24.85	30.85	60	1980	2145	23.87	23.87	120	1795	2145
30	D	36	48	2825	2820	24.85	30.85	60	2285	2490	23.87	23.87	120	2075	2490
36	A	48	60	3000	3025	37.28	37.28	90	2500	2885	35.80	35.80	180	2500	2885
36	B	48	60	3500	3525	37.28	37.28	90	2920	3360	35.80	35.80	180	2920	3360
36	C	48	60	4145	4155	37.28	37.28	90	3450	3960	35.80	35.80	180	3450	3960
36	D	48	60	4830	4835	37.28	37.28	90	4020	4605	35.80	35.80	180	4020	4605
42	A	48	60	3930	4000	37.28	37.28	90	3280	3820	35.80	35.80	180	3280	3820
42	B	48	60	4540	4585	37.28	37.28	90	3785	4370	35.80	35.80	180	3785	4370
42	C	48	60	5495	5540	37.28	37.28	90	4580	5280	35.80	35.80	180	4580	5280
42	D	48	60	6380	6415	37.28	37.28	90	5315	6115	35.80	35.80	180	5315	6115
48	A	54	66	5575	5620	37.28	37.28	90	4250	4905	35.80	35.80	180	4250	4905
48	B	54	66	6300	6355	37.28	37.28	90	4800	5545	35.80	35.80	180	4800	5545
48	C	54	66	7630	7690	37.28	37.28	90	5815	6710	35.80	35.80	180	5815	6710
48	D	54	66	8810	8890	37.28	37.28	90	6715	7755	35.80	35.80	180	6715	7755
54	A	..	..	6925	7040	37.28	37.28	90	5180	6025	35.80	35.80	180	5180	6025
54	B	..	..	7990	8130	37.28	37.28	90	5975	6960	35.80	35.80	180	5975	6960
54	C	..	..	9820	9960	37.28	37.28	90	7330	8510	35.80	35.80	180	7330	8510
54	D	..	..	11570	11725	37.28	37.28	90	8635	10020	35.80	35.80	180	8635	10020
60	A	..	..	7960	8135	37.28	37.28	90	5960	6975	35.80	35.80	180	5960	6975
60	B	..	..	9520	9645	37.28	37.28	90	7110	8245	35.80	35.80	180	7110	8245
60	C	..	..	11495	11660	37.28	37.28	90	8585	9970	35.80	35.80	180	8585	9970
60	D	..	..	13720	13905	37.28	37.28	90	10230	11870	35.80	35.80	180	10230	11870

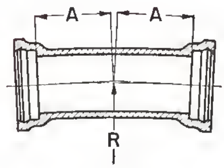
Dimensions in inches.
For bell and spigot dimensions, see page 276.

Dimensions and Weights of A.W.W.A.—N.E.W.W.A. Standard Bell and Spigot Bends

Bell and Bell Bends

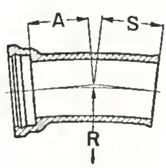


11¼°

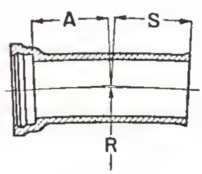


5⅝°

Bell and Spigot Bends



11¼°



5⅝°

Size	Class	11¼° Bend (1/32)					5⅝° Bend (1/64)				
		Dimensions			Weights		Dimensions			Weights	
		A	S	R	Bell and Spigot	Bell and Bell	A	S	R	Bell and Spigot	Bell and Bell
3	D	11.82	11.82	120	55	75	......	......	......	......	......
4	D	11.82	11.82	120	70	95	......	......	......	......	......
6	D	11.82	11.82	120	105	140	......	......	......	......	......
8	D	11.82	11.82	120	150	200	......	......	......	......	......
10	D	11.82	11.82	120	205	265	......	......	......	......	......
12	D	11.82	11.82	120	260	340	......	......	......	......	......
14	B	17.73	17.73	180	375	455	......	......	......	......	......
14	D	17.73	17.73	180	450	545	......	......	......	......	......
16	B	17.73	17.73	180	455	565	......	......	......	......	......
16	D	17.73	17.73	180	565	695	......	......	......	......	......

Dimensions in inches.

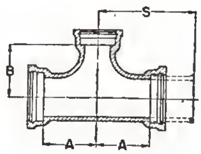
For bell and spigot dimensions, see page 276.

Dimensions and Weights of A.W.W.A.—N.E.W.W.A. Standard Bell and Spigot Bends

Size	Class	11¼° Bend (1/32)					5⅝° Bend (1/64)				
		Dimensions			Weights		Dimensions			Weights	
		A	S	R	Bell and Spigot	Bell and Bell	A	S	R	Bell and Spigot	Bell and Bell
18	B	17.73	17.73	180	540	670	......	......	.....	......	......
18	D	17.73	17.73	180	685	835	......	......	.....	......	......
20	B	23.64	23.64	240	800	955	23.58	23.58	480	800	955
20	D	23.64	23.64	240	1030	1215	23.58	23.58	480	1030	1215
24	B	23.64	23.64	240	1060	1255	23.58	23.58	480	1060	1255
24	D	23.64	23.64	240	1375	1620	23.58	23.58	480	1375	1620
30	A	23.64	23.64	240	1345	1640	23.58	23.58	480	1345	1640
30	B	23.64	23.64	240	1530	1830	23.58	23.58	480	1530	1830
30	C	23.64	23.64	240	1795	2145	23.58	23.58	480	1795	2145
30	D	23.64	23.64	240	2075	2490	23.58	23.58	480	2075	2490
36	A	23.64	23.64	240	1795	2180	23.58	23.58	480	1795	2180
36	B	23.64	23.64	240	2095	2540	23.58	23.58	480	2095	2540
36	C	23.64	23.64	240	2470	2980	23.58	23.58	480	2470	2980
36	D	23.64	23.64	240	2875	3460	23.58	23.58	480	2875	3460
42	A	23.64	23.64	240	2370	2905	23.58	23.58	480	2370	2905
42	B	23.64	23.64	240	2720	3305	23.58	23.58	480	2720	3305
42	C	23.64	23.64	240	3290	3985	23.58	23.58	480	3290	3985
42	D	23.64	23.64	240	3815	4615	23.58	23.58	480	3815	4615
48	A	23.64	23.64	240	3055	3715	23.58	23.58	480	3055	3715
48	B	23.64	23.64	240	3455	4195	23.58	23.58	480	3450	4195
48	C	23.64	23.64	240	4180	5075	23.58	23.58	480	4180	5075
48	D	23.64	23.64	240	4825	5870	23.58	23.58	480	4825	5870
54	A	23.64	23.64	240	3740	4585	23.58	23.58	480	3740	4585
54	B	23.64	23.64	240	4315	5305	23.58	23.58	480	4315	5305
54	C	23.64	23.64	240	5285	6470	23.58	23.58	480	5285	6470
54	D	23.64	23.64	240	6225	7610	23.58	23.58	480	6225	7610
60	A	23.64	23.64	240	4320	5330	23.58	23.58	480	4320	5330
60	B	23.64	23.64	240	5125	6260	23.58	23.58	480	5125	6260
60	C	23.64	23.64	240	6195	7580	23.58	23.58	480	6195	7580
60	D	23.64	23.64	240	7370	9015	23.58	23.58	480	7370	9015

Dimensions in inches.
For bell and spigot dimensions, see page 276.

Dimensions and Weights of A.W.W.A.—N.E.W.W.A. Standard Bell and Spigot Tees



Tees

Nominal Diam. Inches		Class	Dimensions Inches			Approx. Weight, Pounds	
Run	Branch		A	S	B	2 Bell	3 Bell
3	3	D	10	22	10	95	100
4	3	D	11	23	11	120	125
4	4	D	11	23	11	130	130
6	3	D	12	24	12	175	170
6	4	D	12	24	12	180	180
6	6	D	12	24	12	200	200
8	4	D	13	25	13	250	250
8	6	D	13	25	13	270	265
8	8	D	13	25	13	290	285
10	4	D	14	26	14	340	330
10	6	D	14	26	14	360	350
10	8	D	14	26	14	380	370
10	10	D	14	26	14	405	390
12	4	D	15	27	15	445	425
12	6	D	15	27	15	460	440
12	8	D	15	27	15	485	465
12	10	D	15	27	15	505	495
12	12	D	15	27	15	535	515
14	4	B	16	28	16	495	485
14	4	D	16	28	16	595	570
14	6	B	16	28	16	515	505
14	6	D	16	28	16	610	585
14	8	B	16	28	16	540	525
14	8	D	16	28	16	635	610
14	10	B	16	28	16	560	555
14	10	D	16	28	16	655	630
14	12	B	16	28	16	590	580
14	12	D	16	28	16	680	655
14	14	B	16	28	16	600	590
14	14	D	16	28	16	725	695

Dimensions in inches.
Large diameter tees furnished with ribs when requested.
For bell and spigot dimensions, see page 276.

Dimensions and Weights of A.W.W.A.—N.E.W.W.A. Standard Bell and Spigot Tees

Nominal Diam. Inches		Class	Dimensions Inches			Approx. Weight, Pounds	
Run	Branch		A	S	B	2 Bell	3 Bell
16	4	B	17	29	17	620	615
16	4	D	17	29	17	765	740
16	6	B	17	29	17	635	630
16	6	D	17	29	17	775	755
16	8	B	17	29	17	660	655
16	8	D	17	29	17	800	775
16	10	B	17	29	17	685	680
16	10	D	17	29	17	825	800
16	12	B	17	29	17	710	710
16	12	D	17	29	17	850	825
16	14	B	17	29	17	720	715
16	14	D	17	29	17	885	860
16	16	B	17	29	17	760	755
16	16	D	17	29	17	935	915
18	4	B	18	30	18	755	745
18	4	D	18	30	18	945	915
18	6	B	18	30	18	770	765
18	6	D	18	30	18	955	925
18	8	B	18	30	18	795	785
18	8	D	18	30	18	980	950
18	10	B	18	30	18	820	810
18	10	D	18	30	18	1005	975
18	12	B	18	30	18	845	835
18	12	D	18	30	18	1030	1000
18	14	B	18	30	18	850	845
18	14	D	18	30	18	1055	1025
18	16	B	18	30	18	885	880
18	16	D	18	30	18	1105	1075
18	18	B	18	30	18	925	915
18	18	D	18	30	18	1155	1125
20	4	B	19	31	19	910	900
20	4	D	19	31	19	1160	1130
20	6	B	19	31	19	930	915
20	6	D	19	31	19	1175	1145
20	8	B	19	31	19	950	940
20	8	D	19	31	19	1195	1165
20	10	B	19	31	19	970	965
20	10	D	19	31	19	1215	1185
20	12	B	19	31	19	1000	990
20	12	D	19	31	19	1240	1210

Dimensions in inches.
Large diameter tees furnished with ribs when requested.
For bell and spigot dimensions, see page 276.

Dimensions and Weights of A.W.W.A.—N.E.W.W.A. Standard Bell and Spigot Tees

Nominal Diam. Inches		Class	Dimensions Inches			Approx. Weight, Pounds	
Run	Branch		A	S	B	2 Bell	3 Bell
20	14	B	19	31	19	1010	995
20	14	D	19	31	19	1270	1240
20	16	B	19	31	19	1040	1030
20	16	D	19	31	19	1315	1290
20	18	B	19	31	19	1075	1065
20	18	D	19	31	19	1360	1330
20	20	B	19	31	19	1115	1105
20	20	D	19	31	19	1420	1390
24	6	B	21	33	21	1280	1260
24	6	D	21	33	21	1655	1615
24	8	B	21	33	21	1305	1280
24	8	D	21	33	21	1675	1630
24	10	B	21	33	21	1325	1305
24	10	D	21	33	21	1695	1650
24	12	B	21	33	21	1350	1330
24	12	D	21	33	21	1715	1675
24	14	B	21	33	21	1355	1335
24	14	D	21	33	21	1745	1700
24	16	B	21	33	21	1390	1370
24	16	D	21	33	21	1785	1745
24	18	B	21	33	21	1420	1395
24	18	D	21	33	21	1825	1780
24	20	B	21	33	21	1455	1430
24	20	D	21	33	21	1880	1835
24	24	B	21	33	21	1530	1505
24	24	D	21	33	21	1985	1945
30	6	A	13	25	24	1290	1320
30	6	B	13	25	24	1450	1430
30	6	C	13	25	24	1690	1670
30	6	D	13	25	24	1945	1935
30	8	A	14	26	24	1365	1390
30	8	B	14	26	24	1525	1505
30	8	C	14	26	24	1775	1755
30	8	D	14	26	24	2040	2030
30	10	A	15	27	24	1430	1460
30	10	B	15	27	24	1605	1585
30	10	C	15	27	24	1865	1840
30	10	D	15	27	24	2135	2125
30	12	A	15	27	24	1460	1485
30	12	B	15	27	24	1630	1610

Dimensions in inches.
Large diameter tees furnished with ribs when requested.
For bell and spigot dimensions, see page 276.

Dimensions and Weights of A.W.W.A.—N.E.W.W.A. Standard Bell and Spigot Tees

Nominal Diam. Inches		Class	Dimensions Inches			Approx. Weight, Pounds	
Run	Branch		A	S	B	2 Bell	3 Bell
30	12	C	15	27	24	1885	1865
30	12	D	15	27	24	2155	2145
30	14	A	18	30	26	1625	1650
30	14	B	18	30	26	1815	1795
30	14	C	18	30	26	2135	2110
30	14	D	18	30	26	2430	2420
30	16	A	19	31	26	1710	1735
30	16	B	19	31	26	1910	1890
30	16	C	19	31	26	2250	2225
30	16	D	19	31	26	2555	2540
30	18	A	20	34	26	1840	1815
30	18	B	20	34	26	2050	1975
30	18	C	20	34	26	2425	2335
30	18	D	20	34	26	2745	2655
30	20	A	21	36	26	1945	1905
30	20	B	21	36	26	2170	2070
30	20	C	21	36	26	2580	2455
30	20	D	21	36	26	2910	2785
30	24	A	23	38	26	2130	2080
30	24	B	23	38	26	2365	2255
30	24	C	23	38	26	2825	2700
30	24	D	23	38	26	3165	3040
30	30	A	26	43	26	2445	2355
30	30	B	26	43	26	2765	2600
30	30	C	26	43	26	3245	3055
30	30	D	26	43	26	3745	3545
36	8	A	14	26	27	1785	1805
36	8	B	14	26	27	2070	2090
36	8	C	14	26	27	2420	2430
36	8	D	14	26	27	2800	2795
36	10	A	15	27	27	1875	1895
36	10	B	15	27	27	2165	2190
36	10	C	15	27	27	2525	2535
36	10	D	15	27	27	2920	2920
36	12	A	16	28	27	1960	1985
36	12	B	16	28	27	2260	2285
36	12	C	16	28	27	2635	2645
36	12	D	16	28	27	3040	3040
36	14	A	18	30	29	2110	2130
36	14	B	18	30	29	2430	2455

Dimensions in inches.
Large diameter tees furnished with ribs when requested.
For bell and spigot dimensions, see page 276.

Dimensions and Weights of A.W.W.A.—N.E.W.W.A. Standard Bell and Spigot Tees

Nominal Diam. Inches		Class	Dimensions Inches			Approx. Weight, Pounds	
Run	Branch		A	S	B	2 Bell	3 Bell
36	14	C	18	30	29	2860	2865
36	14	D	18	30	29	3295	3295
36	16	A	19	31	29	2210	2230
36	16	B	19	31	29	2540	2560
36	16	C	19	31	29	3000	3005
36	16	D	19	31	29	3440	3440
36	18	A	20	34	29	2370	2325
36	18	B	20	34	29	2715	2665
36	18	C	20	34	29	3215	3135
36	18	D	20	34	29	3690	3585
36	20	A	21	36	29	2505	2425
36	20	B	21	36	29	2865	2775
36	20	C	21	36	29	3405	3275
36	20	D	21	36	29	3890	3730
36	24	A	23	38	29	2710	2630
36	24	B	23	38	29	3080	2990
36	24	C	23	38	29	3685	3560
36	24	D	23	38	29	4190	4030
36	30	A	26	43	29	3075	2930
36	30	B	26	43	29	3535	3370
36	30	C	26	43	29	4170	3955
36	30	D	26	43	29	4850	4585
36	36	A	29	46	29	3430	3290
36	36	B	29	46	29	3995	3825
36	36	C	29	46	29	4705	4490
36	36	D	29	46	29	5465	5200
42	12	A	16	28	30	2545	2615
42	12	B	16	28	30	2895	2935
42	12	C	16	28	30	3470	3505
42	12	D	16	28	30	3990	4030
42	14	A	18	30	32	2735	2805
42	14	B	18	30	32	3110	3150
42	14	C	18	30	32	3750	3785
42	14	D	18	30	32	4305	4345
42	16	A	19	31	32	2850	2920
42	16	B	19	31	32	3235	3280
42	16	C	19	31	32	3910	3945
42	16	D	19	31	32	4485	4520
42	18	A	20	34	32	3045	3035
42	18	B	20	34	32	3455	3400

Dimensions in inches.
Large diameter tees furnished with ribs when requested.
For bell and spigot dimensions, see page 276.

Dimensions and Weights of A.W.W.A.—N.E.W.W.A. Standard Bell and Spigot Tees

Nominal Diam. Inches		Class	Dimensions Inches			Approx. Weight, Pounds	
Run	Branch		A	S	B	2 Bell	3 Bell
42	18	C	20	34	32	4180	4100
42	18	D	20	34	32	4790	4690
42	20	A	21	36	32	3205	3150
42	20	B	21	36	32	3635	3525
42	20	C	21	36	32	4405	4265
42	20	D	21	36	32	5040	4870
42	24	A	23	38	32	3430	3380
42	24	B	23	38	32	3885	3780
42	24	C	23	38	32	4730	4595
42	24	D	23	38	32	5390	5220
42	30	A	26	43	32	3865	3730
42	30	B	26	43	32	4385	4205
42	30	C	26	43	32	5310	5050
42	30	D	26	43	32	6155	5845
42	36	A	29	46	32	4250	4115
42	36	B	29	46	32	4910	4705
42	36	C	29	46	32	5885	5630
42	36	D	29	46	32	6815	6510
42	42	A	32	49	32	4745	4610
42	42	B	32	49	32	5440	5235
42	42	C	32	49	32	6565	6310
42	42	D	32	49	32	7595	7285
48	12	A	17	29	33	3345	3395
48	12	B	17	29	33	3760	3815
48	12	C	17	29	33	4520	4585
48	12	D	17	29	33	5195	5280
48	14	A	18	30	35	3475	3520
48	14	B	18	30	35	3900	3955
48	14	C	18	30	35	4710	4775
48	14	D	18	30	35	5400	5485
48	16	A	19	31	35	3615	3660
48	16	B	19	31	35	4050	4105
48	16	C	19	31	35	4900	4960
48	16	D	19	31	35	5615	5700
48	18	A	20	34	35	3860	3795
48	18	B	20	34	35	4320	4255
48	18	C	20	34	35	5230	5145
48	18	D	20	34	35	5990	5900
48	20	A	21	36	35	4055	3935
48	20	B	21	36	35	4540	4405

Dimensions in inches.
Large diameter tees furnished with ribs when requested.
For bell and spigot dimensions, see page 276.

Dimensions and Weights of A.W.W.A.—N.E.W.W.A. Standard Bell and Spigot Tees

Nominal Diam. Inches		Class	Dimensions Inches			Approx. Weight, Pounds	
Run	Branch		A	S	B	2 Bell	3 Bell
48	20	C	21	36	35	5500	5335
48	20	D	21	36	35	6285	6110
48	24	A	23	38	35	4330	4210
48	24	B	23	38	35	4830	4700
48	24	C	23	38	35	5875	5720
48	24	D	23	38	35	6700	6520
48	30	A	26	43	35	4845	4620
48	30	B	26	43	35	5445	5190
48	30	C	26	43	35	6560	6250
48	30	D	26	43	35	7580	7230
48	36	A	29	46	35	5280	5055
48	36	B	29	46	35	5995	5735
48	36	C	29	46	35	7210	6900
48	36	D	29	46	35	8320	7975
48	42	A	32	49	35	5815	5590
48	42	B	32	49	35	6565	6305
48	42	C	32	49	35	7925	7620
48	42	D	32	49	35	9150	8800
48	48	A	35	52	35	6390	6165
48	48	B	35	52	35	7220	6965
48	48	C	35	52	35	8720	8410
48	48	D	35	52	35	10065	9715
54	20	A	28	46	38.5	6015	5745
54	20	B	28	46	38.5	6885	6585
54	20	C	28	46	38.5	8460	8050
54	20	D	28	46	38.5	9885	9395
54	24	A	30	48	40	6365	6095
54	24	B	30	48	40	7275	6970
54	24	C	30	48	40	8945	8535
54	24	D	30	48	40	10420	9925
54	30	A	33	51	40	6835	6565
54	30	B	33	51	40	7845	7540
54	30	C	33	51	40	9585	9175
54	30	D	33	51	40	11270	10775
54	36	A	36	54	42	7390	7120
54	36	B	36	54	42	8550	8250
54	36	C	36	54	42	10425	10015
54	36	D	36	54	42	12245	11755
54	42	A	39	57	42	8020	7755
54	42	B	39	57	42	9120	8920
54	42	C	39	57	42	11275	10865

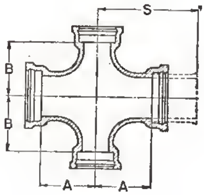
Dimensions in inches.
Large diameter tees furnished with ribs when requested.
For bell and spigot dimensions, see page 276.

Dimensions and Weights of A.W.W.A.—N.E.W.W.A. Standard Bell and Spigot Tees

Nominal Diam. Inches		Class	Dimensions Inches			Approx. Weight, Pounds	
Run	Branch		A	S	B	2 Bell	3 Bell
54	42	D	39	57	42	13230	12735
54	48	A	42	60	45	8840	8570
54	48	B	42	60	45	10140	9840
54	48	C	42	60	45	12430	12020
54	48	D	42	60	45	14535	14040
54	54	A	45	63	45	9600	9330
54	54	B	45	63	45	11070	10780
54	54	C	45	63	45	13565	13160
54	54	D	45	63	45	15955	15460
60	20	A	28	46	42	6915	6650
60	20	B	28	46	42	8160	7750
60	20	C	28	46	42	9875	9390
60	20	D	28	46	42	11685	11100
60	24	A	30	48	44	7315	7040
60	24	B	30	48	44	8600	8195
60	24	C	30	48	44	10425	9940
60	24	D	30	48	44	12290	11710
60	30	A	33	51	44	7845	7575
60	30	B	33	51	44	9265	8850
60	30	C	33	51	44	11160	10680
60	30	D	33	51	44	13265	12675
60	36	A	36	54	44	8385	8120
60	36	B	36	54	44	9980	9570
60	36	C	36	54	44	12000	11515
60	36	D	36	54	44	14260	13670
60	42	A	39	57	48	9205	8940
60	42	B	39	57	48	10900	10490
60	42	C	39	57	48	13145	12660
60	42	D	39	57	48	15595	15000
60	48	A	42	60	48	9935	9670
60	48	B	42	60	48	11730	11320
60	48	C	42	60	48	14150	13665
60	48	D	42	60	48	16770	16175
60	54	A	45	63	48	10720	10455
60	54	B	45	63	48	12695	12285
60	54	C	45	63	48	15345	14860
60	54	D	45	63	48	18230	17640
60	60	A	48	66	48	11455	11190
60	60	B	48	66	48	13625	13210
60	60	C	48	66	48	16420	15940
60	60	D	48	66	48	19575	18980

Dimensions in inches.
Large diameter tees furnished with ribs when requested.
For bell and spigot dimensions, see page 276.

Dimensions and Weights of A.W.W.A.—N.E.W.W.A. Standard Bell and Spigot Crosses



Crosses

Nominal Diam. Inches		Class	Dimensions Inches			Approx. Weight, Pounds	
Run	Branch		A	S	B	3 Bell	4 Bell
3	3	D	10	22	10	125	130
4	3	D	11	23	11	150	155
4	4	D	11	23	11	170	170
6	3	D	12	24	12	205	200
6	4	D	12	24	12	220	220
6	6	D	12	24	12	260	255
8	4	D	13	25	13	290	290
8	6	D	13	25	13	325	325
8	8	D	13	25	13	370	370
10	4	D	14	26	14	380	370
10	6	D	14	26	14	415	405
10	8	D	14	26	14	455	445
10	10	D	14	26	14	505	495
12	4	D	15	27	15	485	465
12	6	D	15	27	15	515	495
12	8	D	15	27	15	560	540
12	10	D	15	27	15	610	590
12	12	D	15	27	15	665	645
14	4	B	16	28	16	535	525
14	4	D	16	28	16	635	610
14	6	B	16	28	16	570	560
14	6	D	16	28	16	665	640
14	8	B	16	28	16	620	610
14	8	D	16	28	16	710	685
14	10	B	16	28	16	670	660
14	10	D	16	28	16	760	730
14	12	B	16	28	16	730	720
14	12	D	16	28	16	810	785
14	14	B	16	28	16	745	740
14	14	D	16	28	16	890	860

Dimensions in inches.
Large diameter crosses furnished with ribs when requested.
For bell and spigot dimensions, see page 276.

Dimensions and Weights of A.W.W.A.—N.E.W.W.A. Standard Bell and Spigot Crosses

Nominal Diam. Inches		Class	Dimensions Inches			Approx. Weight, Pounds	
Run	Branch		A	S	B	3 Bell	4 Bell
16	4	B	17	29	17	660	655
16	4	D	17	29	17	800	780
16	6	B	17	29	17	690	690
16	6	D	17	29	17	830	805
16	8	B	17	29	17	740	735
16	8	D	17	29	17	875	855
16	10	B	17	29	17	790	785
16	10	D	17	29	17	925	900
16	12	B	17	29	17	845	840
16	12	D	17	29	17	975	950
16	14	B	17	29	17	860	860
16	14	D	17	29	17	1045	1020
16	16	B	17	29	17	940	940
16	16	D	17	29	17	1150	1125
18	4	B	18	30	18	795	785
18	4	D	18	30	18	985	955
18	6	B	18	30	18	830	820
18	6	D	18	30	18	1010	980
18	8	B	18	30	18	870	865
18	8	D	18	30	18	1055	1025
18	10	B	18	30	18	920	915
18	10	D	18	30	18	1100	1070
18	12	B	18	30	18	975	965
18	12	D	18	30	18	1150	1125
18	14	B	18	30	18	990	985
18	14	D	18	30	18	1210	1180
18	16	B	18	30	18	1060	1050
18	16	D	18	30	18	1305	1275
18	18	B	18	30	18	1135	1130
18	18	D	18	30	18	1405	1375
20	4	B	19	31	19	950	940
20	4	D	19	31	19	1195	1170
20	6	B	19	31	19	985	975
20	6	D	19	31	19	1225	1200
20	8	B	19	31	19	1030	1020
20	8	D	19	31	19	1265	1240
20	10	B	19	31	19	1075	1065
20	10	D	19	31	19	1310	1280
20	12	B	19	31	19	1125	1115
20	12	D	19	31	19	1355	1330

Dimensions in inches.
Large diameter crosses furnished with ribs when requested.
For bell and spigot dimensions, see page 276.

Dimensions and Weights of A.W.W.A.—N.E.W.W.A. Standard Bell and Spigot Crosses

Nominal Diam. Inches		Class	Dimensions Inches			Approx. Weight, Pounds	
Run	Branch		A	S	B	3 Bell	4 Bell
20	14	B	19	31	19	1145	1130
20	14	D	19	31	19	1420	1390
20	16	B	19	31	19	1215	1200
20	16	D	19	31	19	1515	1485
20	18	B	19	31	19	1280	1265
20	18	D	19	31	19	1600	1570
20	20	B	19	31	19	1360	1350
20	20	D	19	31	19	1720	1690
24	6	B	21	33	21	1335	1315
24	6	D	21	33	21	1705	1665
24	8	B	21	33	21	1380	1355
24	8	D	21	33	21	1745	1705
24	10	B	21	33	21	1430	1410
24	10	D	21	33	21	1785	1745
24	12	B	21	33	21	1475	1450
24	12	D	21	33	21	1825	1785
24	14	B	21	33	21	1485	1460
24	14	D	21	33	21	1885	1845
24	16	B	21	33	21	1550	1530
24	16	D	21	33	21	1975	1930
24	18	B	21	33	21	1610	1585
24	18	D	21	33	21	2045	2005
24	20	B	21	33	21	1685	1660
24	20	D	21	33	21	2155	2110
24	24	B	21	33	21	1840	1815
24	24	D	21	33	21	2370	2325
30	6	A	13	25	24	1350	1375
30	6	B	13	25	24	1505	1485
30	6	C	13	25	24	1745	1725
30	6	D	13	25	24	1995	1985
30	8	A	14	26	24	1445	1470
30	8	B	14	26	24	1600	1580
30	8	C	14	26	24	1850	1830
30	8	D	14	26	24	2110	2100
30	10	A	15	27	24	1535	1560
30	10	B	15	27	24	1705	1685
30	10	C	15	27	24	1955	1935
30	10	D	15	27	24	2220	2210
30	12	A	15	27	24	1585	1615
30	12	B	15	27	24	1750	1730

Dimensions in inches.
Large diameter crosses furnished with ribs when requested.
For bell and spigot dimensions, see page 276.

Dimensions and Weights of A.W.W.A.—N.E.W.W.A. Standard Bell and Spigot Crosses

Nominal Diam. Inches		Class	Dimensions Inches			Approx. Weight, Pounds	
Run	Branch		A	S	B	3 Bell	4 Bell
30	12	C	15	27	24	2000	1975
30	12	D	15	27	24	2260	2250
30	14	A	18	30	26	1775	1800
30	14	B	18	30	26	1960	1940
30	14	C	18	30	26	2300	2280
30	14	D	18	30	26	2590	2575
30	16	A	19	31	26	1895	1920
30	16	B	19	31	26	2085	2065
30	16	C	19	31	26	2460	2435
30	16	D	19	31	26	2755	2745
30	18	A	20	34	26	2060	2035
30	18	B	20	34	26	2260	2185
30	18	C	20	34	26	2680	2590
30	18	D	20	34	26	2990	2900
30	20	A	21	36	26	2205	2160
30	20	B	21	36	26	2420	2315
30	20	C	21	36	26	2890	2770
30	20	D	21	36	26	3205	3075
30	24	A	23	38	26	2470	2425
30	24	B	23	38	26	2680	2575
30	24	C	23	38	26	3250	3130
30	24	D	23	38	26	3560	3435
30	30	A	26	43	26	2920	2825
30	30	B	26	43	26	3260	3100
30	30	C	26	43	26	3825	3635
30	30	D	26	43	26	4425	4225
36	8	A	14	26	27	1865	1885
36	8	B	14	26	27	2140	2165
36	8	C	14	26	27	2490	2500
36	8	D	14	26	27	2865	2865
36	10	A	15	27	27	1970	1990
36	10	B	15	27	27	2255	2280
36	10	C	15	27	27	2615	2625
36	10	D	15	27	27	3000	3000
36	12	A	16	28	27	2085	2105
36	12	B	16	28	27	2375	2400
36	12	C	16	28	27	2745	2755
36	12	D	16	28	27	3140	3140
36	14	A	18	30	29	2255	2275
36	14	B	18	30	29	2565	2590

Dimensions in inches.
Large diameter crosses furnished with ribs when requested.
For bell and spigot dimensions, see page 276.

Dimensions and Weights of A.W.W.A.—N.E.W.W.A. Standard Bell and Spigot Crosses

Nominal Diam. Inches		Class	Dimensions Inches			Approx. Weight, Pounds	
Run	Branch		A	S	B	3 Bell	4 Bell
36	14	C	18	30	29	3020	3025
36	14	D	18	30	29	3435	3435
36	16	A	19	31	29	2390	2410
36	16	B	19	31	29	2705	2730
36	16	C	19	31	29	3195	3205
36	16	D	19	31	29	3625	3625
36	18	A	20	34	29	2580	2535
36	18	B	20	34	29	2915	2860
36	18	C	20	34	29	3455	3375
36	18	D	20	34	29	3920	3810
36	20	A	21	36	29	2750	2670
36	20	B	21	36	29	3095	3000
36	20	C	21	36	29	3695	3565
36	20	D	21	36	29	4160	4000
36	24	A	23	38	29	3025	2950
36	24	B	23	38	29	3375	3285
36	24	C	23	38	29	4080	3950
36	24	D	23	38	29	4545	4385
36	30	A	26	43	29	3500	3360
36	30	B	26	43	29	3980	3815
36	30	C	26	43	29	4685	4470
36	30	D	26	43	29	5445	5180
36	36	A	29	46	29	4020	3875
36	36	B	29	46	29	4675	4510
36	36	C	29	46	29	5490	5275
36	36	D	29	46	29	6365	6100
42	12	A	16	28	30	2660	2735
42	12	B	16	28	30	3005	3045
42	12	C	16	28	30	3565	3605
42	12	D	16	28	30	4080	4120
42	14	A	18	30	32	2870	2945
42	14	B	18	30	32	3235	3275
42	14	C	18	30	32	3895	3930
42	14	D	18	30	32	4440	4475
42	16	A	19	31	32	3020	3090
42	16	B	19	31	32	3395	3435
42	16	C	19	31	32	4095	4135
42	16	D	19	31	32	4650	4690
42	18	A	20	34	32	3245	3230
42	18	B	20	34	32	3640	3580

Dimensions in inches.
Large diameter crosses furnished with ribs when requested.
For bell and spigot dimensions, see page 276.

Dimensions and Weights of A.W.W.A.—N.E.W.W.A. Standard Bell and Spigot Crosses

Nominal Diam. Inches		Class	Dimensions Inches			Approx. Weight, Pounds	
Run	Branch		A	S	B	3 Bell	4 Bell
42	18	C	20	34	32	4405	4325
42	18	D	20	34	32	4990	4890
42	20	A	21	36	32	3435	3380
42	20	B	21	36	32	3850	3740
42	20	C	21	36	32	4675	4535
42	20	D	21	36	32	5280	5110
42	24	A	23	38	32	3725	3675
42	24	B	23	38	32	4160	4050
42	24	C	23	38	32	5090	4950
42	24	D	23	38	32	5705	5535
42	30	A	26	43	32	4260	4120
42	30	B	26	43	32	4785	4605
42	30	C	26	43	32	5770	5510
42	30	D	26	43	32	6685	6375
42	36	A	29	46	32	4780	4645
42	36	B	29	46	32	5520	5315
42	36	C	29	46	32	6575	6315
42	36	D	29	46	32	7600	7295
42	42	A	32	49	32	5515	5380
42	42	B	32	49	32	6290	6085
42	42	C	32	49	32	7570	7315
42	42	D	32	49	32	8740	8430
48	12	A	17	29	33	3455	3505
48	12	B	17	29	33	3865	3920
48	12	C	17	29	33	4610	4675
48	12	D	17	29	33	5275	5355
48	14	A	18	30	35	3600	3650
48	14	B	18	30	35	4020	4075
48	14	C	18	30	35	4845	4905
48	14	D	18	30	35	5525	5610
48	16	A	19	31	35	3775	3820
48	16	B	19	31	35	4200	4255
48	16	C	19	31	35	5070	5135
48	16	D	19	31	35	5770	5855
48	18	A	20	34	35	4040	3980
48	18	B	20	34	35	4490	4420
48	18	C	20	34	35	5435	5350
48	18	D	20	34	35	6170	6085
48	20	A	21	36	35	4265	4145
48	20	B	21	36	35	4735	4605

Dimensions in inches.
Large diameter crosses furnished with ribs when requested.
For bell and spigot dimensions, see page 276.

Dimensions and Weights of A.W.W.A.—N.E.W.W.A. Standard Bell and Spigot Crosses

Nominal Diam. Inches		Class	Dimensions Inches			Approx. Weight, Pounds	
Run	Branch		A	S	B	3 Bell	4 Bell
48	20	C	21	36	35	5745	5585
48	20	D	21	36	35	6505	6330
48	24	A	23	38	35	4595	4475
48	24	B	23	38	35	5080	4945
48	24	C	23	38	35	6205	6045
48	24	D	23	38	35	6985	6805
48	30	A	26	43	35	5195	4965
48	30	B	26	43	35	5810	5555
48	30	C	26	43	35	6970	6660
48	30	D	26	43	35	8055	7705
48	36	A	29	46	35	5740	5515
48	36	B	29	46	35	6535	6275
48	36	C	29	46	35	7815	7510
48	36	D	29	46	35	9020	8675
48	42	A	32	49	35	6480	6250
48	42	B	32	49	35	7305	7050
48	42	C	32	49	35	8805	8490
48	42	D	32	49	35	10150	9800
48	48	A	35	52	35	7300	7075
48	48	B	35	52	35	8235	7980
48	48	C	35	52	35	9945	9630
48	48	D	35	52	35	11465	11115
54	20	A	28	46	38.5	6225	5955
54	20	B	28	46	38.5	7075	6775
54	20	C	28	46	38.5	8695	8285
54	20	D	28	46	38.5	10085	9595
54	24	A	30	48	40	6655	6390
54	24	B	30	48	40	7540	7230
54	24	C	30	48	40	9280	8875
54	24	D	30	48	40	10715	10225
54	30	A	33	51	40	7205	6930
54	30	B	33	51	40	8230	7925
54	30	C	33	51	40	10005	9600
54	30	D	33	51	40	11750	11255
54	36	A	36	54	42	7920	7650
54	36	B	36	54	42	9190	8890
54	36	C	36	54	42	11125	10720
54	36	D	36	54	42	13040	12545
54	42	A	39	57	42	8795	8525
54	42	B	39	57	42	10075	9770
54	42	C	39	57	42	12270	11860

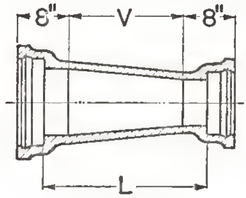
Dimensions in inches.
Large diameter crosses furnished with ribs when requested.
For bell and spigot dimensions, see page 276.

Dimensions and Weights of A.W.W.A.—N.E.W.W.A. Standard Bell and Spigot Crosses

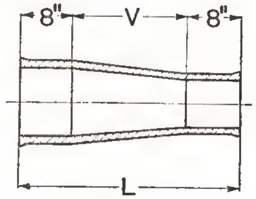
Nominal Diam. Inches		Class	Dimensions Inches			Approx. Weight, Pounds	
Run	Branch		A	S	B	3 Bell	4 Bell
54	42	D	39	57	42	14345	13850
54	48	A	42	60	45	10030	9760
54	48	B	42	60	45	11450	11155
54	48	C	42	60	45	13960	13550
54	48	D	42	60	45	16290	15795
54	54	A	45	63	45	11155	10885
54	54	B	45	63	45	12860	12560
54	54	C	45	63	45	15735	15315
54	54	D	45	63	45	18465	17970
60	20	A	28	46	42	7130	6865
60	20	B	28	46	42	8345	7940
60	20	C	28	46	42	10145	9635
60	20	D	28	46	42	11890	11300
60	24	A	30	48	44	7615	7350
60	24	B	30	48	44	8870	8460
60	24	C	30	48	44	10770	10290
60	24	D	30	48	44	12590	12000
60	30	A	33	51	44	8225	7955
60	30	B	33	51	44	9650	9235
60	30	C	33	51	44	11585	11100
60	30	D	33	51	44	13735	13145
60	36	A	36	54	44	8880	8615
60	36	B	36	54	44	10530	10120
60	36	C	36	54	44	12610	12130
60	36	D	36	54	44	14935	14340
60	42	A	39	57	48	10065	9800
60	42	B	39	57	48	11825	11415
60	42	C	39	57	48	14235	13755
60	42	D	39	57	48	16815	16220
60	48	A	42	60	48	11075	10810
60	48	B	42	60	48	12935	12530
60	48	C	42	60	48	15595	15110
60	48	D	42	60	48	18375	17785
60	54	A	45	63	48	12190	11930
60	54	B	45	63	48	14325	13915
60	54	C	45	63	48	17320	16840
60	54	D	45	63	48	20520	19925
60	60	A	48	66	48	13210	12945
60	60	B	48	66	48	15630	15220
60	60	C	48	66	48	18815	18335
60	60	D	48	66	48	22410	21815

Dimensions in inches.
Large diameter crosses furnished with ribs when requested.
For bell and spigot dimensions, see page 276.

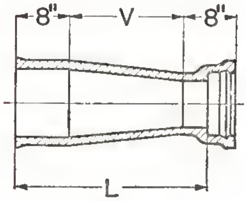
Dimensions and Weights of A.W.W.A.—N.E.W.W.A. Standard Bell and Spigot Reducers



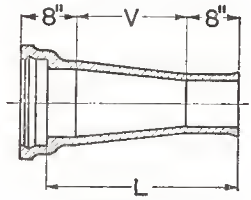
Bell & Bell



Spigot & Spigot



Small End Bell



Large End Bell

			Laying Length (L)				Weight			
Size	Class	V	Bell & Bell	Large End Bell	Small End Bell	Spigot & Spigot	Bell & Bell	Large End Bell	Small End Bell	Spigot & Spigot
4x 3	D	8	16.5	20.0	20.5	24	70	55	55	40
6x 3	D	18	26.5	30.0	30.5	34	110	95	85	70
6x 4	D	18	26.0	30.0	30.0	34	125	105	100	80
8x 4	D	18	26.0	30.0	30.0	34	155	135	120	100
8x 6	D	18	26.0	30.0	30.0	34	180	155	145	120
10x 4	D	18	26.0	30.0	30.0	34	185	170	145	130
10x 6	D	18	26.0	30.0	30.0	34	210	190	170	145
10x 8	D	18	26.0	30.0	30.0	34	245	210	205	170
12x 4	D	18	26.0	30.0	30.0	34	225	205	175	155
12x 6	D	18	26.0	30.0	30.0	34	250	225	200	175
12x 8	D	18	26.0	30.0	30.0	34	280	245	230	200
12x10	D	18	26.0	30.0	30.0	34	315	275	270	230
14x 6	B	20	28.0	32.0	32.0	36	270	250	220	195
14x 6	D	20	28.0	32.0	32.0	36	305	280	250	225
14x 8	B	20	28.0	32.0	32.0	36	305	270	250	220
14x 8	D	20	28.0	32.0	32.0	36	340	305	285	250
14x10	B	20	28.0	32.0	32.0	36	345	305	290	250
14x10	D	20	28.0	32.0	32.0	36	380	340	325	285
14x12	B	20	28.0	32.0	32.0	36	385	335	330	280
14x12	D	20	28.0	32.0	32.0	36	420	370	365	320
16x 6	B	20	28.0	32.0	32.0	36	320	295	245	220
16x 6	D	20	28.0	32.0	32.0	36	365	340	290	265
16x 8	B	20	28.0	32.0	32.0	36	355	320	280	250

Dimensions in inches.
For bell and spigot dimensions, see page 276.

Dimensions and Weights of A.W.W.A.—N.E.W.W.A. Standard Bell and Spigot Reducers

Size	Class	V	Laying Length (L)				Weight			
			Bell & Bell	Large End Bell	Small End Bell	Spigot & Spigot	Bell & Bell	Large End Bell	Small End Bell	Spigot & Spigot
16x 8	D	20	28.0	32.0	32.0	36	400	370	325	290
16x10	B	20	28.0	32.0	32.0	36	395	350	320	280
16x10	D	20	28.0	32.0	32.0	36	440	400	365	325
16x12	B	20	28.0	32.0	32.0	36	435	385	360	310
16x12	D	20	28.0	32.0	32.0	36	485	435	405	360
16x14	B	20	28.0	32.0	32.0	36	445	390	370	320
16x14	D	20	28.0	32.0	32.0	36	535	480	460	405
18x 8	B	20	28.0	32.0	32.0	36	400	365	315	280
18x 8	D	20	28.0	32.0	32.0	36	460	430	370	335
18x10	B	20	28.0	32.0	32.0	36	440	395	355	310
18x10	D	20	28.0	32.0	32.0	36	500	460	410	370
18x12	B	20	28.0	32.0	32.0	36	480	430	395	345
18x12	D	20	28.0	32.0	32.0	36	545	495	450	405
18x14	B	20	28.0	32.0	32.0	36	490	435	405	350
18x14	D	20	28.0	32.0	32.0	36	595	540	505	450
18x16	B	20	28.0	32.0	32.0	36	540	470	455	385
18x16	D	20	28.0	32.0	32.0	36	660	585	570	495
20x10	B	26	34.0	38.0	38.0	42	545	505	445	405
20x10	D	26	34.0	38.0	38.0	42	640	600	525	485
20x12	B	26	34.0	38.0	38.0	42	595	545	495	450
20x12	D	26	34.0	38.0	38.0	42	690	645	575	525
20x14	B	26	34.0	38.0	38.0	42	605	550	505	455
20x14	D	26	34.0	38.0	38.0	42	750	695	635	580
20x16	B	26	34.0	38.0	38.0	42	660	590	565	490
20x16	D	26	34.0	38.0	38.0	42	825	750	710	630
20x18	B	26	34.0	38.0	38.0	42	715	630	615	530
20x18	D	26	34.0	38.0	38.0	42	895	805	780	690
24x14	B	26	34.0	38.0	38.0	42	720	665	595	545
24x14	D	26	34.0	38.0	38.0	42	910	855	755	700
24x16	B	26	34.0	38.0	38.0	42	780	705	655	580
24x16	D	26	34.0	38.0	38.0	42	985	910	835	755
24x18	B	26	34.0	38.0	38.0	42	830	745	710	625
24x18	D	26	34.0	38.0	38.0	42	1,060	965	905	815
24x20	B	26	34.0	38.0	38.0	42	895	795	770	670
24x20	D	26	34.0	38.0	38.0	42	1,145	1,030	990	875
30x18	A	26	33.5	37.5	38.0	42	985	900	790	710
30x18	B	26	33.5	37.5	38.0	42	1,045	960	865	780
30x18	C	26	33.5	37.5	38.0	42	1,250	1,160	1,045	950
30x18	D	26	33.5	37.5	38.0	42	1,385	1,290	1,130	1,040
30x20	Short A	26	33.5	37.5	38.0	42	1,045	945	855	755
30x20	Short B	26	33.5	37.5	38.0	42	1,105	1,010	930	830
30x20	Short C	26	33.5	37.5	38.0	42	1,340	1,225	1,130	1,015
30x20	Short D	26	33.5	37.5	38.0	42	1,475	1,355	1,220	1,105

Dimensions in inches.

For bell and spigot dimensions, see page 276.

Dimensions and Weights of A.W.W.A.—N.E.W.W.A. Standard Bell and Spigot Reducers

Size	Class	V	Laying Length (L)				Weight			
			Bell & Bell	Large End Bell	Small End Bell	Spigot & Spigot	Bell & Bell	Large End Bell	Small End Bell	Spigot & Spigot
30x20	Long A	66	73.5	77.5	78.0	82	1,755	1,660	1,565	1,465
30x20	Long B	66	73.5	77.5	78.0	82	1,885	1,790	1,710	1,610
30x20	Long C	66	73.5	77.5	78.0	82	2,295	2,180	2,085	1,970
30x20	Long D	66	73.5	77.5	78.0	82	2,510	2,395	2,255	2,140
30x24	Short A	26	33.5	37.5	38.0	42	1,170	1,045	975	855
30x24	Short B	26	33.5	37.5	38.0	42	1,230	1,110	1,055	930
30x24	Short C	26	33.5	37.5	38.0	42	1,510	1,360	1,300	1,150
30x24	Short D	26	33.5	37.5	38.0	42	1,645	1,495	1,390	1,240
30x24	Long A	66	73.5	77.5	78.0	82	1,975	1,850	1,785	1,660
30x24	Long B	66	73.5	77.5	78.0	82	2,110	1,985	1,935	1,810
30x24	Long C	66	73.5	77.5	78.0	82	2,595	2,445	2,390	2,235
30x24	Long D	66	73.5	77.5	78.0	82	2,820	2,665	2,565	2,410
36x20	Short A	32	39.5	43.5	44.0	48	1,380	1,280	1,135	1,040
36x20	Short B	32	39.5	43.5	44.0	48	1,530	1,430	1,245	1,145
36x20	Short C	32	39.5	43.5	44.0	48	1,840	1,725	1,520	1,405
36x20	Short D	32	39.5	43.5	44.0	48	2,035	1,920	1,670	1,555
36x20	Long A	66	73.5	77.5	78.0	82	2,105	2,005	1,860	1,765
36x20	Long B	66	73.5	77.5	78.0	82	2,325	2,230	2,045	1,945
36x20	Long C	66	73.5	77.5	78.0	82	2,820	2,705	2,500	2,385
36x20	Long D	66	73.5	77.5	78.0	82	3,120	3,005	2,755	2,640
36x24	Short A	32	39.5	43.5	44.0	48	1,520	1,400	1,280	1,155
36x24	Short B	32	39.5	43.5	44.0	48	1,675	1,550	1,390	1,265
36x24	Short C	32	39.5	43.5	44.0	48	2,040	1,885	1,715	1,565
36x24	Short D	32	39.5	43.5	44.0	48	2,235	2,085	1,875	1,720
36x24	Long A	66	73.5	77.5	78.0	82	2,335	2,210	2,090	1,965
36x24	Long B	66	73.5	77.5	78.0	82	2,560	2,435	2,275	2,155
36x24	Long C	66	73.5	77.5	78.0	82	3,135	2,985	2,815	2,665
36x24	Long D	66	73.5	77.5	78.0	82	3,440	3,290	3,080	2,930
36x30	Short A	32	39.0	43.5	43.5	48	1,690	1,500	1,450	1,255
36x30	Short B	32	39.0	43.5	43.5	48	1,930	1,755	1,645	1,470
36x30	Short C	32	39.0	43.5	43.5	48	2,265	2,055	1,945	1,735
36x30	Short D	32	39.0	43.5	43.5	48	2,630	2,375	2,265	2,010
36x30	Long A	66	73.0	77.5	77.5	82	2,575	2,380	2,330	2,140
36x30	Long B	66	73.0	77.5	77.5	82	2,960	2,785	2,680	2,500
36x30	Long C	66	73.0	77.5	77.5	82	3,485	3,275	3,165	2,955
36x30	Long D	66	73.0	77.5	77.5	82	4,040	3,790	3,680	3,425
42x20	Short A	32	39.0	43.0	44.0	48	1,675	1,575	1,335	1,235
42x20	Short B	32	39.0	43.0	44.0	48	1,825	1,725	1,470	1,375
42x20	Short C	32	39.0	43.0	44.0	48	2,235	2,120	1,815	1,700
42x20	Short D	32	39.0	43.0	44.0	48	2,485	2,370	2,005	1,890
42x20	Long A	66	73.0	77.0	78.0	82	2,530	2,430	2,190	2,095
42x20	Long B	66	73.0	77.0	78.0	82	2,775	2,675	2,420	2,325
42x20	Long C	66	73.0	77.0	78.0	82	3,415	3,300	2,990	2,875
42x20	Long D	66	73.0	77.0	78.0	82	3,785	3,670	3,305	3,190
42x24	Short A	32	39.0	43.0	44.0	48	1,820	1,695	1,480	1,355

Dimensions in inches.

For bell and spigot dimensions, see page 276.

Dimensions and Weights of A.W.W.A.—N.E.W.W.A. Standard Bell and Spigot Reducers

Size	Class	V	Laying Length (L)				Weight			
			Bell & Bell	Large End Bell	Small End Bell	Spigot & Spigot	Bell & Bell	Large End Bell	Small End Bell	Spigot & Spigot
42x24	Short B	32	39.0	43.0	44.0	48	1,975	1,850	1,620	1,495
42x24	Short C	32	39.0	43.0	44.0	48	2,440	2,290	2,015	1,865
42x24	Short D	32	39.0	43.0	44.0	48	2,690	2,540	2,210	2,060
42x24	Long A	66	73.0	77.0	78.0	82	2,770	2,645	2,430	2,305
42x24	Long B	66	73.0	77.0	78.0	82	3,020	2,895	2,665	2,540
42x24	Long C	66	73.0	77.0	78.0	82	3,745	3,590	3,320	3,170
42x24	Long D	66	73.0	77.0	78.0	82	4,125	3,975	3,645	3,495
42x30	Short A	32	38.5	43.0	43.5	48	1,990	1,800	1,650	1,460
42x30	Short B	32	38.5	43.0	43.5	48	2,235	2,060	1,885	1,705
42x30	Short C	32	38.5	43.0	43.5	48	2,670	2,465	2,250	2,040
42x30	Short D	32	38.5	43.0	43.5	48	3,095	2,840	2,615	2,360
42x30	Long A	66	72.5	77.0	77.5	82	3,015	2,820	2,675	2,480
42x30	Long B	66	72.5	77.0	77.5	82	3,435	3,255	3,080	2,905
42x30	Long C	66	72.5	77.0	77.5	82	4,105	3,895	3,680	3,475
42x30	Long D	66	72.5	77.0	77.5	82	4,750	4,495	4,270	4,015
42x36	Short A	32	38.5	43.0	43.5	48	2,240	1,995	1,900	1,655
42x36	Short B	32	38.5	43.0	43.5	48	2,570	2,285	2,215	1,930
42x36	Short C	32	38.5	43.0	43.5	48	3,060	2,740	2,635	2,315
42x36	Short D	32	38.5	43.0	43.5	48	3,540	3,180	3,060	2,700
42x36	Long A	66	72.5	77.0	77.5	82	3,400	3,155	3,060	2,820
42x36	Long B	66	72.5	77.0	77.5	82	3,925	3,640	3,570	3,285
42x36	Long C	66	72.5	77.0	77.5	82	4,690	4,370	4,270	3,945
42x36	Long D	66	72.5	77.0	77.5	82	5,445	5,080	4,960	4,600
48x30	Short A	66	72.5	77.0	77.5	82	3,525	3,335	3,125	2,935
48x30	Short B	66	72.5	77.0	77.5	82	3,990	3,815	3,540	3,360
48x30	Short C	66	72.5	77.0	77.5	82	4,780	4,570	4,235	4,025
48x30	Short D	66	72.5	77.0	77.5	82	5,530	5,275	4,890	4,635
48x30	Long A	132	138.5	143.0	143.5	148	5,870	5,675	5,470	5,275
48x30	Long B	132	138.5	143.0	143.5	148	6,675	6,500	6,225	6,050
48x30	Long C	132	138.5	143.0	143.5	148	7,995	7,785	7,450	7,240
48x30	Long D	132	138.5	143.0	143.5	148	9,230	8,975	8,590	8,335
48x36	Short A	66	72.5	77.0	77.5	82	3,930	3,685	3,530	3,285
48x36	Short B	66	72.5	77.0	77.5	82	4,495	4,215	4,045	3,760
48x36	Short C	66	72.5	77.0	77.5	82	5,385	5,065	4,840	4,520
48x36	Short D	66	72.5	77.0	77.5	82	6,245	5,880	5,605	5,240
48x36	Long A	132	138.5	143.0	143.5	148	6,560	6,315	6,155	5,915
48x36	Long B	132	138.5	143.0	143.5	148	7,510	7,225	7,055	6,770
48x36	Long C	132	138.5	143.0	143.5	148	9,005	8,685	8,460	8,140
48x36	Long D	132	138.5	143.0	143.5	148	10,445	10,080	9,805	9,440
48x42	Short A	66	72.0	77.0	77.0	82	4,410	4,070	4,010	3,670
48x42	Short B	66	72.0	77.0	77.0	82	5,010	4,655	4,560	4,205
48x42	Short C	66	72.0	77.0	77.0	82	6,065	5,640	5,515	5,095
48x42	Short D	66	72.0	77.0	77.0	82	7,015	6,535	6,375	5,895
48x42	Long A	132	138.0	143.0	143.0	148	7,350	7,010	6,950	6,610
48x42	Long B	132	138.0	143.0	143.0	148	8,385	8,030	7,935	7,580

Dimensions in inches.
For bell and spigot dimensions, see page 276.

Dimensions and Weights of A.W.W.A.—N.E.W.W.A. Standard Bell and Spigot Reducers

Size	Class	V	Laying Length (L)				Weight			
			Bell & Bell	Large End Bell	Small End Bell	Spigot & Spigot	Bell & Bell	Large End Bell	Small End Bell	Spigot & Spigot
48x42	Long C	132	138.0	143.0	143.0	148	10,150	9,730	9,605	9,185
48x42	Long D	132	138.0	143.0	143.0	148	11,750	11,270	11,110	10,630
54x36	Short A	66	72.0	76.5	77.5	82	4,435	4,190	3,925	3,680
54x36	Short B	66	72.0	76.5	77.5	82	5,145	4,860	4,545	4,260
54x36	Short C	66	72.0	76.5	77.5	82	6,205	5,885	5,500	5,180
54x36	Short D	66	72.0	76.5	77.5	82	7,270	6,910	6,450	6,085
54x36	Long A	132	138.0	142.5	143.5	148	7,375	7,130	6,865	6,620
54x36	Long B	132	138.0	142.5	143.5	148	8,550	8,265	7,950	7,665
54x36	Long C	132	138.0	142.5	143.5	148	10,345	10,025	9,640	9,320
54x36	Long D	132	138.0	142.5	143.5	148	12,140	11,775	11,320	10,955
54x42	Short A	66	71.5	76.5	77.0	82	4,925	4,585	4,415	4,075
54x42	Short B	66	71.5	76.5	77.0	82	5,675	5,315	5,075	4,720
54x42	Short C	66	71.5	76.5	77.0	82	6,900	6,480	6,200	5,775
54x42	Short D	66	71.5	76.5	77.0	82	8,070	7,590	7,250	6,770
54x42	Long A	132	137.5	142.5	143.0	148	8,190	7,850	7,675	7,335
54x42	Long B	132	137.5	142.5	143.0	148	9,455	9,100	8,855	8,500
54x42	Long C	132	137.5	142.5	143.0	148	11,535	11,110	10,830	10,405
54x42	Long D	132	137.5	142.5	143.0	148	13,500	13,015	12,675	12,195
54x48	Short A	66	71.5	76.5	77.0	82	5,500	5,100	4,985	4,585
54x48	Short B	66	71.5	76.5	77.0	82	6,290	5,835	5,690	5,240
54x48	Short C	66	71.5	76.5	77.0	82	7,655	7,110	6,950	6,405
54x48	Short D	66	71.5	76.5	77.0	82	8,935	8,300	8,115	7,475
54x48	Long A	132	137.5	142.5	143.0	148	9,180	8,780	8,665	8,265
54x48	Long B	132	137.5	142.5	143.0	148	10,495	10,040	9,895	9,440
54x48	Long C	132	137.5	142.5	143.0	148	12,800	12,255	12,095	11,550
54x48	Long D	132	137.5	142.5	143.0	148	14,940	14,300	14,120	13,480
60x36	Short A	66	72.0	76.5	77.5	82	4,885	4,640	4,255	4,010
60x36	Short B	66	72.0	76.5	77.5	82	5,740	5,455	5,065	4,780
60x36	Short C	66	72.0	76.5	77.5	82	6,885	6,565	6,060	5,735
60x36	Short D	66	72.0	76.5	77.5	82	8,135	7,770	7,160	6,800
60x36	Long A	132	138.0	142.5	143.5	148	8,085	7,840	7,455	7,210
60x36	Long B	132	138.0	142.5	143.5	148	9,555	9,270	8,880	8,595
60x36	Long C	132	138.0	142.5	143.5	148	11,460	11,140	10,635	10,315
60x36	Long D	132	138.0	142.5	143.5	148	13,560	13,200	12,590	12,225
60x42	Short A	66	71.5	76.5	77.0	82	5,380	5,040	4,750	4,410
60x42	Short B	66	71.5	76.5	77.0	82	6,280	5,925	5,610	5,255
60x42	Short C	66	71.5	76.5	77.0	82	7,600	7,175	6,770	6,350
60x42	Short D	66	71.5	76.5	77.0	82	8,955	8,475	7,980	7,500
60x42	Long A	132	137.5	142.5	143.0	148	8,915	8,575	8,285	7,945
60x42	Long B	132	137.5	142.5	143.0	148	10,485	10,135	9,815	9,460
60x42	Long C	132	137.5	142.5	143.0	148	12,680	12,260	11,855	11,435
60x42	Long D	132	137.5	142.5	143.0	148	14,960	14,480	13,990	13,510
60x48	Short A	66	71.5	76.5	77.0	82	5,965	5,565	5,335	4,935
60x48	Short B	66	71.5	76.5	77.0	82	6,915	6,460	6,240	5,785
60x48	Short C	66	71.5	76.5	77.0	82	8,365	7,820	7,540	6,995

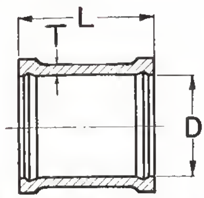
Dimensions in inches.
For bell and spigot dimensions, see page 276.

Dimensions and Weights of A.W.W.A.—N.E.W.W.A. Standard Bell and Spigot Reducers

Size	Class	V	Laying Length (L)				Weight			
			Bell & Bell	Large End Bell	Small End Bell	Spigot & Spigot	Bell & Bell	Large End Bell	Small End Bell	Spigot & Spigot
60x48	Short D	66	71.5	76.5	77.0	82	9,840	9,200	8,865	8,230
60x48	Long A	132	137.5	142.5	143.0	148	9,925	9,525	9,295	8,895
60x48	Long B	132	137.5	142.5	143.0	148	11,555	11,100	10,880	10,430
60x48	Long C	132	137.5	142.5	143.0	148	13,975	13,430	13,150	12,605
60x48	Long D	132	137.5	142.5	143.0	148	16,440	15,800	15,470	14,830
60x54	Short A	66	71.0	76.5	76.5	82	6,515	6,005	5,885	5,370
60x54	Short B	66	71.0	76.5	76.5	82	7,615	7,020	6,945	6,345
60x54	Short C	66	71.0	76.5	76.5	82	9,265	8,560	8,435	7,730
60x54	Short D	66	71.0	76.5	76.5	82	10,970	10,150	10,000	9,180
60x54	Long A	132	137.0	142.5	142.5	148	10,825	10,315	10,195	9,685
60x54	Long B	132	137.0	142.5	142.5	148	12,710	12,110	12,035	11,440
60x54	Long C	132	137.0	142.5	142.5	148	15,475	14,770	14,645	13,940
60x54	Long D	132	137.0	142.5	142.5	148	18,345	17,525	17,375	16,550

Dimensions in inches.
For bell and spigot dimensions, see page 276.

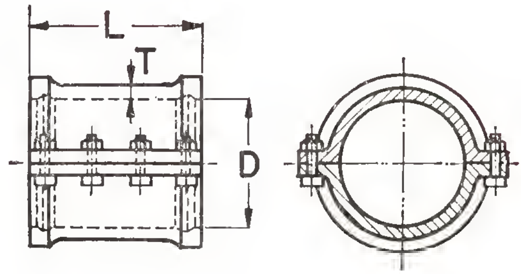
Dimensions and Weights of A.W.W.A.—N.E.W.W.A. Solid Sleeves



Nom'l Diam. Inches	Class	D	L	T	Approx. Weight Pounds	Nom'l Diam. Inches	Class	D	L	T	Approx. Weight Pounds
3	D	4.76	10	.65	35	36	A	39.00	15	1.25	810
3	D	4.76	15	.65	50	36	B	39.40	15	1.40	920
4	D	5.80	10	.65	45	36	C	39.80	15	1.60	1055
4	D	5.80	15	.65	65	36	D	40.20	15	1.80	1195
6	D	7.90	10	.70	65	36	A	39.00	24	1.25	1175
6	D	7.90	15	.70	90	36	B	39.40	24	1.40	1340
8	D	10.10	12	.75	100	36	C	39.80	24	1.60	1540
8	D	10.10	15	.75	120	36	D	40.20	24	1.80	1750
10	D	12.20	12	.80	130	42	A	45.30	15	1.40	1050
10	D	12.20	18	.80	180	42	B	45.60	15	1.50	1140
12	D	14.30	14	.85	185	42	C	46.20	15	1.75	1340
12	D	14.30	18	.85	225	42	D	46.70	15	1.95	1530
14	B	16.20	15	.85	215	42	A	45.30	24	1.40	1530
14	B	16.20	18	.85	255	42	B	45.60	24	1.50	1660
14	D	16.50	15	.90	235	42	C	46.20	24	1.75	1960
14	D	16.50	18	.90	275	42	D	46.70	24	1.95	2230
16	B	18.50	15	.90	270	48	A	51.60	15	1.50	1280
16	B	18.50	24	.90	400	48	B	51.90	15	1.65	1435
16	D	18.90	15	1.00	300	48	C	52.50	15	1.95	1710
16	D	18.90	24	1.00	445	48	D	53.10	15	2.20	1950
18	B	20.60	15	.95	320	48	A	51.60	24	1.50	1865
18	B	20.60	24	.95	470	48	B	51.90	24	1.65	2080
18	D	21.00	15	1.05	360	48	C	52.50	24	1.95	2490
18	D	21.00	24	1.05	530	48	D	53.10	24	2.20	2845
20	B	22.70	15	1.00	370	54	A	57.70	15	1.60	1580
20	B	22.70	24	1.00	540	54	B	58.20	15	1.80	1800
20	D	23.10	15	1.15	435	54	C	58.90	15	2.15	2115
20	D	23.10	24	1.15	640	54	D	59.50	15	2.45	2410
24	B	26.90	15	1.05	470	54	A	57.70	24	1.60	2280
24	B	26.90	24	1.05	685	54	B	58.20	24	1.80	2595
24	D	27.40	15	1.25	575	54	C	58.90	24	2.15	3080
24	D	27.40	24	1.25	840	54	D	59.50	24	2.45	3525
30	A	32.80	15	1.15	625	60	A	63.90	15	1.70	1850
30	B	33.10	15	1.15	630	60	B	64.50	15	1.90	2075
30	C	33.50	15	1.32	735	60	C	65.30	15	2.25	2455
30	D	33.80	15	1.50	860	60	D	65.90	15	2.60	2850
30	A	32.80	24	1.15	910	60	A	63.90	24	1.70	2670
30	B	33.10	24	1.15	920	60	B	64.50	24	1.90	3000
30	C	33.50	24	1.32	1075	60	C	65.30	24	2.25	3570
30	D	33.80	24	1.50	1250	60	D	65.90	24	2.60	4150

Dimensions in inches.

Dimensions and Weights—Standard Split Sleeve

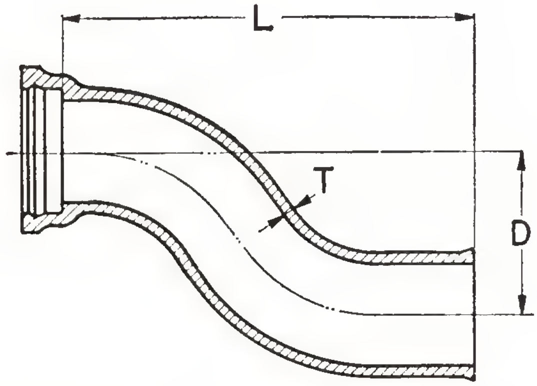


SPLIT SLEEVE

Size	Class	Dimensions in Inches			Weight Pounds
		D	T	L	
3	D	4.76	.65	15	80
4	D	5.80	.65	15	100
6	D	7.90	.70	15	130
8	D	10.10	.75	15	165
10	D	12.20	.80	18	245
12	D	14.30	.85	18	295
14	B	16.20	.85	18	310
14	D	16.50	.90	18	355
16	B	18.50	.90	24	510
16	D	18.90	1.00	24	575
18	B	20.60	.95	24	585
18	D	21.00	1.05	24	685
20	B	22.70	1.00	24	665
20	D	23.10	1.15	24	800
24	B	26.90	1.05	24	820
24	D	27.40	1.25	24	1010

Sleeves will be furnished assembled with suitable gasket, steel bolts and nuts. Weights include weights of bolts, nuts and gaskets.

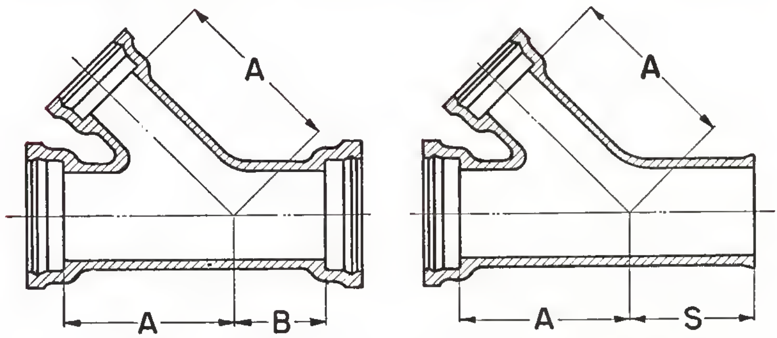
Dimensions and Weights of A.W.W.A.-N.E.W.W.A. Standard Bell and Spigot Offsets



OFFSETS

Size	Class	Dimensions in Inches T	L	D	Weight Pounds
3	D	.48	27	6	60
3	D	.48	30	12	70
3	D	.48	38	18	80
4	D	.52	27	6	80
4	D	.52	30	12	90
4	D	.52	38	18	110
6	D	.55	28	6	120
6	D	.55	34	12	145
6	D	.55	41	18	175
8	D	.60	29	6	180
8	D	.60	36	12	220
8	D	.60	43	18	260
10	D	.68	30	6	245
10	D	.68	38	12	305
10	D	.68	46	18	365
12	D	.75	34	6	350
12	D	.75	45	12	450
12	D	.75	56	18	550
14	B	.66	35	6	375
14	B	.66	46	12	475
14	B	.66	57	18	580
14	D	.82	35	6	455
14	D	.82	46	12	580
14	D	.82	57	18	710
16	B	.70	35	6	460
16	B	.70	48	12	600
16	B	.70	58	18	710
16	D	.89	35	6	570
16	D	.89	48	12	750
16	D	.89	58	18	895

Dimensions and Weights of A.W.W.A.-N.E.W.W.A. Standard Type 2 Bell & Spigot WYE Branches



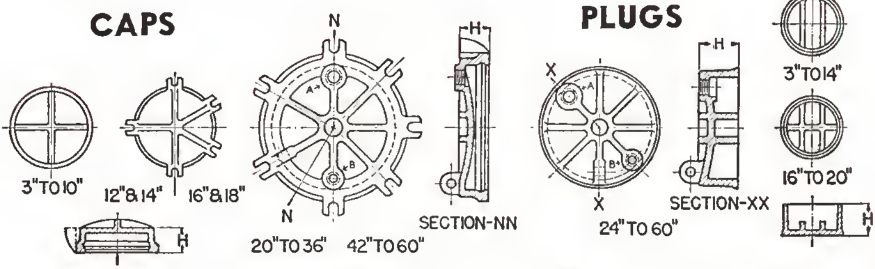
Size		Class	Dimensions—Inches			Weight—Pounds	
Run	Branch		A	S	B	All Bell	B-S-B
3	3	D	9.50	10.50	7.00	95	80
4	4	D	10.50	11.50	7.50	125	110
6	4	D	13.00	13.00	9.00	185	160
6	6	D	13.00	13.00	9.00	200	175
8	4	D	16.00	14.00	10.00	270	235
8	6	D	16.00	14.00	10.00	285	255
8	8	D	16.00	14.00	10.00	310	275
10	6	D	18.50	15.50	11.50	390	355
10	8	D	18.50	15.50	11.50	420	380
10	10	D	18.50	15.50	11.50	445	400
12	6	D	21.50	15.50	11.50	515	470
12	8	D	21.50	15.50	11.50	545	500
12	10	D	21.50	15.50	11.50	570	525
12	12	D	21.50	15.50	11.50	605	555
14	6	B	24.00	16.00	12.00	580	525
14	6	D	24.00	16.00	12.00	670	615
14	8	B	24.00	16.00	12.00	610	555
14	8	D	24.00	16.00	12.00	700	645
14	10	B	24.00	16.00	12.00	640	590
14	10	D	24.00	16.00	12.00	730	675
14	12	B	24.00	16.00	12.00	675	620
14	12	D	24.00	16.00	12.00	765	710
14	14	B	24.00	16.00	12.00	680	625
14	14	D	24.00	16.00	12.00	800	750
16	8	B	31.00	17.50	13.50	890	820
16	8	D	31.00	17.50	13.50	1070	995
16	10	B	31.00	17.50	13.50	935	860
16	10	D	31.00	17.50	13.50	1110	1035
16	12	B	31.00	17.50	13.50	980	905
16	12	D	31.00	17.50	13.50	1155	1080

Dimensions and Weights of A.W.W.A.-N.E.W.W.A. Standard Type 2 Bell & Spigot WYE Branches

Size		Class	Dimensions—Inches			Weight—Pounds	
Run	Branch		A	S	B	All Bell	B-S-B
16	14	B	31.00	17.50	13.50	990	915
16	14	D	31.00	17.50	13.50	1205	1130
16	16	B	31.00	17.50	13.50	1040	965
16	16	D	31.00	17.50	13.50	1285	1205
18	10	B	34.00	18.00	14.00	1150	1065
18	10	D	34.00	18.00	14.00	1400	1310
18	12	B	34.00	18.00	14.00	1195	1110
18	12	D	34.00	18.00	14.00	1445	1355
18	14	B	34.00	18.00	14.00	1205	1120
18	14	D	34.00	18.00	14.00	1500	1415
18	16	B	34.00	18.00	14.00	1270	1185
18	16	D	34.00	18.00	14.00	1585	1495
18	18	B	34.00	18.00	14.00	1305	1225
18	18	D	34.00	18.00	14.00	1655	1565
20	12	B	37.00	18.75	14.75	1455	1355
20	12	D	37.00	18.75	14.75	1770	1650
20	14	B	37.00	18.75	14.75	1465	1365
20	14	D	37.00	18.75	14.75	1830	1715
20	16	B	37.00	18.75	14.75	1530	1430
20	16	D	37.00	18.75	14.75	1920	1805
20	18	B	37.00	18.75	14.75	1585	1485
20	18	D	37.00	18.75	14.75	1995	1880
20	20	B	37.00	18.75	14.75	1630	1530
20	20	D	37.00	18.75	14.75	2055	1935
24	16		40.00	12.75	8.75		
24	18		40.00	18.75	14.75		
24	20		40.00	18.75	14.75		
24	24		42.00	19.75	15.75		
30	20		49.50	17.00	12.50		
30	24		49.50	17.00	12.50		
30	30		52.50	22.75	18.25		
36	24		54.00	19.75	15.25		
36	30		56.00	19.75	15.25		
36	36		60.00	24.00	19.50		
42	24		60.00	16.75	11.75		
42	30		63.00	16.75	11.75		
42	36		66.00	21.00	16.00		
42	42		69.00	25.25	20.25		
48	30		68.00	14.00	9.00		
48	36		71.00	18.00	13.00		
48	42		74.00	22.25	17.25		
48	48		77.00	26.50	21.50		

24″ and larger sizes are sometimes reinforced with ribs and bolts when necessary. Consult the manufacturer for his recommendations. Weights of these sizes are dependent upon individual company reinforcement design.

Dimensions and Weights of A.W.W.A.-N.E.W.W.A.

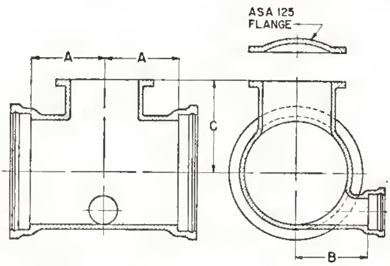


Size	Class	CAPS H	CAPS No. of Lugs	CAPS Weight Without Lugs	CAPS Weight With Lugs	PLUGS H	PLUGS No. of Ribs	PLUGS Weight
3	D	4.60	0	20	....	5.50	0	7
4	D	4.60	0	25	....	5.50	0	8
6	D	4.65	0	40	....	5.50	0	14
8	D	4.75	0	60	....	5.50	2	25
10	D	4.75	0	85	....	6.00	2	40
12	D	4.75	4	110	140	6.00	2	50
14	B	4.90	4	135	165	6.00	2	60
14	D	4.90	4	150	180	6.00	2	65
16	B	5.00	6	185	230	6.50	3	90
16	D	5.00	6	200	245	6.50	3	95
18	B	5.00	6	230	280	6.50	3	110
18	D	5.00	6	250	300	6.50	3	120
20	B	5.00	6	280	330	6.50	3	150
20	D	5.00	6	310	360	6.50	3	155
24	B	5.25	6	390	440	8.00	4	375
24	D	5.25	6	440	490	8.00	4	470
30	A	5.75	6	590	665	8.00	4	480
30	B	5.75	6	595	670	8.00	4	555
30	C	5.75	6	645	725	8.00	4	640
30	D	5.75	6	700	785	8.00	4	725
36	A	6.00	6	845	925	8.00	4	680
36	B	6.00	6	915	995	8.00	4	785
36	C	6.00	6	1000	1085	8.00	4	915
36	D	6.00	6	1085	1170	8.00	4	1050
42	A	7.00	8	1275	1395	9.00	4	990
42	B	7.00	8	1395	1520	9.00	4	1140
42	C	7.00	8	1545	1675	9.00	4	1355
42	D	7.00	8	1685	1820	9.00	4	1550
48	A	7.00	8	1790	1915	9.00	4	1340
48	B	7.00	8	1945	2075	9.00	4	1505
48	C	7.00	8	2140	2275	9.00	4	1800
48	D	7.00	8	2335	2475	9.00	4	2045
54	A	7.50	8	2375	2515	9.00	4	1695
54	B	7.50	8	2555	2700	9.00	4	1945
54	C	7.50	8	2800	2950	9.00	4	2355
54	D	7.50	8	3045	3195	9.00	4	2735
60	A	7.50	8	2900	3045	9.00	4	2045
60	B	7.50	8	3105	3250	9.00	4	2435
60	C	7.50	8	3395	3545	9.00	4	2905
60	D	7.50	8	3680	3835	9.00	4	3395

Note: Bosses A & B cast on only when so ordered. Tap boss A for 3″ W.I. pipe. Tap boss B for 2″ W.I. pipe.

For lug dimensions see page 314.

Dimensions and Weights of A.W.W.A.—N.E.W.W.A. Standard Blow-Off Branches with Manhole



Size	Class	Dimensions			Weight	Size	Class	Dimensions			Weight
		A	B	C				A	B	C	
30x 6	A	21	20	26.0	2220	42x16	C	21	26	32.0	4640
30x 6	B	21	20	26.0	2380	42x16	D	21	26	32.0	5205
30x 6	C	21	20	26.0	2720	48x12	A	21	30	35.0	4330
30x 6	D	21	20	26.0	3045	48x12	B	21	30	35.0	4790
30x 8	A	21	20	26.0	2240	48x12	C	21	30	35.0	5655
30x 8	B	21	20	26.0	2400	48x12	D	21	30	35.0	6415
30x 8	C	21	20	26.0	2735	48x16	A	21	30	35.0	4345
30x 8	D	21	20	26.0	3060	48x16	B	21	30	35.0	4795
30x12	A	21	20	26.0	2285	48x16	C	21	30	35.0	5710
30x12	B	21	20	26.0	2435	48x16	D	21	30	35.0	6455
30x12	C	21	20	26.0	2770	54x12	A	28	33	38.5	6155
30x12	D	21	20	26.0	3090	54x12	B	28	33	38.5	6975
36x 8	A	21	23	29.0	2760	54x12	C	28	33	38.5	8370
36x 8	B	21	23	29.0	3110	54x12	D	28	33	38.5	9695
36x 8	C	21	23	29.0	3555	54x16	A	28	33	38.5	6160
36x 8	D	21	23	29.0	4005	54x16	B	28	33	38.5	6985
36x12	A	21	23	29.0	2805	54x16	C	28	33	38.5	8425
36x12	B	21	23	29.0	3145	54x16	D	28	33	38.5	9735
36x12	C	21	23	29.0	3590	60x12	A	28	36	42.0	7065
36x12	D	21	23	29.0	4035	60x12	B	28	36	42.0	8145
42x12	A	21	26	32.0	3535	60x12	C	28	36	42.0	9715
42x12	B	21	26	32.0	3900	60x12	D	28	36	42.0	11400
42x12	C	21	26	32.0	4570	60x16	A	28	36	42.0	7065
42x12	D	21	26	32.0	5170	60x16	B	28	36	42.0	8145
42x16	A	21	26	32.0	3555	60x16	C	28	36	42.0	9770
42x16	B	21	26	32.0	3910	60x16	D	28	36	42.0	11445

Dimensions in inches.

For dimensions and drilling of flanges, see page 345.

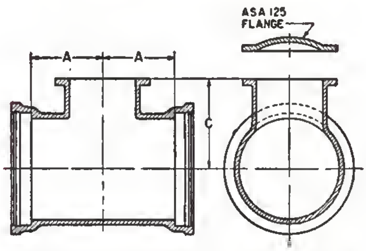
For bell dimensions, see page 276.

Above weights include weights of blank flange, steel bolts, nuts and gasket which equal 299 #.

Manholes are regularly furnished with 20″ blank flange, bolts, nuts and gasket.

Dimensions and Weights of A.W.W.A.—N.E.W.W.A. Standard Manhole Pipe

(Bell-Bell & Flg. Tee)



Size	Class	Dimensions		Weight
		A	C	
30	A	21	26	2155
30	B	21	26	2320
30	C	21	26	2660
30	D	21	26	2990
36	A	21	29	2675
36	B	21	29	3025
36	C	21	29	3485
36	D	21	29	3935
42	A	21	32	3400
42	B	21	32	3775
42	C	21	32	4470
42	D	21	32	5075
48	A	21	35	4185
48	B	21	35	4655
48	C	21	35	5540
48	D	21	35	6320
54	A	28	38.5	5995
54	B	28	38.5	6835
54	C	28	38.5	8255
54	D	28	38.5	9600
60	A	28	42	6900
60	B	28	42	8005
60	C	28	42	9595
60	D	28	42	11310

NOTE:—Above weights include the weights of blank flange, steel bolts, nuts and gasket which equal 299#.

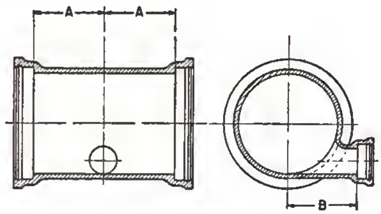
Dimensions in inches.

For dimensions and drilling of flanges, see page 345.

For bell dimensions, see page 276.

Manholes are regularly furnished with 20″ blank flange, bolts, nuts and gasket.

Dimensions and Weights of A.W.W.A.—N.E.W.W.A. Standard Blow-Off Branches



Size	Class	A	B	Weight	Size	Class	A	B	Weight
8x3	D	12	7	225	24x 6	B	12	16	920
8x4	D	12	7	230	24x 6	D	12	16	1165
10x3	D	12	8	290	24x 8	B	12	16	935
10x4	D	12	8	300	24x 8	D	12	16	1175
10x6	D	12	8	310	30x 6	A	13	20	1325
12x3	D	12	10	365	30x 6	B	13	20	1435
12x4	D	12	10	370	30x 6	C	13	20	1675
12x6	D	12	10	385	30x 6	D	13	20	1940
14x4	B	12	11	415	30x 8	A	13	20	1345
14x4	D	12	11	480	30x 8	B	13	20	1455
14x6	B	12	11	425	30x 8	C	13	20	1690
14x6	D	12	11	495	30x 8	D	13	20	1950
16x4	B	12	12	510	30x12	A	13	20	1385
16x4	D	12	12	605	30x12	B	13	20	1490
16x6	B	12	12	525	30x12	C	13	20	1725
16x6	D	12	12	620	30x12	D	13	20	1980
18x4	B	12	13	600	36x 8	A	13	23	1750
18x4	D	12	13	730	36x 8	B	13	23	2025
18x6	B	12	13	615	36x 8	C	13	23	2345
18x6	D	12	13	740	36x 8	D	13	23	2695
20x4	B	12	14	700	36x12	A	13	23	1800
20x4	D	12	14	870	36x12	B	13	23	2065
20x6	B	12	14	710	36x12	C	13	23	2375
20x6	D	12	14	880	36x12	D	13	23	2720

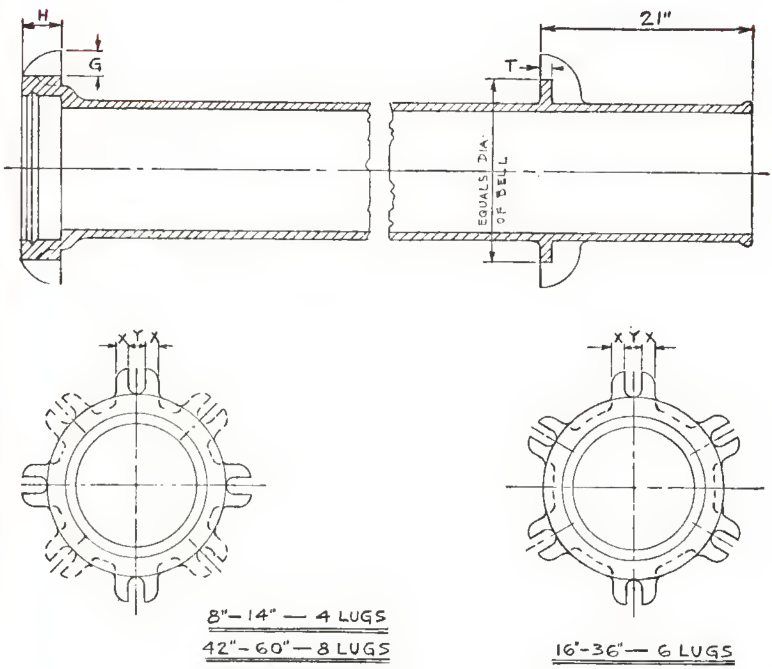
Dimensions in inches.
For bell dimensions, see page 276.

Dimensions and Weights of A.W.W.A.—N.E.W.W.A. Standard Blow-Off Branches

Size	Class	A	B	Weight	Size	Class	A	B	Weight
42x12	A	15	26	2555	54x12	A	19	33	4505
42x12	B	15	26	2850	54x12	B	19	33	5170
42x12	C	15	26	3395	54x12	C	19	33	6245
42x12	D	15	26	3895	54x12	D	19	33	7295
42x16	A	15	26	2575	54x16	A	19	33	4515
42x16	B	15	26	2870	54x16	B	19	33	5175
42x16	C	15	26	3460	54x16	C	19	33	6300
42x16	D	15	26	3940	54x16	D	19	33	7340
48x12	A	17	30	3435	60x12	A	21	36	5540
48x12	B	17	30	3840	60x12	B	21	36	6430
48x12	C	17	30	4610	60x12	C	21	36	7740
48x12	D	17	30	5300	60x12	D	21	36	9155
48x16	A	17	30	3440	60x16	A	21	36	5555
48x16	B	17	30	3850	60x16	B	21	36	6440
48x16	C	17	30	4660	60x16	C	21	36	7795
48x16	D	17	30	5335	60x16	D	21	36	9185

Dimensions in inches.
For bell dimensions, see page 276.

Standard Lugs for Pipe and Fittings, A.W.W.A.-N.E.W.W.A.



NOTE: A pair of lugs is placed on the vertical axis of each bell, the others at equal distances around circumference. Since there are only 6 lugs on fittings for sizes 16″ through 36″ purchaser should furnish sketch showing location of lugs.

Lugs on spigot ends of pipe are located, unless otherwise ordered, with face of lug 21″ from end of spigot. This dimension varies for fittings.

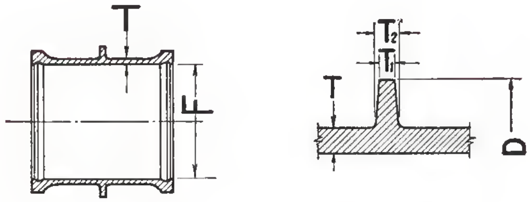
Pipe and fittings furnished with lugs only when specifically ordered.

For dimensions see page 314.

Standard Lugs for Pipe and Fittings, A.W.W.A.-N.E.W.W.A.

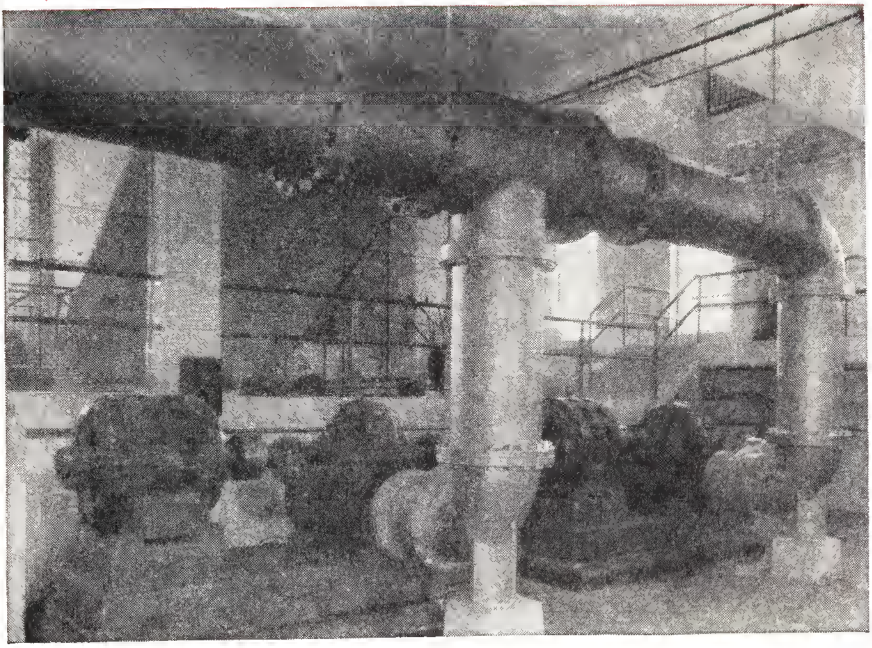
Nominal Diameter Pipe	Class	Number of Lugs on Each End	Dimensions in Inches							Weight of Lugs	
			G	H	T	X	Y	Diam. of Bolt	Length of Bolt	Bell End	Spigot End
8	A B	4	2.50	4.00	1.00	1.25	1.63	1.38	24.50	30	40
8	C D	4	2.50	4.00	1.00	1.25	1.63	1.38	24.50	30	40
10	A B	4	2.50	4.00	1.00	1.25	1.63	1.38	24.50	30	40
10	C D	4	2.50	4.00	1.00	1.25	1.63	1.38	24.50	30	40
12	A B	4	2.50	4.00	1.00	1.25	1.63	1.38	24.50	30	40
12	C D	4	2.50	4.00	1.00	1.25	1.63	1.38	24.50	30	45
14	A B	4	2.50	4.00	1.00	1.25	1.63	1.38	24.50	30	40
14	C D	4	2.50	4.00	1.00	1.25	1.63	1.38	24.50	30	45
16	A B	6	2.50	4.00	1.00	1.25	1.63	1.38	24.50	45	65
16	C D	6	2.50	4.00	1.00	1.25	1.63	1.38	24.50	45	70
18	A B	6	2.50	4.00	1.00	1.25	1.63	1.38	24.50	50	70
18	C D	6	2.50	4.00	1.00	1.25	1.63	1.38	24.50	50	75
20	A B	6	2.50	4.00	1.00	1.25	1.63	1.38	24.50	50	70
20	C D	6	2.50	4.00	1.00	1.25	1.63	1.38	24.50	50	75
24	A B	6	2.50	4.00	1.00	1.25	1.63	1.38	24.50	50	75
24	C D	6	2.50	4.00	1.00	1.25	1.63	1.38	24.50	50	80
30	A	6	3.00	4.50	1.50	1.50	2.00	1.75	25.50	75	115
30	B	6	3.00	4.50	1.50	1.50	2.00	1.75	25.50	75	115
30	C	6	3.00	4.50	1.50	1.50	2.00	1.75	25.50	80	125
30	D	6	3.00	4.50	1.50	1.50	2.00	1.75	25.50	85	135
36	A	6	3.00	4.50	1.50	1.50	2.00	1.75	25.50	80	120
36	B	6	3.00	4.50	1.50	1.50	2.00	1.75	25.50	80	130
36	C	6	3.00	4.50	1.50	1.50	2.00	1.75	25.50	85	135
36	D	6	3.00	4.50	1.50	1.50	2.00	1.75	25.50	85	145
42	A	8	3.00	5.00	1.50	1.50	2.00	1.75	25.50	120	185
42	B	8	3.00	5.00	1.50	1.50	2.00	1.75	25.50	125	190
42	C	8	3.00	5.00	1.50	1.50	2.00	1.75	25.50	130	205
42	D	8	3.00	5.00	1.50	1.50	2.00	1.75	25.50	135	220
48	A	8	3.00	5.00	1.50	1.50	2.00	1.75	25.50	125	190
48	B	8	3.00	5.00	1.50	1.50	2.00	1.75	25.50	130	200
48	C	8	3.00	5.00	1.50	1.50	2.00	1.75	25.50	135	220
48	D	8	3.00	5.00	1.50	1.50	2.00	1.75	25.50	140	235
54	A	8	3.00	5.50	1.50	1.50	2.00	1.75	25.50	140	215
54	B	8	3.00	5.50	1.50	1.50	2.00	1.75	25.50	145	230
54	C	8	3.00	5.50	1.50	1.50	2.00	1.75	25.50	150	245
54	D	8	3.00	5.50	1.50	1.50	2.00	1.75	25.50	150	260
60	A	8	3.00	5.50	1.50	1.50	2.00	1.75	25.50	145	220
60	B	8	3.00	5.50	1.50	1.50	2.00	1.75	25.50	145	235
60	C	8	3.00	5.50	1.50	1.50	2.00	1.75	25.50	150	255
60	D	8	3.00	5.50	1.50	1.50	2.00	1.75	25.50	155	275

Laying Dimensions and Weights of Standard Wall Sleeves



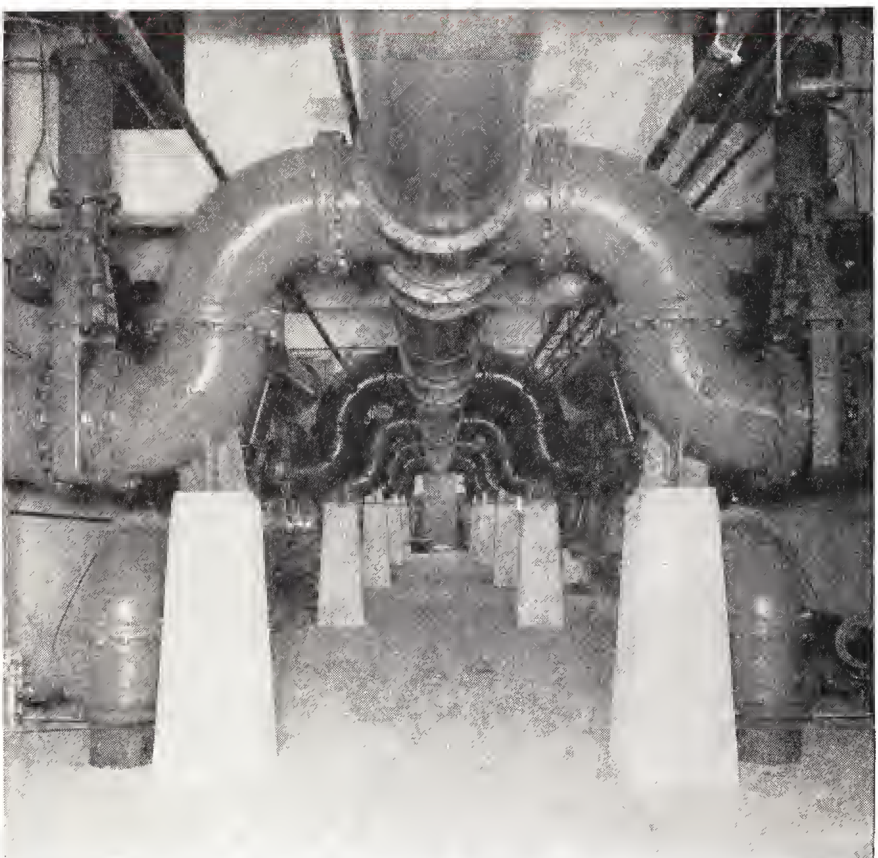
Size	Class	T	F	Intermediate Flange				Length and Weight			
								Short Type		Long Type	
				T_2	T_1	D	Wt.	Length	Weight	Length	Weight
3	D	0.65	4.76	0.75	0.50	9.00	6	10	40	15	55
4	D	0.65	5.80	0.75	0.50	10.00	6	10	50	15	70
6	D	0.70	7.90	0.75	0.50	12.00	7	10	70	15	95
8	D	0.75	10.10	0.75	0.50	14.50	10	12	110	15	130
10	D	0.80	12.20	0.75	0.50	16.50	10	12	140	18	190
12	D	0.85	14.30	0.75	0.50	19.00	13	14	200	18	240
14	B	0.85	16.20	1.00	0.75	22.00	29	15	245	18	285
14	D	0.90	16.50	1.00	0.75	22.00	26	15	260	18	300
16	B	0.90	18.50	1.00	0.75	24.50	33	15	305	24	435
16	D	1.00	18.90	1.00	0.75	24.50	29	15	330	24	475
18	B	0.95	20.60	1.00	0.75	26.75	37	15	355	24	505
18	D	1.05	21.00	1.00	0.75	26.75	32	15	390	24	560
20	B	1.00	22.70	1.00	0.75	29.00	41	15	410	24	580
20	D	1.15	23.10	1.00	0.75	29.00	35	15	470	24	675
24	B	1.05	26.90	1.00	0.75	33.50	50	15	520	24	735
24	D	1.25	27.40	1.00	0.75	33.50	41	15	615	24	880
30	B	1.15	33.10	1.25	1.00	40.00	80	15	710	24	1000
30	D	1.50	33.80	1.25	1.00	40.00	56	15	915	24	1305
36	B	1.40	39.40	1.25	1.00	47.00	98	15	1020	24	1440
36	D	1.80	40.20	1.25	1.00	47.00	67	15	1260	24	1815
42	B	1.50	45.60	1.50	1.25	54.50	171	15	1310	24	1830
42	D	1.95	46.70	1.50	1.25	54.50	115	15	1645	24	2345
48	B	1.65	51.90	1.50	1.25	61.25	198	15	1635	24	2280
48	D	2.20	53.10	1.50	1.25	61.25	126	15	2075	24	2970

Dimensions in inches.

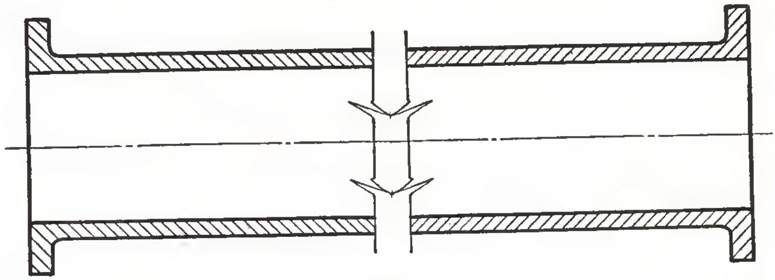


SECTION 13

Flanged Pipe and Fittings for Water



Standard Thicknesses and Weights of Pit Cast Cast Iron Flanged Pipe A.W.W.A. 1908 Specifications



CLASS "A"

Size	Outside Dia.	Thickness	Barrel Wt./Ft.	Wt./Flg.	Weight* 12′ Flg. Pipe
3	3.80	0.39	13.0	6	170
4	4.80	0.42	18.0	10	235
6	6.90	0.44	27.9	14	365
8	9.05	0.46	38.7	22	510
10	11.10	0.50	52.0	29	680
12	13.20	0.54	67.0	45	895
14	15.30	0.57	82.3	54	1095
16	17.40	0.60	98.8	67	1320
18	19.50	0.64	118.3	70	1560
20	21.60	0.67	137.5	89	1830
24	25.80	0.76	186.5	123	2485
30	31.74	0.88	266.2	191	3575
36	37.96	0.99	358.7	286	4875
42	44.20	1.10	464.7	408	6390
48	50.50	1.26	608.1	491	8280
		CLASS "B"			
3	3.96	0.42	14.6	6	185
4	5.00	0.45	20.1	10	260
6	7.10	0.48	31.1	13	400
8	9.05	0.51	42.7	22	555
10	11.10	0.57	58.8	29	765
12	13.20	0.62	76.5	45	1010
14	15.30	0.66	94.7	54	1245
16	17.40	0.70	114.6	67	1510
18	19.50	0.75	137.8	70	1795
20	21.60	0.80	163.1	89	2135
24	25.80	0.89	217.3	123	2855
30	32.00	1.03	312.7	184	4120
36	38.30	1.15	418.8	274	5575
42	44.50	1.28	542.3	393	7295
48	50.80	1.42	687.3	474	9195

Flanges are American Standard, Class 125.

*Weight includes two flanges with calculated weight of pipe rounded off to nearest 5 lb.

Dimensions in inches.

Standard Thicknesses and Weights of Pit Cast Cast Iron Flanged Pipe A.W.W.A. 1908 Specifications

CLASS "C"

Size	Outside Dia.	Thickness	Barrel Wt./Ft.	Wt./Flg.	Weight* 12′ Flg. Pipe
3	3.96	0.45	15.5	6	200
4	5.00	0.48	21.3	10	275
6	7.10	0.51	32.9	13	420
8	9.30	0.56	48.0	21	620
10	11.40	0.62	65.5	28	840
12	13.50	0.68	85.5	43	1110
14	15.65	0.74	108.1	51	1400
16	17.80	0.80	133.3	63	1725
18	19.92	0.87	162.5	65	2080
20	22.06	0.92	190.6	82	2450
24	26.32	1.04	257.7	112	3315
30	32.40	1.20	367.0	173	4750
36	38.70	1.36	497.8	259	6490
42	45.10	1.54	657.5	364	8620
48	51.40	1.71	832.9	439	10875

CLASS "D"

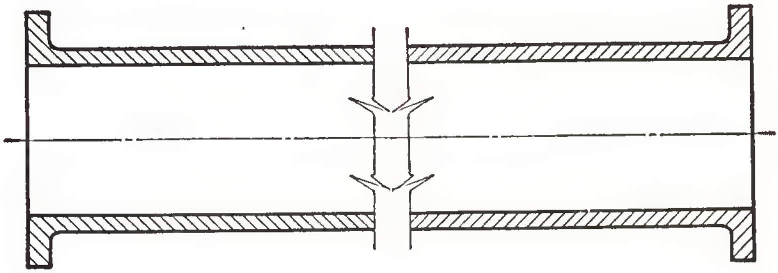
Size	Outside Dia.	Thickness	Barrel Wt./Ft.	Wt./Flg.	Weight* 12′ Flg. Pipe
3	3.96	0.48	16.4	6	210
4	5.00	0.52	22.8	10	295
6	7.10	0.55	35.3	13	450
8	9.30	0.60	51.2	21	655
10	11.40	0.68	71.5	28	915
12	13.50	0.75	93.7	43	1210
14	15.65	0.82	119.2	51	1530
16	17.80	0.89	147.5	63	1895
18	19.92	0.96	178.4	65	2270
20	22.06	1.03	212.3	82	2710
24	26.32	1.16	286.1	112	3655
30	32.74	1.37	421.3	163	5380
36	39.16	1.58	582.0	242	7470
42	45.58	1.78	764.2	341	9850
48	51.98	1.96	961.0	406	12345

Flanges are American Standard, Class 125.

*Weight includes two flanges with calculated weight of pipe rounded off to nearest 5 lb.

Dimensions in inches.

Standard Thicknesses and Weights of Pit Cast Cast Iron Flanged Pipe—A.S.A. A21.2 Specifications



Size	CLASS 100					CLASS 150				
	Out-side Diam.	Thick-ness	Bbl. Wt. Per Ft.	Wt. Per Flg.	Wt.* 12′ Flg. Pipe	Out-side Diam.	Thick-ness	Bbl. Wt. Per Ft.	Wt. Per Flg.	Wt.* 12′ Flg. Pipe
3	3.80″	0.37″	12.4	6	160	3.80″	0.37″	12.4	6	160
4	4.80″	0.40″	17.3	10	230	4.80″	0.40″	17.3	10	230
6	6.90″	0.43″	27.3	14	355	6.90″	0.43″	27.3	14	355
8	9.05″	0.46″	38.7	22	510	9.05″	0.46″	38.7	22	510
10	11.10″	0.50″	52.0	29	680	11.10″	0.54″	55.9	29	730
12	13.20″	0.54″	67.0	45	895	13.20″	0.58″	71.8	45	950
14	15.30″	0.58″	83.7	54	1110	15.65″	0.63″	92.8	51	1215
16	17.40″	0.63″	103.6	67	1375	17.80″	0.68″	114.1	63	1495
18	19.50″	0.68″	125.4	70	1645	19.92″	0.79″	148.1	65	1905
20	21.60″	0.71″	145.4	89	1925	22.06″	0.83″	172.7	82	2235
24	25.80″	0.80″	196.0	123	2600	26.32″	0.93″	231.5	112	3000
30	32.00″	0.94″	286.2	184	3800	32.40″	1.10″	337.5	173	4395
36	38.30″	1.13″	411.7	274	5490	38.70″	1.22″	448.2	259	5895
42	44.50″	1.16″	492.8	393	6700	45.10″	1.35″	578.9	364	7675
48	50.80″	1.37″	663.8	474	8915	51.40″	1.48″	724.2	439	9570

Flanges are American Standard, Class 125.

*Weight includes two flanges with calculated weight of pipe rounded off to nearest five pounds.

Classes correspond to Table No. 3, A.S.A. A21.2 Specifications.

Dimensions in inches.

Standard Thicknesses and Weights of Pit Cast Cast Iron Flanged Pipe—A.S.A. A21.2 Specifications—Continued

Size	CLASS 200					CLASS 250				
	Out-side Diam.	Thick-ness	Bbl. Wt. Per Ft.	Wt. Per Flg.	Wt.* 12′ Flg. Pipe	Out-side Diam.	Thick-ness	Bbl. Wt. Per Ft.	Wt. Per Flg.	Wt.* 12′ Flg. Pipe
3	3.80″	0.37″	12.4	11	170	3.80″	0.37″	12.4	11	170
4	4.80″	0.40″	17.3	17	240	4.80″	0.40″	17.3	17	240
6	6.90″	0.43″	27.3	29	385	6.90″	0.43″	27.3	29	385
8	9.05″	0.46″	38.7	43	550	9.05″	0.50″	41.9	43	590
10	11.10″	0.58″	59.8	61	840	11.40″	0.63″	66.5	59	915
12	13.20″	0.63″	77.6	89	1110	13.50″	0.68″	85.5	85	1195
14	15.65″	0.68″	99.8	108	1415	15.65″	0.79″	115.1	108	1595
16	17.80″	0.79″	131.7	134	1850	17.80″	0.85″	141.2	134	1960
18	19.92″	0.85″	158.9	163	2235	19.92″	0.92″	171.3	163	2380
20	22.06″	0.90″	186.7	200	2640	22.06″	0.97″	200.5	200	2805
24	26.32″	1.00″	248.2	296	3570	26.32″	1.17″	288.4	296	4055
30	32.74″	1.19″	368.0	403	5220	32.74″	1.39″	427.1	403	5930
36	39.16″	1.43″	528.9	549	7445	39.16″	1.54″	567.9	549	7915
42	45.58″	1.58″	681.4	738	9655	45.58″	1.71″	735.3	738	10300
48	51.98″	1.73″	852.1	1071	12365	51.98″	2.02″	989.2	1071	14010

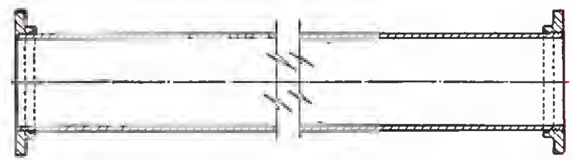
All Flanges American Standard Class 250, with allowance for raised face.

*Weight includes two flanges with calculated pipe weights rounded off to nearest five pounds.

Classes correspond to Table No. 3, A.S.A. A21.2 Specifications.

Dimensions in inches.

Flanged Pipe With Threaded Flanges



Nominal Inside Diameter Inches	Class or Maximum Working Pressure	Outside Diameter of Pipe Inches	Minimum Thickness of Pipe Inches	Weight Pounds			Weight—with Flanges—Pounds					
				One Flange Only		Per Foot Without Flanges	12 Foot Length		16 Foot Length		18 Foot Length	
				A.S.A. 125	A.S.A. 250		Per Foot	Per Length	Per Foot	Per Length	Per Foot	Per Length
3	150	3.96	0.38	7	....	13.3	14.6	175	14.1	225	14.1	255
3	250	3.96	0.38	7	....	13.3	14.6	175	14.1	225	14.1	255
3	250	3.96	0.38	....	12	13.3	15.4	185	14.7	235	14.7	265
4	150	4.80	0.38	13	....	16.5	18.8	225	18.1	290	18.1	325
4	250	4.80	0.38	13	....	16.5	18.8	225	18.1	290	18.1	325
4	250	4.80	0.38	....	20	16.5	20.0	240	19.1	305	18.6	335
6	150	6.90	0.38	17	....	24.3	27.1	325	26.6	425	26.1	470
6	250	6.90	0.38	17	....	24.3	27.1	325	26.6	425	26.1	470
6	250	6.90	0.38	....	34	24.3	30.0	360	28.4	455	28.1	505
8	150	9.05	0.41	27	....	34.7	39.2	470	38.1	610	37.8	680
8	250	9.05	0.41	27	....	34.7	39.2	470	38.1	610	37.8	680
8	250	9.05	0.41	....	50	34.7	42.9	515	40.9	655	40.3	725
10	150	11.10	0.44	38	....	46.0	52.5	630	50.6	810	50.3	905
10	250	11.10	0.44	38	....	46.0	52.5	630	50.6	810	50.3	905
10	250	11.10	0.44	....	70	46.0	57.5	690	54.7	875	53.9	970

12	150	13.20	0.48	58	....	59.8	69.6	835	67.2	1075	66.1	1190
12	250	13.20	0.52	58	....	64.6	74.2	890	71.9	1150	71.1	1280
12	250	13.20	0.52	....	102	64.6	81.7	980	77.5	1240	75.8	1365
14	150	15.30	0.51	72	....	73.9	85.8	1030	82.8	1325	81.9	1475
14	250	15.30	0.59	72	....	85.1	97.1	1165	94.1	1505	93.1	1675
14	250	15.30	0.59	....	130	85.1	106.7	1280	101.2	1620	99.4	1790
16	150	17.40	0.54	90	....	89.2	104.2	1250	100.3	1605	99.2	1785
16	250	17.40	0.63	90	....	103.6	118.8	1425	115.0	1840	113.6	2045
16	250	17.40	0.63	....	162	103.6	130.4	1565	123.8	1980	121.7	2190
18	150	19.50	0.58	90	....	107.6	122.5	1470	118.8	1900	117.5	2115
18	250	19.50	0.68	90	....	125.4	140.4	1685	136.6	2185	135.3	2435
18	250	19.50	0.68	....	200	125.4	158.8	1905	150.3	2405	147.5	2655
20	150	21.60	0.62	115	....	127.5	146.7	1760	141.9	2270	140.3	2525
20	250	21.60	0.72	115	....	147.4	166.7	2000	161.9	2590	160.3	2885
20	250	21.60	0.72	....	245	147.4	188.3	2260	178.1	2850	174.7	3145
24	150	25.80	0.73	160	....	179.4	206.2	2475	199.4	3190	197.2	3550
24	250	25.80	0.79	160	....	193.7	220.4	2645	213.8	3420	211.4	3805
24	250	25.80	0.79	....	370	193.7	255.4	3065	240.0	3840	234.7	4225

Class 150 and 250 are normally furnished with flanges meeting A.S.A. Class 125 specifications. See page 345.

Class 250 can also be furnished with flanges meeting A.S.A. Class 250 specifications. See page 364.

All sizes of flanged pipe can be made to meet requirements for pipe with greater wall thickness than shown.

Weights shown are subject to a variation of not more than 10% for individual pieces and not more than a total of 5% on any one shipment of 100 or more pieces. To obtain the weight of any short length of pipe, figure length from face to face of flanges and add the weight of two flanges.

After facing flanges, an inspection limit of plus or minus 1/16 inch shall be allowed on all contact surface to contact surface dimensions of full length or short length flanged pipe in sizes up to and including 10 inches; and plus or minus 1/8 inch on sizes larger than 10 inches.

Minimum thickness recommended for cast iron pipe to be threaded for pressure service is .38″.

Minimum thickness shown in table is A.S.A. standard for centrifugally cast pipe with 5 ft. cover, condition B, except where such indicated thickness is less than .38″, in which case .38″ is shown.

Dimensions of ASA B18.2 Regular Unfinished Square Head and Heavy Unfinished Hexagon Head Bolts and Heavy Unfinished Hexagon Nuts for American Standard Flanges

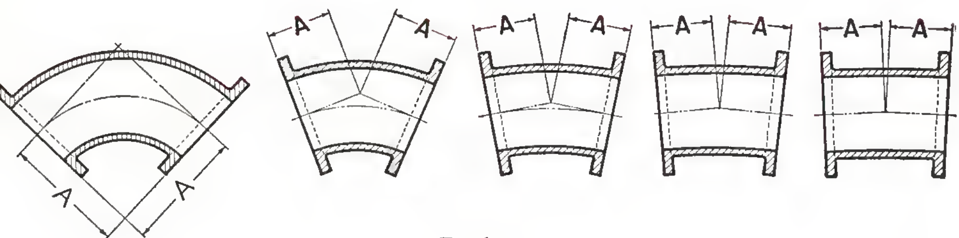
Dia. of Bolt	Threads Per Inch	Area at Root of Thread	BOLTS: Hexagon Heads: Width Across Flats	BOLTS: Hexagon Heads: Width Across Corners	BOLTS: Hexagon Heads: Height	BOLTS: Square Heads: Width Across Flats	BOLTS: Square Heads: Width Across Corners	BOLTS: Square Heads: Height	NUTS: Hexagon: Width Across Flats	NUTS: Hexagon: Width Across Corners	NUTS: Hexagon: Height	Load at 10,000 psi Stress	Weight per 100: Hex. Head	Weight per 100: Sq. Head	Weight per 100: Hex. Nut	Weight per 100: Inch Under Head
1/2″	13	0.126	7/8	0.969	7/16	3/4	0.995	21/64	7/8	0.969	1/2	1260	8.2	5.1	6.6	5.6
5/8″	11	0.202	1 1/16	1.175	17/32	15/16	1.244	27/64	1 1/16	1.175	5/8	2020	14	10	11	8.7
3/4″	10	0.302	1 1/4	1.382	5/8	1 1/8	1.494	1/2	1 1/4	1.382	3/4	3020	24	18	19	12.5
7/8″	9	0.419	1 7/16	1.589	23/32	1 5/16	1.742	19/32	1 7/16	1.589	7/8	4190	36	29	28	17.0
1″	8	0.551	1 5/8	1.796	13/16	1 1/2	1.991	21/32	1 5/8	1.796	1	5510	53	42	41	22.3
1 1/8″	7	0.693	1 13/16	2.002	29/32	1 11/16	2.239	3/4	1 13/16	2.002	1 1/8	6930	73	60	56	28.2
1 1/4″	7	0.890	2	2.209	1	1 7/8	2.489	27/32	2	2.209	1 1/4	8900	94	84	73	34.8
1 1/2″	6	1.294	2 3/8	2.622	1 3/16	2 1/4	2.986	1	2 3/8	2.622	1 1/2	12940	162	143	123	50.07
1 3/4″	5	1.744	2 3/4	3.035	1 3/8	2 5/8	3.485	1 5/32	2 3/4	3.035	1 3/4	17440	254	226	208	68.15
2″	4 1/2	2.300	3 1/8	3.449	1 9/16	3	3.982	1 11/32	3 1/8	3.449	2	23000	377	343	303	89.00
2 1/4″	4 1/2	3.021	3 1/2	3.862	1 3/4	3 3/8	4.479	1 1/2	3 1/2	3.862	2 1/4	30210	538	484	422	112.7

Weights from AISC Manual 1948.

All bolts and nuts shall be threaded in accordance with American Standard for Screw Threads, ASA B1.1 Coarse Thread Series, Class 2 Fit.

Weights in pounds.

Dimensions and Weights of Flanged Fittings for Water

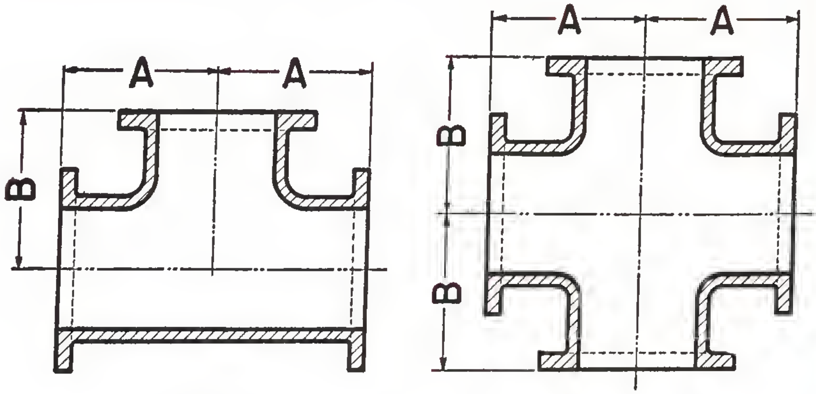


Bends

Size	Class	90° Bend (1/4)		45° Bend (1/8)		22½° Bend (1/16)		11¼° Bend (1/32)		5⅝° Bend (1/64)	
		A	Wt.	A	Wt.	A	Wt.	A	Wt.	A	Wt.
6	D	16	100	9.94	80	9.55	80	......	......	......	......
8	D	16	145	9.94	125	9.55	125	......	......	......	......
10	D	16	205	9.94	170	9.55	170	......	......	......	......
12	D	16	285	9.94	240	9.55	240	......	......	......	......
14	B	18	330	14.91	330	14.32	330	......	......	......	......
14	D	18	380	14.91	385	14.32	385	......	......	......	......
16	B	24	495	14.91	405	14.32	405	......	......	......	......
16	D	24	590	14.91	475	14.32	475	......	......	......	......
18	B	24	575	14.91	465	14.32	465	......	......	......	......
18	D	24	690	14.91	550	14.32	550	......	......	......	......
20	B	24	690	19.88	690	19.10	690	23.64	820	23.58	820
20	D	24	830	19.88	830	19.10	830	23.64	1000	23.58	1000
24	B	30	1105	24.85	1105	23.87	1105	23.64	1105	23.58	1105
24	D	30	1350	24.85	1350	23.87	1350	23.64	1345	23.58	1345
30	A	36	1640	24.85	1435	23.87	1435	23.64	1430	23.58	1430
30	B	36	1845	24.85	1600	23.87	1600	23.64	1600	23.58	1600
30	C	36	2075	24.85	1790	23.87	1790	23.64	1790	23.58	1790
30	D	36	2315	24.85	1985	23.87	1985	23.64	1985	23.58	1985
36	A	48	2830	37.28	2690	35.80	2690	23.64	1985	23.58	1985
36	B	48	3180	37.28	3015	35.80	3015	23.64	2195	23.58	2195
36	C	48	3650	37.28	3455	35.80	3455	23.64	2475	23.58	2475
36	D	48	4145	37.28	3915	35.80	3915	23.64	2770	23.58	2770
42	A	48	3740	37.28	3560	35.80	3560	23.64	2645	23.58	2645
42	B	48	4200	37.28	3985	35.80	3985	23.64	2920	23.58	2920
42	C	48	4865	37.28	4605	35.80	4605	23.64	3310	23.58	3310
42	D	48	5485	37.28	5185	35.80	5185	23.64	3685	23.58	3685
48	A	54	5280	37.28	4565	35.80	4565	23.64	3375	23.58	3375
48	B	54	5815	37.28	5005	35.80	5005	23.64	3655	23.58	3655
48	C	54	6770	37.28	5790	35.80	5790	23.64	4155	23.58	4155
48	D	54	7610	37.28	6475	35.80	6475	23.64	4590	23.58	4590

Laying dimensions are A.W.W.A.—N.E.W.W.A.
Flanges are American Standard, Class 125.
Dimensions in inches.

Dimensions and Weights of Flanged Fittings for Water



Tees   Crosses

Size		Class	Dimensions		Weight	
Run	Branch		A	B	Tee	Cross
6	4	D	12	12	120	145
6	6	D	12	12	135	165
8	4	D	13	13	180	205
8	6	D	13	13	185	225
8	8	D	13	13	200	260
10	4	D	14	14	245	270
10	6	D	14	14	260	295
10	8	D	14	14	275	320
10	10	D	14	14	290	360
12	4	D	15	15	345	370
12	6	D	15	15	350	385
12	8	D	15	15	370	420
12	10	D	15	15	395	455
12	12	D	15	15	415	515
14	4	B	16	16	400	425
14	4	D	16	16	460	485
14	6	B	16	16	410	445
14	6	D	16	16	470	500
14	8	B	16	16	425	485
14	8	D	16	16	490	535
14	10	B	16	16	450	520
14	10	D	16	16	500	565

Laying dimensions are A.W.W.A.—N.E.W.W.A.
Flanges are American Standard, Class 125.
Dimensions in inches.

Dimensions and Weights of Flanged Fittings for Water

Size		Class	Dimensions		Weight	
Run	Branch		A	B	Tee	Cross
14	12	B	16	16	475	585
14	12	D	16	16	525	625
14	14	B	16	16	485	600
14	14	D	16	16	555	675
16	4	B	17	17	500	525
16	4	D	17	17	595	615
16	6	B	17	17	510	545
16	6	D	17	17	600	625
16	8	B	17	17	530	580
16	8	D	17	17	610	665
16	10	B	17	17	550	620
16	10	D	17	17	630	695
16	12	B	17	17	580	680
16	12	D	17	17	655	745
16	14	B	17	17	580	695
16	14	D	17	17	680	790
16	16	B	17	17	610	745
16	16	D	17	17	715	855
18	4	B	18	18	600	625
18	4	D	18	18	715	740
18	6	B	18	18	610	645
18	6	D	18	18	715	750
18	8	B	18	18	625	675
18	8	D	18	18	735	785
18	10	B	18	18	645	715
18	10	D	18	18	755	815
18	12	B	18	18	670	770
18	12	D	18	18	785	870
18	14	B	18	18	680	785
18	14	D	18	18	795	900
18	16	B	18	18	700	825
18	16	D	18	18	825	955
18	18	B	18	18	720	870
18	18	D	18	18	850	1005
20	6	B	19	19	755	790
20	6	D	19	19	895	930
20	8	B	19	19	780	825
20	8	D	19	19	915	960
20	10	B	19	19	790	855
20	10	D	19	19	925	990
20	12	B	19	19	820	910
20	12	D	19	19	955	1040
20	14	B	19	19	820	920

Laying dimensions are A.W.W.A.—N.E.W.W.A.
Flanges are American Standard, Class 125.
Dimensions in inches.

Dimensions and Weights of Flanged Fittings for Water

Size		Class	Dimensions		Weight	
Run	Branch		A	B	Tee	Cross
20	14	D	19	19	970	1075
20	16	B	19	19	845	960
20	16	D	19	19	1000	1130
20	18	B	19	19	860	995
20	18	D	19	19	1015	1165
20	20	B	19	19	890	1070
20	20	D	19	19	1055	1245
24	6	B	21	21	1080	1115
24	6	D	21	21	1305	1335
24	8	B	21	21	1095	1140
24	8	D	21	21	1315	1360
24	10	B	21	21	1115	1185
24	10	D	21	21	1330	1385
24	12	B	21	21	1140	1225
24	12	D	21	21	1355	1430
24	14	B	21	21	1140	1230
24	14	D	21	21	1365	1465
24	16	B	21	21	1165	1280
24	16	D	21	21	1390	1510
24	18	B	21	21	1170	1295
24	18	D	21	21	1400	1535
24	20	B	21	21	1200	1365
24	20	D	21	21	1435	1600
24	24	B	21	21	1270	1500
24	24	D	21	21	1520	1755
30	12	A	15	24	1225	1320
30	12	B	15	24	1330	1415
30	12	C	15	24	1445	1525
30	12	D	15	24	1565	1635
30	14	A	18	26	1385	1500
30	14	B	18	26	1515	1625
30	14	C	18	26	1680	1805
30	14	D	18	26	1825	1930
30	16	A	19	26	1460	1595
30	16	B	19	26	1595	1720
30	16	C	19	26	1775	1915
30	16	D	19	26	1925	2065
30	18	A	20	26	1520	1675
30	18	B	20	26	1665	1805
30	18	C	20	26	1860	2020
30	18	D	20	26	2015	2165
30	20	A	21	26	1610	1795
30	20	B	21	26	1750	1930

Laying dimensions are A.W.W.A.—N.E.W.W.A.
Flanges are American Standard, Class 125.
Dimensions in inches.

Dimensions and Weights of Flanged Fittings for Water

Size		Class	Dimensions		Weight	
Run	Branch		A	B	Tee	Cross
30	20	C	21	26	1955	2160
30	20	D	21	26	2125	2295
30	24	A	23	26	1775	2040
30	24	B	23	26	1930	2170
30	24	C	23	26	2170	2455
30	24	D	23	26	2350	2590
30	30	A	26	26	2015	2370
30	30	B	26	26	2235	2610
30	30	C	26	26	2480	2870
30	30	D	26	26	2725	3130
36	12	A	16	27	1745	1830
36	12	B	16	27	1880	1960
36	12	C	16	27	2065	2140
36	12	D	16	27	2265	2325
36	14	A	18	29	1885	1995
36	14	B	18	29	2045	2150
36	14	C	18	29	2275	2385
36	14	D	18	29	2505	2595
36	16	A	19	29	1975	2100
36	16	B	19	29	2140	2260
36	16	C	19	29	2390	2525
36	16	D	19	29	2625	2745
36	18	A	20	29	2050	2195
36	18	B	20	29	2230	2355
36	18	C	20	29	2495	2540
36	18	D	20	29	2750	2880
36	20	A	21	29	2145	2320
36	20	B	21	29	2335	2485
36	20	C	21	29	2615	2795
36	20	D	21	29	2875	3030
36	24	A	23	29	2340	2580
36	24	B	23	29	2540	2755
36	24	C	23	29	2870	3110
36	24	D	23	29	3145	3350
36	30	A	26	29	2605	2925
36	30	B	26	29	2880	3200
36	30	C	26	29	3215	3540
36	30	D	26	29	3570	3890
36	36	A	29	29	2975	3455
36	36	B	29	29	3270	3765
36	36	C	29	29	3670	4185
36	36	D	29	29	4090	4615
42	12	A	16	30	2300	2385

Laying dimensions are A.W.W.A.—N.E.W.W.A.
Flanges are American Standard, Class 125.
Dimensions in inches.

Dimensions and Weights of Flanged Fittings for Water

Size		Class	Dimensions		Weight	
Run	Branch		A	B	Tee	Cross
42	12	B	16	30	2485	2560
42	12	C	16	30	2745	2810
42	12	D	16	30	2990	3050
42	14	A	18	32	2490	2590
42	14	B	18	32	2695	2785
42	14	C	18	32	3010	3105
42	14	D	18	32	3295	3375
42	16	A	19	32	2585	2710
42	16	B	19	32	2810	2920
42	16	C	19	32	3150	3265
42	16	D	19	32	3450	3550
42	18	A	20	32	2685	2815
42	18	B	20	32	2915	3030
42	18	C	20	32	3275	3410
42	18	D	20	32	3595	3700
42	20	A	21	32	2790	2960
42	20	B	21	32	3035	3185
42	20	C	21	32	3425	3580
42	20	D	21	32	3755	3880
42	24	A	23	32	3015	3235
42	24	B	23	32	3285	3475
42	24	C	23	32	3725	3930
42	24	D	23	32	4075	4240
42	30	A	26	32	3335	3610
42	30	B	26	32	3665	3940
42	30	C	26	32	4130	4400
42	30	D	26	32	4570	4825
42	36	A	29	32	3725	4150
42	36	B	29	32	4105	4525
42	36	C	29	32	4630	5040
42	36	D	29	32	5140	5550
42	42	A	32	32	4185	4815
42	42	B	32	32	4610	5255
42	42	C	32	32	5220	5860
42	42	D	32	32	5785	6425
48	16	A	19	35	3245	3360
48	16	B	19	35	3470	3575
48	16	C	19	35	3900	4005
48	16	D	19	35	4250	4335
48	18	A	20	35	3365	3485
48	18	B	20	35	3605	3700
48	18	C	20	35	4060	4165
48	18	D	20	35	4425	4515

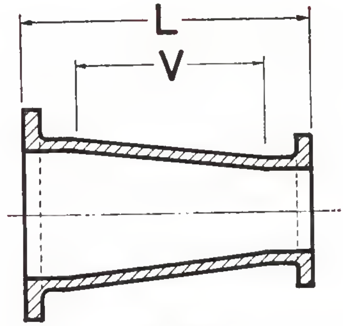
Laying dimensions are A.W.W.A.—N.E.W.W.A.
Flanges are American Standard, Class 125.
Dimensions in inches.

Dimensions and Weights of Flanged Fittings for Water

Size		Class	Dimensions		Weight	
Run	Branch		A	B	Tee	Cross
48	20	A	21	35	3500	3640
48	20	B	21	35	3750	3880
48	20	C	21	35	4230	4365
48	20	D	21	35	4620	4720
48	24	A	23	35	3765	3950
48	24	B	23	35	4035	4200
48	24	C	23	35	4580	4755
48	24	D	23	35	4990	5130
48	30	A	26	35	4140	4375
48	30	B	26	35	4485	4725
48	30	C	26	35	5060	5280
48	30	D	26	35	5575	5775
48	36	A	29	35	4585	4940
48	36	B	29	35	4965	5320
48	36	C	29	35	5630	5970
48	36	D	29	35	6220	6550
48	42	A	32	35	5085	5600
48	42	B	32	35	5510	6050
48	42	C	32	35	6260	6765
48	42	D	32	35	6915	7415
48	48	A	35	35	5620	6345
48	48	B	35	35	6085	6810
48	48	C	35	35	6915	7640
48	48	D	35	35	7640	8350

Laying dimensions are A.W.W.A.—N.E.W.W.A.
Flanges are American Standard, Class 125.
Dimensions in inches.

Dimensions and Weights of Flanged Fittings for Water



Reducers

Size	Class	L	V	Weight
6x 4	D	26	18	90
8x 4	D	26	18	110
8x 6	D	26	18	130
10x 4	D	26	18	135
10x 6	D	26	18	155
10x 8	D	26	18	185
12x 4	D	26	18	175
12x 6	D	26	18	195
12x 8	D	26	18	220
12x10	D	26	18	250
14x 6	B	28	20	215
14x 6	D	28	20	240
14x 8	B	28	20	245
14x 8	D	28	20	265
14x10	B	28	20	275
14x10	D	28	20	300
14x12	B	28	20	320
14x12	D	28	20	340
16x 6	B	28	20	250
16x 6	D	28	20	280
16x 8	B	28	20	280
16x 8	D	28	20	305
16x10	B	28	20	315
16x10	D	28	20	340
16x12	B	28	20	355
16x12	D	28	20	385
16x14	B	28	20	365
16x14	D	28	20	425

Dimensions in inches.
Flanges are ASA 125. For dimensions and drilling of flanges, see page 345.

Dimensions and Weights of Flanged Fittings for Water

Reducers

Size	Class	L	V	Weight
18x 8	B	28	20	310
18x 8	D	28	20	345
18x10	B	28	20	345
18x10	D	28	20	375
18x12	B	28	20	385
18x12	D	28	20	425
18x14	B	28	20	395
18x14	D	28	20	460
18x16	B	28	20	430
18x16	D	28	20	505
20x10	B	34	26	445
20x10	D	34	26	500
20x12	B	34	26	495
20x12	D	34	26	550
20x14	B	34	26	505
20x14	D	34	26	600
20x16	B	34	26	545
20x16	D	34	26	655
20x18	B	34	26	585
20x18	D	34	26	700
24x14	B	34	26	610
24x14	D	34	26	725
24x16	B	34	26	655
24x16	D	34	26	780
24x18	B	34	26	690
24x18	D	34	26	835
24x20	B	34	26	750
24x20	D	34	26	900
30x18	A	33.5	26	815
30x18	B	33.5	26	870
30x18	C	33.5	26	985
30x18	D	33.5	26	1045
30x20	A	73.5	66	1585
30x20	B	73.5	66	1705
30x20	C	73.5	66	2010
30x20	D	73.5	66	2150
30x24	A	73.5	66	1795
30x24	B	73.5	66	1920
30x24	C	73.5	66	2280
30x24	D	73.5	66	2430
36x20	A	73.5	66	1940
36x20	B	73.5	66	2085

Dimensions in inches.
Flanges are ASA 125. For dimensions and drilling of flanges, see page 345.

Dimensions and Weights of Flanged Fittings for Water

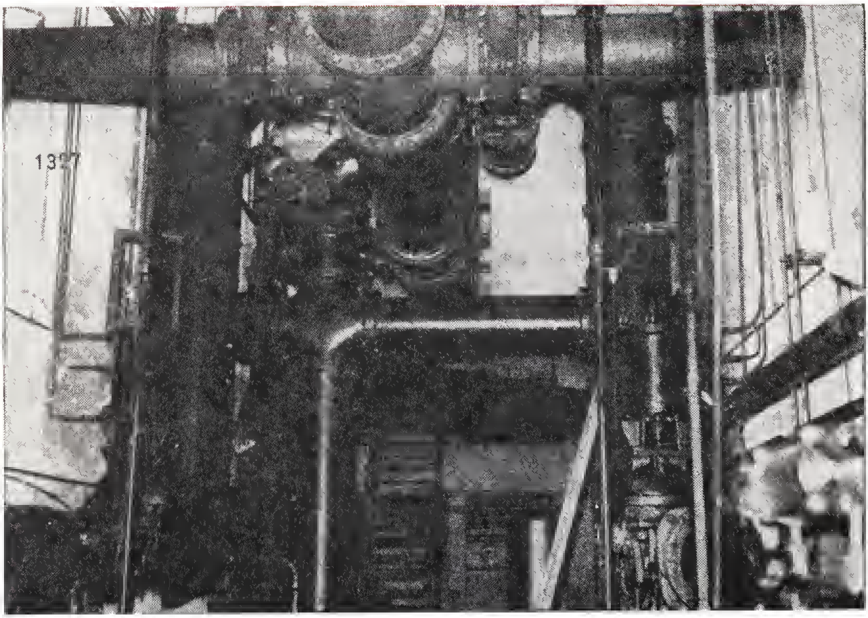
Reducers

Size	Class	L	V	Weight
36x20	C	73.5	66	2460
36x20	D	73.5	66	2670
36x24	A	73.5	66	2160
36x24	B	73.5	66	2310
36x24	C	73.5	66	2745
36x24	D	73.5	66	2960
36x30	A	73	66	2375
36x30	B	73	66	2675
36x30	C	73	66	3055
36x30	D	73	66	3445
42x20	A	73	66	2330
42x20	B	73	66	2515
42x20	C	73	66	2970
42x20	D	73	66	3215
42x24	A	73	66	2565
42x24	B	73	66	2750
42x24	C	73	66	3270
42x24	D	73	66	3525
42x30	A	72.5	66	2780
42x30	B	72.5	66	3130
42x30	C	72.5	66	3590
42x30	D	72.5	66	4035
42x36	A	72.5	66	3170
42x36	B	72.5	66	3560
42x36	C	72.5	66	4100
42x36	D	72.5	66	4635
48x30	A	72.5	66	3250
48x30	B	72.5	66	3605
48x30	C	72.5	66	4140
48x30	D	72.5	66	4635
48x36	A	72.5	66	3665
48x36	B	72.5	66	4050
48x36	C	72.5	66	4670
48x36	D	72.5	66	5260
48x42	A	72	66	4110
48x42	B	72	66	4545
48x42	C	72	66	5265
48x42	D	72	66	5910

Dimensions in inches.
Flanges are ASA 125. For dimensions and drilling of flanges, see page 345.

SECTION 14

A.S.A. Flanged Fittings



American Standard

Cast Iron Pipe Flanges and Flanged Fittings, Class 125

Introductory Notes

1. SCOPE

This standard for Cast Iron Pipe Flanges and Flanged Fittings, Class 125, covers:

(a) pressure ratings,
(b) sizes and method of designating openings of reducing fittings,
(c) marking,
(d) minimum requirements for materials,
(e) dimensions and tolerances,
(f) bolt, nut, and gasket dimensions,
(g) tests.

2. PRESSURE RATING

These flanges and fittings are rated as follows:

For maximum saturated steam service pressures of

125 psi (gage) sizes 1 to 12 in., incl.
100 psi (gage) sizes 14 to 24 in., incl.
50 psi (gage) sizes 30 to 48 in., incl.

For maximum liquid and gas service pressures at 150° F. of

175 psi (gage) sizes 1 to 12 in., incl.
150 psi (gage) sizes 14 to 48 in., incl.
for flanges only.[1]

3. SIZE*

The size of the flanges and fittings scheduled in the following tables is identified by the corresponding "nominal pipe size." For pipe 14 in. and larger the corresponding OD of the pipe is given.

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[1] It will be noted that water service ratings as shown for sizes 14 in. and larger in this standard are applicable to flanges only and not to fittings. Water service ratings on fittings 14 in. and larger are withheld in this issue of the standard pending receipt of final report on research work which is now being conducted by ASA Sectional Committee A21.

*A Simplified Practice Recommendation on Pipe Fittings is published by the U. S. Department of Commerce, National Bureau of Standards, Division of Simplified Practice.

Reducing fittings shall be designated by the size of the openings in their proper sequence as indicated in the sketches, Fig. 1.

4. MARKING

Fittings.—The manufacturer's name or trade mark and numerals as shown below to indicate the maximum saturated steam service pressure shall be cast on the exterior surface of all fittings.

For Sizes	*Numerals*
1 to 12 in., incl.	125
14 to 24 in., incl.	100
30 to 48 in., incl.	50

Flanges.— The manufacturer's name or trade mark shall be cast on all loose flanges.

The above marking requirements comply with principles established in MSS Standard Practice SP-25–1936.

5. MATERIAL

Castings.—The dimensions prescribed in this standard are based upon gray iron castings of high quality produced under regular control of chemical and physical properties by a recognized process. The manufacturer shall be prepared to certify that his product has been so produced and that the chemical and physical properties thereof, as proved by test specimens, are at least equal to the requirements shown herein which are taken from the ASTM Specification A 126–1942.

Class A (regular gray iron)	
Sulphur	0.12 per cent maximum
Phosphorous	0.75 per cent maximum
Tensile strength	21,000 psi minimum

Class B (higher strength gray iron)	
Sulphur	0.12 per cent maximum
Phosphorous	0.75 per cent maximum
Tensile strength	31,000 psi minimum

It is intended that material required by this standard shall be in accordance with the requirements specified herein or the latest edition of ASTM A 126.

Flanges and fittings shall be made of material at least equal to the requirements of Class A iron for sizes 12 in. and smaller and Class B iron for sizes 14 in. and larger.

Bolting.—The bolting used with these flanges and fittings shall be made of carbon steel which conforms to the requirements of MSS Standard Practice SP-39–1945 for bolts.*

Fitting Dimensions and Tolerances

6. WALL THICKNESS

It is recognized that some variations are absolutely unavoidable in the making of patterns and castings. Equipment shall be designed to produce wall thicknesses given in the tables. Wall thickness at no point shall be less than 87½ per cent of the thickness given in the tables.

7. CENTER TO FACE DIMENSIONS

a. Side Outlet Fittings.—Side outlet elbows, side outlet tees, and side outlet crosses, shall have all openings on intersecting center lines. Long radius elbows with side outlet shall have the side outlet on the radial center line of the elbow.

b. Elbows.—1. The center to face dimensions for straight size 90 deg. elbows, 90 deg. long radius elbows, 45 deg. elbows, side outlet elbows, and double branch elbows are shown in Table 4.

2. Reducing 90 deg. elbows, reducing 90 deg. long radius elbows, reducing side outlet elbows, and reducing double branch elbows shall have same center to face dimensions as straight size fittings shown in Table 4 corresponding to the size of the larger opening.

3. For 90 deg. long radius elbows with side outlet the center to face dimensions of side outlet shall be the same as dimension "A," Table 4, for a straight size 90 deg. elbow corresponding to the size of the larger opening.

4. Special degree elbows ranging from 1 to 45 deg., inclusive, shall have the same center to face dimensions given for 45 deg. elbows and those over 45 deg. and up to 90 deg., inclusive, shall have the same center to face dimensions given for 90 deg. elbows. The angle designation of an elbow is its deflection from straight line flow and is the angle between the flange faces.

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*The carbon steel bolts prescribed for the flanges in this standard are based upon using a flat ring gasket which extends to the bolts.

In all cases where these cast iron flanges are bolted to a steel flange, the latter shall be plain faced, i.e., without projection or raised face.

Where cast iron to cast iron flanges or cast iron to steel flanges are used with full-face gaskets, higher strength bolts may properly be used.

Where cast iron flanges are bolted to a steel flange and flat ring gasket is used, carbon steel bolts prescribed in this standard shall be employed.

c. *Tees, Crosses, and Laterals.*—1. The center to face dimensions for straight size tees and crosses, with or without side outlet, and laterals are shown in Table 4.

2. Reducing tees and reducing crosses, with or without side outlet, and reducing laterals, sizes 16 in. and smaller, shall have the same center to face dimensions as straight size fittings shown in Table 4 corresponding to the size of the largest opening.

For sizes 18 in. and larger, if: (1) The outlet of a reducing tee, (2) the branch of a reducing lateral, or, if (3) the largest outlet of a reducing side outlet tee, reducing cross, and reducing side outlet cross is the same size or smaller than given in Tables 5 and 6 (short body pattern), the center to face dimensions shown in these tables shall be used. If a branch or any outlet is larger than shown in Tables 5 and 6, the center to face dimensions shall be the same as for the straight size fitting shown in Table 4 corresponding to the size of the largest opening.

Tees, crosses, and laterals, reducing on the run only, shall have the same center to face dimensions as straight size fittings shown in Table 4 corresponding to the size of the largest opening.

3. Tees reducing on both runs are generally known as bull head tees and have the same center to face dimensions as straight size fittings corresponding to the size of the outlet.

d. *True Y's.*—Center to face dimensions for straight size true Y's are shown in Table 4. Reducing sizes are considered special and should be made to suit conditions.

e. *Reducers and Eccentric Reducers.*—The face to face dimensions for all reductions of reducers and eccentric reducers shall be the same as given in Table 4 for the larger opening.

8. CENTER TO FACE TOLERANCES

An inspection tolerance of plus or minus 1/32 in. shall be allowed on all center to contact surface dimensions for sizes up to and including 10 in. and plus or minus 1/16 in. on sizes larger than 10 in. An inspection tolerance of plus or minus 1/16 in. shall be allowed on all contact surface to contact surface dimensions for sizes up to and including 10 in. and plus or minus 1/8 in. on sizes larger than 10 in. The largest opening in the fitting governs the tolerance to be applied to all openings.

9. THREAD OF SCREWED FLANGES

The flanges shall have an American Standard Taper Pipe Thread in accordance with ASA B2.1–1945. The thread shall be concentric with the axis of the flange and variations in alignment shall not exceed 1/16 in. per ft.

Threads shall be chamfered approximately to the major diameter of the thread at the back of the flange at an angle of approximately 45 deg. with the axis of the thread for the purpose of easy entrance in making a joint and for the protection of the thread. The chamfer shall be concentric with the thread, and shall be included in measurements of the thread length.

The gaging notch of working gage should come flush with the bottom of chamfer and the maximum allowable thread variation is one turn large or one turn small from the gaging notch.

10. FACINGS*

These cast iron flanges and flanged fittings shall be plain faced; i.e., without projection or raised face and finished in accordance with MSS SP-6–1947.

11. FLANGE BOLT HOLES

Bolt holes shall be in multiples of four so that fittings may be made to face in any quarter. The bolt holes shall straddle the center line.

For bolts smaller than 1¾ in. in diameter, the bolt holes shall be ⅛ in. larger than the nominal diameter of the bolt; for bolts 1¾ in. in diameter and larger, bolt holes shall be ¼ in. larger than the nominal diameter of the bolt.

12. SPOT FACING

Flanges.—The bolt holes of these cast iron flanges need not be spot faced for ordinary service except, as follows: In sizes 12 in. and smaller when rough flanges, after facing, are oversize more than ⅛ in. in thickness, they shall be spot faced to the specified thickness of flange (minimum) with a plus tolerance of 1/16 in. In sizes 14 to 24 in., inclusive, when rough flanges, after facing, are oversize more than 3/16 in. in thickness they shall be spot faced to the specified thickness of flange (minimum) with a plus tolerance of 1/16 in. In sizes 30 in. and larger when rough flanges, after facing, are oversize more than ¼ in. in thickness they shall be spot faced to the specified thickness of flange (minimum) with a plus tolerance of ⅛ in.

Fittings.—The bolt holes of the flanges on these cast iron fittings need not be spot faced on sizes smaller than 18 in. for ordinary service, except as required for oversize thickness of flanges as indicated above. The bolt

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*See footnote on page 338.

holes of all flanges on fittings 18 to 24 in., inclusive, shall be spot faced to the specified thickness of the flange (minimum) with a plus tolerance of 1/16 in., and of all flanges on fittings sizes 30 to 48 in., inclusive, they shall be spot faced to the specified thickness of the flange (minimum) with a plus tolerance of 1/8 in.

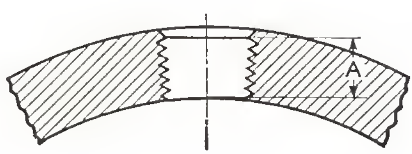
Where spot facing of flanges and fittings is necessary, the spot facing diameter shall be in accordance with MSS Standard Practice SP-9–1947.

13. CROSSES AND LATERALS

Crosses and laterals (Y-branches) both straight and reducing shall be reinforced where necessary to compensate for the inherent weakness in the casting design.

14. DRAIN TAPPINGS

Holes may be tapped in the wall of fitting if the metal thickness is sufficient to provide the effective length of thread specified in Table 1; where thread length is insufficient or size of tapping is such that reinforcement of opening is necessary, a boss should be added.



Minimum Thread Length

TABLE NO. 1

Size of tapping	3/8	1/2	3/4	1	1 1/4	1 1/2	2
Length of thread, "A"	0.41	0.53	0.55	0.68	0.71	0.72	0.76

All dimensions given in inches.

In no case shall the effective length of thread "A" be less than that shown in table above. These lengths are equal to the effective thread lengths of American Standard External Pipe Threads (ASA B2.1–1945).

The method of designating the locations of the tapped holes for drains is shown in Fig. 2. Each possible location is designated by a letter so that desired locations for the various types of fittings may be definitely specified without the use of further sketches or description. For further detail in applying tappings, see MSS Standard Practice SP-28–1945.

Bolt, Nut, and Gasket Dimensions

15. BOLTS AND NUTS

Bolts shall have American Standard Regular Unfinished Square Heads or American Standard Heavy Unfinished Hexagonal Heads and the nuts shall be American Standard Heavy Unfinished Hexagonal dimensions all as specified in American Standard for Wrench Head Bolts and Nuts and Wrench Openings (ASA B18.2–1941). For bolts of 1¾ in. in diameter and larger, bolt-studs with a nut on each end are recommended.

Hexagonal nuts for pipe sizes 1 to 48 in. can be conveniently pulled up with open wrenches of minimum design of heads. Hexagonal nuts for pipe sizes 48 to 96 in. can be conveniently pulled up with box wrenches.

All bolts, or bolt-studs if used, and all nuts shall be threaded in accordance with American Standard for Screw Threads (ASA B1.1–1935) Coarse-Thread Series, Class 2 Fit.

16. GASKETS*

Ring gaskets shall be in accordance with dimensions given in Table 2.

17. TESTS

These fittings shall be designed to withstand, without showing leaks hydrostatic test pressures of twice the rated steam pressure. Hydrostatic tests of cast iron fittings covered by this standard are not required unless specified by the user.

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*See footnote on page 338.

Class 125 Cast Iron Flanges and Fittings

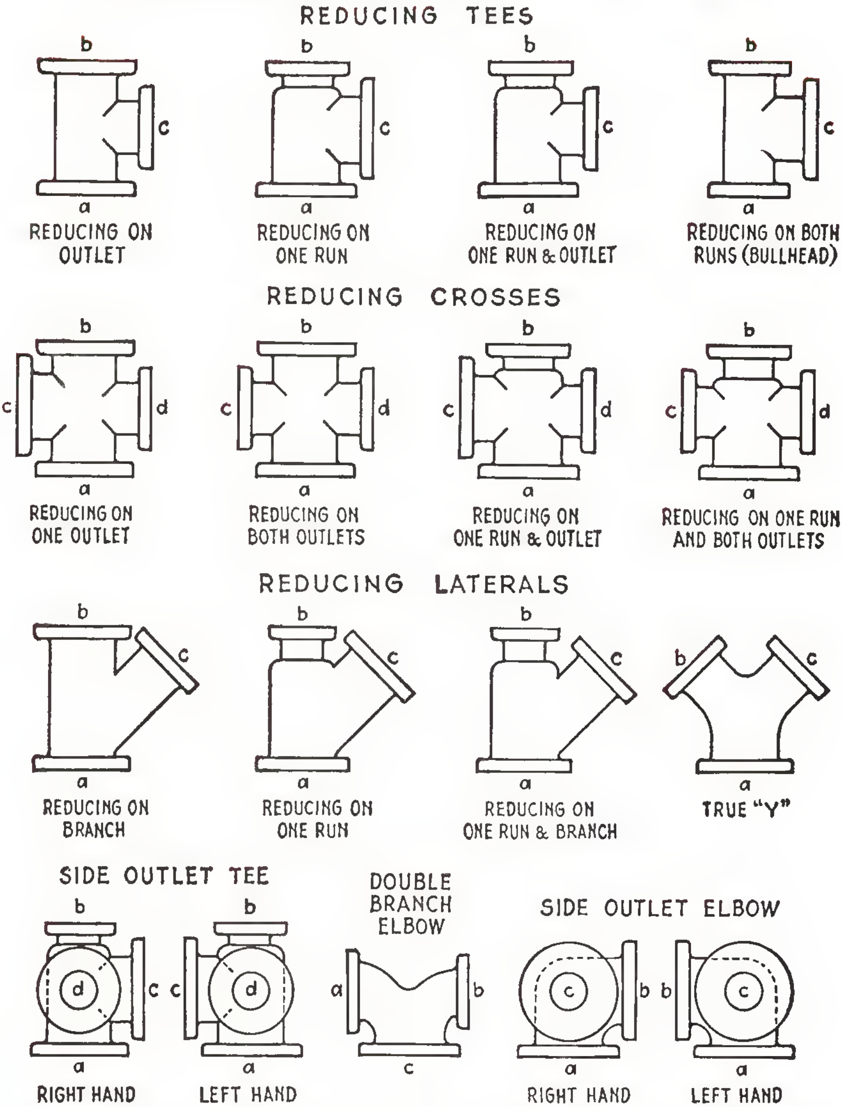


Fig. 1 Method of Designating Outlets of Reducing Fittings in Specifications

Note: The largest opening establishes the basic size of a reducing fitting. The largest opening is named first, except for bull head tees which are reducing on both runs and for double branch elbows where both branches are reducing, the outlet is the largest opening and named last in both cases.

In designating the openings of reducing fittings they should be read in the order indicated by the sequence of the letters a, b, c, and d. In designating the outlets of side outlet reducing fittings the side outlet is named last and in the case of the cross which is not shown the side outlet is designated by the letter e.

Class 125 Cast Iron Flanges and Fittings

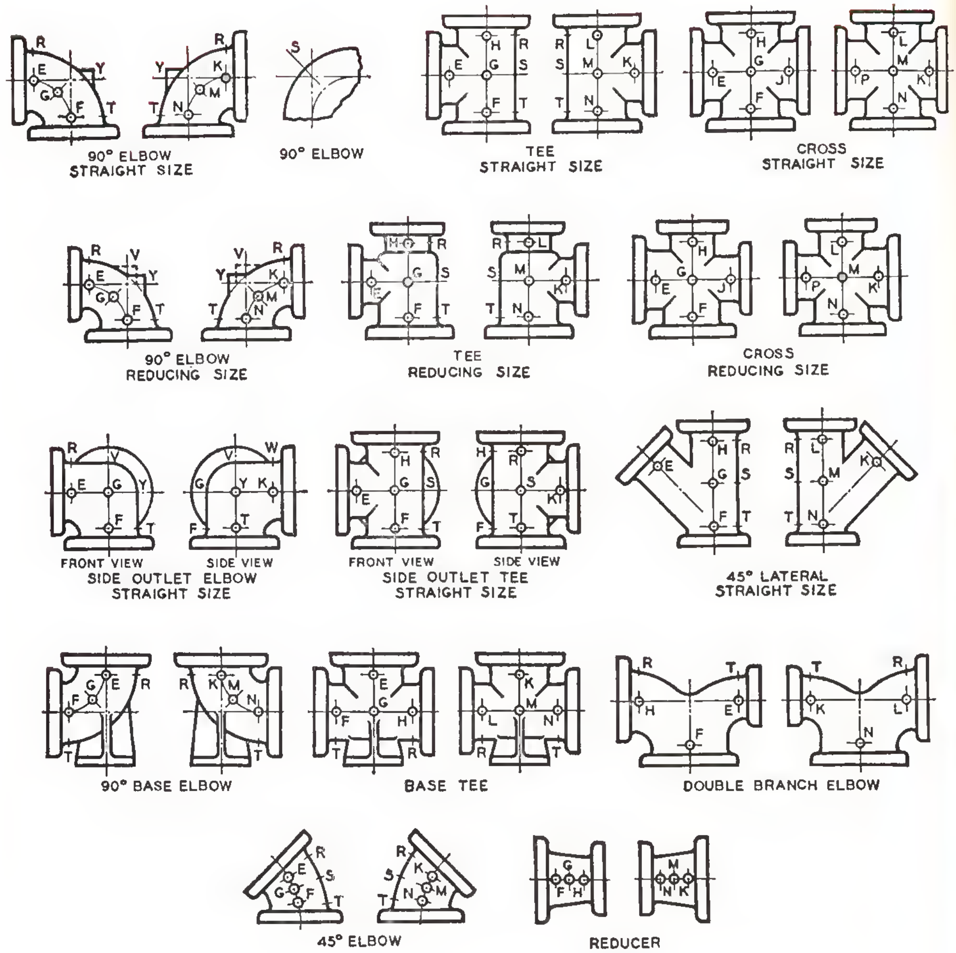


Fig. 2 Method of Designating Location of Tapped Holes for Drains When Specified

Note: The above sketches show two views of the same fitting and represent fittings with symmetrical shapes, with the exception of the side outlet elbow and the side outlet tee (straight sizes).

Class 125 Cast Iron Flanges and Fittings

Dimensions of Cast Iron Flanges, Bolts, and Ring Gaskets

TABLE NO. 2

Nominal Pipe Size	Diam. of Flange	Thickness[1] of Flange (Min.)	Diam. of Bolt Circle	Number[2] of Bolts	Diam. of Bolts	Diam.[2] of Bolt Holes	Length[3,4] of Bolts	Length[3,4] of Bolt-Stud With Two Nuts	Size of Flat Ring Gasket
1	4¼	7/16	3⅛	4	½	⅝	1¾	....	1x2⅝
1¼	4⅝	½	3½	4	½	⅝	2	....	1¼x3
1½	5	9/16	3⅞	4	½	⅝	2	....	1½x3⅜
2	6	⅝	4¾	4	⅝	¾	2¼	....	2x4⅛
2½	7	11/16	5½	4	⅝	¾	2½	....	2½x4⅞
3	7½	¾	6	4	⅝	¾	2½	....	3x5⅜
3½	8½	13/16	7	8	⅝	¾	2¾	....	3½x6⅜
4	9	15/16	7½	8	⅝	¾	3	....	4x6⅞
5	10	15/16	8½	8	¾	⅞	3	....	5x7¾
6	11	1	9½	8	¾	⅞	3¼	....	6x8¾
8	13½	1⅛	11¾	8	¾	⅞	3½	....	8x11
10	16	1 3/16	14¼	12	⅞	1	3¾	....	10x13⅜
12	19	1¼	17	12	⅞	1	3¾	....	12x16⅛
14 OD	21	1⅜	18¾	12	1	1⅛	4¼	....	14x17¾
16 OD	23½	1 7/16	21¼	16	1	1⅛	4½	....	16x20¼
18 OD	25	1 9/16	22¾	16	1⅛	1¼	4¾	....	18x21⅝
20 OD	27½	1 11/16	25	20	1⅛	1¼	5	....	20x23⅞
24 OD	32	1⅞	29½	20	1¼	1⅜	5½	....	24x28¼
30 OD	38¾	2⅛	36	28	1¼	1⅜	6¼	....	30x34¾
36 OD	46	2⅜	42¾	32	1½	1⅝	7	....	36x41¼
42 OD	53	2⅝	49½	36	1½	1⅝	7½	....	42x48
48 OD	59½	2¾	56	44	1½	1⅝	7¾	....	48x54½
*54 OD	66¼	3	62¾	44	1¾	2	8½	10½	54x61
*60 OD	73	3⅛	69¼	52	1¾	2	8¾	10¾	60x67½
*72 OD	86½	3½	82½	60	1¾	2	9½	11½	72x80¾
*84 OD	99¾	3⅞	95½	64	2	2¼	10½	12¾	84x93½
*96 OD	113¼	4¼	108½	68	2¼	2½	11½	14	96x106¼

All dimensions given in inches.

* These sizes are included for convenience and do not carry a definite rating.

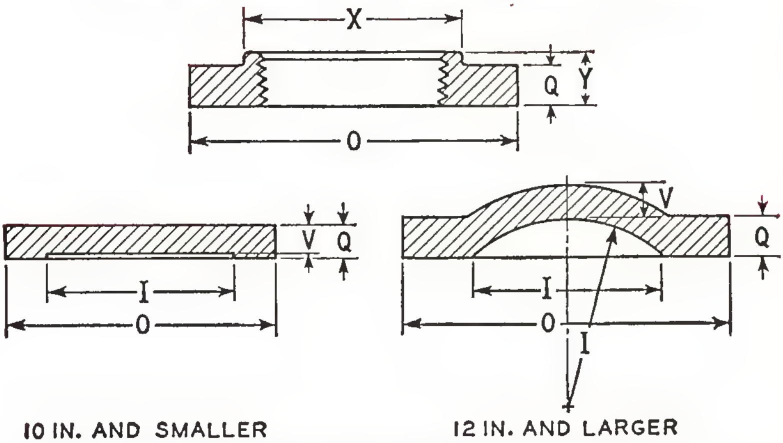
[1] For facing, see Introductory Note 10.

[2] For flange bolt holes, see Introductory Note 11.

[3] For spot facing, see Introductory Note 12.

[4] For bolts and nuts, see Introductory Note 15.

Class 125 Cast Iron Flanges and Fittings



Dimensions of Screwed Companion and Blind Flanges[2,3]

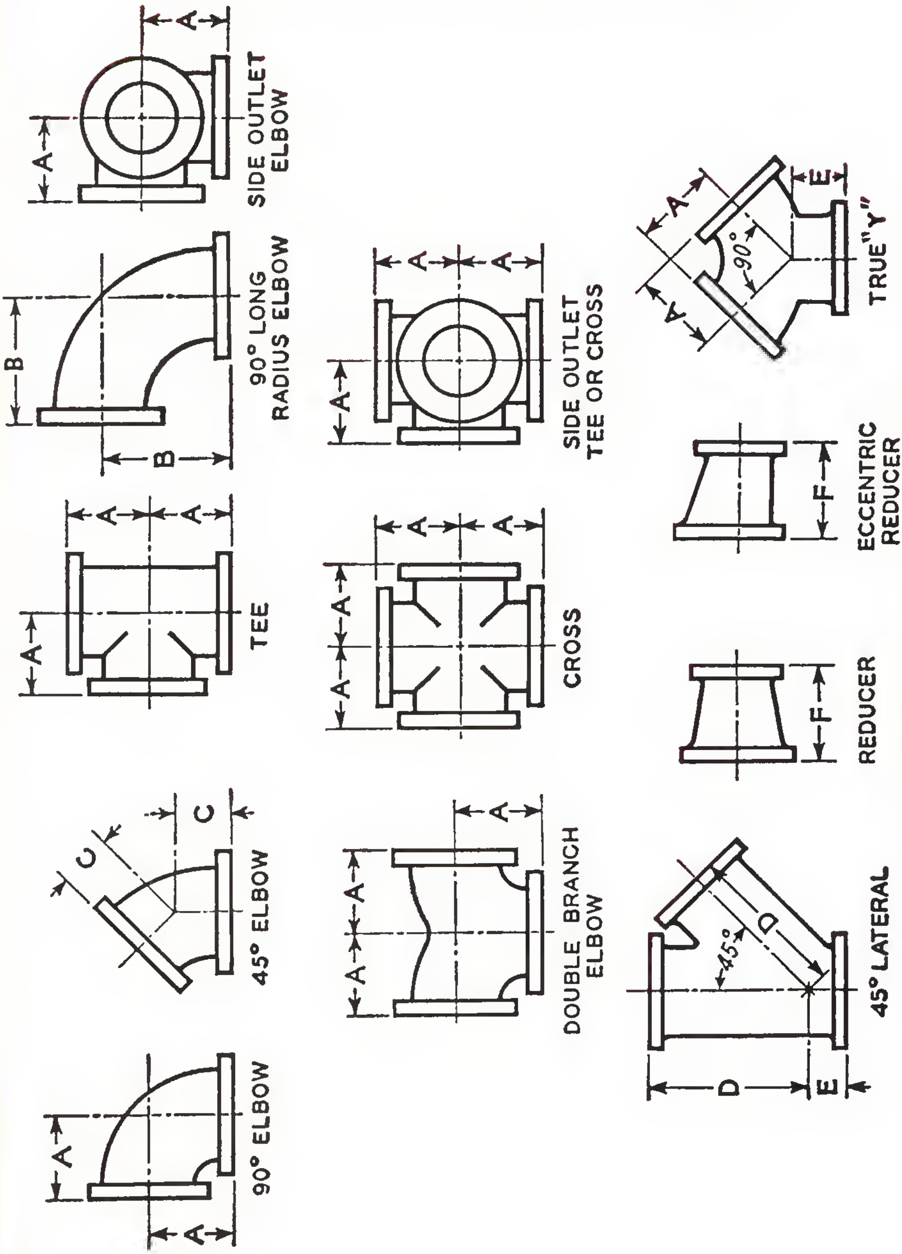
TABLE NO. 3

Nominal[6] Pipe Size I	Diam. of Flange O	Thickness[1] of Flange (Min.) Q	Wall[4] Thickness V	Diam. Hub (Min.) X	Length of Hub and Threads[5] (Min.) Y
1	4¼	7/16	3/8	1 15/16	11/16
1¼	4 5/8	½	7/16	2 5/16	13/16
1½	5	9/16	½	2 9/16	7/8
2	6	5/8	9/16	3 1/16	1
2½	7	11/16	5/8	3 9/16	1 1/8
3	7½	¾	11/16	4¼	1 3/16
3½	8½	13/16	¾	4 13/16	1¼
4	9	15/16	7/8	5 5/16	1 5/16
5	10	15/16	7/8	6 7/16	1 7/16
6	11	1	15/16	7 9/16	1 9/16
8	13½	1 1/8	1 1/16	9 11/16	1¾
10	16	1 3/16	1 1/8	11 15/16	1 15/16
12	19	1¼	13/16	14 1/16	2 3/16
14 OD	21	1 3/8	7/8	15 3/8	2¼
16 OD	23½	1 7/16	1	17½	2½
18 OD	25	1 9/16	1 1/16	19 5/8	2 11/16
20 OD	27½	1 11/16	1 1/8	21¾	2 7/8
24 OD	32	1 7/8	1¼	26	3¼
30 OD	38¾	2 1/8	1 7/16	....	....
36 OD	46	2 3/8	1 5/8	....	....
42 OD	53	2 5/8	1 13/16	....	....
48 OD	59½	2¾	2	....	....

All dimensions given in inches.

[1] For facing, see Introductory Note 10.
[2] For flange bolt holes, refer to Table 2, also see Introductory Note 11.
[3] For spot facing, see Introductory Note 12.
[4] For wall thickness tolerance, see Introductory Note 6.
[5] For thread of screwed flanges, see Introductory Note 9.
[6] All blind flanges for sizes 12 in. and larger must be dished with inside radius equal to the port diameter.

Class 125 Cast Iron Flanges and Fittings



The illustrations on this page apply to Table 4

Class 125 Cast Iron Flanges and Fittings

Dimensions of Elbows, Double Branch Elbows, Tees, Crosses, Laterals, True Y's (Straight Sizes), and Reducers [1,2,3,5,12]

TABLE NO. 4

Nominal Pipe Size	Inside Diam. of Fittings	Center[6,7,8,9] to Face 90 Deg. Elbow Tees, Crosses, True "Y" and Double Branch Elbow A	Center to Face 90 Deg. Long Radius Elbow[6,7,8] B	Center[8] to Face 45 Deg. Elbow C	Center[10] to Face Lateral D	Short Center[10] to Face True "Y" and Lateral E	Face[11] to Face Reducer F	Diam. of Flange	Thickness of Flange (Min.)	Wall[4] Thickness
1	1	3½	5	1¾	5¾	1¾	....	4¼	7/16	5/16
1¼	1¼	3¾	5½	2	6¼	1¾	....	4⅝	½	5/16
1½	1½	4	6	2¼	7	2	....	5	9/16	5/16
2	2	4½	6½	2½	8	2½	5	6	⅝	5/16
2½	2½	5	7	3	9½	2½	5½	7	11/16	5/16
3	3	5½	7¾	3	10	3	6	7½	¾	⅜
3½	3½	6	8½	3½	11½	3	6½	8½	13/16	7/16
4	4	6½	9	4	12	3	7	9	15/16	½
5	5	7½	10¼	4½	13½	3½	8	10	15/16	½
6	6	8	11½	5	14½	3½	9	11	1	9/16
8	8	9	14	5½	17½	4½	11	13½	1⅛	⅝
10	10	11	16½	6½	20½	5	12	16	1 3/16	¾
12	12	12	19	7½	24½	5½	14	19	1¼	13/16
14 OD	14	14	21½	7½	27	6	16	21	1⅜	⅞
16 OD	16	15	24	8	30	6½	18	23½	1 7/16	1
18 OD	18	16½	26½	8½	32	7	19	25	1 9/16	1 1/16
20 OD	20	18	29	9½	35	8	20	27½	1 11/16	1⅛
24 OD	24	22	34	11	40½	9	24	32	1⅞	1¼
30 OD	30	25	41½	15	49	10	30	38¾	2⅛	1 7/16
36 OD	36	28*	49	18	....	....	36	46	2⅜	1⅝
42 OD	42	31*	56½	21	....	....	42	53	2⅝	1 13/16
48 OD	48	34*	64	24	....	....	48	59½	2¾	2

All dimensions given in inches.

For weights, see tables 1A, 2A, 3A, 4A and 5A, beginning with page 354.

*Does not apply to true Y's or double branch elbows.

1 For facing, see Introductory Note 10.

2 For flange bolt holes, refer to Table 2, also see Introductory Note 11.

3 For spot facing, see Introductory Note 12.

4 For wall thickness tolerance, see Introductory Note 6.

5 For center to face tolerances, see Introductory Note 8.

6 For intersecting center lines of side outlet elbows, see Introductory Note 7a.

7 For center to face dimensions of reducing elbows and side outlet elbows, see Introductory Note 7b2 and 3.

8 For center to face dimensions of special degree elbows, see Introductory Note 7b4.

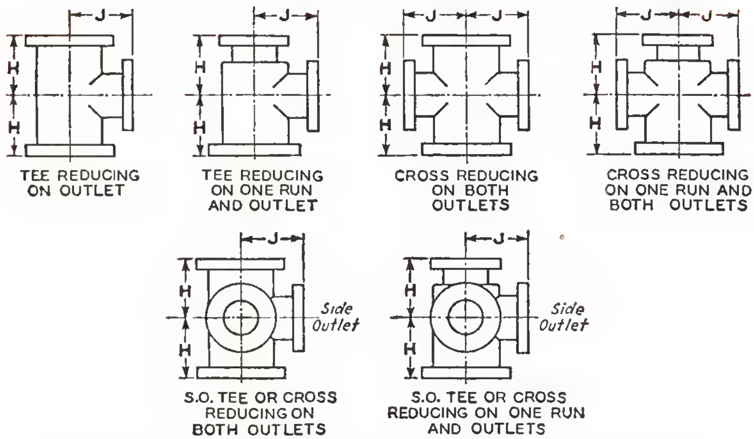
9 For center to face dimensions of reducing tees and crosses, see Table 5.

10 For center to face dimensions of reducing laterals, see Table 6.

11 For face to face dimensions of reducers and eccentric reducers, see Introductory Note 7e.

12 For reinforcement of crosses and laterals, see Introductory Note 13.

Class 125 Cast Iron Flanges and Fittings



Dimensions of Reducing Tees and Reducing Crosses (Short Body Patterns)[1, 2, 3, 4, 5, 10]

TABLE NO. 5

Nominal Pipe Size	Size[6, 9] of Outlet and Smaller	Center[7, 8] to Face Run H	Center to Face Outlet or Side Outlet J
18 OD	12	13	15½
20 OD	14	14	17
24 OD	16	15	19
30 OD	20	18	23
36 OD	24	20	26
42 OD	24	23	30
48 OD	30	26	34

All reducing tees and crosses, sizes, 16 in. and smaller, shall have same center to face dimensions as straight size fittings, corresponding to the size of the largest opening. See Table 4. See Introductory Note 7c2 and 7c3.

All dimensions given in inches.

[1] For facing, see Introductory Note 10.

[2] For flange bolt holes refer to Table 2, also see Introductory Note 11.

[3] For spot facing, see Introductory Note 12.

[4] For flange dimensions, wall thickness, and port diameter, see Table 4.

[5] For center to face tolerances, see Introductory Note 8.

[6] For center to face dimensions of tees and crosses having outlets larger than given in the above table, see Introductory Note 7c2.

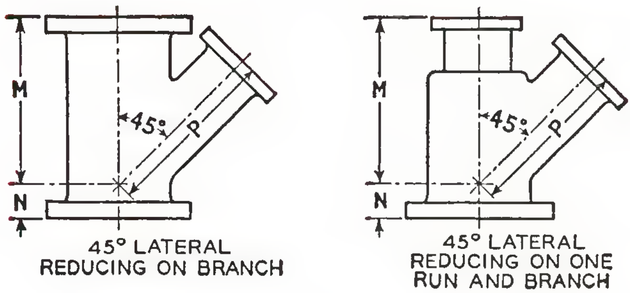
[7] For center to face dimensions of tees and crosses reducing on one run only, see Introductory Note 7c2.

[8] For center to face dimensions of tees reducing on both runs, known as bull head tees, see Introductory Note 7c3.

[9] For center to face dimensions of reducing side outlet tees and crosses having two different size reductions on the outlets, see Introductory Note 7c2.

[10] For reinforcement of crosses, see Introductory Note 13.

Class 125 Cast Iron Flanges and Fittings



Reducing Laterals (Short Body Pattern)[1,2,3,4,5,8]

TABLE NO. 6

Nominal Pipe Size	Size[6] of Branch and Smaller	Center[7] to Face Run M	Center to Face Run N	Center to Face Branch P
18 OD	8	25	1	27½
20 OD	10	27	1	29½
24 OD	12	31½	½	34½
30 OD	14	39	0	42

All reducing laterals sizes 16 inches and smaller, shall have same center to face dimensions as straight size fittings corresponding to size of the largest opening. See Table 4. See Introductory Note 7c2.

All dimensions given in inches.

1 For facing, see Introductory Note 10.

2 For flange bolt holes refer to Table 2, also see Introductory Note 11.

3 For spot facing, see Introductory Note 12.

4 For flange dimensions, wall thickness, and port diameter, see Table 4.

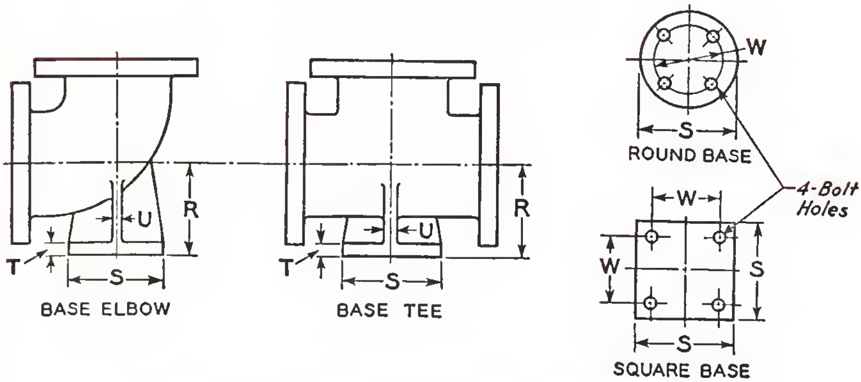
5 For center to face tolerances, see Introductory Note 8.

6 For center to face dimensions of laterals having branch larger than given in the above table, see Introductory Note 7c2.

7 For center to face dimensions of lateral reducing on run only, see Inductory Note 7c2.

8 For reinforcement of laterals, see Introductory Note 13.

Class 125 Cast Iron Flanges and Fittings



Dimensions of Base Elbows and Base Tees[1,3,5,6]

TABLE NO. 7

Nominal[6] Pipe Size	Center to Base R	Diam. of[2,4] Round Base or Width of Square Base S	Thickness of Base T	Thickness of Ribs U	Size of Supporting Pipe for Base	Base Drilling[2] Bolt Circl or Bolt Spacing W	Base Drilling[2] Diam. of Drilled Holes
1	3½	3½	7/16	⅜	¾	2¾	⅝
1¼	3⅝	3½	7/16	⅜	¾	2¾	⅝
1½	3¾	4¼	7/16	½	1	3⅛	⅝
2	4⅛	4⅝	½	½	1¼	3½	⅝
2½	4½	4⅝	½	½	1¼	3½	⅝
3	4⅞	5	9/16	½	1½	3⅞	⅝
3½	5¼	5	9/16	½	1½	3⅞	⅝
4	5½	6	⅝	½	2	4¾	¾
5	6¼	7	11/16	⅝	2½	5½	¾
6	7	7	11/16	⅝	2½	5½	¾
8	8⅜	9	15/16	⅞	4	7½	¾
10	9¾	9	15/16	⅞	4	7½	¾
12	11¼	11	1	1	6	9½	⅞
14 OD	12½	11	1	1	6	9½	⅞
16 OD	13¾	11	1	1	6	9½	⅞
18 OD	15	13½	1⅛	1⅛	8	11¾	⅞
20 OD	16	13½	1⅛	1⅛	8	11¾	⅞
24 OD	18½	13½	1⅛	1⅛	8	11¾	⅞

All dimensions given in inches.

[1] Bases not finished unless so ordered.

[2] Bolt hole template shown for round base is the same as for the flange of the supporting pipe size, except using only four holes in all cases so placed as to straddle center lines. The bases of these fittings are intended for support in compression and are not to be used for anchors or supports in tension or shear.

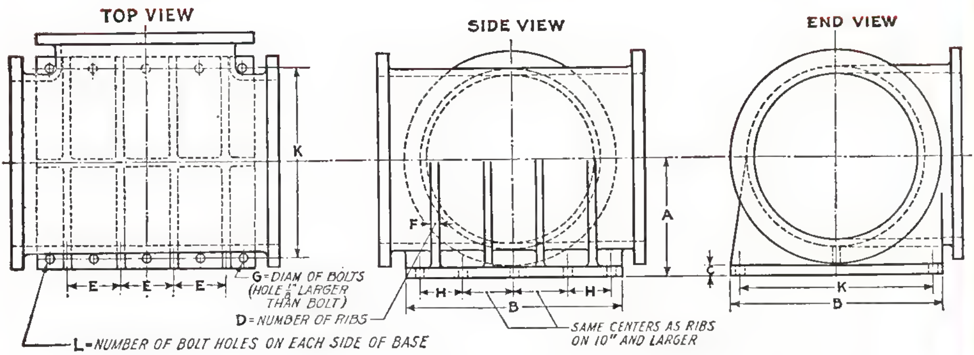
[3] The base dimensions apply to all straight and reducing sizes.

[4] For reducing fitting the size and center to face dimension of base are determined by the size of the largest opening of fitting. In the case of reducing base elbows orders shall specify whether the base shall be opposite the larger or smaller opening.

[5] For the fitting dimensions, refer to Tables 4 and 5.

[6] For tees, sizes larger than 24 in., anchorage fittings are recommended, see Tables 8 and 9.

Class 125 Cast Iron Flanges and Fittings



Dimensions of Anchorage Bases for Tees (Straight Sizes)[1,2]

TABLE NO. 8

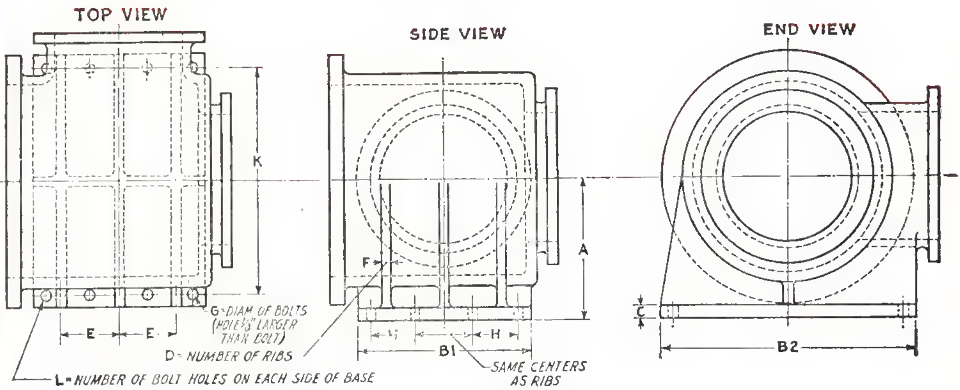
Nominal Pipe Size	Center to Base A	Width and Length of Square Base B	Thickness[1] of Base C	Number of Ribs D	Centers of Ribs and Inside Bolts E	Thickness of Ribs F	Diam. of Bolts G	Longitudinal Centers From End Bolt to 2nd Bolt H	Transverse Bolt Centers K	Number of Bolt Holes on Each Side of Bases L
2½	4½	7	11/16	1	....	7/16	⅝	4½	4½	2
3	4⅞	7½	¾	1	....	7/16	⅝	5	5	2
3½	5¼	8½	13/16	1	....	7/16	⅝	6	6	2
4	5½	9	15/16	2	4¼	½	⅝	3¼	6½	3
5	6¼	10	15/16	2	5	½	⅞	3¾	7½	3
6	7	11	1	2	6	9/16	⅞	4⅜	8¾	3
8	8⅜	13½	1⅛	2	8	⅝	1	5½	11	3
10	9¾	16	1 3/16	3	4⅞	¾	1⅛	4¼	13⅜	4
12	11¼	19	1¼	3	5¾	13/16	1¼	4⅞	15½	4
14 OD	12½	21	1⅜	3	6¾	⅞	1¼	5½	17¾	4
16 OD	13¾	23½	1 7/16	3	7¾	1	1⅜	6	19¾	4
18 OD	15	25	1 9/16	3	8½	1 1/16	1⅜	6⅝	21¾	4
20 OD	16	27½	1 11/16	3	9½	1⅛	1½	7¼	24	4
24 OD	18½	32	1⅞	3	11⅜	1¼	1⅝	8½	28⅜	4
30 OD	22	38¾	2⅛	4	9⅜	1 7/16	1¾	7⅞	34½	5
36 OD	25½	46	2⅜	4	11¼	1⅝	1⅞	9⅛	40¾	5
42 OD	29¼	53	2⅝	4	13	1 13/16	2	10⅜	46¾	5
48 OD	32¾	59½	2¾	4	14⅞	2	2¼	11¾	53¼	5

All dimensions given in inches.

[1] Bases not finished unless so ordered.

[2] For the tee dimensions, refer to Table 4.

Class 125 Cast Iron Flanges and Fittings



Dimensions of Anchorage Bases for Reducing Tees (Short Body Pattern)[1,3]

TABLE NO. 9

Nominal Pipe Size	Outlet[2] Sizes and Smaller	Center to Base	Length of Base	Width of Base	Thickness[3] of Base	Number of Ribs	Centers of Ribs and Inside Bolts	Thickness of Ribs	Diam. of Bolts	Longitudinal Center From End Bolt to 2nd Bolt	Transverse Bolt Centers	Number of Bolt Holes on Each Side of Base
		A	B1	B2	C	D	E	F	G	H	K	L
18 OD	12	15	19	25	1 9/16	3	5 1/4	1 1/16	1 1/4	5 1/8	21 1/2	4
20 OD	14	16	21	27 1/2	1 11/16	3	6	1 1/8	1 1/4	5 3/8	23 1/4	4
24 OD	16	18 1/2	23 1/2	32	1 7/8	3	7	1 1/4	1 3/8	6 1/4	28	4
30 OD	20	22	27 1/2	38 3/4	2 1/8	3	9	1 7/16	1 1/2	7 1/4	34 3/4	4
36 OD	24	25 1/2	32	46	2 3/8	3	10 3/4	1 5/8	1 1/2	8 3/8	41 1/2	4
42 OD	24	29 1/4	36 1/2	53	2 5/8	4	8 1/2	1 13/16	1 5/8	7 1/2	48 1/2	5
48 OD	30	32 3/4	41 3/4	59 1/2	2 3/4	4	9 3/4	2	1 5/8	8 1/4	53 3/4	5

Reducing tees sizes 16 in. and smaller, shall have the same base dimensions as a straight size tee shown in Table 8 corresponding to size of the largest opening.

All dimensons given in inches.

[1] Bases not finished unless so ordered.

[2] For sizes 18 inches and larger, if the outlet is the same size or smaller than given in Table 9 (short body pattern), the base dimensions shown in this table shall be used. If the outlet is larger than shown in Table 9, the base dimensions shall be the same as for the straight size tee shown in Table 8, corresponding to the size of the largest opening.

Tees reducing on run only shall have the same base dimensions as straight size tees shown in Table 8 corresponding to the size of the largest opening.

[3] For the reducing tee dimensions, refer to Table 5.

APPENDIX[1]

REPRINT FROM ASA-B16a-1939

Table 1A Theoretical Weights of Class 125 Flanges, Elbows, Crosses, Tees, Side Outlet Tees, and Laterals[2]

Nominal Pipe Size	Companion Flanges Lb	Blind Flanges Lb	90 Deg Elbow Lb	45 Deg Elbow Lb	90 Deg Long Radius Elbow Lb	Side Outlet Elbow Lb	Tees Lb	Cross and Side Outlet Tees (Not Ribbed) Lb	Laterals[3] (Not Ribbed) Lb
1	2	2	5	4	7	8	9	11	10
1 ¼	2	3	7	6	9	10	11	15	13
1 ½	3	3	9	8	11	13	15	19	17
2	5	5	14	12	16	20	21	28	25
2 ½	7	7	19	17	23	28	30	39	36
3	8	9	24	20	28	34	37	48	44
3 ½	11	12	31	27	37	46	49	63	59
4	14	16	41	36	48	59	64	82	75
5	17	20	52	45	62	74	81	105	96
6	22	25	68	60	85	96	105	135	125
8	31	42	110	94	145	150	165	210	210
10	45	63	175	145	230	240	270	330	340
12	63	88	250	220	350	340	380	470	520
14 O.D.	82	115	350	270	470	470	530	650	680
16 O.D.	105	160	470	360	670	620	700	850	950
18 O.D.	120	190	580	420	840	760	860	1040	1150
20 O.D.	150	250	740	540	1080	970	1100	1330	1480
24 O.D.	220	370	1160	800	1640	1510	1730	2080	2080
30 O.D.	...	620	1850	1430	2800	2350	2710	3210	3680
36 O.D.	...	990	2800	2280	4450	3500	4050	4750	....
42 O.D.	...	1470	4010	3380	6610	4930	5790	6710	....
48 O.D.	...	2000	5400	4680	9250	6520	7620	8740	....

All dimensions given in inches.

[1] For information only, not mandatory.

[2] All weights listed are for fittings faced and drilled, based on minimum thicknesses and dimensions given in preceding tables, without allowances for variation. Cast iron is assumed to weigh 0.26 lb per cu in.

[3] Weights of crosses and laterals do not include reinforcing ribs.

APPENDIX

REPRINT FROM ASA-B16a-1939

Table 2A Theoretical Weights of Class 125 Reducing Elbows Reducers, and Eccentric Reducers[1]

Nominal Pipe Size	Reducing Elbows Lb	Reducers and Eccentric Reducers Lb	Nominal Pipe Size	Reducing Elbows Lb	Reducers and Eccentric Reducers Lb
3 × 2½	22	19	12 × 10	220	180
3 × 2	19	16	12 × 8	190	155
3 × 1½	17		12 × 6	165	140
3½ × 3	28	24	14 × 12	320	250
3½ × 2	24	20	14 × 10	280	220
4 × 3½	37	31	14 × 8	240	200
4 × 3	33	28	16 × 14	420	340
4 × 2½	31	26	16 × 12	380	310
4 × 2	29	24	16 × 10	340	280
5 × 4	48	39	16 × 8	300	250
5 × 3	40	32	18 × 16	540	430
5 × 2½	37	31	18 × 14	480	380
6 × 5	60	50	18 × 12	440	350
6 × 4	56	47	18 × 10	390	320
6 × 3½	51	43	20 × 18	680	520
6 × 3	47	39	20 × 16	640	490
8 × 6	90	77	20 × 14	570	450
8 × 5	82	71	20 × 12	520	410
8 × 4	77	66	24 × 20	1010	760
10 × 8	150	120	24 × 18	930	700
10 × 6	125	100	24 × 16	880	670
10 × 5	115	95	24 × 12	740	580

All dimensions given in inches.

[1] All weights listed are for fittings faced and drilled, based on minimum thicknesses and dimensions given in preceding tables, without allowances for variation. Cast iron is assumed to weigh 0.26 lb per cu in.

APPENDIX

REPRINT FROM ASA-B16a-1939

Table 3A Theoretical Weights of Class 125 Reducing Laterals[1]

Nominal Pipe Size	Lateral[2] Reducing Outlet (Not Ribbed) Lb	Nominal Pipe Size	Lateral[2] Reducing Outlet (Not Ribbed) Lb
3 × 3 × 2½	42	12 × 12 × 10	470
3 × 3 × 2	39	12 × 12 × 8	430
3 × 3 × 1½	36	12 × 12 × 6	400
3½ × 3½ × 3	55	14 × 14 × 12	640
3½ × 3½ × 2½	52	14 × 14 × 10	590
3½ × 3½ × 2	49	14 × 14 × 8	550
4 × 4 × 3½	70	16 × 16 × 14	880
4 × 4 × 3	66	16 × 16 × 12	830
4 × 4 × 2½	63	16 × 16 × 10	790
4 × 4 × 2	60	16 × 16 × 8	740
5 × 5 × 4	93	18 × 18 × 16	1100
5 × 5 × 3½	86	18 × 18 × 14	1030
5 × 5 × 3	82	18 × 18 × 12	980
5 × 5 × 2½	79	18 × 18 × 10	930
6 × 6 × 5	120	20 × 20 × 18	1400
6 × 6 × 4	115	20 × 20 × 16	1350
6 × 6 × 3½	105	20 × 20 × 14	1270
6 × 6 × 3	105	20 × 20 × 12	1220
		20 × 20 × 10	*840
8 × 8 × 6	195		
8 × 8 × 5	180	24 × 24 × 20	2040
8 × 8 × 4	175	24 × 24 × 18	1950
		24 × 24 × 16	1890
10 × 10 × 8	310	24 × 24 × 14	1810
10 × 10 × 6	280	24 × 24 × 12	*1250
10 × 10 × 5	270		

All dimensions given in inches.

[1] Weights of laterals do not include reinforcing ribs.

[2] All weights listed are for fittings faced and drilled, based on minimum thicknesses and dimensions given in preceding tables, without allowances for variation. Cast iron is assumed to weigh 0.26 lb per cu in.

* These sizes made in the short body pattern only

APPENDIX

REPRINT FROM ASA-B16a-1939

Table 4A Theoretical Weights of Class 125 Reducing Tees[1]

Size	Weight Lb	Size	Weight Lb	Size	Weight Lb
3 × 3 × 2½	36	6 × 6 × 3	89	14 × 14 × 10	480
3 × 3 × 2	33	6 × 5 × 6	100	14 × 14 × 8	460
3 × 3 × 1½	31	6 × 5 × 5	95	14 × 12 × 14	510
3 × 2½ × 3	35	6 × 5 × 4	92	14 × 12 × 12	490
3 × 2½ × 2½	34	6 × 5 × 3	84	14 × 12 × 10	460
3 × 2½ × 2	31	6 × 4 × 6	98	14 × 12 × 8	440
3 × 2½ × 1½	29	6 × 4 × 5	93	14 × 10 × 14	490
3 × 2 × 3	33	6 × 4 × 4	89	14 × 10 × 12	470
3 × 2 × 2½	32	6 × 4 × 3	82	14 × 10 × 10	450
3 × 2 × 2	29	6 × 3 × 6	92	14 × 10 × 8	420
3 × 2 × 1½	27	6 × 3 × 5	86	14 × 8 × 14	480
3 × 1½ × 3	32	6 × 3 × 4	83	14 × 8 × 12	460
3 × 1½ × 2½	30	6 × 3 × 3	76	14 × 8 × 10	430
3 × 1½ × 2	27	8 × 8 × 6	150	14 × 8 × 8	410
3 × 1½ × 1½	25	8 × 8 × 5	145	16 × 16 × 14	670
3½ × 3½ × 3	46	8 × 8 × 4	145	16 × 16 × 12	650
3½ × 3½ × 2½	44	8 × 6 × 8	155	16 × 16 × 10	620
3½ × 3½ × 2	42	8 × 6 × 6	140	16 × 16 × 8	610
4 × 4 × 3½	60	8 × 6 × 5	135	16 × 14 × 16	680
4 × 4 × 3	57	8 × 6 × 4	130	16 × 14 × 14	650
4 × 4 × 2½	55	8 × 5 × 8	150	16 × 14 × 12	630
4 × 4 × 2	53	8 × 5 × 6	135	16 × 14 × 10	600
4 × 3 × 4	57	8 × 5 × 5	130	16 × 14 × 8	580
4 × 3 × 3	50	8 × 5 × 4	125	16 × 12 × 16	670
4 × 3 × 2½	49	8 × 4 × 8	150	16 × 12 × 14	640
4 × 3 × 2	46	8 × 4 × 6	135	16 × 12 × 12	620
4 × 2½ × 4	56	8 × 4 × 5	130	16 × 12 × 10	590
4 × 2½ × 3	49	8 × 4 × 4	125	16 × 12 × 8	570
4 × 2½ × 2½	47	10 × 10 × 8	250	16 × 10 × 16	650
4 × 2½ × 2	45	10 × 10 × 6	240	16 × 10 × 14	620
4 × 2 × 4	54	10 × 10 × 5	230	16 × 10 × 12	600
4 × 2 × 3	47	10 × 8 × 10	260	16 × 10 × 10	570
4 × 2 × 2½	45	10 × 8 × 8	240	16 × 10 × 8	550
4 × 2 × 2	43	10 × 8 × 6	220	16 × 8 × 16	640
5 × 5 × 4	78	10 × 6 × 10	250	16 × 8 × 14	610
5 × 5 × 3½	74	10 × 6 × 8	230	16 × 8 × 12	580
5 × 5 × 3	70	10 × 6 × 6	210	16 × 8 × 10	560
5 × 5 × 2½	68	12 × 12 × 10	360	16 × 8 × 8	540
5 × 4 × 5	78	12 × 12 × 8	340	18 × 18 × 16	860
5 × 4 × 4	75	12 × 12 × 6	320	18 × 18 × 14	820
5 × 4 × 3	68	12 × 10 × 12	370	18 × 18 × 12	*660
5 × 4 × 2½	66	12 × 10 × 10	340	18 × 18 × 10	*640
5 × 3 × 5	72	12 × 10 × 8	320	20 × 20 × 18	1060
5 × 3 × 4	68	12 × 10 × 6	310	20 × 20 × 16	1040
5 × 3 × 3	61	12 × 8 × 12	350	20 × 20 × 14	*840
5 × 3 × 2½	59	12 × 8 × 10	330	20 × 20 × 12	*820
5 × 2½ × 5	70	12 × 8 × 8	310	20 × 20 × 10	*790
5 × 2½ × 4	67	12 × 8 × 6	300	24 × 24 × 20	1640
5 × 2½ × 3	60	12 × 6 × 12	340	24 × 24 × 18	1600
5 × 2½ × 2½	58	12 × 6 × 10	320	24 × 24 × 16	*1170
6 × 6 × 5	99	12 × 6 × 8	300	24 × 24 × 14	*1140
6 × 6 × 4	96	12 × 6 × 6	280	24 × 24 × 12	*1110
6 × 6 × 3½	92	14 × 14 × 12	500	....	....

All dimensions given in inches.

[1] All weights listed are for fittings faced and drilled, based on minimum thicknesses and dimensions given in preceding tables, without allowances for variation. Cast iron is assumed to weigh 0.26 lb per cu in.

* These sizes made in short body pattern only

APPENDIX

REPRINT FROM ASA-B16a-1939

Table 5A Theoretical Weights of Class 125 Reducing Crosses[1,2]

Size	Weight Lb	Size	Weight Lb
3 × 3 × 2½ × 2½	44	12 × 12 × 10 × 10	420
3 × 3 × 2 × 2	40	12 × 12 × 8 × 8	380
3 × 3 × 1½ × 1½	36	12 × 12 × 6 × 6	350
3½ × 3½ × 3 × 3	57		
3½ × 3½ × 2½ × 2½	53	14 × 14 × 12 × 12	600
		14 × 14 × 10 × 10	550
3½ × 3½ × 2 × 2	47	14 × 14 × 8 × 8	500
4 × 4 × 3½ × 3½	74		
4 × 4 × 3 × 3	68	16 × 16 × 14 × 14	790
4 × 4 × 2½ × 2½	64	16 × 16 × 12 × 12	740
4 × 4 × 2 × 2	59	16 × 16 × 10 × 10	690
		16 × 16 × 8 × 8	650
5 × 5 × 4 × 4	96		
5 × 5 × 3½ × 3½	89	18 × 18 × 16 × 16	1000
5 × 5 × 3 × 3	82	18 × 18 × 14 × 14	930
5 × 5 × 2½ × 2½	78	18 × 18 × 12 × 12	*750
		18 × 18 × 10 × 10	*700
6 × 6 × 5 × 5	120		
6 × 6 × 4 × 4	115	20 × 20 × 18 × 18	1250
6 × 6 × 3½ × 3½	105	20 × 20 × 16 × 16	1200
6 × 6 × 3 × 3	100	20 × 20 × 14 × 14	*960
		20 × 20 × 12 × 12	*910
8 × 8 × 6 × 6	190	20 × 20 × 10 × 10	*860
8 × 8 × 5 × 5	175		
8 × 8 × 4 × 4	165	24 × 24 × 20 × 20	1900
		24 × 24 × 18 × 18	1810
10 × 10 × 8 × 8	300	24 × 24 × 16 × 16	*1310
10 × 10 × 6 × 6	270	24 × 24 × 14 × 14	*1250
10 × 10 × 5 × 5	250	24 × 24 × 12 × 12	*1210
		.. ..	....

All dimensions given in inches.

[1] Weights of crosses do not include reinforcing ribs.

[2] All weights listed are for fittings faced and drilled, based on minimum thicknesses and dimensions given in preceding tables, without allowances for variation. Cast iron is assumed to weigh 0.26 lb per cu in.

* These sizes made in the short body pattern only.

ASA
B16b-1944

American Standard

Cast Iron Pipe Flanges and Flanged Fittings, Class 250

Introductory Notes

1. PRESSURE RATING

These flanges and fittings are rated as follows:

For maximum saturated steam service pressures of

250 psi (gage) sizes 1 to 12 in., incl.
200 psi (gage) sizes 14 to 24 in., incl.
100 psi (gage) sizes 30 to 48 in., incl.*

For maximum water service pressures at or near the ordinary range of air temperature

400 psi (gage) sizes 1 to 12 in., incl.
300 psi (gage) sizes 14 to 48 in., incl.,*

for flanges only.[1]

2. SIZES

The sizes of the fittings in the following tables will be identified by the corresponding "nominal pipe size."

3. MARKING

All fittings shall have marks cast on them indicating the manufacturer and figures indicating the service pressure rating. Sizes up to and including 12 in. shall carry the figures "250" indicating the saturated steam service pressure rating. Sizes 14 to 24 in., inclusive, shall carry the figures "200" indicating the saturated steam service pressure rating. Sizes 30 to 48 in., inclusive,* shall carry the figures "100" indicating the saturated steam service pressure rating. These marking requirements comply with principles established in MSS Standard Practice SP-25.

4. MATERIAL

Castings.—The dimensions prescribed in this standard are based upon gray iron castings of high quality produced under regular control of chemical and physical properties by a recognized process. The manufac-

* Sizes 30 to 48 in. are included for convenience where special fittings larger than 24 in. are required (see Table 2).

[1] It will be noted that water service ratings as shown for sizes 14 in. and larger in this standard are applicable to flanges only and not to fittings. Water service ratings on fittings 14 in. and larger are withheld in this issue of the standard pending receipt of final report on research work which is now being conducted by ASA Sectional Committee A21.

turer shall be prepared to certify that his product has been so produced that the chemical and physical properties thereof, as proved by test specimens, are at least equal to the requirements specified in A.S.T.M. Specification A 126. Flanges and fittings 12 in. and smaller shall be made of material at least equal to the requirements of A.S.T.M. Specification A 126, Class "A" regular gray iron.

Flanges and fittings 14 in. and larger shall be made of material at least equal to the requirements of A.S.T.M. Specification A 126, Class "B" higher strength gray iron.

Requirements of A.S.T.M. A 126 are as follows:

	Class A
Sulphur	0.12 per cent max
Phosphorus	0.75 per cent max
Tensile strength	21,000 psi min
	Class B
Sulphur	0.12 per cent max
Phosphorus	0.75 per cent max
Tensile strength	31,000 psi min

It is intended that material required by this standard shall be in accordance with the requirements shown herein or as required in the latest edition of A.S.T.M. Standard Specifications for Gray Iron Castings for Valves, Flanges, and Pipe Fittings (A 126).

Bolting.—Carbon steel bolts shall be used with these flanges and fittings and shall be made of metal which conforms to A.S.T.M. Specification A 107.

5. WALL THICKNESS TOLERANCE

Patterns shall be designed to produce castings having the wall thicknesses given in the tables. The wall thicknesses of the castings at no point shall be less than 87½ per cent of the dimensions given.

6. TESTS

These fittings shall be designed to withstand, without showing leaks, hydrostatic test pressures of twice the rated steam pressure. Hydrostatic tests of cast iron fittings covered by this standard are not required unless specified by the user.

7. FACING

These cast iron flanges and flanged fittings shall have a raised face 1/16 in. high of the diameters given in Table 2. The raised face is included in the minimum flange thickness and center to face dimensions.

An inspection limit of plus or minus 1/32 in. shall be allowed on all center to contact surface dimensions for sizes up to and including 10 in. and plus or minus 1/16 in. on sizes larger than 10 in. An inspection limit of plus or minus 1/16 in. shall be allowed on all contact-surface-to-contact-surface dimensions for sizes up to and including 10 in. and plus or minus 1/8 in. on sizes larger than 10 in.

8. BOLTING

Bolt holes are in multiples of four, so that fittings may be made to face in any quarter.

Bolt holes shall straddle the center line.

For bolts having a diameter of 1 1/4 in. and less the bolt holes shall be drilled 1/8 in. larger than the nominal diameter of the bolt. Holes for 1 1/2 in. diameter bolts shall be drilled 3/16 in. larger than the nominal diameter of the bolt. Holes for bolts having a diameter 1 3/4 and 2 in. shall be drilled 1/4 in. larger than the nominal diameter of the bolt.

Bolts shall be of carbon steel with American Standard regular unfinished square heads or American Standard heavy unfinished hexagonal heads and the nuts shall be of carbon steel with American Standard heavy hexagonal dimensions, all as specified in American Standard for Wrench Head Bolts and Nuts and Wrench Openings (ASA B18.2–1941). For bolts 1 3/4 in. in diameter and larger, bolt-studs with a nut on each end are recommended.

Hexagonal nuts for pipe sizes 1 in. to 16 in. can be conveniently pulled up with open wrenches of minimum design of heads. Hexagonal nuts for pipe sizes 18 in. to 48 in. can be conveniently pulled up with box wrenches.

All bolts, or bolt-studs if used, and all nuts shall be threaded in accordance with American Standard for Screw Threads (ASA B1.1–1935) Coarse-Thread Series, Class 2 Fit.

9. SPOT FACING

The bolt holes of these cast iron flanges and flanged fittings need not be spot faced for ordinary service except as follows: In sizes 12 in. and smaller when rough flanges, after facing, are oversize more than 1/8 in. in thickness, they shall be spot faced to the specified thickness of flange (minimum) with a plus tolerance of 1/16 in. In sizes 14 to 24 in., inclusive, when rough flanges, after facing, are oversize more than 3/16 in. in thickness they shall be spot faced to the specified thickness of flange (minimum) with a plus tolerance of 1/16 in. In sizes 30 in. and larger when rough flanges, after facing, are oversize more than 1/4 in. in thickness they shall be spot faced to the specified thickness of flange (minimum) with a plus tolerance of ⅛ in.

10. REDUCING FITTINGS

Reducing elbows carry same dimensions center to face as straight size elbows corresponding to the size of the larger opening.

Tees sizes 16 in. and smaller, reducing on the outlet, have the same dimension center to face and face to face as straight size fittings corresponding to the size of the larger opening. Sizes 18 in. and larger reducing on the outlet are made in two lengths depending on the size of the outlet as given in Table 5. Tees reducing on the run only have the same dimension center to face and face to face as straight size fittings corresponding to the size of the larger opening.

Tees increasing on the outlet are generally known as Bull Head Tees and have the same center to face and face to face dimensions as straight fittings the size of the outlet.

Reducers for all reductions have the same face to face dimensions as given in Table 4 for the larger opening.

Reducing fittings listed in this standard shall be ordered by the designation of the outlets in their proper sequence as indicated in the sketches in Fig 1.

11. ELBOWS

Special degree elbows ranging from 1 to 45 deg., inclusive, have the same center to face dimension given for 45-deg. elbows and those over 45 deg. and up to 90 deg., inclusive, shall have the same center to face dimensions given for 90-deg. elbows. The angle designation of an elbow is its deflection from straight line flow and is the angle between the flange faces.

12. DRAIN TAPPINGS

The maximum size of hole that can be tapped in the wall of the fitting without adding a boss is shown in Table 1.

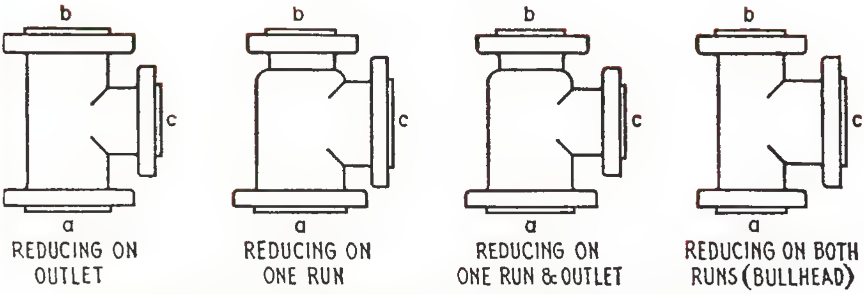
When bosses are required the method of designating the locations of the tapped holes for drains is shown in Fig 2. Each possible location is designated by a letter so that desired locations for the various types of fittings may be definitely specified without the use of further sketches or description.

Maximum Size of Tapped Hole in Fitting Without Adding Bosses

TABLE NO. 1

Size of Fitting (Inches)	2–3	4–5	6	8	10	12	14–24
Size of Tapped Hole (Inches)	⅜	½	¾	1	1¼	1½	2

REDUCING TEES



NOTE:– In designating the outlets of reducing fittings the openings should be read in the order indicated by the sequence of the letters a, b, and c.

Fig. 1 Method of Designating Outlets of Reducing Fittings in Specifications

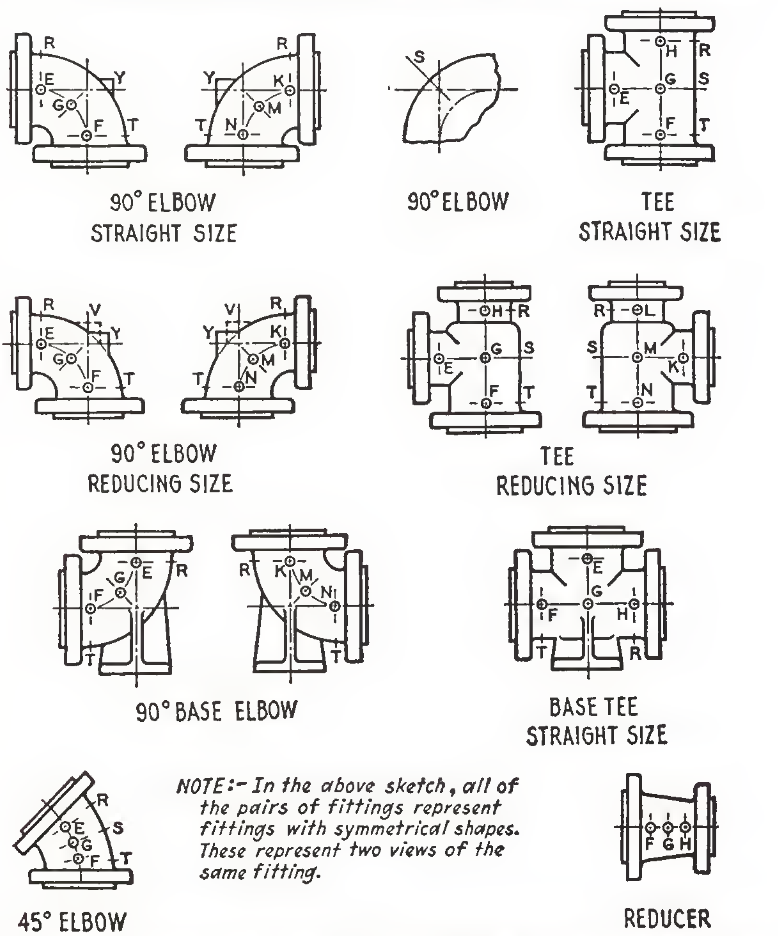


Fig. 2 Method of Designating Location of Tapped Holes for Drains When Specified

Class 250 Cast Iron Flanges and Fittings

Dimensions of Cast Iron Flanges, Drilling for Bolts and Their Lengths

TABLE NO. 2

Nominal Pipe Size	Diam. of Flange	Thickness [3] of Flange (Min.)	Diam. of Raised Face	Diam. of Bolt Circle	Diam.[1] of Bolt Holes	Number [1] of Bolts	Size of Bolts	Length [2] of Bolts	Lgth.[4] of Bolt Studs with Two Nuts	Size of Ring Gasket
1	4 7/8	11/16	2 11/16	3 1/2	3/4	4	5/8	2 1/2	....	1 x 2 7/8
1 1/4	5 1/4	3/4	3 1/16	3 7/8	3/4	4	5/8	2 1/2	....	1 1/4 x 3 1/4
1 1/2	6 1/8	13/16	3 9/16	4 1/2	7/8	4	3/4	2 3/4	....	1 1/2 x 3 3/4
2	6 1/2	7/8	4 3/16	5	3/4	8	5/8	2 3/4	....	2 x 4 3/8
2 1/2	7 1/2	1	4 15/16	5 7/8	7/8	8	3/4	3 1/4	....	2 1/2 x 5 1/8
3	8 1/4	1 1/8	5 11/16	6 5/8	7/8	8	3/4	3 1/2	....	3 x 5 7/8
3 1/2	9	1 3/16	6 5/16	7 1/4	7/8	8	3/4	3 1/2	....	3 1/2 x 6 1/2
4	10	1 1/4	6 15/16	7 7/8	7/8	8	3/4	3 3/4	....	4 x 7 1/8
5	11	1 3/8	8 5/16	9 1/4	7/8	8	3/4	4	....	5 x 8 1/2
6	12 1/2	1 7/16	9 11/16	10 5/8	7/8	12	3/4	4	....	6 x 9 7/8
8	15	1 5/8	11 15/16	13	1	12	7/8	4 1/2	....	8 x12 1/8
10	17 1/2	1 7/8	14 1/16	15 1/4	1 1/8	16	1	5 1/4	....	10 x14 1/4
12	20 1/2	2	16 7/16	17 3/4	1 1/4	16	1 1/8	5 1/2	....	12 x16 5/8
14 OD	23	2 1/8	18 15/16	20 1/4	1 1/4	20	1 1/8	6	....	13 1/4 x19 1/8
16 OD	25 1/2	2 1/4	21 1/16	22 1/2	1 3/8	20	1 1/4	6 1/4	....	15 1/4 x21 1/4
18 OD	28	2 3/8	23 5/16	24 3/4	1 3/8	24	1 1/4	6 1/2	....	17 x23 1/2
20 OD	30 1/2	2 1/2	25 9/16	27	1 3/8	24	1 1/4	6 3/4	....	19 x25 3/4
24 OD	36	2 3/4	30 1/4	32	1 11/16	24	1 1/2	7 3/4	9 1/2	23 x30 1/2
*30 OD	43	3	37 3/16	39 1/4	2	28	1 3/4	8 1/2	10 1/2	29 x37 1/2
*36 OD	50	3 3/8	43 11/16	46	2 1/4	32	2	9 1/2	11 3/4	34 1/2 x44
*42 OD	57	3 11/16	50 7/16	52 3/4	2 1/4	36	2	10 1/4	12 1/2	40 1/4 x50 3/4
*48 OD	65	4	58 7/16	60 3/4	2 1/4	40	2	10 3/4	13	46 x58 3/4

All dimensions given in inches.

* These sizes are included for convenience where special fittings larger than 24 in. are required.

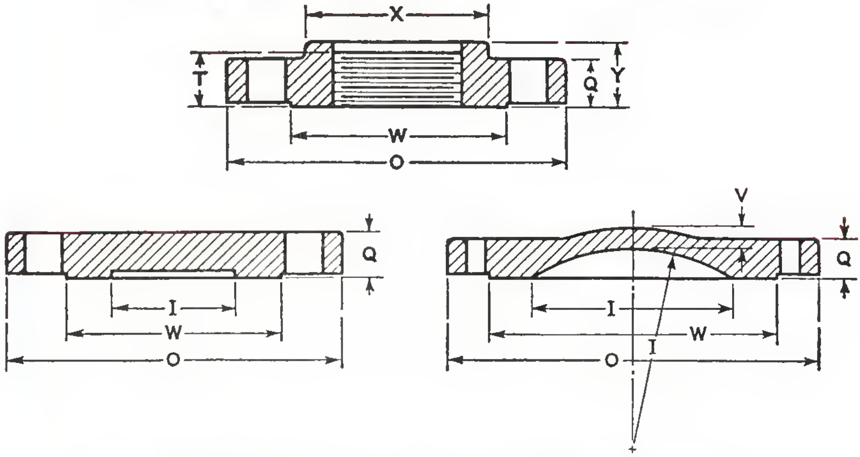
[1] Drilling templates are in multiples of four, so that fittings may be made to face in any quarter, and bolt holes straddle the center line. For bolts smaller than 1 1/2 in. the bolt holes shall be drilled 1/8 in. larger in diameter than the nominal diameter of the bolt. Holes for bolts 1 1/2 in. shall be drilled 3/16 in. larger in diameter than the nominal diameter of the bolt. Holes for bolts 1 3/4 in. and larger shall be drilled 1/4 in. larger than nominal diameter of bolts.

[2] For spot facing the bolt holes on both flanges and fittings, see Par. 9, Spot Facing.

[3] All Class 250 cast iron flanges have a 1/16-in. raised face. This raised face is included in the face to face, center to face, and the minimum thickness of flange dimensions.

[4] For bolting specifications, see Par. 8, Bolting.

Class 250 Cast Iron Flanges and Fittings



8 IN. AND SMALLER 10 IN. AND LARGER

Dimensions of Screwed Companion and Blind Flanges[1,3]

TABLE NO. 3

Nominal Pipe Size	Diam.[2] of Port I	Diam. of Flange O	Thickness[1] of Flange (Min.) Q	Wall Thickness V	Diam. Hub (Min.) X	Length Through Hub (Min.) Y	Length of Threads (Min.) T	Diam.[1] of Raised Face W
1	1	4 7/8	11/16	....	2 1/16	7/8	0.68	2 11/16
1 1/4	1 1/4	5 1/4	3/4	....	2 1/2	1	0.76	3 1/16
1 1/2	1 1/2	6 1/8	13/16	....	2 3/4	1 1/8	0.87	3 9/16
2	2	6 1/2	7/8	....	3 5/16	1 1/4	1.00	4 3/16
2 1/2	2 1/2	7 1/2	1	....	3 15/16	1 7/16	1.14	4 15/16
3	3	8 1/4	1 1/8	....	4 5/8	1 9/16	1.20	5 11/16
3 1/2	3 1/2	9	1 3/16	....	5 1/4	1 5/8	1.25	6 5/16
4	4	10	1 1/4	....	5 3/4	1 3/4	1.30	6 15/16
5	5	11	1 3/8	....	7	1 7/8	1.41	8 5/16
6	6	12 1/2	1 7/16	....	8 1/8	1 15/16	1.51	9 11/16
8	8	15	1 5/8	....	10 1/4	2 3/16	1.71	11 15/16
10	10	17 1/2	1 7/8	15/16	12 5/8	2 3/8	1.92	14 1/16
12	12	20 1/2	2	1	14 3/4	2 9/16	2.12	16 7/16
14 OD	13 1/4	23	2 1/8	1 1/8	16 1/4	2 11/16	2.25	18 15/16
16 OD	15 1/4	25 1/2	2 1/4	1 1/4	18 3/8	2 7/8	2.45	21 1/16
18 OD	17	28	2 3/8	1 3/8	....	....	....	23 5/16
20 OD	19	30 1/2	2 1/2	1 1/2	....	....	....	25 9/16
24 OD	23	36	2 3/4	1 5/8	....	....	....	30 1/4

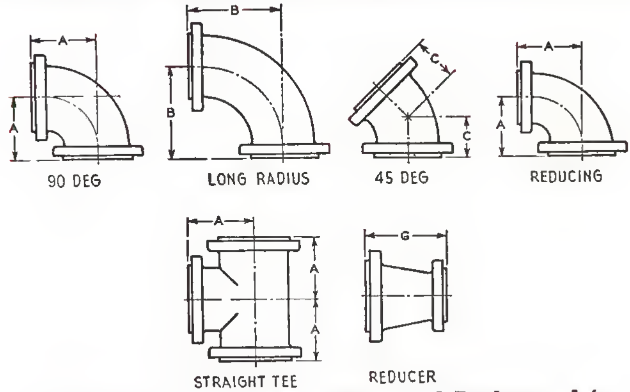
All dimensions given in inches.

[1] All Class 250 cast iron flanges have a 1/16-inch raised face. This raised face is included in the minimum thickness of flange dimensions.

[2] All blind flanges for sizes 10 inches (17 1/2 inches OD) and larger must be dished, with inside radius equal to the port diameter. The wall thickness at no point shall be less than 87 1/2 per cent of the dimensions given in the table.

[3] For drilling templates refer to Table 2.

Class 250 Cast Iron Flanges and Fittings



Dimensions of Elbows, Tees, and Reducers[1,6]

TABLE NO. 4

Nominal Pipe Size	Inside Diam. of Fitting (Min.)	Wall[5] Thickness of Body	Diam. of Flange	Thickness[1] of Flange (Min.)	Diam.[1] of Raised Face	Center[1,2,3] to Face Elbow and Tee A	Center[1] to Face Long Radius Elbow B	Center[1,3] to Face 45 Deg. Elbow C	Face[1,4] to Face Reducer G
2	2	7/16	6 1/2	7/8	4 3/16	5	6 1/2	3	5
2 1/2	2 1/2	1/2	7 1/2	1	4 15/16	5 1/2	7	3 1/2	5 1/2
3	3	9/16	8 1/4	1 1/8	5 11/16	6	7 3/4	3 1/2	6
3 1/2	3 1/2	9/16	9	1 3/16	6 5/16	6 1/2	8 1/2	4	6 1/2
4	4	5/8	10	1 1/4	6 15/16	7	9	4 1/2	7
5	5	11/16	11	1 3/8	8 5/16	8	10 1/4	5	8
6	6	3/4	12 1/2	1 7/16	9 11/16	8 1/2	11 1/2	5 1/2	9
8	8	13/16	15	1 5/8	11 15/16	10	14	6	11
10	10	15/16	17 1/2	1 7/8	14 1/16	11 1/2	16 1/2	7	12
12	12	1	20 1/2	2	16 7/16	13	19	8	14
14 OD	13 1/4	1 1/8	23	2 1/8	18 15/16	15	21 1/2	8 1/2	16
16 OD	15 1/4	1 1/4	25 1/2	2 1/4	21 1/16	16 1/2	24	9 1/2	18
18 OD	17	1 3/8	28	2 3/8	23 5/16	18	26 1/2	10	19
20 OD	19	1 1/2	30 1/2	2 1/2	25 9/16	19 1/2	29	10 1/2	20
24 OD	23	1 5/8	36	2 3/4	30 1/4	22 1/2	34	12	24

All dimensions given in inches.

[1] All Class 250 cast iron flanges have a 1/16-inch raised face. This raised face is included in the face to face, center to face, and the minimum thickness of flange dimensions.

[2] Reducing elbows carry the same dimensions center to face as regular straight size elbows corresponding to the size of the larger opening. Tees 16 inch and smaller reducing on the outlet have the same dimensions center to face and face to face as straight size fittings corresponding to the size of the larger opening. Sizes 18 inch and larger reducing on the outlet are made in two lengths depending on the size of the outlet. For dimensions of the short body pattern see Table 5.

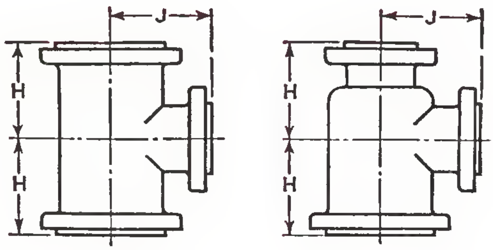
[3] Special degree elbows ranging from 1 to 45 deg., inclusive, have the same center to face dimensions given for 45-deg. elbows, and those over 45 deg. and up to 90 deg., inclusive, shall have the same center to face dimensions given for 90-deg. elbows. The angle designation of an elbow is its deflection from straight line flow and is the angle between the flange faces.

[4] Reducers, for all reductions, use the same face to face dimensions given in the above table of dimensions for the larger opening.

[5] Wall thickness at no point shall be less than 87½ per cent of the dimensions given in the table.

[6] For drilling templates refer to Table 2.

Class 250 Cast Iron Flanges and Fittings



Dimensions of Reducing Tees[2, 4] (Short Body Patterns)

TABLE NO. 5

Nominal[2] Pipe Size	Size[3] of Outlet and Smaller	Center[1] to Face Run H	Face[1] to Face Run H+H	Center[1] to Face Outlet J
All reducing tees sizes 16 in. and smaller have same face to face and center to face dimensions as straight sizes. See Table 4				
18OD	12	14	28	17
20OD	14	15½	31	18½
24OD	16	17	34	21½

All dimensions given in inches.

[1] All Class 250 cast iron flanges have a 1/16-in. raised face. This raised face is included in the face to face, center to face, and the minimum thickness of flange dimensions.

[2] Short body patterns are used for sizes 18 in. and larger.

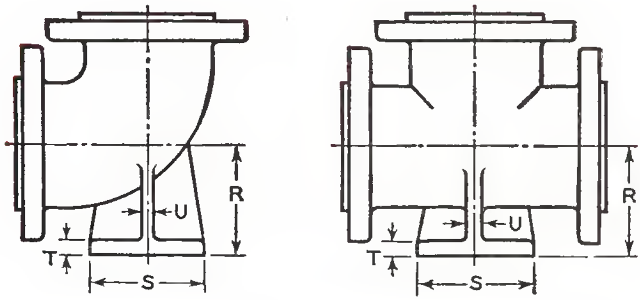
[3] Long body patterns are used when outlets are larger than given in the above table, and, therefore, have the same dimensions as straight size fittings.

[4] Tees reducing on the run only carry same dimensions center to face and face to face as straight size fittings corresponding to size of the larger opening. Tees increasing on outlet, known as Bull Head Tees, will have same center to face and face to face dimensions as a straight fitting of the size of the outlet. For example: A 12x12x18-in. tee will be governed by the dimensions of the 18-in. long body tee, given in Table 4, namely 18 in. center to face of all openings and 36 in. face to face.

For flange dimensions, wall thicknesses, and port diameters, see Table 4.

For drilling dimensions, see Table 2.

Class 250 Cast Iron Flanges and Fittings



Dimensions of Base Elbows and Base Tees[3,4]

TABLE NO. 6

Nominal Pipe Size	Center to Base R	Diam.[1,2] of Round Base S	Thickness of Base T	Thickness of Ribs U	Size of Supporting Pipe for Base
2	4½	5¼	¾	½	1¼
2½	4¾	5¼	¾	½	1¼
3	5¼	6⅛	13/16	⅝	1½
3½	5⅝	6⅛	13/16	⅝	1½
4	6	6½	⅞	⅝	2
5	6¾	7½	1	¾	2½
6	7½	7½	1	¾	2½
8	9	10	1¼	⅞	4
10	10½	10	1¼	⅞	4
12	12	12½	1 7/16	1	6
14OD	13½	12½	1 7/16	1	6
16OD	14¾	12½	1 7/16	1⅛	6
18OD	16¼	15	1⅝	1⅛	8
20OD	17⅞	15	1⅝	1¼	8
24OD	20¾	17½	1⅞	1¼	10

All dimensions given in inches.

[1] Bases when drilled should be to the template of the flange of the supporting pipe size using only four holes in all cases so placed as to miss the ribs. For drilling templates refer to Table 2. These bases are intended for supports in compression and are not to be used for anchors or supports in tension or shear.

[2] Size and center to face dimension of base are determined by the size of the largest opening of fitting.

[3] Dimensions for base fittings apply to straight and reducing sizes, and long and short body patterns.

[4] Bases not finished unless so ordered.

APPENDIX[1]

Theoretical Weights of Class 250 Flanges, Elbows, and Tees[2]

TABLE NO. 1A

Nominal Pipe Size	Companion Flanges, Pounds	Blind Flanges, Pounds	90-Deg. Elbow, Pounds	45-Deg. Elbow, Pounds	90-Deg. Long Radius Elbow, Pounds	Tees, Pounds
1	3	3	....	....	....	....
1¼	4	4	....	....	....	....
1½	6	6	....	....	....	....
2	7	8	20	18	23	32
2½	11	12	30	28	34	46
3	14	16	40	35	44	58
3½	18	20	49	44	55	76
4	23	26	65	58	72	99
5	29	34	87	76	98	135
6	37	46	115	105	135	180
8	56	75	185	155	220	280
10	81	120	290	240	350	430
12	115	155	410	340	510	620
14 OD	155	210	560	440	710	870
16 OD	195	270	750	620	960	1150
18 OD	....	350	970	780	1260	1490
20 OD	....	440	1220	960	1630	1880
24 OD	....	670	1840	1430	2470	2800

All dimensions given in inches.

[1] For information only, not mandatory.

[2] All weights listed are for fittings faced and drilled, based on minimum thicknesses and dimensions given in preceding tables, without allowances for variation. Cast iron is assumed to weigh 0.26 pound per cubic inch.

Appendix

Class 250 Reducing Elbows, and Reducers, Stock Sizes and Weights[1]

TABLE NO. 2A

Nominal Pipe Size	Reducing Elbow, Weight,[2] Pounds	Reducers, Weight,[2] Pounds	Nominal Pipe Size	Reducing Elbow, Weight,[2] Pounds	Reducers, Weight,[2] Pounds
2½x2	26	22	6x4	93	77
3 x2½	35	29	8x6	155	130
4 x3	52	44	8x5	140	115
4 x2½	48	40	8x4	130	105
5 x4	78	63	10x8	240	190
5 x3	65	54	10x6	210	170
6 x5	100	85	10x5	190	155

All dimensions given in inches.

[1] This table is given for information only, and is not part of the standard. It is recommended that stock size fittings be used in laying out piping and that special sizes, not included in the list, be used only when absolutely necessary.

[2] The weights listed are given for convenience in estimating and shipping, and it is intended that they be used for no other purpose.

Class 250 Reducing Tees, Stock Sizes and Weights[1]

TABLE NO. 3A

Nominal Pipe Size	Weight[2], Pounds	Nominal Pipe Size	Weight[2], Pounds	Nominal Pipe Size	Weight[2], Pounds
2½x2½x2	42	5x5x2½	110	8x 8x 2	218
2½x2 x2	35	5x4x5	125	8x 6x 8	260
3 x3 x2½	58	5x4x4	120	8x 6x 6	240
3 x3 x2	53	6x6x5	170	10x10x 8	400
3 x2½x3	58	6x6x4	160	10x10x 6	370
3 x2½x2½	54	6x6x2½	149	10x10x 5	360
3 x2 x3	54	6x6x2	145	10x10x 4	352
3 x2 x2	46	6x6x3	150	10x 8x10	400
4 x4 x3	89	6x5x6	175	10x 8x 8	360
4 x4 x2½	85	6x5x5	160	10x 8x 6	340
4 x4 x2	80	8x8x6	260	10x 8x 5	335
4 x3 x4	90	8x8x5	240	10x 6x10	380
4 x3 x3	80	8x8x4	240	10x 6x 8	350
4 x3 x2	71	8x8x3	220	10x 6x 6	320
5 x5 x4	125	8x8x2½	223	8x 8x10	350
5 x5 x3	115	....	....	....	....

All dimensions given in inches.

[1] This table is given for information only, and is not part of the standard. It is recommended that stock size fittings be used in laying out piping and that special sizes, not included in the list, be used only when absolutely necessary.

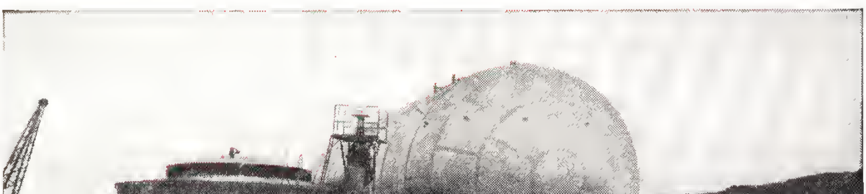
[2] The weights listed are given for convenience in estimating and shipping, and it is intended that they be used for no other purpose.

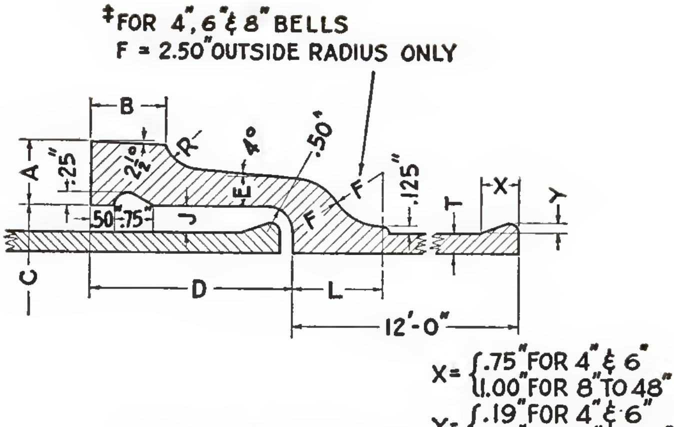
SECTION 15

A.G.A. Weights and Dimensions

(Bell-and-Spigot Pipe & Fittings)

Based on 1929 Specifications





BELL & SPIGOT PIPE

BELL NO. 1—STANDARD BELL

Nom. Diam., Ins.	Actual Outside Diam., Ins.	T	Actual Inside Diam., Ins.	Dimensions in Inches									Approximate Weight in Pounds		
				A	B	C	D	E	F	J	L	R	Bell †	Per ft. *	12′ 0″ Lgth.
4	4.80	.40	4.00	1.30	1.50	5.80	4.00	.59	‡1.09	.50	3.25	.75	27.0	19.50	234
6	6.90	.43	6.04	1.40	1.50	7.90	4.00	.62	‡1.12	.50	3.25	.80	39.5	30.58	367
8	9.05	.45	8.15	1.50	1.50	10.05	4.00	.69	‡1.19	.50	3.25	.80	52.8	42.42	509
10	11.10	.49	10.12	1.50	1.50	12.10	4.00	.69	1.19	.50	2.10	.90	57.93	55.91	671
12	13.20	.54	12.12	1.60	1.50	14.20	4.50	.75	1.25	.50	2.20	1.00	79.47	73.83	886
16	17.40	.62	16.16	1.80	1.75	18.40	4.50	.90	1.40	.50	2.50	1.10	125.18	112.58	1351
20	21.60	.68	20.24	2.00	1.75	22.85	4.50	.97	1.60	.63	2.80	1.15	169.10	153.83	1846
24	25.80	.76	24.28	2.10	2.00	27.05	5.00	1.05	1.68	.63	2.80	1.25	235.10	206.41	2477
30	31.74	.85	30.04	2.30	2.00	32.99	5.00	1.15	1.78	.63	3.00	1.30	315.20	284.00	3408
36	37.96	.95	36.06	2.50	2.00	39.21	5.00	1.25	1.88	.63	3.20	1.40	410.20	379.25	4551
42	44.20	1.07	42.06	2.80	2.00	45.45	5.00	1.40	2.03	.63	3.40	1.45	537.50	497.66	5972
48	50.50	1.26	47.98	3.00	2.00	51.75	5.00	1.50	2.13	.63	3.60	1.60	657.00	663.50	7962

Note—Pipe heavier than these standards may be made by reducing the cores, or internal diameters "C" and "D"; same for specials.

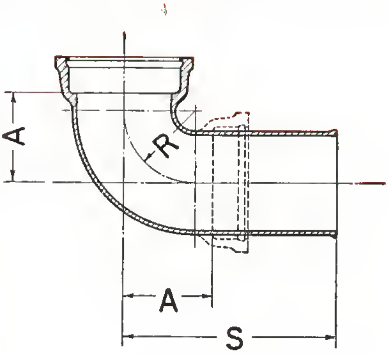
Dimension "L" for sizes 4″, 6″ and 8″, and Dimension "F", shown in sketch as 2.50 (outside radius only), apply to bells of *straight pipe only*. For bells of *special castings* the correct dimensions for "F" and "L" are.

Size	*"F"*	*"L"*
4	1.09	1.90
6	1.12	2.00
8	1.19	2.10

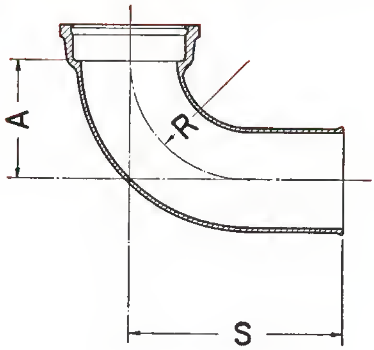
*Weight per foot includes Bell and Bead.

†Weight of Bell includes only metal beyond O. D. of pipe.

‡See Sketch for Special outside radius dimensions for 4″, 6″ and 8″ Bells.



STANDARD
90° BEND



LONG RADIUS
90° BEND

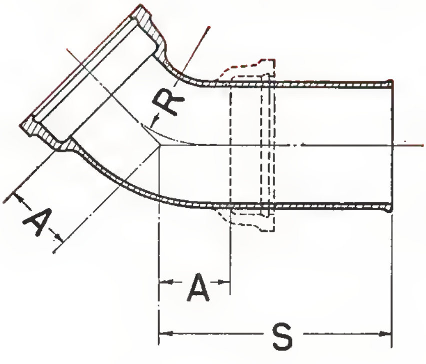
STANDARD 90° BENDS

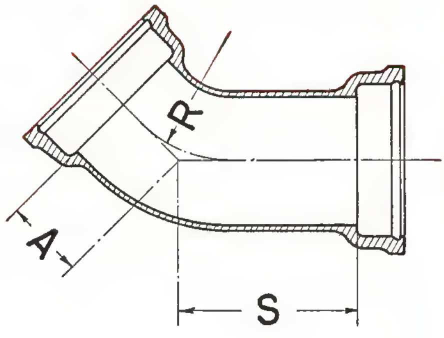
Nominal Diameter, Inches	Dimensions in Inches			Approximate Weight in Pounds	
	A	R	S	1 Bell	2 Bells
4	4.50	2.60	26	68	61
6	6.25	4.25	26	100	95
8	8.00	5.90	26	149	139
10	9.75	7.65	26	198	185
12	11.25	9.05	27	278	267
16	17.00	14.50	32	491	486
20	19.00	16.20	34	707	699
24	21.00	18.20	36	1003	1002
30	24.00	21.00	39	1478	1467
36	28.00	24.80	42	2121	2122
42	32.00	28.60	45	2984	3025
48	35.00	31.40	48	4193	4184

LONG RADIUS 90° BENDS

Nominal Diameter, Inches	Dimensions in Inches			Approximate Weight in Pounds
	A	R	S	
24	30	30	42	1158
30	36	36	48	1791
36	48	48	60	2926
42	60	60	72	4550
48	66	66	78	6527

See Page 372 for Bell and Spigot Dimensions.





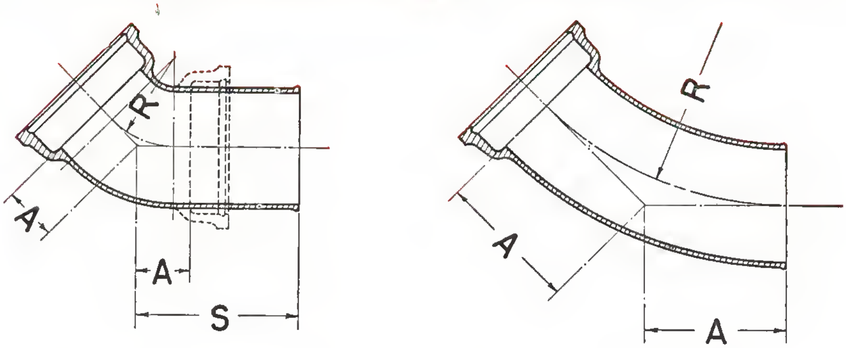
TYPE 1 45° BENDS

Nominal Diameter, Inches	Dimensions in Inches			Approximate Weight in Pounds	
	A	R	S	2 Bells	1 Bell
4	3.16	3.04	23.00	59	63
6	4.23	5.38	23.00	90	97
8	5.31	7.75	23.00	129	138
10	6.39	10.36	23.00	168	183
12	7.22	12.12	24.00	237	253
16	9.12	16.00	25.00	397	410
20	11.03	19.87	27.25	585	607
24	12.94	24.48	29.00	856	874
30	15.67	30.54	31.50	1274	1303

TYPE 2 45° BENDS

Nominal Diameter, Inches	Dimensions in Inches			Approximate Weight in Pounds
	A	R	S	
4	3.16	3.04	13.65	74
6	4.23	5.38	14.48	113
8	5.31	7.75	15.31	161
10	6.39	10.36	16.14	210
12	7.22	12.12	16.97	291

See Page 372 for Bell and Spigot Dimensions.



STANDARD 45° BEND

LONG RADIUS 45° BEND

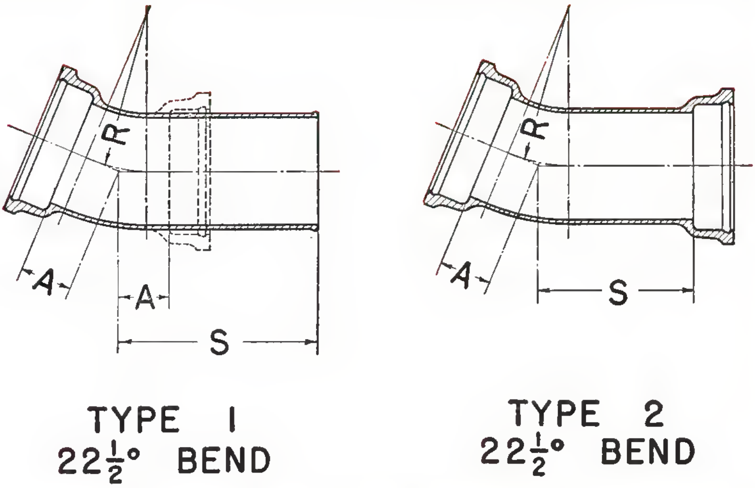
STANDARD 45° BENDS

Nominal Diameter, Inches	Dimensions in Inches			Approximate Weight in Pounds	
	A	R	S	2 Bells	1 Bell
16	7.73	12.62	23	377	387
20	9.30	15.69	23	546	544
24	10.15	17.75	23	774	748
30	11.65	20.87	23	1111	1053
36	13.34	24.50	23	1557	1445
42	14.84	27.62	23	2149	1948
48	16.35	30.75	23	2903	2625

LONG RADIUS 45° BENDS

Nominal Diameter, Inches	Dimensions in Inches		Approximate Weight in Pounds
	A	R	
16	19.88	48	448
20	19.88	48	610
24	24.85	60	971
30	24.85	60	1332
36	37.28	90	2446
42	37.28	90	3208
48	37.28	90	4247

See Page 372 for Bell and Spigot Dimensions.



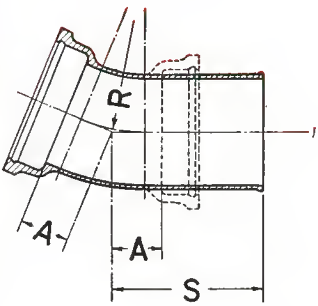
TYPE 1 22½° BENDS

Nominal Diameter, Inches	Dimensions in Inches			Approximate Weight in Pounds	
	A	R	S	2 Bells	1 Bell
4	2.69	4.00	20.25	58	58
6	3.53	7.70	20.75	87	91
8	4.38	11.50	21.25	124	130
10	5.22	15.70	22.00	160	175
12	5.81	18.15	22.50	223	239
16	7.27	24.00	23.75	373	390
20	8.71	29.75	24.75	538	559
24	10.16	37.00	26.00	783	798
30	12.20	46.25	27.75	1153	1176

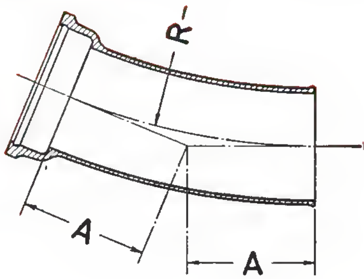
TYPE 2 22½° BENDS

Nominal Diameter, Inches	Dimensions in Inches			Approximate Weight in Pounds
	A	R	S	
4	2.69	4.00	14.70	75
6	3.53	7.70	15.53	114
8	4.38	11.50	16.38	162
10	5.22	15.70	17.25	211
12	5.81	18.15	17.81	290

See Page 372 for Bell and Spigot Dimensions.



STANDARD 22½° BEND



LONG RADIUS 22½° BEND

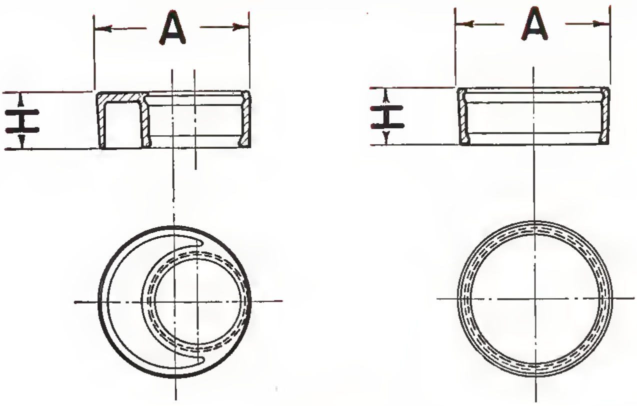
STANDARD 22½° BEND

Nominal Diameter, Inches	Dimensions in Inches			Approximate Weight in Pounds	
	A	R	S	2 Bells	1 Bell
16	5.00	12.62	23	335	366
20	5.92	15.69	23	475	508
24	6.33	17.75	23	666	694
30	7.15	20.87	23	935	966
36	8.07	24.50	23	1280	1306
42	8.89	27.62	23	1740	1744
48	9.72	30.75	23	2291	2319

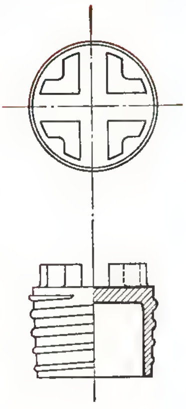
LONG RADIUS 22½° BENDS

Nominal Diameter, Inches	Dimensions in Inches		Approximate Weight in Pounds
	A	R	
16	19.10	96	449
20	19.10	96	611
24	23.87	120	971
30	23.87	120	1331
36	35.80	180	2446
42	35.80	180	3209
48	35.80	180	4247

See Page 372 for Bell and Spigot Dimensions.



BUSHINGS



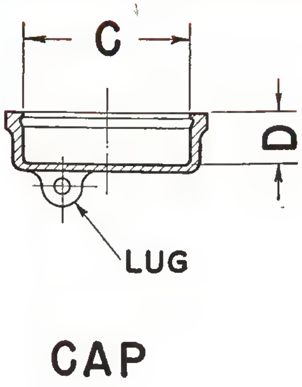
SCREW PLUG

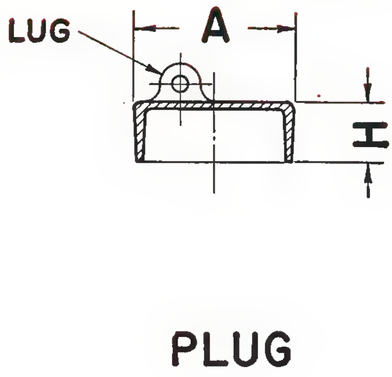
BUSHINGS

Nominal Diameter, Inches	Dimensions in Inches		Approximate Weight in Pounds
	A	H	
6x 3	7.00	4.50	21
6x 4	7.00	4.50	13
8x 4	9.15	4.50	33
8x 6	9.15	4.50	18
10x 6	11.20	4.50	39
10x 8	11.20	4.50	20
12x 6	13.30	5.00	68
12x 8	13.30	5.00	61
12x10	13.30	5.00	28
16x12	17.50	5.00	95

SCREW PLUGS

Nominal Diameter, Inches	Approximate Weight in Pounds
3	7
4	10
6	20
8	25
10	45
12	55

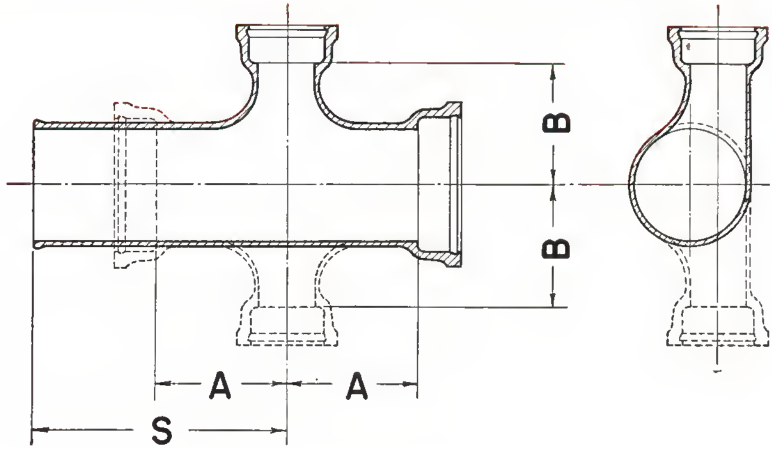




CAPS AND PLUGS

Nominal Diameter, Inches	Dimensions in Inches				Approximate Weight in Pounds	
	A	H	D	C	Caps	Plugs
4	4.90	4.75	4.00	5.80	25	9
6	7.00	4.75	4.00	7.90	37	16
8	9.15	4.75	4.00	10.05	52	24
10	11.20	4.75	4.00	12.10	65	34
12	13.30	5.25	4.50	14.20	95	50
16	17.50	5.25	4.50	18.40	151	83
20	21.70	5.25	4.50	22.85	220	127
24	25.90	5.75	5.00	27.05	330	193
30	31.84	5.75	5.00	32.99	476	294
36	38.06	5.75	5.00	39.21	668	433
42	44.30	5.75	5.00	45.45	916	620
48	50.60	5.75	5.00	51.75	1266	901

Sizes 4″ to 16″ inclusive are furnished without Lugs.



TEES AND CROSSES

TEES AND CROSSES

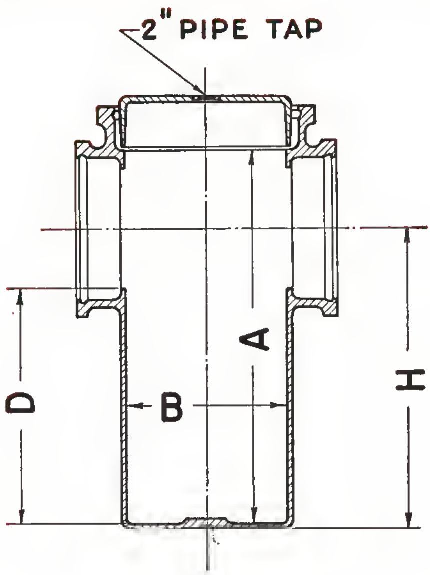
Nominal Diameter, Inches	Dimensions in Inches			Approximate Weights in Pounds			
				Tees		Crosses	
	A	B	S	2 Bells	3 Bells	3 Bells	4 Bells
4x 4	8	8	26	106	105	138	137
6x 4	8	8	26	144	138	174	169
6x 6	8	8	26	156	151	200	194
8x 4	10	10	26	194	192	226	224
8x 6	10	10	26	208	206	254	251
8x 8	10	10	26	223	221	284	282
10x 4	12	11	26	253	251	287	285
10x 6	12	12	26	267	266	315	314
10x 8	12	12	26	283	282	348	346
10x10	12	12	26	296	295	373	372
12x 4	14	13	27	343	350	379	385
12x 6	14	13	27	359	366	409	416
12x 8	14	13	27	376	383	443	450
12x10	14	14	27	390	397	471	478
12x12	14	14	27	410	417	512	519

See Page 372 for Bell and Spigot Dimensions.

TEES AND CROSSES

Nominal Diameter, Inches	Dimensions in Inches			Approximate Weight in Pounds			
				Tees		Crosses	
	A	B	S	2 Bells	3 Bells	3 Bells	4 Bells
16x 6	14	14	29	536	534	582	580
16x 8	14	14	29	552	549	612	610
16x10	14	14	29	563	561	636	634
16x12	17	17	32	655	652	768	765
16x16	17	17	32	709	707	877	875
20x 6	15	15	29	724	730	767	774
20x 8	15	15	29	738	745	796	802
20x10	15	15	29	749	755	817	824
20x12	19	19	34	898	893	1011	1006
20x16	19	19	34	953	947	1120	1115
20x20	19	19	34	1001	995	1216	1211
24x 8	17	17	30	1023	1056	1081	1114
24x10	17	17	30	1034	1067	1103	1136
24x12	17	17	30	1056	1089	1147	1180
24x16	21	21	36	1289	1291	1456	1458
24x20	21	21	36	1336	1338	1552	1554
24x24	21	21	36	1403	1405	1684	1686
30x 8	20	20	32	1488	1546	1546	1604
30x10	20	20	32	1499	1557	1568	1626
30x12	20	20	32	1521	1579	1612	1670
30x16	24	24	39	1834	1828	2002	1995
30x20	24	24	39	1882	1876	2098	2091
30x24	24	24	39	1948	1942	2230	2223
30x30	24	24	39	2035	2029	2404	2398
36x12	25	25	34	2206	2358	2308	2460
36x16	25	25	34	2255	2407	2406	2558
36x20	25	25	34	2297	2449	2489	2641
36x24	28	28	42	2718	2726	3015	3023
36x30	28	28	42	2789	2798	3158	3166
36x36	28	28	42	2859	2867	3296	3305
42x16	29	29	36	3109	3421	3269	3580
42x20	29	29	36	3154	3466	3358	3670
42x24	29	29	36	3216	3528	3483	3794
42x30	32	32	45	3831	3878	4221	4268
42x36	32	32	45	3908	3955	4376	4423
42x42	32	32	45	3997	4144	4553	4701
48x16	32	32	39	4414	4717	4574	4876
48x20	32	32	39	4459	4761	4663	4965
48x24	32	32	39	4521	4824	4788	5090
48x30	32	32	39	4581	4883	4907	5209
48x36	35	35	48	5331	5329	5799	5797
48x42	35	35	48	5415	5413	5966	5964
48x48	35	35	48	5470	5468	6076	6074

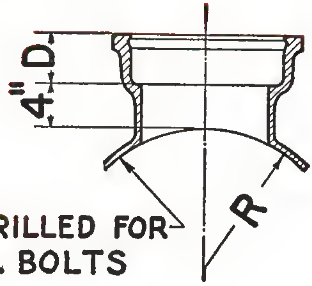
See Page 372 for Bell and Spigot Dimensions.



LINE DRIPS
OPEN TOP

Nominal Diameter, Inches	Dimensions in Inches				Plug Size, Inches	Capacity in Quarts	Approximate Weight in Pounds
	A	B	D	H			
4	17.79	14.16	12.30	14.87	14	32	298
4	30.09	14.16	24.60	27.17	14	64	382
6	19.89	14.16	12.30	15.89	14	32	327
6	32.19	14.16	24.60	28.19	14	64	412
8	34.39	14.16	24.60	29.24	14	64	453
8	46.79	14.16	37.00	41.64	14	96	538
10	36.40	14.16	24.60	30.23	14	64	504
10	48.80	14.16	37.00	42.63	14	96	589
12	37.31	16.16	23.40	30.08	16	84	667
12	48.91	16.16	35.00	41.68	16	126	766
16	42.78	20.24	24.60	33.36	20	138	907
16	55.18	20.24	37.00	45.76	20	208	1051
20	47.92	24.28	25.40	36.28	24	203	1304
20	60.52	24.28	38.00	48.88	24	304	1500
24	49.32	30.04	22.60	35.59	30	280	1826
24	60.72	30.04	34.00	46.99	30	420	2070
30	55.27	36.06	22.60	38.57	36	399	2617
36	62.89	42.06	24.00	43.10	42	576	3652
42	69.16	47.98	24.00	46.29	48	752	5261
48	75.97	53.96	24.60	49.94	54	974	6506

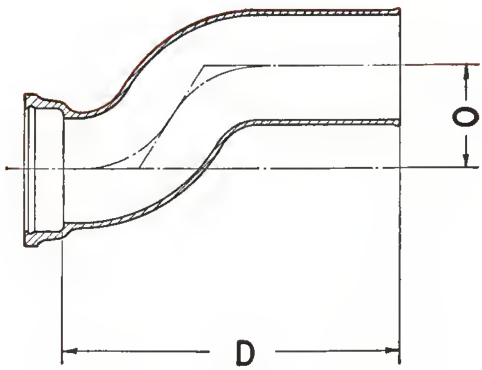
Note—Approx. Wts. shown do not include weight of Plug.
See Page 372 for Bell and Spigot Dimensions.



HAT FLANGES

Nominal Diameter, Inches	Dimensions in Inches D	Dimensions in Inches R	Approximate Weight in Pounds
20x 6	4.00	11.00	73
20x 8	4.00	11.00	97
20x10	4.00	11.00	120
20x12	4.50	11.00	158
24x 6	4.00	13.00	72
24x 8	4.00	13.00	96
24x10	4.00	13.00	117
24x12	4.50	13.00	156
30x 6	4.00	16.00	72
30x 8	4.00	16.00	94
30x10	4.00	16.00	116
30x12	4.50	16.00	153
36x 6	4.00	19.25	71
36x 8	4.00	19.25	93
36x10	4.00	19.25	116
36x12	4.50	19.25	150
42x 6	4.00	22.37	71
42x 8	4.00	22.37	93
42x10	4.00	22.37	114
42x12	4.50	22.37	150
48x 6	4.00	25.50	71
48x 8	4.00	25.50	93
48x10	4.00	25.50	113
48x12	4.50	25.50	150

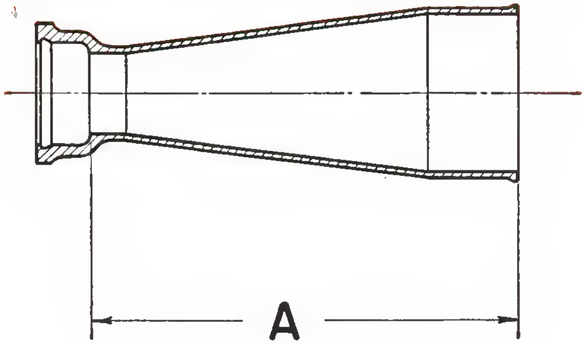
See Page 372 for Bell and Spigot Dimensions.



OFFSETS

Nominal Diameter, Inches	Dimensions in Inches		Approximate Weight in Pounds
	Offset O	D	
4	6	30.67	73
4	12	34.14	83
4	18	37.60	93
6	6	31.92	113
6	12	35.39	129
6	18	38.85	145
8	6	33.74	162
8	12	36.65	182
8	18	40.11	204
10	6	35.18	216
10	12	37.80	234
10	18	41.26	270
12	6	36.54	294
12	12	39.06	323
12	18	42.52	362
16	6	39.01	470
16	12	42.80	510
16	18	45.13	570
20	6	41.17	616
20	12	45.96	623
20	18	48.43	705

See Page 372 for Bell and Spigot Dimensions.



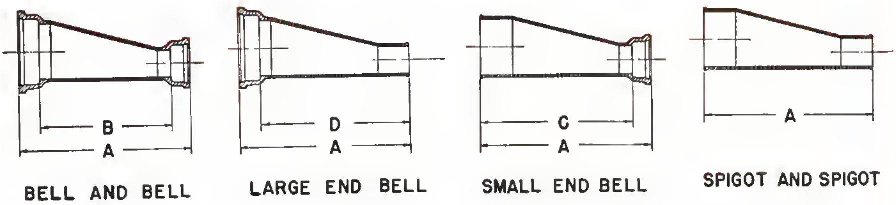
Concentric Reducers

SMALL END BELL

Nominal Diameter, Inches	Dimensions in Inches A	Approximate Weight in Pounds
14x 4	32.0	178
14x 6	32.0	198
18x 8	32.0	280
18x10	32.0	303
24x12	37.5	508
30x16	37.5	727
30x20	37.5	820
30x24	37.0	940
36x30	43.0	1418
42x36	43.0	1866
48x42	43.0	2475
54x48	43.0	3089

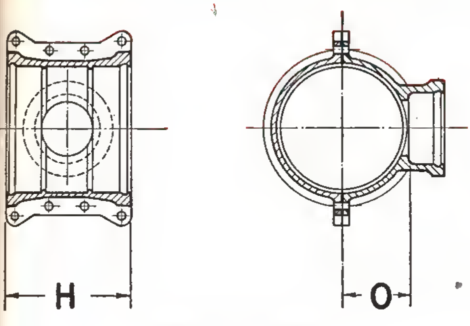
See Page 372 for Bell and Spigot Dimensions.

Eccentric Reducers

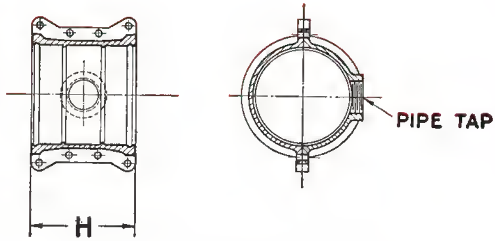


Nominal Diameter, Inches		Dimensions in Inches				Approximate Weight in Pounds			
		A	B	C	D	2 Bells	Large Bell	Small Bell	2 Spigots
4	3	20.0	12.0	16.0	16.0	57	44	39	26
6	3	25.0	17.0	21.0	21.0	80	66	55	41
6	4	20.0	12.0	16.0	16.0	81	63	56	38
8	4	28.0	20.0	24.0	24.0	117	99	84	66
8	6	20.0	12.0	16.0	16.0	114	89	81	56
10	4	36.0	28.0	32.0	32.0	160	142	122	104
10	6	28.0	20.0	24.0	24.0	156	131	118	93
10	8	20.0	12.0	16.0	16.0	148	115	110	77
12	6	37.0	28.5	33.0	32.5	222	198	171	148
12	8	29.0	20.5	25.0	24.5	212	181	162	130
12	10	21.0	12.5	17.0	16.5	193	158	142	107
16	8	46.0	37.5	42.0	41.5	388	356	304	272
16	10	38.0	29.5	34.0	33.5	366	331	282	247
16	12	29.0	20.0	24.5	24.5	344	293	259	209
20	10	54.0	45.5	50.0	49.5	586	551	469	434
20	12	46.0	37.0	41.5	41.5	569	518	441	401
20	16	30.0	21.0	25.5	25.5	509	425	392	308
24	16	46.5	37.0	42.0	41.5	792	716	641	565
24	20	30.5	21.0	26.0	25.5	677	572	527	421
30	20	55.0	45.5	50.5	50.0	1226	1121	1023	917
30	24	40.0	30.0	35.0	35.0	1102	952	899	748
36	24	64 0	54.0	59.0	59.0	1843	1692	1576	1426
36	30	40.0	30.0	35.0	35.0	1484	1281	1217	1014
42	30	64.0	54.0	59.0	59.0	2465	2262	2108	1904
42	36	40.0	30.0	35.0	35.0	1965	1698	1607	1341
48	36	64.0	54.0	59.0	59.0	3247	2980	2821	2554
48	42	40.0	30.0	35.0	35.0	2566	2208	2139	1782

See Page 372 for Bell and Spigot Dimensions.



HUB SLEEVE



SERVICE SLEEVE

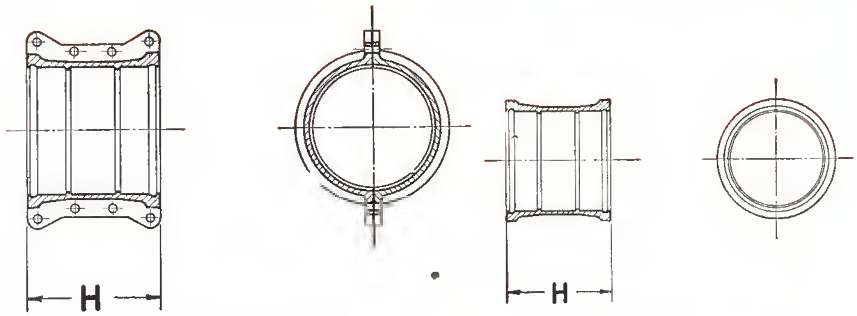
HUB SLEEVES

Nominal Diameter, Inches	Dimensions in Inches		Approximate Weight in Pounds
	H	O	
10x 4	15	6.54	170
10x 6	15	6.54	196
12x 4	15	7.64	208
12x 6	15	7.64	238
16x 6	18	9.82	343
16x 8	18	9.82	352
20x 6	18	12.10	441
20x 8	18	12.10	448
20x10	18	12.10	451

See Page 372 for Bell and Spigot Dimensions.

SERVICE SLEEVES

Nominal Diameter, Inches	Dimensions in Inches	Maximum Pipe Tap, Inches	Approximate Weight in Pounds
	H		
2	8	1.50	38
3	12	3.00	57
4	12	3.00	69
6	12	3.00	94
8	15	3.00	133
10	15	3.00	158
12	15	4.00	201
16	18	4.00	323

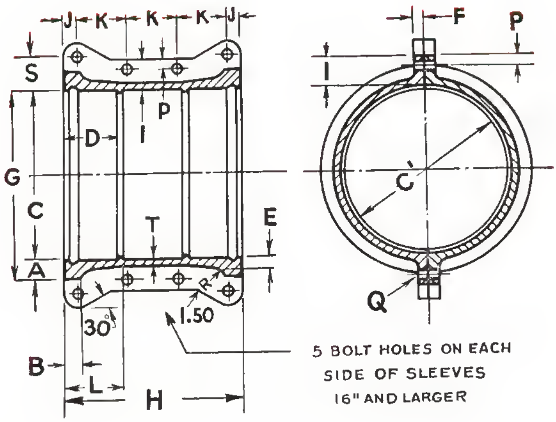


SPLIT SLEEVE SOLID SLEEVE

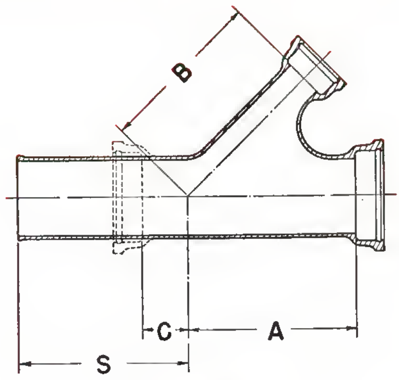
SPLIT AND SOLID SLEEVES

Nominal Diameter, Inches	Dimensions in Inches	Approximate Weight in Pounds	
	H	Split Sleeve	Solid Sleeve
2	8	37	20
3	12	56	38
4	12	67	47
6	12	87	65
8	15	127	100
10	15	151	122
12	15	191	160
16	18	314	269
20	18	420	372
24	18	552	500
30	18	729	676
36	18	939	871
42	18	1204	1133
48	18	1507	1421

Split Sleeves



Nominal Diameter, Inches	Dimensions in Inches								
	A	B	C	C′	D	E	F	G	H
2	1.12	1.25	3.38	3.08	2.00	.56	.75	5.62	8
3	1.30	1.25	4.80	4.50	4.00	.56	.75	7.40	12
4	1.30	1.50	5.80	5.43	4.00	.68	.75	8.40	12
6	1.40	1.50	7.90	7.53	4.00	.75	.81	10.70	12
8	1.50	1.50	10.05	9.80	4.00	.81	.81	13.05	15
10	1.50	1.50	12.10	11.85	4.00	.81	.87	15.10	15
12	1.60	1.50	14.20	13.95	4.50	.93	.94	17.40	15
16	1.80	1.75	18.40	18.15	4.50	1.06	1.06	22.00	18
20	2.00	1.75	22.85	22.45	4.50	1.12	1.12	26.85	18
24	2.10	2.00	27.05	26.65	5.00	1.31	1.25	31.25	18
30	2.30	2.00	32.99	32.59	5.00	1.43	1.31	37.59	18
36	2.50	2.00	39.21	38.81	5.00	1.50	1.43	44.21	18
42	2.80	2.00	45.45	45.05	5.00	1.68	1.56	51.05	18
48	3.00	2.00	51.75	51.35	5.00	1.75	1.75	57.75	18



Y – BRANCHES

Nominal Diameter, Inches	Dimensions in Inches				Approximate Weight in Pounds	
	A	B	C	S	3 Bells	2 Bells
4x 4	11.15	11.15	3.16	23	105	109
6x 4	15.50	15.25	4.25	23	154	161
6x 6	15.50	15.50	4.25	23	171	178
8x 4	19.30	18.80	5.31	23	215	224
8x 6	19.30	19.05	5.31	23	234	243
8x 8	19.30	19.30	5.31	23	254	263
10x 4	22.75	22.00	6.75	23	285	297
10x 6	22.75	22.25	6.75	23	305	317
10x 8	22.75	22.50	6.75	23	327	339
10x10	22.75	22.75	6.75	23	347	360
12x 4	26.75	26.00	7.25	23	396	406
12x 6	26.75	26.25	7.25	23	418	428
12x 8	26.75	26.50	7.25	23	442	453
12x10	26.75	26.75	7.25	23	466	476
12x12	26.75	26.75	7.25	23	502	512
16x16	33.13	33.13	9.12	23	864	859
20x20	38.53	38.53	11.03	23	1271	1245
24x24	43.00	43.00	13.00	23	1828	1753
30x30	52.50	52.50	13.75	23	2784	2672
36x36	60.38	60.38	18.37	23	4090	3818
42x42	70.00	70.00	22.00	23	5981	5489
48x48	80.00	80.00	25.00	23	8677	7926

See Page 372 for Bell and Spigot Dimensions.

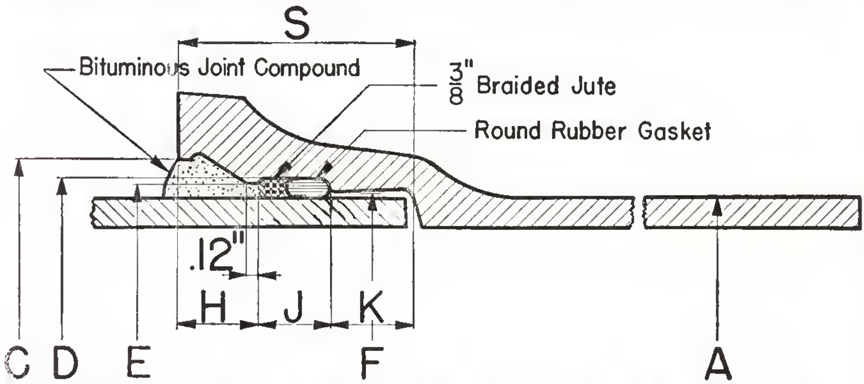
SECTION 16

Special Types of Pipe and Fittings

PAGE

Roll-On Joint Pipe

Standard Dimensions, Thicknesses and Weights of Cast Iron Roll-On Joint Pipe for Water or Other Liquids. For 150 PSI pressure, laid without blocks on flat bottomed trench with tamped backfill under 5 feet of cover.



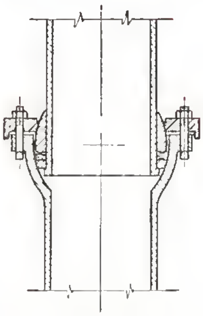
Size	A	C	D	E	F	H	J	K	Round Rubber Gasket I. D.	Round Rubber Gasket Thickness	S
3	3.96	4.93	4.43	4.31	4.05	1.06	1.13	1.31	3.17	0.47	3.50
4	4.80	6.00	5.35	5.23	4.89	1.31	1.25	1.44	3.81	0.55	4.00
6	6.90	8.10	7.45	7.33	6.99	1.31	1.25	1.44	5.50	0.55	4.00
8	9.05	10.25	9.60	9.48	9.14	1.31	1.25	1.44	7.25	0.55	4.00
10	11.10	12.30	11.65	11.53	11.20	1.31	1.25	1.44	8.88	0.55	4.00
12	13.20	14.40	13.75	13.63	13.30	1.31	1.38	1.56	10.56	0.55	4.25

Size	Pit Cast ASA A21.2			Centrifugally Cast in Metal Molds ASA A21.6					Centrifugally Cast in Sand Lined Molds ASA A21.8						
		12 ft. lgth.			12 ft. lgth.		18 ft. lgth.			16 ft. lgth.		16½ ft. lgth.		20 ft. lgth.	
	Thickness, Inches	Avg. per ft.†	Avg. per lgth.*	Thickness, Inches	Avg. per ft.†	Avg. per lgth.*	Avg. per ft.†	Avg. per lgth.*	Thickness, Inches	Avg. per ft.†	Avg. per lgth.*	Avg. per ft.†	Avg. per lgth.*	Avg. per ft.†	Avg. per lgth.*
3	0.37	14.2	170	0.32	12.5	150	12.0	215	0.32	12.4	195	12.3	205	.....	.....
4	0.40	19.2	230	0.35	16.6	200	16.1	290	0.35	16.5	265	16.4	270	.....	.....
6	0.43	30.0	360	0.38	26.4	315	25.6	460	0.38	25.9	415	25.8	425	.....	.....
8	0.46	42.9	515	0.41	38.1	455	36.9	665	0.41	37.0	590	36.9	610	.....	.....
10	0.54	60.8	730	0.44	50.5	605	49.0	880	0.44	49.1	785	49.0	810	.....	.....
12	0.58	77.9	935	0.48	65.3	785	63.4	1140	0.48	63.7	1020	63.6	1050	63.0	1260

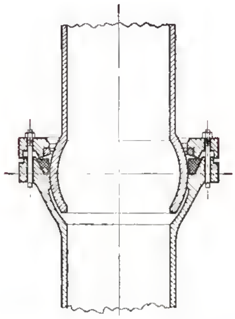
*Including bell. Calculated weight of pipe rounded off to nearest 5 lb.

†Average weight per foot based on calculated weight of pipe before rounding. Dimensions in inches.

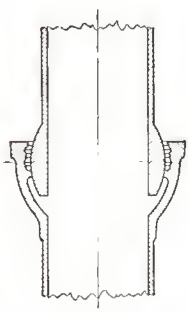
SUBMARINE AND LOCK TYPE MECHANICAL JOINTS



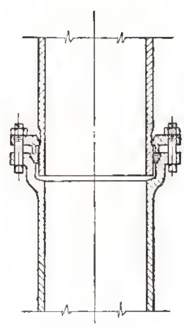
MECHANICAL FLEXIBLE JOINT PIPE "MOLOX" TYPE



MECHANICAL FLEXIBLE JOINT PIPE "USIFLEX" TYPE



TYPE-2 METROPOLITAN JOINT FOR FLEXIBLE JOINT PIPE



LOCK TYPE MECHANICAL JOINT

Weights and Dimensions of Plain End Iron Pipe Size Pipe

A.S.A. CLASS 23

Size	O.D.	Thick-ness	I.D.	Barrel Wt. Ft.	Weight per Length*			
					12 Ft.	16 Ft.	16½ Ft.	18 Ft.
3	3.50	0.35**	2.80	10.8	130	175	....	....
4	4.50	0.38	3.74	15.3	185	245	250	275
6	6.62	0.41	5.80	25.0	300	400	410	450
8	8.62	0.44	7.74	35.3	425	565	580	635
10	10.75	0.48	9.79	48.3	580	775	795	870
12	12.75	0.52	11.71	62.3	750	995	1030	1120

A.S.A. CLASS 25

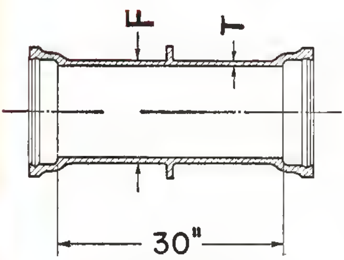
Size	O.D.	Thick-ness	I.D.	Barrel Wt. Ft.	Weight per Length*			
					12 Ft.	16 Ft.	16½ Ft.	18 Ft.
3	3.50	0.41	2.68	12.4	150	200	....	....
4	4.50	0.44	3.62	17.5	210	280	290	315
6	6.62	0.48	5.66	28.9	345	460	475	520
8	8.62	0.52	7.58	41.3	495	660	680	745
10	10.75	0.56	9.63	55.9	670	895	920	1005
12	12.75	0.60	11.55	71.5	860	1145	1180	1285

A.S.A. CLASS 27

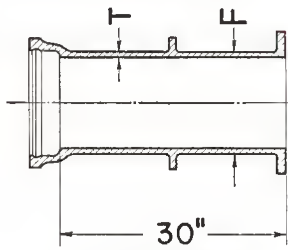
Size	O.D.	Thick-ness	I.D.	Barrel Wt. Ft.	Weight per Length*			
					12 Ft.	16 Ft.	16½ Ft.	18 Ft.
3	3.50	0.48	2.54	14.2	170	225	....	....
4	4.50	0.52	3.46	20.3	245	325	335	365
6	6.62	0.56	5.50	33.3	400	535	550	600
8	8.62	0.60	7.42	47.2	565	755	780	850
10	10.75	0.65	9.45	64.3	770	1030	1060	1155
12	12.75	0.70	11.35	82.7	990	1325	1365	1490

All dimensions given in inches.
*Calculated weights rounded to nearest 5 pounds.
** .38″ is minimum thickness of Cast Iron Pressure pipe recommended for threading.

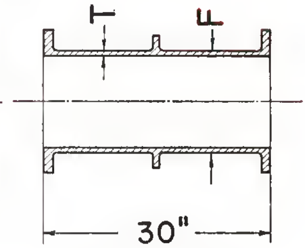
Laying Dimensions and Weights of Standard Wall Castings



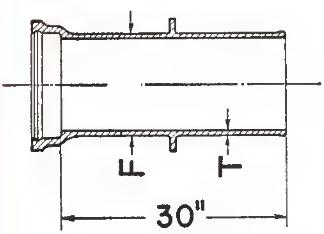
Bell and Bell



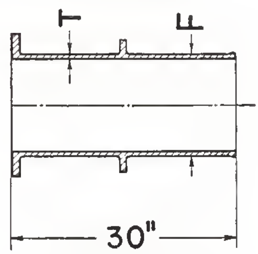
Bell and Flange



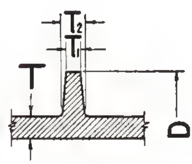
Flange and Flange



Bell and Spigot



Flange and Spigot

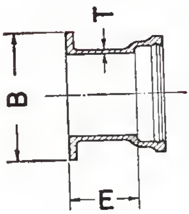


Detail Intermediate Flange

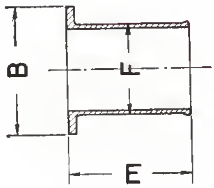
Nom. Diam.	Class	T	F	Intermediate Flange				Wall Pipe Weights				
				T_2	T_1	D	Int. Flg. Wt.	Bell & Bell	Bell & Flange	Flange & Flange	Bell & Spigot	Flange & Spigot
3	D	0.48	3.96	0.75	0.50	7.00	4	85	70	55	65	50
4	D	0.52	5.00	0.75	0.50	8.00	5	110	95	85	85	75
6	D	0.55	7.10	0.75	0.50	10.00	6	165	140	120	130	105
8	D	0.60	9.30	0.75	0.50	12.50	9	235	205	180	185	155
10	D	0.68	11.40	0.75	0.50	14.50	10	315	280	245	245	215
12	D	0.75	13.50	0.75	0.50	16.50	12	395	365	330	320	285
14	B	0.66	15.30	1.00	0.75	19.50	26	440	405	370	355	320
14	D	9.82	15.65	1.00	0.75	19.50	24	515	470	425	420	375
16	B	0.70	17.40	1.00	0.75	21.75	30	545	500	450	435	385
16	D	0.89	17.80	1.00	0.75	21.75	28	655	590	525	525	460
18	B	0.75	19.50	1.00	0.75	23.75	33	645	580	520	515	450
18	D	0.96	19.92	1.00	0.75	23.75	30	785	695	605	635	545
20	B	0.80	21.60	1.00	0.75	25.75	35	755	690	620	600	535
20	D	1.03	22.06	1.00	0.75	25.75	32	940	835	725	755	645
24	B	0.89	25.80	1.00	0.75	30.25	45	985	910	835	790	715
24	D	1.16	26.32	1.00	0.75	30.25	40	1255	1115	980	1010	870
30	B	1.03	32.00	1.25	1.00	36.50	70	1450	1335	1220	1155	1040
30	D	1.37	32.74	1.25	1.00	36.50	60	1945	1695	1440	1535	1280
36	B	1.15	38.30	1.25	1.00	43.00	88	2025	1855	1685	1585	1415
36	D	1.58	39.16	1.25	1.00	43.00	72	2700	2355	2010	2115	1775
42	B	1.28	44.50	1.50	1.25	49.50	130	2660	2465	2275	2080	1885
42	D	1.78	45.58	1.50	1.25	49.50	105	3625	3160	2700	2825	2360
48	B	1.42	50.80	1.50	1.25	56.50	172	3380	3110	2835	2640	2370
48	D	1.96	51.98	1.50	1.25	56.50	138	4630	3990	3350	3590	2950

Dimensions in inches.
Fittings can be furnished in lengths other than 30″.
A.S.A. Class 125 Standard Flanges used, see page 345 for dimensions.
Wall Flange in center of laying length unless otherwise specified.

Laying Dimensions and Weights of Standard Fittings

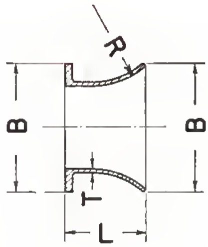


Flange and Bell

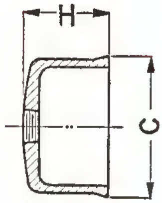


Flange and Spigot

E—To Be Specified by Purchaser



Flange and Flare

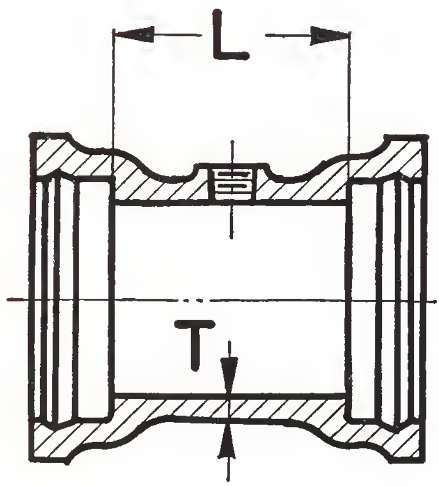


Round Nose Plug

Size	Class	Data for Flange & Bell or Flange & Spigot						Flange & Flare			Round Nose Plugs			
		T	F. O.D.	Wt. of Bell	Wt. of Bead	Wt. Single Flange	Wt. per Ft. of Bbl.	R	L	Wt.	C	H	Wt. Not Tapped	Max. Tap Size
3	D	0.48	3.96	20	0.3	6	16.4	6	8	20	4.34	5.50	10	2
4	D	0.52	5.00	25	0.4	10	22.8	6	8	30	5.28	6.00	15	2½
6	D	0.55	7.10	35	0.5	13	35.3	6	8	40	7.38	6.00	25	4
8	D	0.60	9.30	49	1.2	21	51.2	8	10	70	9.56	6.00	40	4
10	D	0.68	11.40	62	1.4	28	71.5	10	10	95	11.63	6.00	55	4
12	D	0.75	13.50	76	1.7	43	93.7	12	12	155	13.73	6.00	70	4
14	B	0.66	15.30	88	1.9	54	94.7	14	12	165	....	....	....	....
14	D	0.82	15.65	96	1.9	51	119.2	14	12	190	....	....	....	....
16	B	0.70	17.40	114	2.1	67	114.6	16	16	240	....	....	....	....
16	D	0.89	17.80	128	2.2	63	147.5	16	16	280	....	....	....	....
18	B	0.75	19.50	133	2.4	70	137.8	18	16	275	....	....	....	....
18	D	0.96	19.92	154	2.4	65	178.4	18	16	320	....	....	....	....
20	B	0.80	21.60	156	2.6	89	163.1	20	18	355	....	....	....	....
20	D	1.03	22.06	189	2.7	82	212.3	20	18	425	....	....	....	....
24	B	0.89	25.80	199	3.2	123	217.3	24	18	480	....	....	....	....
24	D	1.16	26.32	250	3.2	112	286.1	24	18	570	....	....	....	....
30	B	1.03	32.00	298	3.9	184	312.7	....	....	....	....	....	....	....
30	D	1.37	32.74	416	4.0	163	421.3	....	....	....	....	....	....	....
36	B	1.15	38.30	446	4.7	274	418.8	....	....	....	....	....	....	....
36	D	1.58	39.16	586	4.8	242	582.0	....	....	....	....	....	....	....
42	B	1.28	44.50	586	5.4	393	542.3	....	....	....	....	....	....	....
42	D	1.78	45.58	805	5.8	341	764.2	....	....	....	....	....	....	....
48	B	1.42	50.80	745	6.2	474	687.3	....	....	....	....	....	....	....
48	D	1.96	51.98	1046	6.3	406	961.0	....	....	....	....	....	....	....

Dimensions in inches.
B is 125 Std. Flange O.D.

Dimensions and Weights—Tapped Tee



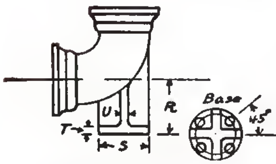
TAPPED TEE

Size	Class	Dimensions in Inches		Weight Pounds
		T	L	
3	D	.48	12	55
4	D	.52	12	75
6	D	.55	12	105
8	D	.60	12	150
10	D	.68	12	195
12	D	.75	12	245

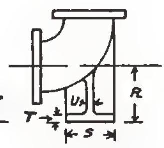
When ordering specify size of tap.
Tapped crosses can be furnished by the addition of another tapped boss.

Weights and Dimensions of Standard Bases for Fittings

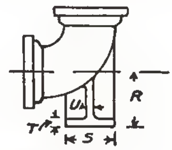
Bases can be furnished for Tees and Bends as follows
125# Flanged—Mech-Joint—Short Body—A.W.W.A. B. & S.



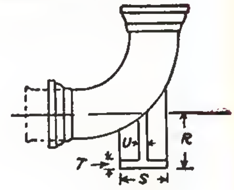
Short Body



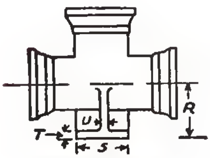
125# Flanged



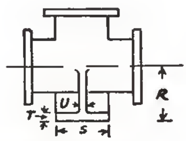
Mechanical Joint



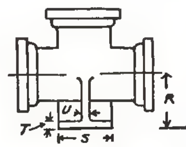
A.W.W.A.



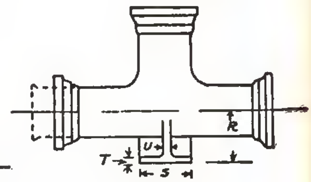
Short Body



125# Flanged



Mechanical Joint

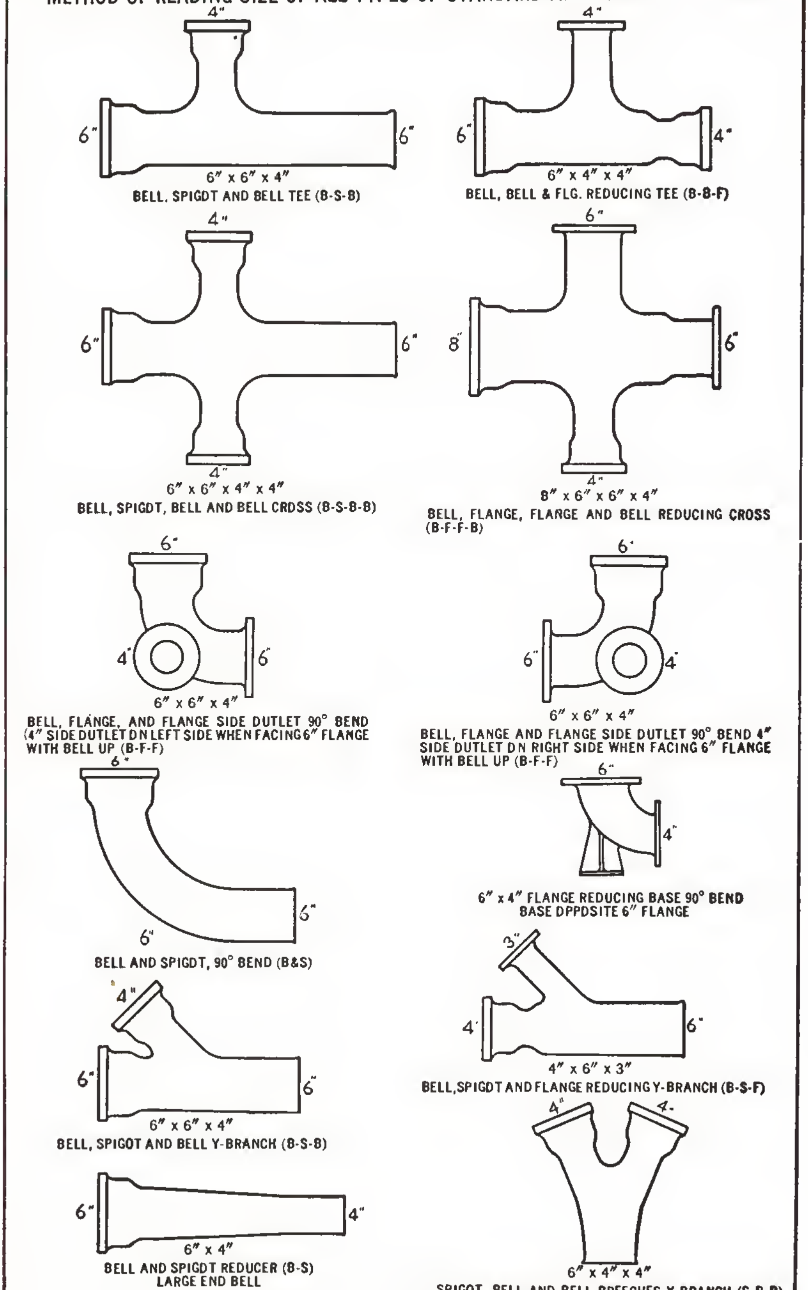


A.W.W.A.

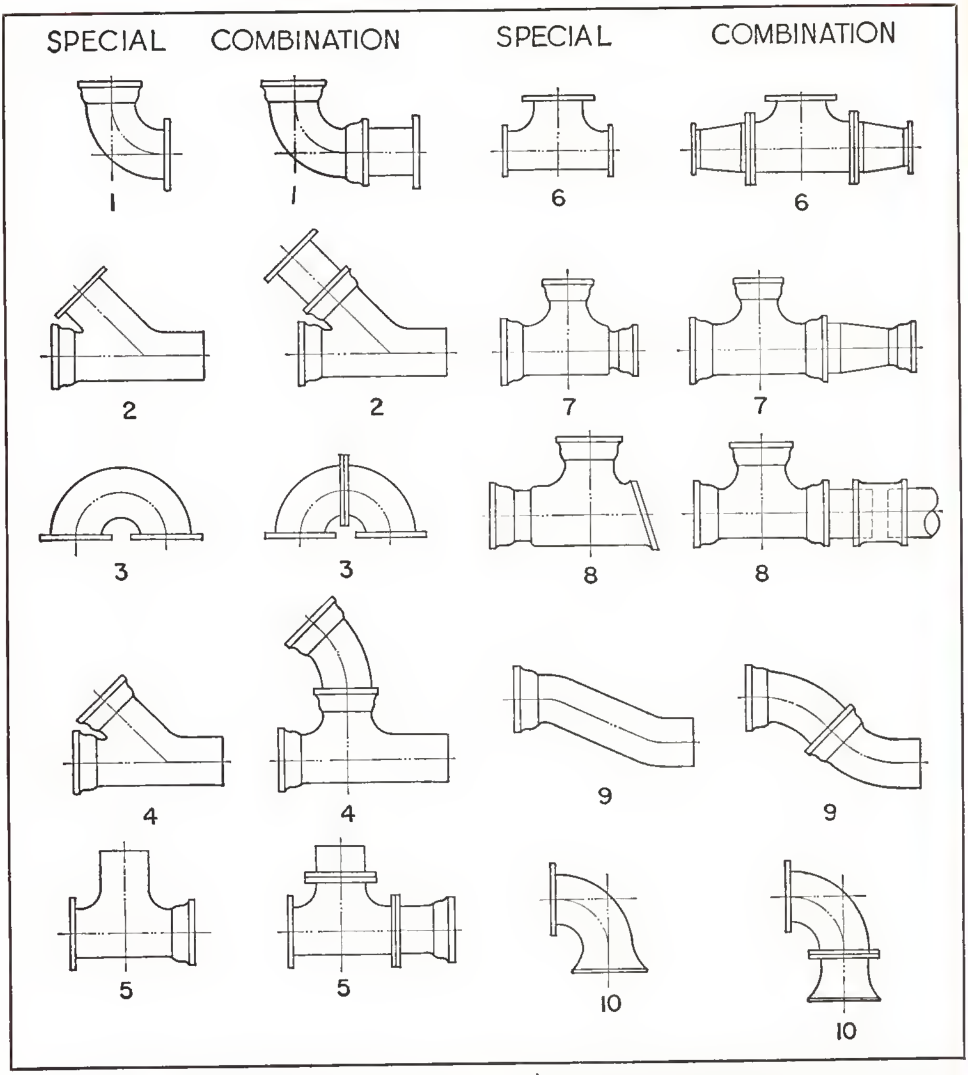
Size	Center to Base R	Diam. of Base S	Thick. of Base T	Thick. of Rib U	Diam. of B.C. of Base	Size of Holes in Base	No. of Holes in Base	Supporting Pipe Size	Wt. of Base, Lbs. Tees	Bends A.W.W.A.	Bends 125 Lb. Flg. & Mech. Joint	Bends Short Body
3	4.88	5.00	0.56	0.50	3.88	5/8	4	1½	5	20	10	10
4	5.50	6.00	0.62	0.50	4.75	¾	4	2	10	25	10	10
6	7.00	7.00	0.69	0.62	5.50	¾	4	2½	15	35	20	20
8	8.38	9.00	0.94	0.88	7.50	¾	4	4	30	60	40	40
10	9.75	9.00	0.94	0.88	7.50	¾	4	4	30	65	45	45
12	11.25	11.00	1.00	1.00	9.50	7/8	4	6	45	85	65	65
14	12.50	11.00	1.00	1.00	9.50	7/8	4	6	50	95	70	.....
16	13.75	11.00	1.00	1.00	9.50	7/8	4	6	50	110	75	.....
18	15.00	13.50	1.12	1.12	11.75	7/8	4	8	75	155	115	.....
20	16.00	13.50	1.12	1.12	11.75	7/8	4	8	75	160	120	.....
24	18.50	13.50	1.12	1.12	11.75	7/8	4	8	80	175	130	.....
30	23.00	16.00	1.19	1.15	14.25	1	4	10	120	260	190	.....
36	26.00	19.00	1.25	1.15	17.00	1	4	12	160	390	250	.....
42	30.00	23.50	1.44	1.28	21.25	1 1/8	4	16	270	575	410	.....
48	34.00	25.00	1.56	1.42	22.75	1¼	4	18	335	740	515	.....
54	38.00	27.50	1.69	1.55	25.00	1¼	4	20	.....	.....	.....	.....
60	42.00	32.00	1.88	1.67	29.50	1 3/8	4	24	.....	.....	.....	.....

Dimensions in inches.
Bases are not faced nor drilled unless specified.
Dimension "R" is a finished dimension, unfinished bases will be 1/8" longer.

METHOD OF READING SIZE OF ALL TYPES OF STANDARD AND SPECIAL FITTINGS



Combination of Standard Fittings That May Be Used in Place of Special Fittings

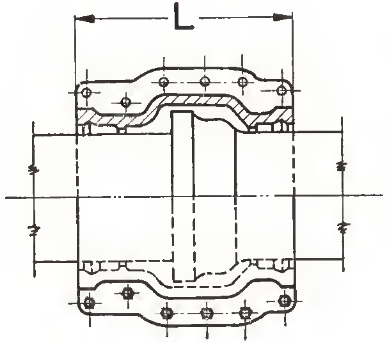


The illustrations in the "SPECIAL" columns on this page indicate typical fittings that are often required with a combination of bell, spigot, and flange outlets. The laying dimensions of these fittings are not covered by any standard and they are therefore usually named "SPECIAL" inasmuch as they are made to order to suit certain conditions in piping installations.

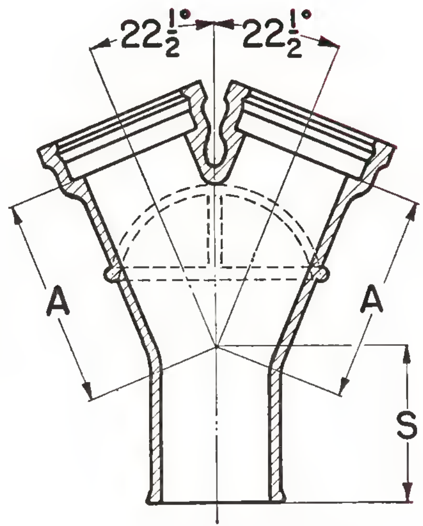
To the right of each "SPECIAL" fitting is shown a combination of Standard fittings that can be used to obtain the same outlet effects as the Specials. The laying dimensions may not be interchangeable since the dimensions of the Standard fittings are fixed whereas the Specials can be made to any desired lengths.

The use of Standard fittings wherever possible is always recommended as the most economical and such fittings can usually be shipped out of stock. In sending inquiries for fittings of dimensions deviating from the Standard, state specifically the type of outlets wanted, reading, size, etc., as shown on page 399, and give exact dimension from center line to outlet.

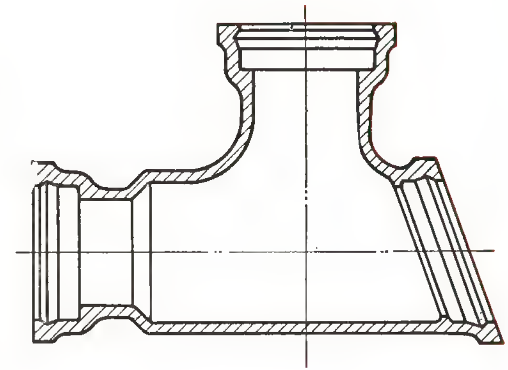
Non-Standard Fittings



Bell Split Sleeve



Type 1 Y Branch

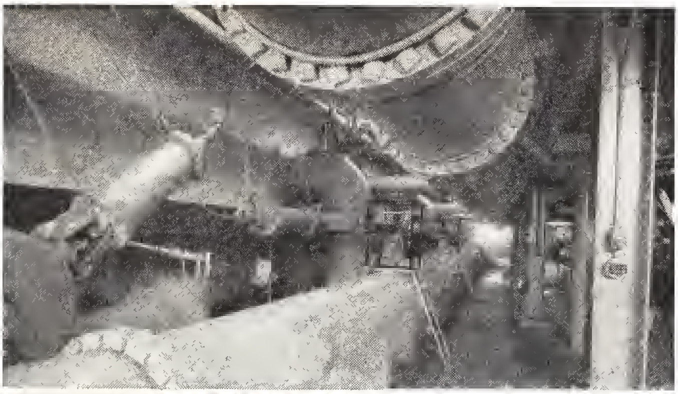


Cutting-in Tee

SECTION 17

Industrial Uses

Cast iron pipe carries hot corrosive liquid in chemical plant



Paper Mills
Installation of cast iron pipe for supply and backwash lines in filtration plant.

Rayon Plants
Cast iron pipe is widely used for water supply in rayon and other process industries.

Coal Mines
Cast iron pipe in mine refuse disposal system.

Steam Generating Plants
Cast iron pipe carries over 40 tons of ash daily in ash removal system.

Railroads
Cast iron water line from pumping station to water tank.

Oil Refineries
Cast iron pipe installed for cooling coil.

SECTION 18

Salvaging and Re-Using Cast Iron Pipe

It is impossible to foretell future requirements or population shifts in cities, large or small, but any public official can be sure that, when water, gas or sewer mains must be abandoned, rerouted, or replaced by larger sizes, the pipe can be salvaged, or reused, if it is cast iron pipe.

Springfield, Missouri. In connection with changes at a pumping station, part of a 50-year-old 18-inch cast iron water main was recently taken up and relaid in another part of the city. Note cast marks and date clearly discernible on pipe in right center.

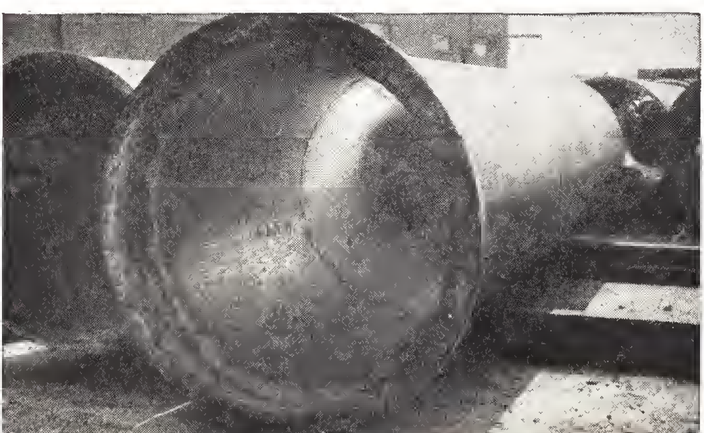
San Francisco, Cal. A 12-inch cast iron line, originally laid in 1892 by the Spring Valley Water Co., subsequently taken over by the San Francisco Water Department, was removed after more than 40 years of service. In excellent condition it was relaid elsewhere in the city, saving a substantial sum to the taxpayers.

Columbus, Ohio. Recent completion of a new sewage treatment plant and intercepting sewer resulted in the abandonment of a 48-inch cast iron force main. After 37 years' service, without any maintenance cost, the pipe was taken up and sold by the city for a substantial price per ton, over and above all removal expense.

Richmond, Va. A section of a cast iron water main, salvaged and relaid at 88 years of age, uncovered for inspection in its 113th year of service to the taxpayers of Richmond, Va.

Kenosha, Wis. Removing a 14-inch cast iron water main for replacement with new 24-inch cast iron pipe. After 43 years' service, the old 14-inch pipe proved to be in excellent condition and was relaid in another section of the city.

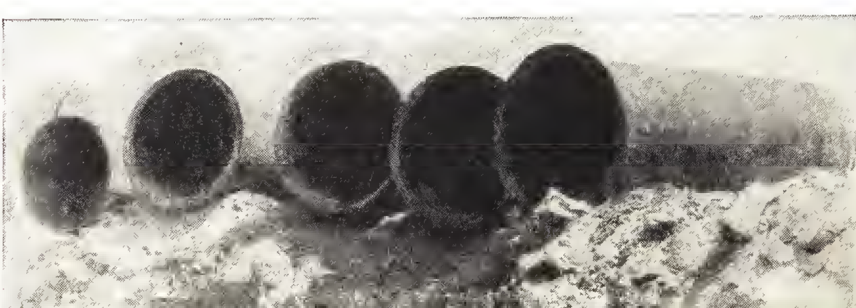
Chicago, Ill. Note the fine condition of this 36-inch cast iron pipe, both interior and exterior, after 70 years of service in its original location in Chicago's water supply system. The maker's stencil is clearly legible. Naturally, this pipe was salvaged and relaid elsewhere, at a considerable saving to the city.



Ft. Worth, Texas. This city was recently required by the State Highway Department to relocate a 36-inch cast iron water main which had been in service for 46 years. When taken up the pipe was found in fine condition (interiors almost literally "as clean as a whistle"), moved to a new location and relaid.

Nashua, N. H. Eighty-year-old cast iron pipe recently removed from the system, being cleaned and redipped for relaying in other sections of the distribution system.

Glendale, Cal. Installing a 48-inch bell and spigot cast iron intercepting sewer crossing under Los Angeles River. This is the third location for the pipe. It was first used in Philadelphia from 1901 to 1923 then reconditioned and installed at Glendale in 1925 and relocated at Glendale in 1938.



Escanaba, Mich. This 16-inch cast iran pipe, after nearly half a century of service in the water supply system af Iran Mauntain, Michigan, was taken up and relaid in Escanaba, abaut fifty miles away.

New Yark, N. Y. Remaving a 36-inch cast iran water main fram tunnel in Highbridge. Installed in 1848 ta carry water fram Cratan Aqueduct acrass Harlem River and abandaned when bridge was recanstructed. Sald as scrap.

SECTION 19

Useful Tables

Please note that while all tables and formulas contained in the following pages have been carefully checked and every precaution taken in proofreading, we do not assume responsibility for their accuracy.

Pressures in Pounds per Square Inch, Corresponding to Heads of Water in Feet

Head Ft.	0	1	2	3	4	5	6	7	8	9
0	....	0.433	0.866	1.299	1.732	2.165	2.598	3.031	3.464	3.987
10	4.330	4.763	5.196	5.629	6.062	6.495	6.928	7.361	7.794	8.277
20	8.660	9.093	9.526	9.959	10.392	10.825	11.258	11.691	12.124	12.557
30	12.990	13.423	13.856	14.289	14.722	15.155	15.588	16.021	16.454	16.887
40	17.320	17.753	18.186	18.619	19.052	19.485	19.918	20.351	20.784	21.217
50	21.650	22.083	22.516	22.949	23.382	23.815	24.248	24.681	25.114	25.547
60	25.980	26.413	26.846	27.279	27.712	28.145	28.578	29.011	29.444	29.877
70	30.310	30.743	31.176	31.609	32.042	32.475	32.908	33.341	33.774	34.207
80	34.640	35.073	35.506	35.939	36.372	36.805	37.238	37.671	38.104	38.537
90	38.970	39.403	39.836	40.269	40.702	41.135	41.568	42.001	42.436	42.867

Heads of Water in Feet, Corresponding to Pressures in Pounds per Square Inch

Pressure Lbs. per Sq. In.	0	1	2	3	4
0	....	2.309	4.619	6.928	9.238
10	23.095	25.404	27.714	30.023	32.333
20	46.189	48.499	50.808	53.118	55.427
30	69.284	71.594	73.903	76.213	78.522
40	92.379	94.688	96.998	99.307	101.62
50	115.47	117.78	120.09	122.40	124.71
60	138.57	140.88	143.19	145.50	147.81
70	161.66	163.97	166.28	168.59	170.90
80	184.76	187.07	189.38	191.69	194.00
90	207.85	210.16	212.47	214.78	217.09
	5	6	7	8	9
0	11.547	13.857	16.166	18.476	20.785
10	34.642	36.952	39.261	41.570	43.880
20	57.737	60.046	62.356	64.665	66.975
30	80.831	83.141	85.450	87.760	90.069
40	103.93	106.24	108.55	110.85	113.16
50	127.02	129.33	131.64	133.95	136.26
60	150.12	152.42	154.73	157.04	159.35
70	173.21	175.52	177.83	180.14	182.45
80	196.31	198.61	200.92	203.23	205.54
90	219.40	221.71	224.02	226.33	228.64

At 62° F., 1 foot head = 0.433 lb. per square inch; 0.433 × 144 = 62.355 lbs. per cubic foot. 1 lb. per square inch = 2.30947 feet head. 1 atmosphere = 14.7 lbs. per square incb = 33.94 feet head.

Linear Expansion of Cast Iron Pipe

The coefficient of linear expansion of cast iron may be taken as 0.0000058 per degree Fahrenheit. The expansion or contraction in *inches* that will take place in a line of given length with various temperature changes is shown in the following table:

Temp. Difference °F	Length of Line in Feet			
	100	500	1000	5280
5	0.035	0.17	0.35	1.83
10	0.070	0.35	0.70	3.67
20	0.139	0.70	1.39	7.34
30	0.209	1.04	2.09	11.01
40	0.278	1.39	2.78	14.70
50	0.348	1.74	3.48	18.35
60	0.418	2.09	4.18	22.04
70	0.487	2.44	4.87	25.72
80	0.557	2.79	5.57	29.39
90	0.626	3.13	6.26	33.05
100	0.696	3.48	6.96	36.71
120	0.835	4.17	8.35	44.10
150	1.043	5.22	10.43	55.10

Weight of Lead and Jute per Joint

Nominal Dia. of Pipe, Inches	3	4	6	8	10	12	14
Approx. Pounds of Lead Required per Joint...........	6.50	8.00	11.25	14.50	17.50	20.50	24.00
Approx. Pounds of Jute Required per Joint...........	0.18	0.21	0.31	0.44	0.53	0.61	0.81

Nominal Dia. of Pipe Inches	16	18	20	24	30	36	42	48
Approx. Pounds of Lead Required per Joint..	33.0	36.90	40.50	52.50	64.75	77.25	104.25	119.00
Approx. Pounds of Jute Required per Joint..	0.94	1.00	1.25	1.50	2.06	3.00	3.50	4.00

The weight of lead per joint is based on the depth of lead required by A.W.W.A. laying specifications plus an allowance of .25″ projection beyond the bell face for calking.

Maximum Deflection Full Length Pipe

BELL AND SPIGOT PIPE*

Nom. Pipe Diam.	Joint Opening	Max. Deflection With Pipe Length of:				Approx. Radius of Curve Produced by Succession of Joints With Pipe Lengths of:			
		12 ft.	16 ft.	18 ft.	20 ft.	12 ft.	16 ft.	18 ft.	20 ft.
		in.				*ft.*			
2	0.41	23.6	31.5	35.4	39.4	73	98	110	122
3	0.43	14.8	19.7	22.2	24.7	112	149	168	186
4	0.41	11.1	14.8	16.7	18.5	156	208	234	260
6	0.58	11.1	14.8	16.7	18.5	156	208	234	260
8	0.65	9.7	12.9	14.6	16.2	178	238	268	297
10	0.75	9.3	12.4	14.0	15.5	186	248	279	310
12	0.75	7.9	10.5	11.9	13.2	218	292	327	363
14	0.75	6,7	8.9	10.1	11.2	258	345	387	430
16	0.75	5.9	7.9	8.8	9.7	293	390	440	488
18	0.75	5.3	7.1	8.0	8.8	326	434	489	543
20	0.75	4.8	6.4	7.2	8.0	360	480	540	600
24	0.75	4.0	5.3	6.0	6.7	432	577	648	720
30	0.75	3.3	4.4	5.0	5.5	524	699	786	873
36	0.75	2.8	3.7	4.2	4.7	617	824	926	1,028
42	0.75	2.4	3.2	3.6	4.0	720	960	1,080	1,200
48	0.75	2.1	2.8	3.2	3.5	823	1,097	1,234	1,371
54	0.75	1.9	2.5	2.9	3.2	909	1,211	1,364	1,515
60	0.75	1.7	2.3	2.6	2.8	1,016	1,355	1,524	1,695

* Limiting factors: (1) joint opening not to exceed 0.75 in.; (2) calking space at face of bell to be not less than 0.25 in. in width.

MECHANICAL JOINT PIPE

Size of Pipe	Bend in One Joint Angle	Deflection in Inches				Approximate Radius in feet of Curve Produced by Succession of Joints			
		12 ft. length	16 ft. length	18 ft. length	20 ft. length	12 ft. length	16 ft. length	18 ft. length	20 ft. length
3	8°–18′	21	28	31	—	85	110	125	—
4	8°–18′	21	28	31	—	85	110	125	—
6	7°– 7′	18	24	27	—	100	130	145	—
8	5°–21′	13	18	20	—	130	170	195	—
10	5°–21′	13	18	20	—	130	170	195	—
12	5°–21′	13	18	20	22	130	170	195	220
14	3°–35′	9	12	13½	15	190	250	285	320
16	3°–35′	9	12	13½	15	190	250	285	320
18	3°– 0′	7½	10	11	12	230	300	340	380
20	3°– 0′	7½	10	11	12	230	300	340	380
24	2°–23′	6	8	9	10	300	400	450	500
30	2°–23′	6	8	9	10	300	400	450	500
36	2°– 5′	5	7	8	—	330	440	500	—
42	2°– 0′	5	6	7½	—	340	450	510	—
48	2°– 0′	5	6	7½	—	340	450	510	—

Equivalents of Fractions of an Inch

Fractions			Decimals	Milli-meters	Fractions			Decimals	Milli-meters
		1/64	0.015625	.3969			33/64	0.515625	13.0966
	1/32		0.03125	.7937		17/32		0.53125	13.4935
		3/64	0.046875	1.1906			35/64	0.546875	13.8904
1/16			0.0625	1.5875	9/16			0.5625	14.2872
		5/64	0.078125	1.9843			37/64	0.578125	14.6841
	3/32		0.09375	2.3812		19/32		0.59375	15.0810
		7/64	0.109375	2.7781			39/64	0.609375	15.4778
1/8			0.125	3.1749	5/8			0.625	15.8747
		9/64	0.140625	3.5718			41/64	0.640625	16.2716
	5/32		0.15625	3.9687		21/32		0.65625	16.6684
		11/64	0.171875	4.3655			43/64	0.671875	17.0653
3/16			0.1875	4.7624	11/16			0.6875	17.4622
		13/64	0.203125	5.1593			45/64	0.703125	17.8591
	7/32		0.21875	5.5561		23/32		0.71875	18.2559
		15/64	0.234375	5.9530			47/64	0.734375	18.6528
1/4			0.25	6.3499	3/4			0.75	19.0497
		17/64	0.265625	6.7468			49/64	0.765625	19.4465
	9/32		0.28125	7.1436		25/32		0.78125	19.8434
		19/64	0.296875	7.5405			51/64	0.796875	20.2403
5/16			0.3125	7.9374	13/16			0.8125	20.6371
		21/64	0.328125	8.3342			53/64	0.828125	21.0340
	11/32		0.34375	8.7311		27/32		0.84375	21.4309
		23/64	0.359375	9.1280			55/64	0.859375	21.8277
3/8			0.375	9.5248	7/8			0.875	22.2246
		25/64	0.390625	9.9217			57/64	0.890625	22.6215
	13/32		0.40625	10.3186		29/32		0.90625	23.0183
		27/64	0.421875	10.7154			59/64	0.921875	23.4152
7/16			0.4375	11.1123	15/16			0.9375	23.8121
		29/64	0.453125	11.5092			61/64	0.953125	24.2089
	15/32		0.46875	11.9060		31/32		0.96875	24.6058
		31/64	0.484375	12.3029			63/64	0.984375	25.0027
1/2			0.50	12.6998	1			1.00	25.3995

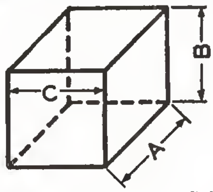
Circumferences and Areas of Circles

Diam.	Circum.	Area	Diam.	Circum.	Area	Diam.	Circum.	Area
1/64	0.04909	0.00019	2 11/16	8.4430	5.6727	7	21.991	38.485
1/32	0.09818	0.00077	3/4	8.6394	5.9396	1/8	22.384	39.871
3/64	0.14726	0.00173	13/16	8.8357	6.2126	1/4	22.776	41.282
1/16	0.19635	0.00307	7/8	9.0321	6.4918	3/8	23.169	42.718
3/32	0.29452	0.00690	15/16	9.2284	6.7771	1/2	23.562	44.179
1/8	0.39270	0.01227	3	9.4248	7.0686	5/8	23.955	45.664
5/32	0.49087	0.01917	1/16	9.6211	7.3662	3/4	24.347	47.173
3/16	0.58905	0.02761	1/8	9.8175	7.6699	7/8	24.740	48.707
7/32	0.68722	0.03758	3/16	10.014	7.9798	8	25.133	50.265
1/4	0.78540	0.04909	1/4	10.210	8.2958	1/8	25.525	51.849
9/32	0.88357	0.06213	5/16	10.407	8.6179	1/4	25.918	53.456
5/16	0.98175	0.07670	3/8	10.603	8.9462	3/8	26.311	55.088
11/32	1.0799	0.09281	7/16	10.799	9.2806	1/2	26.704	56.745
3/8	1.1781	0.11045	1/2	10.996	9.6211	5/8	27.096	58.426
13/32	1.2763	0.12962	9/16	11.192	9.9678	3/4	27.489	60.132
7/16	1.3744	0.15033	5/8	11.388	10.321	7/8	27.882	61.862
15/32	1.4726	0.17257	11/16	11.585	10.680	9	28.274	63.617
1/2	1.5708	0.19635	3/4	11.781	11.045	1/8	28.667	65.397
17/32	1.6690	0.22166	13/16	11.977	11.416	1/4	29.060	67.201
9/16	1.7671	0.24850	7/8	12.174	11.793	3/8	29.452	69.029
19/32	1.8653	0.27688	15/16	12.370	12.177	1/2	29.845	70.882
5/8	1.9635	0.30680	4	12.566	12.566	5/8	30.238	72.760
21/32	2.0617	0.33824	1/16	12.763	12.962	3/4	30.631	74.662
11/16	2.1598	0.37122	1/8	12.959	13.364	7/8	31.023	76.589
23/32	2.2580	0.40574	3/16	13.155	13.772	10	31.416	78.540
3/4	2.3562	0.44179	1/4	13.352	14.186	1/4	32.201	82.516
25/32	2.4544	0.47937	5/16	13.548	14.607	1/2	32.987	86.590
13/16	2.5525	0.51849	3/8	13.744	15.033	3/4	33.772	90.763
27/32	2.6507	0.55914	7/16	13.941	15.466	11	34.558	95.033
7/8	2.7489	0.60132	1/2	14.137	15.904	1/4	35.343	99.402
29/32	2.8471	0.64504	9/16	14.334	16.349	1/2	36.128	103.87
15/16	2.9452	0.69029	5/8	14.530	16.800	3/4	36.914	108.43
31/32	3.0434	0.73708	11/16	14.726	17.257	12	37.699	113.10
1	3.1416	0.7854	3/4	14.923	17.721	1/4	38.485	117.86
1/16	3.3379	0.8866	13/16	15.119	18.190	1/2	39.270	122.72
1/8	3.5343	0.9940	7/8	15.315	18.665	3/4	40.055	127.68
3/16	3.7306	1.1075	15/16	15.512	19.147	13	40.841	132.73
1/4	3.9270	1.2272	5	15.708	19.635	1/4	41.626	137.89
5/16	4.1233	1.3530	1/16	15.904	20.129	1/2	42.412	143.14
3/8	4.3197	1.4849	1/8	16.101	20.629	3/4	43.197	148.49
7/15	4.5160	1.6230	3/16	16.297	21.135	14	43.982	153.94
1/2	4.7124	1.7671	1/4	16.493	21.648	1/4	44.768	159.48
9/16	4.9087	1.9175	5/16	16.690	22.166	1/2	45.553	165.13
5/8	5.1051	2.0739	3/8	16.886	22.691	3/4	46.338	170.87
11/16	5.3014	2.2365	7/16	17.082	23.221	15	47.124	176.71
3/4	5.4978	2.4053	1/2	17.279	23.758	1/4	47.909	182.65
13/16	5.6941	2.5802	9/16	17.475	24.301	1/2	48.695	188.69
7/8	5.8905	2.7612	5/8	17.671	24.850	3/4	49.480	194.83
15/16	6.0868	2.9483	11/16	17.868	25.406	16	50.265	201.06
2	6.2832	3.1416	3/4	18.064	25.967	1/4	51.051	207.39
1/16	6.4795	3.3410	13/16	18.261	26.535	1/2	51.836	213.82
1/8	6.6759	3.5466	7/8	18.457	27.109	3/4	52.622	220.35
3/16	6.8722	3.7583	15/16	18.653	27.688	17	53.407	226.98
1/4	7.0686	3.9761	6	18.850	28.274	1/4	54.192	233.71
5/16	7.2649	4.2000	1/8	19.242	29.465	1/2	54.978	240.53
3/8	7.4613	4.4301	1/4	19.635	30.680	3/4	55.763	247.45
7/16	7.6576	4.6664	3/8	20.028	31.919	18	56.549	254.47
1/2	7.8540	4.9087	1/2	20.420	33.183	1/4	57.334	261.59
9/16	8.0503	5.1572	5/8	20.813	34.472	1/2	58.119	268.80
5/8	8.2467	5.4119	3/4	21.206	35.785	3/4	58.905	276.12
			7/8	21.598	37.122			

Circumferences and Areas of Circles

Diam.	Circum.	Area	Diam.	Circum.	Area	Diam.	Circum.	Area
19	59.690	283.53	34½	108.385	934.82	50	157.080	1963.5
¼	60.476	291.04	¾	109.170	948.42	51	160.221	2042.8
½	61.261	298.65	35	109.956	962.11	52	163.363	2123.7
¾	62.046	306.35	¼	110.741	975.91	53	166.504	2206.2
20	62.832	314.16	½	111.527	989.8	54	169.646	2290.2
¼	63.617	322.06	¾	112.312	1003.8	55	172.788	2375.8
½	64.403	330.06	36	113.097	1017.9	56	175.929	2463.0
¾	65.188	338.16	¼	113.883	1032.1	57	179.071	2551.8
21	65.973	346.36	½	114.668	1046.3	58	182.212	2642.1
¼	66.759	354.66	¾	115.454	1060.7	59	185.354	2734.0
½	67.544	363.05	37	116.239	1075.2	60	188.496	2827.4
¾	68.330	371.54	¼	117.024	1089.8	61	191.637	2922.5
22	69.115	380.13	½	117.810	1104.5	62	194.779	3019.1
¼	69.900	388.82	¾	118.596	1119.2	63	197.920	3117.2
½	70.686	397.61	38	119.381	1134.1	64	201.062	3217.0
¾	71.471	406.49	¼	120.166	1149.1	65	204.204	3318.3
23	72.257	415.48	½	120.951	1164.2	66	207.345	3421.2
¼	73.042	424.56	¾	121.737	1179.3	67	210.487	3525.7
½	73.827	433.74	39	122.522	1194.6	68	213.628	3631.7
¾	74.613	443.01	¼	123.308	1210.0	69	216.770	3739.3
24	75.398	452.39	½	124.093	1225.4	70	219.911	3848.5
¼	76.184	461.86	¾	124.878	1241.0	71	223.053	3959.2
½	76.969	471.44	40	125.664	1256.6	72	226.195	4071.5
¾	77.754	481.11	¼	126.449	1272.4	73	229.336	4185.4
25	78.540	490.87	½	127.235	1288.2	74	232.478	4300.8
¼	79.325	500.74	¾	128.020	1304.2	75	235.619	4417.9
½	80.111	510.71	41	128.805	1320.3	76	238.761	4536.5
¾	80.896	520.77	¼	129.591	1336.4	77	241.903	4656.6
26	81.681	530.93	½	130.376	1352.7	78	245.044	4778.4
¼	82.467	541.19	¾	131.161	1369.0	79	248.186	4901.7
½	83.252	551.55	42	131.947	1385.4	80	251.327	5026.5
¾	84.038	562.00	¼	132.732	1402.0	81	254.469	5153.0
27	84.823	572.56	½	133.518	1418.6	82	257.611	5281.0
¼	85.608	583.21	¾	134.303	1435.4	83	260.752	5410.6
½	86.394	593.96	43	135.088	1452.2	84	263.894	5541.8
¾	87.179	604.81	¼	135.874	1469.1	85	267.035	5674.5
28	87.965	615.75	½	136.659	1486.2	86	270.177	5808.8
¼	88.750	626.80	¾	137.445	1503.3	87	273.319	5944.7
½	89.535	637.94	44	138.230	1520.5	88	276.460	6082.1
¾	90.321	649.18	¼	139.015	1537.9	89	279.602	6221.1
29	91.106	660.52	½	139.801	1555.3	90	282.743	6361.7
¼	91.892	671.96	¾	140.586	1572.8	91	285.885	6503.9
½	92.677	683.49	45	141.372	1590.4	92	289.027	6647.6
¾	93.462	695.13	¼	142.157	1608.2	93	292.168	6792.9
30	94.248	706.86	½	142.942	1626.0	94	295.310	6939.8
¼	95.033	718.69	¾	143.728	1643.9	95	298.451	7088.2
½	95.819	730.62	46	144.513	1661.9	96	301.593	7238.2
¾	96.604	742.64	¼	145.299	1680.0	97	304.734	7389.8
31	97.389	754.77	½	146.084	1698.2	98	307.876	7543.0
¼	98.175	766.99	¾	146.869	1716.5	99	311.018	7697.7
½	98.960	779.31	47	147.655	1734.9	100	314.159	7854.0
¾	99.746	791.73	¼	148.440	1753.5	101	317.30	8011.85
32	100.531	804.25	½	149.226	1772.1	102	320.44	8171.28
¼	101.316	816.86	¾	150.011	1790.8	103	323.58	8332.29
½	102.102	829.58	48	150.796	1809.6	104	326.73	8494.87
¾	102.887	842.39	¼	151.582	1828.5	105	329.87	8659.01
33	103.673	855.30	½	152.367	1847.5	106	333.01	8824.73
¼	104.458	868.31	¾	153.153	1866.5	107	336.15	8992.02
½	105.243	881.41	49	153.938	1885.7	108	339.29	9160.88
¾	106.029	894.62	¼	154.723	1905.0	109	342.43	9331.32
34	106.814	907.92	½	155.509	1924.4	110	345.58	9503.32
¼	107.600	921.32	¾	156.294	1943.9			

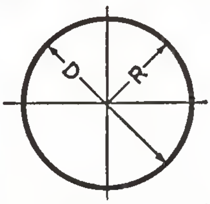
USEFUL FORMULAE FOR ESTIMATING WEIGHTS OF CAST IRON PIPE AND FITTINGS



PARALLELEPIPEDS

VOLUME IN CUB. INCHES = A X B X C

WEIGHT IN POUNDS = VOLUME X .26



CIRCLE

R = RADIUS; D = DIAMETER

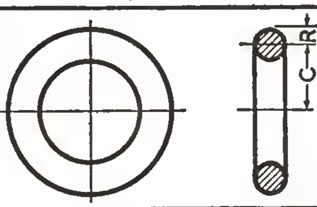
CIRCUMFERENCE = 3.14 X D

AREA = $3.14 \times R^2$

SPHERE

AREA = $3.14 \times D^2$ VOLUME = $\frac{3.14 \times D^3}{6}$

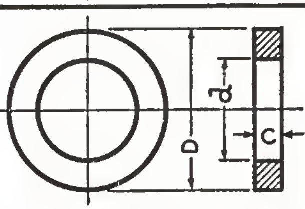
WEIGHT IN POUNDS = VOLUME X .26



TORUS

VOLUME IN CUB. INCHES = $2 \times 3.14^2 \times C \times R^2 = 19.72 \times C \times R^2$

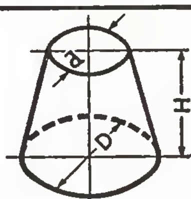
WEIGHT IN POUNDS = VOLUME X .26



CIRCULAR RING

VOLUME IN CUB. INCHES = (AREA D − AREA d) X C

WEIGHT IN POUNDS = VOLUME X .26



FRUSTUM OF CONE

VOLUME = $\frac{H}{3} \times$ (AREA [d] + AREA [D] + $\sqrt{\text{AREA [d]} \times \text{AREA [D]}}$)

WEIGHT IN POUNDS = VOLUME X .26

ONE CUB. INCH OF IRON WEIGHS 0.26 POUNDS

ONE CUB. FOOT OF IRON WEIGHS 450 POUNDS

Specific Gravities and Weights

Substance	Specific Gravity	Weight, Pounds per Cu. Ft.	Substance	Specific Gravity	Weight, Pounds per Cu. Ft.
Ashlar Masonry			**Minerals**		
Granite, syenite, gneiss	2.3–3.0	165	Asbestos	2.1–2.8	153
Limestone, marble	2.3–2.8	160	Barytes	4.50	281
Sandstone, bluestone	2.1–2.4	140	Basalt	2.7–3.2	184
Mortar Rubble Masonry			Bauxite	2.55	159
Granite, syenite, gneiss	2.2–2.8	155	Borax	1.7–1.8	109
Limestone, marble	2.2–2.6	150	Chalk	1.8–2.6	137
Sandstone, bluestone	2.0–2.2	130	Clay, marl	1.8–2.6	137
Dry Rubble Masonry			Dolomite	2.9	181
Granite, syenite, gneiss	1.9–2.3	130	Feldspar, orthoclase	2.5–2.6	159
Limestone, marble	1.9–2.1	125	Gneiss, serpentine	2.4–2.7	159
Sandstone, bluestone	1.8–1.9	110	Granite, syenite	2.5–3.1	175
Brick Masonry			Greenstone, trap	2.8–3.2	187
Pressed brick	2.2–2.3	140	Gypsum, alabaster	2.3–2.8	159
Common brick	1.8–2.0	120	Hornblende	3.0	187
Soft brick	1.5–1.7	100	Limestone, marble	2.5–2.8	165
Concrete Masonry			Magnesite	3.0	187
Cement, stone, sand	2.2–2.4	144	Phosphate rock, apatite	3.2	200
Cement, slag, etc.	1.9–2.3	130	Porphyry	2.6–2.9	172
Cement, cinder, etc.	1.5–1.7	100	Pumice, natural	0.37–0.90	40
Various Building Mat'l			Quartz, flint	2.5–2.8	165
Ashes, cinders		40–45	Sandstone, bluestone	2.2–2.5	147
Cement, portland, loose		90	Shale, slate	2.7–2.9	175
Cement, portland, set	2.7–3.2	183	Soapstone, talc	2.6–2.8	169
Lime, gypsum, loose		53–64	**Stone, Quarried, Piled**		
Mortar, set	1.4–1.9	103	Basalt, granite, gneiss		96
Slags, bank slag		67–72	Limestone, marble, quartz		95
Slags, bank screenings		98–117	Sandstone		82
Slags, machine slag		96	Shale		92
Slags, slag sand		49–55	Greenstone, hornblende		107
Earth, etc., Excavated			**Bituminous Substances**		
Clay, dry		63	Asphaltum	1.1–1.5	81
Clay, damp, plastic		110	Coal, anthracite	1.4–1.7	97
Clay and gravel, dry		100	Coal, bituminous	1.2–1.5	84
Earth, dry, loose		76	Coal, lignite	1.1–1.4	78
Earth, dry, packed		95	Coal, peat, turf, dry	0.65–0.85	47
Earth, moist, loose		78	Coal, charcoal, pine	0.28–0.44	23
Earth, moist, packed		96	Coal, charcoal, oak	0.47–0.57	33
Earth, mud, flowing		108	Coal, coke	1.0–1.4	75
Earth, mud, packed		115	Graphite	1.9–2.3	131
Riprap, limestone		80–85	Paraffine	0.87–0.91	56
Riprap, sandstone		90	Petroleum	0.87	54
Riprap, shale		105	Petroleum, refined	0.79–0.82	50
Sand, gravel, dry, loose		90–105	Petroleum, benzine	0.73–0.75	46
Sand, gravel, dry, packed		100–120	Petroleum, gasoline	0.66–0.69	42
Sand, gravel, dry, wet		118–120	Pitch	1.07–1.15	69
Excavations in Water			Tar, bituminous	1.20	75
Sand or gravel		60	**Coal and Coke, Piled**		
Sand or gravel and clay		65	Coal, anthracite		47–58
Clay		80	Coal, bituminous, lignite		40–54
River mud		90	Coal, peat, turf		20–26
Soil		70	Coal, charcoal		10–14
Stone riprap		65	Coal, coke		23–32

The specific gravities of solids and liquids refer to water at 4°C., those of gases to air at 0°C. and 760 mm pressure. The weights per cubic foot are derived from average specific gravities, except where stated that weights are for bulk, heaped or loose material, etc.

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Specific Gravities and Weights

Substance	Specific Gravity	Weight, Pounds per Cu. Ft.	Substance	Specific Gravity	Weight, Pounds per Cu. Ft.
Metals, Alloys, Ores			Timber, U. S. Seasoned		
Aluminum, cast-hammered	2.55–2.75	165	Ash, white-red	0.62–0.65	40
Aluminum, bronze	7.7	481	Cedar, white-red	0.32–0.38	22
Brass, cast-rolled	8.4–8.7	534	Chestnut	0.66	41
Bronze, 7.9 to 14% Sn	7.4–8.9	509	Cypress	0.48	30
Copper, cast-rolled	8.8–9.0	556	Fir, Douglas spruce	0.51	32
Copper, ore, pyrites	4.1–4.3	262	Fir, eastern	0.40	25
Gold, cast-hammered	19.25–19.3	1205	Elm, white	0.72	45
Iron, cast, pig	7.2	450	Hemlock	0.42–0.52	29
Iron, wrought	7.6–7.9	485	Hickory	0.74–0.84	49
Iron, steel	7.8–7.9	490	Locust	0.73	46
Iron, spiegel-eisen	7.5	468	Maple, hard	0.68	43
Iron, ferro-silicon	6.7–7.3	437	Maple, white	0.53	33
Iron ore, hematite	5.2	325	Oak, chestnut	0.86	54
Iron ore, hematite in bank		160–180	Oak, live	0.95	59
Iron ore, hematite, loose		130–160	Oak, red, black	0.65	41
Iron ore, limonite	3.6–4.0	237	Oak, white	0.74	46
Iron ore, magnetite	4.9–5.2	315	Pine, Oregon	0.51	32
Iron, slag	2.5–3.0	172	Pine, red	0.48	30
Lead	11.37	710	Pine, white	0.41	26
Lead ore, galena	7.3–7.6	475	Pine, yellow, long-leaf	0.70	44
Manganese	7.2–8.0	500	Pine, yellow, short-leaf	0.61	38
Manganese ore, pyrolusite	3.7–4.6	259	Poplar	0.48	30
Mercury	13.6	849	Redwood, California	0.42	26
Nickel	8.9–9.2	565	Spruce, white, black	0.40–0.46	27
Nickel, monel metal	8.8–9.0	556	Walnut, black	0.61	38
Platinum, cast-hammered	21.1–21.5	1330	Walnut, white	0.41	26
Silver, cast-hammered	10.4–10.6	656	Moisture Contents:		
Tin, cast-hammered	7.2–7.5	459	Seasoned timber 15 to 20%		
Tin, ore, cassiterite	6.4–7.0	418	Green timber up to 50%		
Zinc, cast-rolled	6.9–7.2	440			
Zinc, ore, blende	3.9–4.2	253	Various Liquids		
Various Solids			Alcohol. 100%	0.79	49
Cereals, oats, bulk		32	Acids, muriatic, 40%	1.20	75
Cereals, barley, bulk		99	Acids, nitric, 91%	1.50	94
Cereals, corn, rye, bulk		48	Acids, sulphuric, 87%	1.80	112
Cereals, wheat, bulk		48	Lye, soda, 66%	1.70	106
Hay and Straw, bales		20	Oils, vegetable	0.91–0.94	58
Cotton, flax, hemp	1.47–1.50	93	Oils, mineral, lubricants	0.90–0.93	57
Fats	0.90–0.97	58	Water, 4°C., max. density	1.0	62.428
Flour, loose	0.40–0.50	28	Water, 100°C	0.9584	59.830
Flour, pressed	0.70–0.80	47	Water, ice	0.88–0.92	56
Glass, common	2.40–2.60	156	Water, snow, fresh fallen	.125	8
Glass, plate or crown	2.45–2.72	161	Water, sea water	1.02–1.03	64
Glass, crystal	2.90–3.00	184			
Leather	0.86–1.02	59	Gases, Air = 1		
Paper	0.70–1.15	58	Air, 0°C., 760 mm	1.0	.08071
Potatoes, piled		42	Ammonia	0.5920	.0478
Rubber, caoutchouc	0.92–0.96	59	Carbon dioxide	1.5291	.1234
Rubber goods	1.0–2.0	94	Carbon monoxide	0.9673	.0781
Salt, granulated, piled		48	Gas, illuminating	0.35–0.45	.028-.036
Saltpeter		67	Gas, natural	0.47–0.48	.038-.039
Starch	1.53	96	Hydrogen	0.0693	.00559
Sulphur	1.93–2.07	125	Nitrogen	0.9714	.0784
Wool	1.32	82	Oxygen	1.1056	.0892

The specific gravities of solids and liquids refer to water at 4°C., those of gases to air at 0°C. and 760 mm pressure. The weights per cubic foot are derived from average specific gravities, except where stated that weights are for bulk, heaped or loose material, etc.

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A Table of Constants for Certain Gases and Vapors

Name of Gas or Vapor		Formula	Molecular Weight	Specific Gravity Gas or Vapor at 60° F. 30″ Hg. Pres. Air = 1.0	Boiling Point ° Fahr.	Specific Gravity Liquid at 60° F. Water = 1.0
Carbon (to CO)		C	12.010	....	....	....
Carbon (to CO_2)		C	12.010	....	....	....
Carbon Monoxide		CO	28.010	0.9672	−313.6	....
Carbon Dioxide		CO_2	44.010	1.5291	−109.3	....
Hydrogen		H_2	2.0160	0.06952	−423.0	....
Methane	Paraffin Series C_nH_{2n+2}	CH_4	16.042	0.5545	−258.5	....
Ethane		C_2H_6	30.068	1.0493	−127.5	....
Propane		C_3H_8	44.094	1.562	− 43.9	0.509*
n-Butane		C_4H_{10}	58.120	2.086	31.5	0.585*
Iso-Butane		C_4H_{10}	58.120	2.068	13.6	0.565*
n-Pentane		C_5H_{12}	72.146	2.49*	97.2	0.631
n-Hexane		C_6H_{14}	86.172	2.97*	156.2	0.664
Ethylene	Olefin Series C_nH_{2n}	C_2H_4	28.052	0.9748	−155.0	....
Propylene		C_3H_6	42.078	1.481	− 52.6	....
Butylene		C_4H_8	56.104	1.935	23.0	0.630*
Benzene	Aromatic Series C_nH_{2n-6}	C_6H_6	78.108	2.712*	176.2	0.884
Toluene		C_7H_8	92.134	3.178*	231.3	0.871
Xylene		C_8H_{10}	106.160	3.662*	282.2	0.870
Acetylene		C_2H_2	26.036	0.9073	−118.5	....
Naphthalene		$C_{10}H_8$	128.164	....	424.2	1.145‡
Ammonia		NH_3	17.032	0.5963	− 28.0	....
Nitrous Oxide		N_2O	44.016	1.530	−129.1	....
Nitric Oxide		NO	30.008	1.0367	−241.2	....
Hydrogen Sulphide		H_2S	34.076	1.194	− 79.2	....
Sulphur Dioxide		SO_2	64.060	2.2637	14.0	....
Water Vapor		H_2O	18.016	0.6221*	212.0	.999041
Oxygen		O_2	32.0000	1.1053	−297.4	....
Nitrogen		N_2	28.016	0.9673	−320.4	....
Nitrogen "Atmospheric"		†	28.161	0.9721	....	....
Air		....	....	1.0000	−317.6	....

* Theoretical or calculated data. The substance does not exist as a gas at 60° F. and 30 inches of mercury pressure.

† Consists of Nitrogen together with 0.94% of Argon by volume, about 0.03% of Carbon Dioxide and a trace of Hydrogen.

‡ Solid.

A Table of Constants for Certain Gases and Vapors

60°F.—30″Hg. Pres.		Specific Heat Const. Pres. Btu./lb./°F. at 60° F. Water = 1.0	Ratio Specific Heat Const. Pres. to Specific Heat Const. Volume	Heat of Combustion—Dry Gas at 60° F. and 30″ Hg. Pressure			
				B.t.u. per Cu. Ft.		B.t.u. per Lb.	
Lbs. per Cu. Ft.	Cu. Ft. per Lb.			Gross	Net	Gross	Net
....	....	....	....	....	....	3,958	3,958
....	....	....	....	....	....	14,092	14,092
.07405	13.504	0.2478	1.404	321.7	321.7	4,345	4,345
.11707	8.542	0.1989	1.304	....	....	....	....
.005323	187.874	3.3890	1.410	325.0	274.6	61,061	51,589
.04245	23.557	.5284	1.310	1014.4	913.3	23,896	21,515
.08034	12.447	.3861	1.220	1794	1641	22,330	20,430
.11962	8.360	.3650	1.150	2593	2386	21,675	19,942
.1597	6.263	.3510	1.108	3405	3142	21,321	19,678
.15833	6.316	.3510	1.108	3368	3108	21,271	19,628
.1907*	5.245*	....	....	4023*	3720*	21,101	19,513
.2277*	4.392*	....	....	4771*	4418*	20,954	19,402
.07464	13.398	.3592	1.255	1615	1513	21,638	20,277
.11339	8.819	....	....	2380	2226	20,990	19,629
.14815	6.750	....	....	3079	2877	20,780	19,419
.2076*	4.816*	....	....	3758*	3606*	18,100§	17,367§
.2433*	4.110*	....	....	4453*	4251*	18,300§	17,471§
.2803*	3.567*	....	....	5189*	4937*	18,510§	17,610§
.06947	14.395	.3832	1.260	1491	1440	21,460	20,727
....	....	....	....	....	....	17,280‡	16,684‡
.04566	21.903	.5232	1.310	442	365	9,678	7,996
.11716	8.536	.2004	....	....	....	....	....
.07937	12.599	.2329	....	....	....	....	....
.0914	10.972	.2430	....	649	598	7,100	6,539
.17331	5.770	.1516	....	....	....	....	....
.04763*	20.995*	.4820	1.324				
.08463	11.817	.2178	1.401				
.07406	13.503	.2477	1.404				
.07443	13.436	.2460	....				
.07656	13.061	.2400	1.403				

Atmosphere	By Volume	By Weight
O_2	20.99%	23.20%
N_2, etc.	79.01%	76.80%

* Theoretical or calculated data. The substance does not exist as a gas at 60° F. and 30 inches of mercury pressure.

‡ Solid. § Liquid.

Gas Volume Correction Factors

The observed volume of saturated gas is multiplied by the factor taken from this table for correcting to the volume of saturated gas under the "standard conditions" of 30 inches of mercury pressure and 60 deg. Fahrenheit.

Temp. (°F.)	Total Gas Pressure—Inches of Mercury																				Temp. (°F.)
	28.6	28.7	28.8	28.9	29.0	29.1	29.2	29.3	29.4	29.5	29.6	29.7	29.8	29.9	30.0	30.1	30.2	30.3	30.4	30.5	
32	1.019	1.023	1.026	1.030	1.033	1.037	1.041	1.044	1.048	1.051	1.055	1.059	1.062	1.066	1.069	1.073	1.076	1.080	1.084	1.087	32
33	1.017	1.020	1.024	1.027	1.031	1.035	1.038	1.042	1.045	1.049	1.052	1.056	1.060	1.063	1.067	1.070	1.074	1.078	1.081	1.085	33
34	1.014	1.018	1.022	1.025	1.029	1.032	1.036	1.039	1.043	1.047	1.050	1.054	1.057	1.061	1.064	1.068	1.072	1.075	1.079	1.082	34
35	1.012	1.016	1.019	1.023	1.026	1.030	1.033	1.037	1.041	1.044	1.048	1.051	1.055	1.058	1.062	1.065	1.069	1.073	1.076	1.080	35
36	1.010	1.013	1.017	1.020	1.024	1.028	1.031	1.035	1.038	1.042	1.045	1.049	1.052	1.056	1.060	1.063	1.067	1.070	1.074	1.077	36
37	1.007	1.011	1.014	1.018	1.022	1.025	1.029	1.032	1.036	1.039	1.043	1.046	1.050	1.054	1.057	1.061	1.064	1.068	1.071	1.075	37
38	1.005	1.009	1.012	1.016	1.019	1.023	1.026	1.030	1.033	1.037	1.040	1.044	1.048	1.051	1.055	1.058	1.062	1.065	1.069	1.072	38
39	1.003	1.006	1.010	1.013	1.017	1.020	1.024	1.027	1.031	1.035	1.038	1.042	1.045	1.049	1.052	1.056	1.059	1.063	1.066	1.070	39
40	1.000	1.004	1.007	1.011	1.014	1.018	1.022	1.025	1.029	1.032	1.036	1.039	1.043	1.046	1.050	1.053	1.057	1.060	1.064	1.067	40
41	.998	1.002	1.005	1.009	1.012	1.016	1.019	1.023	1.026	1.030	1.033	1.037	1.040	1.044	1.047	1.051	1.054	1.058	1.061	1.065	41
42	.996	.999	1.003	1.006	1.010	1.013	1.017	1.020	1.024	1.027	1.031	1.034	1.038	1.041	1.045	1.048	1.052	1.055	1.059	1.062	42
43	.993	.997	1.000	1.004	1.007	1.011	1.014	1.018	1.021	1.025	1.028	1.032	1.035	1.039	1.042	1.046	1.049	1.053	1.056	1.060	43
44	.991	.994	.998	1.001	1.005	1.008	1.012	1.015	1.019	1.022	1.026	1.029	1.033	1.036	1.040	1.043	1.047	1.050	1.054	1.057	44
45	.989	.992	.996	.999	1.003	1.006	1.010	1.013	1.017	1.020	1.024	1.027	1.031	1.034	1.037	1.041	1.044	1.048	1.051	1.055	45
46	.986	.990	.993	.997	1.000	1.004	1.007	1.011	1.014	1.018	1.021	1.025	1.028	1.032	1.035	1.039	1.042	1.046	1.049	1.052	46
47	.984	.987	.991	.994	.998	1.001	1.005	1.008	1.012	1.015	1.019	1.022	1.026	1.029	1.033	1.036	1.040	1.043	1.046	1.050	47
48	.982	.985	.988	.992	.995	.999	1.002	1.006	1.009	1.013	1.016	1.020	1.023	1.027	1.030	1.034	1.037	1.041	1.044	1.047	48
49	.979	.983	.986	.990	.993	.996	1.000	1.003	1.007	1.010	1.014	1.017	1.021	1.024	1.028	1.031	1.035	1.038	1.041	1.045	49
50	.977	.980	.984	.987	.991	.994	.998	1.001	1.004	1.008	1.011	1.015	1.018	1.022	1.025	1.029	1.032	1.036	1.039	1.042	50
51	.974	.978	.981	.985	.988	.992	.995	.998	1.002	1.005	1.009	1.012	1.016	1.019	1.023	1.026	1.030	1.033	1.036	1.040	51
52	.972	.975	.979	.982	.986	.989	.993	.996	1.000	1.003	1.006	1.010	1.013	1.017	1.020	1.024	1.027	1.031	1.034	1.037	52
53	.970	.973	.976	.980	.983	.987	.990	.994	.997	1.000	1.004	1.007	1.011	1.014	1.018	1.021	1.025	1.028	1.031	1.035	53
54	.967	.971	.974	.977	.981	.984	.988	.991	.995	.998	1.001	1.005	1.008	1.012	1.015	1.019	1.022	1.025	1.029	1.032	54
55	.965	.968	.972	.975	.978	.982	.985	.989	.992	.996	.999	1.002	1.006	1.009	1.013	1.016	1.020	1.023	1.026	1.030	55
56	.962	.966	.969	.973	.976	.979	.983	.986	.990	.993	.997	1.000	1.003	1.007	1.010	1.014	1.017	1.020	1.024	1.027	56
57	.960	.963	.967	.970	.974	.977	.980	.984	.987	.991	.994	.997	1.001	1.004	1.008	1.011	1.015	1.018	1.021	1.025	57
58	.957	.961	.964	.968	.971	.975	.978	.981	.985	.988	.992	.995	.998	1.002	1.005	1.009	1.012	1.015	1.019	1.022	58
59	.955	.958	.962	.965	.969	.972	.975	.979	.982	.986	.989	.992	.996	.999	1.003	1.006	1.009	1.013	1.016	1.020	59
60	.953	.956	.959	.963	.966	.970	.973	.976	.980	.983	.986	.990	.993	.997	1.000	1.003	1.007	1.010	1.014	1.017	60
61	.950	.953	.957	.960	.964	.967	.970	.974	.977	.981	.984	.987	.991	.994	.998	1.001	1.004	1.008	1.011	1.014	61
62	.948	.951	.954	.958	.961	.964	.968	.971	.975	.978	.981	.985	.988	.992	.995	.998	1.002	1.005	1.008	1.012	62
63	.945	.949	.952	.955	.959	.962	.965	.969	.972	.975	.979	.982	.986	.989	.992	.996	.999	1.002	1.006	1.009	63
64	.943	.946	.949	.953	.956	.959	.963	.966	.970	.973	.976	.980	.983	.986	.990	.993	.996	1.000	1.003	1.007	64
65	.940	.943	.947	.950	.954	.957	.960	.964	.967	.970	.974	.977	.980	.984	.987	.991	.994	.997	1.001	1.004	65

66	.938	.941	.944	.948	.951	.954	.958	.961	.964	.968	.971	.974	.978	.981	.985	.988	.991	.995	.998	1.001	66
67	.935	.938	.942	.945	.949	.952	.955	.958	.962	.965	.969	.972	.975	.979	.982	.985	.989	.992	.995	.999	67
68	.932	.936	.939	.942	.946	.949	.952	.956	.959	.963	.966	.969	.973	.976	.979	.983	.986	.989	.993	.996	68
69	.930	.933	.937	.940	.943	.947	.950	.953	.957	.960	.963	.967	.970	.973	.977	.980	.983	.987	.990	.993	69
70	.927	.931	.934	.937	.941	.944	.947	.951	.954	.957	.961	.964	.967	.971	.974	.977	.981	.984	.987	.991	70
71	.925	.928	.931	.935	.938	.941	.945	.948	.951	.955	.958	.961	.965	.968	.971	.975	.978	.981	.985	.988	71
72	.922	.925	.929	.932	.935	.939	.942	.945	.949	.952	.955	.959	.962	.965	.969	.972	.975	.978	.982	.985	72
73	.919	.923	.926	.929	.933	.936	.939	.943	.946	.949	.953	.956	.959	.963	.966	.969	.972	.976	.979	.982	73
74	.917	.920	.923	.927	.930	.933	.937	.940	.943	.947	.950	.953	.956	.960	.963	.966	.970	.973	.976	.980	74
75	.914	.917	.921	.924	.927	.931	.934	.937	.941	.944	.947	.950	.954	.957	.960	.964	.967	.970	.974	.977	75
76	.911	.915	.918	.921	.925	.928	.931	.935	.938	.941	.944	.948	.951	.954	.958	.961	.964	.967	.971	.974	76
77	.909	.912	.915	.919	.922	.925	.929	.932	.935	.938	.942	.945	.948	.952	.955	.958	.961	.965	.968	.971	77
78	.906	.909	.913	.916	.919	.923	.926	.929	.932	.936	.939	.942	.945	.949	.952	.955	.959	.962	.965	.968	78
79	.903	.907	.910	.913	.916	.920	.923	.926	.930	.933	.936	.939	.943	.946	.949	.952	.956	.959	.962	.966	79
80	.901	.904	.907	.910	.914	.917	.920	.923	.927	.930	.933	.937	.940	.943	.946	.950	.953	.956	.959	.963	80
81	.898	.901	.904	.908	.911	.914	.917	.921	.924	.927	.930	.934	.937	.940	.943	.947	.950	.953	.956	.960	81
82	.895	.898	.902	.905	.908	.911	.915	.918	.921	.924	.928	.931	.934	.937	.941	.944	.947	.950	.954	.957	82
83	.892	.895	.899	.902	.905	.908	.912	.915	.918	.921	.925	.928	.931	.934	.938	.941	.944	.947	.951	.954	83
84	.889	.893	.896	.899	.902	.906	.909	.912	.915	.919	.922	.925	.928	.932	.935	.938	.941	.944	.948	.951	84
85	.886	.890	.893	.896	.899	.903	.906	.909	.912	.916	.919	.922	.925	.929	.932	.935	.938	.941	.945	.948	85
86	.884	.887	.890	.893	.897	.900	.903	.906	.909	.913	.916	.919	.922	.926	.929	.932	.935	.939	.942	.945	86
87	.881	.884	.887	.890	.894	.897	.900	.903	.906	.910	.913	.916	.919	.923	.926	.929	.932	.935	.939	.942	87
88	.878	.881	.884	.887	.891	.894	.897	.900	.903	.907	.910	.913	.916	.920	.923	.926	.929	.932	.936	.939	88
89	.875	.878	.881	.884	.888	.891	.894	.897	.900	.904	.907	.910	.913	.916	.920	.923	.926	.929	.933	.936	89
90	.872	.875	.878	.881	.885	.888	.891	.894	.897	.901	.904	.907	.910	.913	.917	.920	.923	.926	.929	.933	90
91	.869	.872	.875	.878	.881	.885	.888	.891	.894	.897	.901	.904	.907	.910	.913	.917	.920	.923	.926	.929	91
92	.866	.869	.872	.875	.878	.882	.885	.888	.891	.894	.898	.901	.904	.907	.910	.914	.917	.920	.923	.926	92
93	.863	.866	.869	.872	.875	.878	.882	.885	.888	.891	.894	.898	.901	.904	.907	.910	.914	.917	.920	.923	93
94	.859	.863	.866	.869	.872	.875	.879	.882	.885	.888	.891	.894	.898	.901	.904	.907	.910	.914	.917	.920	94
95	.856	.859	.863	.866	.869	.872	.875	.878	.882	.885	.888	.891	.894	.898	.901	.904	.907	.910	.913	.917	95
96	.853	.856	.859	.863	.866	.869	.872	.875	.878	.882	.885	.888	.891	.894	.898	.901	.904	.907	.910	.913	96
97	.850	.853	.856	.859	.863	.866	.869	.872	.875	.878	.882	.885	.888	.891	.894	.897	.901	.904	.907	.910	97
98	.847	.850	.853	.856	.859	.862	.866	.869	.872	.875	.878	.881	.885	.888	.891	.894	.897	.900	.904	.907	98
99	.843	.846	.850	.853	.856	.859	.862	.865	.869	.872	.875	.878	.881	.884	.887	.891	.894	.897	.900	.903	99
100	.840	.843	.846	.850	.853	.856	.859	.862	.865	.868	.872	.875	.878	.881	.884	.887	.890	.894	.897	.900	100
101	.837	.840	.843	.846	.849	.852	.856	.859	.862	.865	.868	.871	.874	.878	.881	.884	.887	.890	.893	.896	101
102	.833	.836	.840	.843	.846	.849	.852	.855	.858	.862	.865	.868	.871	.874	.877	.880	.884	.887	.890	.893	102
103	.830	.833	.836	.839	.842	.846	.849	.852	.855	.858	.861	.864	.867	.871	.874	.877	.880	.883	.886	.889	103
104	.826	.830	.833	.836	.839	.842	.845	.848	.851	.855	.858	.861	.864	.867	.870	.873	.876	.880	.883	.886	104
105	.823	.826	.829	.832	.835	.839	.842	.845	.848	.851	.854	.857	.860	.863	.867	.870	.873	.876	.879	.882	105
106	.819	.822	.826	.829	.832	.835	.838	.841	.844	.847	.851	.854	.857	.860	.863	.866	.869	.872	.875	.879	106
107	.816	.819	.822	.825	.828	.831	.834	.838	.841	.844	.847	.850	.853	.856	.859	.862	.866	.869	.872	.875	107
108	.812	.815	.818	.821	.825	.828	.831	.834	.837	.840	.843	.846	.849	.853	.856	.859	.862	.865	.868	.871	108
109	.809	.812	.815	.818	.821	.824	.827	.830	.833	.836	.840	.843	.846	.849	.852	.855	.858	.861	.864	.867	109
110	.805	.808	.811	.814	.817	.820	.823	.826	.830	.833	.836	.839	.842	.845	.848	.851	.854	.857	.860	.864	110

Formula used: $\text{Correction factor} = \dfrac{(H - W)\,(60 + 459.7)}{(T + 459.7)\,(30 - 0.5217)}$

H = total gas pressure. W = vapor pressure of water at T°.
T = temperature of gas (°F).

Correcting Gas Volume

For temperatures and/or pressures not covered by the table "Gas Volume Correction Factors" the following formula may be used for correcting gas saturated with water vapor to standard conditions:

$$Q = 17.64V \times \frac{H - W}{460 + T}$$

Where Q = volume of gas corrected to 60° F., 30 inches of mercury pressure and saturated with water vapor.

V = volume as measured.

H = absolute pressure of the gas in inches of mercury.

T = temperature of the gas in degrees F.

W = vapor pressure of water at temperature T (see table below).

Where the gas is partly saturated, W in the above formula is equal to the vapor pressure of water at the dew point temperature of the gas (see table below). When the gas is dry W = 0. In each case Q is volume of gas at 60° F., 30 inches of mercury pressure and saturated with water vapor.

Natural gas is usually measured and corrected on a dry basis to a temperature of 60° F. and a specified pressure base. There is no uniformity in the pressure bases used. The more commonly used are: (1) Atmospheric pressure at point of measurement plus a small specified gauge pressure; (2) 14.65 pounds per square inch (14.4 lbs. + 4 oz.), and 14.73 pounds per square inch (30 inches of mercury), specified in California.

The formula for correcting a dry gas to 60° F. and any given pressure base is as follows:

$$Q_d = V \times \frac{520}{460 + T} \times \frac{P}{P_s}$$

Where Q_d = volume of gas corrected to 60° F. and the specified pressure base.

V = volume as measured.

T = temperature of the gas in degrees F.

P = absolute pressure of the gas in pounds per square inch.

P_s = pressure base to which the gas is to be corrected—pounds per square inch absolute.

Flow of Gas Through Pipes

Low Pressures

The flow of gas through pipes under low pressures (up to about 1½ lbs. per sq. in.) may be computed by the use of the well known formula:

$$Q = c\sqrt{\frac{d^5\,(p_1 - p_2)}{G \times 1}} \qquad (1)$$

Where Q = flow in cubic feet per hour.
d = internal diameter of pipe in inches.
p_1 = initial pressure in inches of water.
p_2 = final pressure in inches of water.
G = specific gravity of the gas. (Air = 1.)
1 = length of pipe in yards.
c = a constant, given as 1000 by Molesworth and as 1350 by Pole.

Since the length of most low pressure mains is given in feet rather than yards, it is generally found more convenient to use the formula in the following revised form:

$$Q = C\sqrt{\frac{d^5\,(p_1 - p_2)}{G \times L}} \qquad (2)$$

Where C = $\sqrt{3}\,c$
L = length of pipe in feet.
All other symbols are as above.

The Spitzglass Formula, which is extensively used in low pressure gas flow calculations, is as follows:

$$Q = 3{,}550\sqrt{\frac{d^5\,(p_1 - p_2)}{G\,L\,(1 + 3.6/d + 0.03\,d)}} \qquad (3)$$

This is in effect Formula No. 2 with the constant

C equal to $\dfrac{3{,}550}{\sqrt{1 + 3.6/d + 0.03\,d}}$

In the following table are given for various pipe sizes:

Values of $\sqrt{d^5}$.

Values of C recommended in the American Gas Handbook, but revised for use in Formula No. 2.

Values of $\dfrac{3{,}550}{\sqrt{1 + 3.6/d + 0.03\,d}}$ designated in the table as C_s.

These constants, substituted in Formula No. 2, will enable the same answers to be obtained as with the Spitzglass Formula.

Constants for use in Formula No. 2

Diameter (d) Inches (Internal)	$\sqrt{d^5}$	C	Cs
0.75	0.4871	1732	1471
0.824 (¾″ Pipe)	0.6163	1732	1528
1.000	1.000	1732	1650
1.049 (1″ Pipe)	1.127	1732	1680
1.38 (1¼″ Pipe)	2.237	1905	1859
1.50	2.756	1905	1913
1.61 (1½″ Pipe)	3.289	1905	1959
2.00	5.657	2078	2100
2.067 (2″ Pipe)	6.143	2078	2119
2.469 (2½″ Pipe)	9.579	2078	2231
3.00	15.59	2252	2346
3.068	16.49	2252	2359
4.00	32.00	2338	2498
4.026	32.52	2338	2500
6.00	88.18	2338	2661
8.00	181.0	2338	2731
10.00	316.2	2338	2756
12.00	498.8	2338	2756
16.00	1024	2338	2718
20.00	1789	2338	2661
24.00	2822	2338	2597
30.00	4930	2338	2498
36.00	7776	2338	2405

It will be noted that the constants recommended in the American Gas Handbook are slightly more conservative than those derived from the Spitzglass Formula for pipe sizes 1½″ and larger.

High Pressures

Actual tests on flow of natural gas through high pressure transmission lines conducted by the Bureau of Mines and the American Gas Association have indicated that the Weymouth formula is generally the most accurate for computing flows in pipes 6 inches and larger. The Weymouth formula is as follows:

$$Q = 18.062 \frac{T_0}{P_0} \left[\frac{(P_1^2 - P_2^2) d^{16/3}}{G\,T\,L} \right]^{1/2}$$

Where Q = cubic feet per hour at temperature and pressure bases T_0 and P_0.

d = inside diameter of pipe in inches.

G = specific gravity of gas. (Air = 1.)
L = length of pipe in miles.

P_0 = base pressure	Pounds per square inch absolute. (14.7 + gauge pressure in lbs. per sq. in.)	
P_1 = initial pressure		
P_2 = final pressure		
T_0 = base temperature	° F. absolute (459.7° + ° F. above zero.)	
T = flowing temperature		

If the base and flowing temperatures are 519.7° (60° F. above zero) and the base pressure is 30 inches of mercury (14.73 lbs. per sq. in.) the formula becomes:

$$Q = 27.95\sqrt{\frac{(P_1^2 - P_2^2)\, d^{16/3}}{G\, L}}$$

Other commonly used formulae are:

The Pittsburgh Formula:

$$Q = 36.78\sqrt{\frac{(P_1^2 - P_2^2)\, d^5}{G\, L}}$$

The Cox Formula:

$$G = 33.3\sqrt{\frac{(P_1^2 - P_2^2)\, d^5}{G\, L}}$$

The Oliphant Formula:

$$Q = 42\, a\sqrt{\frac{P_1^2 - P_2^2}{L}}$$

$$\text{where } a = \sqrt{d^5} + \frac{d^3}{30}$$

For pipes 4″ or under there are some indications that the Pittsburgh or Cox formulae are most applicable.

Values of $(d)^{8/3}$ and $(d)^{16/3}$

(Note — $d^{8/3} = \sqrt{d^{16/3}}$)

Diameter (d), Inches		$(d)^{8/3}$	$(d)^{16/3}$
External	Internal		
2.375	2.067	6.933	48.063
3.500	3.068	19.87	394.99
4.500	4.026	41.02	1,682.6
6.625	6.040	121.0	14,640
6.625	6.125	125.6	15,773
6.625	6.250	132.5	17,567
8.625	8.071	262.1	68,700
8.625	8.125	266.8	71,182
8.625	8.185	272.1	74,035
10.000	9.625	419.2	175,710
10.750	10.192	488.3	238,440
10.750	10.250	495.7	245,760
12.750	12.090	770.0	592,870
12.750	12.188	786.7	618,920
12.750	12.250	797.5	635,930
14.000	13.500	1033.3	1,067,600
15.000	14.500	1250.2	1,563,000
16.000	15.250	1430.2	2,045,400
16.000	15.375	1461.7	2,136,500
16.000	15.500	1493.5	2,230,600
18.000	17.250	1986.6	3,946,500
18.000	17.375	2025.3	4,101,600
18.000	17.500	2064.3	4,261,400
20.000	19.250	2661.6	7,084,200
20.000	19.375	2707.9	7,333,000
20.000	19.432	2729.3	7,449,200
22.000	21.125	3410.4	11,631,000
22.000	21.375	3519.1	12,384,000
22.000	21.500	3574.1	12,775,000
24.000	23.125	4340.8	18,843,000
24.000	23.375	4466.8	19,953,000
24.000	23.500	4531.0	20,529,000
26.000	25.125	5415.4	29,326,000
26.000	25.500	5633.4	31,736,000
28.000	27.125	6642.3	44,120,000
28.000	27.500	6889.8	47,471,000
30.000	29.125	8030.0	64,482,000
30.000	29.500	8308.3	69,030,000

Flow of Gas Through Pipes of Varying Dimensions

Actual Determinations

The data given in these tables show the rates of flow of 0.6 specific gravity gas (in cu. ft. per hour) for different pressure drops (in 10ths inches of water column) in different sizes and varying lengths of pipe. For gas of any specific gravity other than 0.6, multiply the flow figures in the table by $\sqrt{\frac{0.6}{\text{sp. gr. of gas}}}$

LENGTH OF STRAIGHT PIPE IN FEET

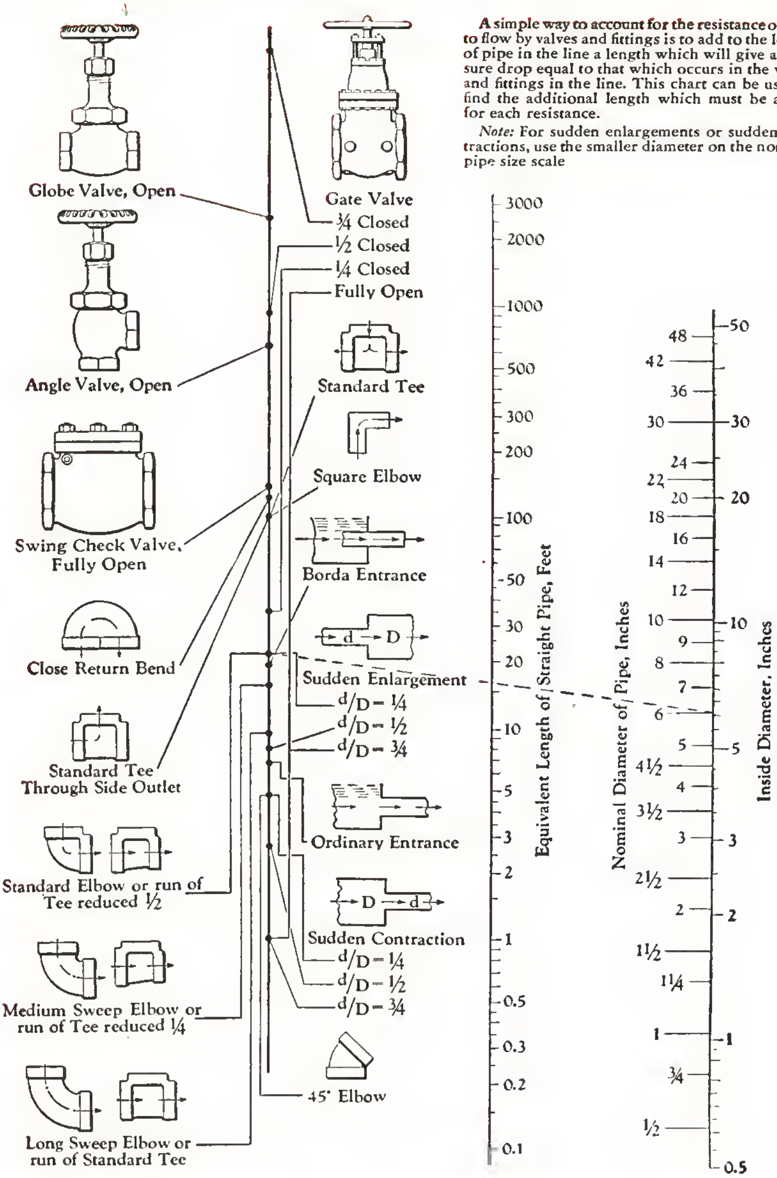
Size Pipe Inches	Press. Drop 10th Ins.	10	20	30	40	50	60	70	80	90	100	125	150	175	200	300	400	500	600	700	800	900	1000
1	3	415	300	240	210	190	170	160	150	142	135	125	112	100	90	75	62	50	45	40	35	No	30
	5	540	440	325	285	250	225	215	195	185	177	155	140	130	120	100	80	70	65	57	48	Tests	40
	10	.....	560	440	400	360	335	310	290	270	260	235	215	195	180	145	125	110	100	90	80	Made	70
	15	.....	.....	565	510	440	410	380	355	340	325	295	265	240	225	180	155	135	125	110	105	with	90
	20	.....	.....	.....	570	510	465	440	410	395	380	345	310	285	265	215	185	160	145	135	125	This	105
	30	.....	.....	.....	.....	.....	580	540	505	480	465	420	380	350	330	265	225	200	180	165	155	Lgt.	135
1¼	3	850	610	505	430	390	360	340	310	295	285	200	230	210	195	155	135	115	100	90	85	No	75
	5	1125	790	660	570	510	465	440	410	390	375	335	305	280	260	205	180	165	140	125	115	Tests	100
	10	.....	1135	940	810	725	670	630	590	560	545	485	440	410	380	305	260	230	205	190	175	Made	155
	15	.....	.....	1155	1000	890	820	770	725	685	670	600	525	450	435	375	325	285	260	235	225	with	195
	20	.....	.....	.....	1150	1020	960	895	835	800	770	700	630	585	545	440	380	335	305	280	260	This	230
	30	.....	.....	.....	.....	.....	1175	1100	1030	980	940	860	780	720	670	545	470	420	380	350	325	Lgt.	285
1½	3	1325	940	770	680	600	550	510	475	450	440	395	350	325	300	240	205	175	160	140	130	No	120
	5	1700	1200	1000	865	780	720	670	620	600	570	510	455	430	400	315	265	240	215	195	180	Tests	150
	10	.....	1925	1450	1230	1120	1040	960	900	855	830	745	670	620	580	465	400	350	315	290	270	Made	240
	15	.....	.....	1770	1550	1375	1275	1175	1100	1050	1015	910	830	770	720	580	490	440	395	360	340	with	300
	20	.....	.....	.....	1760	1575	1470	1370	1275	1225	1170	1075	950	895	830	670	590	510	460	430	400	This	350
	30	.....	.....	.....	.....	.....	1805	1675	1575	1495	1450	1320	1180	1100	925	875	720	640	565	520	490	Lgt.	430
2	3	2420	1725	1430	1225	1115	1025	960	900	850	830	750	670	625	580	470	410	360	320	300	280	No	250
	5	3100	2225	1855	1600	1450	1375	1250	1175	1120	1075	970	880	820	760	610	530	470	420	390	365	Tests	320
	10	.....	3160	2635	2275	2055	1900	1775	1675	1575	1545	1380	1270	1175	1085	870	760	670	610	560	525	Made	470
	15	.....	.....	3210	2790	2500	2325	2170	2025	1950	1825	1685	1545	1425	1335	1075	930	825	760	700	655	with	590
	20	.....	.....	.....	3220	2925	2690	2500	2360	2250	2160	1980	1770	1650	1550	1255	1095	970	880	805	760	This	670
	30	.....	.....	.....	.....	.....	3300	3080	2885	2745	2650	2415	2200	2000	1890	1550	1345	1200	1075	1000	940	Lgt.	825
2½	3	3900	2800	2320	2000	1800	1670	1550	1450	1380	1335	1225	1080	1000	940	735	645	570	500	465	430	No	385
	5	5040	3625	3000	2600	2350	2175	2025	1890	1810	1745	1570	1420	1315	1225	995	845	740	660	620	570	Tests	500
	10	.....	5150	4285	3695	3340	3100	2880	2700	2570	2480	2240	2025	1890	1760	1415	1225	1085	990	910	850	Made	740
	15	.....	.....	5220	4550	4050	3780	3520	3300	3150	3050	2750	2500	2310	2155	1750	1500	1340	1225	1120	1020	with	950
	20	.....	.....	.....	5240	4735	4400	4080	3800	3650	3510	3200	2900	2680	2500	2030	1775	1570	1410	1310	1225	This	1070
	30	.....	.....	.....	.....	.....	5150	5000	4690	4475	4310	3910	3565	3290	3080	2500	2180	1925	1750	1600	1525	Lgt.	1340

3	3	7000	5610	4400	3490	3145	2875	2670	2480	2360	2280	2040	1810	1665	1540	1220	1025	870	755	665	625	No	530
	5	9100	6500	5300	4600	4435	3780	3530	3290	3140	3020	2905	2840	2450	2140	1640	1385	1210	1085	980	900	Tests	760
	10	.....	9300	7650	6600	5900	5500	5100	4800	4600	4400	3900	3600	3250	3000	2840	2140	1820	1640	1500	1390	Made	1225
	15	.....	.....	9380	8150	7300	6780	6290	5860	5600	5410	4880	4400	4050	3800	3050	2600	2290	2075	1895	1770	with	1600
	20	.....	.....	.....	9380	8500	7860	7300	6835	6480	6290	5640	5140	4740	4410	3560	3050	2700	2440	2240	2080	This	1820
	30	.....	.....	.....	.....	.....	9650	8990	8410	8000	7740	6990	6350	5850	5450	4410	3800	3380	3050	2790	2630	Lgt.	2290
3½	3	10350	7340	6050	5190	4690	4320	4035	3750	3565	3445	3115	2770	2575	2375	1890	1605	1400	1245	1130	1050	No	905
	5	.....	9500	7880	6780	6140	5670	5280	4940	4685	4500	4000	3660	3380	3185	2500	2300	1890	1690	1545	1445	Tests	1245
	10	.....	.....	.....	9740	8755	8080	7540	7080	6710	6510	5815	5280	4900	4550	3650	3160	2780	2500	2335	2150	Made	1885
	15	.....	.....	.....	.....	.....	9945	9245	8650	8260	7960	7190	6500	6000	5620	4500	3910	3500	3150	2850	2700	with	2350
	20	.....	.....	.....	.....	.....	.....	.....	10050	9580	9250	8350	7550	7000	6540	5290	4580	4020	3660	3400	3150	This	2775
	30	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	9335	8610	8050	6550	5660	5000	4500	4195	3955	Lgt.	3450
4	3	.....	10200	8420	7280	6580	6050	5635	5250	5000	4840	4355	3905	3610	3385	2720	2285	2000	1790	1655	1560	No	1350
	5	.....	.....	.....	9450	8500	7880	7325	6870	6550	6300	5600	5125	4760	4400	3145	3010	2870	2670	2400	2100	Tests	1800
	10	.....	.....	.....	.....	.....	.....	.....	9800	9350	9040	8090	7380	6810	6350	5120	4400	3900	3550	3280	3050	Made	2690
	15	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	9860	9080	8400	7860	6325	5450	4810	4360	4000	3740	with	3360
	20	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	9700	9550	7375	6365	5610	5140	4750	4400	This	3880
	30	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	9050	7850	6990	6300	5820	5500	Lgt.	4820

Size Pipe Inches	Press. Drop 10th Ins.	25	50	75	100	125	150	175	200	250	300	350	400	450	500	600	700	800	900	1000
6	3	32000	22600	18500	16000	14400	13000	12100	11300	10100	9250	8550	8000	7550	7150	6500	6050	5650	5300	5100
	5	41500	29200	23800	20600	18500	16800	15600	14600	13000	11900	11000	10300	9750	9250	8400	7800	7400	6800	6500
	10	58100	41200	33800	29000	26000	23900	22000	20600	18400	16400	15500	14500	13700	13050	11900	11000	10300	9750	9250
	15	71500	50500	41300	35800	32100	29000	27000	25300	22600	20600	19200	17900	16800	15900	14600	13500	12600	11500	11200
	20	82500	58000	47800	41200	37000	33800	31000	29200	26000	23800	22000	20600	19400	18400	16800	15600	14500	13700	13000
8	3	65000	46000	37800	32600	29200	25800	24600	23000	20600	18700	17400	16300	15300	14500	13300	12300	11500	10800	10300
	5	84000	57500	48500	42000	37800	34400	31800	29800	26600	24000	22500	21000	19800	18800	17200	14900	14800	14000	13500
	10	118000	84000	68500	59500	53000	48500	45000	42000	37600	33200	31800	29600	28000	26600	24200	21900	21000	19800	18700
	15	145000	99500	84000	73000	65500	59500	55000	51500	46000	42000	39000	37400	34200	32500	29800	27500	25700	24200	23000
	20	168000	118000	97500	84000	75500	69000	63500	59500	53200	48500	45000	42000	39600	37500	34400	30800	29600	28000	26600
10	3	116000	82000	67500	58000	52000	47500	44000	41000	36800	33600	31000	29000	27400	26000	23700	21900	20300	19400	18400
	5	150000	106000	87000	75000	67500	61000	56800	53000	47500	46500	40000	37500	35500	33600	30600	28400	26600	25000	23600
	10	212000	150000	122000	105000	95000	87000	80000	75000	67000	60000	56500	53000	50000	47500	43300	40000	37500	35300	33600
	15	260000	184000	150000	130000	117000	105000	97000	95000	82000	75000	70000	65000	61500	58000	53000	49000	46000	42000	41000
	20	300000	212000	174000	150000	134000	122000	113000	105000	95000	87000	80500	75000	70500	67000	61000	57000	53000	50000	47500
12	3	183000	128000	105000	91500	82000	74500	69000	64500	57700	52500	48500	45500	43000	40700	37200	34400	32300	30400	28800
	5	234000	166000	135000	117500	110000	96000	89000	83500	74500	67000	63000	59000	55500	52700	48000	44500	41500	39200	37200
	10	331000	235000	192000	166000	148000	136000	125000	117000	105000	94000	89000	83000	78500	74500	68000	63000	58800	55500	52500
	15	406000	288000	236000	204000	184000	166000	154000	144000	128000	117000	109000	102000	96500	91000	83500	77000	72000	68000	64500
	20	470000	334000	272000	236000	210000	192000	177000	166000	148000	135000	125000	117000	110000	105000	96000	89000	83000	78800	74500

A simple way to account for the resistance offered to flow by valves and fittings is to add to the length of pipe in the line a length which will give a pressure drop equal to that which occurs in the valves and fittings in the line. This chart can be used to find the additional length which must be added for each resistance.

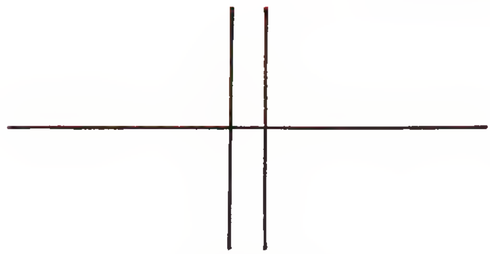
Note: For sudden enlargements or sudden contractions, use the smaller diameter on the nominal pipe size scale



From "Flow of Fluids through Valves, Fittings and Pipe." Copyright 1942 by Crane Company.

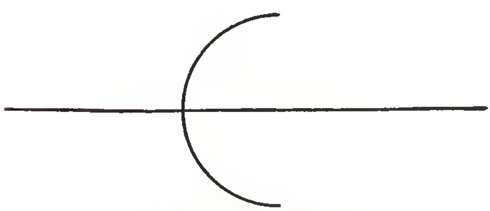
Drawing Symbols

The symbols shown for bell and spigot, flanged, and screwed joints, are approved by American Standards Association and are reproduced from a publication issued by *The American Society of Mechanical Engineers* entitled "American Standard Graphical Symbols." The symbol for the mechanical joint is suggested by the Cast Iron Pipe Research Association as an addition to those now in use on drawings.

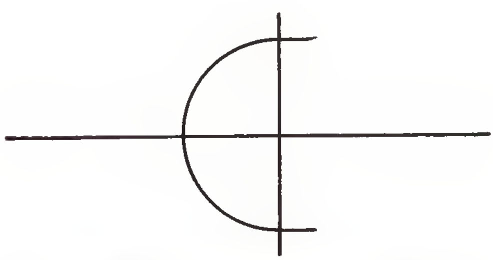


Flanged Joint

Screwed Joint



Bell and Spigot Joint



Suggested Symbol for Mechanical Joint

Millimeters and Equivalent Decimals and Nearest Fractions of Inches

One Millimeter = 0.03937″ | One Inch = 25.40 Mill.

Millimeter	Inches		Millimeter	Inches	
	Decimal	Nearest Fraction		Decimal	Nearest Fraction
1	0.03937	3/64	51	2.00787	2 1/64
2	0.07874	5/64	52	2.04724	2 3/64
3	0.11811	1/8	53	2.08661	2 5/64
4	0.15748	5/32	54	2.12598	2 1/8
5	0.19685	13/64	55	2.16535	2 5/32
6	0.23622	15/64	56	2.20472	2 13/64
7	0.27559	9/32	57	2.24409	2 1/4
8	0.31496	5/16	58	2.28346	2 9/32
9	0.35433	23/64	59	2.32283	2 21/64
10	0.39370	25/64	60	2.36220	2 23/64
11	0.43307	7/16	61	2.40157	2 13/32
12	0.47244	15/32	62	2.44094	2 7/16
13	0.51181	1/2	63	2.48031	2 31/64
14	0.55118	35/64	64	2.51968	2 33/64
15	0.59055	19/32	65	2.55905	2 9/16
16	0.62992	5/8	66	2.59842	2 19/32
17	0.66929	43/64	67	2.63779	2 41/64
18	0.70886	45/64	68	2.67716	2 43/64
19	0.74803	3/4	69	2.71653	2 23/32
20	0.78740	25/32	70	2.75590	2 3/4
21	0.82677	53/64	71	2.79527	2 51/64
22	0.86614	55/64	72	2.83464	2 53/64
23	0.90051	29/32	73	2.87401	2 7/8
24	0.94488	15/16	74	2.91338	2 29/32
25	0.98425	63/64	75	2.95275	2 61/64
26	1.02362	1 1/64	76	2.99212	2 63/64
27	1.06299	1 1/16	77	3.03149	3 1/32
28	1.10236	1 7/64	78	3.07086	3 5/64
29	1.14173	1 19/64	79	3.11023	3 7/64
30	1.18110	1 3/16	80	3.14960	3 5/32
31	1.22047	1 7/32	81	3.18897	3 3/16
32	1.25984	1 1/4	82	3.22834	3 15/64
33	1.29921	1 19/64	83	3.26771	3 17/64
34	1.33858	1 11/32	84	3.30708	3 5/16
35	1.37795	1 3/8	85	3.34645	3 11/32
36	1.41732	1 27/64	86	3.38582	3 25/64
37	1.45669	1 29/64	87	3.42519	3 27/64
38	1.49606	1 1/2	88	3.46456	3 15/32
39	1.53543	1 17/32	89	3.50393	3 1/2
40	1.57480	1 37/64	90	3.54330	3 35/64
41	1.61417	1 39/64	91	3.58267	3 37/64
42	1.65354	1 21/32	92	3.62204	3 5/8
43	1.69291	1 11/16	93	3.66141	3 21/32
44	1.73228	1 47/64	94	3.70078	3 45/64
45	1.77165	1 49/64	95	3.74015	3 47/64
46	1.81102	1 13/16	96	3.77952	2 25/32
47	1.85039	1 27/32	97	3.81889	3 13/16
48	1.88976	1 57/64	98	3.85826	3 55/64
49	1.92913	1 59/64	99	3.89763	3 57/64
50	1.96850	1 31/32	100	3.93700	3 15/16

Equivalents of Measure

LENGTHS

1 meter, m = 10 decimeters, dm = 100 centimeters, cm = 1000 millimeters, mm.
1 meter, m = 0.1 decameter, dkm = 0.01 hectometer, hm = 0.001 kilometer, km.
1 meter, m = 39.37 inches, U. S. Standard = 39.370113 inches, British Standard.
1 millimeter, mm = 1000 microns, μ = 0.03937 inch = 39.37 mils.

Meters m	Inches In.	Feet Ft.	Yard Yd.	Rods r.	Chains Ch.	Miles, U. S.		Kilometers Km.
						Statute	Nautical	
1	39.37	3.28083	1.09361	0.19884	0.04971	0.0006214	0.0005396	0.001
0.02540	1	0.08333	0.02778	0.005051	0.001263	0.00001578	0.00001371	0.00002540
0.30480	12	1	0.33333	0.06061	0.01515	0.0001894	0.0001645	0.0003048
0.91440	36	3	1	0.18182	0.04545	0.0005682	0.0004934	0.0009144
5.02921	198	16.5	5.5	1	0.25	0.003125	0.002714	0.005029
20.1168	792	66	22	4	1	0.01250	0.01085	0.02012
1609.35	63360	5280	1760	320	80	1	0.86839	1.60935
1853.25	72962.5	6080.20	2026.73	368.497	92.1243	1.15155	1	1.85325
1000	39370	3280.83	1093.61	198.838	49.7096	0.62137	0.53959	1

1 yard, U. S. = 1.0000029 yards British. 1 yard British = 0.9999971 yard U. S.
1 chain, Gunter's = 100 links. 1 link = 7.92 inches.
1 cable length, U. S. = 120 fathoms = 960 spans = 720 feet = 219.457 meters.
1 league, U. S. = 3 statute miles = 24 furlongs.
1 international geographical mile = $^1/_{15}°$ at equator = 7422 m = 4.611808 U. S. statute miles.
1 international nautical mile = $^1/_{60}°$ at meridian = 1852 m = 0.999326 U. S. nautical miles.
1 U. S. nautical mile = $^1/_{60}°$ of circumference of sphere whose surface equals that of the earth = 6080.27 feet = 1.15155 statute miles = 1853.27 meters.
1 British nautical mile = 6080.00 feet = 1.15152 statute miles = 1853.19 meters.

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Equivalents of Measure

SURFACES AND AREAS

1 sq. meter, m^2 = 100 sq. decimeters, dm^2 = 10000 sq. centimeters, cm^2.
1 sq. meter, m^2 = 0.01 are, a = 0.0001 hectare, ha.
1 sq. millimeter, mm^2 = 0.01 cm^2 = 0.00155 sq. inch = 1973.5 circular mils.
1 are, a = 1 sq. decameter, dkm = 0.0247104 acre.

Sq. Meters m^2	Sq. Inches Sq. In.	Sq. Feet Sq. Ft.	Sq. Yards Sq. Yd.	Sq. Rods Sq. r.	Acres A	Hectares Ha.	Sq. Miles Statute	Sq. Kilometers Km^2
1	1550.00	10.7639	1.19599	0.03954	0.0002471	0.0001	0.0000003861	0.000001
0.0006452	1	0.006944	0.0007716	0.00002551	0.0000001594	0.00000006452	0.0000000002491	0.0000000006452
0.09290	144	1	0.11111	0.003673	0.00002296	0.000009290	0.00000003587	0.00000009290
0.83613	1296	9	1	0.03306	0.0002066	0.00008361	0.0000003228	0.0000008361
25.2930	39204	272.25	30.25	1	0.00625	0.002529	0.000009766	0.00002529
4046.87	6272640	43560	4840	160	1	0.40469	0.001563	0.004047
10000	15499969	107639	11959.9	395.366	2.47104	1	0.003861	0.01
2589999	....	27878400	3097600	102400	640	259.000	1	2.59000
1000000	....	10763867	1195985	39536.6	247.104	100	0.38610	1

1 sq. rod, sq. pole, or sq. perch = 625 sq. links = 1/160 acre.
1 sq. chain, Gunter's = 16 sq. rods = 1/10 acre.
1 acre = 4 sq. roods = 160 sq. rods. Square of 1 acre = 208.7103 feet square.

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Equivalents of Measure

MASSES AND WEIGHTS

1 gram, g = 10 decigrams, dg = 100 centigrams, cg = 1000 milligrams, mg.
1 gram, g = 0.1 decagram, dkg = 0.01 hectogram, hg = 0.001 kilogram, kg.
1 kilogram, kg = 1 cu. decimeter of water or liter, 4°C, 45° Lat. and sea level = 15432.35639 grains, U. S. and British Standard.

Kilograms Kg.	Grains Gr.	Ounces		Pounds		Tons		
		Troy Oz. T.	Avoirdupois Oz. Av.	Troy Lb. T.	Avoirdupois Lb. Av.	Net, Short 2000 Lbs.	Gross, Long 2240 Lbs.	Metric 1000 Kg.
1	15432.4	32.1507	35.2740	2.67923	2.20462	0.001102	0.0009842	0.001
0.00006480	1	0.002083	0.002286	0.0001736	0.0001429	0.00000007143	0.00000006378	0.00000006480
0.03110	480	1	1.09714	0.08333	0.06857	0.00003429	0.00003061	0.00003110
0.02835	437.5	0.91146	1	0.07595	0.06250	0.00003125	0.00002790	0.00002835
0.37324	5760	12	13.1657	1	0.82286	0.0004114	0.0003674	0.0003732
0.45359	7000	14.5833	16	1.21528	1	0.00050	0.0004464	0.0004536
907.185	14000000	29166.7	32000	2430.56	2000	1	0.89286	0.90719
1016.05	15680000	3266.7	35840	2722.22	2240	1.12	1	1.01605
1000	15432356	32150.7	35274.0	2679.23	2204.62	1.10231	0.98421	1

1 ounce avoir. = 16 drams, avoir. 1 ounce troy = 20 pennyweight, dwt.
1 ounce apoth., ℥ = 8 drams, ʒ = 24 scruples, ℈ = 480 grains, gr = 31.1035 gr.
1 hundredweight = 1/20 long ton = 4 quarters = 8 stone = 112 lbs. = 50.8024 kg.

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Annuity Table

Giving Yearly Payments Required to Redeem $100 at End of Any Year, From 1 to 100

Years	2½%	3%	3½%	4%	4½%	5%	6%
1	100.00	100.00	100.00	100.00	100.00	100.00	100.00
2	49.38	49.26	49.14	49.02	48.90	48.78	48.54
3	32.51	32.36	32.19	32.03	31.88	31.72	31.41
4	24.08	23.90	23.73	23.55	23.37	23.20	22.86
5	19.02	18.84	18.65	18.46	18.28	18.10	17.74
6	15.65	15.46	15.27	15.08	14.89	14.70	14.34
7	13.25	13.05	12.85	12.66	12.47	12.28	11.91
8	11.45	11.25	11.05	10.85	10.66	10.47	10.10
9	10.05	9.84	9.64	9.45	9.26	9.07	8.70
10	8.93	8.72	8.52	8.33	8.14	7.95	7.59
11	8.01	7.81	7.61	7.42	7.23	7.04	6.68
12	7.25	7.05	6.85	6.66	6.47	6.28	5.93
13	6.60	6.40	6.21	6.01	5.83	5.65	5.30
14	6.05	5.85	5.66	5.47	5.28	5.10	4.76
15	5.58	5.38	5.18	4.99	4.81	4.63	4.30
16	5.16	4.96	4.77	4.58	4.40	4.23	3.90
17	4.79	4.60	4.40	4.22	4.04	3.87	3.54
18	4.47	4.27	4.08	3.90	3.72	3.55	3.24
19	4.18	3.98	3.79	3.61	3.44	3.27	2.96
20	3.91	3.72	3.54	3.36	3.19	3.02	2.72
21	3.68	3.49	3.30	3.13	2.96	2.80	2.50
22	3.46	3.27	3.09	2.92	2.75	2.60	2.30
23	3.27	3.08	2.90	2.73	2.57	2.41	2.13
24	3.09	2.90	2.73	2.56	2.40	2.25	1.97
25	2.93	2.74	2.57	2.40	2.24	2.10	1.82
26	2.78	2.59	2.42	2.26	2.10	1.96	1.69
27	2.64	2.46	2.29	2.12	1.97	1.83	1.57
28	2.51	2.33	2.16	2.00	1.85	1.71	1.46
29	2.39	2.21	2.04	1.89	1.74	1.60	1.36
30	2.28	2.10	1.94	1.78	1.64	1.51	1.26
31	2.17	2.00	1.84	1.69	1.54	1.41	1.18
32	2.08	1.90	1.74	1.60	1.46	1.33	1.10
33	1.99	1.82	1.66	1.51	1.37	1.25	1.03
34	1.90	1.73	1.58	1.43	1.30	1.18	.96
35	1.82	1.65	1.50	1.36	1.23	1.11	.90
36	1.75	1.58	1.43	1.29	1.16	1.04	.84
37	1.67	1.51	1.36	1.22	1.10	.98	.79
38	1.61	1.45	1.30	1.16	1.04	.93	.74
39	1.54	1.38	1.24	1.11	.99	.88	.69
40	1.48	1.33	1.18	1.05	.93	.83	.65
41	1.43	1.27	1.13	1.00	.89	.78	.61
42	1.37	1.22	1.08	.95	.84	.74	.57
43	1.32	1.17	1.03	.91	.80	.70	.53
44	1.27	1.12	.99	.87	.76	.66	.50
45	1.23	1.08	.95	.83	.72	.63	.47
46	1.18	1.04	.91	.79	.68	.59	.44
47	1.14	1.00	.87	.75	.65	.56	.41
48	1.10	.96	.83	.72	.62	.53	.39
49	1.06	.92	.80	.69	.59	.50	.37
50	1.03	.89	.76	.66	.56	.48	.34

Annuity Table
Giving Yearly Payments Required to Redeem $100 at End of Any Year, From 1 to 100 (continued)

Years	2½%	3%	3½%	4%	4½%	5%	6%
51	.99	.85	.73	.63	.53	.45	.32
52	.96	.82	.70	.60	.51	.43	.30
53	.93	.79	.67	.57	.48	.41	.29
54	.89	.76	.65	.55	.46	.39	.27
55	.87	.73	.62	.52	.44	.37	.25
56	.84	.71	.60	.50	.42	.35	.24
57	.81	.68	.57	.48	.40	.33	.22
58	.78	.66	.55	.46	.38	.31	.21
59	.76	.64	.53	.44	.36	.30	.20
60	.74	.61	.51	.42	.35	.28	.19
61	.71	.59	.49	.40	.33	.27	.18
62	.69	.57	.47	.39	.31	.26	.17
63	.67	.55	.45	.37	.30	.24	.16
64	.65	.53	.44	.35	.29	.23	.15
65	.63	.51	.42	.34	.27	.22	.14
66	.61	.50	.40	.32	.26	.21	.13
67	.59	.48	.39	.31	.25	.20	.12
68	.57	.46	.37	.30	.24	.19	.12
69	.56	.45	.36	.29	.23	.18	.11
70	.54	.43	.35	.27	.22	.17	.10
71	.52	.42	.33	.26	.21	.16	.10
72	.51	.41	.32	.25	.20	.15	.09
73	.49	.39	.31	.24	.19	.15	.09
74	.48	.38	.30	.23	.18	.14	.08
75	.47	.37	.29	.22	.17	.13	.08
76	.45	.35	.28	.21	.16	.13	.07
77	.44	.34	.27	.21	.16	.12	.07
78	.43	.33	.26	.20	.15	.11	.06
79	.41	.32	.25	.19	.14	.11	.06
80	.40	.31	.24	.18	.14	.10	.06
81	.39	.30	.23	.17	.13	.10	.05
82	.38	.29	.22	.17	.13	.09	.05
83	.37	.28	.21	.16	.12	.09	.05
84	.36	.27	.21	.15	.11	.08	.05
85	.35	.26	.20	.15	.11	.08	.04
86	.34	.26	.19	.14	.10	.08	.04
87	.33	.25	.18	.14	.10	.07	.04
88	.32	.24	.18	.13	.10	.07	.04
89	.31	.23	.17	.13	.09	.07	.03
90	.30	.23	.17	.12	.09	.06	.03
91	.30	.22	.16	.12	.08	.06	.03
92	.29	.21	.15	.11	.08	.06	.03
93	.28	.21	.15	.11	.08	.05	.03
94	.27	.20	.14	.10	.07	.05	.03
95	.26	.19	.14	.10	.07	.05	.02
96	.26	.19	.13	.09	.07	.05	.02
97	.25	.18	.13	.09	.06	.04	.02
98	.24	.18	.12	.09	.06	.04	.02
99	.24	.17	.12	.08	.06	.04	.02
100	.23	.16	.12	.08	.06	.04	.02

Annuity Table

Capitalization of Annuity of $1,000 for From 5 to 100 years

Years	2½%	3%	3½%	4%	4½%	5%	5½%	6%
5	4,645.88	4,579.60	4,514.92	4,451.68	4,389.91	4,329.45	4,268.09	4,212.40
10	8,752.17	8,530.13	8,316.45	8,110.74	7,912.67	7,721.73	7,537.54	7,360.19
15	12,381.41	11,937.80	11,517.23	11,118.06	10,739.42	10,379.53	10,037.48	9,712.30
20	15,589.215	14,877.27	14,212.12	13,590.21	13,007.88	12,462.13	11,950.26	11,469.96
25	18,424.67	17,413.01	16,481.28	15,621.93	14,828.12	14,093.86	13,413.82	12,783.38
30	20,930.59	19,600.21	18,391.85	17,291.86	16,288.77	15,372.36	14,533.63	13,764.85
35	23,145.31	21,487.04	20,000.43	18,664.37	17,460.89	16,374.36	15,390.48	14,488.65
40	25,103.53	23,114.36	21,354.83	19,792.65	18,401.49	17,159.01	16,044.92	15,046.31
45	26,833.15	24,518.49	22,495.23	20,719.89	19,156.24	17,773.99	16,547.65	15,455.85
50	28,362.48	25,729.58	23,455.21	21,482.08	19,761.93	18,255.86	16,931.97	15,761.87
70	32,897.85	29,123.36	26,000.65	23,394.57	21,202.16	19,342.74	17,752.90	16,384.51
100	36,614.21	31,598.81	27,655.36	24,504.96	21,949.21	19,847.90	18,095.83	16,612.64