# HANDBOOK

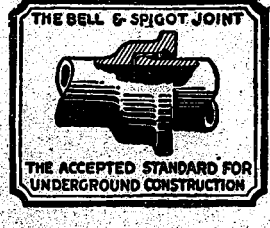
OF

# CAST IRON PIPE

FOR

## WATER, GAS, STEAM, AIR, CHEMICALS AND ABRASIVES

1927




CAST IRON PIPE RESEARCH ASSOCIATION
CHICAGO, ILLINOIS

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**PRICE $3.00**

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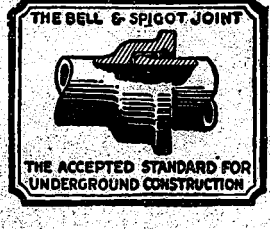
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# INTRODUCTION

CAST IRON PIPE needs no introduction to the Engineers of the Water Works and Gas Industries. Because of its dependable quality, resistance to corrosion, ease of installation and reasonable cost, it has become their standard conduit. Next to the air which we breathe, nothing is more essential to us than water, light and fuel. The excellent work of these engineers in design, operation, and the selection of materials, is well shown by these vital elements being the most dependable of the many Public Services that make possible our dense city life.

But since the establishment of specifications on Cast Iron Pipe and Fittings, by the various engineering associations, numerous new fittings have been developed on which complete standards have not been written. Required data regarding weights, dimensions and capacities, while available, is often scattered through several handbooks. Information regarding many of the problems arising in the field may be quite inaccessible to the engineer. With the hope that a new compilation of tables and chapters on these subjects may be of aid, not only to the water and gas Engineers, but to the many others to whom Cast Iron Pipe recommends itself, this book has been published.

CAST IRON PIPE RESEARCH ASSOCIATION

May, 1927.

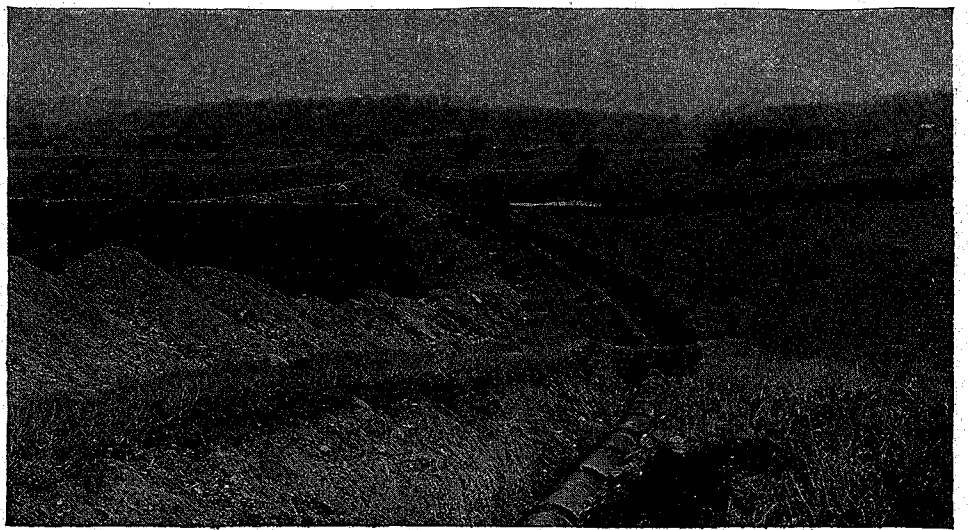


48-Inch Cast Iron Pipe Laid on Top of the Ground

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Long, Easy Curves Can be Laid with Full Length Bell and Spigot Cast Iron Pipe

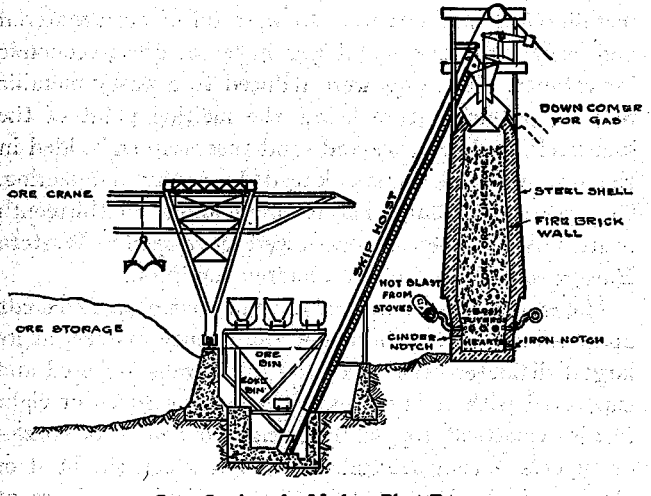
## SECTION 1

# 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. But the ancient metallurgical methods were so wasteful of both material and labor, that the metal was never of great economic importance. The ores were reduced to a pasty metallic mass at a temperature below the melting point of the iron itself, and the clay and sand that were embedded in the ore were laboriously kneaded out by hammering. Our present metallurgy had its origin 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 round 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 seven or eight feet is cylindrical, topped by a ring of openings for nozzles or tuyeres as they are called, through which the blast of air is forced. Immediately above this is a divergent conical section called the "Bosh." The "Bosh" is surmounted by another cylindrical section, then another cone and 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 rich 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.




Cross Section of a Modern Blast Furnace

At present coke is the only one of commercial importance, though in the past much charcoal was consumed. 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 the carbonates of calcium or magnesium, which are charged in the furnace as raw limestone or 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 CO is formed. This gas has very active reducing properties so that at temperature 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:

$$6\,C + 3\,O_2 = 6\,CO$$
$$2\,Fe_2O_3 + 6\,CO = 2\,Fe_2 + 6\,CO_2$$

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 limestone. This column slowly travels 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.

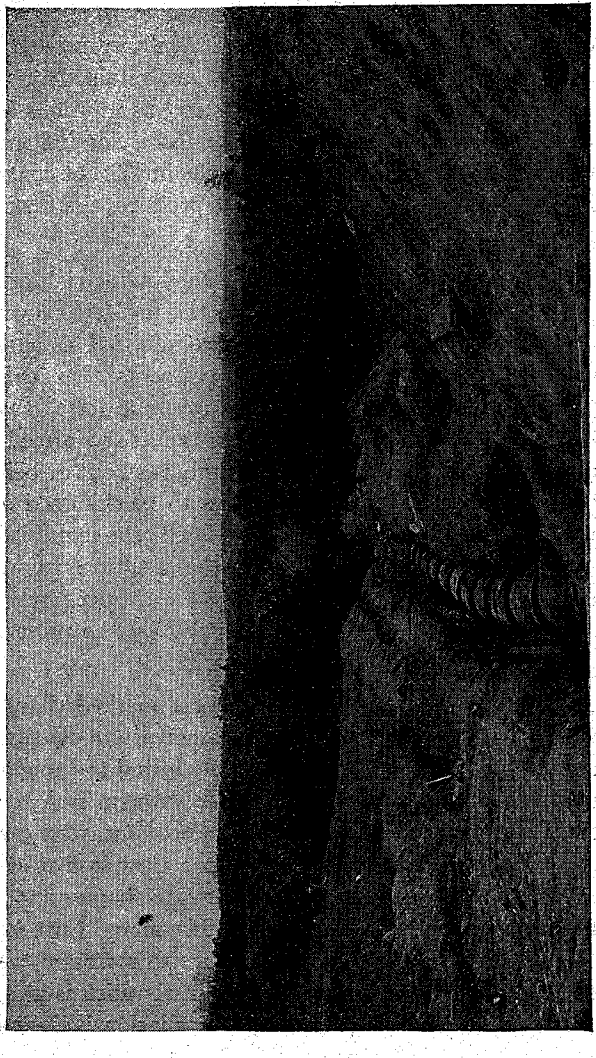
Their great difference in specific gravity separates the iron and slag into layers, permitting the withdrawal of iron through a hole or notch at the bottom, and the slag through another notch higher up. Both of these notches are usually plugged but as often as the slag level rises to approach the tuyeres, 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 metal is either caught in large ladles, to be carried to the steel plant or pig casting machine, or it is led out into a series of pig molds that have been made in a sand bed in front of the furnace. The arrangement of these molds, a long channel with shorter and narrower channels opening into it on one side, suggested a litter of pigs at lunch time to some old Englishman and his terms of sow for the main channel and pigs for the shorter ones, are current today. On solidifying the pigs and the sow are broken into convenient sizes for handling. The term "Pig Iron" is usually taken to mean the product of the blast furnace and "Cast Iron" the product of the foundry. These terms are used somewhat indiscriminately, though, and rightly so because the function of the foundry is not to alter the properties of the pig iron but to form it into useful shapes.

Iron has never been produced in an absolutely pure state except by the most careful 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 impurities because each has its peculiar modifying influence on the metal, and it is only through the intelligent control of these effects that 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 elimination is accomplished through treatments that cause these elements to separate from the iron and form gas or a 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, 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 that 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 while losing the original granular structure. At the same time wrought iron completely loses its typical qualities if melted, and steel castings are only used in limited services. Cast iron readily lends itself to being formed into intricate shapes, and to this owes its chief value for the foundryman. Cast iron pipe has also shown a greater resistance to corrosion than has that of either steel or wrought iron, which is also a valuable asset where a permanent installation is desired.



Large Cast Iron Pipe Through the Open Country

## SECTION 2

# THE EVOLUTION OF PIPING

THE modern gas and water supply systems can trace the history of their development to pre-historic times. The use of gas, of course, is comparatively new, beginning during the last years of the eighteenth century but its close relation to the earlier experiments of the water-works engineer is in that both services need a cheap, strong and durable conduit. Cast Iron Pipe, the first material to meet these requirements, had become available through improvements and economies in metallurgy made during the eighteenth century. Its present popularity is due to the splendid service which these original and later lines are still giving.

The most ancient civilizations originated in the flat plains of the Euphrates and the Nile and extensive networks of canals were dug leading out from the rivers. Probably these channels were the earliest efforts toward diverting water from its natural course, though they seem to have been more for irrigation than for domestic supply. In the cities the populations were dependent on the water carrier, who filled his jars and skin bags from the springs, or wells around which the first inhabitants had settled. These conditions in defiance of all laws of sanitation must have caused many such epidemics as was prophesied by Moses for the Egyptians. A more apparent defect in such a system was the danger to which an insufficient water supply exposed the city during a long drought or a siege. With the advancement in culture we are not

of the classical Greeks and Romans. The other forms of early conduit were pipe made of wood and lead, masonry channels, pierced stones and tunnels. Very good examples of the last two mentioned were found at Jerusalem dating from the time of the Judean kings. One of these, an inverted syphon across a marsh, is a series of masonry covered stone blocks through which fifteen-inch holes had been dug. The other is the seventeen-hundred-foot tunnel connecting the Virgins Pool with the upper Pool of Saloam. An old inscription on the tunnel wall states that it was driven from both ends. Though no mention is made of the fact, it was shown by recent examination that the two parties nearly missed each other.

In their distributing lines the Greeks and Romans both made use of pipe of the various materials and the more highly developed systems of the Latin cities contained large quantities of that made from both wood and lead. The short life of the wood pipe, the breaks in the clay lines and the high cost and poisoning where lead was used, must have given continuous trouble. But, representing as they did, the most suitable materials known to engineers, the use of each was an important step toward our modern practice.

The best known achievements of any of the ancient water works engineers were the aqueducts leading into the Grecian and the Roman cities, both from the size of the undertakings and the present state of their ruins.

The Greeks used the tunnel almost exclusively, and with great skill. Some of their most brilliant feats were the eight-foot-square tunnel, forty-two hundred feet long, which the engineer Polycrates drove through the solid rock at Samos, passing an Athenian tunnel twice under the

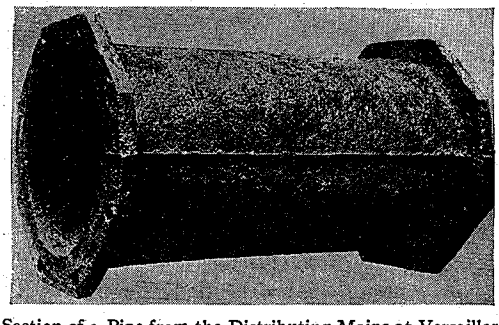
River Illissus and at one point carrying the conduit into Syracuse under the sea. The water usually flowed through the tunnels in clay pipe though channels in the rock floor were also used and occasionally a line of pierced stones cemented together. Little is known of the engineering methods employed in establishing the carefully adjusted grades and lines of these tunnels. Generally, shafts were dug at short intervals, possibly as guides to the working parties, as vents, or for decreasing the distance each face was driven.

The Roman engineers inherited the engineering experience of the Greeks and were able to carry it to a much higher state of perfection. The preference for vented tunnels was still marked, 304 miles of the 359 miles of conduit leading into Rome being under ground. A portion of this was of sheet lead pipe, which was coming into more common use, but the major portion was rock cut or masonry-lined tunnels. The systems stretched out to more distant water sources which called for much greater precision in establishing the grades. But it was in the manner in which the conduit spanned the subgrade areas that the greatest advancement was shown. Massive stone arches were built in tiers from hill to hill, surmounted by a water channel of well jointed stone blocks. This course or specus continued the gentle slope of the tunnels which it connected to make a constant gradient where inverted syphons would otherwise have been needed. On occasions such syphons of lead or bronze pipe were successfully used, but never to a proportion suggesting standard practice. The earlier aqueducts are rather heavy and clumsy, giving an impression of unnecessary mass of material. Many of the later ones show a grace-

ful use of arches that leaves nothing to be desired and still stand as some of the most perfect monuments of the ancient designing engineer. The Pont du Garde at Nimes, which is often referred to as an excellent example of the ornamental effects which they achieved. Ruins of many such installations are scattered throughout the old Roman Empire, monuments to the thought and labor which they gave to their water supply. At convenient points in or near the city, the water from these systems discharged into reservoirs or pools and was carried in pipes from there to the point of use. The poorer people were supplied by neighborhood fountains, though the residences and palaces of the richer classes enjoyed an individual connection as we do today.

These are the various expedients that were tried by the water works engineers down through the first few centuries of our era. The cities that sprang up in Europe during the middle ages turned their attention more to distribution systems and extended the use of the networks of mains much as we use today. Pipe of the old Roman materials, clay, wood, lead and stone, were installed with varying success, but more extensively than ever before. The growing application of the principles of mechanics to the problems of every day life led to many improvements in pumping machines, driven by water wheels. This, with the increase of wealth of the common people, permitted expansions in residence supply lines and a general demand for more modern conveniences. London, typical of such cities, experimented with pipe of stone, wood, cast lead and "Red Earth, baked" as early as 1235. In 1609-1613 Sir Hugh Myddelton built his boarded aqueduct, the "New River," and laid over four hundred miles

of new wooden mains in addition to the pipe already installed. A water power pumping plant had been built at London Bridge in 1582, and the city, no doubt, considered herself equipped with a highly efficient 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 twenty years. In addition, the great fire of



Section of a Pipe from the Distributing Mains at Versailles
After 250 Years of Service

1666 destroyed quantities of both lead and wood pipe at the time when it was most needed.

We can imagine, therefore, with what interest was watched the experiment with cast iron pipe that was being made at Versailles. Unfortunately, when this line was begun (1664) the production of iron in England and most of Europe was in the hands of a powerful group of furnace men. They controlled prices and production through ownership of the forest where charcoal was burned and had crushed Dudley's attempt to make cheaper iron with coke in 1619. So it was only after Darby had

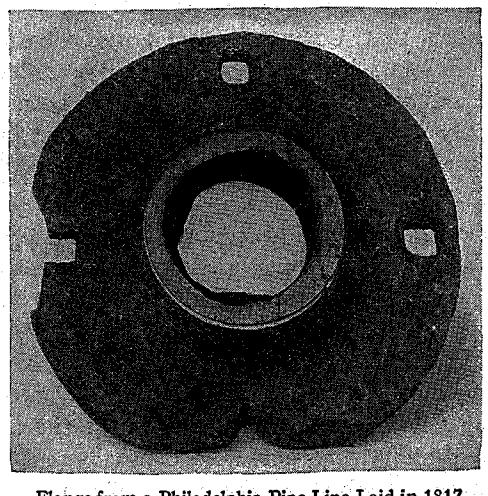
established a coke iron industry in 1738 that cast iron pipe could be afforded by the water works companies. Immediately cast iron mains began to be installed by many of the more progressive cities.

The joints of all these earliest lines were of the bolted type, with lead gaskets, and some trouble was experienced through the rusting of bolts. This difficulty was overcome by Thomas Simpson, engineer of the Chelsea Water Company, London, who, in 1785, invented the bell and spigot joint. It was used for the first time soon afterwards when that Company relaid a forty-five-year-old line whose joints had "perished." Thus was developed the bell and spigot cast iron pipe that has been used so extensively ever since. Many of the original lines are still in use, apparently good for many centuries more of service.

Most of the cities of this country are young enough to have planned their piping with modern materials and design. Some of the older towns went through very disagreeable experimental stages before building the finest type of systems in the world. Undoubtedly, New York has the greatest of these. A series of yellow fever epidemics following the Revolutionary War showed the necessity for more sanitary conditions. An unusually severe one in 1798 caused a group of the more prominent citizens, headed by Aaron Burr, to make plans for the water works installation which was chartered in 1799 as the Manhattan Company. Wells were dug at various points and the water was pumped through the city in bored pine logs. Philadelphia was also laying a log pipe system at the same time, but after a number of breaks ordered some cast iron pipe from England. Her experience with these were so

satisfactory that New York followed her example and Baltimore imported Cast Iron Pipe for her new gas lines. Its superiority over other materials created such a demand for it that in 1834 a foundry was built at Millville, New Jersey, to supply the neighboring cities. This was the beginning of the important cast iron pipe industry of that district and the United States.

With its rapid growth, New York soon found the capacity of the local wells to be inadequate. Agitation



Flange from a Philadelphia Pipe Line Laid in 1817

for relief became so insistent that in 1834 a fifty foot dam was begun on the Croton River, some forty miles away from the city. An aqueduct was also built, largely of the cut and cover type. Cast iron pipe was used in portions of it, bringing the water over the stone arched "High Bridge" across the Harlem River and then on into the

city. This system came into service in 1842, designed to supply 36,000,000 gallons daily.

By 1880 the system was being forced to 95,000,000 gallons a day and additional water was needed. A second storage reservoir was built in the Croton water shed and another aqueduct, increasing the supply by 300,000,000 gallons daily. This relief again proved to be only temporary, and in 1905 the Catskill Aqueduct Commission was authorized to provide a new supply of water from the Catskill Mountains. Beginning at the Schoharie Reservoir the first eighteen miles of this system is spanned by the Shandaken Tunnel, the longest continuous tunnel in the

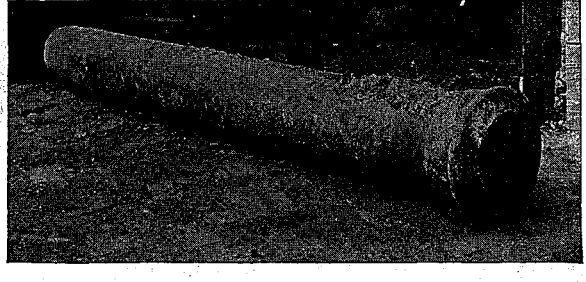


Pipe Cast in Early American Foundry after 93 Years of Service

world. Through it are brought some 300,000,000 gallons of water to the great reservoir created by the Ashokan dam. Supplementing the local supply from the Esopus Creek drainage area a reserve of 130 billion gallons is impounded here to be drawn off by the aqueduct to the Kensico Reservoir, ninety-two miles away. A large portion of this distance is traversed through a reinforced concrete channel, 241 square feet in section, the valleys being crossed by syphons or pressure tunnels. The most remarkable of these, the Storm King Tunnel, was driven three thousand feet through solid rock at a depth of eleven hundred feet below the Hudson River. From the Kensico Reservoir the water flows to the equalizing

reservoir at Hill View and thence by deep pressure tunnels to the various boroughs of the city. This system has been in operation since 1917. It furnishes a dependable yield of 600,000,000 gallons per day.

Staten Island, in addition to ten or twelve million gallons from local sources, receives its supply of Catskill water through two lines of flexible joint cast iron pipe 36 inches and 42 inches in diameter, passing under the Narrows. The watershed on Long Island can furnish about 120,000,000 gallons for use in the Boroughs of Brooklyn and Queens. When all water works under con-

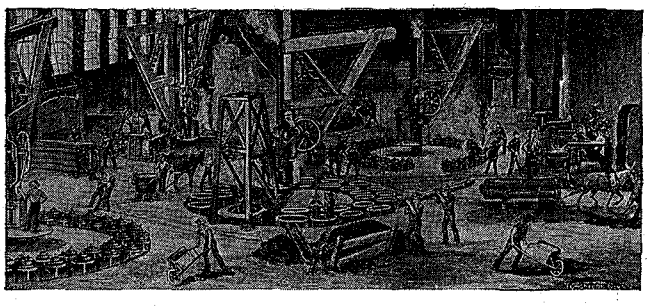


Earliest Cast Iron Gas Pipe after 80 Years of Service in Baltimore

struction are finally completed New York City will have a daily supply of over a billion gallons and a storage capacity of nearly three hundred billion gallons. While these figures and the cost of such projects are almost beyond conception, it has permitted New York's six million inhabitants to now have a per capita consumption of 131 gallons daily (789 million total), and at the rate of thirteen cents per thousand. The importance of cast iron pipe in such a development may be appreciated from the

fact that at the end of 1921, exclusive of fire line piping, 3,067 miles of cast iron mains had been laid in the City of New York in sizes ranging from 4 inches to 60 inches.

A study of the coking process showed the possibilities of generating gas from coal, and in 1792 Murclock introduced it for lighting in London. The cheaper bored logs were first tried, but these were soon replaced with cast iron mains. Since then cast iron pipe has been used for



View of Early Pipe Foundry

nearly all the gas piping that has been laid in Europe or in the United States.

Since the introduction of Cast Iron Pipe, many substitutes of various materials have been offered. Some, after trial, have failed, some are accepted only as a cheap material and only a short life is expected, while others are still so recent that their life and performance cannot be judged as compared to the many old cast iron mains now in use. A specific comparison of these materials is covered in another chapter of this book. So far Cast

Iron has been the only material specified by the Standards of the American Water Works and American Gas Associations, and it has met in performance the exacting service which this implies.

SECTION 3

# MANUFACTURE OF CAST IRON PIPE AND FITTINGS

THE manufacture of cast iron pipe had its origin about the year 1660, in some forgotten French foundry, for pipe lines to the fountains at Versailles. The underlying principal of the process, the introduction of molten cast iron into molds, where it solidifies into the desired shape, is the same today as it was then; but where formally hand labor was used exclusively and technical control was unknown, now the most modern machines of the electrical and the mechanical engineer are utilized and the whole operation is guided by one of the newest of sciences, metallurgy. An unusual type of plant design has been developed in the industry to permit the vertical casting of pipe twelve and sixteen feet long. This requires very heavy and expensive equipment, the cost of which is prohibitive unless used to maximum capacity; consequently, the manufacture of cast iron pipe is essentially a system of mass production ranking among the largest foundry operations in the iron industry.

The heavy initial investment in such plants limits the manufacture of cast iron pipe to companies with large financial resources that can take advantage of economical developments and offset with more efficient machinery the constantly rising cost of labor. The sharp competition between modern plants has prevented the manufacturing extravagance and waste that often is passed on to the

customer in the price, so that today water and gas pipes are the cheapest commodities made of cast iron to engineering specifications. To the users of cast iron pipe, the large units have also meant manufacturing capacities well able to meet the emergency demands of construction work, and an assurance of quality that comes only with supervision by a staff of metallurgists and engineers beyond the means of a smaller foundry.

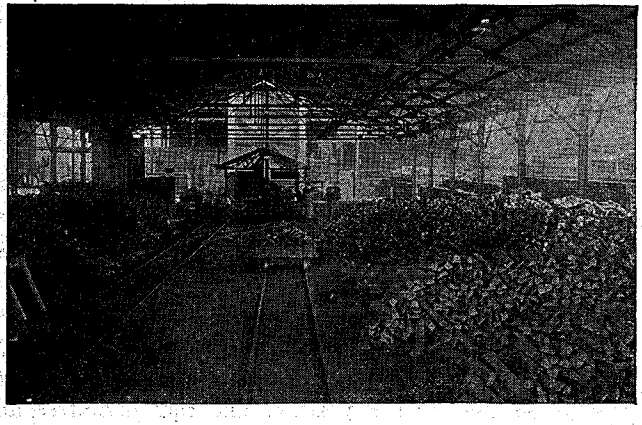
The most striking feature of the industry that has persisted throughout its whole history is the unsurpassed fitness of cast iron pipe for conduits. It is often mentioned in the trade that the first cast iron pipe line has been in continuous use since its installation; but of even more importance to the manufacturer of cast iron pipe is the knowledge that through the long period since its introduction no substitute has yet been offered to check the increasing use of cast iron pipe, nor has any material given so satisfactory a combination of qualities to resist the conditions to which conduits are subjected.

With the fact established that cast iron pipe has an almost indeterminable life, the problem of the manufacturer for many years has been to produce pipe with the best combination of physical properties and to eliminate the causes of defective workmanship that arise wherever the human equation enters into the process.

Cast iron pipe was originally made in horizontally cast sections, four to five feet in length. The mold or cavity into which the molten iron was poured was formed in two boxes of damp sand, each containing an impression of half the outer circumference of the pipe, and by closing these two half molds around a core whose diameter was that of the pipe bore. The core was supported and held

concentric by tight-fitting extensions of the mold proper, the shoulders formed by these extensions being the end walls of the mold. An opening was made at some point through which the metal could be poured. The core was a cylinder of sand, reinforced with iron rods, and, naturally, the limit in length of such molds was the extreme length at which the core would support itself without deflection. Any sagging in the middle of the core would cause eccentricity in the mold and a corresponding thin place in the pipe wall. Another objectionable feature of this method was that any sand or slag washed from the mold surface by the flowing iron would tend to float in the heavier metal and would collect in a streak at the highest point in the circumference of the pipe. But, with the limited experience of the early foundry men, this pouring position was used some hundred and fifty years until the advantages of pouring "on the bank" were discovered. In this method the mold was formed as before, but before pouring one end was raised so that the foreign substances would segregate at one end only, where their effect would not be so apparent. The tendency of the core to deflect was not so great in this position, and that permitted an increase in length to nine feet. The next change in pouring position came some fifty years later (about 1850), when the present method of vertical pouring came into use. By this means all tendency for the core to sag was removed, the elimination of sand and slag from the body of the pipe was made much more positive, and the commercial length of cast iron pipe was increased to twelve, and later, also, sixteen feet. In this way we may now cast iron pipe, knowing that they will be free from defects that were once, no doubt, quite common.

The control and improvement in the physical properties of cast iron were made possible through the discoveries within the past fifty years, that the strength, resistance to shock, machinability and other qualities of the castings are largely affected by the presence with the iron of non-ferrous elements. A study of these effects has been the chief activity of the foundry metallurgist, and by them he is able to select only such iron as is best suited



Storage of Pig Iron

for his class of work. As an example of the value of such research, it is well known that the presence of phosphorus is desirable within certain limits, but that an excess of this element causes the casting to be extremely brittle, and for that reason pipe with high phosphorus content is liable to breakage under the shocks incident to installation and service. Fortunately, most American pig irons are well within the margin of safety on phosphorus,

and those that are too high are not used by the pipe maker. Experience has shown that phosphorus should not exceed one percent as a maximum.

Crude cast iron is known as pig iron, from being cast into short bars or "pigs" at the blast furnace where it is reduced from the ore. It is graded by its content of non-ferrous elements, but as these commercial grades cover wider ranges of these elements than is permitted in foundry practice, it must be sorted at the foundry according to its analysis and blended to prevent excessive variations. The more important of these controlling elements are carbon, silicon, sulphur, manganese and phosphorus, all of which are in either the ore or the fuel, and are absorbed by the iron while being smelted in the blast furnace.

Carbon is taken up from the fuel, usually to the extent of about three and one-half percent in all grades. Silicon and sulphur are present in relatively large quantities, as impurities in the ore and the coke and the amount of their absorption is regulated in the blast furnace operation. These two elements are used for the commercial grading of pig iron, premiums being paid for higher silicons and lower sulphurs. The standard foundry grades range from one and a quarter percent to three and a quarter percent for silicon, and up to a maximum of about six-hundredth of one percent for sulphur. The manganese and phosphorus content of the iron is due to the occurrence of these elements in the ore, so their proportions are regulated through the ore supply. For foundry pig iron in general the amounts of each will fall between four-tenths and one percent, though, at any one furnace with uniform

ores, the percentages of these two elements will be almost constant in all commercial grades.

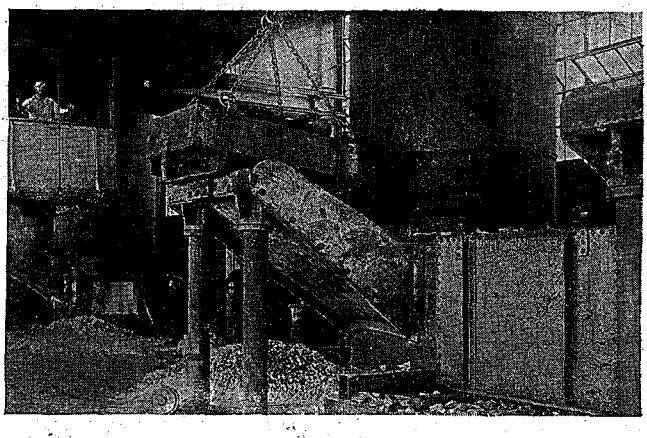
As it cools and solidifies, these elements either break their chemical bond with the iron, and separate as non-ferrous masses in the metal, or remain as a combination with the iron similar to an alloy. Carbon may follow either of these courses, forming in flakes of graphite interspersed through the casting, or retaining its alloyed condition as a carbide of iron. With a separation of all the carbon as graphite, a soft granular metal is obtained, but so divided into cells by the graphite as to have little strength. Or, if the carbon all remains in the combined form, the castings will be too hard to be machined, and, therefore, only suitable for special classes of service. Between these extremes are the gradual changes in the ratio of the two carbon conditions, that give increase in strength and hardness as the proportion of graphite becomes smaller, accompanied by a decrease in the size of the graphite flakes themselves.

One of the most effective agencies in determining these final proportions is the rate at which the casting is cooled. Bulky, slow-cooling castings have a much more open grain and larger percentage of graphitic carbon than smaller castings of the same analysis. In special cases, such as chilled car wheels, all of the carbon in wearing surfaces of the castings may be retained in the combined state by using metal blocks in parts of the mold to cause quicker cooling than would be obtained with sand. But as the size of the casting is determined by its purpose, as well as the extent to which strength, hardness, elasticity, and ease of machining must be given relative importance, other means must usually be used to influence the carbon

condition and the physical properties of the metal. This is accomplished largely through the amounts of silicon and sulphur present in the pig iron; increases in silicon causing increases in the tendency for graphitic carbon to form, and increases in sulphur producing the opposite effect. By balancing these two effects against the nature of the casting itself, similar properties may be given to different castings, though widely varying in size. Manganese and phosphorus have somewhat more complex reactions. Manganese has a strong affinity for sulphur and will unite with it to form a manganese sulphide that is without influence on the state of the carbon. In this way, by decreasing the amount of active sulphur, manganese has an indirect effect of increasing the graphitic carbon. But as its direct effect is to toughen the metal and to increase the combined carbon, the amount of manganese present must be considered in determining the silicon-sulphur ratio. Phosphorus is usually considered more for its influence on the fluidity of the molten metal and the brittleness of the casting. Rapid pouring is essential so that the metal will not begin to solidify before the mold is filled, and this is facilitated by the increase in fluidity given by phosphorus. With excessively high phosphorus, though, the iron is liable to be brittle, with a resulting low resistance to shocks. For this reason, while its presence is desirable within limits, pig iron must be selected that will not exceed a desired maximum.

The actual pipe casting operation is divided into three departments: melting, casting, and cleaning and inspection, so the plant is designed with this in view. The principal building is the foundry, a one-story structure to support the heavy cranes and to house the equipment and

molding pits. At one end or side is the two-story cupola house in which are located the cupolas used to melt the pig iron as it is brought from the adjacent storage yard. The cupolas themselves are just at the edge of the foundry so that the molten metal can be lead from them through gutters into ladles that are served by the foundry cranes. As soon as the pipe is cast, it is rolled out at other points around the foundry into the cleaning sheds, where it is cleaned, coated and tested. These three departments are



Cupola Charging Floor

under the supervision of the metallurgist, the foundry superintendent, and the chief inspector, respectively; though, naturally, there is a great overlapping of duties and co-operation between these department heads.

The cupola is a steel shell, usually about eight feet in diameter, 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 gutter 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 lead 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 weighed 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 cast iron is mixed with the pig, originating either from defective castings and runners in the foundry or from outside sources. When used so that the proper analysis of the metal is obtained, scrap iron has no injurious effects on the quality of the castings, as the function of the cupola is merely to melt the iron and not to change its properties. 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. Up until the

last few years, all charging was done by hand, but of late many foundries have installed mechanical charging machines with excellent results.

The floor plan of the foundry is divided into rectangular or circular pits, in which the molds are rammed and



Tapping a Cupola

poured. These trenchlike units vary considerably in size in various shops, but to give some idea as to their dimensions, they may be said to average about a hundred feet in length, eight to ten feet in width, and to have a capacity

of fifty to seventy tons of pipe per day. Their depth is such that only about three feet of the mold length extends above the floor level, which permits the floor to be used as a working platform convenient to the top of the long flasks. The shape of the pit is made to conform to the movement of the crane; circular pits being used with revolving jib cranes, and rectangular pits with bridge type travelers.

Two variations in molding practice, the "up socket" and the "down socket," are now in general use, so named

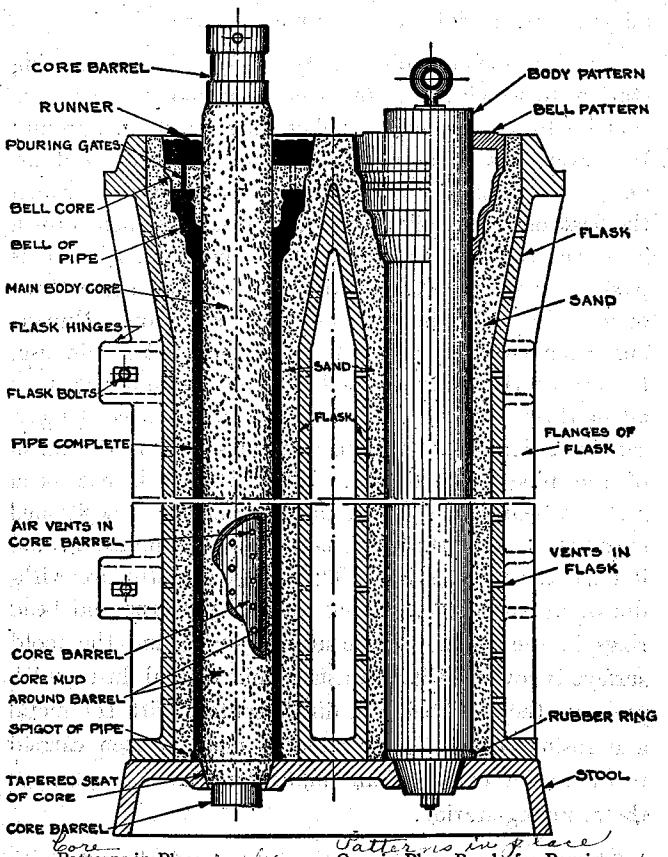


Interior of a Modern Pipe Foundry

from the position of the socket or bell in the mold. Engineering Society specifications require all pipe larger in diameter than sixteen inches to be cast with the bell down, the smaller sizes being cast up socket or down socket at the manufacturer's discretion. The high tem-

perature of molten iron has a tendency to destroy the cohesiveness of the sand mold and to cause it to disintegrate. This cutting action is not apparent with smaller volumes of metal, and the more rapid solidification in the thin sections of lighter pipe. So no preference is stated for sizes in which experience has shown either method to be safe. In heavier pipe, though, spongy, dirty castings might occur from sand having been entrapped in the metal and floating to the upper portion of the mold. This danger is eliminated by making an extension in the spigot end of the pipe, which is then removed to leave a perfect casting. The molding methods are so nearly identical for both bell positions that only a description of the "up socket" will be given here.

The molds for cast iron pipe are made in cylindrical containers or flasks, whose interior walls are shaped somewhat like the pipe itself. Two side castings are bolted or clamped together to form one, two or three vertical chambers, depending on the size of the pipe, which are open at the top but partially closed at the bottom by a third casting called the chill plate. In the picture a single flask is suspended from the crane, and double flasks are shown in the pit. The section of the double flask opposite has the patterns in place with the sand rammed around them in the ~~left-hand~~ right hand chamber, and the cores assembled in the mold as for pouring on the ~~right~~ left. A conical hole is machined in the chill plate for each mold chamber to support the barrel pattern and aline it concentrically with the flask walls. The barrel pattern is a straight metal cylinder with a tapered seat at one end to fit the chill plate, and handling rings at the other.




Core Patterns in Place ready for pouring. Pattern in place Core in Place Ready for Pouring

Section of Cast Iron Pipe Mold

All patterns and mold dimensions are made about one percent larger than the finished size of the casting to allow for the shrinkage of the metal as it cools.

Usually some one point on the pit is used as a ramming station, to which the empty flasks and molding sand are brought to be rammed. Rubber rings are slipped around the lower ends of the patterns to form the bead contour, and the patterns, one to each chamber, are lowered through the flask onto the chill plate. Damp sand is then thrown in at the top between the pattern and the flask and is packed firmly in place to give a mold wall some three or four times the thickness of the pipe section. Numerous mechanical means for packing the sand are in use, to replace the older method of hand ramming, but as all of these produce the same results, no especial merit can be assigned to any one method so far as the finish of the pipe is concerned. When the flask has been rammed nearly to the top, the bell pattern is positioned over the barrel pattern and more sand is rammed around it until the mold is full. The barrel patterns are withdrawn by the crane, leaving the bell patterns and bead rings in the mold. These are removed, and the mold surface is covered with a wash of coke or coal dust, which prevents the sand being in direct contact with the metal and fusing to it. The completed mold is then carried to the drying oven and an empty flask takes its place at the ramming station.

These ovens are built in the bottom of the pits with heavy cast iron covers on which the molds are placed. Hot gases pass up through holes in the cover plate and chill plate and bake the mold until it is thoroughly dry.

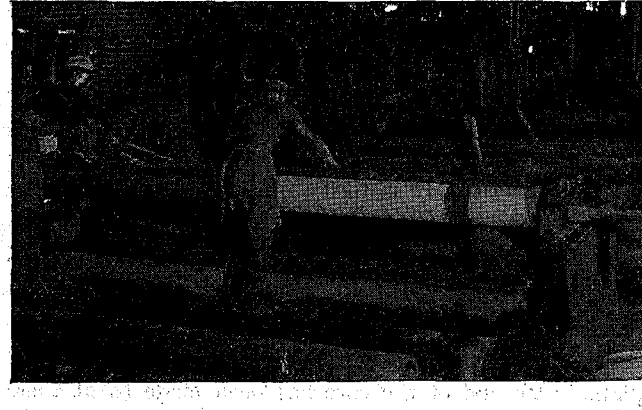
The molds are then quite hard, sufficiently so to withstand the attrition and pressure of the fluid metal.

While the molds are being rammed and dried in the pits, the cores are being prepared in another part of the building. A pipe, drilled at close intervals with small vent holes, is supported horizontally by bearings at each end, and is given a coating of coarse paper, straw or excelsior, while being slowly revolved. On this coating a layer of clay and sand is daubed, and then brought to a cylindrical shape by turning against a knife edge. It is painted with a wash similar to that put on the mold and is placed in an oven to dry. The head core for the inside of the bell and the top of the mold, is made of a mixture of sand, clay and some adhesive substances like molasses or tar. It is formed in a box which can be removed, and after being blacked, is also baked.

After the mold and cores are dry they are ready for assembling. The barrel core is lowered through the mold carefully so as not to injure the surfaces of the mold or core and is seated in the conical opening in the chill plate. One end of the core has been made to fit there so that it not only supports the weight of the core, but also insures the core being centrally located with the mold as well as preventing any leakage of the molten iron. The bell core is then placed over the barrel core and brought down against a shoulder molded for it by the bell pattern. This forms the upper end of the pipe and holds the barrel core concentric at the top, as does the conical seat at the bottom. A runner basin is formed at the top of the flask by the mold walls extending above the head core. When pouring, this basin is kept full of metal, so that the iron may be fed into the mold from

the bottom of the basin and any slag or sand will float on the surface without entering the pipe. Small holes are made around the head core for this purpose. The iron solidifying in the runner is removed from the pipe and remelted the following day.

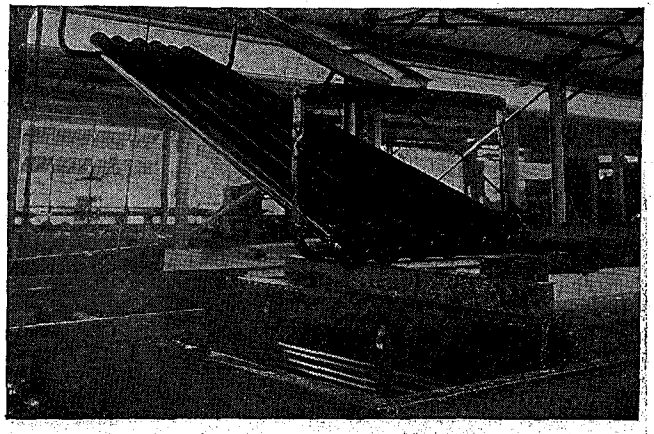
As soon as a group of molds and cores are assembled, iron is brought from the cupola in a ladle and the molds are poured. In a short time the iron solidifies, while at



Core Making Showing Core Bar with Paper Wrapping

the same time the heat penetrates the sand coating on the core and destroys the paper or excelsior wrapping. This permits the core bar to be withdrawn so that the cooling pipe can contract without developing strains. After cooling until quite black, the flask is lifted out of the pit and is suspended horizontally with one clamped edge down, over a rail runway. The clamps are knocked off and pipes roll out, the sand falling between them into a bin. At intervals the sand is taken up, redampened,

and carried to the ramming station to be used again. The runway leads out under the long cleaning shed. The sand from the bell is rapped out and the sand remaining from the barrel core and on the outside of the pipe is removed. Scrapers and polishers are worked over the inner and outer surfaces, and the pipe may then be washed to remove any dust that might affect the coating. Each workman examines the pipe for defects as he per-



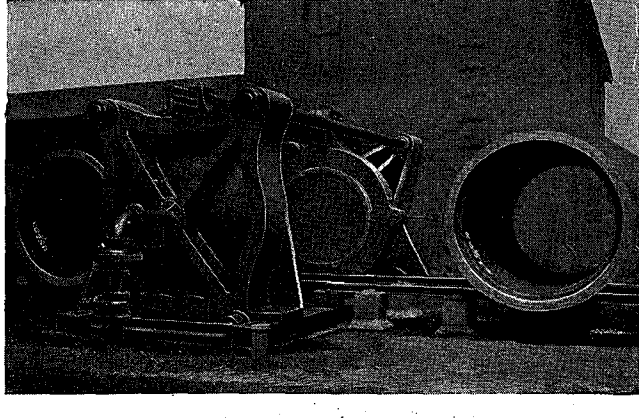
Dipping Pipe

forms his portion of the cleaning, and such pipe as they pass are then given a careful examination by the plant inspector. After being cleaned, the pipes are rolled into an oven where they are heated to about 300° F. At this temperature they are dipped in a vat of tar and oil coating and are then placed in an inclined position to drain.

The next step is the hydrostatic test in which the pipes are brought, one at a time, into a testing press and sealed

with flat gaskets forced against each end. They are then filled with water and the pressure is brought up above the test point, which is usually three hundred pounds. While at this pressure the pipe is rapped sharply with a hammer to give a shock test under the static load. From the testing press they are rolled onto the scales, the weight is stencilled on the bell and recorded and the pipe is ready for shipment.

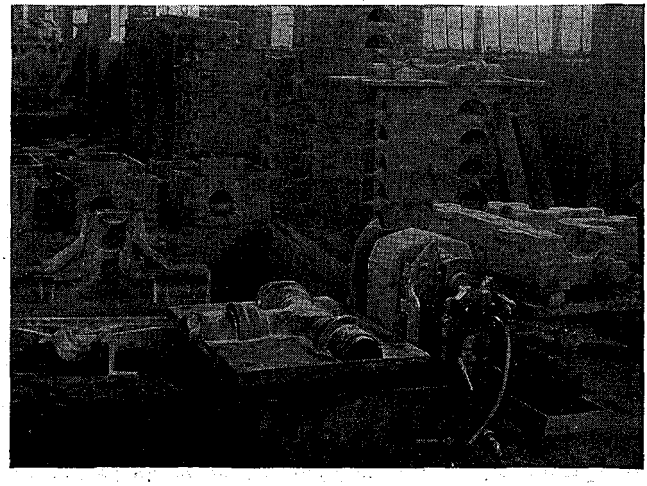
The fittings or special castings used with cast iron pipe are made in a different department from the pipe, and



Hydrostatic Press for Testing Large Cast Iron Pipe

by methods more nearly resembling those usually encountered in grey iron foundries. In fact, in the past, a number of general foundries in various parts of the country have supplied fittings in their localities to be used with pipe furnished by standard pipe manufacturers. This practice seems to be losing favor with the en-

gineers, however, because of the delays due to an incomplete line of patterns, and the poor workmanship from lack of skill on such castings. The heavy expense of replacing castings, once installed, is also seldom realized by foundrymen inexperienced in the water-works field, and fittings have often been shipped out and put into



Molding Machine for Making Fittings

service that would have been rejected by the pipe shop inspector.

Most of the smaller size 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 still plays a very important part, though molding machines of various kinds are used extensively. The picture 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 cut. 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 as 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, it 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, the gate into which the iron is poured, and another which serves as an index when the mold is full and permits 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 as described for the six-inch tee. Above this size 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 utilized.

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 suited for cleaning in this way are brushed or sand blasted. All fins and gates are chipped and ground off and the fittings are heated and dipped in the same coating as is used for the pipe.

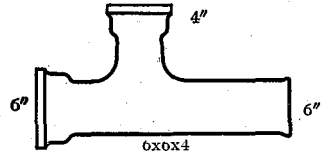
After the pipe and fittings are coated and weighed, they are given a final inspection, quite often with a representative of the purchaser collaborating with the plant inspector. They are then loaded on cars for shipment, and it is worthy of note that the precautions against rough handling in the field, which are suggested elsewhere in this book, are scrupulously observed by the manufacturer. The pipe are tiered on the cars, usually by means of a locomotive crane, so that shifting and damage in transit are reduced to a minimum.

With the loading and shipping of the pipe, the activities of the manufacturer end except for the cooperation

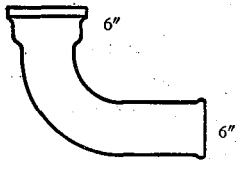
known by the somewhat undefinable term of "service." In the pipe industry this takes the form of assistance in securing favorable freight tariffs and expediting shipments, and technical advice to the less experienced users of cast iron pipe, and in the solution of unusual problems. Considerable saving of time and money for the engineer is often possible through minor changes in the design of intricate castings, required to meet local conditions, or the same results may be obtained through the use of patterns which the foundry has made at some previous time. The service of engineers in the field is also available, both from the cast iron pipe companies and from the Cast Iron Pipe Publicity Bureau. These engineers are constantly engaged in the study of corrosion, electrolysis and unusual installation conditions and acting in liaison between the distribution engineer and the foundry, endeavoring to simplify the problems of both, through their observations and research. It has been largely through the generous cooperation and thoughtful criticism of the users of cast iron pipe that the manufacturers have been able to make improvements in their products, and in return the pipe makers offer their experience in the field with the dual hope that it may be of immediate assistance, and also uncover new lines of improvement in composition, design, durability or finish of cast iron pipe.

# METHOD OF READING SIZE OF FITTINGS

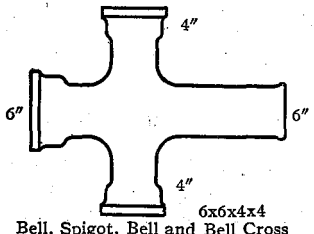
## STANDARD FITTINGS



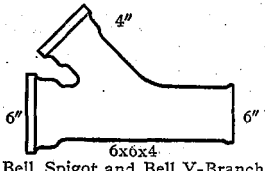

6x0x4
Bell, Spigot and Bell Tee (B-S-B)



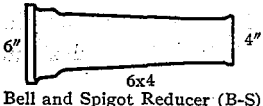

6"
Bell and Spigot ¼ Bend (B. & S.)




6x6x4x4
Bell, Spigot, Bell and Bell Cross (B-S-B-B)

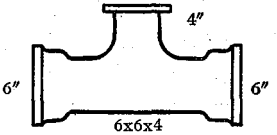



6x6x4
Bell, Spigot and Bell Y-Branch (B-S-B)

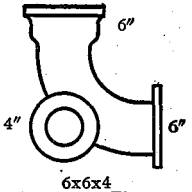



6x4
Bell and Spigot Reducer (B-S) (Large End Bell)

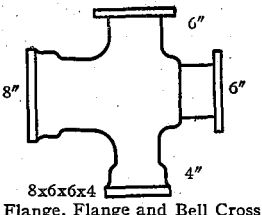
## SPECIAL FITTINGS



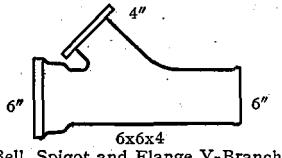

6x6x4
Bell, Bell and Flange Tee (B-B-F)



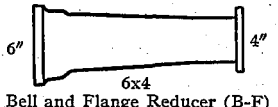

6x6x4
Bell, Flange and Flange Side Outlet Ell (B-F-F)




8x6x6x4
Bell, Flange, Flange and Bell Cross (B-F-F-B)




6x6x4
Bell, Spigot and Flange Y-Branch (B-S-F)




6x4
Bell and Flange Reducer (B-F) (Large End Bell)

# INFORMATION REQUIRED ON REQUESTS FOR QUOTATIONS

IN order to enable the foundries to submit prompt and correct quotations on required piping material it is suggested that inquiries include as complete information as possible. In addition to the usual details regarding destination, method of shipment and routing or delivery road, below are listed the more important items of information that are necessary for the intelligent consideration of your inquiry or order. When part of the material is urgently needed state desired time of shipment.

## BELL AND SPIGOT PIPE

Size; class or pressure; kind of service; Standard, A. W. W. A. or A. G. A.; Type 1 or 2; coated or uncoated; length of each pipe, whether 12 feet, 16 feet or 5 meter; number of lengths required or total length in feet.

## FLANGED PIPE

Size; class or pressure; kind of service; coated or uncoated; number of 12 foot lengths (shop will furnish all lengths as ordered, no allowance made for gaskets unless specified); state exact length when under 12 foot; state whether Standard or Special drilling.

## BELL AND SPIGOT FITTINGS

Size; class; coated or uncoated; type, whether Bell and Spigot, All Bell or Spigot and Spigot; Standard, whether A. W. W. A., A. G. A. or Special; if Special, sketch should be sent.

## FLANGED FITTINGS

Size; pressure; coated or uncoated; Standard, whether American, water, gas or special; if special, sketch should be sent; state whether Standard or Special drilling.

NOTE: For special pipe and materials send blue prints.

For standard names of fittings see page 165.
For method of reading fittings see page 47.
For standard of drilling see pages 147 and 149.

SECTION 4

# PRINCIPLES OF BUSINESS CONDUCT ADOPTED BY THE CAST IRON PIPE ~~PUBLICITY BUREAU~~ Research Association

I.

THE FOUNDATION of business is confidence which springs from integrity, fair dealing, efficient service, and mutual benefit.

II.

THE REWARD of business for service rendered is a fair profit plus a safe reserve, as commensurate with risks involved and foresight exercised.

III.

EQUITABLE CONSIDERATION is due in business alike to capital, management, employees, and the public.

IV.

KNOWLEDGE—thorough and specific—and unceasing study of the facts and forces affecting a business enterprise are essential to a lasting individual success and to efficient service to the public.

V.

PERMANENCY and continuity of service are basic aims of the business, that knowledge gained may be fully utilized, confidence established and efficiency increased.

VI.

OBLIGATIONS to itself and society prompt business unceasingly to strive toward continuity of operation, bettering conditions of employment and increasing the efficiency and opportunities of individual employees.

VII.

CONTRACTS and undertakings, written or oral, are to be performed in letter and in spirit. Changed conditions do not justify their cancellation without mutual consent.

VIII.

REPRESENTATION of goods and services should be truthfully made and scrupulously fulfilled.

IX.

WASTE in any form—of capital, labor, services, materials, or natural resources—is intolerable and constant effort will be made toward its elimination.

X.

EXCESS of every nature—inflation of credit, over-expansion, over-buying, over-stimulation of sales—which create artificial conditions and produce crises and depressions are condemned.

XI.

UNFAIR COMPETITION, embracing all acts characterized by bad faith, deception, fraud, or oppression, including commercial bribery, is wasteful, despicable and a public wrong. Business will rely for its success on the excellence of its own service.

XII.

CONTROVERSIES will, where possible, be adjusted by voluntary agreement or impartial arbitration.

XIII.

CORPORATE FORMS do not absolve from or alter the moral obligations of individuals. Responsibilities will be as courageously and conscientiously discharged by those acting in representative capacities as when acting for themselves.

XIV.

LAWFUL COOPERATION among business men and in useful business organizations in support of these principles of business conduct is commended.

XV.

BUSINESS should render restrictive legislation unnecessary through so conducting itself as to deserve and inspire public confidence.

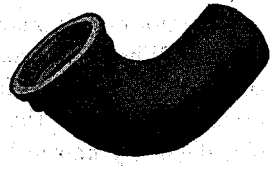
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SECTION 5

# AMERICAN WATER WORKS ASSOCIATION STANDARD

## Bell and Spigot Cast Iron Pipe and Fittings



# American Water Works Association Standard Specifications for Cast Iron Water Pipe and Fittings

STANDARD SPECIFICATIONS FOR WATER PIPE. On May 12, 1908, the American Waterworks Association adopted a set of specifications for Cast Iron Water Pipe and Fittings. These specifications in turn were adopted as the manufacturers' standard by the Bell and Spigot Cast Iron Pipe makers throughout the country. Another specification in use, less widely, however, than the American Waterworks Association Specifications, is that adopted by the New England Waterworks Association in 1902. The latter specifications use outside diameters similar to the American Waterworks Association, but include a wider range of wall thickness for the many classes provided for. These latter specifications have been largely replaced by the American Waterworks Association Specifications.

The adoption of a standard specification for water pipe has resulted in economy not only in manufacture but also in maintenance work. When it becomes necessary to install special castings in existing lines laid with standard pipe, it is not necessary to dig up the pipe to ascertain its thickness as it is definitely known before hand. Furthermore, standard pipe and fittings can usually be obtained from stock, whereas pipe and fittings made to special specifications must be made upon order and consequently there is liable to be some delay in delivery.

The specifications as they now stand provide for pipe for working heads of from 100 ft. to 800 ft., with a different wall thickness for each 100 ft. The classes are designated by letters: Class "A" being for pressures not to exceed 100 ft., Class "B," 200 ft., and so on to Class "H" for pressures not to exceed 800 ft.

The type of joint specified is the Bell and Spigot Joint and no other joint has been approved by either Association. The reason for this is the fact that experience has shown that the Bell and Spigot joint is best fitted for underground use. Pipe with joints other than Bell and Spigot now on the market is made with a wall thickness materially less than that recommended by the American Waterworks Association. This pipe, besides having a joint that lacks the advantages of the Bell and Spigot joints, weighs less per foot and will withstand less water pressure. These pipe are cast "on the flat," and the advantages that come from making pipe by pouring the metal into vertical moulds (as required by the American Waterworks Association Specifications) is lost.

For pipe work inside of pumping stations, filter plants and for any place where the class of work does not necessitate placing the pipe underground, flanged pipe is made with wall thickness similar to that specified by the American Waterworks Association. Tables giving the dimensions of flanged pipe and fittings are included with the tables of dimensions that are part of the American Waterworks Association Specifications.

# American Water Works Association Standard Specifications for Cast Iron Water Pipe and Fittings

Adopted May 12, 1908

## Description of Pipes

SECTION 1. The pipes shall be made with hub and spigot joints and shall accurately conform to the dimensions given in Table No. 1. They shall be straight and shall be true circles in section, with their inner and outer surfaces concentric, and shall be of the specified dimensions in outside diameter. They shall be at least 12 ft. in length, exclusive of socket.

Pipes with thickness and weight intermediate between the classes in Tables Nos. 1 and 3 shall be made of the same outside diameter as the next heavier class. Pipes with thickness and weight less than shown by Tables Nos. 1 and 3 shall be made of the same outside diameter as the Class A pipe.

All pipes having the same outside diameter shall have the same inside diameter at both ends. The inside diameter of the lighter pipes of each standard outside diameter shall be gradually increased for a distance of about 6 inches from each end of the pipe so as to obtain the required standard thickness and weight for each size and class of pipe.

For pipes of each size, from 4-inch to 24-inch, inclusive, there shall be two standards of outside diameter, and for

pipes from 30-inch to 60-inch, inclusive, there shall be four standards of outside diameter, as shown by Table No. 1.

For pipes 4-inch to 12-inch, inclusive, one class of fittings shall be furnished, made from Class D pattern. Those having spigot ends shall have outside diameters of spigot ends midway between the two standards of outside diameter, as shown by Table No. 1, and shall be tapered back for a distance of 6 inches.

For pipes from 14-inch to 24-inch, inclusive, two classes of fittings shall be furnished; Class B fittings with Classes A and B pipes, and Class D fittings with Classes C and D pipes; the former shall have cast on them the letters "AB" and the latter "CD." For pipes 30-inch to 60-inch, inclusive, four classes of fittings shall be furnished, one for each class of pipe, and shall have cast on them the letter of the class to which they belong.

### Allowable Variation in Diameter of Pipes and Sockets

SECTION 2. Especial care shall be taken to have the sockets of the required size. The sockets and spigots will be tested by circular gauges, and no pipe will be received which is defective in joint room from any cause. The diameters of the sockets and the outside diameters of the spigot ends of the pipes shall not vary from the standard dimensions by more than .06 of an inch for pipes 16 inches or less in diameter; .08 of an inch for 18-inch, 20-inch and 24-inch pipes; .10 of an inch for 30-inch, 36-inch and 42-inch pipes; .12 of an inch for 48-inch, and .15 of an inch for 54-inch and 60-inch pipes.

### Allowable Variation in Thickness

SECTION 3. For pipes whose standard thickness is less than 1 inch, the thickness of metal in the body of the pipe shall not be more than .08 of an inch less than the standard thickness, and for pipes whose standard thickness is 1 inch or more, the variation shall not exceed .10 of an inch, except that for spaces not exceeding 8 inches in length in any direction, variations from the standard thickness of .02 of an inch in excess of the allowance above given shall be permitted.

For fittings of standard patterns a variation of 50 per cent greater than allowed for straight pipes shall be permitted.

### Defective Spigots May Be Cut

SECTION 4. Defective spigot ends on pipes 12 inches or more in diameter may be cut off in a lathe and a half-round wrought-iron band shrunk into a groove cut in the end of the pipe. Not more than 12 per cent of the total number of accepted pipes of each size shall be cut and banded, and no pipe shall be banded which is less than 11 feet in length, exclusive of the socket.

In case the length of a pipe differs from 12 feet, the standard weight of the pipe given in Table No. 3 shall be modified in accordance therewith.

### Fittings

SECTION 5. All fittings shall be made in accordance with the cuts and the dimensions given in the tables forming a part of these specifications.

The diameters of the sockets and the external diameters of the spigot ends of the fittings shall not vary from the

standard dimensions by more than .12 of an inch for castings 16 inches or less in diameter; .15 of an inch for 18-inch, 20-inch and 24-inch; .20 of an inch for 30-inch, 36-inch and 42-inch, and .24 of an inch for 48-inch, 54-inch and 60-inch. These variations apply only to fittings made from standard patterns.

The flanges on all manhole castings and manhole covers shall be faced true and smooth, and drilled to receive bolts of the sizes given in the tables. The manufacturer shall furnish and deliver all bolts for bolting on the manhole covers, the bolts to be of the sizes shown on plans and made of the best quality of mild steel, with hexagonal heads and nuts and sound, well-fitting threads.

### Marking

SECTION 6. Every pipe and fitting shall have distinctly cast upon it the initials of the maker's name. When cast especially to order, each pipe larger than 4 inches 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:

| 1908 | 1908 | 1908 |
|---|---|---|
| 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 not be less than 2 inches in length and ⅛ of an inch in relief for pipes 8 inches in diameter and larger. For smaller sizes of pipes the letters may be 1 inch in length. The weight and the class letter shall be conspicuously painted in white in the inside of each pipe and fitting after the coating has become hard.

### Allowable Percentage of Variation in Weight

SECTION 7. No pipe shall be accepted the weight of which shall be less than the standard weight by more than 5 per cent for pipes 16 inches or less in diameter, and 4 per cent for pipes more than 16 inches in diameter, and no excess above the standard weight of more than the given percentage for the several sizes shall be paid for. The total weight to be paid for shall not exceed for each size and class of pipe received the sum of the standard weights of the same number of pieces of the given size and class by more than 2 per cent.

No fitting shall be accepted the weight of which shall be less than the standard weight by more than 10 per cent for pipes 12 inches or less in diameter, and 8 per cent for larger sizes, except that curves, Y pieces and breeches pipe may be 12 per cent below the standard weight, and no excess above the standard weight of more than the above percentages for the several sizes will be paid for. These variations apply only to castings made from the standard patterns.

### Quality of Iron

SECTION 8. All pipes and fittings shall be made of cast-iron of good quality, and of such character as shall make the metal of the castings strong, tough and of even grain, and soft enough to satisfactorily admit of drilling and cutting. The metal shall be made without any admixture of cinder iron or other inferior metal, and shall be remelted in a cupola or air furnace.

The contractor shall have the right to make and break three bars from each heat or run of metal, and the test shall be based upon the average results of the three bars.

Should the dimensions of the three bars differ from those given below, a proper allowance therefor shall be made in the results of the tests.

### Tests of Material

SECTION 9. Specimen bars of the metal used, each being 26 inches long by 2 inches wide and 1 inch thick, shall be made without charge as often as the engineer may direct, and in default of definite instructions, the contractor shall make and test at least one bar from each heat or run of metal. The bars, when placed flatwise upon supports 24 inches apart, and loaded in the center, shall support a load of 2,000 pounds, and show a deflection of not less than .30 of an inch before breaking; or if preferred, tensile bars shall be made which will show a breaking point of not less than 20,000 pounds per square inch.

### Casting of Pipe

SECTION 10. The straight pipes shall be cast in dry sand moulds in a vertical position. Pipes 16 inches or less in diameter shall be cast with the hub end up or down, as specified in the proposals. Pipes 18 inches or more in diameter shall be cast with the hub end down.

The pipes 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.

### Quality of Castings

SECTION 11. The pipes and fittings shall be smooth, free from scale, lumps, blisters, sand holes and 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 12. All pipes and fittings shall be thoroughly cleaned and subjected to a careful hammer inspection. No casting shall be coated unless entirely clean and free from rust, and approved in these respects by the engineer immediately before being dipped.

### Coating

SECTION 13. Every pipe and fitting shall be coated inside and out with coal-tar pitch varnish. The varnish shall be made from coal tar. To this material sufficient oil shall be added to make a smooth coating, tough and tenacious when cold, and not brittle nor with any tendency to scale off.

Each casting shall be heated to a temperature of 300 degrees Fahrenheit immediately before it is dipped, and shall possess not less than this temperature at the time it is put in the vat. The ovens in which the pipes are heated shall be so arranged that all portions of the pipe shall be heated to an even temperature. Each casting shall remain in the bath at least five minutes.

The varnish shall be heated to a temperature of 300 degrees Fahrenheit (or less if the engineer shall so order), and shall be maintained at this temperature during the time the casting is immersed.

Fresh pitch and oil shall be added when necessary to keep the mixture at the proper consistency, and the vat shall be emptied of its contents and refilled with fresh pitch when deemed necessary by the engineer. After

being coated the pipe shall be carefully drained of the surplus varnish. Any pipe or fitting that is to be recoated shall first be thoroughly scraped and cleaned.

### Hydrostatic Test

SECTION 14. When the coating has become hard, the straight pipes shall be subjected to a proof by hydrostatic pressure, and, if required by the engineer, they shall also be subjected to a hammer test under this pressure.

The pressure to which the different sizes and classes of pipes shall be subjected are as follows:

| | 20-Inch Diameter and Larger, Lbs. Per Square Inch | Less Than 20-Inch Diameter, Lbs. Per Square Inch |
|---|---|---|
| Class A Pipe | 150 | 300 |
| Class B Pipe | 200 | 300 |
| Class C Pipe | 250 | 300 |
| Class D Pipe | 300 | 300 |

### Weighing

SECTION 15. The pipes and fittings shall be weighed for payment under the supervision of the engineer after the application of the coal-tar pitch varnish. If desired by the engineer, the pipes and 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.

### Contractor to Furnish Men and Material

SECTION 16. The contractor shall provide all tools, testing machines, materials and men necessary for the

required testing, inspection and weighing at the foundry of the pipe and fittings; and should the purchaser have no inspector at the works, the contractor shall, if required by the engineer, furnish a sworn statement that all of the tests have been made as specified, this statement to contain the results of the tests upon the test bars.

### Power of Engineer to Inspect

SECTION 17. The engineer shall be at liberty at all times to inspect the material at the foundry, and the moldings, castings and coating of the pipes and fittings. The forms, sizes, uniformity and conditions of all pipes and other castings herein referred to shall be subject to his inspection and approval, and he may reject, without proving, any pipe or other casting which is not in conformity with the specifications or drawings.

### Inspector to Report

SECTION 18. The inspector at the foundry shall report daily to the foundry office all pipes and fittings rejected, with the causes for rejection.

### Castings to be Delivered Sound and Perfect

SECTION 19. All the pipes and other castings must be delivered in all respects sound and conformable to these specifications. The inspection shall not relieve the contractor of any of his obligations in this respect, and any defective pipes or other castings 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,

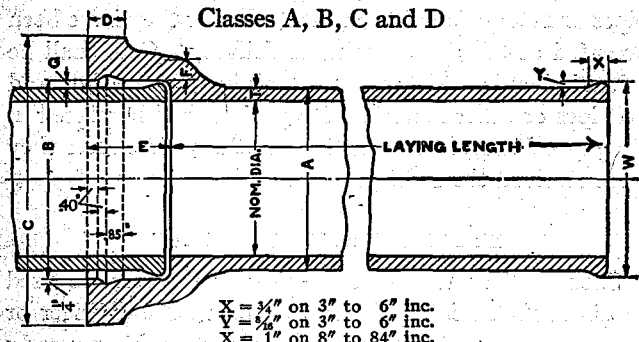
however, that the contractor shall not be held liable for pipes or fittings found to be cracked after they have been accepted at the agreed point of delivery. Care shall be taken in handling the pipes not to injure the coating, and no pipes or other material of any kind shall be placed in the pipes during transportation or at any time after they have received the coating.

### Definition of the Word "Engineer"

SECTION 20. 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.

## Dimensions of A. W. W. A. Standard Bell and Spigot Pipe

### Classes A, B, C and D




X = ¾″ on 3″ to 6″ inc.
Y = 5/16″ on 3″ to 6″ inc.
X = 1″ on 8″ to 84″ inc.
Y = ¼″ on 8″ to 84″ inc.

### Table No. 1

| Nominal Diameter Inches | Class | Dimensions, Inches | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | A | B | C | D | E | F | G | T | W |
| 3 | A | 3.80 | 4.60 | 7.20 | 1.25 | 3.50 | .65 | .40 | .39 | 4.18 |
| | B | 3.96 | 4.76 | 7.36 | 1.25 | 3.50 | .65 | .40 | .42 | 4.34 |
| | C | 3.96 | 4.76 | 7.36 | 1.25 | 3.50 | .65 | .40 | .45 | 4.34 |
| | D | 3.96 | 4.76 | 7.36 | 1.25 | 3.50 | .65 | .40 | .48 | 4.34 |
| 4 | A | 4.80 | 5.60 | 8.20 | 1.50 | 3.50 | .65 | .40 | .42 | 5.18 |
| | B | 5.00 | 5.80 | 8.40 | 1.50 | 3.50 | .65 | .40 | .45 | 5.38 |
| | C | 5.00 | 5.80 | 8.40 | 1.50 | 3.50 | .65 | .40 | .48 | 5.38 |
| | D | 5.00 | 5.80 | 8.40 | 1.50 | 3.50 | .65 | .40 | .52 | 5.38 |
| 6 | A | 6.90 | 7.70 | 10.50 | 1.50 | 3.50 | .70 | .40 | .44 | 7.28 |
| | B | 7.10 | 7.90 | 10.70 | 1.50 | 3.50 | .70 | .40 | .48 | 7.48 |
| | C | 7.10 | 7.90 | 10.70 | 1.50 | 3.50 | .70 | .40 | .51 | 7.48 |
| | D | 7.10 | 7.90 | 10.70 | 1.50 | 3.50 | .70 | .40 | .55 | 7.48 |
| 8 | A | 9.05 | 9.85 | 12.85 | 1.50 | 4.00 | .75 | .40 | .46 | 9.55 |
| | B | 9.05 | 9.85 | 12.85 | 1.50 | 4.00 | .75 | .40 | .51 | 9.55 |
| | C | 9.30 | 10.10 | 13.10 | 1.50 | 4.00 | .75 | .40 | .56 | 9.80 |
| | D | 9.30 | 10.10 | 13.10 | 1.50 | 4.00 | .75 | .40 | .60 | 9.80 |

Dimensions continued on next page.
For weights see pages 70 and 71.
For Classes E, F, G and H see pages 72 & 74.

Pipe listed in this Table can be furnished with plain ends for use with special couplings. For weights on plain end pipe see pages 145 and 146 under heading "weight per foot without flanges."

# Dimensions of A. W. W. A. Standard Bell and Spigot Pipe

## Classes A, B, C and D

## Table No. 1 (continued)

| Nominal Diameter Inches | Class | Dimensions, Inches | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | A | B | C | D | E | F | G | T | W |
| 10 | A | 11.10 | 11.90 | 14.90 | 1.50 | 4.00 | .75 | .40 | .50 | 11.60 |
| | B | 11.10 | 11.90 | 14.90 | 1.50 | 4.00 | .75 | .40 | .57 | 11.60 |
| | C | 11.40 | 12.20 | 15.40 | 1.50 | 4.00 | .80 | .40 | .62 | 11.90 |
| | D | 11.40 | 12.20 | 15.40 | 1.50 | 4.00 | .80 | .40 | .68 | 11.90 |
| 12 | A | 13.20 | 14.00 | 17.20 | 1.50 | 4.00 | .80 | .40 | .54 | 13.70 |
| | B | 13.20 | 14.00 | 17.20 | 1.50 | 4.00 | .80 | .40 | .62 | 13.70 |
| | C | 13.50 | 14.30 | 17.70 | 1.50 | 4.00 | .85 | .40 | .68 | 14.00 |
| | D | 13.50 | 14.30 | 17.70 | 1.50 | 4.00 | .85 | .40 | .75 | 14.00 |
| 14 | A | 15.30 | 16.10 | 19.50 | 1.50 | 4.00 | .85 | .40 | .57 | 15.80 |
| | B | 15.30 | 16.10 | 19.50 | 1.50 | 4.00 | .85 | .40 | .66 | 15.80 |
| | C | 15.65 | 16.45 | 20.05 | 1.50 | 4.00 | .90 | .40 | .74 | 16.15 |
| | D | 15.65 | 16.45 | 20.05 | 1.50 | 4.00 | .90 | .40 | .82 | 16.15 |
| 16 | A | 17.40 | 18.40 | 22.00 | 1.75 | 4.00 | .90 | .50 | .60 | 17.90 |
| | B | 17.40 | 18.40 | 22.00 | 1.75 | 4.00 | .90 | .50 | .70 | 17.90 |
| | C | 17.80 | 18.80 | 22.60 | 1.75 | 4.00 | 1.00 | .50 | .80 | 18.30 |
| | D | 17.80 | 18.80 | 22.60 | 1.75 | 4.00 | 1.00 | .50 | .89 | 18.30 |
| 18 | A | 19.50 | 20.50 | 24.30 | 1.75 | 4.00 | .95 | .50 | .64 | 20.00 |
| | B | 19.50 | 20.50 | 24.30 | 1.75 | 4.00 | .95 | .50 | .75 | 20.00 |
| | C | 19.92 | 20.92 | 25.12 | 1.75 | 4.00 | 1.05 | .50 | .87 | 20.42 |
| | D | 19.92 | 20.92 | 25.12 | 1.75 | 4.00 | 1.05 | .50 | .96 | 20.42 |
| 20 | A | 21.60 | 22.60 | 26.60 | 1.75 | 4.00 | 1.00 | .50 | .67 | 22.10 |
| | B | 21.60 | 22.60 | 26.60 | 1.75 | 4.00 | 1.00 | .50 | .80 | 22.10 |
| | C | 22.06 | 23.06 | 27.66 | 1.75 | 4.00 | 1.15 | .50 | .92 | 22.56 |
| | D | 22.06 | 23.06 | 27.66 | 1.75 | 4.00 | 1.15 | .50 | 1.03 | 22.56 |
| 24 | A | 25.80 | 26.80 | 31.00 | 2.00 | 4.00 | 1.05 | .50 | .76 | 26.30 |
| | B | 25.80 | 26.80 | 31.00 | 2.00 | 4.00 | 1.05 | .50 | .89 | 26.30 |
| | C | 26.32 | 27.32 | 32.32 | 2.00 | 4.00 | 1.25 | .50 | 1.04 | 26.82 |
| | D | 26.32 | 27.32 | 32.32 | 2.00 | 4.00 | 1.25 | .50 | 1.16 | 26.82 |
| 30 | A | 31.74 | 32.74 | 37.34 | 2.00 | 4.50 | 1.15 | .50 | .88 | 32.24 |
| | B | 32.00 | 33.00 | 37.60 | 2.00 | 4.50 | 1.15 | .50 | 1.03 | 32.50 |
| | C | 32.40 | 33.40 | 38.60 | 2.00 | 4.50 | 1.32 | .50 | 1.20 | 32.90 |
| | D | 32.74 | 33.74 | 39.74 | 2.00 | 4.50 | 1.50 | .50 | 1.37 | 33.24 |
| 36 | A | 37.96 | 38.96 | 43.96 | 2.00 | 4.50 | 1.25 | .50 | .99 | 38.46 |
| | B | 38.30 | 39.30 | 44.90 | 2.00 | 4.50 | 1.40 | .50 | 1.15 | 38.80 |
| | C | 38.70 | 39.70 | 45.90 | 2.00 | 4.50 | 1.60 | .50 | 1.36 | 39.20 |
| | D | 39.16 | 40.16 | 46.96 | 2.00 | 4.50 | 1.80 | .50 | 1.58 | 39.66 |

Dimensions continued on next page.

See notes on preceding page.

# Dimensions of A. W. W. A. Standard Bell and Spigot Pipe

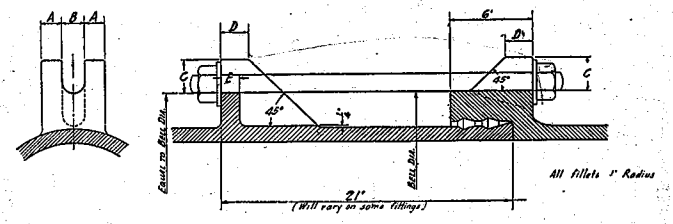
## Classes A, B, C and D

## Table No. 1 (continued)

| Nominal Diameter Inches | Class | Dimensions, Inches | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | A | B | C | D | E | F | G | T | W |
| 42 | A | 44.20 | 45.20 | 50.80 | 2.00 | 5.00 | 1.40 | .50 | 1.10 | 44.70 |
| | B | 44.50 | 45.50 | 51.50 | 2.00 | 5.00 | 1.50 | .50 | 1.28 | 45.00 |
| | C | 45.10 | 46.10 | 52.90 | 2.00 | 5.00 | 1.75 | .50 | 1.54 | 45.60 |
| | D | 45.58 | 46.58 | 54.18 | 2.00 | 5.00 | 1.95 | .50 | 1.78 | 46.08 |
| 48 | A | 50.50 | 51.50 | 57.50 | 2.00 | 5.00 | 1.50 | .50 | 1.26 | 51.00 |
| | B | 50.80 | 51.80 | 58.40 | 2.00 | 5.00 | 1.65 | .50 | 1.42 | 51.30 |
| | C | 51.40 | 52.40 | 60.00 | 2.00 | 5.00 | 1.95 | .50 | 1.71 | 51.90 |
| | D | 51.98 | 52.98 | 61.38 | 2.00 | 5.00 | 2.20 | .50 | 1.96 | 52.48 |
| 54 | A | 56.66 | 57.66 | 64.06 | 2.25 | 5.50 | 1.60 | .50 | 1.35 | 57.16 |
| | B | 57.10 | 58.10 | 65.30 | 2.25 | 5.50 | 1.80 | .50 | 1.55 | 57.60 |
| | C | 57.80 | 58.80 | 66.80 | 2.25 | 5.50 | 2.15 | .50 | 1.90 | 58.30 |
| | D | 58.40 | 59.40 | 68.20 | 2.25 | 5.50 | 2.45 | .50 | 2.23 | 58.90 |
| 60 | A | 62.80 | 63.80 | 70.60 | 2.25 | 5.50 | 1.70 | .50 | 1.39 | 63.30 |
| | B | 63.40 | 64.40 | 71.80 | 2.25 | 5.50 | 1.90 | .50 | 1.67 | 63.90 |
| | C | 64.20 | 65.20 | 73.60 | 2.25 | 5.50 | 2.25 | .50 | 2.00 | 64.70 |
| | D | 64.82 | 65.82 | 75.22 | 2.25 | 5.50 | 2.60 | .50 | 2.38 | 65.32 |
| 72 | A | 75.34 | 76.59 | 84.19 | 2.25 | 5.50 | 1.87 | .63 | 1.62 | 75.84 |
| | B | 76.00 | 77.25 | 85.65 | 2.25 | 5.50 | 2.20 | .63 | 1.95 | 76.50 |
| | C | 76.88 | 78.13 | 87.33 | 2.25 | 5.50 | 2.64 | .63 | 2.39 | 77.38 |
| | D | 77.74 | 78.99 | 89.09 | 2.25 | 5.50 | 3.09 | .63 | 2.82 | 78.24 |
| 84 | A | 87.54 | 88.79 | 96.99 | 2.50 | 5.50 | 2.10 | .63 | 1.72 | 88.04 |
| | B | 88.54 | 89.79 | 98.79 | 2.50 | 5.50 | 2.60 | .63 | 2.22 | 89.04 |
| | C | 89.58 | 90.83 | 100.83 | 2.50 | 5.50 | 3.12 | .63 | 2.74 | 90.08 |
| | D | 90.58 | 91.83 | 102.83 | 2.50 | 5.50 | 3.62 | .63 | 3.21 | 91.08 |

See notes on page 66.

# Lugs for High Pressure Bell and Spigot Pipe and Fittings Classes E to H




## Table No. 2-A

| Nominal Dia. | Class | Bell Dia. | No. of Lugs | Dimensions A | B | C | D | E | Size of Bolts Dia. | L'th | Weight of Lugs, Lbs. One Bell | One Spigot |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 6 | EF | 11.52 | | | | | | | | | | |
| | GH | 11.88 | 4 | 1.50 | 1.25 | 2.25 | 1.50 | .88 | 1 | 26 | 34 | 68 |
| 8 | EF | 13.92 | | | | | | | | | | |
| | GH | 14.30 | 4 | 1.50 | 1.25 | 2.25 | 1.50 | 1.00 | 1 | 26 | 34 | 70 |
| 10 | EF | 16.30 | | | | | | | | | | |
| | GH | 16.74 | 4 | 1.50 | 1.50 | 2.50 | 2.00 | 1.19 | 1¼ | 27 | 36 | 83 |
| 12 | EF | 18.68 | | | | | | | | | | |
| | GH | 19.28 | 4 | 1.50 | 1.63 | 2.50 | 2.00 | 1.38 | 1⅜ | 27 | 38 | 88 |
| 14 | EF | 21.08 | | | | | | | | | | |
| | GH | 21.82 | 6 | 1.50 | 1.63 | 2.50 | 2.00 | 1.50 | 1⅜ | 27 | 55 | 135 |
| 16 | EF | 23.56 | | | | | | | | | | |
| | GH | 24.44 | 6 | 1.50 | 1.63 | 2.50 | 2.25 | 1.63 | 1⅜ | 27 | 56 | 141 |
| 18 | EF | 26.04 | | | | | | | | | | |
| | GH | 27.08 | 6 | 1.62 | 1.75 | 3.00 | 2.25 | 1.88 | 1½ | 28 | 72 | 198 |
| 20 | EF | 28.44 | | | | | | | | | | |
| | GH | 29.52 | 6 | 1.62 | 1.75 | 3.00 | 2.50 | 2.00 | 1½ | 28 | 73 | 200 |
| 24 | EF | 33.40 | | | | | | | | | | |
| | GH | 34.86 | 6 | 1.75 | 2.00 | 3.25 | 2.75 | 2.00 | 1¾ | 28 | 89 | 240 |
| 30 | E | 40.60 | | | | | | | | | | |
| | F | 41.46 | 8 | 1.75 | 2.00 | 3.25 | 2.75 | 2.00 | 1¾ | 28 | 121 | 371 |
| 36 | E | 48.00 | | | | | | | | | | |
| | F | 49.04 | 12 | 1.75 | 2.00 | 3.25 | 2.75 | 2.25 | 1¾ | 28 | 191 | 613 |

Dimension 21 inches in above cut is for pipe; this dimension varies for fittings.
Two lugs are placed on the vertical axis of each bell, the others at equal distances around circumference.
Dimensions in inches.
Weights given in pounds. All weights approximate.
Pipe furnished with lugs only when specifically ordered.

# Weights of A. W. W. A. Standard Bell and Spigot Cast Iron Pipe Classes A and B—Table No. 3




| Nominal Inside Diameter, Inches | Class A—100-Foot Head 43 Pounds Pressure | | | | | | | Class B—200-Foot Head 86 Pounds Pressure | | | | | | | Approximate Pounds Lead per Joint 2 Inches Thick | Approximate Pounds Hemp per Joint | Nominal Inside Diameter, Inches |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Thickness, Inches | Weight of 12-Foot Length Pounds Per | | Weight of 16-Foot Length Pounds Per | | Weight of 5-Meter Length Pounds Per | | Thickness, Inches | Weight of 12-Foot Length Pounds Per | | Weight of 16-Foot Length Pounds Per | | Weight of 5-Meter Length Pounds Per | | | | |
| | | Foot | Length | Foot | L'gth | Foot | L'gth | | Foot | Length | Foot | L'gth | Foot | L'gth | | | |
| 3 | .39 | 14.5 | 175 | .... | .... | .... | .... | .42 | 16.2 | 194 | .... | .... | .... | .... | 6.00 | .18 | 3 |
| 4 | .42 | 20.0 | 240 | 19.7 | 315 | 19.3 | 325 | .45 | 21.7 | 260 | 21.2 | 340 | 21.3 | 350 | 7.50 | .21 | 4 |
| 6 | .44 | 30.8 | 370 | 30.3 | 485 | 30.0 | 493 | .48 | 33.3 | 400 | 32.5 | 520 | 32.5 | 533 | 10.25 | .31 | 6 |
| 8 | .46 | 42.9 | 515 | 42.2 | 675 | 41.8 | 686 | .51 | 47.5 | 570 | 46.6 | 745 | 46.2 | 758 | 13.25 | .44 | 8 |
| 10 | .50 | 57.1 | 685 | 55.9 | 895 | 55.7 | 914 | .57 | 63.8 | 765 | 62.5 | 1000 | 62.4 | 1024 | 16.00 | .53 | 10 |
| 12 | .54 | 72.5 | 870 | 71.2 | 1140 | 71.0 | 1165 | .62 | 82.1 | 985 | 80.6 | 1290 | 80.5 | 1321 | 19.00 | .61 | 12 |
| 14 | .57 | 89.6 | 1075 | .... | .... | .... | .... | .66 | 102.5 | 1230 | .... | .... | .... | .... | 22.00 | .81 | 14 |
| 16 | .60 | 108.3 | 1300 | .... | .... | .... | .... | .70 | 125.0 | 1500 | .... | .... | .... | .... | 30.00 | .94 | 16 |
| 18 | .64 | 129.2 | 1550 | .... | .... | .... | .... | .75 | 150.0 | 1800 | .... | .... | .... | .... | 33.80 | 1.00 | 18 |
| 20 | .67 | 150.0 | 1800 | .... | .... | .... | .... | .80 | 175.0 | 2100 | .... | .... | .... | .... | 37.00 | 1.25 | 20 |
| 24 | .76 | 204.2 | 2450 | .... | .... | .... | .... | .89 | 233.3 | 2800 | .... | .... | .... | .... | 44.00 | 1.50 | 24 |
| 30 | .88 | 291.7 | 3500 | .... | .... | .... | .... | 1.03 | 333.3 | 4000 | .... | .... | .... | .... | 54.25 | 2.06 | 30 |
| 36 | .99 | 391.7 | 4700 | .... | .... | .... | .... | 1.15 | 454.2 | 5450 | .... | .... | .... | .... | 64.75 | 3.00 | 36 |
| 42 | 1.10 | 512.5 | 6150 | .... | .... | .... | .... | 1.28 | 591.7 | 7100 | .... | .... | .... | .... | 75.25 | 3.62 | 42 |
| 48 | 1.26 | 666.7 | 8000 | .... | .... | .... | .... | 1.42 | 750.0 | 9000 | .... | .... | .... | .... | 85.50 | 4.37 | 48 |
| 54 | 1.35 | 800.0 | 9600 | .... | .... | .... | .... | 1.55 | 933.3 | 11200 | .... | .... | .... | .... | 97.60 | 6.25 | 54 |
| 60 | 1.39 | 916.7 | 11000 | .... | .... | .... | .... | 1.67 | 1104.2 | 13250 | .... | .... | .... | .... | 108.30 | 8.25 | 60 |
| 72 | 1.67 | 1281.9 | 15380 | .... | .... | .... | .... | 1.95 | 1547.3 | 18570 | .... | .... | .... | .... | 146.00 | 12.50 | 72 |
| 84 | 1.72 | 1635.8 | 19630 | .... | .... | .... | .... | 2.22 | 2104.1 | 25250 | .... | .... | .... | .... | 170.00 | 15.00 | 84 |

All weights are approximate; those per foot include allowance for bell; those per length include standard bells; proportionate allowance to be made for any variation from the standard length.

All pipe are tested by water pressure, as per Section 14 of Standard Specifications.

The difference in weight per foot of 12-foot and 16-foot or 5-meter lengths is due to the weight of the bell being spread over longer lengths.

For dimensions see Table No. 1.

5 meter pipe is 16 feet 4 7/8 inches long.

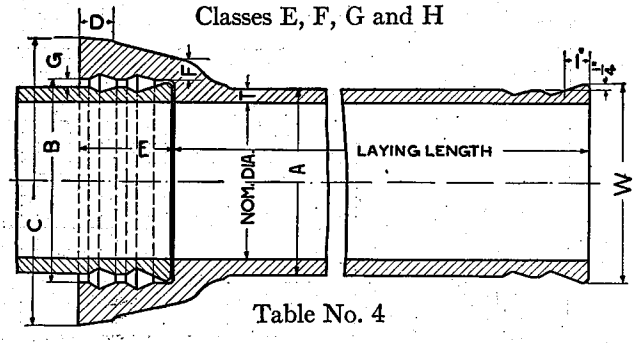
# Weights of A. W. W. A. Standard Bell and Spigot Cast Iron Pipe Classes C and D Table No. 3 (continued)

| Nominal Inside Diameter, Inches | Class C—300-Foot Head 130 Pounds Pressure | | | | | | | Class D—400-Foot Head 173 Pounds Pressure | | | | | | | Approximate Pounds Lead per Joint 2 Inches Thick | Approximate Pounds Hemp per Joint | Nominal Inside Diameter, Inches |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Thickness, Inches | Weight of 12-Foot Length Pounds Per | | Weight of 16-Foot Length Pounds Per | | Weight of 5-Meter Length Pounds Per | | Thickness, Inches | Weight of 12-Foot Length Pounds Per | | Weight of 16-Foot Length Pounds Per | | Weight of 5-Meter Length Pounds Per | | | | |
| | | Foot | Length | Foot | L'gth | Foot | L'gth | | Foot | Length | Foot | L'gth | Foot | L'gth | | | |
| 3 | .45 | 17.1 | 205 | .... | .... | .... | .... | .48 | 18.0 | 216 | .... | .... | .... | .... | 6.00 | .18 | 3 |
| 4 | .48 | 23.3 | 280 | 22.8 | 365 | 22.8 | 375 | .52 | 25.0 | 300 | 24.4 | 390 | 24.4 | 400 | 7.50 | .21 | 4 |
| 6 | .51 | 35.8 | 430 | 35.0 | 560 | 34.9 | 573 | .55 | 38.3 | 460 | 37.5 | 600 | 37.4 | 614 | 10.25 | .31 | 6 |
| 8 | .56 | 52.1 | 625 | 50.9 | 815 | 50.9 | 835 | .60 | 55.8 | 670 | 54.7 | 875 | 54.6 | 896 | 13.25 | .44 | 8 |
| 10 | .62 | 70.8 | 850 | 69.4 | 1110 | 69.3 | 1137 | .68 | 76.7 | 920 | 75.3 | 1205 | 75.2 | 1234 | 16.00 | .53 | 10 |
| 12 | .68 | 91.7 | 1100 | 90.0 | 1440 | 89.9 | 1475 | .75 | 100.0 | 1200 | 98.4 | 1575 | 98.3 | 1613 | 19.00 | .61 | 12 |
| 14 | .74 | 116.7 | 1400 | .... | .... | .... | .... | .82 | 129.2 | 1550 | .... | .... | .... | .... | 22.00 | .81 | 14 |
| 16 | .80 | 143.8 | 1725 | .... | .... | .... | .... | .89 | 158.3 | 1900 | .... | .... | .... | .... | 30.00 | .94 | 16 |
| 18 | .87 | 175.0 | 2100 | .... | .... | .... | .... | .96 | 191.7 | 2300 | .... | .... | .... | .... | 33.80 | 1.00 | 18 |
| 20 | .92 | 208.3 | 2500 | .... | .... | .... | .... | 1.03 | 229.2 | 2750 | .... | .... | .... | .... | 37.00 | 1.25 | 20 |
| 24 | 1.04 | 279.2 | 3350 | .... | .... | .... | .... | 1.16 | 306.7 | 3680 | .... | .... | .... | .... | 44.00 | 1.50 | 24 |
| 30 | 1.20 | 400.0 | 4800 | .... | .... | .... | .... | 1.37 | 450.0 | 5400 | .... | .... | .... | .... | 54.25 | 2.06 | 30 |
| 36 | 1.36 | 545.8 | 6550 | .... | .... | .... | .... | 1.58 | 625.0 | 7500 | .... | .... | .... | .... | 64.75 | 3.00 | 36 |
| 42 | 1.54 | 716.7 | 8600 | .... | .... | .... | .... | 1.78 | 825.0 | 9900 | .... | .... | .... | .... | 75.25 | 3.62 | 42 |
| 48 | 1.71 | 908.3 | 10900 | .... | .... | .... | .... | 1.96 | 1050.0 | 12600 | .... | .... | .... | .... | 85.50 | 4.37 | 48 |
| 54 | 1.90 | 1141.7 | 13700 | .... | .... | .... | .... | 2.23 | 1341.7 | 16100 | .... | .... | .... | .... | 97.60 | 6.25 | 54 |
| 60 | 2.00 | 1341.7 | 16100 | .... | .... | .... | .... | 2.38 | 1583.3 | 19000 | .... | .... | .... | .... | 108.30 | 8.25 | 60 |
| 72 | 2.39 | 1904.3 | 22850 | .... | .... | .... | .... | 2.82 | 2246.9 | 27187 | .... | .... | .... | .... | 146.00 | 12.50 | 72 |
| 84 | 2.74 | 2584.4 | 31165 | .... | .... | .... | .... | 3.24 | 3084.6 | 37023 | .... | .... | .... | .... | 170.00 | 15.00 | 84 |

For notes see preceding page.

## Dimensions of A. W. W. A. Standard Bell and Spigot Pipe

### Classes E, F, G and H




### Table No. 4

| Nominal Diameter Inches | Class | Dimensions, Inches | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | A | B | C | D | E | F | G | T | W |
| 6 | E | 7.22 | 8.02 | 11.52 | 1.50 | 4.00 | .75 | .40 | .58 | 7.72 |
| | F | 7.22 | 8.02 | 11.52 | 1.50 | 4.00 | .75 | .40 | .61 | 7.72 |
| | G | 7.38 | 8.18 | 11.88 | 1.50 | 4.00 | .85 | .40 | .65 | 7.88 |
| | H | 7.38 | 8.18 | 11.88 | 1.50 | 4.00 | .85 | .40 | .69 | 7.88 |
| 8 | E | 9.42 | 10.22 | 13.92 | 1.50 | 4.00 | .85 | .40 | .66 | 9.92 |
| | F | 9.42 | 10.22 | 13.92 | 1.50 | 4.00 | .85 | .40 | .71 | 9.92 |
| | G | 9.60 | 10.40 | 14.30 | 1.50 | 4.00 | .95 | .40 | .75 | 10.10 |
| | H | 9.60 | 10.40 | 14.30 | 1.50 | 4.00 | .95 | .40 | .80 | 10.10 |
| 10 | E | 11.60 | 12.40 | 16.30 | 1.75 | 4.50 | .95 | .40 | .74 | 12.10 |
| | F | 11.60 | 12.40 | 16.30 | 1.75 | 4.50 | .95 | .40 | .80 | 12.10 |
| | G | 11.84 | 12.64 | 16.74 | 1.75 | 4.50 | 1.05 | .40 | .86 | 12.34 |
| | H | 11.84 | 12.64 | 16.74 | 1.75 | 4.50 | 1.05 | .40 | .92 | 12.34 |
| 12 | E | 13.78 | 14.58 | 18.68 | 1.75 | 4.50 | 1.05 | .40 | .82 | 14.28 |
| | F | 13.78 | 14.58 | 18.68 | 1.75 | 4.50 | 1.05 | .40 | .89 | 14.28 |
| | G | 14.08 | 14.88 | 19.28 | 1.75 | 4.50 | 1.20 | .40 | .97 | 14.58 |
| | H | 14.08 | 14.88 | 19.28 | 1.75 | 4.50 | 1.20 | .40 | 1.04 | 14.58 |
| 14 | E | 15.98 | 16.78 | 21.08 | 2.00 | 4.50 | 1.15 | .40 | .90 | 16.48 |
| | F | 15.98 | 16.78 | 21.08 | 2.00 | 4.50 | 1.15 | .40 | .99 | 16.48 |
| | G | 16.32 | 17.12 | 21.82 | 2.00 | 4.50 | 1.35 | .40 | 1.07 | 16.82 |
| | H | 16.32 | 17.12 | 21.82 | 2.00 | 4.50 | 1.35 | .40 | 1.16 | 16.82 |

For weights, see page 74.

Can be furnished with single lead groove if desired. For dimensions, see Table No. 1.

# Dimensions of A. W. W. A. Standard Bell and Spigot Pipe Classes E, F, G and H

## Table No. 4 (continued)

| Nominal Diameter Inches | Class | Dimensions, Inches | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | A | B | C | D | E | F | G | T | W |
| 16 | E | 18.16 | 18.96 | 23.56 | 2.00 | 4.50 | 1.25 | .40 | .98 | 18.66 |
| | F | 18.16 | 18.96 | 23.56 | 2.00 | 4.50 | 1.25 | .40 | 1.08 | 18.66 |
| | G | 18.54 | 19.34 | 24.44 | 2.00 | 4.50 | 1.45 | .40 | 1.18 | 19.04 |
| | H | 18.54 | 19.34 | 24.44 | 2.00 | 4.50 | 1.45 | .40 | 1.27 | 19.04 |
| 18 | E | 20.34 | 21.14 | 26.04 | 2.25 | 4.50 | 1.40 | .40 | 1.07 | 20.84 |
| | F | 20.34 | 21.14 | 26.04 | 2.25 | 4.50 | 1.40 | .40 | 1.17 | 20.84 |
| | G | 20.78 | 21.58 | 27.08 | 2.25 | 4.50 | 1.65 | .40 | 1.28 | 21.28 |
| | H | 20.78 | 21.58 | 27.08 | 2.25 | 4.50 | 1.65 | .40 | 1.39 | 21.28 |
| 20 | E | 22.54 | 23.34 | 28.44 | 2.25 | 4.50 | 1.50 | .40 | 1.15 | 23.04 |
| | F | 22.54 | 23.34 | 28.44 | 2.25 | 4.50 | 1.50 | .40 | 1.27 | 23.04 |
| | G | 23.02 | 23.82 | 29.52 | 2.25 | 4.50 | 1.75 | .40 | 1.39 | 23.52 |
| | H | 23.02 | 23.82 | 29.52 | 2.25 | 4.50 | 1.75 | .40 | 1.51 | 23.52 |
| 24 | E | 26.90 | 27.90 | 33.40 | 2.25 | 5.00 | 1.70 | .50 | 1.31 | 27.40 |
| | F | 26.90 | 27.90 | 33.40 | 2.25 | 5.00 | 1.70 | .50 | 1.45 | 27.40 |
| | G | 27.76 | 28.56 | 34.86 | 2.25 | 5.00 | 1.95 | .50 | 1.75 | 28.26 |
| | H | 27.76 | 28.56 | 34.86 | 2.25 | 5.00 | 1.95 | .50 | 1.88 | 28.26 |
| 30 | E | 33.10 | 34.10 | 40.60 | 2.25 | 5.00 | 1.80 | .50 | 1.55 | 33.60 |
| | F | 33.46 | 34.46 | 41.46 | 2.25 | 5.00 | 2.00 | .50 | 1.73 | 33.96 |
| 36 | E | 39.60 | 40.60 | 48.00 | 2.25 | 5.00 | 2.05 | .50 | 1.80 | 40.10 |
| | F | 40.04 | 41.04 | 49.04 | 2.25 | 5.00 | 2.30 | .50 | 2.02 | 40.54 |

For weights, see page 74.

Can be furnished with single lead groove if desired. For dimensions, see Table No. 1.

# Weights of A. W. W. A. Standard Bell and Spigot Cast Iron Pipe Classes E, F, G and H

Table No. 5



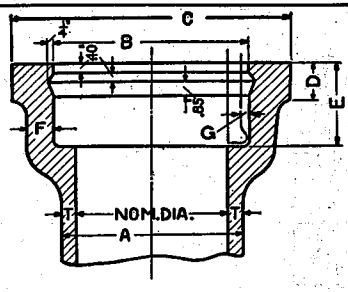

| Nominal Inside Diameter, Inches | Class E 500-Foot Head 217 Pounds Pressure | | | Class F 600-Foot Head 260 Pounds Pressure | | | Class G 700-Foot Head 304 Pounds Pressure | | | Class H 800-Foot Head 347 Pounds Pressure | | | Approximate Pounds of Lead per Joint | Approximate Pounds of Hemp per Joint | Nominal Inside Diameter, Inches |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Thickness, Inches | Weight, Pounds per | | Thickness, Inches | Weight, Pounds per | | Thickness, Inches | Weight, Pounds per | | Thickness, Inches | Weight, Pounds per | | | | |
| | | Foot | 12-Foot Length | | Foot | 12-Foot Length | | Foot | 12-Foot Length | | Foot | 12-Foot Length | | | |
| 6 | .58 | 42.5 | 510 | .61 | 44.3 | 531 | .65 | 48.1 | 577 | .69 | 50.5 | 606 | 21.9 | .22 | 6 |
| 8 | .66 | 60.9 | 731 | .71 | 66.8 | 802 | .75 | 72.3 | 868 | .80 | 76.1 | 913 | 28.2 | .28 | 8 |
| 10 | .74 | 86.9 | 1043 | .80 | 92.8 | 1114 | .86 | 101.4 | 1217 | .92 | 107.3 | 1288 | 34.5 | .34 | 10 |
| 12 | .82 | 114.6 | 1375 | .89 | 122.8 | 1474 | .97 | 136.2 | 1634 | 1.04 | 144.4 | 1733 | 40.8 | .40 | 12 |
| 14 | .90 | 145.6 | 1747 | .99 | 158.8 | 1905 | 1.07 | 175.1 | 2101 | 1.16 | 187.5 | 2250 | 47.1 | .46 | 14 |
| 16 | .98 | 180.7 | 2168 | 1.08 | 196.5 | 2358 | 1.18 | 218.0 | 2616 | 1.27 | 233.8 | 2805 | 53.4 | .52 | 16 |
| 18 | 1.07 | 221.8 | 2662 | 1.17 | 239.3 | 2872 | 1.28 | 268.2 | 3218 | 1.39 | 287.8 | 3453 | 59.7 | .57 | 18 |
| 20 | 1.15 | 265.8 | 3190 | 1.27 | 287.3 | 3448 | 1.39 | 321.8 | 3862 | 1.51 | 345.8 | 4149 | 66.0 | .65 | 20 |
| 24 | 1.31 | 359.1 | 4309 | 1.45 | 392.3 | 4707 | 1.75 | 479.8 | 5758 | 1.88 | 510.6 | 6127 | 79.4 | .78 | 24 |
| 30 | 1.55 | 530.9 | 6371 | 1.73 | 588.8 | 7065 | .... | ..... | .... | ..... | ..... | .... | 122.9 | .93 | 30 |
| 36 | 1.80 | 738.1 | 8857 | 2.02 | 821.0 | 9852 | .... | ..... | .... | ..... | ..... | .... | 146.7 | 1.11 | 36 |

All weights are approximate; those per foot include allowance for bell; those per length include standard sockets; proportionate allowance to be made for any variation from the standard length. The above classes of pipe are tested by water pressure to 500 pounds per square inch.

For dimensions, see Table No. 4.

## STANDARD A. W. W. A. BELL & SPIGOT FITTINGS

### Dimensions of Bells for A. W. W. A. Standard Fittings




### Table No. 6

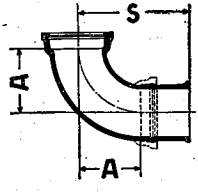
| Nominal Diameter Inches | Classes | Dimensions, Inches | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | A | B | C | D | E | F | G | T |
| 3 | D | 3.96 | 4.66 | 7.26 | 1.25 | 3.50 | .65 | .35 | .48 |
| 4 | D | 5.00 | 5.70 | 8.30 | 1.50 | 4.00 | .65 | .35 | .52 |
| 6 | D | 7.10 | 7.80 | 10.60 | 1.50 | 4.00 | .70 | .35 | .55 |
| 8 | D | 9.30 | 10.00 | 13.00 | 1.50 | 4.00 | .75 | .35 | .60 |
| 10 | D | 11.40 | 12.10 | 15.30 | 1.50 | 4.00 | .80 | .35 | .68 |
| 12 | D | 13.50 | 14.20 | 17.60 | 1.50 | 4.00 | .85 | .35 | .75 |
| 14 | B | 15.30 | 16.10 | 19.50 | 1.50 | 4.00 | .85 | .40 | .66 |
| 14 | D | 15.65 | 16.45 | 20.05 | 1.50 | 4.00 | .90 | .40 | .82 |
| 16 | B | 17.40 | 18.40 | 22.00 | 1.75 | 4.00 | .90 | .50 | .70 |
| 16 | D | 17.80 | 18.80 | 22.60 | 1.75 | 4.00 | 1.00 | .50 | .89 |
| 18 | B | 19.50 | 20.50 | 24.30 | 1.75 | 4.00 | .95 | .50 | .75 |
| 18 | D | 19.92 | 20.92 | 25.12 | 1.75 | 4.00 | 1.05 | .50 | .96 |
| 20 | B | 21.60 | 22.60 | 26.60 | 1.75 | 4.00 | 1.00 | .50 | .80 |
| 20 | D | 22.06 | 23.06 | 27.66 | 1.75 | 4.00 | 1.15 | .50 | 1.03 |
| 24 | B | 25.80 | 26.80 | 31.00 | 2.00 | 4.00 | 1.05 | .50 | .89 |
| 24 | D | 26.32 | 27.32 | 32.32 | 2.00 | 4.00 | 1.25 | .50 | 1.16 |
| 30 | A | 31.74 | 32.74 | 37.34 | 2.00 | 4.50 | 1.15 | .50 | .88 |
| 30 | B | 32.00 | 33.00 | 37.60 | 2.00 | 4.50 | 1.15 | .50 | 1.03 |
| 30 | C | 32.40 | 33.40 | 38.60 | 2.00 | 4.50 | 1.32 | .50 | 1.20 |
| 30 | D | 32.74 | 33.74 | 39.74 | 2.00 | 4.50 | 1.50 | .50 | 1.37 |

| Nom. Dia. Inches | Class | Dimensions, Inches | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | A | B | C | D | E | F | G | T |
| 72 | A | 75.34 | 76.59 | 84.19 | 2.25 | 5.50 | 1.87 | .63 | 1.62 |
| 72 | B | 76.00 | 77.25 | 85.65 | 2.25 | 5.50 | 2.20 | .63 | 1.95 |
| 72 | C | 76.88 | 78.13 | 87.33 | 2.25 | 5.50 | 2.64 | .63 | 2.39 |
| 72 | D | 77.74 | 78.99 | 88.99 | 2.25 | 5.50 | 3.07 | .63 | 2.82 |
| 84 | A | 87.54 | 88.79 | 96.99 | 2.50 | 5.50 | 2.10 | .63 | 1.72 |
| 84 | B | 88.54 | 89.79 | 98.79 | 2.50 | 5.50 | 2.60 | .63 | 2.22 |
| 84 | C | 89.58 | 90.83 | 100.83 | 2.50 | 5.50 | 3.12 | .63 | 2.74 |
| 84 | D | 90.58 | 91.83 | 102.83 | 2.50 | 5.50 | 3.62 | .63 | 3.24 |

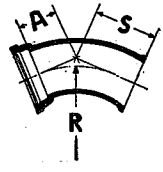
# Laying Dimensions of A. W. W. A. Standard Bell and Spigot Bends

## (All Classes)

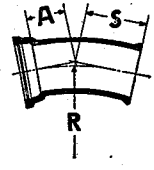
¼ Bend (90°)

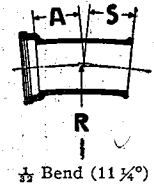



⅛ Bend (45°)

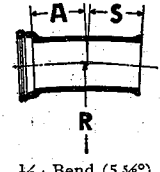



1/16 Bend (22 ½°)




1/32 Bend (11 ¼°)




1/64 Bend (5 5/8°)

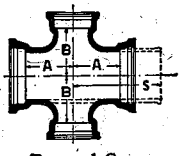
## Table No. 7

| Size | 90° Bend (¼) | | 45° Bend (⅛) | | | 22 ½° Bend (1/16) | | | 11 ¼° Bend (1/32) | | | 5 5/8° Bend (1/64) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | A | S | A | S | R | A | S | R | A | S | R | A | S | R |
| 3 | 16 | 24 | 9.94 | 15.94 | 24 | 9.55 | 15.55 | 48 | 11.82 | 11.82 | 120 | ..... | ..... | ... |
| 4 | 16 | 24 | 9.94 | 15.94 | 24 | 9.55 | 15.55 | 48 | 11.82 | 11.82 | 120 | ..... | ..... | ... |
| 6 | 16 | 24 | 9.94 | 15.94 | 24 | 9.55 | 15.55 | 48 | 11.82 | 11.82 | 120 | ..... | ..... | ... |
| 8 | 16 | 26 | 9.94 | 15.94 | 24 | 9.55 | 15.55 | 48 | 11.82 | 11.82 | 120 | ..... | ..... | ... |
| 10 | 16 | 28 | 9.94 | 15.94 | 24 | 9.55 | 15.55 | 48 | 11.82 | 11.82 | 120 | ..... | ..... | ... |
| 12 | 16 | 28 | 9.94 | 15.94 | 24 | 9.55 | 15.55 | 48 | 11.82 | 11.82 | 120 | ..... | ..... | ... |
| 14 | 18 | 30 | 14.91 | 20.91 | 36 | 14.32 | 14.32 | 72 | 17.73 | 17.73 | 180 | ..... | ..... | ... |
| 16 | 24 | 36 | 14.91 | 20.91 | 36 | 14.32 | 14.32 | 72 | 17.73 | 17.73 | 180 | ..... | ..... | ... |
| 18 | 24 | 36 | 14.91 | 20.91 | 36 | 14.32 | 14.32 | 72 | 17.73 | 17.73 | 180 | ..... | ..... | ... |
| 20 | 24 | 36 | 19.88 | 25.88 | 48 | 19.10 | 19.10 | 96 | 23.64 | 23.64 | 240 | 23.58 | 23.58 | 480 |
| 24 | 30 | 42 | 24.85 | 30.85 | 60 | 23.87 | 23.87 | 120 | 23.64 | 23.64 | 240 | 23.58 | 23.58 | 480 |
| 30 | 36 | 48 | 24.85 | 30.85 | 60 | 23.87 | 23.87 | 120 | 23.64 | 23.64 | 240 | 23.58 | 23.58 | 480 |
| 36 | 48 | 60 | 37.28 | 37.28 | 90 | 35.80 | 35.80 | 180 | 23.64 | 23.64 | 240 | 23.58 | 23.58 | 480 |
| 42 | 48 | 60 | 37.28 | 37.28 | 90 | 35.80 | 35.80 | 180 | 23.64 | 23.64 | 240 | 23.58 | 23.58 | 480 |
| 48 | 54 | 66 | 37.28 | 37.28 | 90 | 35.80 | 35.80 | 180 | 23.64 | 23.64 | 240 | 23.58 | 23.58 | 480 |
| 54 | .. | .. | 37.28 | 37.28 | 90 | 35.80 | 35.80 | 180 | 23.64 | 23.64 | 240 | 23.58 | 23.58 | 480 |
| 60 | .. | .. | 37.28 | 37.28 | 90 | 35.80 | 35.80 | 180 | 23.64 | 23.64 | 240 | 23.58 | 23.58 | 480 |

Dimensions in inches.
For Bell Dimensions see page 75.
For weights see page 88. 89

# Laying Dimensions of A. W. W. A. Standard Bell and Spigot Tees and Crosses

## (All Classes)




Tee and Cross

## Table No. 8

| Size | A | B | S | Size | A | B | S | Size | A | B | S |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 3 | 10 | 10 | 22 | 36x 8 | 14 | 27 | 26 | 48x16 | 19 | 35 | 31 |
| 4 | 11 | 11 | 23 | 36x10 | 15 | 27 | 27 | 48x18 | 20 | 35 | 34 |
| 6 | 12 | 12 | 24 | 36x12 | 16 | 27 | 28 | 48x20 | 21 | 35 | 36 |
| 8 | 13 | 13 | 25 | 36x14 | 18 | 29 | 30 | 48x24 | 23 | 35 | 38 |
| 10 | 14 | 14 | 26 | 36x16 | 19 | 29 | 31 | 48x30 | 26 | 35 | 43 |
| 12 | 15 | 15 | 27 | 36x18 | 20 | 29 | 34 | 48x36 | 29 | 35 | 46 |
| 14 | 16 | 16 | 28 | 36x20 | 21 | 29 | 36 | 48x42 | 32 | 35 | 49 |
| 16 | 17 | 17 | 29 | 36x24 | 23 | 29 | 38 | 48x48 | 35 | 35 | 52 |
| 18 | 18 | 18 | 30 | 36x30 | 26 | 29 | 43 | 54x20 | 28 | 38.5 | 46 |
| 20 | 19 | 19 | 31 | 36x36 | 29 | 29 | 46 | 54x24 | 30 | 40 | 48 |
| 24 | 21 | 21 | 33 | 42x12 | 16 | 30 | 28 | 54x30 | 33 | 40 | 51 |
| 30x 6 | 13 | 24 | 25 | 42x14 | 18 | 32 | 30 | 54x36 | 36 | 42 | 54 |
| 30x 8 | 14 | 24 | 26 | 42x16 | 19 | 32 | 31 | 54x42 | 39 | 42 | 57 |
| 30x10 | 15 | 24 | 27 | 42x18 | 20 | 32 | 34 | 54x48 | 42 | 45 | 60 |
| 30x12 | 15 | 24 | 27 | 42x20 | 21 | 32 | 36 | 54x54 | 45 | 45 | 63 |
| 30x14 | 18 | 26 | 30 | 42x24 | 23 | 32 | 38 | 60x20 | 28 | 42 | 46 |
| 30x16 | 19 | 26 | 31 | 42x30 | 26 | 32 | 43 | 60x24 | 30 | 44 | 48 |
| 30x18 | 20 | 26 | 34 | 42x36 | 29 | 32 | 46 | 60x30 | 33 | 44 | 51 |
| 30x20 | 21 | 26 | 36 | 42x42 | 32 | 32 | 49 | 60x36 | 36 | 44 | 54 |
| 30x24 | 23 | 26 | 38 | 48x12 | 17 | 33 | 29 | 60x42 | 39 | 48 | 57 |
| 30x30 | 26 | 26 | 43 | 48x14 | 18 | 35 | 30 | 60x48 | 42 | 48 | 60 |
| | | | | | | | | 60x54 | 45 | 48 | 63 |
| | | | | | | | | 60x60 | 48 | 48 | 66 |

Dimensions in inches.

Reducing tees and crosses in sizes up to and including 24" have same laying dimensions as straight sizes.

Large diameter tees and crosses furnished with ribs as required.

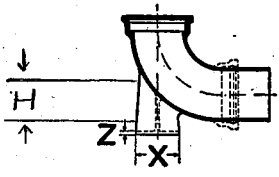
For bell dimensions, see page 75.

Tees and crosses reduce on branches only.

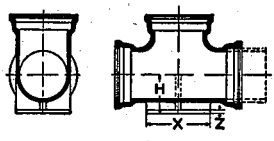
For base tees, see page 78.

For weights, see page 89.

# Base Dimensions of A. W. W. A. Standard Bell and Spigot Base Ells and Tees (All Classes)




Base Ell




Base Tee

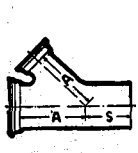
## Table No. 9

| Base Ells | | | | | Base Tees | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Size of Fitting | H | X | Width of Base | Z | Size of Fitting | H | X | Width of Base | Z |
| 3 | 5 | 5 | 5 | 5/16 | 3 | 4 1/2 | 7 1/2 | 4 | 5/8 |
| 4 | 5 1/2 | 6 | 6 | 5/16 | 4 | 5 1/2 | 9 | 5 | 5/8 |
| 6 | 6 1/2 | 7 | 7 | 7/16 | 6 | 6 1/2 | 11 | 7 1/2 | 3/4 |
| 8 | 7 1/2 | 9 | 9 | 9/16 | 8 | 7 1/2 | 13 1/2 | 9 1/2 | 3/4 |
| 10 | 9 | 10 | 10 | 9/16 | 10 | 9 | 16 | 11 1/2 | 7/8 |
| 12 | 10 | 11 | 11 | 1 | 12 | 10 | 19 | 13 1/2 | 1 |
| 14 | 12 | 12 | 12 | 1 | 14 | 12 | 21 | 16 | 1 |
| 16 | 13 | 12 | 12 | 1 | 16 | 13 | 23 1/2 | 18 | 1 |
| 18 | 14 | 13 1/2 | 13 1/2 | 1 1/16 | 18 | 14 | 25 | 20 | 1 1/16 |
| 20 | 15 | 13 1/2 | 13 1/2 | 1 1/16 | 20 | 15 | 27 1/2 | 22 | 1 1/16 |
| 24 | 17 1/2 | 14 | 14 | 1 1/16 | 24 | 17 1/2 | 27 1/2 | 26 1/2 | 1 1/4 |
| 30 | 21.75 | 30 | 30 | 1.38 | 30 | 21 | 27 1/2 | 32 | 1 3/8 |
| 36 | 25.50 | 30 | 30 | 1.72 | 36 | 24 1/2 | 27 1/2 | 34 | 1 1/2 |
| 42 | 25.75 | 42 | 42 | 1.78 | 42 | 28 | 27 1/2 | 36 | 1 3/4 |
| 48 | 32.25 | 42 | 42 | 2.00 | 48 | 31 1/2 | 32 | 36 | 1 7/8 |
| 54 | 36.00 | 48 | 48 | 2.25 | 54 | 36 | 42 | 42 | 2 |
| 60 | 39.00 | 48 | 48 | 2.38 | 60 | 39 | 48 | 48 | 2 1/4 |

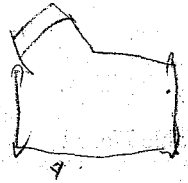
Dimensions in inches.
For other dimensions see pages 76 and 77.
For bell dimensions see page 75.
For weights see pages 88 and 98.
Bases drilled if required.

# Laying Dimensions of A. W. W. A. Standard Bell and Spigot Y Branches

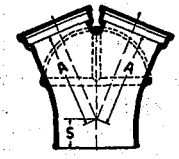
## (All Classes)




Y-Branch
Type 2



LARGE END




Y-Branch
(Breeches Y)
Type 1

## Table No. 10

| Y Branches Type 2 (45°) | | | | | | Y Branches Type 1 (45°) | | |
|---|---|---|---|---|---|---|---|---|
| Size | A | S | Size | A | S | Size | A | S |
| 3 | 9.50 | 10.50 | 36x24 | 54.00 | 19.75 | 12 | 21.5 | 16 |
| 4 | 10.50 | 11.50 | 36x30 | 56.00 | 19.75 | 14 | 24.0 | 16 |
| 6 | 13.00 | 13.00 | 36x36 | 60.00 | 24.00 | 16 | 27.5 | 17 |
| 8 | 16.00 | 14.00 | | | | 18 | 30.0 | 18 |
| | | | 42x24 | 60.00 | 16.75 | 20 | 34.0 | 18 |
| 10 | 18.50 | 15.50 | 42x30 | 63.00 | 16.75 | | | |
| 12 | 21.50 | 15.50 | 42x36 | 66.00 | 21.00 | 24x20 | 34.0 | 12 |
| 14 | 24.00 | 16.00 | 42x42 | 69.00 | 25.25 | 24x24 | 38.0 | 18 |
| 16 | 31.00 | 17.50 | 48x24 | 62.00 | 13.50 | 30x24 | 38.0 | 12 |
| | | | 48x30 | 68.00 | 14.00 | 30x30 | 48.0 | 18 |
| 18 | 34.00 | 18.00 | 48x36 | 71.00 | 18.00 | | | |
| 20 | 37.00 | 18.75 | 48x42 | 74.00 | 22.25 | 36x30 | 48.0 | 10 |
| | | | 48x48 | 77.00 | 26.50 | 36x36 | 56.0 | 18 |
| 24x16 | 40.00 | 12.75 | 54x24 | 74.00 | 14.00 | 42x30 | 48.0 | 6 |
| 24x18 | 40.00 | 18.75 | 54x30 | 78.00 | 17.00 | 42x36 | 56.0 | 10 |
| 24x20 | 40.00 | 18.75 | 54x36 | 82.00 | 21.00 | 42x42 | 66.0 | 18 |
| 24x24 | 42.00 | 19.75 | 54x42 | 87.00 | 24.00 | | | |
| | | | 54x48 | 91.00 | 34.00 | 48x36 | 56.0 | 2 |
| 30x20 | 49.50 | 17.00 | 54x54 | 97.00 | 39.00 | 48x42 | 66.0 | 10 |
| 30x24 | 49.50 | 17.00 | 60x24 | 78.00 | 12.00 | 48x48 | 76.0 | 18 |
| 30x30 | 52.50 | 22.75 | 60x30 | 84.00 | 15.00 | | | |
| | | | 60x36 | 88.00 | 19.00 | | | |
| | | | 60x42 | 93.00 | 24.00 | | | |
| | | | 60x48 | 96.00 | 29.00 | | | |
| | | | 60x54 | 101.00 | 32.00 | | | |
| | | | 60x60 | 106.00 | 36.00 | | | |

Dimensions in inches.

For weights see pages 92.

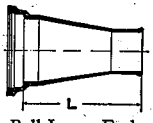
Reducing Y-Branches in sizes up to and including 20" have same laying dimensions as straight sizes.

Large diameter Y-Branches are furnished with ribs as required.

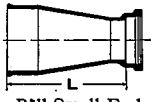
For bell dimensions see page 75.

# Laying Dimensions of A. W. W. A. Standard Bell and Spigot Reducers

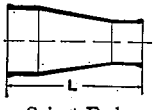
## (All Classes)



Bell Large End



Bell Small End



Spigot Ends

## Table No. 11

| Size | Laying Length (L) | | | Size | Laying Length (L) | | |
|---|---|---|---|---|---|---|---|
| | Large End Bell | Small End Bell | Spigot Ends | | Large End Bell | Small End Bell | Spigot Ends |
| 3 | 20.5 | 21.0 | 24 | 42x24 | 77.0 | 78.0 | 82 |
| 4 | 20.0 | 20.5* | 24 | 42x30 | 43.0 | 43.5 | 48 |
| 6 | 30.0 | 30.0* | 34 | 42x30 | 77.0 | 77.5 | 82 |
| 8 | 30.0 | 30.0 | 34 | 42x36 | 43.0 | 43.5 | 48 |
| 10 | 30.0 | 30.0 | 34 | 42x36 | 77.0 | 77.5 | 82 |
| 12 | 30.0 | 30.0 | 34 | | | | |
| | | | | 48x30 | 77.0 | 77.5 | 82 |
| 14 | 32.0 | 32.0 | 36 | 48x30 | 143.0 | 143.5 | 148 |
| 16 | 32.0 | 32.0 | 36 | 48x36 | 77.0 | 77.5 | 82 |
| 18 | 32.0 | 32.0 | 36 | 48x36 | 143.0 | 143.5 | 148 |
| 20 | 38.0 | 38.0 | 42 | 48x42 | 77.0 | 77.0 | 82 |
| 24 | 38.0 | 38.0 | 42 | 48x42 | 143.0 | 143.0 | 148 |
| | | | | | | | |
| 30x18 | 37.5 | 38.0 | 42 | 54x36 | 76.5 | 77.5 | 82 |
| 30x20 | 37.5 | 38.0 | 42 | 54x36 | 142.5 | 143.5 | 148 |
| 30x20 | 77.5 | 78.0 | 82 | 54x42 | 76.5 | 77.0 | 82 |
| 30x24 | 37.5 | 38.0 | 42 | 54x42 | 142.5 | 143.0 | 148 |
| 30x24 | 77.5 | 78.0 | 82 | 54x48 | 76.5 | 77.0 | 82 |
| | | | | 54x48 | 142.5 | 143.0 | 148 |
| 36x20 | 43.5 | 44.0 | 48 | | | | |
| 36x20 | 77.5 | 78.0 | 82 | 60x36 | 76.5 | 77.5 | 82 |
| 36x24 | 43.5 | 44.0 | 48 | 60x36 | 142.5 | 143.5 | 148 |
| 36x24 | 77.5 | 78.0 | 82 | 60x42 | 76.5 | 77.0 | 82 |
| 36x30 | 43.5 | 43.5 | 48 | 60x42 | 142.5 | 143.0 | 148 |
| 36x30 | 77.5 | 77.5 | 82 | 60x48 | 76.5 | 77.0 | 82 |
| | | | | 60x48 | 142.5 | 143.0 | 148 |
| 42x20 | 43.0 | 44.0 | 48 | 60x54 | 76.5 | 76.5 | 82 |
| 42x20 | 77.0 | 78.0 | 82 | 60x54 | 142.5 | 142.5 | 148 |
| 42x24 | 43.0 | 44.0 | 48 | | | | |

Dimensions in inches.

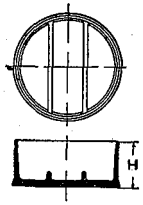
In sizes under 24 inches dimension represents larger end, laying length remains the same for all reductions.

*6x3 Reducers Small End Bell have a laying length of 30.5 inches and 4x2 Reducers Small End Bell have a laying length of 21 inches.

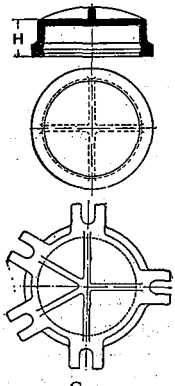
For bell dimensions see page 75.
For weights see page 94.

# Dimensions of A. W. W. A. Standard Bell and Spigot Plugs and Caps

(All Classes)




Plug




Cap

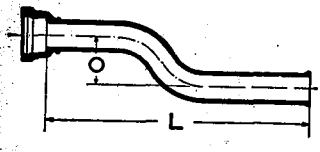
## Table No. 12

| Plugs | | | | Caps | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Size | H | Size | H | Size | H | No. of Lugs | Size | H | No. of Lugs |
| 3 | 5.5 | 18 | 6.5 | 3 | 4.60 | | 18 | 5.00 | 6 |
| 4 | 5.5 | 20 | 6.5 | 4 | 4.60 | | 20 | 5.00 | 6 |
| 6 | 5.5 | 24 | 8.0 | 6 | 4.65 | | 24 | 5.25 | 6 |
| 8 | 5.5 | 30 | 8.0 | 8 | 4.75 | | 30 | 5.75 | 6 |
| 10 | 6.0 | 36 | 8.0 | 10 | 4.75 | | 36 | 6.00 | 6 |
| 12 | 6.0 | 42 | 9.0 | 12 | 4.75 | 4 | 42 | 7.00 | 8 |
| 14 | 6.0 | 48 | 9.0 | 14 | 4.90 | 4 | 48 | 7.00 | 8 |
| 16 | 6.5 | 54 | 9.0 | 16 | 5.00 | 6 | 54 | 7.50 | 8 |
| | | 60 | 9.0 | | | | 60 | 7.50 | 8 |

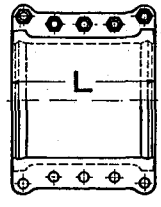
Dimensions in inches.
For bell dimensions see page 75.
Caps 12″ and larger can be furnished with lugs.
For weights see page 97.

# Laying Dimensions of A. W. W. A. Standard Bell and Spigot Offsets and Sleeves

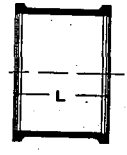
## (All Classes)




Offset




Split Sleeve




Solid Sleeve

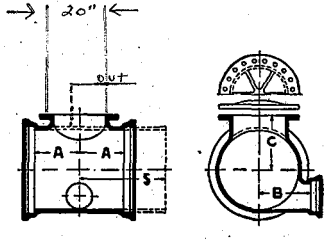
## Table No. 13

| Bell & Spigot Offsets | | | | | | Split Sleeves | | Solid Sleeves | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Size | O | L | Size | O | L | Size of Pipe | L | Size of Pipe | Length (L) | |
| | | | | | | | | | Short | Long |
| 4 | 6 | 27 | 14 | 6 | 35 | 3 | 15 | 3 | 10 | 15 |
| | 12 | 30 | | 12 | 46 | 4 | 15 | 4 | 10 | 15 |
| | 18 | 38 | | 18 | 57 | 6 | 15 | 6 | 10 | 15 |
| | | | | | | 8 | 15 | 8 | 12 | 15 |
| 6 | 6 | 28 | 16 | 6 | 35 | 10 | 18 | 10 | 12 | 18 |
| | 12 | 34 | | 12 | 48 | 12 | 18 | 12 | 14 | 18 |
| | 18 | 41 | | 18 | 58 | 14 | 18 | 14 | 15 | 18 |
| | | | | | | 16 | 24 | 16 | 15 | 24 |
| 8 | 6 | 29 | 18 | 6 | 36 | 18 | 24 | 18 | 15 | 24 |
| | 12 | 36 | | 12 | 48 | 20 | 24 | 20 | 15 | 24 |
| | 18 | 43 | | 18 | 59 | 24 | 24 | 24 | 15 | 24 |
| | | | | | | | | 30 | 15 | 24 |
| 10 | 6 | 30 | 20 | 6 | 36 | | | 36 | 15 | 24 |
| | 12 | 38 | | 12 | 48 | | | 42 | 15 | 24 |
| | 18 | 46 | | 18 | 60 | | | 48 | 15 | 24 |
| | | | | | | | | 54 | 15 | 24 |
| 12 | 6 | 34 | | | | | | 60 | 15 | 24 |
| | 12 | 45 | | | | | | | | |
| | 18 | 56 | | | | | | | | |

Dimensions in inches.
Split Sleeves furnished complete with bolts.
For bell dimensions see page 75.
For weights see pages 98. 97 + 98

# Dimensions of A. W. W. A. Standard Bell and Spigot Blow-Off Branches and Manhole Pipe

(All Classes)




## Table No. 14

| Size | | Blow-Off Branches | | | | | Manhole Pipe Without Blow-Off Branch | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Without Manhole | | With Manhole | | | | | |
| Run | Std. Outlets | A | B | A | B | C | A | C | S |
| 8 | 3 & 4 | 12 | 7 | .. | .. | .... | .. | .... | .. |
| 10 | 3, 4 & 6 | 12 | 8 | .. | .. | .... | .. | .... | .. |
| 12 | 3, 4 & 6 | 12 | 10 | .. | .. | .... | .. | .... | .. |
| 14 | 4 & 6 | 12 | 11 | .. | .. | .... | .. | .... | .. |
| 16 | 4 & 6 | 12 | 12 | .. | .. | .... | .. | .... | .. |
| 18 | 4 & 6 | 12 | 13 | .. | .. | .... | .. | .... | .. |
| 20 | 4 & 6 | 12 | 14 | .. | .. | .... | .. | .... | .. |
| 24 | 6 & 8 | 12 | 16 | .. | .. | .... | .. | .... | .. |
| 30 | 6, 8 & 12 | 13 | 20 | 17.21 | 20 | 26.0 | 17.21 | 26.0 | 31.36 |
| 36 | 8 & 12 | 13 | 23 | 17.21 | 23 | 29.0 | 17.21 | 29.0 | 31.36 |
| 42 | 12 & 16 | 15 | 26 | 17.21 | 26 | 32.0 | 17.21 | 32.0 | 31.96 |
| 48 | 12 & 16 | 17 | 30 | 17.21 | 30 | 35.0 | 17.21 | 35.0 | 31.36 |
| 54 | 12 & 16 | 19 | 33 | 19.25 | 33 | 38.5 | 19.25 | 38.5 | 31.96 |
| 60 | 12 & 16 | 21 | 36 | 21.29 | 36 | 42.0 | 21.29 | 42.0 | 31.96 |

Dimensions in inches.

For dimensions and drilling of flanges, see page 145.

For bell dimensions, see page 75.

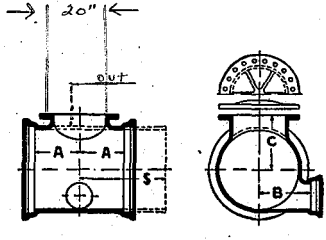
For weights, see page 92.

Manholes are regularly furnished with blind flanges and necessary bolts.

Approximate weight 20" blind flange 227 lbs

# Dimensions of A. W. W. A. Standard Bell and Spigot Blow-Off Branches and Manhole Pipe

(All Classes)




## Table No. 14

| Size | | Blow-Off Branches | | | | | Manhole Pipe Without Blow-Off Branch | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Without Manhole | | With Manhole | | | | | |
| Run | Std. Outlets | A | B | A | B | C | A | C | S |
| 8 | 3 & 4 | 12 | 7 | .. | .. | .... | .. | .... | .. |
| 10 | 3, 4 & 6 | 12 | 8 | .. | .. | .... | .. | .... | .. |
| 12 | 3, 4 & 6 | 12 | 10 | .. | .. | .... | .. | .... | .. |
| 14 | 4 & 6 | 12 | 11 | .. | .. | .... | .. | .... | .. |
| 16 | 4 & 6 | 12 | 12 | .. | .. | .... | .. | .... | .. |
| 18 | 4 & 6 | 12 | 13 | .. | .. | .... | .. | .... | .. |
| 20 | 4 & 6 | 12 | 14 | .. | .. | .... | .. | .... | .. |
| 24 | 6 & 8 | 12 | 16 | .. | .. | .... | .. | .... | .. |
| 30 | 6, 8 & 12 | 13 | 20 | 17.21 | 20 | 26.0 | 17.21 | 26.0 | 31.36 |
| 36 | 8 & 12 | 13 | 23 | 17.21 | 23 | 29.0 | 17.21 | 29.0 | 31.36 |
| 42 | 12 & 16 | 15 | 26 | 17.21 | 26 | 32.0 | 17.21 | 32.0 | 31.96 |
| 48 | 12 & 16 | 17 | 30 | 17.21 | 30 | 35.0 | 17.2 | 35.0 | 31.36 |
| 54 | 12 & 16 | 19 | 33 | 19.25 | 33 | 38.5 | 19.28 | 38.5 | 31.40 |
| 60 | 12 & 16 | 21 | 36 | 21.28 | 36 | 42.0 | 21.28 | 42.0 | 31.40 |

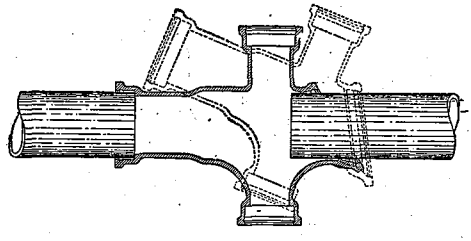
Dimensions in inches.

For dimensions and drilling of flanges, see page 145.
For bell dimensions, see page 75.
For weights, see page 92.

Manholes are regularly furnished with blind flanges and necessary bolts.

Approximate weight 20" blind flange 227 lbs.

# Dimensions and Weights of Cutting In Tees and Crosses for Use with Standard A. W. W. A. Pipe



## Table No. 15

| Nominal Diameter, Inches | Will Take Pipe of | | Laying Length On Run* | Weights | |
|---|---|---|---|---|---|
| | Inside Diameter, Inches | Maximum Thickness, Inches | | 3-Way | 4-Way |
| 3 | 3 | .48 | 16 | 107 | 141 |
| 4 | 4 | .52 | 19 | 140 | 184 |
| 6 | 6 | .55 | 21 | 215 | 281 |
| 8 | 8 | .60 | 23 | 335 | 434 |
| 10 | 10 | .68 | 24 | 458 | 589 |
| 12 | 12 | .75 | 24 | 616 | 787 |
| 14 | 14 | .82 | 36 | 800 | 900 |
| 16 | 16 | .89 | 36 | 1200 | 1460 |

Dimensions in inches.

For bell dimensions, see page 75.

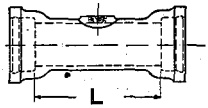
Weights given in pounds. All weights approximate.

*Length to be cut from pipe to receive Cutting-in-Fitting.

All Class D. Branches with side outlets of diameters differing from main run are made to order only.

Cutting-in Branches are enlarged back of bell, as shown above, and can be slipped over the cut pipe and then drawn back into position for calking. The necessity for sleeves and extra joints is thus avoided. The lead space, however, is somewhat greater than with the usual bell; hence, the spigot tee with sleeve is generally preferred.

## Dimensions and Weights of Double Bell Pipe With Boss (Tapped Tee)

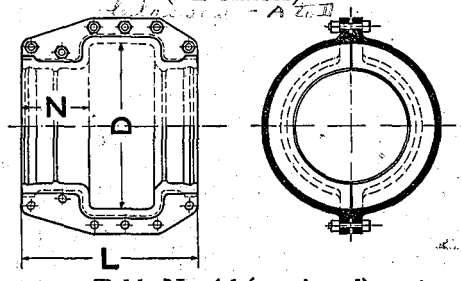



### Table No. 16

| Size | Class | L | Approximate Weight, Pounds |
|---|---|---|---|
| 3 | D | 12 | 55 |
| 4 | D | 12 | 69 |
| 6 | D | 12 | 101 |
| 8 | D | 12 | 154 |
| 10 | D | 13 | 202 |
| 12 | D | 13 | 264 |

Pipe can be tapped for any regular size outlet.

## Dimensions and Weights of Split Bell End Sleeves (All Classes)

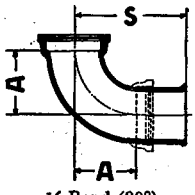



### Table No. 16 (continued) 16 A

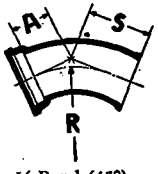
| Size of Pipe | L | D | ~~S~~ N | Approximate Weight, Pounds |
|---|---|---|---|---|
| 3 | 22 | 8 ¼ | 8 | 135 |
| 4 | 22 | 9 ½ | 8 | 159 |
| 6 | 22 | 11 ¾ | 8 | 210 |
| 8 | 22 | 14 ¼ | 8 | 281 |
| 10 | 22 | 16 ½ | 8 | 367 |
| 12 | 22 | 18 ¾ | 8 | 435 |
| 14 | 22 | 21 | 8 | 482 |
| 16 | 22 | 23 ⅝ | 9 | 608 |
| 18 | 22 | 26 ⅛ | 8 | 724 |
| 20 | 23 | 28 ⅝ | 10 | 973 |
| 24 | 23 | 33 ¾ | 10 | 1201 |

All dimensions in inches. All weights approximate.
For Bell dimensions see page 75.
Split Sleeves furnished complete with bolts.
These sleeves will cover any standard bell and spigot joint.

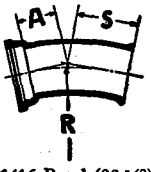
# Dimensions of High Pressure Bell and Spigot Bends, Tees and Crosses (All Classes)



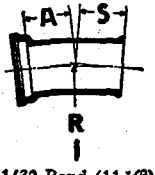

¼ Bend (90°)



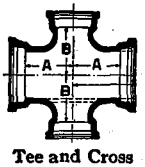

⅛ Bend (45°)




1/16 Bend (22½°)




1/32 Bend (11¼°)



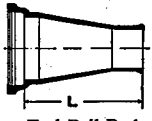

Tee and Cross

## Table No. 17

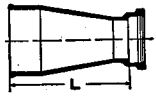
| Size | 90° Bend | | 45° Bend | | 22½° Bend | | 11¼° Bend | | Tees and Crosses | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | A | S | A | S | A | S | A | S | Size | A | B | Size | A | B |
| 6 | 12.25 | 31 | 12.19 | 30.94 | 7.02 | 25.77 | 6.98 | 25.73 | 6 | 12 | 12 | 30x30 | 26 | 26 |
| 8 | 14.25 | 33 | 12.19 | 30.94 | 7.02 | 25.77 | 6.98 | 25.73 | 8 | 13 | 13 | | | |
| 10 | 16.50 | 35 | 12.44 | 30.94 | 9.66 | 28.16 | 9.59 | 28.09 | 10 | 14 | 14 | 36x6 | 13 | 27 |
| 12 | 19.00 | 37 | 12.94 | 30.94 | 12.55 | 30.55 | 12.46 | 30.46 | 12 | 15 | 15 | 36x8 | 14 | 27 |
| | | | | | | | | | | | | 36x10 | 15 | 27 |
| 14 | 21.00 | 39 | 15.43 | 33.43 | 14.93 | 32.93 | 14.82 | 32.82 | 14 | 16 | 16 | 36x12 | 16 | 27 |
| 16 | 27.25 | 45 | 18.16 | 35.91 | 17.57 | 35.32 | 17.43 | 35.18 | 16 | 17 | 17 | 36x14 | 18 | 29 |
| 18 | 27.50 | 45 | 20.90 | 38.40 | 20.20 | 37.70 | 20.04 | 37.54 | 18 | 18 | 18 | 36x16 | 19 | 29 |
| | | | | | | | | | 20 | 19 | 19 | 36x18 | 20 | 29 |
| 20 | 27.75 | 45 | 23.63 | 40.88 | 22.84 | 40.09 | 22.66 | 39.91 | 24 | 21 | 21 | 36x20 | 21 | 29 |
| 24 | 34.25 | 51 | 29.10 | 45.85 | 28.12 | 44.87 | 27.89 | 44.64 | | | | 36x24 | 23 | 29 |
| 30 | 40.75 | 57 | 29.60 | 45.85 | 28.62 | 44.87 | 28.39 | 44.64 | 30x6 | 13 | 24 | 36x30 | 26 | 29 |
| 36 | 53.00 | 69 | 42.28 | 58.28 | 40.80 | 56.80 | 28.64 | 44.64 | 30x8 | 14 | 24 | 36x36 | 29 | 29 |
| | | | | | | | | | 30x10 | 15 | 24 | | | |
| | | | | | | | | | 30x12 | 15 | 24 | | | |
| | | | | | | | | | 30x14 | 18 | 26 | | | |
| | | | | | | | | | 30x16 | 19 | 26 | | | |
| | | | | | | | | | 30x18 | 20 | 26 | | | |
| | | | | | | | | | 30x20 | 21 | 26 | | | |
| | | | | | | | | | 30x24 | 23 | 26 | | | |

Dimensions in inches.
Bell dimensions same as pipe.
For bell dimensions, see page 72.
Fittings furnished without lugs unless otherwise specified.
For lugs see page 69.
Reducing Ells, Tees and Crosses in sizes up to and including 24" have same laying dimensions as straight sizes.
For weights see pages 99 and 100.

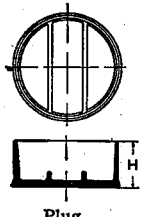
## Dimensions of High Pressure Bell and Spigot Reducers, Sleeves, Plugs and Caps (All Classes)



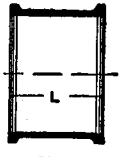

Large End Bell Reducers



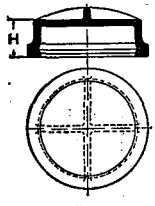

Small End Bell




Plug




Sleeve




Cap

## Table No. 18

| Size | Laying Lengths (L) of Reducers | | Size | Laying Lengths (L) of Reducers | | Solid Sleeves | | Caps |
|---|---|---|---|---|---|---|---|---|
| | Large End Bell | Small End Bell | | Large End Bell | Small End Bell | Size | L | H |
| 8x6 | 38.25 | 38.25 | 20x12 | 39.75 | 39.00 | 6 | 18 | 6.00 |
| 10x6 | 38.50 | 38.25 | 20x14 | 39.75 | 39.00 | 8 | 18 | 6.00 |
| 10x8 | 38.50 | 38.25 | 20x16 | 39.75 | 39.25 | 10 | 18 | 6.00 |
| | | | 20x18 | 39.75 | 39.50 | 12 | 18 | 6.00 |
| 12x6 | 39.00 | 38.25 | | | | | | |
| 12x8 | 39.00 | 38.25 | 24x12 | 40.25 | 39.00 | 14 | 18 | 6.25 |
| 12x10 | 39.00 | 38.50 | 24x14 | 40.25 | 39.00 | 16 | 18 | 6.25 |
| | | | 24x16 | 40.25 | 39.25 | 18 | 18 | 6.50 |
| 14x6 | 39.00 | 38.25 | 24x18 | 40.25 | 39.50 | 20 | 18 | 6.63 |
| 14x8 | 39.00 | 38.25 | 24x20 | 40.25 | 39.75 | | | |
| 14x10 | 39.00 | 38.50 | | | | 24 | 18 | 7.00 |
| 14x12 | 39.00 | 39.00 | 30x20 | 40.75 | 39.75 | 30 | 18 | 7.63 |
| | | | 30x24 | 40.75 | 40.25 | 36 | 18 | 7.75 |
| 16x6 | 39.25 | 38.25 | 36x24 | 41.00 | 40.25 | | | |
| 16x8 | 39.25 | 38.25 | 36x30 | 41.00 | 40.75 | | | |
| 16x10 | 39.25 | 38.50 | | | | | | |
| 16x12 | 39.25 | 39.00 | | | | | | |
| 16x14 | 39.25 | 39.00 | | | | | | |
| 18x10 | 39.50 | 38.50 | | | | | | |
| 18x12 | 39.50 | 39.00 | | | | | | |
| 18x14 | 39.50 | 39.00 | | | | | | |
| 18x16 | 39.50 | 39.25 | | | | | | |

Dimensions in inches.
For bell dimensions, see page 72.
Fittings furnished without lugs unless otherwise specified.
For lugs see page 69.
For weights see pages 99 and 101.
For Plugs H = 10 inches on all sizes.

## Weights of A. W. W. A. Standard Bell and Spigot Bends

### Table No. 19

| Size | Class | 90° Bend | | 45° Bend | | 22½° Bend | | 11¼° Bend | | 5⅝° Bend | | Base Bends | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | With One Bell | With Two Bells | With One Bell | With Two Bells | With One Bell | With Two Bells | With One Bell | With Two Bells | With One Bell | With Two Bells | With One Bell | With Two Bells |
| 3 | D | 65 | 73 | 53 | 65 | 53 | 62 | 53 | 70 | ..... | ..... | 83 | 91 |
| 4 | D | 82 | 94 | 66 | 80 | 66 | 80 | 66 | 91 | ..... | ..... | 107 | 119 |
| 6 | D | 130 | 140 | 105 | 121 | 105 | 121 | 104 | 138 | ..... | ..... | 170 | 180 |
| 8 | D | 200 | 211 | 150 | 178 | 150 | 178 | 150 | 204 | ..... | ..... | 265 | 276 |
| 10 | D | 278 | 280 | 202 | 234 | 202 | 234 | 192 | 260 | ..... | ..... | 352 | 354 |
| 12 | D | 366 | 366 | 265 | 307 | 265 | 307 | 250 | 338 | ..... | ..... | 457 | 457 |
| 14 | B | 406 | 406 | 359 | 403 | 312 | 400 | 364 | 452 | ..... | ..... | 518 | ..... |
| 14 | D | 504 | 504 | 442 | 490 | 382 | 478 | 450 | 546 | ..... | ..... | 616 | ..... |
| 16 | B | 594 | 592 | 445 | 503 | 388 | 502 | 453 | 567 | ..... | ..... | 725 | ..... |
| 16 | D | 750 | 730 | 558 | 612 | 484 | 612 | 570 | 698 | ..... | ..... | 882 | ..... |
| 18 | B | 710 | 706 | 533 | 599 | 464 | 599 | 542 | 677 | ..... | ..... | 883 | ..... |
| 18 | D | 888 | 862 | 663 | 736 | 574 | 727 | 674 | 827 | ..... | ..... | 1061 | ..... |
| 20 | B | 840 | 836 | 758 | 835 | 676 | 834 | 808 | 966 | 808 | ..... | 1009 | ..... |
| 20 | D | 1070 | 1064 | 964 | 1046 | 858 | 1047 | 1028 | 1217 | 1028 | ..... | 1234 | ..... |
| 24 | B | 1290 | 1276 | 1181 | 1275 | 1072 | 1274 | 1080 | 1282 | 1080 | ..... | 1481 | ..... |
| 24 | D | 1656 | 1623 | 1515 | 1625 | 1372 | 1625 | 1380 | 1633 | 1380 | ..... | 1848 | ..... |
| 30 | A | 1814 | ..... | 1475 | ..... | 1342 | ..... | 1350 | ..... | 1350 | ..... | ..... | ..... |
| 30 | B | 2082 | ..... | 1684 | ..... | 1528 | ..... | 1540 | ..... | 1540 | ..... | ..... | ..... |
| 30 | C | 2454 | ..... | 1983 | ..... | 1800 | ..... | 1810 | ..... | 1810 | ..... | ..... | ..... |
| 30 | D | 2836 | ..... | 2291 | ..... | 2080 | ..... | 2090 | ..... | 2090 | ..... | ..... | ..... |
| 36 | A | 2964 | ..... | 2472 | ..... | 2472 | ..... | 1790 | ..... | 1790 | ..... | ..... | ..... |
| 36 | B | 3500 | ..... | 2916 | ..... | 2916 | ..... | 2100 | ..... | 2100 | ..... | ..... | ..... |
| 36 | C | 4120 | ..... | 3430 | ..... | 3430 | ..... | 2470 | ..... | 2470 | ..... | ..... | ..... |
| 36 | D | 4820 | ..... | 4012 | ..... | 4012 | ..... | 2880 | ..... | 2880 | ..... | ..... | ..... |
| 42 | A | 3919 | ..... | 3286 | ..... | 3286 | ..... | 2380 | ..... | 2380 | ..... | ..... | ..... |
| 42 | B | 4535 | ..... | 3778 | ..... | 3778 | ..... | 2720 | ..... | 2720 | ..... | ..... | ..... |
| 42 | C | 5485 | ..... | 4600 | ..... | 4600 | ..... | 3310 | ..... | 3310 | ..... | ..... | ..... |
| 42 | D | 6364 | ..... | 5360 | ..... | 5360 | ..... | 3850 | ..... | 3850 | ..... | ..... | ..... |
| 48 | A | 5572 | ..... | 4230 | ..... | 4230 | ..... | 3150 | ..... | 3150 | ..... | ..... | ..... |
| 48 | B | 6295 | ..... | 4820 | ..... | 4820 | ..... | 3480 | ..... | 3480 | ..... | ..... | ..... |
| 48 | C | 7619 | ..... | 5796 | ..... | 5796 | ..... | 4170 | ..... | 4170 | ..... | ..... | ..... |
| 48 | D | 8789 | ..... | 6750 | ..... | 6750 | ..... | 4860 | ..... | 4860 | ..... | ..... | ..... |
| 54 | A | ..... | ..... | 5180 | ..... | 5180 | ..... | 3750 | ..... | 3750 | ..... | ..... | ..... |
| 54 | B | ..... | ..... | 5990 | ..... | 5990 | ..... | 4330 | ..... | 4330 | ..... | ..... | ..... |
| 54 | C | ..... | ..... | 7330 | ..... | 7330 | ..... | 5290 | ..... | 5290 | ..... | ..... | ..... |
| 54 | D | ..... | ..... | 8620 | ..... | 8620 | ..... | 6220 | ..... | 6220 | ..... | ..... | ..... |
| 60 | A | ..... | ..... | 5990 | ..... | 5990 | ..... | 4340 | ..... | 4340 | ..... | ..... | ..... |
| 60 | B | ..... | ..... | 7130 | ..... | 7130 | ..... | 5140 | ..... | 5140 | ..... | ..... | ..... |
| 60 | C | ..... | ..... | 8590 | ..... | 8590 | ..... | 6200 | ..... | 6200 | ..... | ..... | ..... |
| 60 | D | ..... | ..... | 10240 | ..... | 10240 | ..... | 7400 | ..... | 7400 | ..... | ..... | ..... |

Weights given in pounds. All weights approximate.
For dimensions, see page 76.

# Weights of A. W. W. A. Standard Bell and Spigot Tees and Crosses—Table No. 20

| Size | Class | Tees | | Crosses | | Size | Class | Tees | | Crosses | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Two Bells | Three Bells | Three Bells | Four Bells | | | Two Bells | Three Bells | Three Bells | Four Bells |
| 3 | D | 92 | 94 | 124 | 125 | 18x10 | B | 795 | 790 | 900 | 895 |
| 4x3 | D | 121 | 120 | 153 | 153 | 18x10 | D | 1038 | 1012 | 1216 | 1190 |
| 4 | D | 125 | 128 | 164 | 166 | 18x12 | B | 815 | 810 | 940 | 935 |
| | | | | | | 18x12 | D | 1075 | 1049 | 1290 | 1264 |
| 6x3 | D | 173 | 170 | 207 | 204 | 18x14 | B | 825 | 820 | 955 | 950 |
| 6x4 | D | 185 | 183 | 223 | 221 | 18x14 | D | 1083 | 1057 | 1306 | 1280 |
| 6 | D | 203 | 200 | 259 | 257 | 18x16 | B | 855 | 850 | 1020 | 1015 |
| | | | | | | 18x16 | D | 1108 | 1082 | 1356 | 1330 |
| 8x4 | D | 262 | 255 | 301 | 294 | 18 | B | 895 | 889 | 1101 | 1096 |
| 8x6 | D | 278 | 270 | 333 | 325 | 18 | D | 1170 | 1144 | 1480 | 1454 |
| 8 | D | 301 | 294 | 378 | 372 | | | | | | |
| | | | | | | 20x4 | B | 923 | 916 | 1006 | 999 |
| 10x4 | D | 356 | 338 | 395 | 377 | 20x4 | D | 1172 | 1148 | 1273 | 1248 |
| 10x6 | D | 371 | 351 | 424 | 406 | 20x6 | B | 930 | 920 | 1010 | 1000 |
| 10x8 | D | 389 | 371 | 461 | 443 | 20x6 | D | 1188 | 1164 | 1304 | 1280 |
| 10 | D | 414 | 395 | 511 | 493 | 20x8 | B | 945 | 935 | 1035 | 1025 |
| | | | | | | 20x8 | D | 1212 | 1188 | 1352 | 1328 |
| 12x4 | D | 473 | 445 | 514 | 486 | 20x10 | B | 955 | 945 | 1060 | 1050 |
| 12x6 | D | 486 | 458 | 540 | 512 | 20x10 | D | 1252 | 1227 | 1431 | 1407 |
| 12x8 | D | 502 | 474 | 573 | 545 | 20x12 | B | 975 | 965 | 1100 | 1090 |
| 12x10 | D | 519 | 491 | 605 | 577 | 20x12 | D | 1288 | 1263 | 1502 | 1479 |
| 12 | D | 540 | 512 | 651 | 623 | 20x14 | B | 980 | 970 | 1110 | 1100 |
| | | | | | | 20x14 | D | 1342 | 1318 | 1613 | 1588 |
| 14x4 | B | 485 | 480 | 535 | 530 | 20x16 | B | 1010 | 1000 | 1170 | 1160 |
| 14x4 | D | 614 | 588 | 666 | 641 | 20x16 | D | 1347 | 1323 | 1622 | 1597 |
| 14x6 | B | 500 | 495 | 560 | 555 | 20x18 | B | 1035 | 1025 | 1225 | 1215 |
| 14x6 | D | 634 | 608 | 730 | 700 | 20x18 | D | 1365 | 1341 | 1658 | 1634 |
| 14x8 | B | 515 | 510 | 600 | 595 | | | | | | |
| 14x8 | D | 662 | 636 | 787 | 761 | 20 | B | 1077 | 1070 | 1314 | 1307 |
| 14x10 | B | 535 | 525 | 635 | 625 | 20 | D | 1462 | 1438 | 1852 | 1828 |
| 14x10 | D | 679 | 653 | 822 | 796 | | | | | | |
| 14x12 | B | 560 | 550 | 680 | 670 | 24x6 | B | 1309 | 1289 | 1425 | 1405 |
| 14x12 | D | 698 | 672 | 860 | 834 | 24x6 | D | 1670 | 1637 | 1809 | 1775 |
| 14 | B | 575 | 569 | 723 | 715 | 24x8 | B | 1323 | 1303 | 1453 | 1433 |
| 14 | D | 750 | 724 | 938 | 963 | 24x8 | D | 1699 | 1664 | 1863 | 1830 |
| | | | | | | 24x10 | B | 1341 | 1321 | 1489 | 1469 |
| 16x4 | B | 615 | 610 | 675 | 670 | 24x10 | D | 1732 | 1699 | 1933 | 1900 |
| 16x4 | D | 783 | 760 | 864 | 841 | 24x12 | B | 1362 | 1342 | 1532 | 1511 |
| 16x6 | B | 630 | 625 | 695 | 690 | 24x12 | D | 1768 | 1735 | 2005 | 1972 |
| 16x6 | D | 802 | 779 | 902 | 879 | 24x14 | B | 1402 | 1381 | 1609 | 1589 |
| 16x8 | B | 645 | 640 | 730 | 725 | 24x14 | D | 1810 | 1777 | 2088 | 2055 |
| 16x8 | D | 831 | 808 | 961 | 938 | 24x16 | B | 1443 | 1423 | 1694 | 1673 |
| 16x10 | B | 660 | 655 | 760 | 755 | 24x16 | D | 1858 | 1825 | 2185 | 2151 |
| 16x10 | D | 872 | 849 | 1042 | 1019 | 24x18 | B | 1460 | 1440 | 1727 | 1706 |
| 16x12 | B | 685 | 680 | 805 | 800 | 24x18 | D | 1998 | 1965 | 2430 | 2397 |
| 16x12 | D | 884 | 861 | 1066 | 1043 | 24x20 | B | 1474 | 1454 | 1756 | 1736 |
| 16x14 | B | 695 | 690 | 825 | 820 | 24x20 | D | 2150 | 2116 | 2731 | 2697 |
| 16x14 | D | 903 | 880 | 1104 | 1082 | 24 | B | 1523 | 1503 | 1854 | 1834 |
| 16 | B | 729 | 727 | 904 | 901 | 24 | D | 2295 | 2262 | 2980 | 2947 |
| 16 | D | 991 | 969 | 1282 | 1259 | 30x6 | A | 1272 | 1300 | 1407 | 1434 |
| 18x4 | B | 755 | 750 | 820 | 815 | 30x6 | B | 1433 | 1417 | 1580 | 1563 |
| 18x4 | D | 953 | 927 | 1046 | 1020 | 30x6 | C | 1693 | 1673 | 1870 | 1850 |
| 18x6 | B | 765 | 760 | 840 | 835 | 30x6 | D | 1934 | 1920 | 2113 | 2099 |
| 18x6 | D | 968 | 942 | 1075 | 1049 | 30x8 | A | 1318 | 1346 | 1453 | 1481 |
| 18x8 | B | 780 | 775 | 890 | 865 | 30x8 | B | 1482 | 1466 | 1624 | 1609 |
| 18x8 | D | 1000 | 974 | 1140 | 1114 | 30x8 | C | 1765 | 1745 | 1953 | 1934 |
| | | | | | | 30x8 | D | 2004 | 1990 | 2182 | 2168 |

Weights given in pounds. All weights approximate.
For dimensions, see page 77.

## Weights of A. W. W. A. Standard Bell and Spigot Tees and Crosses—Table No. 20 (Continued)

| Size | Class | Tees | | Crosses | | Size | Class | Tees | | Crosses | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Two Bells | Three Bells | Three Bells | Four Bells | | | Two Bells | Three Bells | Three Bells | Four Bells |
| 30x10 | A | 1369 | 1396 | 1512 | 1540 | 36x18 | A | 2279 | 2246 | 2581 | 2548 |
| 30x10 | B | 1538 | 1521 | 1685 | 1668 | 36x18 | B | 2701 | 2650 | 3073 | 3022 |
| 30x10 | C | 1857 | 1837 | 2075 | 2056 | 36x18 | C | 3206 | 3136 | 3673 | 3604 |
| 30x10 | D | 2108 | 2094 | 2319 | 2306 | 36x18 | D | 4088 | 3991 | 4907 | 4810 |
| 30x12 | A | 1395 | 1420 | 1555 | 1580 | 36x20 | A | 2409 | 2346 | 2752 | 2689 |
| 30x12 | B | 1555 | 1540 | 1715 | 1700 | 36x20 | B | 2885 | 2800 | 3336 | 3251 |
| 30x12 | C | 1911 | 1891 | 2184 | 2164 | 36x20 | C | 3721 | 3610 | 4525 | 4414 |
| 30x12 | D | 2154 | 2140 | 2411 | 2398 | 36x20 | D | 4298 | 4153 | 5179 | 5034 |
| 30x14 | A | 1547 | 1575 | 1737 | 1764 | 36x24 | A | 2451 | 2513 | 2844 | 2907 |
| 30x14 | B | 1805 | 1789 | 2085 | 2069 | 36x24 | B | 3099 | 3014 | 3624 | 3539 |
| 30x14 | C | 2159 | 2140 | 2497 | 2477 | 36x24 | C | 4020 | 3909 | 4949 | 4843 |
| 30x14 | D | 2715 | 2701 | 3278 | 3265 | 36x24 | D | 4872 | 4727 | 5920 | 5774 |
| 30x16 | A | 1648 | 1675 | 1805 | 1832 | 36x30 | A | 2830 | 2708 | 3242 | 3120 |
| 30x16 | B | 1899 | 1883 | 2200 | 2184 | 36x30 | B | 3785 | 3629 | 4660 | 4504 |
| 30x16 | C | 2272 | 2253 | 2662 | 2642 | 36x30 | C | 4501 | 4308 | 5570 | 5377 |
| 30x16 | D | 2854 | 2840 | 3481 | 3467 | 36x30 | D | 5601 | 5359 | 6941 | 6699 |
| 30x18 | A | 1757 | 1741 | 2024 | 2007 | 36 | A | 3067 | 2946 | 3539 | 3418 |
| 30x18 | B | 2044 | 1976 | 2387 | 2318 | 36 | B | 4251 | 4096 | 5305 | 5149 |
| 30x18 | C | 2434 | 2353 | 2862 | 2781 | 36 | C | 5089 | 4896 | 6379 | 6185 |
| 30x18 | D | 2980 | 2966 | 3649 | 3636 | 36 | D | 6371 | 6128 | 8053 | 7811 |
| 30x20 | A | 1857 | 1818 | 2157 | 2118 | 42x12 | A | 2507 | 2577 | 2942 | 3010 |
| 30x20 | B | 2182 | 2088 | 2584 | 2490 | 42x12 | B | 2870 | 2889 | 3400 | 3440 |
| 30x20 | C | 2812 | 2700 | 3483 | 3372 | 42x12 | C | 3478 | 3507 | 3830 | 3860 |
| 30x20 | D | 3231 | 3111 | 3980 | 3861 | 42x12 | D | 3971 | 3989 | 4307 | 4325 |
| 30x24 | A | 1979 | 1940 | 2312 | 2274 | 42x14 | A | 2671 | 2739 | 3080 | 3148 |
| 30x24 | B | 2313 | 2219 | 2742 | 2648 | 42x14 | B | 3075 | 3114 | 3467 | 3537 |
| 30x24 | C | 3010 | 2899 | 3751 | 3639 | 42x14 | C | 3747 | 3776 | 4147 | 4177 |
| 30x24 | D | 3498 | 3378 | 4368 | 4249 | 42x14 | D | 4877 | 4896 | 5776 | 5794 |
| 30 | A | 2212 | 2129 | 2602 | 2520 | 42x16 | A | 2778 | 2846 | 3131 | 3170 |
| 30 | B | 2599 | 2453 | 3106 | 2960 | 42x16 | B | 3196 | 3225 | 3552 | 3592 |
| 30 | C | 3500 | 3327 | 4433 | 4260 | 42x16 | C | 3891 | 3920 | 4325 | 4354 |
| 30 | D | 4116 | 3926 | 5251 | 5061 | 42x16 | D | 5067 | 5085 | 6019 | 6038 |
| 36x8 | A | 1751 | 1777 | 1938 | 1963 | 42x18 | A | 2950 | 2941 | 3268 | 3258 |
| 36x8 | B | 2055 | 2073 | 2268 | 2287 | 42x18 | B | 3407 | 3357 | 3794 | 3744 |
| 36x8 | C | 2421 | 2433 | 2679 | 2691 | 42x18 | C | 4630 | 4549 | 5511 | 5431 |
| 36x8 | D | 2780 | 2780 | 3038 | 3039 | 42x18 | D | 5375 | 5265 | 6375 | 6263 |
| 36x10 | A | 1810 | 1835 | 1996 | 2021 | 42x20 | A | 3104 | 3056 | 3459 | 3411 |
| 36x10 | B | 2128 | 2147 | 2345 | 2364 | 42x20 | B | 3582 | 3486 | 4009 | 3913 |
| 36x10 | C | 2534 | 2546 | 2822 | 2834 | 42x20 | C | 4833 | 4697 | 5757 | 5621 |
| 36x10 | D | 2903 | 2902 | 3188 | 3188 | 42x20 | D | 5644 | 5470 | 6712 | 6538 |
| 36x12 | A | 1884 | 1909 | 2084 | 2109 | 42x24 | A | 3314 | 3266 | 3724 | 3676 |
| 36x12 | B | 2219 | 2238 | 2458 | 2477 | 42x24 | B | 3852 | 3756 | 4370 | 4274 |
| 36x12 | C | 2644 | 2656 | 2962 | 2973 | 42x24 | C | 5246 | 5110 | 6344 | 6208 |
| 36x12 | D | 3032 | 3033 | 3349 | 3350 | 42x24 | D | 6163 | 5989 | 7351 | 7177 |
| 36x14 | A | 2039 | 2065 | 2279 | 2304 | 42x30 | A | 3679 | 3553 | 4144 | 4018 |
| 36x14 | B | 2415 | 2433 | 2709 | 2728 | 42x30 | B | 4774 | 4590 | 5790 | 5604 |
| 36x14 | C | 2872 | 2883 | 3251 | 3263 | 42x30 | C | 6071 | 5824 | 7392 | 7145 |
| 36x14 | D | 3674 | 3674 | 4380 | 4380 | 42x30 | D | 7128 | 6825 | 8693 | 8390 |
| 36x16 | A | 2135 | 2160 | 2410 | 2436 | 42x36 | A | 4076 | 3950 | 4705 | 4579 |
| 36x16 | B | 2521 | 2540 | 2853 | 2872 | 42x36 | B | 5151 | 4966 | 6267 | 6081 |
| 36x16 | C | 3003 | 3014 | 3431 | 3442 | 42x36 | C | 6674 | 6428 | 8152 | 7906 |
| 36x16 | D | 3842 | 3841 | 4613 | 4612 | 42x36 | D | 7862 | 7559 | 9660 | 9357 |

Weights given in pounds. All weights approximate. For dimensions, see page 77.

# Weights of A. W. W. A. Standard Bell and Spigot Tees and Crosses—Table No. 20 (Continued)

| Size | Class | Tees | | Crosses | | Size | Class | Tees | | Crosses | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Two Bells | Three Bells | Three Bells | Four Bells | | | Two Bells | Three Bells | Three Bells | Four Bells |
| 42 | A | 4393 | 4267 | 5109 | 4983 | 54x30 | A | 7497 | 7220 | 8425 | 8149 |
| 42 | B | 5836 | 5651 | 7156 | 6970 | 54x30 | B | 8600 | 8295 | 9252 | 9309 |
| 42 | C | 7677 | 7431 | 9541 | 9295 | 54x30 | C | 10480 | 10062 | 11645 | 11227 |
| 42 | D | 8983 | 8680 | 11205 | 10902 | 54x30 | D | 12246 | 11762 | 13540 | 13056 |
| 48x12 | A | 3266 | 3319 | 3653 | 3707 | 54x36 | A | 8210 | 7935 | 9451 | 9175 |
| 48x12 | B | 3752 | 3804 | 4107 | 4160 | 54x36 | B | 9466 | 9161 | 10881 | 10577 |
| 48x12 | C | 4510 | 4576 | 4940 | 5007 | 54x36 | C | 11904 | 11391 | 13639 | 13220 |
| 48x12 | D | 5902 | 5962 | 6951 | 7011 | 54x36 | D | 13730 | 13246 | 15742 | 15259 |
| 48x14 | A | 3422 | 3476 | 3762 | 3815 | 54x42 | A | 9060 | 8754 | 10746 | 10470 |
| 48x14 | B | 4173 | 4226 | 4836 | 4889 | 54x42 | B | 10716 | 10411 | 12819 | 12514 |
| 48x14 | C | 5240 | 5305 | 6180 | 6246 | 54x42 | C | 12924 | 12505 | 15289 | 14870 |
| 48x14 | D | 6122 | 6183 | 7222 | 7282 | 54x42 | D | 16638 | 14611 | 17812 | 17306 |
| 48x16 | A | 3565 | 3619 | 3947 | 4001 | 54x48 | A | 10411 | 10136 | 12910 | 12634 |
| 48x16 | B | 4046 | 4098 | 4466 | 4519 | 54x48 | B | 11825 | 11520 | 14534 | 14229 |
| 48x16 | C | 5342 | 5408 | 6243 | 6309 | 54x48 | C | 14354 | 13936 | 17540 | 17119 |
| 48x16 | D | 6359 | 6420 | 7526 | 7587 | 54x48 | D | 16677 | 16171 | 20217 | 19712 |
| 48x18 | A | 3775 | 3729 | 4166 | 4120 | 54 | A | 11567 | 11290 | 14773 | 14497 |
| 48x18 | B | 4287 | 4225 | 4718 | 4655 | 54 | B | 13153 | 12848 | 16683 | 16377 |
| 48x18 | C | 5782 | 5710 | 6843 | 6771 | 54 | C | 15947 | 15528 | 18277 | 19687 |
| 48x18 | D | 6744 | 6643 | 7966 | 7865 | 54 | D | 18508 | 18003 | 23166 | 22660 |
| 48x20 | A | 3956 | 3860 | 4378 | 4282 | 60x20 | A | 7301 | 6895 | 7552 | 7279 |
| 48x20 | B | 4500 | 4380 | 4973 | 4853 | 60x20 | B | 8531 | 8311 | 9336 | 8923 |
| 48x20 | C | 6080 | 5939 | 7222 | 7081 | 60x20 | C | 10485 | 1002 | 11170 | 10687 |
| 48x20 | D | 7052 | 6870 | 8329 | 8147 | 60x20 | D | 12470 | 11878 | 13247 | 12655 |
| 48x24 | A | 4221 | 4125 | 4706 | 4609 | 60x24 | A | 7604 | 7330 | 8118 | 7844 |
| 48x24 | B | 5262 | 5142 | 6196 | 6076 | 60x24 | B | 9268 | 8854 | 10052 | 9639 |
| 48x24 | C | 6560 | 6419 | 7899 | 7758 | 60x24 | C | 11187 | 10594 | 12128 | 11645 |
| 48x24 | D | 7655 | 7473 | 8999 | 8817 | 60x24 | D | 13289 | 12697 | 14351 | 13760 |
| 48x30 | A | 4748 | 4553 | 5361 | 5166 | 60x30 | A | 8547 | 8274 | 10544 | 9271 |
| 48x30 | B | 5951 | 5717 | 7105 | 6870 | 60x30 | B | 10148 | 9735 | 11259 | 10846 |
| 48x30 | C | 7566 | 7286 | 9155 | 8875 | 60x30 | C | 12200 | 11717 | 13483 | 13000 |
| 48x30 | D | 8769 | 8426 | 10523 | 10180 | 60x30 | D | 14696 | 14557 | 16158 | 15566 |
| 48x36 | A | 5150 | 4953 | 5859 | 5662 | 60x36 | A | 9272 | 8999 | 10568 | 10262 |
| 48x36 | B | 6732 | 6498 | 8079 | 7845 | 60x36 | B | 11471 | 11059 | 12997 | 12584 |
| 48x36 | C | 8205 | 7925 | 9938 | 9658 | 60x36 | C | 13635 | 13152 | 15325 | 14842 |
| 48x36 | D | 9619 | 9276 | 11677 | 11334 | 60x36 | D | 16164 | 15572 | 18220 | 17629 |
| 48x42 | A | 5503 | 5307 | 6266 | 6069 | 60x42 | A | 10732 | 9752 | 12829 | 12557 |
| 48x42 | B | 7377 | 7143 | 8918 | 8684 | 60x42 | B | 12583 | 12172 | 14857 | 14445 |
| 48x42 | C | 8938 | 8659 | 10872 | 10592 | 60x42 | C | 15083 | 14600 | 17721 | 17238 |
| 48x42 | D | 10590 | 10247 | 12975 | 12632 | 60x42 | D | 17728 | 18288 | 20640 | 20049 |
| 48 | A | 6043 | 5846 | 7043 | 6846 | 60x48 | A | 10681 | 11310 | 13888 | 13615 |
| 48 | B | 8385 | 8150 | 10310 | 10075 | 60x48 | B | 13570 | 13157 | 16089 | 15676 |
| 48 | C | 10063 | 9784 | 12424 | 12144 | 60x48 | C | 16327 | 15844 | 18450 | 19067 |
| 48 | D | 11913 | 11596 | 14840 | 14512 | 60x48 | D | 19367 | 18775 | 23105 | 22514 |
| 54x20 | A | 6267 | 5991 | 6635 | 6359 | 60x54 | A | 12849 | 12576 | 16055 | 15782 |
| 54x20 | B | 7238 | 6933 | 7613 | 7307 | 60x54 | B | 15251 | 14839 | 19012 | 18600 |
| 54x20 | C | 9061 | 8415 | 9760 | 9342 | 60x54 | C | 18036 | 17553 | 22227 | 21744 |
| 54x20 | D | 10578 | 10073 | 11308 | 10802 | 60x54 | D | 21244 | 20653 | 26011 | 25419 |
| 54x24 | A | 6654 | 6379 | 7143 | 6867 | 60 | A | 13584 | 13311 | 17058 | 16785 |
| 54x24 | B | 7884 | 7578 | 8645 | 8340 | 60 | B | 16036 | 15624 | 20007 | 19595 |
| 54x24 | C | 9625 | 7908 | 10509 | 10090 | 60 | C | 19217 | 18734 | 23918 | 23436 |
| 54x24 | D | 11220 | 10714 | 12141 | 11633 | 60 | D | 22775 | 22130 | 28171 | 27579 |

Weights given in pounds. All weights approximate. For dimensions, see page 77.

## Weights of A. W. W. A. Standard Bell and Spigot Y-Branches, Type 1, and Blow-Off Branches—Table No. 21

| Size | Class | Y-Branches Type 1 | Size | Class | Blow Off Branches | Size | Class | Blow Off Branches | Blow Off Branches with Manhole |
|---|---|---|---|---|---|---|---|---|---|
| 12 | D | 687 | 8x3 | D | 223 | 30x8 | A | 1269 | 1717 |
| 14 | B | 738 | 8x4 | D | 227 | 30x8 | B | 1382 | 1847 |
| 14 | D | 894 | 10x3 | D | 285 | 30x8 | C | 1616 | 2104 |
| 16 | B | 942 | 10x4 | D | 286 | 30x8 | D | 1867 | 2379 |
| 16 | D | 1275 | | | | | | | |
| 18 | B | 1266 | 10x6 | D | 300 | 30x12 | A | 1315 | 1761 |
| 18 | D | 1607 | 12x3 | D | 364 | 30x12 | B | 1426 | 1892 |
| 20 | B | 1635 | 12x4 | D | 365 | 30x12 | C | 1658 | 2146 |
| 20 | D | 2296 | 12x6 | D | 379 | 30x12 | D | 1913 | 2424 |
| 24x20 | B | 1663 | | | | | | | |
| 24x20 | D | 2393 | 14x4 | B | 400 | 36x8 | A | 1653 | 2134 |
| 24 | B | 2300 | 14x4 | D | 471 | 36x8 | B | 1922 | 2440 |
| 24 | D | 2957 | 14x6 | B | 415 | 36x8 | C | 2234 | 2779 |
| 30x24 | A | 2171 | 14x6 | D | 486 | 36x8 | D | 2576 | 3160 |
| 30x24 | B | 2217 | | | | 36x12 | A | 1702 | 2183 |
| 30x24 | C | 2717 | 16x4 | B | 497 | 36x12 | B | 1972 | 2484 |
| 30x24 | D | 2811 | 16x4 | D | 597 | 36x12 | C | 2285 | 2830 |
| 30 | A | 3153 | 16x6 | C | 513 | 36x12 | D | 2627 | 3211 |
| 30 | B | 3687 | 16x6 | D | 613 | | | | |
| 30 | C | 4285 | | | | 42x12 | A | 2432 | 2815 |
| 30 | D | 4941 | 18x4 | B | 586 | 42x12 | B | 2728 | 3122 |
| 36x30 | A | 3343 | 18x4 | D | 704 | 42x12 | C | 3271 | 3684 |
| 36x30 | B | 3874 | 18x6 | B | 603 | 42x12 | D | 3768 | 4198 |
| 36x30 | C | 4486 | 18x6 | D | 720 | | | | |
| 36x30 | D | 5189 | | | | 42x16 | A | 2489 | 2872 |
| 36 | A | 4949 | 20x4 | B | 687 | 42x16 | B | 2786 | 3179 |
| 36 | B | 5858 | 20x4 | D | 850 | 42x16 | C | 3365 | 3778 |
| 36 | C | 6804 | 20x6 | B | 705 | 42x16 | D | 3862 | 4292 |
| 36 | D | 8082 | 20x6 | D | 867 | | | | |
| 42x30 | A | 3368 | | | | 48x12 | A | 3274 | 3480 |
| 42x30 | B | 3890 | 24x6 | B | 916 | 48x12 | B | 3699 | 3892 |
| 42x30 | C | 4543 | 24x6 | D | 1149 | 48x12 | C | 4417 | 4586 |
| 42x30 | D | 5241 | 24x8 | B | 935 | 48x12 | D | 5107 | 5256 |
| 42x36 | A | 4904 | 24x8 | D | 1170 | | | | |
| 42x36 | B | 5789 | | | | 48x16 | A | 3337 | 3543 |
| 42x36 | C | 6761 | 30x6 | A | 1206 | 48x16 | B | 3762 | 3955 |
| 42x36 | D | 8025 | 30x6 | B | 1312 | 48x16 | C | 4523 | 4693 |
| 42 | A | 7394 | 30x6 | C | 1528 | 48x16 | D | 5214 | 5363 |
| 42 | B | 8417 | 30x6 | D | 1776 | | | | |
| 42 | C | 10377 | | | | 54x12 | A | 4287 | 4488 |
| 42 | D | 12072 | | | | 54x12 | B | 4945 | 5130 |
| | | | | | | 54x12 | C | 5981 | 6137 |
| 48x36 | A | 4727 | | | | 54x12 | D | 7002 | 7131 |
| 48x36 | B | 5584 | | | | | | | |
| 48x36 | C | 6494 | | | | 54x16 | A | 4355 | 4556 |
| 48x36 | D | 7731 | | | | 54x16 | B | 5013 | 5198 |
| | | | | | | 54x16 | C | 6096 | 6252 |
| 48x42 | A | 7345 | | | | 54x16 | D | 7126 | 7255 |
| 48x42 | B | 8338 | | | | | | | |
| 48x42 | C | 10249 | | | | 60x12 | A | 5263 | 5464 |
| 48x42 | D | 11924 | | | | 60x12 | B | 6159 | 6337 |
| 48 | A | 10200 | | | | 60x12 | C | 7418 | 7569 |
| 48 | B | 12132 | | | | 60x12 | D | 8798 | 8917 |
| 48 | C | 14716 | | | | 60x16 | A | 5336 | 5536 |
| 48 | D | 16965 | | | | 60x16 | B | 6233 | 6411 |
| | | | | | | 60x16 | C | 7542 | 7694 |
| | | | | | | 60x16 | D | 8927 | 9046 |

Weights given in pounds. All weights approximate.
For dimensions see pages 79 and 83.
Weights do not include manhole covers.
Manhole Pipe are from 5% to 10% lighter than the corresponding size and class Blow-off Branch with manhole.

# Weights of A. W. W. A. Standard Bell and Spigot Y-Branches Type 2

## Table No. 22

| Size | Class | Y-Branch Type 2 | Size | Class | Y-Branch Type 2 | Size | Class | Y-Branch Type 2 |
|---|---|---|---|---|---|---|---|---|
| 3 | D | 78 | 18x16 | B | 1295 | 36 | A | 4950 |
| 4 | D | 103 | 18x16 | D | 1657 | 36 | B | 6510 |
| 6x4 | D | 167 | 18 | B | 1360 | 36 | C | 7910 |
| 6 | D | 181 | 18 | D | 1740 | 36 | D | 9180 |
| 8x4 | D | 234 | 20x12 | B | 1520 | 42x24 | A | 5100 |
| 8x6 | D | 268 | 20x12 | D | 1868 | 42x24 | B | 5840 |
| 8 | D | 291 | 20x14 | B | 1525 | 42x24 | C | 7310 |
| 10x6 | D | 366 | 20x14 | D | 1928 | 42x24 | D | 8120 |
| 10x8 | D | 398 | 20x16 | B | 1589 | | | |
| 10 | D | 434 | 20x16 | D | 2014 | 42x30 | A | 5545 |
| | | | | | | 42x30 | B | 6780 |
| 12x6 | D | 520 | 20x18 | B | 1654 | 42x30 | C | 7765 |
| 12x8 | D | 553 | 20x18 | D | 2080 | 42x30 | D | 9025 |
| 12x10 | D | 588 | 20 | B | 1725 | | | |
| 12 | D | 632 | 20 | D | 2200 | 42x36 | A | 6445 |
| | | | | | | 42x36 | B | 7895 |
| 14x6 | B | 566 | 24x16 | B | 1835 | 42x36 | C | 9400 |
| 14x6 | D | 825 | 24x16 | D | 2570 | 42x36 | D | 10890 |
| 14x8 | B | 614 | 24x18 | B | 1980 | | | |
| 14x8 | D | 860 | 24x18 | D | 2680 | 42 | A | 7590 |
| 14x10 | B | 634 | | | | 42 | B | 9165 |
| 14x10 | D | 900 | 24x20 | B | 2200 | 42 | C | 11565 |
| | | | 24x20 | D | 3085 | 42 | D | 13370 |
| 14x12 | B | 690 | 24 | B | 2600 | | | |
| 14x12 | D | 946 | 24 | D | 3600 | 48x30 | A | 6680 |
| 14 | B | 690 | | | | 48x30 | B | 7975 |
| 14 | D | 985 | 30x20 | A | 2743 | 48x30 | C | 9515 |
| | | | 30x20 | B | 3142 | 48x30 | D | 10900 |
| 16x8 | B | 802 | 30x20 | C | 3758 | | | |
| 16x8 | D | 1167 | 30x20 | D | 4123 | 48x36 | A | 7850 |
| 16x10 | B | 850 | | | | 48x36 | B | 9500 |
| 16x10 | D | 1214 | 30x24 | A | 3178 | 48x36 | C | 11310 |
| 16x12 | B | 905 | 30x24 | B | 3874 | 48x36 | D | 12955 |
| 16x12 | D | 1270 | 30x24 | C | 4334 | | | |
| 16x14 | B | 915 | 30x24 | D | 4852 | 48x42 | A | 9115 |
| 16x14 | D | 1322 | | | | 48x42 | B | 10890 |
| 16 | B | 965 | 30 | A | 3519 | 48x42 | C | 13100 |
| 16 | D | 1415 | 30 | B | 4360 | 48x42 | D | 15115 |
| | | | 30 | C | 4950 | | | |
| 18x10 | B | 1170 | 30 | D | 5760 | 48 | A | 10600 |
| 18x10 | D | 1460 | | | | 48 | B | 12555 |
| 18x12 | B | 1180 | 36x24 | A | 3572 | 48 | C | 15130 |
| 18x12 | D | 1512 | 36x24 | B | 4262 | 48 | D | 17385 |
| 18x14 | B | 1235 | 36x24 | C | 5330 | | | |
| 18x14 | D | 1575 | 36x24 | D | 5875 | | | |
| | | | 36x30 | A | 4340 | | | |
| | | | 36x30 | B | 4890 | | | |
| | | | 36x30 | C | 5740 | | | |
| | | | 36x30 | D | 6625 | | | |

Weights given in pounds. All weights approximate.
For dimensions, see page 79.

# Weights of A. W. W. A. Standard Bell and Spigot Reducers

## Table No. 23

| Size | Class | Large End Bell | Small End Bell | Spigot Ends |
|---|---|---|---|---|
| 3x2 | D | 39 | 35 | 31 |
| 4x2 | D | 44 | 40 | 36 |
| 4x3 | D | 50 | 45 | 40 |
| 6x4 | D | 104 | 97 | 82 |
| 8x4 | D | 132 | 119 | 104 |
| 8x6 | D | 150 | 143 | 121 |
| 10x4 | D | 162 | 146 | 131 |
| 10x6 | D | 180 | 169 | 150 |
| 10x8 | D | 201 | 198 | 170 |
| 12x4 | D | 201 | 179 | 163 |
| 12x6 | D | 218 | 202 | 181 |
| 12x8 | D | 240 | 231 | 202 |
| 12x10 | D | 267 | 261 | 229 |
| 14x6 | B | 249 | 216 | 194 |
| 14x6 | D | 288 | 256 | 234 |
| 14x8 | B | 275 | 248 | 220 |
| 14x8 | D | 314 | 288 | 260 |
| 14x10 | B | 305 | 279 | 250 |
| 14x10 | D | 344 | 320 | 290 |
| 14x12 | B | 339 | 321 | 284 |
| 14x12 | D | 378 | 360 | 324 |
| 16x6 | B | 300 | 248 | 226 |
| 16x6 | D | 355 | 300 | 278 |
| 16x8 | B | 326 | 280 | 252 |
| 16x8 | D | 381 | 332 | 304 |
| 16x10 | B | 356 | 312 | 282 |
| 16x10 | D | 410 | 364 | 334 |
| 16x12 | B | 391 | 353 | 317 |
| 16x12 | D | 445 | 405 | 368 |
| 16x14 | B | 389 | 370 | 315 |
| 16x14 | D | 484 | 461 | 407 |
| 18x8 | B | 374 | 315 | 287 |
| 18x8 | D | 438 | 373 | 345 |
| 18x10 | B | 404 | 347 | 317 |
| 18x10 | D | 468 | 405 | 375 |
| 18x12 | B | 438 | 388 | 352 |
| 18x12 | D | 502 | 446 | 410 |
| 18x14 | B | 437 | 406 | 350 |
| 18x14 | D | 541 | 502 | 448 |
| 18x16 | B | 469 | 457 | 383 |
| 18x16 | D | 585 | 569 | 492 |

| Size | Class | Large End Bell | Small End Bell | Spigot Ends |
|---|---|---|---|---|
| 20x10 | B | 516 | 445 | 414 |
| 20x10 | D | 615 | 529 | 499 |
| 20x12 | B | 556 | 491 | 455 |
| 20x12 | D | 656 | 576 | 539 |
| 20x14 | B | 554 | 508 | 453 |
| 20x14 | D | 700 | 638 | 583 |
| 20x16 | B | 592 | 564 | 490 |
| 20x16 | D | 751 | 711 | 635 |
| 20x18 | B | 633 | 617 | 531 |
| 20x18 | D | 800 | 776 | 683 |
| 24x14 | B | 680 | 607 | 552 |
| 24x14 | D | 866 | 764 | 710 |
| 24x16 | B | 717 | 663 | 589 |
| 24x16 | D | 917 | 838 | 762 |
| 24x18 | B | 758 | 717 | 630 |
| 24x18 | D | 965 | 901 | 810 |
| 24x20 | B | 803 | 776 | 675 |
| 24x20 | D | 1027 | 987 | 871 |
| 30x18 | A | 903 | 796 | 710 |
| 30x18 | B | 969 | 878 | 791 |
| 30x18 | C | 1166 | 1048 | 956 |
| 30x18 | D | 1305 | 1146 | 1054 |
| 30x20 Short | A | 941 | 856 | 754 |
| | B | 1014 | 937 | 836 |
| | C | 1227 | 1134 | 1018 |
| | D | 1366 | 1232 | 1115 |
| 30x20 Long | A | 1661 | 1569 | 1468 |
| | B | 1804 | 1728 | 1626 |
| | C | 2190 | 2098 | 1981 |
| | D | 2423 | 2289 | 2172 |
| 30x24 Short | A | 1049 | 981 | 854 |
| | B | 1113 | 1063 | 935 |
| | C | 1354 | 1300 | 1144 |
| | D | 1493 | 1398 | 1242 |
| 30x24 Long | A | 1921 | 1869 | 1661 |
| | B | 1998 | 1946 | 1820 |
| | C | 2438 | 2384 | 2228 |
| | D | 2670 | 2575 | 2419 |

Weights given in pounds. All weights approximate.

For dimensions, see page 80.

# Weights of A. W. W. A. Standard Bell and Spigot Reducers

## Table No. 23 (continued)

| Size | Class | Large End Bells | Small End Bells | Spigot Ends | Size | Class | Large End Bells | Small End Bells | Spigot Ends |
|---|---|---|---|---|---|---|---|---|---|
| | A | 1286 | 1141 | 1039 | | A | 1806 | 1660 | 1467 |
| 36x20 | B | 1450 | 1272 | 1170 | 42x30 | B | 2065 | 1889 | 1711 |
| Short | C | 1739 | 1534 | 1417 | Short | C | 2480 | 2275 | 2065 |
| | D | 1951 | 1705 | 1589 | | D | 2869 | 2650 | 2399 |
| | A | 2018 | 1872 | 1771 | | A | 2839 | 2683 | 2500 |
| 36x20 | B | 2274 | 2095 | 1994 | 42x30 | B | 3271 | 3095 | 2917 |
| Long | C | 2738 | 2533 | 2416 | Long | C | 3938 | 3732 | 3523 |
| | D | 3072 | 2827 | 2710 | | D | 4563 | 4344 | 4093 |
| | A | 1339 | 1280 | 1153 | | A | 1984 | 1891 | 1645 |
| 36x24 | B | 1564 | 1411 | 1283 | 42x36 | B | 2281 | 2207 | 1926 |
| Short | C | 1884 | 1718 | 1562 | Short | C | 2735 | 2642 | 2320 |
| | D | 2096 | 1890 | 1734 | | D | 3184 | 3076 | 2714 |
| | A | 2211 | 2091 | 1964 | | A | 3143 | 3050 | 2803 |
| 36x24 | B | 2468 | 2314 | 2188 | 42x36 | B | 3639 | 3565 | 3285 |
| Long | C | 2985 | 2820 | 2664 | Long | C | 4373 | 4279 | 3958 |
| | D | 3319 | 3113 | 2957 | | D | 5101 | 4993 | 4631 |
| | A | 1490 | 1436 | 1243 | | A | 3381 | 3168 | 2975 |
| 36x30 | B | 1747 | 1645 | 1467 | 48x30 | B | 3883 | 3606 | 3428 |
| Short | C | 2051 | 1939 | 1730 | Short | C | 4641 | 4801 | 4092 |
| | D | 2375 | 2264 | 2013 | | D | 5388 | 5013 | 4762 |
| | A | 2366 | 2312 | 2119 | | A | 5769 | 5556 | 5362 |
| 36x30 | B | 2783 | 2680 | 2502 | 48x30 | B | 6635 | 6359 | 6180 |
| Long | C | 3271 | 3159 | 2950 | Long | C | 7928 | 7588 | 7379 |
| | D | 3796 | 3684 | 3434 | | D | 9214 | 8839 | 8588 |
| | A | 1602 | 1364 | 1262 | | A | 3684 | 3525 | 3278 |
| 42x20 | B | 1768 | 1515 | 1413 | 48x36 | B | 4252 | 4077 | 3796 |
| Short | C | 2168 | 1869 | 1753 | Short | C | 5076 | 4849 | 4527 |
| | D | 2445 | 2092 | 1975 | | D | 5925 | 5662 | 5300 |
| | A | 2491 | 2254 | 2152 | | A | 6316 | 6156 | 5909 |
| 42x20 | B | 2764 | 2511 | 2410 | 48x36 | B | 7299 | 7125 | 6844 |
| Long | C | 3405 | 3106 | 2989 | Long | C | 8713 | 8485 | 8164 |
| | D | 3839 | 3486 | 3369 | | D | 10184 | 9920 | 9558 |
| | A | 1715 | 1504 | 1376 | | A | 4066 | 3998 | 3659 |
| 42x24 | B | 1881 | 1654 | 1527 | 48x42 | B | 4667 | 4564 | 4212 |
| Short | C | 2313 | 2053 | 1898 | Short | C | 5649 | 5516 | 5100 |
| | D | 2590 | 2276 | 2120 | | D | 6585 | 6429 | 5959 |
| | A | 2685 | 2472 | 2346 | | A | 7003 | 6936 | 6597 |
| 42x24 | B | 2958 | 2730 | 2603 | 48x42 | B | 8049 | 7948 | 7594 |
| Long | C | 3652 | 3392 | 3237 | Long | C | 9746 | 9612 | 9197 |
| | D | 4086 | 3772 | 3616 | | D | 11373 | 11217 | 10747 |

Weights given in pounds. All weights approximate.

For dimensions, see page 80.

# Weights of A. W. W. A. Standard Bell and Spigot Reducers

## Table No. 23 (continued)

| Size | Class | Large End Bells | Small End Bells | Spigot Ends | Size | Class | Large End Bells | Small End Bells | Spigot Ends |
|---|---|---|---|---|---|---|---|---|---|
| 54x36 Short | A | 4228 | 3969 | 3722 | 60x36 Long | A | 7999 | 7631 | 7384 |
| | B | 4925 | 4610 | 4330 | | B | 9516 | 9126 | 8846 |
| | C | 5953 | 5580 | 5259 | | C | 11405 | 10902 | 10581 |
| | D | 6995 | 6543 | 6181 | | D | 13527 | 12916 | 12554 |
| 54x36 Long | A | 7216 | 6957 | 6710 | 60x42 Short | A | 5092 | 4816 | 4477 |
| | B | 8401 | 8087 | 7806 | | B | 5991 | 5676 | 5321 |
| | C | 10178 | 9805 | 9484 | | C | 7264 | 6855 | 6440 |
| | D | 11962 | 11510 | 11148 | | D | 8593 | 8089 | 7619 |
| 54x42 Short | A | 4609 | 4442 | 4103 | 60x42 Long | A | 8687 | 8411 | 8072 |
| | B | 5340 | 5100 | 4745 | | B | 10265 | 9950 | 9595 |
| | C | 6526 | 6247 | 5832 | | C | 12439 | 12030 | 11614 |
| | D | 7655 | 7310 | 6841 | | D | 14716 | 14213 | 13743 |
| 54x42 Long | A | 7903 | 7737 | 7398 | 60x48 Short | A | 5572 | 5363 | 4957 |
| | B | 9151 | 8910 | 8556 | | B | 6502 | 6287 | 5832 |
| | C | 11211 | 10932 | 10517 | | C | 7830 | 7555 | 7006 |
| | D | 13152 | 12807 | 12338 | | D | 9259 | 8910 | 8285 |
| 54x48 Short | A | 5083 | 4984 | 4578 | 60x48 Long | A | 9552 | 9344 | 8938 |
| | B | 5851 | 5711 | 5256 | | B | 11187 | 10972 | 10517 |
| | C | 7095 | 6950 | 6401 | | C | 13458 | 13183 | 12634 |
| | D | 8326 | 8137 | 7512 | | D | 15917 | 15568 | 14943 |
| 54x48 Long | A | 8757 | 8660 | 8253 | 60x54 Short | A | 6019 | 5910 | 5404 |
| | B | 10073 | 9933 | 9478 | | B | 7018 | 6961 | 6348 |
| | C | 12239 | 12093 | 11544 | | C | 8574 | 8444 | 7750 |
| | D | 14364 | 14175 | 13550 | | D | 10152 | 9992 | 9178 |
| 60x36 Short | A | 4711 | 4342 | 4096 | 60x54 Long | A | 10360 | 10251 | 9745 |
| | B | 5576 | 5186 | 4906 | | B | 12132 | 12075 | 11462 |
| | C | 6692 | 6189 | 5867 | | C | 14803 | 14673 | 13979 |
| | D | 7934 | 7322 | 6960 | | D | 17530 | 17371 | 16557 |

Weights given in pounds. All weights approximate.
For dimensions, see page 80.

# Weights of A. W. W. A. Standard Bell and Spigot Sleeves Caps and Plugs

## Table No. 24

| Size | Class | Sleeves, Short Pattern | Sleeves, Long Pattern | Split Sleeves | Caps Without Lugs | Caps With Lugs | Plugs |
|---|---|---|---|---|---|---|---|
| 3 | D | 36 | 50 | ... | 20 | .... | 7 |
| 4 | D | 47 | 61 | 72 | 27 | .... | 8 |
| 6 | D | 68 | 87 | 86 | 40 | .... | 14 |
| 8 | D | 104 | 119 | 133 | 59 | .... | 24 |
| 10 | D | 123 | 176 | 158 | 84 | .... | 38 |
| 12 | D | 174 | 223 | 222 | 108 | 142 | 50 |
| 14 | B | 220 | 249 | 264 | 137 | 170 | 63 |
| 14 | D | 240 | 280 | 286 | 149 | 183 | 65 |
| 16 | B | 274 | 391 | 323 | 186 | 237 | 90 |
| 16 | D | 305 | 443 | 359 | 201 | 251 | 96 |
| 18 | B | 321 | 462 | 373 | 228 | 282 | 111 |
| 18 | D | 360 | 518 | 469 | 248 | 305 | 121 |
| 20 | B | 374 | 532 | 428 | 280 | 338 | 151 |
| 20 | D | 440 | 625 | 502 | 310 | 370 | 156 |
| 24 | B | 477 | 680 | 535 | 388 | 440 | 375 |
| 24 | D | 583 | 821 | 652 | 438 | 493 | 472 |
| 30 | A | 648 | 943 | ... | 590 | 682 | 481 |
| 30 | B | 652 | 949 | ... | 596 | 688 | 556 |
| 30 | C | 760 | 1088 | ... | 644 | 738 | 641 |
| 30 | D | 876 | 1262 | ... | 702 | 802 | 723 |
| 36 | A | 833 | 1202 | ... | 844 | 948 | 682 |
| 36 | B | 943 | 1362 | ... | 917 | 1073 | 786 |
| 36 | C | 1077 | 1563 | ... | 998 | 1108 | 914 |
| 36 | D | 1217 | 1772 | ... | 1083 | 1196 | 1050 |
| 42 | A | 1097 | 1577 | ... | 1277 | 1429 | 991 |
| 42 | B | 1184 | 1702 | ... | 1397 | 1573 | 1138 |
| 42 | C | 1381 | 1997 | ... | 1543 | 1726 | 1353 |
| 42 | D | 1561 | 2262 | ... | 1684 | 1876 | 1551 |
| 48 | A | 1337 | 1922 | ... | 1789 | 1965 | 1340 |
| 48 | B | 1481 | 2129 | ... | 1943 | 2125 | 1506 |
| 48 | C | 1752 | 2532 | ... | 2138 | 2330 | 1800 |
| 48 | D | 1986 | 2879 | ... | 2337 | 2535 | 2047 |
| 54 | A | 1612 | 2316 | ... | 2373 | 2555 | 1697 |
| 54 | B | 1835 | 2634 | ... | 2557 | 2751 | 1945 |
| 54 | C | 2156 | 3126 | ... | 2799 | 2902 | 2356 |
| 54 | D | 2450 | 3571 | ... | 3043 | 3251 | 2733 |
| 60 | A | 1906 | 2731 | ... | 2902 | 3089 | 2045 |
| 60 | B | 2127 | 3058 | ... | 3104 | 3296 | 2434 |
| 60 | C | 2491 | 3601 | ... | 3395 | 3594 | 2904 |
| 60 | D | 2895 | 4231 | ... | 3678 | 3884 | 3397 |

Weights given in pounds. All weights approximate.

For dimensions, see pages 81 and 82.

# Weights of A. W. W. A. Standard Bases and Standard Bell and Spigot Offsets

## Table No. 25

| Size | Class | Bases for Tees | Size | Class | Degree of Offset Inches | Weight of Offsets | Size | Class | Degree of Offset Inches | Weight of Offsets |
|---|---|---|---|---|---|---|---|---|---|---|
| 3 | All Classes | 8 | 4 | D | 6 | 78 | 12 | D | 6 | 363 |
| 4 | | 13 | 4 | D | 12 | 91 | 12 | D | 12 | 461 |
| 6 | | 21 | 4 | D | 18 | 111 | 12 | D | 18 | 561 |
| 8 | | 32 | | | | | | | | |
| 10 | | 50 | 6 | D | 6 | 121 | 14 | D | 6 | 456 |
| 12 | | 73 | 6 | D | 12 | 144 | 14 | D | 12 | 582 |
| 14 | | 113 | 6 | D | 18 | 176 | 14 | D | 18 | 711 |
| 16 | | 142 | | | | | | | | |
| 18 | | 177 | 8 | D | 6 | 182 | 16 | D | 6 | 573 |
| 20 | | 225 | 8 | D | 12 | 220 | 16 | D | 12 | 742 |
| 24 | | 300 | 8 | D | 18 | 265 | 16 | D | 18 | 901 |
| 30 | | 418 | | | | | | | | |
| 36 | | 548 | 10 | D | 6 | 253 | 18 | D | 6 | 705 |
| 42 | | 676 | 10 | D | 12 | 315 | 18 | D | 12 | 909 |
| 48 | | 889 | 10 | D | 18 | 378 | 18 | D | 18 | 1101 |
| 54 | | 2130 | | | | | | | | |
| 60 | | 2510 | | | | | 20 | D | 6 | 846 |
| | | | | | | | 20 | D | 12 | 1088 |
| | | | | | | | 20 | D | 18 | 1334 |

Weights given in pounds. All weights approximate.

To find weight of base tee add the weight of base given above to the weight of standard tee found on page 89 or page 189.

For dimensions, see page 82.

# Weights of High Pressure Bell and Spigot Bends, Sleeves, Plugs and Caps

## Table No. 26

| Size | Class | 90° Bends | 45° Bends | 22 ½° Bends | 11 ¼° Bends | Sleeves | Plugs | Caps |
|---|---|---|---|---|---|---|---|---|
| 6 | F | 185 | 196 | 165 | 165 | 126 | 45 | 91 |
| 6 | H | 210 | 222 | 186 | 186 | 143 | 49 | 99 |
| 8 | F | 287 | 288 | 240 | 240 | 174 | 76 | 117 |
| 8 | H | 328 | 329 | 274 | 274 | 195 | 85 | 128 |
| 10 | F | 419 | 397 | 364 | 364 | 235 | 108 | 160 |
| 10 | H | 479 | 454 | 415 | 415 | 261 | 114 | 178 |
| 12 | F | 584 | 526 | 526 | 526 | 297 | 141 | 203 |
| 12 | H | 682 | 612 | 612 | 612 | 341 | 155 | 228 |
| 14 | F | 788 | 729 | 729 | 729 | 375 | 175 | 284 |
| 14 | H | 931 | 862 | 862 | 862 | 439 | 184 | 328 |
| 16 | F | 1121 | 980 | 980 | 980 | 456 | 249 | 357 |
| 16 | H | 1335 | 1167 | 1167 | 1167 | 536 | 265 | 378 |
| 18 | F | 1365 | 1287 | 1287 | 1287 | 615 | 308 | 460 |
| 18 | H | 1653 | 1548 | 1548 | 1548 | 679 | 326 | 538 |
| 20 | F | 1663 | 1663 | 1663 | 1663 | 662 | 381 | 551 |
| 20 | H | 1970 | 1970 | 1970 | 1970 | 783 | 440 | 640 |
| 24 | F | 2547 | 2548 | 2548 | 2548 | 891 | 562 | 828 |
| 24 | H | 3280 | 3280 | 3280 | 3280 | 1038 | 685 | 934 |
| 30 | E | 3879 | 3498 | 3498 | 3498 | 1184 | 984 | 1215 |
| 30 | F | 4300 | 3877 | 3877 | 3877 | 1320 | 1073 | 1338 |
| 36 | E | 6552 | 6199 | 6199 | 4108 | 1609 | 1417 | 1865 |
| 36 | F | 7292 | 6901 | 6901 | 4562 | 1812 | 1537 | 2035 |

Weights given in pounds. All weights approximate.
For dimensions, see pages 86 and 87.
Weights do not include lugs. For lugs, see page 69.

# Weights of High Pressure Bell and Spigot Tees and Crosses
## Table No. 27

| Size | Class | Tees | Crosses | Size | Class | Tees | Crosses | Size | Class | Tees | Crosses |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 6 | F | 278 | 363 | 18x12 | F | 1325 | 1528 | 30x12 | E | 2523 | 2728 |
| 6 | H | 311 | 405 | 18x12 | H | 1587 | 1813 | 30x12 | F | 2774 | 2884 |
| 8x6 | F | 366 | 450 | 18x14 | F | 1377 | 1624 | 30x14 | E | 2834 | 3168 |
| 8x6 | H | 418 | 512 | 18x14 | H | 1654 | 1948 | 30x14 | F | 3118 | 3470 |
| 8 | F | 400 | 516 | 18x16 | F | 1438 | 1747 | 30x16 | E | 3204 | 3663 |
| 8 | H | 458 | 592 | 18x16 | H | 1722 | 2083 | 30x16 | F | 3505 | 3978 |
| 10x6 | F | 477 | 560 | 18 | F | 1509 | 1889 | 30x18 | E | 3381 | 3922 |
| 10x6 | H | 535 | 628 | 18 | H | 1849 | 2278 | 30x18 | F | 3692 | 4250 |
| 10x8 | F | 509 | 624 | 20x6 | F | 1512 | 1596 | 30x20 | E | 3580 | 4242 |
| 10x8 | H | 574 | 708 | 20x6 | H | 1761 | 1854 | 30x20 | F | 3912 | 4996 |
| 10 | F | 548 | 702 | 20x8 | F | 1545 | 1660 | 30x24 | E | 3919 | 4749 |
| 10 | H | 614 | 786 | 20x8 | H | 1801 | 1933 | 30x24 | F | 4273 | 5133 |
| 12x6 | F | 615 | 699 | 20x10 | F | 1584 | 1738 | 30 | E | 4562 | 5770 |
| 12x6 | H | 702 | 783 | 20x10 | H | 1839 | 2011 | 30 | F | 5019 | 6333 |
| 12x8 | F | 647 | 763 | 20x12 | F | 1627 | 1823 | 36x6 | E | 3080 | 3166 |
| 12x8 | H | 742 | 874 | 20x12 | H | 1891 | 2115 | 36x6 | F | 3447 | 3537 |
| 12x10 | F | 686 | 841 | 20x14 | F | 1673 | 1916 | 36x8 | E | 3223 | 3339 |
| 12x10 | H | 781 | 952 | 20x14 | H | 1958 | 2248 | 36x8 | F | 3602 | 3722 |
| 12 | F | 731 | 931 | 20x16 | F | 1733 | 2037 | 36x10 | E | 3377 | 3534 |
| 12 | H | 835 | 1062 | 20x16 | H | 2032 | 2396 | 36x10 | F | 3768 | 2929 |
| 14x6 | F | 774 | 858 | 20x18 | F | 1804 | 2179 | 36x12 | E | 3535 | 3738 |
| 14x6 | H | 913 | 1006 | 20x18 | H | 2181 | 2693 | 36x12 | F | 3940 | 4150 |
| 14x8 | F | 806 | 922 | 20 | F | 1896 | 2363 | 36x14 | E | 4113 | 4537 |
| 14x8 | H | 952 | 1085 | 20 | H | 2202 | 2775 | 36x14 | F | 4558 | 4993 |
| 14x10 | F | 845 | 1000 | 24x6 | F | 2087 | 2170 | 36x16 | E | 4317 | 4824 |
| 14x10 | H | 1040 | 1261 | 24x6 | H | 2574 | 2668 | 36x16 | F | 4776 | 5298 |
| 14x12 | F | 891 | 1091 | 24x8 | F | 2118 | 2235 | 36x18 | E | 4526 | 5122 |
| 14x12 | H | 1045 | 1272 | 24x8 | H | 2614 | 2748 | 36x18 | F | 4999 | 5612 |
| 14 | F | 946 | 1186 | 24x10 | F | 2158 | 2314 | 36x20 | E | 4754 | 5461 |
| 14 | H | 1114 | 1407 | 24x10 | H | 2654 | 2827 | 36x20 | F | 5244 | 5971 |
| 16x6 | F | 972 | 1054 | 24x12 | F | 2204 | 2406 | 36x24 | E | 5250 | 6189 |
| 16x6 | H | 1154 | 1248 | 24x12 | H | 2710 | 2938 | 36x24 | F | 5777 | 6746 |
| 16x8 | F | 1003 | 1119 | 24x14 | F | 2237 | 2475 | 36x30 | E | 6013 | 7345 |
| 16x8 | H | 1194 | 1327 | 24x14 | H | 2760 | 3042 | 36x30 | F | 6603 | 7993 |
| 16x10 | F | 1042 | 1197 | 24x16 | F | 2296 | 2593 | 36 | E | 6873 | 8687 |
| 16x10 | H | 1233 | 1404 | 24x16 | H | 2832 | 3186 | 36 | F | 7616 | 9602 |
| 16x12 | F | 1088 | 1289 | 24x18 | F | 2479 | 2924 | | | | |
| 16x12 | H | 1288 | 1514 | 24x18 | H | 3032 | 3552 | | | | |
| 16x14 | F | 1136 | 1384 | 24x20 | F | 2581 | 3125 | | | | |
| 16x14 | H | 1356 | 1650 | 24x20 | H | 3122 | 3730 | | | | |
| 16 | F | 1198 | 1507 | 24 | F | 2733 | 3421 | | | | |
| 16 | H | 1423 | 1785 | 24 | H | 3316 | 4110 | | | | |
| 18x6 | F | 1212 | 1294 | 30x6 | E | 2244 | 2329 | | | | |
| 18x6 | H | 1453 | 1545 | 30x6 | F | 2472 | 2559 | | | | |
| 18x8 | F | 1243 | 1359 | 30x8 | E | 2355 | 2471 | | | | |
| 18x8 | H | 1493 | 1625 | 30x8 | F | 2596 | 2716 | | | | |
| 18x10 | F | 1282 | 1438 | 30x10 | E | 2477 | 2634 | | | | |
| 18x10 | H | 1530 | 1703 | 30x10 | F | 2727 | 2888 | | | | |

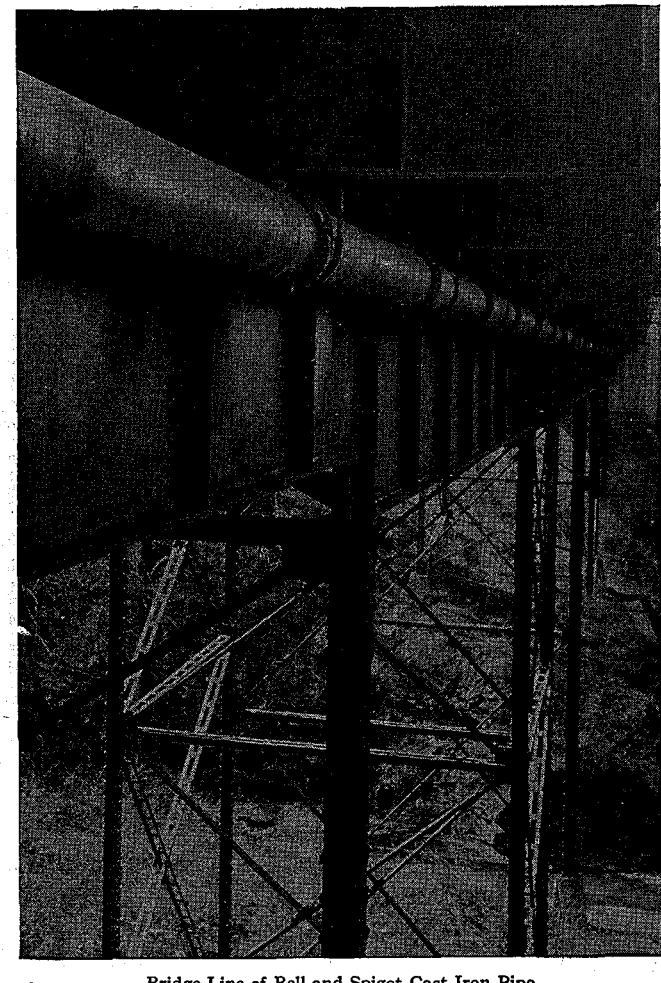
Weights given in pounds. All weights approximate.
For dimensions, see page 86.
Weights do not include lugs. For lugs, see page 69.

# Weights of High Pressure Bell and Spigot Reducers

## Table No. 28

| Size | Class | Large End Bell | Small End Bell | Spigot Ends | Size | Class | Large End Bell | Small End Bell | Spigot Ends |
|---|---|---|---|---|---|---|---|---|---|
| 8x6 | F | 231 | 220 | 175 | 18x16 | F | 889 | 848 | 701 |
| 8x6 | H | 265 | 248 | 200 | 18x16 | H | 1059 | 1015 | 838 |
| 10x6 | F | 291 | 262 | 205 | 20x12 | F | 905 | 762 | 656 |
| 10x6 | H | 329 | 300 | 237 | 20x12 | H | 1059 | 894 | 790 |
| 10x8 | F | 328 | 310 | 254 | 20x14 | F | 964 | 829 | 715 |
| 10x8 | H | 370 | 358 | 293 | 20x14 | H | 1128 | 995 | 859 |
| 12x6 | F | 363 | 311 | 266 | 20x16 | F | 1017 | 923 | 776 |
| 12x6 | H | 417 | 360 | 312 | 20x16 | H | 1202 | 1110 | 933 |
| 12x8 | F | 400 | 359 | 303 | 20x18 | F | 1086 | 1032 | 844 |
| 12x8 | H | 474 | 418 | 369 | 20x18 | H | 1289 | 1247 | 1019 |
| 12x10 | F | 442 | 415 | 345 | 24x12 | F | 1144 | 926 | 830 |
| 12x10 | H | 510 | 482 | 405 | 24x12 | H | 1402 | 1172 | 1067 |
| 14x6 | F | 438 | 370 | 325 | 24x14 | F | 1203 | 1002 | 889 |
| 14x6 | H | 517 | 430 | 381 | 24x14 | H | 1471 | 1272 | 1137 |
| 14x8 | F | 473 | 418 | 362 | 24x16 | F | 1264 | 1096 | 949 |
| 14x8 | H | 558 | 488 | 422 | 24x16 | H | 1545 | 1379 | 1211 |
| 14x10 | F | 518 | 478 | 404 | 24x18 | F | 1332 | 1205 | 1018 |
| 14x10 | H | 610 | 552 | 474 | 24x18 | H | 1631 | 1525 | 1297 |
| 14x12 | F | 566 | 549 | 453 | 24x20 | F | 1407 | 1341 | 1092 |
| 14x12 | H | 664 | 639 | 535 | 24x20 | H | 1726 | 1661 | 1392 |
| 16x6 | F | 532 | 430 | 386 | 30x20 | E | 1774 | 1528 | 1270 |
| 16x6 | H | 632 | 504 | 452 | 30x20 | F | 2005 | 1650 | 1401 |
| 16x8 | F | 569 | 478 | 422 | 30x24 | E | 1927 | 1742 | 1423 |
| 16x8 | H | 673 | 562 | 497 | 30x24 | F | 2128 | 1889 | 1574 |
| 16x10 | F | 611 | 538 | 465 | 36x24 | E | 2466 | 2074 | 1755 |
| 16x10 | H | 725 | 626 | 548 | 36x24 | F | 2748 | 2257 | 1943 |
| 16x12 | F | 660 | 610 | 513 | 36x30 | E | 2739 | 2532 | 2028 |
| 16x12 | H | 785 | 713 | 609 | 36x30 | F | 3056 | 2817 | 2252 |
| 16x14 | F | 719 | 686 | 572 | | | | | |
| 16x14 | H | 855 | 814 | 678 | | | | | |
| 18x10 | F | 721 | 607 | 533 | | | | | |
| 18x10 | H | 863 | 712 | 635 | | | | | |
| 18x12 | F | 770 | 678 | 581 | | | | | |
| 18x12 | H | 923 | 800 | 604 | | | | | |
| 18x14 | F | 829 | 754 | 641 | | | | | |
| 18x14 | H | 992 | 900 | 764 | | | | | |

Weights given in pounds. All weights approximate.
For dimensions, see page 87.
Weights do not include lugs. For lugs, see page 69.



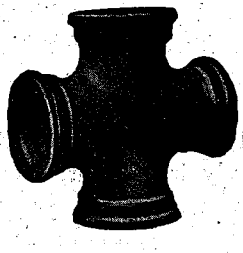
Bridge Line of Bell and Spigot Cast Iron Pipe




SECTION 6

# AMERICAN GAS ASSOCIATION STANDARD

## CAST IRON BELL AND SPIGOT PIPE AND FITTINGS



# American Gas Association Standard Specifications for Cast Iron Gas Pipe and Fittings

SPECIFICATIONS FOR CAST IRON PIPE FOR GAS USES. Standard specifications covering gas pipe and fittings were adopted by the American Gas Institute in 1913 and later revised and adopted by the American Gas Association. These specifications cover both Bell and Spigot and Flanged pipe, as well as the fittings in ordinary use in gas line construction.

Two types of bell are covered by these specifications. The standard bell, known as Bell No. 1, for ordinary construction and an alternate called Bell No. 2, for construction involving the use of cement or combination cement and lead joints. These specifications prepared by gas engineers to fit their particular problem, have been adopted bodily by the Bell and Spigot Pipe makers of the country. Departure from the dimensions of standard pipe and fittings usually makes it necessary to use additional equipment and patterns, with the result that the cost of production is increased. For this reason, adherence to the specifications will result in economy for the pipe user. In the past, there has been some differences of opinion as to Bell dimensions, and while this matter has been almost entirely ironed out, there seems to be a difference of opinion as to the proper depth of Bell. While, as mentioned above, it is advisable to use standard material, the manufacturers are prepared to make Bell dimensions to suit any individual customer at a cost slightly larger than is the case if standard Bells were used.

# American Gas Association Standard Specifications for Cast Iron Pipe and Fittings

### Description of Pipe and Fittings

SECTION 1. All pipe shall be made with bell and spigot joints. The pipe and fittings shall accurately conform to the dimensions given in the tables accompanying and forming a part of these specifications. The pipe shall be straight and of true circles in section, with their inner and outer surfaces concentric; and cast at least 12 feet in length, exclusive of socket or bell. In the case of pipe of different weight from those specified in the tables, the outside diameter of the body and bell dimensions shall conform to the tables.

### Allowable Variation in Diameter

SECTION 2. All sockets and spigots shall be tested by circular gauges. All pipe and fittings shall be rejected which are defective in joint room, or which vary from standard dimensions in the diameters of the sockets and the outside diameters of spigots more than is given in the table below:

| Size | Pipe | Fittings |
|---|---|---|
| 16 in. or less | 0.06 in. | 0.12 in. |
| 20 in. and 24 in. | 0.08 in. | 0.15 in. |
| 30 in., 36 in. and 42 in. | 0.10 in. | 0.20 in. |
| 48 in. | 0.12 in. | 0.24 in. |

### Allowable Variation in Thickness

SECTION 3. The variations allowed below the standard

thickness shall not be greater than that shown in the table below:

| Size | Pipe | Fittings |
|---|---|---|
| 8 in. or less | 0.08 in. | 0.10 in. |
| 10 in. to 36 in. | 0.08 in. | 0.12 in. |
| 42 in. and 48 in. | 0.10 in. | 0.15 in. |

For all sizes of pipe and for fittings 10 inches or larger, variations from the standard thickness of 0.02 inch in excess of the allowances above given shall be permitted for spaces not exceeding 8 inches in length in any direction.

### Treatment of Defective Spigots

SECTION 4. Defective spigot ends on pipe 12 inches or more in diameter may be cut off in a lathe, and a half-round wrought iron band shrunk into a groove cut in the end of the pipe. Not more than 12 per cent of the total number of accepted pipe of each size shall be cut and banded, and no pipe shall be banded which is less than 11 feet in length, exclusive of the socket. In case the length of a pipe differs from 12 feet, the standard weight of the pipe given shall be modified in accordance therewith.

### Marking

SECTION 5. Every pipe and fitting shall have distinctly cast upon it the initials of the maker's name. When cast especially to order, each pipe larger than 4 inches 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:

| | | |
|---|---|---|
| 1913 | 1913 | 1913 |
| 1 | 2 | 3 |

also any initials, not exceeding four, which may be re-

quired by the purchaser. The letters and figures shall be cast on the outside, and shall not be less than 2 inches in length and ⅛-inch in relief, for pipe 8 inches in diameter and larger. For smaller sizes of pipe, the letters may be 1 inch in length. The weight shall be conspicuously painted in white on the inside of each pipe and fitting.

### Allowable Percentage of Variation in Weight

SECTION 6. No pipe shall be accepted the weight of which shall be less than the standard weight by more than 5 per cent for pipe 16 inches or less in diameter, and 4 per cent for pipe more than 16 inches in diameter; and no excess above the standard weight of more than the given percentage for the several sizes shall be paid for. The total weight to be paid for shall not exceed for each size and class of pipe received, the sum of the standard weights of the same number of pieces of the given size and class by more than 2 per cent. No fitting shall be accepted, the weight of which shall be less than the standard weight, by more than 10 per cent for sizes 12 inches or less in diameter, and 8 per cent for larger sizes, except that curves and "Y" pieces 16 inches in diameter and larger may be 12 per cent below the standard weight; and no excess above the standard weight of more than the above percentages for the several sizes will be paid for.

### Quality of Iron

SECTION 7. All pipe and fittings shall be made of cast iron of good quality and of such character as shall make the metal of the fittings strong, tough and of even grain; and soft enough to satisfactorily admit of drilling and

cutting. The metal shall be made without any admixture of cinder iron or other inferior metal, and shall be remelted in a cupola or air furnace.

### Tests of Material

SECTION 8. Specimen bars of the metal used, each being 26 inches long by 2 inches wide and 1 inch thick, shall be made without charge as often as the engineer may direct, and in default of definite instructions, the foundry shall make and test at least one bar from each heat or run of metal. The bars, when placed flatwise upon supports 24 inches apart and loaded in the center, shall support a load of 1,800 pounds and show a deflection of not less than 0.30 inch before breaking; or, if preferred, tensile bars shall be made, which will show a breaking point of not less than 18,000 pounds per square inch. The foundry shall have the right to make and break three bars from each heat or run of metal, and the test shall be based on the average results of the three bars. Should the dimensions of the bars differ from those given above, a proper allowance therefor shall be made in the results of the tests.

### Tests of Pipe

SECTION 9. All pipe, after having a general inspection, shall be subject to a water pressure test of at least 300 pounds per square inch for 16 inches and smaller, and at least 150 pounds per square inch for 20 inches and larger. If required by the engineer, they shall also be subjected to a hammer test under this pressure. Any pipe showing defects by leaking, sweating or otherwise, shall be rejected.

### Casting of Pipe

SECTION 10. The pipe shall be cast vertically in dry sand molds and 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 due to subsequent exposure.

### Quality of Castings

SECTION 11. The pipe and fittings shall be smooth, free from scales, lumps, blisters, and sand holes and defects of every nature which unfit them for the use for which they are intended. No plugging, filling or burning in will be allowed without special permission.

### Cleaning and Inspection

SECTION 12. All pipe and fittings shall be thoroughly cleaned and subjected to a careful hammer inspection.

### Weighing

SECTION 13. The pipe and fittings shall be weighed for payment, under the supervision of the engineer. If desired by the engineer, the pipe and fittings shall be weighed after their delivery, and the weights so ascertained shall be used in the final settlement, providing such weighing is done by a legalized weigh master. Bids shall be submitted and a final settlement made upon the basis of a ton of 2,000 pounds.

### Contractor to Furnish Men and Materials

SECTION 14. The contractor shall provide all tools, testing machines, materials and men necessary for the required testing, inspection and weighing at the foundry

of the pipe and fittings; and should the purchaser have no inspector at the works, the contractor shall, if required by the engineer, furnish a sworn statement that all of the tests have been made as specified, this statement to contain the results of the tests upon the test bars.

### Power of Engineer to Inspect

SECTION 15. The engineer shall be at liberty at all times to inspect the material at the foundry, and the molding and the casting of the pipe and fittings. The forms, sizes, uniformity and condition of all pipe and fittings herein referred to shall be subject to his inspection and approval, and he may reject, without proving, any pipe or other casting which is not in conformity with the specifications or drawings.

### Inspector to Report

SECTION 16. The inspector at the foundry shall report daily to the foundry office, all pipe and fittings rejected, with the causes of rejection.

### Castings to be Delivered Sound and Perfect

SECTION 17. All the pipe and other castings must be delivered in all respects sound and conformable to these specifications. The inspection shall not relieve the contractor of any of his obligations in this respect, and any defective pipe or other castings which may have passed the engineer, shall at all times be subject to rejection when discovered, until the final completion and adjustment of the contract; provided, however, that the contractor shall not be held liable for pipe or fittings found to

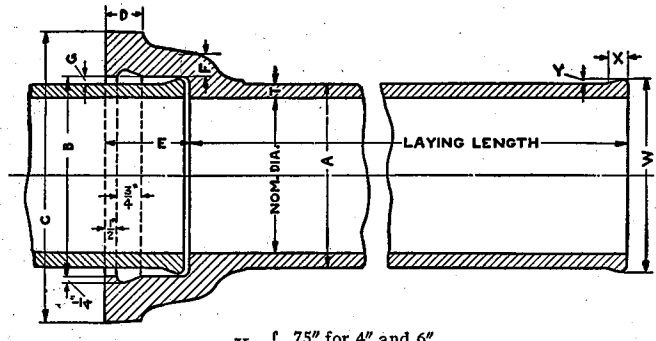
be cracked after they have been accepted at the agreed point of delivery.

### Definition of the Word "Engineer"

SECTION 18. 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.

# Dimensions and Weights of A. G. A. Standard Bell and Spigot Pipe

## Standard Bell




$$X = \begin{cases} .75'' \text{ for 4'' and 6''} \\ 1.00'' \text{ for 8'' to 48''} \end{cases}$$

$$Y = \begin{cases} .19'' \text{ for 4'' and 6''} \\ .25'' \text{ for 8'' to 48''} \end{cases}$$

## Table No. 29

| Nominal Diameter Inches | Dimensions, Inches | | | | | | | | | Approx. Wts. in Lbs. | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | A | B | C | D | E | F | G | T | W | Bell | Per Foot | 12-Ft. Lgth. |
| 3 | 3.78 | 4.80 | 7.40 | 1.25 | 4.00 | .53 | .51 | .39 | 4.06 | | | |
| 4 | 4.80 | 5.80 | 8.40 | 1.50 | 4.00 | .59 | .50 | .40 | 5.18 | 27.00 | ~~19.33~~ | 234 |
| 6 | 6.90 | 7.90 | 10.70 | 1.50 | 4.00 | .62 | .50 | .43 | 7.28 | 39.50 | ~~30.25~~ | 367 |
| 8 | 9.05 | 10.05 | 13.05 | 1.50 | 4.00 | .69 | .50 | .45 | 9.55 | 52.80 | ~~42.08~~ | 509 |
| 10 | 11.10 | 12.10 | 15.10 | 1.50 | 4.00 | .69 | .50 | .49 | 11.60 | 57.93 | 55.91 | 671 |
| 12 | 13.20 | 14.20 | 17.40 | 1.50 | 4.50 | .75 | .50 | .54 | 13.70 | 79.47 | 73.83 | 886 |
| 16 | 17.40 | 18.40 | 22.00 | 1.75 | 4.50 | .90 | .50 | .62 | 17.90 | 125.18 | 112.58 | 1351 |
| 20 | 21.60 | 22.85 | 26.85 | 1.75 | 4.50 | .97 | .63 | .68 | 22.10 | 169.10 | 153.83 | 1846 |
| 24 | 25.80 | 27.05 | 31.25 | 2.00 | 5.00 | 1.05 | .63 | .76 | 26.30 | 235.10 | 206.41 | 2477 |
| 30 | 31.74 | 32.99 | 37.59 | 2.00 | 5.00 | 1.15 | .63 | .85 | 32.24 | 315.20 | 284.00 | 3408 |
| 36 | 37.96 | 39.21 | 44.21 | 2.00 | 5.00 | 1.25 | .63 | .95 | 38.46 | 410.20 | 379.25 | 4551 |
| 42 | 44.20 | 45.45 | 51.05 | 2.00 | 5.00 | 1.40 | .63 | 1.07 | 44.70 | 537.50 | 497.66 | 5972 |
| 48 | 50.50 | 51.75 | 57.75 | 2.00 | 5.00 | 1.50 | .63 | 1.26 | 51.00 | 657.00 | 663.50 | 7962 |

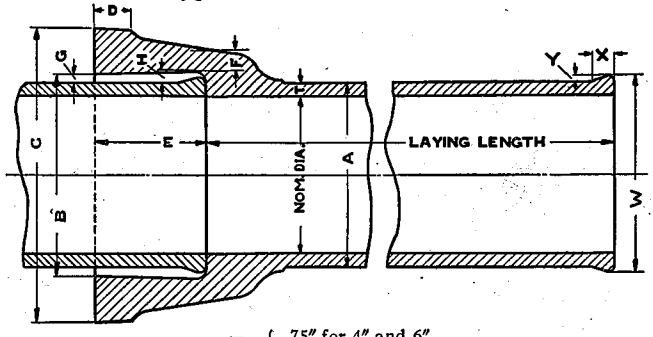
19.5
30.5
42.

For cement joints see page 113.
The above Bell dimensions are standard for both gas pipe and fittings.

*No American Gas Ass'n. Standard for 3" pipe.

# Dimensions and Weights of A. G. A. Standard Bell and Spigot Pipe

## Type 2 Bell for Cement Joint




$$X = \begin{cases} .75'' \text{ for } 4'' \text{ and } 6'' \\ 1.00'' \text{ for } 8'' \text{ to } 48'' \end{cases}$$

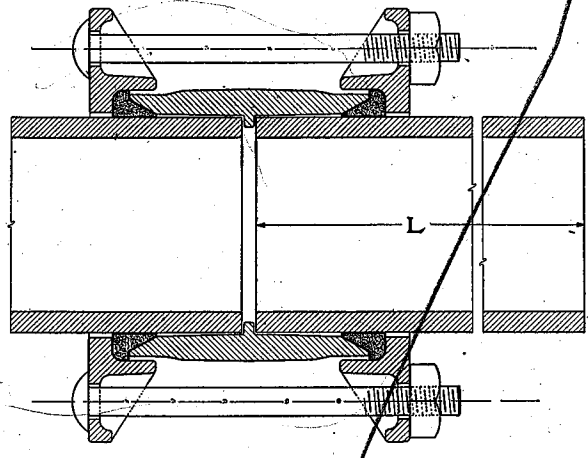
$$Y = \begin{cases} .19'' \text{ for } 4'' \text{ and } 6'' \\ .25'' \text{ for } 8'' \text{ to } 48'' \end{cases}$$

## Table No. 30

| Nominal Diam. Inches | Dimensions, Inches | | | | | | | | | | Approx. Wts. in Pounds | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | A | B | C | D | E | F | G | H | T | W | Bell | Per Foot | 12-Ft. Lgth |
| 4 | 4.80 | 5.80 | 8.40 | 1.50 | 4.00 | .59 | .50 | .63 | .40 | 5.18 | 27.0 | ~~19.3~~ | 234 |
| 6 | 6.90 | 7.90 | 10.70 | 1.50 | 4.00 | .62 | .50 | .63 | .43 | 7.28 | 39.5 | ~~30.3~~ | 367 |
| 8 | 9.05 | 10.05 | 13.05 | 1.50 | 4.50 | .69 | .50 | .63 | .45 | 9.55 | 56.0 | ~~42.3~~ | 512 |
| 10 | 11.10 | 12.10 | 15.10 | 1.50 | 5.00 | .69 | .50 | .63 | .49 | 11.60 | 64.7 | 56.5 | 678 |
| 12 | 13.20 | 14.20 | 17.40 | 1.50 | 5.00 | .75 | .50 | .63 | .54 | 13.70 | 84.2 | 74.3 | 891 |
| 16 | 17.40 | 18.40 | 22.00 | 1.75 | 6.00 | .90 | .50 | .63 | .62 | 17.90 | 146.8 | 115.3 | 1373 |
| 20 | 21.60 | 22.85 | 26.85 | 1.75 | 6.00 | .97 | .63 | .75 | .68 | 22.10 | 198.3 | 156.3 | 1875 |
| 24 | 25.80 | 27.05 | 31.25 | 2.00 | 6.00 | 1.05 | .63 | .75 | .76 | 26.30 | 259.5 | 208.4 | 2501 |
| 30 | 31.74 | 32.99 | 37.59 | 2.00 | 6.50 | 1.15 | .63 | .75 | .85 | 32.24 | 363.7 | 286.3 | 3456 |
| 36 | 37.96 | 39.21 | 44.21 | 2.00 | 6.50 | 1.25 | .63 | .75 | .95 | 38.46 | 472.7 | 384.4 | 4613 |
| 42 | 44.20 | 45.45 | 51.05 | 2.00 | 6.75 | 1.40 | .63 | .75 | 1.07 | 44.70 | 631.8 | 505.5 | 6066 |
| 48 | 50.50 | 51.75 | 57.75 | 2.00 | 7.00 | 1.50 | .63 | .75 | 1.26 | 51.00 | 788.3 | 674.6 | 8093 |

19.5
30.6
42.7

For standard bell, see page 112.

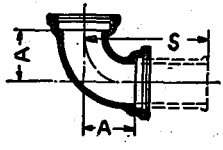



## Table No. 31

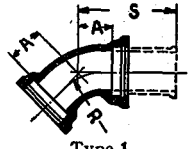
| Pipe Dimensions and Weights | | | | | Coupling Weights | |
|---|---|---|---|---|---|---|
| Nominal Diameter | Actual Outside Diameter | Actual Inside Diameter | Thickness | Weight Per Foot Pounds | Style 53 Cast See Above Fig. | Style 38 Steel See Fig. 10 Page 132 |
| 4 | 4.80 | 4.00 | .40 | 17.25 | 29 | 22 |
| 6 | 6.90 | 6.04 | .43 | 27.13 | 41 | 30 |
| 8 | 9.05 | 8.15 | .45 | 38.06 | 48 | 40 |
| 10 | 11.10 | 10.12 | .49 | 51.09 | 64 | 60 |
| 12 | 13.20 | 12.12 | .54 | 67.21 | 78 | 84 |
| 16 | 17.40 | 16.16 | .62 | 102.15 | 128 | 108 |
| 20 | 21.60 | 20.24 | .68 | 139.70 | 176 | 138 |
| 24 | 25.80 | 24.28 | .76 | 186.60 | 218 | 157 |
| 30 | 31.74 | 30.04 | .85 | 257.30 | These sizes | 225 |
| 36 | 37.96 | 36.06 | .95 | 344.60 | furnished in | 278 |
| 42 | 44.20 | 42.06 | 1.07 | 452.40 | Style 38 | 334 |
| 48 | 50.50 | 47.98 | 1.26 | 608.10 | only. | 395 |

Couplings not furnished unless specifically ordered.
Pipe furnished in random lengths (L) from 11′-0″ to 12′-4″ overall.
Longer lengths can be furnished.
Couplings are also made for A.W.W.A. classes B, C and D pipe.
Dimensions in inches.

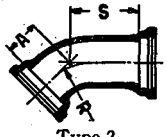
# Laying Dimensions of A. G. A. Standard Bell and Spigot ¼ and ⅛ Bends



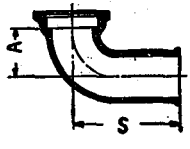

Standard ¼ Bend (90°)



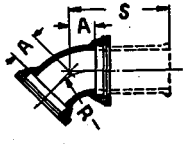

Type 1 ⅛ Bend (45°)



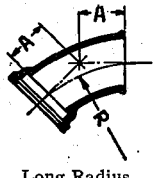

Type 2 ⅛ Bend (45°)




Long Radius ¼ Bend (90°)




Standard ⅛ Bend (45°)




Long Radius ⅛ Bend (45°)

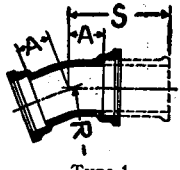
## Table No. 32

| Size | ¼ Bends | | | | ⅛ Bends | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Standard | | Long Radius | | Type 1 | | | Type 2 | | | Standard | | | Long Radius | |
| | A | S | A | S | A | S | R | A | S | R | A | S | R | A | R |
| 4 | 4.50 | 26 | | | 3.16 | 23.00 | 3.04 | 3.16 | 13.65 | 3.04 | | | | | |
| 6 | 6.25 | 26 | | | 4.23 | 23.00 | 5.38 | 4.23 | 14.48 | 5.38 | | | | | |
| 8 | 8.00 | 26 | | | 5.31 | 23.00 | 7.75 | 5.31 | 15.31 | 7.75 | | | | | |
| 10 | 9.75 | 26 | | | 6.39 | 23.00 | 10.36 | 6.39 | 16.14 | 10.36 | | | | | |
| 12 | 11.25 | 27 | | | 7.22 | 24.00 | 12.12 | 7.22 | 16.97 | 12.12 | | | | | |
| 16 | 17.00 | 32 | | | 9.12 | 25.00 | 16.00 | | | | 7.73 | 23 | 12.62 | 19.88 | 48 |
| 20 | 19.00 | 34 | | | 11.03 | 27.25 | 19.87 | | | | 9.30 | 23 | 15.69 | 19.88 | 48 |
| 24 | 21.00 | 36 | 30 | 42 | 12.94 | 29.00 | 24.48 | | | | 10.15 | 23 | 17.75 | 24.85 | 60 |
| 30 | 24.00 | 39 | 36 | 48 | 15.67 | 31.50 | 30.54 | | | | 11.65 | 23 | 20.87 | 24.85 | 60 |
| 36 | 28.00 | 42 | 48 | 60 | | | | | | | 13.34 | 23 | 24.50 | 37.28 | 90 |
| 42 | 32.00 | 45 | 60 | 72 | | | | | | | 14.84 | 23 | 27.62 | 37.28 | 90 |
| 48 | 35.00 | 48 | 66 | 78 | | | | | | | 16.35 | 23 | 30.75 | 37.28 | 90 |

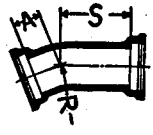
Dimensions in inches.

For dimensions of Bells, see page 112.
For weights, see page 126.

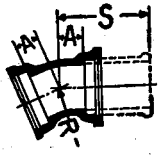
# Laying Dimensions of A. G. A. Standard Bell and Spigot $\frac{1}{16}$ Bends



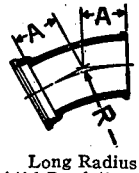

Type 1
1/16 Bend (22 ½°)




Type 2
1/16 Bend (22 ½°)




Standard
1/16 Bend (22 ½°)



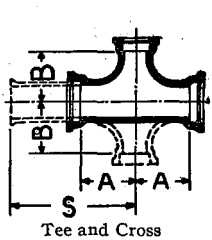

Long Radius
1/16 Bend (22 ½°)

## Table No. 33

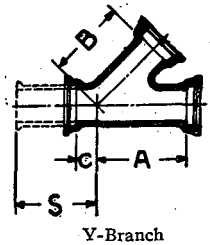
| Size | 1/16 Bends | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Type 1 | | | Type 2 | | | Standard | | | Long Radius | |
| | A | S | R | A | S | R | A | S | R | A | R |
| 4 | 2.69 | 20.25 | 4.00 | 2.69 | 14.70 | 4.00 | | | | | |
| 6 | 3.53 | 20.75 | 7.70 | 3.53 | 15.53 | 7.70 | | | | | |
| 8 | 4.38 | 21.25 | 11.50 | 4.38 | 16.38 | 11.50 | | | | | |
| 10 | 5.22 | 22.00 | 15.70 | 5.22 | 17.25 | 15.70 | | | | | |
| 12 | 5.81 | 22.50 | 18.15 | 5.81 | 17.81 | 18.15 | | | | | |
| 16 | 7.27 | 23.75 | 24.00 | | | | 5.00 | 23 | 12.62 | 19.10 | 96 |
| 20 | 8.71 | 24.75 | 29.75 | | | | 5.92 | 23 | 15.69 | 19.10 | 96 |
| 24 | 10.16 | 26.00 | 37.00 | | | | 6.33 | 23 | 17.75 | 23.87 | 120 |
| 30 | 12.20 | 27.75 | 46.25 | | | | 7.15 | 23 | 20.87 | 23.87 | 120 |
| 36 | | | | | | | 8.07 | 23 | 24.50 | 35.80 | 180 |
| 42 | | | | | | | 8.89 | 23 | 27.62 | 35.80 | 180 |
| 48 | | | | | | | 9.72 | 23 | 30.75 | 35.80 | 180 |

Dimensions in inches.
For weights, see page 126.
For dimensions of Bells, see page 112.

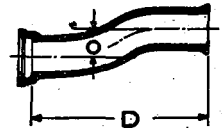
# Laying Dimensions of A. G. A. Standard Tees, Crosses, Y-Branches and Offsets



Tee and Cross



Y-Branch



Offset

## Table No. 34

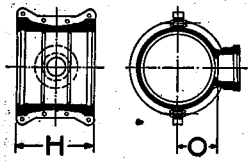
| Tees and Crosses | | | | | Y-Branches | | | | | Offsets | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Size Run | Size Branches | A | B | S | Size | A | B | C | S | Size | O | D |
| 4 | 4 | 8 | 8 | 26 | 4x4 | 11.15 | 11.15 | 3.16 | 23 | | 6 | 30.67 |
| 6 | 4–6 | 8 | 8 | 26 | 6x4 | 15.50 | 15.25 | 4.25 | 23 | 4 | 12 | 34.14 |
| 8 | 4–6–8 | 10 | 10 | 26 | 6x6 | 15.50 | 15.50 | 4.25 | 23 | | 18 | 37.60 |
| 10 | 4 | 12 | 11 | 26 | 8x4 | 19.30 | 18.80 | 5.31 | 23 | | | |
| 10 | 6–8–10 | 12 | 12 | 26 | 8x6 | 19.30 | 19.05 | 5.31 | 23 | | 6 | 31.92 |
| | | | | | | | | | | 6 | 12 | 35.39 |
| 12 | 4–6–8 | 14 | 13 | 27 | 8x8 | 19.30 | 19.30 | 5.31 | 23 | | 18 | 38.85 |
| 12 | 10–12 | 14 | 14 | 27 | 10x4 | 22.75 | 22.00 | 6.75 | 23 | | | |
| 16 | 6–8–10 | 14 | 14 | 29 | 10x6 | 22.75 | 22.25 | 6.75 | 23 | | 6 | 33.74 |
| 16 | 12–16 | 17 | 17 | 32 | 10x8 | 22.75 | 22.50 | 6.75 | 23 | 8 | 12 | 36.65 |
| | | | | | | | | | | | 18 | 40.11 |
| 20 | 6–8–10 | 15 | 15 | 29 | 10x10 | 22.75 | 22.75 | 6.75 | 23 | | | |
| 20 | 12–16–20 | 19 | 19 | 34 | 12x4 | 26.75 | 26.00 | 7.25 | 23 | | 6 | 35.18 |
| 24 | 8–10–12 | 17 | 17 | 30 | 12x6 | 26.75 | 26.25 | 7.25 | 23 | 10 | 12 | 37.80 |
| 24 | 16–20–24 | 21 | 21 | 36 | 12x8 | 26.75 | 26.50 | 7.25 | 23 | | 18 | 41.26 |
| 30 | 8–10–12 | 20 | 20 | 32 | 12x10 | 26.75 | 26.75 | 7.25 | 23 | | 6 | 36.54 |
| 30 | 16–20–24–30 | 24 | 24 | 39 | 12x12 | 26.75 | 26.75 | 7.25 | 23 | 12 | 12 | 39.06 |
| 36 | 12–16–20 | 25 | 25 | 34 | 16x16 | 33.13 | 33.13 | 9.12 | 23 | | 18 | 42.52 |
| 36 | 24–30–36 | 28 | 28 | 42 | 20x20 | 38.53 | 38.53 | 11.03 | 23 | | 6 | 39.01 |
| | | | | | | | | | | 16 | 12 | 42.80 |
| 42 | 16–20–24 | 29 | 29 | 36 | 24x24 | 43.00 | 43.00 | 13.00 | 23 | | 18 | 45.13 |
| 42 | 30–36–42 | 32 | 32 | 45 | 30x30 | 52.50 | 52.50 | 13.75 | 23 | | | |
| 48 | 16–20–24–30 | 32 | 32 | 39 | 36x36 | 60.38 | 60.38 | 18.37 | 23 | | 6 | 41.17 |
| 48 | 36–42–48 | 35 | 35 | 48 | 42x42 | 70.00 | 70.00 | 22.00 | 23 | 20 | 12 | 45.96 |
| | | | | | 48x48 | 80.00 | 80.00 | 25.00 | 23 | | 18 | 48.43 |

Dimensions in inches.

For weights, see page 124.
For dimensions of Bells, see page 112.

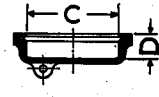
Tees and Crosses reduce on branch only.

## Dimensions of A. G. A. Standard Sleeves, Plugs and Caps



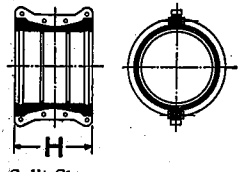

Hub Sleeve

Service Sleeve



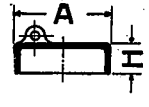

Cap

Lugs furnished on sizes 20" to 48"




Split Sleeve

Solid Sleeve




Plug

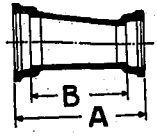
## Table No. 35

| Hub Sleeves | | | Service Sleeves | | | Split Sleeves | | Solid Sleeves | Caps | | | Plugs | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Size | H | O | Size | H | Size Tap | Size | H | H | Size | C | D | A | H |
| 10x4 | 15 | 6.54 | 2 | 8 | 1 ¼ or 1 ½ | 2 | 8 | 8 | 4 | 5.80 | 4.0 | 4.90 | 4.75 |
| 10x6 | 15 | 6.54 | 3 | 12 | 1 ¼ or 3 | 3 | 12 | 12 | 6 | 7.90 | 4.0 | 7.00 | 4.75 |
| 12x4 | 15 | 7.64 | 4 | 12 | 2 or 3 | 4 | 12 | 12 | 8 | 10.05 | 4.0 | 9.15 | 4.75 |
| 12x6 | 15 | 7.64 | 6 | 12 | 3 | 6 | 12 | 12 | 10 | 12.10 | 4.0 | 11.20 | 4.75 |
| | | | | | | 8 | 15 | 15 | | | | | |
| 16x6 | 18 | 9.82 | 8 | 15 | 3 | | | | 12 | 14.20 | 4.5 | 13.30 | 5.25 |
| 16x8 | 18 | 9.82 | 10 | 15 | 3 | 10 | 15 | 15 | 14 | | | 15.30 | 5.25 |
| 20x6 | 18 | 12.10 | 12 | 15 | 3 or 4 | 12 | 15 | 15 | 16 | 18.40 | 4.5 | 17.50 | 5.25 |
| 20x8 | 18 | 12.10 | 16 | 18 | 3 or 4 | 16 | 18 | 18 | 20 | 22.85 | 4.5 | 21.70 | 5.25 |
| 20x10 | 18 | 12.10 | | | | 20 | 18 | 18 | 24 | 27.05 | 5.0 | 25.90 | 5.75 |
| | | | | | | 24 | 18 | 18 | | | | | |
| | | | | | | | | | 30 | 32.99 | 5.0 | 31.84 | 5.75 |
| | | | | | | 30 | 18 | 18 | 36 | 39.21 | 5.0 | 38.06 | 5.75 |
| | | | | | | 36 | 18 | 18 | 42 | 45.45 | 5.0 | 44.30 | 5.75 |
| | | | | | | 42 | 18 | 18 | 48 | 51.75 | 5.0 | 50.60 | 5.75 |
| | | | | | | 48 | 18 | 18 | | | | | |

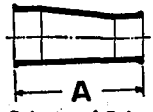
Dimensions in inches.

For weights, see page 124.
For dimensions of Bells, see page 112.

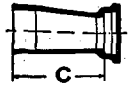
# Laying Dimensions and Weights of A. G. A. Standard Bell and Spigot Reducers



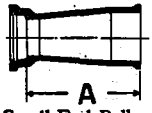
Bell and Bell



Spigot and Spigot Eccentric Reducers



Small End Bell



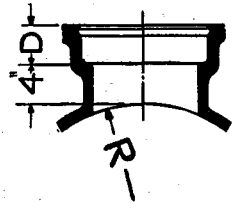
Small End Bell Concentric Reducer

## Table No. 36

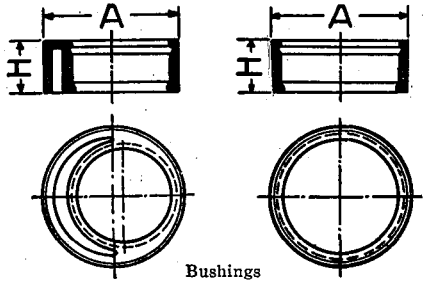
| Eccentric Reducers | | | | | | | | Concentric Reducers | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Weight in Pounds | | | | | | |
| Size | A | B | C | Two Bells | Large Bell | Small Bell | Two Spigots | Size | A | Weight in Pounds |
| 4x3 | 20.0 | 12.0 | 16.0 | 57 | 44 | 39 | 26 | 14x4 | 32.0 | 178 |
| 6x3 | 25.0 | 17.0 | 21.0 | 80 | 66 | 55 | 41 | 14x6 | 32.0 | 198 |
| 6x4 | 20.0 | 12.0 | 16.0 | 81 | 63 | 56 | 38 | 18x8 | 32.0 | 280 |
| | | | | | | | | 18x10 | 32.0 | 303 |
| 8x4 | 28.0 | 20.0 | 24.0 | 117 | 99 | 84 | 66 | 24x12 | 37.5 | 508 |
| 8x6 | 20.0 | 12.0 | 16.0 | 114 | 89 | 81 | 56 | | | |
| | | | | | | | | 30x16 | 37.5 | 727 |
| 10x4 | 36.0 | 28.0 | 32.0 | 160 | 142 | 122 | 104 | 30x20 | 37.5 | 820 |
| 10x6 | 28.0 | 20.0 | 24.0 | 156 | 131 | 118 | 93 | 30x24 | 37.0 | 940 |
| 10x8 | 20.0 | 12.0 | 16.0 | 148 | 115 | 110 | 77 | 36x30 | 43.0 | 1418 |
| | | | | | | | | 42x36 | 43.0 | 1866 |
| 12x6 | 37.0 | 28.5 | 33.0* | 222 | 198 | 171 | 148 | | | |
| 12x8 | 29.0 | 20.5 | 25.0* | 212 | 181 | 162 | 130 | 48x42 | 43.0 | 2475 |
| 12x10 | 21.0 | 12.5 | 17.0* | 193 | 158 | 142 | 107 | 54x48 | 43.0 | 3089 |
| | | | | | | | | | | |
| 16x8 | 46.0 | 37.5 | 42.0* | 388 | 356 | 304 | 272 | | | |
| 16x10 | 38.0 | 29.5 | 34.0* | 366 | 331 | 282 | 247 | | | |
| 16x12 | 29.0 | 20.0 | 24.5 | 344 | 293 | 259 | 209 | | | |
| | | | | | | | | | | |
| 20x10 | 54.0 | 45.5 | 50.0 | 586 | 551 | 469 | 434 | | | |
| 20x12 | 46.0 | 37.0 | 41.5 | 569 | 518 | 441 | 401 | | | |
| 20x16 | 30.0 | 21.0 | 25.5 | 509 | 425 | 392 | 308 | | | |
| | | | | | | | | | | |
| 24x16 | 46.5 | 37.0 | 42.0 | 792 | 716 | 641 | 565 | | | |
| 24x20 | 30.5 | 21.0 | 26.0 | 677 | 572 | 527 | 421 | | | |
| | | | | | | | | | | |
| 30x20 | 55.0 | 45.5 | 50.5 | 1226 | 1121 | 1023 | 917 | | | |
| 30x24 | 40.0 | 30.0 | 35.0 | 1102 | 952 | 899 | 748 | | | |
| | | | | | | | | | | |
| 36x24 | 64.0 | 54.0 | 59.0 | 1843 | 1692 | 1576 | 1426 | | | |
| 36x30 | 40.0 | 30.0 | 35.0 | 1484 | 1281 | 1217 | 1014 | | | |
| | | | | | | | | | | |
| 42x30 | 64.0 | 54.0 | 59.0 | 2465 | 2262 | 2108 | 1904 | | | |
| 42x36 | 40.0 | 30.0 | 35.0 | 1965 | 1698 | 1607 | 1341 | | | |
| | | | | | | | | | | |
| 48x36 | 64.0 | 54.0 | 59.0 | 3247 | 2980 | 2821 | 2554 | | | |
| 48x42 | 40.0 | 30.0 | 35.0 | 2566 | 2208 | 2139 | 1782 | | | |

Dimensions in inches. Weights in pounds. All weights approximate.
For dimensions of Bells see page 112.
*Laying length of reducers with large end bell in sizes indicated is one-half inch greater than for reducers with small end bell.
less

# Dimensions and Weights of A. G. A. Standard Bell Hat Flanges and Bushings




Hat Flanges



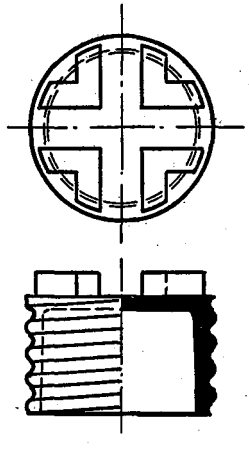

Bushings

## Table No. 37

| Hat Flanges | | | | Bushings | | | |
|---|---|---|---|---|---|---|---|
| Nominal Diameter | Dimensions in Inches | | Approximate Weight in Pounds | Size Inches | Dimensions in Inches | | Approximate Weight in Pounds |
| | D | R | | | A | H | |
| 20x6 | 4.00 | 11.00 | 73 | 6x3 | 7.00 | 4.50 | 21 |
| 20x8 | 4.00 | 11.00 | 97 | 6x4 | 7.00 | 4.50 | 13 |
| 20x10 | 4.00 | 11.00 | 120 | 8x4 | 9.15 | 4.50 | 33 |
| 20x12 | 4.50 | 11.00 | 158 | 8x6 | 9.15 | 4.50 | 18 |
| 24x6 | 4.00 | 13.00 | 72 | 10x6 | 11.20 | 4.50 | 57 |
| 24x8 | 4.00 | 13.00 | 96 | 10x8 | 11.20 | 4.50 | 20 |
| 24x10 | 4.00 | 13.00 | 117 | 12x6 | 13.30 | 5.00 | 72 |
| 24x12 | 4.50 | 13.00 | 156 | 12x8 | 13.30 | 5.00 | 61 |
| | | | | 12x10 | 13.30 | 5.00 | 28 |
| 30x6 | 4.00 | 16.00 | 72 | | | | |
| 30x8 | 4.00 | 16.00 | 94 | 16x12 | 17.50 | 5.00 | 95 |
| 30x10 | 4.00 | 16.00 | 116 | | | | |
| 30x12 | 4.50 | 16.00 | 153 | | | | |
| 36x6 | 4.00 | 19.25 | 71 | | | | |
| 36x8 | 4.00 | 19.25 | 93 | | | | |
| 36x10 | 4.00 | 19.25 | 116 | | | | |
| 36x12 | 4.50 | 19.25 | 150 | | | | |
| 42x6 | 4.00 | 22.37 | 71 | | | | |
| 42x8 | 4.00 | 22.37 | 93 | | | | |
| 42x10 | 4.00 | 22.37 | 114 | | | | |
| 42x12 | 4.50 | 22.37 | 150 | | | | |
| 48x6 | 4.00 | 25.50 | 71 | | | | |
| 48x8 | 4.00 | 25.50 | 93 | | | | |
| 48x10 | 4.00 | 25.50 | 113 | | | | |
| 48x12 | 4.50 | 25.50 | 150 | | | | |

Dimensions in inches.
Weights given in pounds. All weights approximate.
For dimensions of Bells see page 112.

## Standard Screw Plugs for Gas and Water Mains*



### Table No. 38

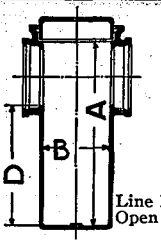
| Size | Weight, Pounds |
|---|---|
| 3 | 7 |
| 4 | 10 |
| 6 | 18 |
| 8 | 26 |
| 10 | 43 |
| 12 | 56 |

All weights are approximate.

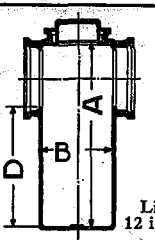
*Useful for temporary "dead ends," lessening liability of damage to pipe when withdrawn.

# Dimensions and Weights of A. G. A. Standard Line Drips and Side Pots

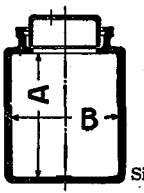
Table No. 39



Line Drip
Open Top



Line Drip
12 in. Top Plug



Side Pot

| Line Drips—Open Tops | | | | | | | Line Drips—12 In. Top Plug | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Diameter Branch Inches | Dimensions—Inches | | | Size Plug Inches | Capacity Quarts | Approximate Weight Pounds | Diameter Branch Inches | Dimensions—Inches | | | Capacity Quarts | Approximate Weight Pounds |
| | A | B | D | | | | | A | B | D | | |
| 4 | 42.49 | 14.16 | 37.0 | 14 | 96 | 467 | 16 | 55.18 | 20.24 | 37.0 | 208 | 1079 |
| 4 | 30.09 | 14.16 | 24.6 | 14 | 64 | 382 | 16 | 42.78 | 20.24 | 24.6 | 138 | 935 |
| 4 | 17.79 | 14.16 | 12.3 | 14 | 32 | 298 | 16 | 30.48 | 20.24 | 12.3 | 69 | 792 |
| | | | | | | | 20 | 60.52 | 24.28 | 38.0 | 304 | 1568 |
| 6 | 44.59 | 14.16 | 37.0 | 14 | 96 | 497 | 20 | 47.92 | 24.28 | 24.4 | 203 | 1372 |
| 6 | 32.19 | 14.16 | 24.6 | 14 | 64 | 412 | 20 | 35.22 | 24.28 | 12.7 | 100 | 1174 |
| 6 | 19.89 | 14.16 | 12.3 | 14 | 32 | 327 | 24 | 60.72 | 30.04 | 34.0 | 420 | 2215 |
| | | | | | | | 24 | 49.32 | 30.04 | 22.6 | 280 | 1970 |
| 8 | 46.79 | 14.16 | 37.0 | 14 | 96 | 538 | 24 | 38.02 | 30.04 | 11.3 | 140 | 1728 |
| 8 | 34.39 | 14.16 | 24.6 | 14 | 64 | 453 | 30 | 66.67 | 36.06 | 34.0 | 600 | 3275 |
| 8 | 22.09 | 14.16 | 12.3 | 14 | 32 | 369 | 30 | 55.27 | 36.06 | 22.6 | 399 | 2948 |
| | | | | | | | 30 | 43.97 | 36.06 | 11.3 | 198 | 2623 |
| 10 | 48.80 | 14.16 | 37.0 | 14 | 96 | 589 | 36 | 74.89 | 42.06 | 36.0 | 864 | 4719 |
| 10 | 36.40 | 14.16 | 24.6 | 14 | 64 | 504 | 36 | 62.89 | 42.06 | 24.0 | 576 | 4267 |
| 10 | 24.10 | 14.16 | 12.3 | 14 | 32 | 420 | 36 | 50.89 | 42.06 | 12.0 | 288 | 3815 |
| | | | | | | | 42 | 81.16 | 47.98 | 36.0 | 1127 | 7016 |
| 12 | 48.91 | 16.16 | 35.0 | 16 | 126 | 766 | 42 | 69.16 | 47.98 | 24.0 | 752 | 6408 |
| 12 | 37.31 | 16.16 | 23.4 | 16 | 84 | 667 | 42 | 57.16 | 47.98 | 12.0 | 376 | 5800 |
| 12 | 25.61 | 16.16 | 11.7 | 16 | 42 | 568 | 48 | 88.37 | 53.96 | 37.0 | 1465 | 9010 |
| | | | | | | | 48 | 75.97 | 53.96 | 24.6 | 974 | 8284 |
| | | | | | | | 48 | 63.67 | 53.96 | 12.3 | 487 | 7504 |

Line Drips—Open Tops (Continued)

| Diameter Branch Inches | Dimensions—Inches A | B | D | Size Plug Inches | Capacity Quarts | Approximate Weight Pounds |
|---|---|---|---|---|---|---|
| 16 | 55.18 | 20.24 | 37.0 | 20 | 208 | 1051 |
| 16 | 42.78 | 20.24 | 24.6 | 20 | 138 | 907 |
| 16 | 30.48 | 20.24 | 12.3 | 20 | 69 | 764 |
| 20 | 60.52 | 24.28 | 38.0 | 24 | 304 | 1500 |
| 20 | 47.92 | 24.28 | 25.4 | 24 | 203 | 1304 |
| 20 | 35.22 | 24.28 | 12.7 | 24 | 100 | 1107 |
| 24 | 60.72 | 30.04 | 34.0 | 30 | 420 | 2070 |
| 24 | 49.32 | 30.04 | 22.6 | 30 | 280 | 1826 |
| 24 | 38.02 | 30.04 | 11.3 | 30 | 140 | 1583 |
| 30 | 66.67 | 36.06 | 34.0 | 36 | 600 | 2944 |
| 30 | 55.27 | 36.06 | 22.6 | 36 | 399 | 2617 |
| 30 | 43.97 | 36.06 | 11.3 | 36 | 198 | 2292 |
| 36 | 74.89 | 42.06 | 36.0 | 42 | 864 | 4104 |
| 36 | 62.89 | 42.06 | 24.0 | 42 | 576 | 3652 |
| 36 | 50.89 | 42.06 | 12.0 | 42 | 288 | 3200 |
| 42 | 81.16 | 47.98 | 36.0 | 48 | 1127 | 5869 |
| 42 | 69.16 | 47.98 | 24.0 | 48 | 752 | 5261 |
| 42 | 57.16 | 47.98 | 12.0 | 48 | 376 | 4652 |
| 48 | 88.37 | 53.96 | 37.0 | 54 | 1465 | 7262 |
| 48 | 75.97 | 53.96 | 24.6 | 54 | 974 | 6506 |
| 48 | 63.67 | 53.96 | 12.3 | 54 | 487 | 5756 |

Side Pots

| Nominal Diameter Inches | A | B | Capacity Quarts | Approximate Weight Pounds |
|---|---|---|---|---|
| 4 | 18 | 16.16 | 63 | 278 |
| 6 | 18 | 16.16 | 63 | 278 |
| 8 | 18 | 16.16 | 63 | 278 |
| 10 | 24 | 20.24 | 130 | 455 |
| 12 | 24 | 20.24 | 130 | 455 |
| 16 | 24 | 20.24 | 130 | 455 |
| 20 | 24 | 20.24 | 130 | 455 |
| 24 | 36 | 24.28 | 282 | 810 |
| 30 | 36 | 24.28 | 282 | 810 |
| 36 | 36 | 24.28 | 282 | 810 |

Dimensions in inches.
Weights given in pounds. All weights approximate.
For dimensions of Bells see page 112.
Weights of Drips figured without plugs.

## Weights of A. G. A. Standard Bell and Spigot Tees, Crosses, Y Branches, Offsets, Caps, Plugs and Sleeves—Table No. 40

| Size | Tees | | Crosses | | Y-Branches | | | Offsets | | Caps | | Plugs | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Two Bells | Three Bells | Three Bells | Four Bells | Size | Three Bells | Two Bells | Size | Weight | Size | Weight | Size | Weight |
| 4x4 | 106 | 105 | 138 | 137 | 4x4 | 105 | 109 | 4x6 | 73 | 4 | 25 | 4 | 9 |
| 6x4 | 144 | 138 | 174 | 169 | | | | 4x12 | 83 | 6 | 37 | 6 | 16 |
| 6x6 | 156 | 151 | 200 | 194 | 6x4 | 154 | 161 | 4x18 | 93 | 8 | 52 | 8 | 24 |
| 8x4 | 194 | 192 | 226 | 224 | 6x6 | 171 | 178 | | | 10 | 65 | 10 | 34 |
| 8x6 | 208 | 206 | 254 | 251 | | | | 6x6 | 113 | 12 | 95 | 12 | 50 |
| | | | | | 8x4 | 215 | 224 | 6x12 | 129 | | | 14 | 66 |
| 8x8 | 223 | 221 | 284 | 282 | 8x6 | 234 | 243 | 6x18 | 145 | 16 | 151 | 16 | 83 |
| 10x4 | 253 | 251 | 287 | 285 | 8x8 | 254 | 263 | | | 20 | 220 | 20 | 127 |
| 10x6 | 267 | 266 | 315 | 314 | | | | 8x6 | 162 | 24 | 330 | 24 | 193 |
| 10x8 | 283 | 282 | 348 | 346 | 10x4 | 285 | 297 | 8x12 | 182 | 30 | 476 | 30 | 294 |
| 10x10 | 296 | 295 | 373 | 372 | 10x6 | 305 | 317 | 8x18 | 204 | 36 | 668 | 36 | 433 |
| 12x4 | 343 | 350 | 379 | 385 | 10x8 | 327 | 339 | | | | | | |
| 12x6 | 359 | 366 | 409 | 416 | 10x10 | 347 | 360 | 10x6 | 216 | 42 | 916 | 42 | 620 |
| 12x8 | 376 | 383 | 443 | 450 | | | | 10x12 | 234 | 48 | 1266 | 48 | 901 |
| 12x10 | 390 | 397 | 471 | 478 | 12x4 | 396 | 406 | 10x18 | 270 | | | | |
| 12x12 | 410 | 417 | 512 | 519 | 12x6 | 418 | 428 | | | | | | |
| 16x6 | 536 | 534 | 582 | 580 | 12x8 | 442 | 453 | 12x6 | 294 | | | | |
| 16x8 | 552 | 549 | 612 | 610 | 12x10 | 466 | 476 | 12x12 | 323 | | | | |
| 16x10 | 563 | 561 | 636 | 634 | 12x12 | 502 | 512 | 12x18 | 362 | | | | |
| 16x12 | 655 | 652 | 768 | 765 | | | | | | | | | |
| 16x16 | 709 | 707 | 877 | 875 | 16x16 | 864 | 859 | 16x6 | 470 | | | | |
| | | | | | | | | 16x12 | 510 | | | | |
| 20x6 | 724 | 730 | 767 | 774 | 20x20 | 1271 | 1245 | 16x18 | 570 | | | | |
| 20x8 | 738 | 745 | 796 | 802 | | | | | | | | | |
| 20x10 | 749 | 755 | 817 | 824 | 24x24 | 1828 | 1753 | 20x6 | 616 | | | | |
| 20x12 | 898 | 893 | 1011 | 1006 | | | | 20x12 | 623 | | | | |
| 20x16 | 953 | 947 | 1120 | 1115 | 30x30 | 2784 | 2672 | 20x18 | 705 | | | | |
| 20x20 | 1001 | 995 | 1216 | 1211 | | | | | | | | | |
| 24x8 | 1023 | 1056 | 1081 | 1114 | 36x36 | 4090 | 3818 | | | | | | |
| 24x10 | 1034 | 1067 | 1103 | 1136 | | | | | | | | | |
| 24x12 | 1056 | 1089 | 1147 | 1180 | 42x42 | 5981 | 5489 | | | | | | |
| 24x16 | 1289 | 1291 | 1456 | 1458 | | | | | | | | | |
| 24x20 | 1336 | 1338 | 1552 | 1554 | 48x48 | 8677 | 7926 | | | | | | |
| 24x24 | 1403 | 1405 | 1684 | 1686 | | | | | | | | | |

## Weights of A. G. A. Standard Bell and Spigot Tees, Crosses, Y Branches, Offsets, Caps, Plugs and Sleeves—Table No. 40 (continued)

| Size | Tees | | Crosses | |
|---|---|---|---|---|
| | Two Bells | Three Bells | Three Bells | Four Bells |
| 30x8 | 1488 | 1546 | 1546 | 1604 |
| 30x10 | 1499 | 1557 | 1568 | 1626 |
| 30x12 | 1521 | 1579 | 1612 | 1670 |
| 30x16 | 1834 | 1828 | 2002 | 1995 |
| 30x20 | 1882 | 1876 | 2098 | 2091 |
| 30x24 | 1948 | 1942 | 2230 | 2223 |
| 30x30 | 2035 | 2029 | 2404 | 2398 |
| 36x12 | 2206 | 2358 | 2308 | 2460 |
| 36x16 | 2255 | 2407 | 2406 | 2558 |
| 36x20 | 2297 | 2449 | 2489 | 2641 |
| 36x24 | 2718 | 2726 | 3015 | 3023 |
| 36x30 | 2789 | 2798 | 3158 | 3166 |
| 36x36 | 2859 | 2867 | 3296 | 3305 |
| 42x16 | 3109 | 3421 | 3269 | 3580 |
| 42x20 | 3154 | 3466 | 3358 | 3670 |
| 42x24 | 3216 | 3528 | 3483 | 3794 |
| 42x30 | 3831 | 3878 | 4221 | 4268 |
| 42x36 | 3908 | 3955 | 4376 | 4423 |
| 42x42 | 3997 | 4144 | 4553 | 4701 |
| 48x16 | 4414 | 4717 | 4574 | 4876 |
| 48x20 | 4459 | 4761 | 4663 | 4965 |
| 48x24 | 4521 | 4824 | 4788 | 5090 |
| 48x30 | 4581 | 4883 | 4907 | 5209 |
| 48x36 | 5331 | 5329 | 5799 | 5797 |
| 48x42 | 5415 | 5413 | 5966 | 5964 |
| 48x48 | 5470 | 5468 | 6076 | 6074 |

| Sleeves | | | | | | | |
|---|---|---|---|---|---|---|---|
| Hub | | Service | | Split | | Solid | |
| Size | Weight | Size | Weight | Size | Weight | Size | Weight |
| 10x4 | 170 | 2 | 38 | 2 | 37 | 2 | 20 |
| 10x6 | 196 | 3 | 57 | 3 | 56 | 3 | 38 |
| | | 4 | 69 | 4 | 67 | 4 | 47 |
| 12x4 | 208 | 6 | 94 | 6 | 87 | 6 | 65 |
| 12x6 | 238 | 8 | 133 | | | | |
| | | 10 | 158 | 8 | 127 | 8 | 100 |
| 16x6 | 343 | 12 | 201 | 10 | 151 | 10 | 122 |
| 16x8 | 352 | 16 | 323 | 12 | 191 | 12 | 160 |
| | | | | 16 | 314 | 16 | 269 |
| 20x6 | 441 | | | | | | |
| 20x8 | 448 | | | 20 | 420 | 20 | 372 |
| 20x10 | 451 | | | 24 | 552 | 24 | 500 |
| | | | | 30 | 729 | 30 | 676 |
| | | | | 36 | 939 | 36 | 871 |
| | | | | 42 | 1204 | 42 | 1133 |
| | | | | 48 | 1507 | 48 | 1421 |

Weights given in pounds. All weights approximate.
For dimensions, see pages 117 and 118.

## Weights of A. G. A. Standard Bell and Spigot ¼—⅛ and $\frac{1}{16}$ Bends

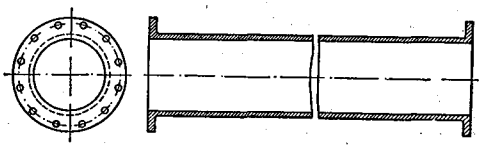
### Table No. 41

| Size | ¼ Bends | | | ⅛ Bends | | | | | | $\frac{1}{16}$ Bends | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Standard | | Long Radius | Type 1 | | Type 2 | Standard | | Long Radius | Type 1 | | Type 2 | Standard | | Long Radius |
| | B. & S. | Two Bells | B. & S. | Two Bells | B. & S. | Two Bells | B. & S. | Two Bells | B. & S. | B. & S. | Two Bells | Two Bells | B. & S. | Two Bells | B. & S. |
| 4 | 68 | 61 | .... | 59 | 63 | 74 | .... | .... | .... | 58 | 58 | 75 | .... | .... | .... |
| 6 | 100 | 95 | .... | 90 | 97 | 113 | .... | .... | .... | 91 | 87 | 114 | .... | .... | .... |
| 8 | 149 | 139 | .... | 129 | 138 | 161 | .... | .... | .... | 130 | 124 | 162 | .... | .... | .... |
| 10 | 198 | 185 | .... | 168 | 183 | 210 | .... | .... | .... | 175 | 160 | 211 | .... | .... | .... |
| 12 | 278 | 267 | .... | 237 | 253 | 291 | .... | .... | .... | 239 | 223 | 290 | .... | .... | .... |
| 16 | 491 | 486 | .... | 397 | 410 | .... | 387 | 377 | 448 | 390 | 373 | .... | 366 | 335 | 449 |
| 20 | 707 | 699 | .... | 585 | 607 | .... | 544 | 546 | 610 | 559 | 538 | .... | 508 | 475 | 611 |
| 24 | 1003 | 1002 | 1158 | 856 | 874 | .... | 748 | 774 | 971 | 798 | 783 | .... | 694 | 666 | 971 |
| 30 | 1478 | 1467 | 1791 | 1274 | 1303 | .... | 1053 | 1111 | 1332 | 1176 | 1153 | .... | 966 | 935 | 1331 |
| 36 | 2121 | 2122 | 2926 | .... | .... | .... | 1445 | 1557 | 2446 | .... | .... | .... | 1306 | 1280 | 2446 |
| 42 | 2984 | 3025 | 4550 | .... | .... | .... | 1948 | 2149 | 3208 | .... | .... | .... | 1744 | 1740 | 3209 |
| 48 | 4193 | 4184 | 6527 | .... | .... | .... | 2625 | 2903 | 4247 | .... | .... | .... | 2319 | 2291 | 4247 |

Weights given in pounds. All weights approximate.
For dimensions, see pages 115 and 116.

# Dimensions and Weights of A. G. A. Standard Flanged Pipe and A. G. A. Standard Drilling of Pipe Flanges

## Table No. 42

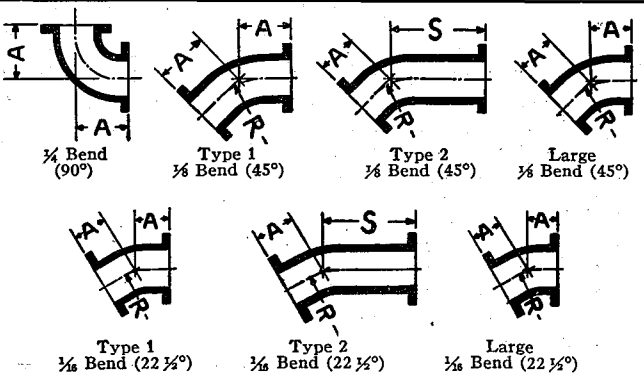


| Nominal Diameter Inches | Actual Outside Diameter | Thickness of Body | Actual Inside Diameter | Dimensions and Drilling of Flanges | | | | | | Approximate Weights | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Diameter of Flange | Thickness of Flange | Diameter of Bolt Circles | Number of Bolts | Diameter of Bolts | Diameter Bolt Holes | One Flange | Foot Without Flanges | 12 Ft. Length With 2 Flanges |
| 4 | 4.80 | .40 | 4.00 | 9 | .720 | 7 1/8 | 4 | 5/8 | 3/4 | 8.19 | 17.22 | 223 |
| 6 | 6.90 | .43 | 6.04 | 11 | .720 | 9 1/8 | 4 | 5/8 | 3/4 | 10.46 | 27.26 | 348 |
| 8 | 9.05 | .45 | 8.15 | 13 | .750 | 11 1/8 | 8 | 5/8 | 3/4 | 12.65 | 37.98 | 481 |
| 10 | 11.10 | .49 | 10.12 | 16 | .860 | 13 3/4 | 8 | 5/8 | 3/4 | 22.53 | 50.91 | 656 |
| 12 | 13.20 | .54 | 12.12 | 18 | .875 | 15 3/4 | 8 | 5/8 | 3/4 | 25.96 | 67.01 | 856 |
| 16 | 17.40 | .62 | 16.16 | 22 1/2 | 1.000 | 20 | 12 | 3/4 | 7/8 | 39.68 | 101.97 | 1303 |
| 20 | 21.60 | .68 | 20.24 | 27 | 1.000 | 24 1/2 | 16 | 3/4 | 7/8 | 51.10 | 139.40 | 1775 |
| 24 | 25.80 | .76 | 24.28 | 31 | 1.125 | 28 1/2 | 16 | 3/4 | 7/8 | 65.00 | 186.58 | 2369 |
| 30 | 31.74 | .85 | 30.04 | 37 1/2 | 1.250 | 35 | 20 | 7/8 | 1 | 96.70 | 257.30 | 3281 |
| 36 | 37.96 | .95 | 36.06 | 44 | 1.375 | 41 1/4 | 24 | 7/8 | 1 | 132.26 | 344.62 | 4400 |
| 42 | 44.20 | 1.07 | 42.06 | 50 3/4 | 1.560 | 47 3/4 | 28 | 1 | 1 1/8 | 186.83 | 452.36 | 5802 |
| 48 | 50.50 | 1.26 | 47.98 | 57 | 1.750 | 54 | 32 | 1 | 1 1/8 | 235.23 | 608.13 | 7768 |

All Flanged Pipe faced to the exact dimension specified. Standard length of Flanged Pipe is 12 feet.
Dimensions in inches.
Weights given in pounds.

# Laying Dimensions of A. G. A. Standard Flanged 1/4—1/8 and 1/16 Bends

Table No. 43



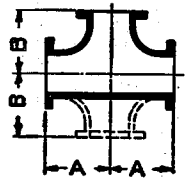

1/4 Bend (90°) — Type 1 1/8 Bend (45°) — Type 2 1/8 Bend (45°) — Large 1/8 Bend (45°)

Type 1 1/16 Bend (22 1/2°) — Type 2 1/16 Bend (22 1/2°) — Large 1/16 Bend (22 1/2°)

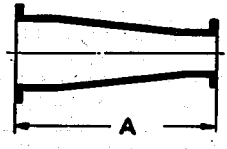
| Size | 1/4 Bends | 1/8 Bends | | | | | | | 1/16 Bends | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Type 1 | | Type 2 | | | Large | | Type 1 | | Type 2 | | | Large | |
| | A | A | R | A | R | S | A | R | A | R | A | R | S | A | R |
| 4 | 8 | 3.16 | 3.04 | 3.16 | 3.04 | 13.65 | .... | .... | 2.69 | 4.00 | 2.69 | 4.00 | 14.70 | .... | .... |
| 6 | 8 | 4.23 | 5.38 | 4.23 | 5.38 | 14.48 | .... | .... | 3.53 | 7.70 | 3.53 | 7.70 | 15.53 | .... | .... |
| 8 | 10 | 5.31 | 7.75 | 5.31 | 7.75 | 15.31 | .... | .... | 4.38 | 11.50 | 4.38 | 11.50 | 16.38 | .... | .... |
| 10 | 12 | 6.39 | 10.36 | 6.39 | 10.36 | 16.14 | .... | .... | 5.22 | 15.70 | 5.22 | 15.70 | 17.25 | .... | .... |
| 12 | 14 | 7.22 | 12.12 | 7.22 | 12.12 | 16.97 | .... | .... | 5.81 | 18.15 | 5.81 | 18.15 | 17.81 | .... | .... |
| 16 | 17 | 9.12 | 16.00 | .... | .... | .... | 7.73 | 12.62 | 7.27 | 24.00 | .... | .... | .... | 5.00 | 12.62 |
| 20 | 19 | 11.03 | 19.87 | .... | .... | .... | 9.30 | 15.69 | 8.71 | 29.75 | .... | .... | .... | 5.92 | 15.69 |
| 24 | 21 | 12.94 | 24.48 | .... | .... | .... | 10.15 | 17.75 | 10.16 | 37.00 | .... | .... | .... | 6.33 | 17.75 |
| 30 | 24 | 15.67 | 30.54 | .... | .... | .... | 11.65 | 20.87 | 12.20 | 46.25 | .... | .... | .... | 7.15 | 20.87 |
| 36 | 28 | .... | .... | .... | .... | .... | 13.34 | 24.50 | .... | .... | .... | .... | .... | 8.07 | 24.50 |
| 42 | 32 | .... | .... | .... | .... | .... | 14.84 | 27.62 | .... | .... | .... | .... | .... | 8.89 | 27.62 |
| 48 | 35 | .... | .... | .... | .... | .... | 16.35 | 30.75 | .... | .... | .... | .... | .... | 9.72 | 30.75 |

Dimensions in inches. For weights see page 130. For drilling of flanges see page 127.

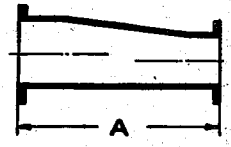
## Laying Dimensions of A. G. A. Standard Flanged Tees, Crosses, Reducers and Hat Flanges



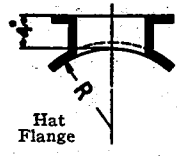
Tee and Cross



Concentric Reducer



Eccentric Reducer



Hat Flange

### Table No. 44

| Tees and Crosses | | | | Reducers | | | | Hat Flanges | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Size Run | Size Branches | A | B | Size | A | Size | A | Size | Size Outlet | R |
| 4 | 4 | 8 | 8 | 4x3 | 10.80 | 30x20 | 44.80 | 20 | 6-8-10-12 | 11.00 |
| 6 | 4-6 | 8 | 8 | 6x3 | 15.90 | 30x24 | 29.80 | 24 | 6-8-10-12 | 13.00 |
| 8 | 4-6-8 | 10 | 10 | 6x4 | 10.90 | 36x24 | 54.00 | 30 | 6-8-10-12 | 16.00 |
| 10 | 4 | 12 | 11 | 8x4 | 19.00 | 36x30 | 30.20 | 36 | 6-8-10-12 | 19.25 |
| 10 | 6-8-10 | 12 | 12 | 8x6 | 11.10 | | | 42 | 6-8-10-12 | 22.37 |
| | | | | | | 42x30 | 54.40 | 48 | 6-8-10-12 | 25.50 |
| 12 | 4-6-8 | 14 | 13 | 10x4 | 27.00 | 42x36 | 30.60 | | | |
| 12 | 10-12 | 14 | 14 | 10x6 | 19.10 | 48x36 | 54.80 | | | |
| 16 | 6-8-10 | 14 | 14 | 10x8 | 11.20 | 48x42 | 31.00 | | | |
| 16 | 12-16 | 17 | 17 | 12x6 | 27.20 | | | | | |
| | | | | 12x8 | 19.30 | | | | | |
| 20 | 6-8-10 | 15 | 15 | 12x10 | 11.30 | | | | | |
| 20 | 12-16-20 | 19 | 19 | | | | | | | |
| 24 | 8-10-12 | 17 | 17 | 16x8 | 36.60 | | | | | |
| 24 | 16-20-24 | 21 | 21 | 16x10 | 28.60 | | | | | |
| | | | | 16x12 | 19.70 | | | | | |
| 30 | 8-10-12 | 20 | 20 | 20x10 | 44.90 | | | | | |
| 30 | 16-20-24-30 | 24 | 24 | 20x12 | 37.00 | | | | | |
| 36 | 12-16-20 | 25 | 25 | 20x16 | 21.30 | | | | | |
| 36 | 24-30-36 | 28 | 28 | | | | | | | |
| 42 | 16-20-24 | 29 | 29 | 24x16 | 35.80 | | | | | |
| 42 | 30-36-42 | 32 | 32 | 24x20 | 20.10 | | | | | |
| 48 | 16-20-24-30 | 32 | 32 | | | | | | | |
| 48 | 36-42-48 | 35 | 35 | | | | | | | |

Dimensions in inches.
For weights, see page 130.
For drilling of flanges, see page 127.

# Weights of A. G. A. Standard Flanged Bends, Tees, Crosses, Reducers and Hat Flanges
## Table No. 45

| Size | ¼ Bends | ⅜ Bends | | | 1/16 Bends | | |
|---|---|---|---|---|---|---|---|
| | | Type 1 | Type 2 | Large | Type 1 | Type 2 | Large |
| 4 | 36 | 25 | 40 | .... | 24 | 41 | .... |
| 6 | 51 | 40 | 63 | .... | 37 | 64 | .... |
| 8 | 78 | 58 | 90 | .... | 53 | 91 | .... |
| 10 | 129 | 97 | 139 | .... | 89 | 140 | .... |
| 12 | 180 | 130 | 184 | .... | 116 | 183 | .... |
| 16 | 315 | 226 | ... | 206 | 202 | ... | 164 |
| 20 | 463 | 349 | ... | 310 | 302 | ... | 239 |
| 24 | 662 | 516 | ... | 434 | 443 | ... | 326 |
| 30 | 1030 | 837 | ... | 674 | 716 | ... | 498 |
| 36 | 1566 | ... | ... | 1001 | ... | ... | 724 |
| 42 | 2324 | ... | ... | 1448 | ... | ... | 1039 |
| 48 | 3340 | ... | ... | 2059 | ... | ... | 1447 |

### Hat Flanges

| Size | Weight | Size | Weight |
|---|---|---|---|
| 20x6 | 43 | 36x6 | 41 |
| 20x8 | 55 | 36x8 | 52 |
| 20x10 | 78 | 36x10 | 75 |
| 20x12 | 97 | 36x12 | 90 |
| 24x6 | 42 | 42x6 | 41 |
| 24x8 | 54 | 42x8 | 52 |
| 24x10 | 76 | 42x10 | 74 |
| 24x12 | 95 | 42x12 | 90 |
| 30x6 | 42 | 48x6 | 41 |
| 30x8 | 53 | 48x8 | 52 |
| 30x10 | 75 | 48x10 | 73 |
| 30x12 | 92 | 48x12 | 90 |

### Tees and Crosses

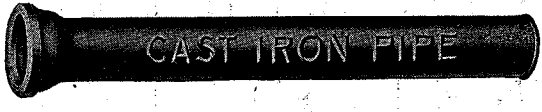
| Size | Tees | Crosses | Size | Tees | Crosses |
|---|---|---|---|---|---|
| 4x4 | 55 | 70 | 30x8 | 1073 | 1096 |
| 6x4 | 71 | 85 | 30x10 | 1085 | 1118 |
| 6x6 | 76 | 94 | 30x12 | 1088 | 1126 |
| 8x4 | 104 | 119 | 30x16 | 1306 | 1387 |
| 8x6 | 110 | 130 | 30x20 | 1321 | 1418 |
| 8x8 | 114 | 139 | 30x24 | 1335 | 1446 |
| 10x4 | 163 | 181 | 30x30 | 1374 | 1524 |
| 10x6 | 170 | 193 | | | |
| 10x8 | 176 | 204 | 36x12 | 1749 | 1797 |
| 10x10 | 189 | 230 | 36x16 | 1766 | 1831 |
| 12x4 | 226 | 244 | 36x20 | 1775 | 1849 |
| 12x6 | 234 | 259 | 36x24 | 2000 | 2127 |
| 12x8 | 240 | 272 | 36x30 | 2024 | 2173 |
| 12x10 | 255 | 300 | 36x36 | 2033 | 2193 |
| 12x12 | 256 | 305 | | | |
| 16x6 | 338 | 359 | 42x16 | 2634 | 2708 |
| 16x8 | 342 | 368 | 42x20 | 2647 | 2733 |
| 16x10 | 355 | 392 | 42x24 | 2657 | 2752 |
| 16x12 | 427 | 487 | 42x30 | 2958 | 3139 |
| 16x16 | 451 | 533 | 42x36 | 2976 | 3166 |
| 20x6 | 469 | 488 | 42x42 | 3092 | 3298 |
| 20x8 | 473 | 495 | 48x16 | 3788 | 3861 |
| 20x10 | 484 | 517 | 48x20 | 3799 | 3885 |
| 20x12 | 603 | 663 | 48x24 | 3810 | 3906 |
| 20x16 | 626 | 708 | 48x30 | 3830 | 3928 |
| 20x20 | 641 | 739 | 48x36 | 4208 | 4398 |
| 24x8 | 680 | 703 | 48x42 | 4219 | 4419 |
| 24x10 | 691 | 725 | 48x48 | 4203 | 4387 |
| 24x12 | 695 | 733 | | | |
| 24x16 | 865 | 947 | | | |
| 24x20 | 880 | 978 | | | |
| 24x24 | 895 | 1006 | | | |

### Reducers

| Size | Wgt. |
|---|---|
| 4x3 | 26 |
| 6x3 | 41 |
| 6x4 | 39 |
| 8x4 | 65 |
| 8x6 | 53 |
| 10x4 | 108 |
| 10x6 | 95 |
| 10x8 | 77 |
| 12x6 | 144 |
| 12x8 | 123 |
| 12x10 | 104 |
| 16x8 | 267 |
| 16x10 | 246 |
| 16x12 | 205 |
| 20x10 | 433 |
| 20x12 | 397 |
| 20x16 | 306 |
| 24x16 | 536 |
| 24x20 | 389 |
| 30x20 | 890 |
| 30x24 | 714 |
| 36x24 | 1395 |
| 36x30 | 987 |
| 42x30 | 1896 |
| 42x36 | 1336 |
| 48x36 | 2547 |
| 48x42 | 1793 |

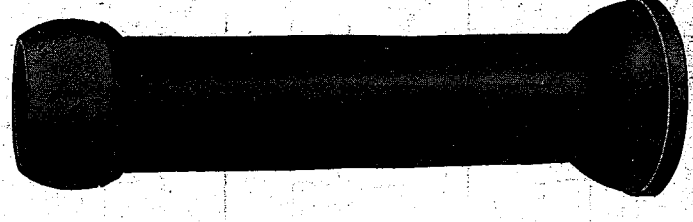
Weights given in pounds. All weights approximate.

For dimensions, see pages 128 and 129. For drilling of flanges, see page 127.




SECTION 7

# JOINTS FOR CAST IRON PIPE



## SECTIONS THROUGH TYPICAL CAST IRON PIPE JOINTS

A. W. W. A. STANDARD

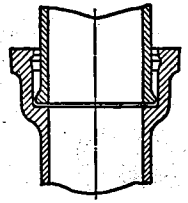


FIG. 1

A. W. W. A. STANDARD (HIGH PRESSURE)

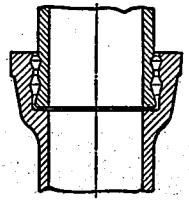


FIG. 2

A. G. A. STANDARD

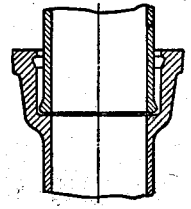


FIG. 3

A. G. A. STANDARD (FOR CEMENT)

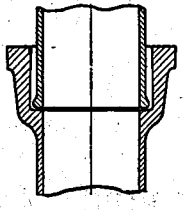


FIG. 4

TURNED & BORED JOINT

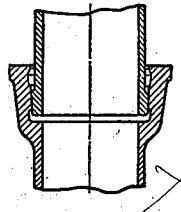


FIG. 5

BELL AND PLAIN END JOINT (METROPOLITAN TYPE)

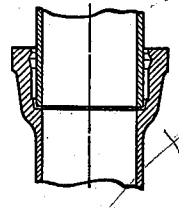


FIG. 6

FLEXIBLE JOINT (METROPOLITAN TYPE)

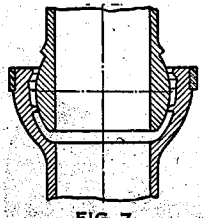


FIG. 7

FLEXIBLE JOINT (NARROWS SIPHON TYPE)

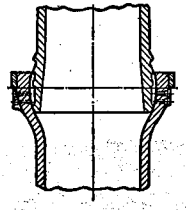


FIG. 8

FLEXIBLE JOINT (WARD TYPE)

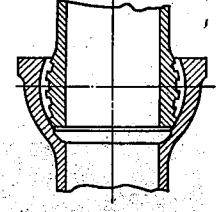


FIG. 9

PLAIN END PIPE WITH DRESSER TYPE COUPLING

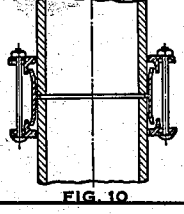


FIG. 10

FLANGED PIPE STANDARD

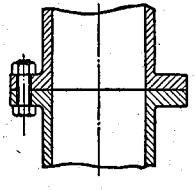


FIG. 11

FLANGED PIPE (HIGH PRESSURE)

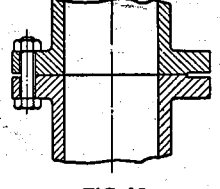


FIG. 12

# TYPES OF JOINTS FOR CAST IRON PIPE

(For Sectional views see page 132)

**American Water Works Association Standard Bell and Spigot Pipe**

## CLASS A-B-C-D

FIG. 1

For ordinary water-works systems the pipe in common use is the A. W. W. A. Bell and Spigot Standard adopted May 12, 1908. This standard is divided into classes designated by letters A-B-C-D-E-F-G and H, each class denoting strength for an additional working pressure of 100 foot head, or 43 pounds per square inch pressure. Thus a Class C pipe is good for a working pressure of 129 pounds per square inch, or a head of 300 feet. For heads up to 400 feet the pipes are made in sizes from 4 inches to 84 inches. For specifications, dimensions and weights of this pipe see pages 53 to 98.

**American Water Works Association Standard Bell and Spigot Pipe**

## CLASS E-F-G-H (high pressure)

FIG. 2

For working pressures over 173 pounds per square inch the A. W. W. A. Standard pipe is made in sizes from 6 inches to 36 inches, and generally known as high-pressure pipe. A typical section through the joint of this pipe is shown in Fig. 2, which in design is similar to Fig. 1,

except that double lead grooves are provided for additional strength and tightness. When this additional protection is not necessary this pipe may be obtained with a single lead groove similar to pipe in Classes A to D. For specifications, dimensions and weight, see pages 53 to 101.

**American Gas Association Standard**
**Bell and Spigot Pipe**
FIG. 3 (for lead)
Type 1

The recognized standard of bell and spigot cast iron pipe for gas is the A. G. A. Standard, adopted October 1913, by the American Gas Institute and revised by the American Gas Association in 1925. This Standard is made in sizes from 4 inches to 48 inches and follows the size scale of the A. W. W. A. Standard, except the 14-inch and 18-inch sizes are excluded. Only one class for each size is made, the outside diameter of the pipe corresponding with the Class A pipe in the A. W. W. A. Standard. For specifications, dimensions and weights, see pages 103 to 130.

**American Gas Association Standard**
**Bell and Spigot Pipe**
FIG. 4 (for cement)
Type 2

To distinguish this pipe from the ordinary A. G. A. Standard pipe for use with lead, it is generally called Type 2. The principal difference between the two types lies in the design of the bell. In the No. 2 the bell is somewhat deeper, the usual lead groove eliminated, and in order to properly secure the cement the inside diameter of the bell is made somewhat larger at the bottom than at the top. This bell is also used with medium

pressure gas by making it up with alternate layers of lead and cement. For specifications, dimensions and weights, see pages 103 to 113.

### Bored Bell and Turned Spigot Pipe

FIG. 5

This type of joint has been used quite extensively in Europe and principally for water lines. The spigot end as well as the inside of the bell are machined on a slight taper, a feature which increases the cost of the pipe. The principal merits in this type lies in the rapidity with which the pipe can be laid and the negligible leakage in the joint. Since this type of pipe is not a recognized standard in this country, pipe foundries only make this pipe to fill special orders.

### Bell and Plain End Joint (Metropolitan Type)

FIG. 6

This type of joint is coming into prominence in this country through its use on deLavaud Centrifugal Pipe. It is a modification of the joint used by the Metropolitan Water Board of London, where the first bell and spigot joint originated. In ordinary bell and spigot pipe the spigot serves two purposes, namely, to center the end of the pipe in the bell and to prevent the hemp from being driven into the pipe between the spigot and the back of the bell. In the new type of joint the taper in the bell fulfills these functions. In laying it is customary to place the end of one pipe in the bell of the next and slide it forward until it rides upon the taper and automatically centers itself.

### Standard Flexible Joint Pipe
### (Metropolitan Type)

FIG. 7

The flexible joint on cast iron pipe is used mostly for submarine lines where the ordinary bell and spigot or flanged joints are not suitable on account of rigidity. As the name implies the joint is flexible, which facilitates the laying of the pipe and permits adjustment of the pipe on river bottoms, where settlements occur after the pipe has been laid. Various types and designs have been brought out, but to James Watt, the inventor of the steam engine, belongs the honor of being the original inventor. Most of the types in general use today are modifications of his original pipe. The Metropolitan joint, which is the most commonly used on account of its simplicity, is shown in Fig. 7. The spigot end of this pipe is carefully machined to a spherical surface, and the integrally cast-on ring on the inside of the bell also machined to a radius corresponding to the diameter of the spigot. This ring serves a threefold purpose: first, it centers the spigot of one pipe with the bell of the other, thus assuring a uniform lead space; second, it provides a stop for the lead and, third, it limits to an exact dimension the distance the spigot extends into the bell, thus providing a solid bearing in the deflection. In this type of joint the lead is stationary and can therefore be readily and effectively caulked, a feature which cannot be accomplished in types where the lead moves with the spigot. In the larger sizes of this type of pipe it is customary to shrink a steel band on the outside of the bell to prevent injury of the pipe in handling and transportation. For dimensions and weights, see page 140.

### Standard Flexible Joint Pipe
### (Narrows Siphon Type)

FIG. 8

This type of flexible joint pipe derives its name from the fact that the first line was installed across the entrance to the New York Harbor, between Brooklyn and Staten Island. Careful and authentic tests have proven this joint to be practically 100 per cent tight. The inside of the bell is carefully machined and ground to gauge on a radius, and the lower end of the spigot is likewise finished to correspond with the diameter of the spherical inside of the bell. Inasmuch as the lead in this joint moves with the spigot in deflecting the pipe the caulking of the lead is not possible, and to compensate for the shrinkage of the lead in cooling, small lead pellets are forced into the lead space by means of gib screws. For dimensions and weights, see page 141.

### Standard Flexible Joint
### (Ward Type)

FIG. 9

This is the oldest type of flexible joint. It is not generally recommended as the lead is retained as a ball on the spigot end, and may be shaved off by the edge of the ball as the pipe is bent. For dimensions and weights, see page 140.

### Plain End Cast Iron Pipe with Dresser Type Couplings

FIG. 10

For high-pressure gas lines and some water lines, an efficient joint can be made by the use of plain-end cast iron pipe and Dresser Couplings. The important

part of this joint is a middle steel ring having in the center a projection against which the two ends of the pipe rest. The middle ring is flared out at each end to receive a rubber ring gasket which later is forced into place by means of two flanges drawn up by bolts. The rubber ring is thus tightly pressed against the outside diameter of the pipe and against the inside of the two flanges, and in this manner a tight joint is secured.

### Cast Iron Standard Flanged Pipe

FIG. 11

This type of joint is used when combined rigidity, strength and tightness are required. The flanges are cast integrally with the pipe and accurately machined to dimensions. The body thicknesses and diameters are made in classes following the A. W. W. A. Standard, and the flanges in accordance with the American Standard for 125 pounds pressure. For dimensions and weights of this pipe, see page 145. For drilling, see page 147.

### Cast Iron Flanged Pipe
### Extra Heavy

FIG. 12

This pipe is similar to the standard except that the faces of the flanges are raised one-sixteenth of an inch to the inside of the bolt holes and body thickness, dimension of flanges and drilling good for a working pressure up to 250 pounds per square inch. This pipe is also made in various classes, although in only one standard for the flanges, namely the American Extra Heavy. For dimensions and weights of this pipe, see page 148. For drilling, see page 149.

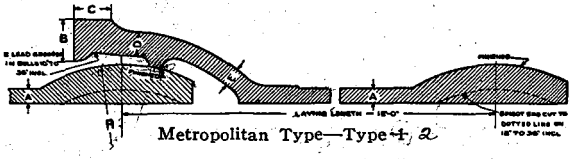
## Maximum Bends in Cast Iron Pipe Joints, Curves Laid with Full Length Bell and Spigot Pipe 12′ 0″ Length

### Table No. 46

| Size of Pipe | Bend in One Joint | Deflection in Inches | Approximate Rad. in Feet of Curve produced by Succession of Joints |
|---|---|---|---|
| 4″ | 4°–00′ | 10.00″ | 170′ |
| 6″ | 3°–30′ | 8.80″ | 196′ |
| 8″ | 3°–14′ | 8.12″ | 212′ |
| 10″ | 3°–07′ | 7.83″ | 226′ |
| 12″ | 3°–00′ | 7.50″ | 230′ |
| 16″ | 2°–41′ | 6.80″ | 260′ |
| 18″ | 2°–26′ | 6.10″ | 283′ |
| 20″ | 2°–09′ | 5.40″ | 320′ |
| 24″ | 1°–47′ | 4.50″ | 390′ |
| 30″ | 1°–26′ | 3.60″ | 480′ |
| 36″ | 1°–12′ | 3.00″ | 570′ |
| 42″ | 1°–02′ | 2.60″ | 660′ |
| 48″ | 0°–55′ | 2.30″ | 750′ |

Joint opening not to exceed .8″.
Caulking space not less than .25″.

## General Dimensions, Thicknesses and Weights of Standard Flexible Joint Pipe



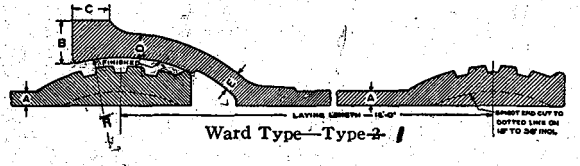

Metropolitan Type—Type ~~1~~, 2

### Table No. 47

| Size Inches | Class | Dimensions—Inches | | | | | | Weight per Length Pounds | Lead per Solid Joint—Pounds | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | A | B | C | D | E | R | | Type ~~1~~ 2 | Type ~~2~~ 1 |
| 6 | B | .48 | 1.56 | 1.37 | 1.00 | .87 | 4.68 | 503 | 9 | 12 |
| 6 | D | .55 | 1.56 | 1.37 | 1.00 | .87 | 4.68 | 555 | 9 | 12 |
| 8 | B | .51 | 1.81 | 1.56 | 1.12 | .94 | 5.92 | 673 | 14 | 19 |
| 8 | D | .60 | 1.81 | 1.56 | 1.12 | .94 | 5.92 | 780 | 14 | 19 |
| 10 | B | .57 | 2.06 | 1.75 | 1.18 | 1.00 | 7.20 | 947 | 22 | 28 |
| 10 | D | .68 | 2.06 | 1.75 | 1.18 | 1.00 | 7.20 | 1080 | 22 | 28 |
| 12 | B | .62 | 2.25 | 1.87 | 1.25 | 1.06 | 8.50 | 1210 | 39 | 49 |
| 12 | D | .75 | 2.25 | 1.87 | 1.25 | 1.06 | 8.50 | 1400 | 39 | 49 |
| 14 | B | .66 | 2.50 | 2.00 | 1.31 | 1.12 | 9.75 | 1450 | 51 | 64 |
| 14 | D | .82 | 2.50 | 2.00 | 1.31 | 1.12 | 9.75 | 1750 | 51 | 64 |
| 16 | B | .70 | 2.75 | 2.12 | 1.43 | 1.25 | 10.88 | 1862 | 60 | 76 |
| 16 | D | .89 | 2.75 | 2.12 | 1.43 | 1.25 | 10.88 | 2250 | 60 | 76 |
| 18 | B | .75 | 2.87 | 2.25 | 1.56 | 1.31 | 12.06 | 2300 | 73 | 91 |
| 18 | D | .96 | 2.87 | 2.25 | 1.56 | 1.31 | 12.06 | 2760 | 73 | 91 |
| 20 | B | .80 | 3.12 | 2.37 | 1.62 | 1.37 | 13.44 | 2625 | 92 | 112 |
| 20 | D | 1.03 | 3.12 | 2.37 | 1.62 | 1.37 | 13.44 | 3200 | 92 | 112 |
| 24 | B | .89 | 3.37 | 2.68 | 1.75 | 1.50 | 15.56 | 3534 | 112 | 136 |
| 24 | D | 1.16 | 3.37 | 2.68 | 1.75 | 1.50 | 15.56 | 4290 | 112 | 136 |
| 30 | B | 1.03 | 3.87 | 3.18 | 2.12 | 1.72 | 18.38 | 5067 | 146 | 181 |
| 30 | D | 1.37 | 3.87 | 3.18 | 2.12 | 1.72 | 18.38 | 6360 | 146 | 181 |
| 36 | B | 1.15 | 4.12 | 3.50 | 2.50 | 1.94 | 21.88 | 6063 | 177 | 225 |
| 36 | D | 1.58 | 4.12 | 3.50 | 2.50 | 1.94 | 21.88 | 7900 | 177 | 225 |

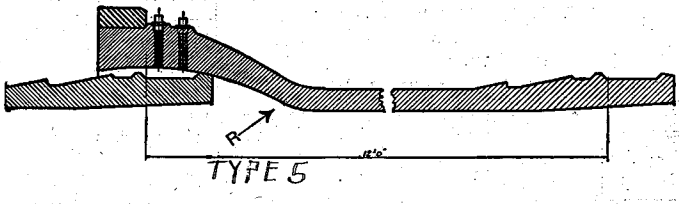
Weights will be furnished on application

All weights approximate.
Deflection about 13 degrees.
For heavy service, see types shown in the following tables.




Ward Type—Type ~~2~~ 1

## General Dimensions, Thickness and Weights of Standard Narrows Siphon Type Flexible Joint Pipe




### Table No. 48

| Size Inches | Thickness Inches | Radius R Inches | Gib Screws | | Weight Pounds |
|---|---|---|---|---|---|
| | | | Diameter Inches | Number | |
| 14 | .82 | 9.50 | 13/16 | 16 | 1903 |
| 16 | .89 | 10.88 | 13/16 | 16 | 2488 |
| 18 | .96 | 11.94 | 13/16 | 18 | 3018 |
| 20 | 1.03 | 13.00 | 13/16 | 20 | 3502 |
| 24 | 1.16 | 15.13 | 13/16 | 24 | 4676 |
| 30 | 1.37 | 18.03 | 13/16 | 28 | 6629 |
| 36 | 1.58 | 21.56 | 13/16 | 36 | 9212 |
| 42 | 1.78 | 24.75 | 13/16 | 40 | 12370 |
| 48 | 1.96 | 28.00 | 13/16 | 44 | 15652 |

All weights approximate.

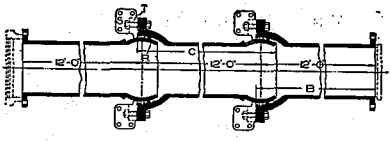
Based on Class D Pipe.

Maximum angle of deflection 10° 30′.

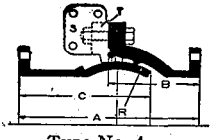
For work in deep water a new type of joint known as the Narrows Siphon Flexible Joint has been developed. This combines absolute tightness with ease of laying and is ideal for deep water installations. Designed primarily for the first Narrows Siphon it proved so satisfactory that it was used for the parallel line of larger capacity.

For work in deep water it is advisable to use a laying cradle and lay the pipe in a continuous line rather than make up several lengths on the surface and join the sections under water. The use of this cradle and resulting deflection of the joint would loosen lead calked in the usual way. In this Type Flexible Joint Pipe the lead is calked throughout the bell instead of only on the surface. This is accomplished by forcing additional lead through the holes in the bell. As a result of this process the joint is absolutely tight even after deflection.

# General Dimensions, Thicknesses and Weights of Standard Flexible Joint Pipe




Type No. 3




Type No. 4

## Table No. 49

Dimensions Common to Nos. 3 and 4

| Size Inches | Class D Thickness Inches | Radius R Inches | Gun-Metal Bolts in | |
|---|---|---|---|---|
| | | | Joint S | Flange T |
| 12 | .75 | 7.80 | 6 | 16 |
| 14 | .82 | 8.95 | 6 | 18 |
| 16 | .89 | 10.10 | 6 | 20 |
| 18 | .96 | 11.35 | 6 | 22 |
| 20 | 1.03 | 12.90 | 6 | 24 |
| 24 | 1.16 | 15.05 | 6 | 28 |
| 30 | 1.37 | 18.75 | 6 | 28 |
| 36 | 1.58 | 22.20 | 6 | 32 |

Full Lengths, Type No. 3

| Size Inches | Lengths—Inches | | Approximate Pounds Section C |
|---|---|---|---|
| | B | C | |
| 12 | 145.13 | 148.93 | 1514 |
| 14 | 145.75 | 150.65 | 1937 |
| 16 | 145.81 | 151.13 | 2402 |
| 18 | 146.00 | 152.00 | 2834 |
| 20 | 146.20 | 152.83 | 3491 |
| 24 | 146.20 | 153.60 | 4693 |
| 30 | 146.75 | 155.75 | 6914 |
| 36 | 147.00 | 157.40 | 9941 |

Short Lengths, Type No. 4

| Size Inches | Lengths—Inches | | | Approximate Pounds per Joint |
|---|---|---|---|---|
| | A | B | C | |
| 12 | 22.00 | 11.13 | 15.80 | 638 |
| 14 | 22.50 | 11.75 | 17.40 | 816 |
| 16 | 25.50 | 13.31 | 19.32 | 1056 |
| 18 | 26.00 | 14.00 | 20.00 | 1212 |
| 20 | 28.00 | 15.20 | 21.63 | 1601 |
| 24 | 31.00 | 16.70 | 23.90 | 2219 |
| 30 | 35.25 | 19.00 | 28.00 | 3180 |
| 36 | 38.00 | 21.00 | 30.40 | 5252 |

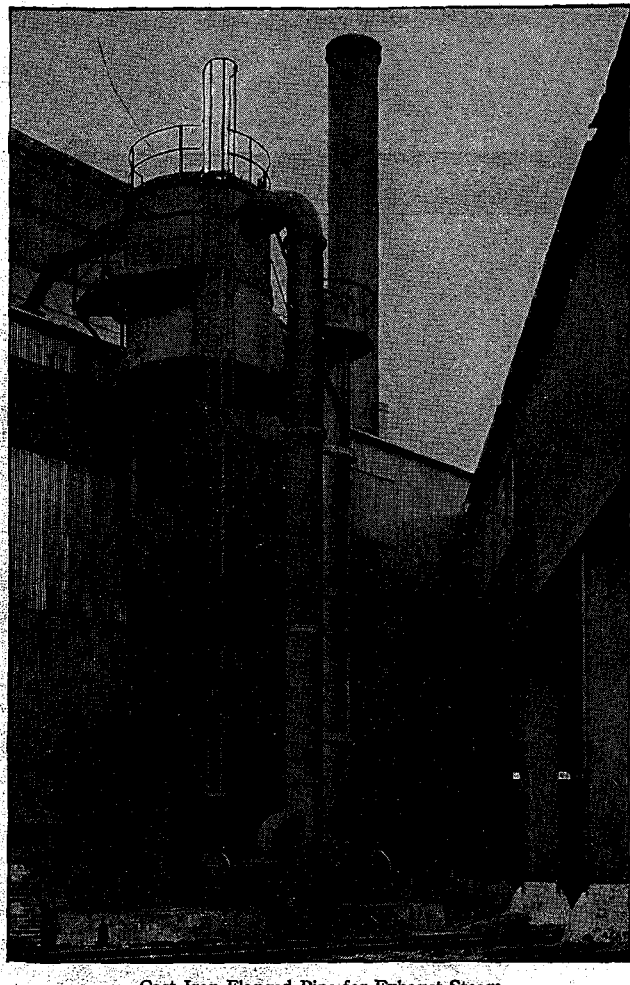
Made to order only. Maximum deflection about 18 degrees. Weights approximate only. Type No. 3 end sections may be ordered bell or spigot instead of flange if desired. Flange dimensions Class D. Bolts furnished to order only—not included with the castings. Type No. 4 joints are furnished complete with lead calked bell and bolted collar, ready for use. Details modified to meet special requirements.




# SECTION 8

# STANDARD FLANGED PIPE





Cast Iron Flanged Pipe for Exhaust Steam

# Dimensions and Weights of Standard Flanged Pipe Classes A and B

## Table No. 50

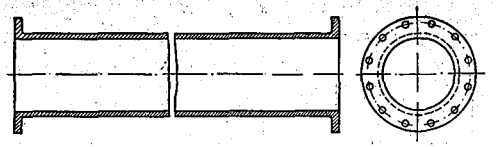



| Dimensions and Drilling of Flanges | | | | | | Class A—100-Foot Head 43 Pounds Pressure | | | | Class B—200-Foot Head 86 Pounds Pressure | | | | Nominal Diameter Inches |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Nominal Diameter Inches | Diameter of Flange, Inches | Thickness of Flange, Inches | Diameter of Bolt Circle, Inches | Number of Bolts | Diameter of Bolts Inches | Thickness Inches | Weight, Pounds per Foot without Flanges | Weight, Pounds per 12-Foot Length 2 Flanges | Weight, Pounds per Single Flange | Thickness Inches | Weight, Pounds per Foot without Flanges | Weight, Pounds per 12-Foot Length 2 Flanges | Weight, Pounds per Single Flange | |
| 3 | 7.50 | .75 | 6.00 | 4 | ⅝ | .39 | 13.0 | 169 | 6.4 | .42 | 14.6 | 188 | 6.2 | 3 |
| 4 | 9.00 | .94 | 7.50 | 8 | ⅝ | .42 | 18.0 | 238 | 11.1 | .45 | 20.1 | 263 | 10.7 | 4 |
| 6 | 11.00 | 1.00 | 9.50 | 8 | ¾ | .44 | 27.9 | 365 | 15.0 | .48 | 31.1 | 402 | 14.4 | 6 |
| 8 | 13.50 | 1.13 | 11.75 | 8 | ¾ | .46 | 38.7 | 511 | 23.1 | .51 | 42.7 | 559 | 23.1 | 8 |
| 10 | 16.00 | 1.19 | 14.25 | 12 | ⅞ | .50 | 51.9 | 687 | 32.2 | .57 | 58.8 | 770 | 32.2 | 10 |
| 12 | 19.00 | 1.25 | 17.00 | 12 | ⅞ | .54 | 67.0 | 899 | 47.7 | .62 | 76.4 | 1012 | 47.7 | 12 |
| 14 | 21.00 | 1.38 | 18.75 | 12 | 1 | .57 | 82.3 | 1104 | 58.1 | .66 | 94.7 | 1253 | 58.1 | 14 |
| 16 | 23.50 | 1.44 | 21.25 | 16 | 1 | .60 | 98.8 | 1332 | 73.2 | .70 | 114.6 | 1522 | 73.2 | 16 |
| 18 | 25.00 | 1.56 | 22.75 | 16 | 1⅛ | .64 | 118.3 | 1576 | 78.1 | .75 | 137.8 | 1810 | 78.1 | 18 |
| 20 | 27.50 | 1.69 | 25.00 | 20 | 1⅛ | .67 | 137.4 | 1848 | 99.8 | .80 | 163.1 | 2157 | 99.8 | 20 |
| 24 | 32.00 | 1.88 | 29.50 | 20 | 1¼ | .76 | 186.5 | 2512 | 137.2 | .89 | 217.3 | 2882 | 137.2 | 24 |
| 30 | 38.75 | 2.13 | 36.00 | 28 | 1¼ | .88 | 266.1 | 3622 | 214.4 | 1.03 | 312.6 | 4166 | 207.2 | 30 |
| 36 | 46.00 | 2.38 | 42.75 | 32 | 1⅜ | .99 | 358.7 | 4959 | 327.4 | 1.15 | 418.7 | 5654 | 314.8 | 36 |
| 40 | 50.75 | 2.50 | 47.25 | 36 | 1⅜ | 1.06 | 427.2 | 5940 | 406.6 | 1.23 | 497.0 | 6753 | 394.5 | 40 |
| 42 | 53.00 | 2.63 | 49.50 | 36 | 1½ | 1.10 | 464.6 | 6492 | 458.5 | 1.28 | 542.2 | 7395 | 444.2 | 42 |
| 48 | 59.50 | 2.75 | 56.00 | 44 | 1½ | 1.26 | 608.0 | 8408 | 555.9 | 1.42 | 687.2 | 9324 | 538.9 | 48 |

See notes on next page.

# Dimensions and Weights of Standard Flanged Pipe Classes C and D

## Table No. 50 (continued)



| Dimensions and Drilling of Flanges | | | | | | Class C—300-Foot Head 130 Pounds Pressure | | | | Class D—400-Foot Head 173 Pounds Pressure | | | | Nominal Diameter Inches |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Nominal Diameter Inches | Diameter of Flange, Inches | Thickness of Flange, Inches | Diameter of Bolt Circle, Inches | Number of Bolts | Diameter of Bolts Inches | Thickness Inches | Weight, Pounds per | | | Thickness Inches | Weight, Pounds per | | | |
| | | | | | | | Foot without Flanges | 12-Foot Length 2Fl'nges | Single Flange | | Foot without Flanges | 12-Foot Length 2Fl'nges | Single Flange | |
| 3 | 7.50 | .75 | 6.00 | 4 | ⅝ | .45 | 15.5 | 198 | 6.2 | .48 | 16.4 | 209 | 6.2 | 3 |
| 4 | 9.00 | .94 | 7.50 | 8 | ⅝ | .48 | 21.3 | 277 | 10.7 | .52 | 22.8 | 295 | 10.7 | 4 |
| 6 | 11.00 | 1.00 | 9.50 | 8 | ¾ | .51 | 32.9 | 424 | 14.4 | .55 | 35.3 | 452 | 14.4 | 6 |
| 8 | 13.50 | 1.13 | 11.75 | 8 | ¾ | .56 | 48.0 | 620 | 22.0 | .60 | 51.2 | 658 | 22.0 | 8 |
| 10 | 16.00 | 1.19 | 14.25 | 12 | ⅞ | .62 | 65.5 | 847 | 30.6 | .68 | 71.4 | 918 | 30.6 | 10 |
| 12 | 19.00 | 1.25 | 17.00 | 12 | ⅞ | .68 | 85.4 | 1116 | 45.6 | .75 | 93.7 | 1216 | 45.6 | 12 |
| 14 | 21.00 | 1.38 | 18.75 | 12 | 1 | .74 | 108.1 | 1407 | 55.1 | .82 | 119.2 | 1541 | 55.1 | 14 |
| 16 | 23.50 | 1.44 | 21.25 | 16 | 1 | .80 | 133.3 | 1738 | 69.1 | .89 | 147.5 | 1908 | 69.1 | 16 |
| 18 | 25.00 | 1.56 | 22.75 | 16 | 1⅛ | .87 | 162.4 | 2094 | 72.8 | .96 | 178.4 | 2286 | 72.8 | 18 |
| 20 | 27.50 | 1.69 | 25.00 | 20 | 1⅛ | .92 | 190.6 | 2473 | 92.9 | 1.03 | 212.3 | 2733 | 92.9 | 20 |
| 24 | 32.00 | 1.88 | 29.50 | 20 | 1¼ | 1.04 | 257.6 | 3345 | 126.8 | 1.16 | 286.0 | 3686 | 126.8 | 24 |
| 30 | 38.75 | 2.13 | 36.00 | 28 | 1¼ | 1.20 | 366.9 | 4795 | 196.0 | 1.37 | 421.2 | 5427 | 186.4 | 30 |
| 36 | 46.00 | 2.38 | 42.75 | 32 | 1½ | 1.36 | 497.7 | 6572 | 299.9 | 1.58 | 581.9 | 7548 | 282.5 | 36 |
| 40 | 50.75 | 2.50 | 47.25 | 36 | 1⅝ | 1.48 | 601.6 | 7965 | 372.7 | 1.72 | 703.4 | 9143 | 351.1 | 40 |
| 42 | 53.00 | 2.63 | 49.50 | 36 | 1½ | 1.54 | 657.4 | 8720 | 415.4 | 1.78 | 764.1 | 9953 | 392.1 | 42 |
| 48 | 59.50 | 2.75 | 56.00 | 44 | 1½ | 1.71 | 832.7 | 11001 | 504.4 | 1.96 | 960.8 | 12471 | 470.8 | 48 |

Flanges in accordance with American Standard for 125 pounds steam pressure. For dimensions of flanges see page 147.
All flanged pipe faced to exact dimension specified. All weights approximate. Standard length of flanged pipe is 12 feet.

# American Standard *Dimensions and Drilling Templates of Flanges for Cast Iron Pipe and Fittings for Maximum Working Saturated Steam Pressure of 125 Pounds per Square Inch

## Table No. 51

| Nominal Size Inches | Diameter of Flange Inches | Thickness of Flange Inches | Diameter of Bolt Circle Inches | Number of Bolts | Size of Bolts Inches | Size of Bolt Holes Inches | Length of Bolts Inches |
|---|---|---|---|---|---|---|---|
| 1 | 4 ¼ | 7/16 | 3 1/8 | 4 | ½ | 5/8 | 1 ½ |
| 1 ¼ | 4 5/8 | ½ | 3 ½ | 4 | ½ | 5/8 | 1 ¾ |
| 1 ½ | 5 | 9/16 | 3 7/8 | 4 | ½ | 5/8 | 2 |
| 2 | 6 | 5/8 | 4 ¾ | 4 | 5/8 | ¾ | 2 |
| 2 ½ | 7 | 11/16 | 5 ½ | 4 | 5/8 | ¾ | 2 ¼ |
| 3 | 7 ½ | ¾ | 6 | 4 | 5/8 | ¾ | 2 ¼ |
| 3 ½ | 8 ½ | 13/16 | 7 | 8 | 5/8 | ¾ | 2 ½ |
| 4 | 9 | 15/16 | 7 ½ | 8 | 5/8 | ¾ | 2 ¾ |
| 5 | 10 | 15/16 | 8 ½ | 8 | ¾ | 7/8 | 2 ¾ |
| 6 | 11 | 1 | 9 ½ | 8 | ¾ | 7/8 | 3 |
| 8 | 13 ½ | 1 1/8 | 11 ¾ | 8 | ¾ | 7/8 | 3 ¼ |
| 10 | 16 | 1 3/16 | 14 ¼ | 12 | 7/8 | 1 | 3 ½ |
| 12 | 19 | 1 ¼ | 17 | 12 | 7/8 | 1 | 3 ½ |
| 14 OD | 21 | 1 3/8 | 18 ¾ | 12 | 1 | 1 1/8 | 4 |
| 16 | 23 ½ | 1 7/16 | 21 ¼ | 16 | 1 | 1 1/8 | 4 ¼ |
| 18 | 25 | 1 7/16 | 22 ¾ | 16 | 1 1/8 | 1 ¼ | 4 ½ |
| 20 | 27 ½ | 1 15/16 | 25 | 20 | 1 1/8 | 1 ¼ | 4 ¾ |
| 24 | 32 | 1 7/8 | 29 ½ | 20 | 1 ¼ | 1 3/8 | 5 ¼ |
| 30 | 38 ¾ | 2 1/8 | 36 | 28 | 1 ¼ | 1 3/8 | 5 ¾ |
| 36 | 46 | 2 3/8 | 42 ¾ | 32 | 1 ½ | 1 5/8 | 6 ½ |
| 42 | 53 | 2 5/8 | 49 ½ | 36 | 1 ½ | 1 5/8 | 7 ¼ |
| 48 | 59 ½ | 2 ¾ | 56 | 44 | 1 ½ | 1 5/8 | 7 ½ |
| 54 | 66 ¼ | 3 | 62 ¾ | 44 | 1 ¾ | 2 | 8 ¼ |
| 60 | 73 | 3 1/8 | 69 ¼ | 52 | 1 ¾ | 2 | 8 ½ |
| 72 | 86 ½ | 3 ½ | 82 ½ | 60 | 1 ¾ | 2 | 9 ½ |
| 84 | 99 ¾ | 3 7/8 | 95 ½ | 64 | 2 | 2 ¼ | 10 ½ |
| 96 | 113 ¼ | 4 ¼ | 108 ½ | 68 | 2 ¼ | 2 ½ | 11 ½ |

All dimensions in inches.

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 ¾ inches the bolt holes are drilled 1/8 inch and for bolts 1 ¾ inches and larger the bolt holes are drilled ¼ inch larger than the nominal diameter of bolts.

The bolt holes on cast iron flanged fittings are not spot faced for ordinary service. When required, the fittings and flanges in sizes 36 inches and larger can be spot faced or back faced, so that standard length bolts can be used.

Flanges to be plain faced.

*See note page 164.

## Dimensions and Weights of High Pressure Flanged Pipe—Classes E, F, G and H.




Table No. 52

| Dimensions and Drilling of Flanges | | | | | | Class E—500-Foot Head 217 Pounds Pressure | | | | Class F—600-Foot Head 260 Pounds Pressure | | | | Nominal Diameter Inches |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Nominal Diameter Inches | Diameter of Flange, Inches | Thickness of Flange, Inches | Diameter of Bolt Circle, Inches | Number of Bolts | Diameter of Bolts Inches | Thickness Inches | Weight, Pounds per | | | Thickness Inches | Weight, Pounds per | | | |
| | | | | | | | Foot without Flanges | 12-Foot Length 2 Flange | Single Flange | | Foot without Flanges | 12-Foot Length 2 Flange | Single Flange | |
| 6 | 12.50 | 1.44 | 10.63 | 12 | ¾ | .58 | 37.7 | 515 | 31.1 | .61 | 39.5 | 536 | 31.1 | 6 |
| 8 | 15.00 | 1.62 | 13.00 | 12 | ⅞ | .66 | 54.7 | 748 | 45.9 | .71 | 60.6 | 819 | 45.9 | 8 |
| 10 | 17.50 | 1.87 | 15.25 | 16 | 1 | .74 | 78.8 | 1079 | 66.5 | .80 | 84.7 | 1149 | 66.5 | 10 |
| 12 | 20.50 | 2.00 | 17.75 | 16 | 1⅛ | .82 | 104.2 | 1441 | 95.1 | .89 | 112.4 | 1539 | 95.1 | 12 |
| 14 | 23.00 | 2.13 | 20.25 | 20 | 1⅛ | .90 | 133.1 | 1837 | 120.1 | .99 | 146.2 | 1995 | 120.1 | 14 |
| 16 | 25.50 | 2.25 | 22.50 | 20 | 1¼ | .98 | 165.0 | 2277 | 148.7 | 1.08 | 180.8 | 2467 | 148.7 | 16 |
| 18 | 28.00 | 2.37 | 24.75 | 24 | 1¼ | 1.07 | 202.3 | 2790 | 181.2 | 1.17 | 219.8 | 3000 | 181.2 | 18 |
| 20 | 30.50 | 2.50 | 27.00 | 24 | 1¼ | 1.15 | 241.1 | 3328 | 217.3 | 1.27 | 262.5 | 3585 | 217.3 | 20 |
| 24 | 36.00 | 2.75 | 32.00 | 24 | 1½ | 1.31 | 328.5 | 4590 | 323.8 | 1.45 | 361.6 | 4987 | 323.8 | 24 |
| 30 | 43.00 | 3.00 | 39.25 | 28 | 1¾ | 1.55 | 484.7 | 6747 | 465.3 | 1.73 | 538.0 | 7357 | 450.3 | 30 |
| 36 | 50.00 | 3.37 | 46.00 | 32 | 2 | 1.80 | 674.2 | 9384 | 646.8 | 2.02 | 748.7 | 10229 | 622.2 | 36 |
| Class G—700-Foot Head. 304 Pounds Presssure | | | | | | | | | | Class H—800-Foot Head. 347 Pounds Pressure | | | | |
| 6 | 12.50 | 1.44 | 10.63 | 12 | ¾ | .65 | 42.9 | 576 | 30.4 | .69 | 45.2 | 603 | 30.4 | 6 |
| 8 | 15.00 | 1.62 | 13.00 | 12 | ⅞ | .75 | 65.1 | 871 | 44.7 | .80 | 68.8 | 915 | 44.7 | 8 |
| 10 | 17.50 | 1.87 | 15.25 | 16 | 1 | .86 | 92.5 | 1239 | 64.3 | .92 | 98.5 | 1311 | 64.3 | 10 |
| 12 | 20.50 | 2 00 | 17.75 | 16 | 1⅛ | .97 | 124.6 | 1678 | 91.6 | 1.04 | 132.9 | 1778 | 91.6 | 12 |
| 14 | 23.00 | 2.12 | 20.25 | 20 | 1⅛ | 1.07 | 160.2 | 2153 | 115.2 | 1.16 | 172.6 | 2302 | 115.2 | 14 |
| 16 | 25.50 | 2.25 | 22.50 | 20 | 1¼ | 1.18 | 199.2 | 2675 | 142.1 | 1.27 | 215.0 | 2864 | 142.1 | 16 |
| 18 | 28.00 | 2.37 | 24.75 | 24 | 1¼ | 1.28 | 244.6 | 3280 | 172.2 | 1.39 | 264.1 | 3514 | 172.2 | 18 |
| 20 | 30.50 | 2.50 | 27.00 | 24 | 1¼ | 1.39 | 294.4 | 3945 | 205.9 | 1.51 | 318.3 | 4231 | 205.9 | 20 |
| 24 | 36.00 | 2.75 | 32.00 | 24 | 1½ | 1.75 | 446.2 | 5948 | 296.8 | 1.88 | 476.9 | 6316 | 296.8 | 24 |

Flanges in accordance with American Standard for 250 pounds steam pressure. For dimensions see page 149. All flanged pipe faced to the exact dimensions specified. The standard length of flanged pipe is 12 feet. All weights approximate. Flanges furnished with raised faces unless otherwise specified. For special flanges see page 151.

# American Standard *Dimensions and Drilling Templates of Flanges for Cast Iron Pipe and Fittings for Maximum Working Saturated Steam Pressure of 250 Pounds per Square Inch

## Table No. 53

| Nominal Size Inches | Diameter of Flange Inches | Thickness of Flange Inches | Diameter of Raised Face Inches | Diameter of Bolt Circle Inches | Number of Bolts | Size of Bolts Inches | Size of Bolt Holes Inches | Length of Bolts Inches |
|---|---|---|---|---|---|---|---|---|
| 1 | 4 3/8 | 11/16 | 2 11/16 | 3 1/2 | 4 | 5/8 | 3/4 | 2 1/4 |
| 1 1/4 | 5 1/4 | 3/4 | 3 1/16 | 3 7/8 | 4 | 5/8 | 3/4 | 2 1/2 |
| 1 1/2 | 6 1/8 | 13/16 | 3 9/16 | 4 1/2 | 4 | 3/4 | 7/8 | 2 1/2 |
| 2 | 6 1/2 | 7/8 | 4 3/16 | 5 | 8 | 5/8 | 3/4 | 3 |
| 2 1/2 | 7 1/2 | 1 | 4 15/16 | 5 7/8 | 8 | 3/4 | 7/8 | 3 |
| 3 | 8 1/4 | 1 1/8 | 5 11/16 | 6 5/8 | 8 | 3/4 | 7/8 | 3 1/4 |
| 3 1/2 | 9 | 1 3/16 | 6 7/16 | 7 1/4 | 8 | 3/4 | 7/8 | 3 1/4 |
| 4 | 10 | 1 1/4 | 6 15/16 | 7 7/8 | 8 | 3/4 | 7/8 | 3 1/2 |
| 5 | 11 | 1 3/8 | 8 5/16 | 9 1/4 | 8 | 3/4 | 7/8 | 3 3/4 |
| 6 | 12 1/2 | 1 7/16 | 9 11/16 | 10 5/8 | 12 | 3/4 | 7/8 | 3 3/4 |
| 8 | 15 | 1 5/8 | 11 15/16 | 13 | 12 | 7/8 | 1 | 4 1/4 |
| 10 | 17 1/2 | 1 7/8 | 14 1/16 | 15 1/4 | 16 | 1 | 1 1/8 | 5 |
| 12 | 20 1/2 | 2 | 16 7/16 | 17 3/4 | 16 | 1 1/8 | 1 1/4 | 5 1/2 |
| 14 O. D. | 23 | 2 1/8 | 18 15/16 | 20 1/4 | 20 | 1 1/8 | 1 1/4 | 5 1/2 |
| 16 O. D. | 25 1/2 | 2 1/4 | 21 1/16 | 22 1/2 | 20 | 1 1/4 | 1 3/8 | 6 |
| 18 O. D. | 28 | 2 3/8 | 23 5/16 | 24 3/4 | 24 | 1 1/4 | 1 3/8 | 6 1/4 |
| 20 O. D. | 30 1/2 | 2 1/2 | 25 7/16 | 27 | 24 | 1 1/4 | 1 3/8 | 6 1/2 |
| 24 O. D. | 36 | 2 3/4 | 30 5/16 | 32 | 24 | 1 1/2 | 1 5/8 | 7 1/2 |
| 30 O. D. | 43 | 3 | 37 3/16 | 39 1/4 | 28 | 1 3/4 | 2 | 8 1/4 |
| 36 O. D. | 50 | 3 3/8 | 43 11/16 | 46 | 32 | 2 | 2 1/4 | 9 1/4 |
| 42 O. D. | 57 | 3 11/16 | 50 7/16 | 52 3/4 | 36 | 2 | 2 1/4 | 9 3/4 |
| 48 O. D. | 65 | 4 | 57 7/16 | 60 3/4 | 40 | 2 | 2 1/4 | 10 1/2 |

All dimensions in inches.

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.

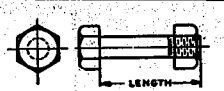
For bolt holes smaller than 1 3/4 inches the bolt holes are drilled 1/8 inch and for bolts 1 3/4 inches and larger the bolt holes are drilled 1/4 inch larger than the nominal diameter of bolts.

The bolt holes on cast iron flanged fittings are not spot faced for ordinary service. When required, the fittings and flanges in sizes 36 inches and larger can be spot faced or back faced, so that standard length bolts can be used.

Flanges shall have a raised face 1/16 inch high included in the minimum flange thickness dimensions.

In sizes 14 inches and larger "Nominal Size" refers to outside diameter of fittings; for flange pipe as shown on page 148, however, this figure represents the inside diameter of the pipe.

*See note page 164.




Hex. Head Bolt and Nut




Square Head Bolt and Nut

# Dimensions of Standard Bolts and Nuts for American Standard Flanges

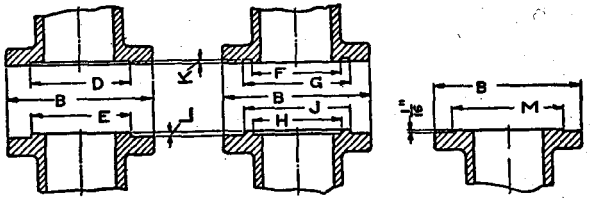
## Table No. 54

| Diameter of Bolt | Threads per Inch | Area at Root of Threads | Hexagon Head | | | Hexagon Nut | | | Square Head | | | Square Nut | | | Total Load at 10,000 Lbs. per Square Inch |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | | | |
| 1/4 | 20 | 0.026 | 3/8 | 29/64 | 3/16 | 1/2 | 37/64 | 1/4 | 3/8 | 17/32 | 3/16 | 1/2 | 45/64 | 1/4 | 260 |
| 5/16 | 18 | 0.045 | 15/32 | 35/64 | 15/64 | 19/32 | 11/16 | 5/16 | 15/32 | 21/32 | 15/64 | 19/32 | 27/32 | 5/16 | 450 |
| 3/8 | 16 | 0.067 | 9/16 | 41/64 | 9/32 | 11/16 | 51/64 | 3/8 | 9/16 | 51/64 | 9/32 | 11/16 | 63/64 | 3/8 | 670 |
| 7/16 | 14 | 0.092 | 21/32 | 3/4 | 21/64 | 25/32 | 29/32 | 7/16 | 21/32 | 59/64 | 21/64 | 25/32 | 1 7/64 | 7/16 | 920 |
| 1/2 | 13 | 0.125 | 3/4 | 7/8 | 3/8 | 7/8 | 1 | 1/2 | 3/4 | 1 1/16 | 3/8 | 7/8 | 1 15/64 | 1/2 | 1250 |
| 9/16 | 12 | 0.161 | 27/32 | 63/64 | 27/64 | 31/32 | 1 1/8 | 9/16 | 27/32 | 1 13/64 | 27/64 | 1 1/32 | 1 3/8 | 9/16 | 1610 |
| 5/8 | 11 | 0.201 | 15/16 | 1 3/32 | 15/32 | 1 1/16 | 1 7/32 | 5/8 | 15/16 | 1 21/64 | 15/32 | 1 1/16 | 1 1/2 | 5/8 | 2010 |
| 3/4 | 10 | 0.301 | 1 1/8 | 1 19/64 | 9/16 | 1 1/4 | 1 7/16 | 3/4 | 1 1/8 | 1 29/32 | 9/16 | 1 1/4 | 1 49/64 | 3/4 | 3010 |
| 7/8 | 9 | 0.419 | 1 5/16 | 1 33/64 | 21/32 | 1 7/16 | 1 21/32 | 7/8 | 1 5/16 | 1 55/64 | 21/32 | 1 7/16 | 2 1/32 | 7/8 | 4190 |
| 1 | 8 | 0.550 | 1 1/2 | 1 47/64 | 3/4 | 1 5/8 | 1 7/8 | 1 | 1 1/2 | 2 1/8 | 3/4 | 1 5/8 | 2 19/64 | 1 | 5500 |
| 1 1/8 | 7 | 0.693 | 1 11/16 | 1 61/64 | 27/32 | 1 13/16 | 2 3/32 | 1 1/8 | 1 11/16 | 2 25/64 | 27/32 | 1 13/16 | 2 9/16 | 1 1/8 | 6930 |
| 1 1/4 | 7 | 0.890 | 1 7/8 | 2 11/64 | 15/16 | 2 | 2 5/16 | 1 1/4 | 1 7/8 | 2 21/32 | 15/16 | 2 | 2 5/64 | 1 1/4 | 8900 |
| 1 3/8 | 6 | 1.056 | 2 1/16 | 2 25/64 | 1 1/32 | 2 1/16 | 2 17/32 | 1 3/8 | 2 1/16 | 2 59/64 | 1 1/32 | 2 1/16 | 3 3/32 | 1 3/8 | 10560 |
| 1 1/2 | 6 | 1.294 | 2 1/4 | 2 39/64 | 1 1/8 | 2 3/8 | 2 3/4 | 1 1/2 | 2 1/4 | 3 5/16 | 1 1/8 | 2 3/8 | 3 23/64 | 1 1/2 | 12940 |
| 1 5/8 | 5 1/2 | 1.515 | 2 7/16 | 2 13/16 | 1 7/32 | 2 9/16 | 2 31/32 | 1 5/8 | 2 7/16 | 3 29/64 | 1 7/32 | 2 9/16 | 3 5/8 | 1 5/8 | 15150 |
| 1 3/4 | 5 | 1.746 | 2 5/8 | 3 1/32 | 1 5/16 | 2 3/4 | 3 5/16 | 1 3/4 | 2 5/8 | 3 23/32 | 1 5/16 | 2 3/4 | 3 5/64 | 1 3/4 | 17460 |
| 1 7/8 | 5 | 2.051 | 2 13/16 | 3 1/4 | 1 13/32 | 2 15/16 | 3 13/32 | 1 7/8 | 2 13/16 | 3 63/64 | 1 13/32 | 2 15/16 | 4 5/32 | 1 7/8 | 20510 |
| 2 | 4 1/2 | 2.301 | 3 | 3 15/32 | 1 1/2 | 3 1/8 | 3 5/8 | 2 | 3 | 4 1/4 | 1 1/2 | 3 1/8 | 4 27/64 | 2 | 23010 |
| 2 1/8 | 4 1/2 | 2.646 | 3 3/16 | 3 11/16 | 1 19/32 | 3 5/16 | 3 53/64 | 2 1/8 | 3 3/16 | 4 1/2 | 1 19/32 | 3 5/16 | 4 11/16 | 2 1/8 | 26460 |
| 2 1/4 | 4 1/2 | 3.021 | 3 3/8 | 3 29/32 | 1 11/16 | 3 1/2 | 4 3/64 | 2 1/4 | 3 3/8 | 4 25/32 | 1 11/16 | 3 1/2 | 4 61/64 | 2 1/4 | 30210 |

All dimensions in inches.

# General Dimensions of Various Facings of Pipe and Fitting Flanges For Extra Heavy (250 lbs.) Pressures

## Table No. 55



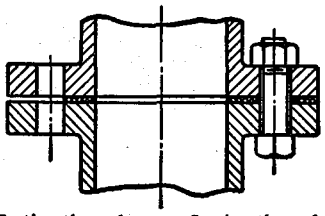

Male and Female Joint  Tongue and Groove Joint  Raised Face

| Size | Diameter of Flange B | Male and Female Joint | | Tongue and Grooved Joint | | | | | | Diameter of Raised Face M |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Diameter of Recess D | Diameter of Male E | Inside Diameter Groove F | Outside Diameter Groove G | Inside Diameter Tongue H | Outside Diameter Tongue J | Depth of Recess K | Height of Face L | |
| 1 | 4 7/8 | 2 3/16 | 2 5/16 | 1 11/16 | 2 9/16 | 1 3/4 | 2 1/2 | 1/16 | 3/16 | 2 |
| 1 1/4 | 5 1/4 | 2 15/16 | 2 3/4 | 2 1/16 | 3 1/16 | 2 1/8 | 3 | 1/16 | 3/16 | 2 1/2 |
| 1 1/2 | 6 1/8 | 3 3/16 | 3 1/8 | 2 1/2 | 3 11/16 | 2 3/4 | 3 5/8 | 1/8 | 3/16 | 2 1/8 |
| 2 | 6 1/2 | 3 11/16 | 3 5/8 | 3 1/16 | 4 5/16 | 3 1/8 | 4 1/8 | 1/16 | 3/16 | 3 5/8 |
| 2 1/2 | 7 1/2 | 4 3/16 | 4 1/8 | 3 5/8 | 4 11/16 | 3 5/8 | 4 5/8 | 1/16 | 3/16 | 4 1/8 |
| 3 | 8 1/4 | 5 1/16 | 5 | 4 3/16 | 5 5/16 | 4 1/4 | 5 1/4 | 1/16 | 3/16 | 5 |
| 3 1/2 | 9 | 5 9/16 | 5 1/2 | 4 11/16 | 5 13/16 | 4 3/4 | 5 3/4 | 1/16 | 3/16 | 5 1/2 |
| 4 | 10 | 6 1/16 | 6 | 5 3/16 | 6 5/16 | 5 1/4 | 6 1/4 | 1/16 | 3/16 | 6 1/16 |
| 5 | 11 | 7 5/16 | 7 1/4 | 6 3/16 | 7 5/16 | 6 1/4 | 7 1/4 | 1/16 | 3/16 | 7 5/16 |
| 6 | 12 1/2 | 8 3/16 | 8 3/16 | 7 3/16 | 8 5/16 | 7 1/4 | 8 1/2 | 1/16 | 3/16 | 8 1/4 |
| 8 | 15 | 10 11/16 | 10 5/8 | 9 5/16 | 10 5/16 | 9 5/8 | 10 7/8 | 3/16 | 1/4 | 10 5/8 |
| 10 | 17 1/2 | 12 13/16 | 12 3/4 | 11 5/16 | 13 5/16 | 11 5/8 | 13 1/8 | 3/16 | 1/4 | 12 3/4 |
| 12 | 20 1/2 | 15 5/16 | 15 1/4 | 13 5/16 | 15 5/16 | 13 5/8 | 15 1/8 | 3/16 | 1/4 | 15 |
| 14 | 23 | 16 9/16 | 16 1/2 | 15 13/16 | 17 7/16 | 15 7/8 | 17 3/8 | 3/16 | 1/4 | 16 1/4 |
| 16 | 25 1/2 | 18 3/16 | 18 1/2 | 18 1/16 | 20 3/16 | 18 3/8 | 20 1/8 | 3/16 | 1/4 | 18 1/2 |
| 18 | 28 | 21 1/16 | 21 | 20 1/16 | 22 7/16 | 20 3/8 | 22 3/8 | 1/16 | 1/4 | 21 |
| 20 | 30 1/2 | 23 1/16 | 23 | 22 1/4 | 24 3/16 | 22 5/8 | 24 5/8 | 3/16 | 1/4 | 23 |
| 24 | 36 | 27 5/16 | 27 1/2 | 26 7/16 | 28 5/16 | 26 1/2 | 28 1/2 | 3/16 | 1/4 | 27 1/4 |

All Dimensions are in inches.

For drilling see page 149.

# Dimensions and Weights of Bolts, Nuts and Gaskets for Standard Flanged Pipe and Fittings

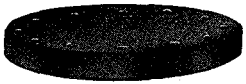


Section through Ring Gasket — Section through Full Gasket

## Table No. 56

| Standard (125 Lbs. Pressure) | | | | | | | | Extra Heavy (250 Lbs. Pressure) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Nominal Diameter of Pipe | Bolts and Nuts | | | Ring Gasket | | Full Gasket | | Nominal Diameter of Pipe | Bolts and Nuts | | | Ring Gasket | | Full Gasket | |
| | Number | Size and Length | Wght. per 100 | Inside Diameter | Outs. Diameter | Inside Diameter | Outs. Diameter | | Number | Size and Length | Wght. per 100 | Inside Diameter | Outs. Diameter | Inside Diameter | Outs. Diameter |
| 2 ¼ | 4 | ⅝x2 ¼ | 47.5 | 2 ½ | 4 ⅛ | 2 ½ | 7 | 2 ¼ | 4 | ¾x3 | 82.9 | 2 ½ | 5 ⅛ | 2 ½ | 7 ½ |
| 3 | 4 | ⅝x2 ¼ | 47.5 | 3 | 5 ⅜ | 3 | 7 ½ | 3 | 8 | ¾x3 ¼ | 86.0 | 3 | 5 ⅞ | 3 | 8 ¼ |
| 3 ½ | 4 | ⅝x2 ½ | 49.6 | 3 ½ | 6 ⅜ | 3 ½ | 8 ½ | 3 ½ | 8 | ¾x3 ¼ | 86.0 | 3 ½ | 6 ½ | 3 ½ | 9 |
| 4 | 8 | ⅝x2 ¾ | 51.7 | 4 | 6 ⅞ | 4 | 9 | 4 | 8 | ¾x3 ½ | 89.1 | 4 | 7 ⅛ | 4 | 10 |
| 5 | 8 | ¾x2 ¾ | 79.8 | 5 | 7 ¾ | 5 | 10 | 5 | 8 | ¾x3 ¾ | 92.1 | 5 | 8 ½ | 5 | 11 |
| 6 | 8 | ¾x3 | 82.9 | 6 | 8 ¾ | 6 | 11 | 6 | 12 | ¾x3 ¾ | 92.1 | 6 | 9 ⅞ | 6 | 12 ½ |
| 8 | 8 | ¾x3 ¼ | 86.0 | 8 | 11 | 8 | 13 ½ | 8 | 12 | ⅞x4 ¼ | 140.0 | 8 | 12 ⅛ | 8 | 15 |
| 10 | 12 | ⅞x3 ½ | 128.6 | 10 | 13 ⅜ | 10 | 16 | 10 | 16 | 1 x5 | 210.0 | 10 | 14 ¼ | 10 | 17 ½ |
| 12 | 12 | ⅞x3 ½ | 128.6 | 12 | 16 ⅛ | 12 | 19 | 12 | 16 | 1 ⅛x5 ¼ | 285.0 | 12 | 16 ⅜ | 12 | 20 ½ |
| 14 | 12 | 1 x4 | 189.0 | 14 | 17 ¾ | 14 | 21 | 14 | 20 | 1 ⅛x5 ½ | 292.0 | 14 | 19 ⅛ | 14 | 23 |
| 16 | 16 | 1 x4 | 189.0 | 16 | 20 ¼ | 16 | 23 ½ | 16 | 20 | 1 ¼x6 | 393.0 | 16 | 21 ¼ | 16 | 25 ½ |
| 18 | 16 | 1 ⅛x4 ½ | 265.0 | 18 | 21 ⅝ | 18 | 25 | 18 | 24 | 1 ¼x6 ¼ | 402.0 | 18 | 23 ½ | 18 | 28 |
| 20 | 20 | 1 ⅛x4 ¾ | 272.0 | 20 | 23 ⅛ | 20 | 27 ½ | 20 | 24 | 1 ⅜x6 ½ | 515.0 | 20 | 25 ⅝ | 20 | 30 ½ |
| 24 | 20 | 1 ¼x5 ¼ | 365.0 | 24 | 28 ¼ | 24 | 32 | 24 | 24 | 1 ⅝x7 ½ | .... | 24 | 30 ⅜ | 24 | 36 |

Dimensions in inches. For standard flanges see pages 147 and 149.



# Dimensions and Weights of American Standard *Blind Flanges

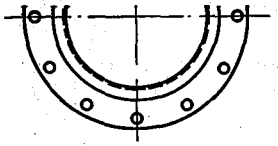


## Table No. 57

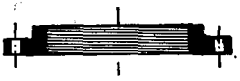
| Size of Pipe | Standard for 125 Lbs. Steam Working Pressure | | | | Extra Heavy for 250 Lbs. Steam Working Pressure | | | |
|---|---|---|---|---|---|---|---|---|
| | Diameter of Flange | Thickness of Flange | Thickness of Dished Section | Approx. Weight Pounds | Diameter of Flange | Thickness of Flange | Thickness of Dished Section | Approx. Weight Pounds |
| 1 ¼ | 5 | 9/16 | .... | 3 | 6 5/8 | 11/16 | .... | 6 |
| 2 | 6 | 5/8 | .... | 5 | 6 1/2 | 7/8 | .... | 8 |
| 2 ½ | 7 | 11/16 | .... | 7 | 7 1/2 | 1 | .... | 12 |
| 3 | 7 ½ | 3/4 | .... | 9 | 8 1/4 | 1 1/8 | .... | 16 |
| 3 ½ | 8 ½ | 13/16 | .... | 12 | 9 | 1 3/16 | .... | 20 |
| 4 | 9 | 15/16 | .... | 16 | 10 | 1 1/4 | .... | 26 |
| 5 | 10 | 15/16 | .... | 20 | 11 | 1 3/8 | .... | 34 |
| 6 | 11 | 1 | .... | 25 | 12 1/2 | 1 7/16 | .... | 46 |
| 8 | 13 ½ | 1 1/8 | .... | 42 | 15 | 1 5/8 | .... | 75 |
| 10 | 16 | 1 3/16 | .... | 63 | 17 1/2 | 1 7/8 | 15/16 | 120 |
| 12 | 19 | 1 1/4 | 15/16 | 88 | 20 1/2 | 2 | 1 | 155 |
| 14 | 21 | 1 3/8 | 7/8 | 115 | 23 | 2 1/8 | 1 1/8 | 210 |
| 16 | 23 ½ | 1 7/16 | 1 | 160 | 25 1/2 | 2 1/4 | 1 1/4 | 270 |
| 18 | 25 | 1 5/8 | 1 1/16 | 190 | 28 | 2 3/8 | 1 3/8 | 350 |
| 20 | 27 ½ | 1 11/16 | 1 1/8 | 250 | 30 1/2 | 2 1/2 | 1 1/2 | 440 |
| 24 | 32 | 1 7/8 | 1 1/4 | 370 | 36 | 2 3/4 | 1 5/8 | 670 |
| 30 | 38 ¾ | 2 1/8 | 1 7/16 | 620 | .... | .... | .... | .... |
| 36 | 46 | 2 3/8 | 1 5/8 | 990 | .... | .... | .... | .... |
| 42 | 53 | 2 5/8 | 1 15/16 | 1470 | .... | .... | .... | .... |
| 48 | 59 ½ | 2 3/4 | 2 | 2000 | .... | .... | .... | .... |

All dimensions in inches. Standard flanges have plain faces. Extra heavy flanges have raised faces.
All blind flanges for sizes 12 inches (19 inches O. D.) and larger are dished, with inside radius equal to the port diameter.
*See note page 164.

# Dimensions and Weights of American Standard *Cast Iron Companion Flanges for Steel or Wrought Iron Pipe







## Table No. 58

| Size of Pipe | Standard for 125 Lbs. Steam Working Pressure | | | | | Extra Heavy for 250 Lbs. Steam Working Pressure | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Diameter of Flange | Thickness of Flange | Diameter of Hub | Thickness of Hub | Approx. Weight Pounds | Diameter of Flange | Thickness of Flange | Diameter of Hub | Thickness of Hub | Approx. Weight Pounds |
| 1 ½ | 5 | 9/16 | 2 9/16 | .87 | 3 | 6 1/8 | 13/16 | 2 3/4 | 1 1/16 | 6 |
| 2 | 6 | 5/8 | 3 1/16 | 1.00 | 5 | 6 1/2 | 7/8 | 3 5/16 | 1 1/4 | 7 |
| 2 ½ | 7 | 11/16 | 3 9/16 | 1.14 | 7 | 7 1/2 | 1 | 3 15/16 | 1 7/16 | 11 |
| 3 | 7 ½ | 3/4 | 4 1/4 | 1.20 | 8 | 8 1/4 | 1 1/16 | 4 5/16 | 1 9/16 | 14 |
| 3 ½ | 8 ½ | 13/16 | 4 13/16 | 1.25 | 11 | 9 | 1 1/8 | 5 1/4 | 1 5/8 | 18 |
| 4 | 9 | 15/16 | 5 5/16 | 1.30 | 14 | 10 | 1 1/4 | 5 3/4 | 1 3/4 | 23 |
| 5 | 10 | 15/16 | 6 3/16 | 1.41 | 17 | 11 | 1 3/8 | 7 | 1 7/8 | 29 |
| 6 | 11 | 1 | 7 5/16 | 1.51 | 22 | 12 1/2 | 1 7/16 | 8 3/8 | 1 15/16 | 37 |
| 8 | 13 ½ | 1 1/8 | 9 11/16 | 1.71 | 31 | 15 | 1 5/8 | 10 1/4 | 2 3/16 | 56 |
| 10 | 16 | 1 3/16 | 11 13/16 | 1.93 | 45 | 17 1/2 | 1 7/8 | 12 5/8 | 2 3/8 | 81 |
| 12 | 19 | 1 1/4 | 14 1/16 | 2.13 | 63 | 20 1/2 | 2 | 14 3/4 | 2 5/8 | 115 |
| 14 | 21 | 1 3/8 | 15 3/8 | 2.25 | 82 | 23 | 2 1/8 | 16 1/4 | 2 11/16 | 155 |
| 16 | 23 ½ | 1 7/16 | 17 1/2 | 2.45 | 105 | 25 1/2 | 2 1/4 | 18 3/8 | 2 7/8 | 195 |
| 18 | 25 | 1 5/16 | 19 5/8 | 2.65 | 120 | 28 | 2 3/8 | 20 5/8 | 3 1/16 | 240 |
| 20 | 27 ½ | 1 11/16 | 21 3/4 | 2.85 | 150 | 30 1/2 | 2 1/2 | 22 3/4 | 3 5/16 | 300 |
| 24 | 32 | 1 7/8 | 26 | 3.25 | 220 | 36 | 2 3/4 | 27 3/8 | 3 11/16 | 450 |

All dimensions in inches. Standard flanges have plain faces. Extra heavy flanges have raised faces.
For standard threads see page 158.
All regular sizes of steel or wrought iron pipe in sizes 14 inches and larger are designated by the outside diameter.
*See note page 164.

# American Standard *Dimensions and Drilling Templates of Flanges for Cast Iron Pipe and Fittings for Maximum Working Saturated Steam Pressure of 25 Pounds per Square Inch

## Table No. 59

| Nominal Pipe Size | Diameter of Flange | Minimum Thickness of Flange[3, 4] | Diameter of Bolt Circle | Number of Bolts[1] | Diameter of Bolts | Diameter of Bolt Holes | Length of Bolts[2, 5] | Size of Ring Gasket |
|---|---|---|---|---|---|---|---|---|
| 4 | 9 | 3/4 | 7 1/2 | 8 | 5/8 | 3/4 | 2 1/4 | 4 X 6 1/8 |
| 5 | 10 | 3/4 | 8 1/2 | 8 | 5/8 | 3/4 | 2 1/2 | 5 X 7 1/8 |
| 6 | 11 | 3/4 | 9 1/2 | 8 | 5/8 | 3/4 | 2 1/2 | 6 X 8 3/4 |
| 8 | 13 1/2 | 3/4 | 11 3/4 | 8 | 5/8 | 3/4 | 2 1/4 | 8 X 11 |
| 10 | 16 | 7/8 | 14 1/4 | 12 | 5/8 | 3/4 | 2 1/2 | 10 X 13 3/8 |
| 12 | 19 | 1 | 17 | 12 | 5/8 | 3/4 | 2 3/4 | 12 X 16 1/8 |
| 14 | 21 | 1 1/8 | 18 3/4 | 12 | 3/4 | 7/8 | 3 1/4 | 14 X 18 |
| 16 | 23 1/2 | 1 1/8 | 21 1/4 | 16 | 3/4 | 7/8 | 3 1/4 | 16 X 20 1/2 |
| 18 | 25 | 1 1/4 | 22 3/4 | 16 | 3/4 | 7/8 | 3 1/2 | 18 X 22 |
| 20 | 27 1/2 | 1 1/4 | 25 | 20 | 3/4 | 7/8 | 3 1/2 | 20 X 24 1/4 |
| 24 | 32 | 1 3/8 | 29 1/2 | 20 | 3/4 | 7/8 | 3 3/4 | 24 X 28 3/4 |
| 30 | 38 3/4 | 1 1/2 | 36 | 28 | 7/8 | 1 | 4 1/4 | 30 X 35 1/8 |
| 36 | 46 | 1 5/8 | 42 3/4 | 32 | 7/8 | 1 | 5 | 36 X 41 7/8 |
| 42 | 53 | 1 3/4 | 49 1/2 | 36 | 1 | 1 1/8 | 5 1/4 | 42 X 48 1/4 |
| 48 | 59 1/2 | 2 | 56 | 44 | 1 | 1 1/8 | 5 1/2 | 48 X 55 |
| 54 | 66 1/4 | 2 1/4 | 62 3/4 | 44 | 1 | 1 1/8 | 5 3/4 | 54 X 61 3/4 |
| 60 | 73 | 2 1/4 | 69 1/4 | 52 | 1 1/8 | 1 1/4 | 6 | 60 X 68 1/8 |
| 72 | 86 1/2 | 2 1/2 | 82 1/2 | 60 | 1 1/8 | 1 1/4 | 6 1/4 | 72 X 81 3/8 |
| 84 | 99 3/4 | 2 3/4 | 95 1/2 | 64 | 1 1/4 | 1 3/8 | 7 1/4 | 84 X 94 1/4 |
| 96 | 113 1/4 | 3 | 108 1/2 | 68 | 1 1/4 | 1 3/8 | 7 3/4 | 96 X 107 1/4 |

All dimensions given in inches.

[1] NOTE: 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. Bolt holes are drilled 1/8 inch larger in diameter than the nominal diameter of the bolt.

[2] NOTE: The bolt holes on cast iron flanged fittings are not spot faced for ordinary service. When required, the fittings and flanges in sizes 36 in. and larger may be spot faced or back faced to minimum thickness of flange with a plus tolerance of 1/8 inch, so that standard length bolts can be used.

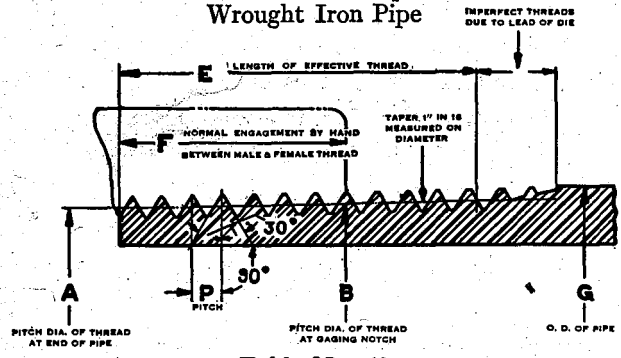
[3] NOTE: All 25 lb. cast iron standard flanges have plain faces.

[4] NOTE: Screwed Companion Flanges "should not be thinner than the '125 lb. American Standard' thickness on sizes 24 in. and smaller. Other types of flanges may have thicknesses as given in the table above."

[5] NOTE: Bolts shall be of steel with standard "Rough Square Heads" and the hexagon nuts shall be of steel with "U. S. standard dimensions."

*See Note page 164.

# Dimensions of American Standard Pipe Threads for Steel or Wrought Iron Pipe



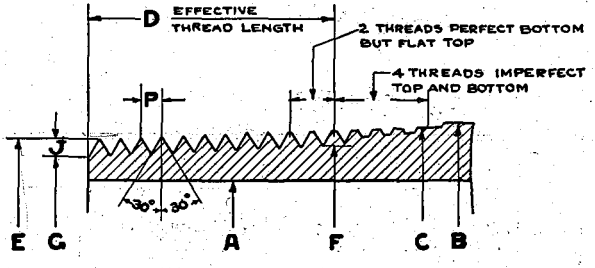

## Table No. 60

| Size | A | B | E | F | G | Depth of Thread | Pitch of Thread | Threads per Inch |
|---|---|---|---|---|---|---|---|---|
| ⅛ | .36351 | .37476 | .2638 | .180 | .405 | .02963 | .03704 | 27 |
| ¼ | .47739 | .48989 | .4018 | .200 | .540 | .04444 | .05556 | 18 |
| ⅜ | .61201 | .62701 | .4078 | .240 | .675 | .04444 | .05556 | 18 |
| ½ | .75843 | .77843 | .5337 | .320 | .840 | .03714 | .07143 | 14 |
| ¾ | .96768 | .98886 | .5457 | .339 | 1.050 | .05714 | .07143 | 14 |
| 1 | 1.21363 | 1.23863 | .6828 | .400 | 1.315 | .06956 | .08696 | 11½ |
| 1¼ | 1.55713 | 1.58338 | .7068 | .420 | 1.660 | .06956 | .08696 | 11½ |
| 1½ | 1.79609 | 1.82234 | .7235 | .420 | 1.900 | .06956 | .08696 | 11½ |
| 2 | 2.26902 | 2.29627 | .7565 | .436 | 2.375 | .06956 | .08696 | 11½ |
| 2½ | 2.71953 | 2.76216 | 1.1375 | .682 | 2.875 | .100 | .12500 | 8 |
| 3 | 3.34063 | 3.38850 | 1.2000 | .766 | 3.500 | .100 | .12500 | 8 |
| 3½ | 3.83750 | 3.88881 | 1.2500 | .821 | 4.000 | .100 | .12500 | 8 |
| 4 | 4.33438 | 4.38713 | 1.3000 | .844 | 4.500 | .100 | .12500 | 8 |
| 4½ | 4.83125 | 4.88594 | 1.3500 | .875 | 5.000 | .100 | .12500 | 8 |
| 5 | 5.39073 | 5.44929 | 1.4063 | .937 | 5.563 | .100 | .12500 | 8 |
| 6 | 6.44609 | 6.50597 | 1.5125 | .958 | 6.625 | .100 | .12500 | 8 |
| 7 | 7.43984 | 7.50234 | 1.6125 | 1.000 | 7.625 | .100 | .12500 | 8 |
| 8 | 8.43359 | 8.50003 | 1.7125 | 1.063 | 8.625 | .100 | .12500 | 8 |
| 9 | 9.42734 | 9.49797 | 1.8125 | 1.130 | 9.625 | .100 | .12500 | 8 |
| 10 | 10.54531 | 10.62094 | 1.9250 | 1.210 | 10.750 | .100 | .12500 | 8 |
| 11 | 11.53906 | 11.61938 | 2.0250 | 1.285 | 11.750 | .100 | .12500 | 8 |
| 12 | 12.53281 | 12.61781 | 2.1250 | 1.360 | 12.750 | .100 | .12500 | 8 |
| 14 O.D. | 13.77500 | 13.87262 | 2.2500 | 1.562 | 14.000 | .100 | .12500 | 8 |
| 15 O.D. | 14.76875 | 14.87419 | 2.3500 | 1.687 | 15.000 | .100 | .12500 | 8 |
| 16 O.D. | 15.76250 | 15.87575 | 2.4500 | 1.812 | 16.000 | .100 | .12500 | 8 |
| 17 O.D. | 16.75625 | 16.87500 | 2.5500 | 1.900 | 17.000 | .100 | .12500 | 8 |
| 18 O.D. | 17.75000 | 17.87500 | 2.6500 | 2.000 | 18.000 | .100 | .12500 | 8 |
| 20 O.D. | 19.73750 | 19.87031 | 2.8500 | 2.125 | 20.000 | .100 | .12500 | 8 |
| 22 O.D. | 21.72500 | 21.86562 | 3.0500 | 2.250 | 22.000 | .100 | .12500 | 8 |
| 24 O.D. | 23.71250 | 23.86094 | 3.2500 | 2.375 | 24.000 | .100 | .12500 | 8 |

Dimensions in inches.

For standard dimensions of pipe, see page 158.

## Dimensions for Cast Iron Pipe Threads




A = Nominal I. D.
B = O. D. of Pipe
C = B − .10
D = P (.80 C + 6.8)
E = (C + .8P) − P (.05 C + 1.1)
F = C − 2 J + .125 P
G = E − 2 J
H = No. Threads Per Inch
J = .8 P
P = Pitch

Total Taper ¾" Per Foot

## Table No. 60 (continued)

| Size | A | B | C | D | E | F | G | H | J |
|---|---|---|---|---|---|---|---|---|---|
| *1 ¼ | 1.375 | 2.000 | 1.900 | .7235 | 1.865 | 1.772 | 1.726 | 11 ½ | .0696 |
| *1 ½ | 1.600 | 2.475 | 2.375 | .7565 | 2.338 | 2.247 | 2.199 | 11 ½ | .0696 |
| *2 | 2.100 | 2.975 | 2.875 | 1.1375 | 2.819 | 2.690 | 2.619 | 8 | .1000 |
| *2 ½ | 2.600 | 3.600 | 3.500 | 1.2000 | 3.440 | 3.315 | 3.241 | 8 | .1000 |
| 3 | 3.120 | 3.960 | 3.860 | 1.2360 | 3.798 | 3.676 | 3.598 | 8 | .1000 |
| 4 | 4.100 | 5.000 | 4.900 | 1.3400 | 4.831 | 4.716 | 4.632 | 8 | .1000 |
| 6 | 6.140 | 7.100 | 7.000 | 1.5500 | 6.918 | 6.816 | 6.719 | 8 | .1000 |
| 8 | 8.030 | 9.050 | 8.950 | 1.7450 | 8.856 | 8.766 | 8.657 | 8 | .1000 |
| 10 | 9.960 | 11.100 | 11.000 | 1.9500 | 10.894 | 10.816 | 10.694 | 8 | .1000 |
| 12 | 12.000 | 13.200 | 13.100 | 2.1600 | 12.981 | 12.916 | 12.781 | 8 | .1000 |
| 14 | 14.000 | 15.300 | 15.200 | 2.3700 | 15.067 | 15.016 | 14.867 | 8 | .1000 |
| 16 | 16.000 | 17.400 | 17.300 | 2.5800 | 17.154 | 17.116 | 16.954 | 8 | .1000 |

*Same as one size larger American Std. Tapered Pipe Thread.
All dimensions in inches.

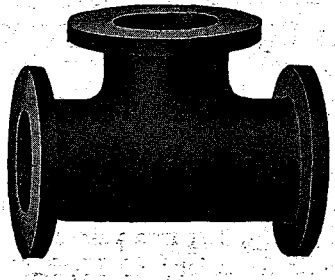
# Dimensions of Standard, Extra Strong and Double Extra Strong Wrought Iron Pipe

## Table No. 61

| Size Pipe | External Dia. | Standard | | | Extra Strong | | | Double Extra Strong | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Thickness | Internal Dia. | Weight Pr. Ft. | Thickness | Internal Dia. | Weight Pr. Ft. | Thickness | Internal Dia. | Weight Pr. Ft. |
| ⅛ | .405 | .068 | .269 | .244 | .095 | .215 | .314 | ..... | ..... | ..... |
| ¼ | .540 | .088 | .364 | .424 | .119 | .302 | .535 | ..... | ..... | ..... |
| ⅜ | .675 | .091 | .493 | .567 | .126 | .423 | .738 | ..... | ..... | ..... |
| ½ | .840 | .109 | .622 | .850 | .147 | .546 | 1.087 | .294 | .252 | 1.714 |
| ¾ | 1.050 | .113 | .824 | 1.130 | .154 | .742 | 1.473 | .308 | .434 | 2.440 |
| 1 | 1.315 | .133 | 1.049 | 1.678 | .179 | .957 | 2.171 | .358 | .599 | 3.659 |
| 1¼ | 1.660 | .140 | 1.380 | 2.272 | .191 | 1.278 | 2.996 | .382 | .896 | 5.214 |
| 1½ | 1.900 | .145 | 1.610 | 2.717 | .200 | 1.500 | 3.631 | .400 | 1.100 | 6.408 |
| 2 | 2.375 | .154 | 2.067 | 3.652 | .218 | 1.939 | 5.022 | .436 | 1.503 | 9.029 |
| 2½ | 2.875 | .203 | 2.469 | 5.793 | .276 | 2.323 | 7.661 | .552 | 1.771 | 13.695 |
| 3 | 3.500 | .216 | 3.068 | 7.575 | .300 | 2.900 | 10.252 | .600 | 2.300 | 18.583 |
| 3½ | 4.000 | .226 | 3.548 | 9.109 | .318 | 3.364 | 12.505 | .636 | 2.728 | 22.850 |
| 4 | 4.500 | .237 | 4.026 | 10.790 | .337 | 3.826 | 14.983 | .674 | 3.152 | 27.541 |
| 4½ | 5.000 | .247 | 4.506 | 12.538 | .355 | 4.290 | 17.611 | .710 | 3.580 | 32.530 |
| 5 | 5.363 | .258 | 5.047 | 14.617 | .375 | 4.813 | 20.778 | .750 | 4.063 | 38.552 |
| 6 | 6.625 | .280 | 6.065 | 18.974 | .432 | 5.761 | 28.573 | .864 | 4.897 | 53.160 |
| 7 | 7.625 | .301 | 7.023 | 23.544 | .500 | 6.625 | 38.048 | .875 | 5.875 | 63.079 |
| 8 | 8.625 | .277 | 8.071 | 24.696 | .500 | 7.625 | 43.388 | .875 | 6.875 | 72.424 |
| 8 | 8.625 | .322 | 7.981 | 28.554 | ..... | ..... | ..... | ..... | ..... | ..... |
| 9 | 9.625 | .342 | 8.941 | 33.907 | .500 | 8.625 | 48.728 | ..... | ..... | ..... |
| 10 | 10.750 | .279 | 10.192 | 31.201 | .500 | 9.750 | 54.735 | ..... | ..... | ..... |
| 10 | 10.750 | .307 | 10.136 | 34.240 | ..... | ..... | ..... | ..... | ..... | ..... |
| 10 | 10.750 | .365 | 10.020 | 40.483 | ..... | ..... | ..... | ..... | ..... | ..... |
| 11 | 11.750 | .375 | 11.000 | 45.557 | .500 | 10.750 | 60.075 | ..... | ..... | ..... |
| 12 | 12.750 | .330 | 12.090 | 43.773 | .500 | 11.750 | 65.415 | ..... | ..... | ..... |
| 12 | 12.750 | .375 | 12.000 | 49.562 | ..... | ..... | ..... | ..... | ..... | ..... |

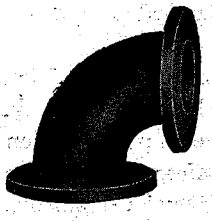
Dimensions in inches.

For standard flanges see page 154.
For standard threads see page 156.



SECTION 9

# STANDARD FLANGED FITTINGS





# STANDARDIZATION OF FLANGES AND FLANGED FITTINGS

RECOGNIZING the importance of the adoption of a standard for cast iron flanges which would cover, in so far as possible, all types of flanges including those on cast iron pipe, flange connections on steam engines, steam pumps, cast iron valves for steam, water, etc., The American Society of Mechanical Engineers appointed a committee in 1892, for the purpose of investigating the subject and reporting thereon to the Society. The A. S. M. E. Council hoped that it might be possible to devise some standard which would be sufficiently broad to induce the various manufacturers to adopt it in place of the dimensions which were then in use by them individually.

The same year the National Association of Master Steam and Hot Water Fitters appointed a committee for a like purpose which recognized the importance of the subject and held numerous meetings, individually and jointly, with the American Society of Mechanical Engineers' Committee.

At the annual convention of the National Association of Master Steam and Hot Water Fitters held in New York, June, 1894, their committee on Flange Standardization recommended the holding of a joint conference with The American Society of Mechanical Engineers' Committee. This recommendation was favorably received and a joint conference was held on July 18, 1894, in the rooms of The American Society of Mechanical Engineers. It was

attended by the members of both committees and also by many representatives of the leading manufacturers.

After discussion of the various dimensions of flanges, the conference reached a unanimous agreement that all manufacturers, engineers, and users should adopt standard dimensions for flange diameters designed for pipe sizes from 2 to 12 inches inclusive and pressures up to 200 lbs. per sq. in. It was further agreed that all manufacturers would send to their customers information compiled by the committees covering diameters of flanges, bolt circles, etc., so that full knowledge could be extended.

In 1901, the "Manufacturers' Standard" for pressures up to 250 pounds was developed. Later, about 1910, a group of manufacturers formed an organization known as The Committee of Manufacturers on Standardization of Fittings and Valves (Manufacturers' Standardization of the Valve and Fittings Industry), and began the work of designing a completely standardized line of flanged fittings, including flange dimensions, center to face and face to face dimensions and shell thicknesses. This work was completed and published in 1912.

During the years 1912 to 1914 a Joint Conference Committee composed of representatives of the Committee of Manufacturers on the Standardization of Fittings and Valves and The American Society of Mechanical Engineers, formulated a group of compromise standard dimensions of pipe flanges and flanged fittings for use under working steam pressures of 125 and 250 lb. per sq. in. These standards were based on the 1912 U. S. Standard and the Manufacturers' Standard adopted the same year. The Joint Committee's report was completed in January, 1914, and revised in March, 1914. This revision was

accepted at conference in Washington which was attended by representatives of the United States Government, The Master Steam and Hot Water Fitters, the Manufacturers' Committee and The American Society of Mechanical Engineers. The A. S. M. E. adopted the report of its committee in December, 1914.

In 1918 the A. S. M. E. Committee on Standardization of Flanges and Pipe Fittings completed in cooperation with the Committee of the Manufacturers a new standard to be known as the "American Low-Pressure Standard" for 50 lbs. per sq. in. working pressure.

In the Spring of 1921 when the unification and extension of the flanged and screwed fittings standards in use in this country seemed desirable, the American Engineering Standards Committee authorized the organization of a Sectional Committee on the Standardization of Pipe Flanges and Fittings under the joint sponsorship of the Heating and Piping Contractors' National Association, which prior to 1918 was known as the National Association of Master Steam and Hot Water Fitters, the Manufacturers' Standardization Society of the Valve and Fittings Industry, and The American Society of Mechanical Engineers. This Sectional Committee numbered sixty-two representatives appointed by twenty-nine national organizations.

After several years of work, the Sectional Committee has completed the revision of the standards known as "Cast Iron Pipe Flanges and Flanged Fittings for working steam pressures of 125 and 250 lbs. per sq. in." These supersede the so called "1914 American Standards." The Committee has also formulated a standard for 25 lbs. per sq. in. working pressure which will supersede

the 50 lbs. standard approved and published by the A. S. M. E. in December, 1918.

All three of these standards contain tables of templates for drilling flange thicknesses, center to face and face to face dimensions of fittings and body thicknesses for all types of fittings that are commonly used and stocked by manufacturers.

By making the flange diameters, bolt circle diameters, number of bolts, center to face, and face to face dimensions of Cast Iron Fittings for 25 and 125 lbs. per sq. in. working pressures, the same, it is possible to interchange fittings in pipe lines designed for these pressures. It should be noted however that the thickness of flange, and thickness of body dimensions differ due to the difference in working pressures.

In working up an "American Standard" for Steel Pipe Flanges and Fittings for 250 lbs. per sq. in., the Sectional Committee on Pipe Flanges and Fittings thought it advisable to make the essential dimensions the same as for Cast Iron Fittings of the same working pressure. This was accomplished and we now have interchangeability between fittings manufactured to these two standards.

Cast Iron Flange Pipe is regularly equipped with flanges which conform to these Standards. Pipe of Classes A, B, C and D being provided with flanges in accordance with the American Standard for 125 lbs. per sq. in. steam working pressure and Classes E, F, G and H being provided with flanges in accordance with the 250 lbs. standard.

In the pages that immediately follow will be found the dimensions of flanged fittings made in accordance with the standard for 125 and 250 lbs. per sq. in. steam working

pressure. In designing these fittings no allowance was made for water hammer.

For use in the design of water plants fittings which conform to the A. W. W. A. Specifications as to radii, laying dimensions and thickness can be furnished. On pages 186 to 192 will be found tables of these fittings equipped with the standard Flanges mentioned above.

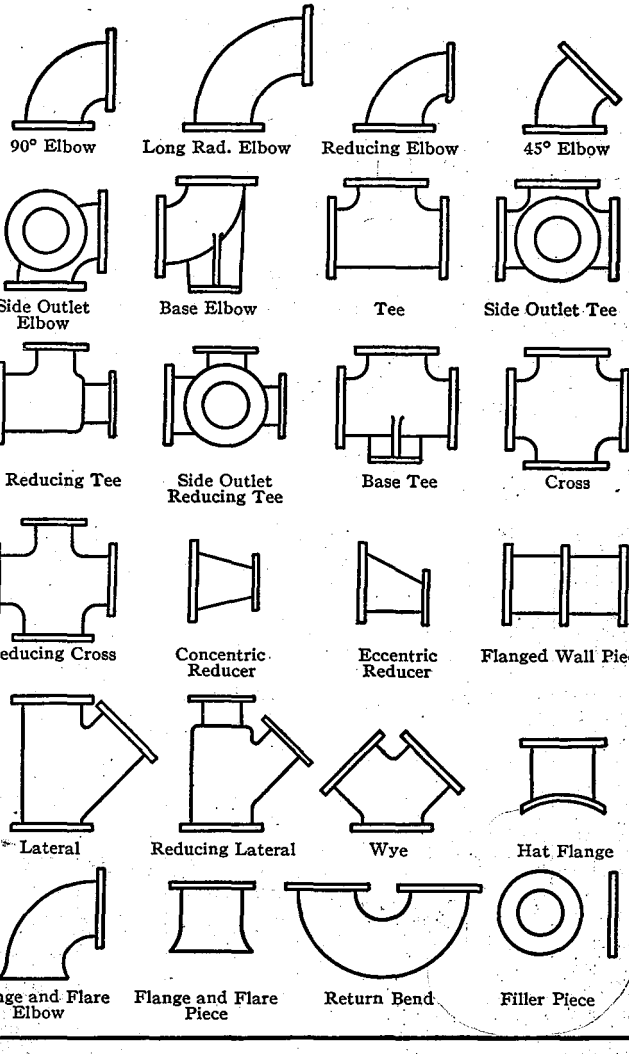
Unless otherwise specified the term "size" in the following tables refer to the nominal inside diameter of the fittings.

**NOTE: The Tables of American Standard Cast Iron Pipe Flanges and Flanged Fittings herewith are based on the tentative specifications and have not been approved by the sponsor organizations. They are, therefore, subject to revision.**

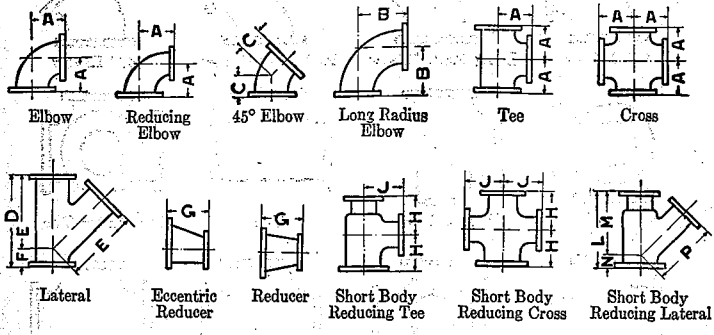
125 lb. and 250 lb. Flanged Standard have been adopted as Standard by the American Standards Association. The 25 lb. Flanged Standard has not yet been adopted, but in all probability the revised dimensions given in this correction pamphlet will be adopted.

## AMERICAN STANDARD FLANGED FITTINGS

### Names of Flanged Fittings



# Laying Dimensions of American Standard Flanged Fittings for Maximum Working Saturated Steam Pressure of 125 Pounds per Square Inch

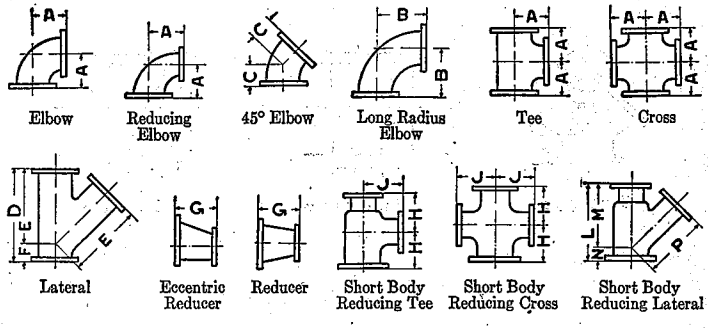



## Table No. 62

| Size | A | B | C | D | E | F | G | Short Body Red. Tees and Crosses | | | Short Body Red. Laterals | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Size of Outlets | H | J | Size of Br'ch's | L | M | N | P |
| 1 | 3 ½ | 5 | 1 ¾ | 7 ½ | 5 ¾ | 1 ¾ | .... | .... | .... | .... | .... | .... | .... | .... | .... |
| 1 ¼ | 3 ¾ | 5 ½ | 2 | 8 | 6 ¼ | 1 ¾ | .... | .... | .... | .... | .... | .... | .... | .... | .... |
| 1 ½ | 4 | 6 | 2 ¼ | 9 | 7 | 2 | .... | .... | .... | .... | .... | .... | .... | .... | .... |
| 2 | 4 ½ | 6 ½ | 2 ½ | 10 ½ | 8 | 2 ½ | .... | .... | .... | .... | .... | .... | .... | .... | .... |
| 2 ½ | 5 | 7 | 3 | 12 | 9 ½ | 2 ½ | .... | .... | .... | .... | .... | .... | .... | .... | .... |
| 3 | 5 ½ | 7 ¾ | 3 | 13 | 10 | 3 | 6 | .... | .... | .... | .... | .... | .... | .... | .... |
| 3 ½ | 6 | 8 ½ | 3 ½ | 14 ½ | 11 ½ | 3 | 6 ½ | .... | .... | .... | .... | .... | .... | .... | .... |
| 4 | 6 ½ | 9 | 4 | 15 | 12 | 3 | 7 | .... | .... | .... | .... | .... | .... | .... | .... |
| 5 | 7 ½ | 10 ¾ | 4 ½ | 17 | 13 ½ | 3 ½ | 8 | .... | .... | .... | .... | .... | .... | .... | .... |
| 6 | 8 | 11 ½ | 5 | 18 | 14 ½ | 3 ½ | 9 | .... | .... | .... | .... | .... | .... | .... | .... |
| 8 | 9 | 14 | 5 ½ | 22 | 17 ½ | 4 ½ | 11 | .... | .... | .... | .... | .... | .... | .... | .... |
| 10 | 11 | 16 ½ | 6 ½ | 25 ½ | 20 ½ | 5 | 12 | .... | .... | .... | .... | .... | .... | .... | .... |
| 12 | 12 | 19 | 7 ½ | 30 | 24 ½ | 5 ½ | 14 | .... | .... | .... | .... | .... | .... | .... | .... |
| 14 | 14 | 21 ½ | 7 ½ | 33 | 27 | 6 | 16 | .... | .... | .... | .... | .... | .... | .... | .... |
| 16 | 15 | 24 | 8 | 36 ½ | 30 | 6 ½ | 18 | .... | .... | .... | .... | .... | .... | .... | .... |
| 18 | 16 ½ | 26 ½ | 8 ½ | 39 | 32 | 7 | 19 | 12 and smaller | 13 | 15 ½ | 8 and smaller | 26 | 25 | 1 | 27 ½ |
| 20 | 18 | 29 | 9 ½ | 43 | 35 | 8 | 20 | 14 " | 14 | 17 | 10 " | 28 | 27 | 1 | 29 ½ |
| 24 | 22 | 34 | 11 | 49 ½ | 40 ½ | 9 | 24 | 16 " | 15 | 19 | 12 " | 32 | 31 ½ | ½ | 34 ½ |
| 30 | 25 | 41 ½ | 15 | 59 | 49 | 10 | 30 | 20 " | 18 | 23 | 14 " | 39 | 39 | 0 | 42 |
| 36 | 28 | 49 | 18 | .... | .... | .... | 36 | 24 " | 20 | 26 | .... | .... | .... | .... | .... |
| 42 | 31 | 56 ½ | 21 | .... | .... | .... | 42 | 24 " | 23 | 30 | .... | .... | .... | .... | .... |
| 48 | 34 | 64 | 24 | .... | .... | .... | 48 | 32 " | 26 | 34 | .... | .... | .... | .... | .... |

See notes on pages 164, 171 and 172.

# Laying Dimensions of American Standard Flanged Fittings for Maximum Working Saturated Steam Pressure of 250 Pounds per Square Inch

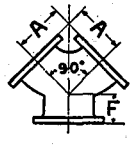



## Table No. 62 (continued)

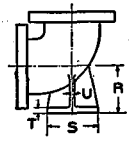
| Size | A | B | C | D | E | F | G | Short Body Reducing Tees and Crosses | | | Short Body Red. Laterals | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Size of Outlets | H | J | Size of Br'ch's | L | M | N | P |
| 1 | 4 | 5 | 2 | 8 ½ | 6 ½ | 2 | | | | | | | | | |
| 1 ¼ | 4 ¼ | 5 ½ | 2 ½ | 9 ½ | 7 ¼ | 2 ¼ | | | | | | | | | |
| 1 ½ | 4 ½ | 6 | 2 ¾ | 11 | 8 ½ | 2 ½ | | | | | | | | | |
| 2 | 5 | 6 ½ | 3 | 11 ½ | 9 | 2 ½ | | | | | | | | | |
| 2 ½ | 5 ½ | 7 | 3 ½ | 13 | 10 ½ | 2 ½ | | | | | | | | | |
| 3 | 6 | 7 ¾ | 3 ½ | 14 | 11 | 3 | 6 | | | | | | | | |
| 3 ½ | 6 ½ | 8 ½ | 4 | 15 ½ | 12 ½ | 3 | 6 ½ | | | | | | | | |
| 4 | 7 | 9 | 4 ½ | 16 ½ | 13 ½ | 3 | 7 | | | | | | | | |
| 5 | 8 | 10 ¼ | 5 | 18 ½ | 15 | 3 ½ | 8 | | | | | | | | |
| 6 | 8 ½ | 11 ½ | 5 ½ | 21 ½ | 17 ½ | 4 | 9 | | | | | | | | |
| 8 | 10 | 14 | 6 | 25 ½ | 20 ½ | 5 | 11 | | | | | | | | |
| 10 | 11 ½ | 16 ½ | 7 | 29 ½ | 24 | 5 ½ | 12 | | | | | | | | |
| 12 | 13 | 19 | 8 | 33 ½ | 27 ½ | 6 | 14 | | | | | | | | |
| 14O.D. | 15 | 21 ¼ | 8 ½ | 37 ½ | 31 | 6 ½ | 16 | | | | | | | | |
| 16 " | 16 ½ | 24 | 9 ½ | 42 | 34 ½ | 7 ½ | 18 | | | | | | | | |
| 18 " | 18 | 26 ½ | 10 | 45 ½ | 37 ½ | 8 | 19 | 12 and smaller | 14 | 17 | 8 and smaller | 34 | 31 | 3 | 32 ½ |
| 20 " | 19 ½ | 29 | 10 ½ | 49 | 40 ½ | 8 ½ | 20 | 14 " | 15 ½ | 18 ½ | 10 " | 37 | 34 | 3 | 36 |
| 24 " | 22 ½ | 34 | 12 | 57 ½ | 47 ½ | 10 | 24 | 16 " | 17 | 21 ½ | 12 " | 44 | 41 | 3 | 43 |
| 30 " | 27 ½ | 41 ½ | 15 | .... | .... | .... | 30 | 20 " | 20 ½ | 25 ½ | ..... | .... | .... | .... | .... |

See notes on pages 164, 171 and 172.
All dimensions in inches.

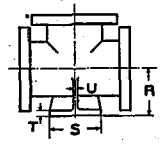
# Laying Dimensions of American Standard Flanged Fittings for Maximum Working Saturated Steam Pressure of 125 and 250 Pounds per Square Inch




True Wye




Base Elbow



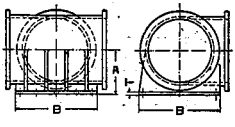

Base Tee

## Table No. 62 (continued)

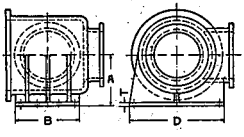
| Size | Standard 125 Lbs. Steam Working Pressure | | | | | | Extra Heavy 250 Lbs. Steam Working Pressure | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | A | F | S | T | U | R | A | F | S | T | U | R |
| 1 | 3 1/4 | 1 3/4 | 3 1/2 | 7/16 | 3/8 | 3 1/4 | 4 | 2 | 4 | 5/8 | 1/2 | 3 3/4 |
| 1 1/4 | 3 3/4 | 1 3/4 | 3 1/2 | 7/16 | 3/8 | 3 5/8 | 4 1/4 | 2 1/4 | 4 | 5/8 | 1/2 | 4 |
| 1 1/2 | 4 | 2 | 4 1/4 | 7/16 | 1/2 | 3 3/4 | 4 1/2 | 2 1/2 | 4 7/8 | 11/16 | 1/2 | 4 1/8 |
| 2 | 4 1/2 | 2 1/2 | 4 5/8 | 1/2 | 1/2 | 4 1/8 | 5 | 2 1/2 | 5 1/4 | 3/4 | 1/2 | 4 1/2 |
| 2 1/2 | 5 | 2 1/2 | 4 5/8 | 1/2 | 1/2 | 4 1/2 | 5 1/2 | 2 1/2 | 5 1/4 | 3/4 | 1/2 | 4 3/4 |
| 3 | 5 1/2 | 3 | 5 | 9/16 | 1/2 | 4 7/8 | 6 | 3 | 6 1/8 | 13/16 | 5/8 | 5 1/4 |
| 3 1/2 | 6 | 3 | 5 | 9/16 | 1/2 | 5 1/4 | 6 1/2 | 3 | 6 1/8 | 13/16 | 5/8 | 5 5/8 |
| 4 | 6 1/4 | 3 | 6 | 5/8 | 1/2 | 5 1/2 | 7 | 3 | 6 1/2 | 7/8 | 5/8 | 6 |
| 5 | 7 1/2 | 3 1/2 | 7 | 11/16 | 5/8 | 6 1/4 | 8 | 3 1/2 | 7 1/2 | 1 | 3/4 | 6 3/4 |
| 6 | 8 | 3 1/2 | 7 | 11/16 | 5/8 | 7 | 8 1/2 | 4 | 7 1/2 | 1 | 3/4 | 7 1/2 |
| 8 | 9 | 4 1/2 | 9 | 13/16 | 7/8 | 8 3/8 | 10 | 5 | 10 | 1 1/4 | 7/8 | 9 |
| 10 | 11 | 5 | 9 | 13/16 | 7/8 | 9 3/4 | 11 1/2 | 5 1/2 | 10 | 1 1/4 | 7/8 | 10 1/2 |
| 12 | 12 | 5 1/2 | 11 | 1 | 1 | 11 1/4 | 13 | 6 | 12 1/2 | 1 5/16 | 1 | 12 |
| 14 | 14 | 6 | 11 | 1 | 1 | 12 1/2 | 15 | 6 1/2 | 12 1/2 | 1 5/16 | 1 | 13 1/2 |
| 16 | 15 | 6 1/2 | 11 | 1 | 1 | 13 3/4 | 16 1/2 | 7 1/2 | 12 1/2 | 1 5/16 | 1 1/8 | 14 3/4 |
| 18 | 16 1/2 | 7 | 13 1/2 | 1 1/8 | 1 1/8 | 15 | 18 | 8 | 15 | 1 5/8 | 1 1/8 | 16 1/4 |
| 20 | 18 | 8 | 13 1/2 | 1 1/8 | 1 1/8 | 16 | 19 1/2 | 8 1/2 | 15 | 1 5/8 | 1 1/4 | 17 7/8 |
| 24 | 22 | 9 | 13 1/2 | 1 1/8 | 1 1/8 | 18 1/2 | 22 1/2 | 10 | 17 1/2 | 1 7/8 | 1 1/4 | 20 3/4 |
| 30 | 25 | 10 | | | | | | | | | | |

See notes on pages 164, 171 and 172.
All dimensions in inches.

# Laying Dimensions of American Standard Flanged Fittings for Maximum Working Saturated Steam Pressure of 125 and 250 Pounds per Square Inch




Anchorage Tees




Reducing Anchorage Tees

## Table No. 62 (continued)

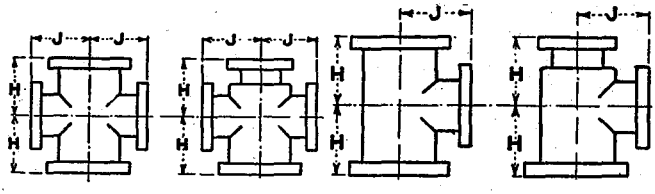
| Size | Size Outlet and Smaller | Standard 125 Lbs. Steam Working Pressure | | | | Extra Heavy 250 Lbs. Steam Working Pressure | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | A | B | D | T | A | B | D | T |
| 2½ | 2½ | 4¼ | 7 | | 11/16 | 4¾ | 7½ | | ¾ |
| 3 | 3 | 4 7/8 | 7½ | | ¾ | 5¼ | 8¼ | | 15/16 |
| 3½ | 3½ | 5¼ | 8½ | | 15/16 | 5 5/8 | 9 | | 15/16 |
| 4 | 5½ | 5½ | 9 | | 15/16 | 6 | 10 | | 15/16 |
| 5 | 5 | 6¼ | 10 | | 15/16 | 6¾ | 11 | | 1 |
| 6 | 6 | 7 | 11 | | 1 | 7½ | 12½ | | 1 1/16 |
| 8 | 8 | 8 3/8 | 13½ | | 1 1/8 | 9 | 15 | | 1 1/8 |
| 10 | 10 | 9¾ | 16 | | 1 3/16 | 10½ | 17½ | | 1¼ |
| 12 | 12 | 11¼ | 19 | | 1¼ | 12 | 20½ | | 1¼ |
| 14 | 14 | 12½ | 21 | | 1 3/8 | 13½ | 23 | | 1 3/8 |
| 16 | 16 | 13¾ | 23½ | | 1 7/16 | 14¾ | 25½ | | 1 7/16 |
| 18 | 18 to 14 | 15 | 25 | | 1 1/2 | 16¼ | 28 | | 1 11/16 |
| 18 | 12 | 15½ | 19 | 25 | 1 5/8 | 16¼ | 20½ | 28 | 1 11/16 |
| 20 | 20 to 16 | 16 | 27½ | | 1 11/16 | 17 7/8 | 30½ | | 1 7/8 |
| 20 | 14 | 16 | 21 | 27½ | 1 11/16 | 17 7/8 | 23 | 30½ | 1 7/8 |
| 24 | 24 to 18 | 18½ | 32 | | 1 7/8 | 20¾ | 36 | | 2 1/16 |
| 24 | 16 | 18½ | 23½ | 32 | 1 7/8 | 20¾ | 25½ | 36 | 2 1/16 |
| 30 | 30 to 24 | 22 | 38¾ | | 2 1/8 | 24¾ | 43 | | 2 5/16 |
| 30 | 20 | 22 | 27½ | 38¾ | 2 1/8 | 24¾ | 30½ | 43 | 2 5/16 |
| 36 | 36 to 30 | 25½ | 46 | | 2 3/8 | | | | |
| 36 | 24 | 25½ | 32 | 46 | 2 3/8 | | | | |
| 42 | 42 to 30 | 29¼ | 53 | | 2 5/8 | | | | |
| 42 | 24 | 29¼ | 36½ | 53 | 2 5/8 | | | | |
| 48 | 48 to 42 | 32¾ | 59½ | | 2¾ | | | | |
| 48 | 30 | 32¾ | 41¾ | 59½ | 2¾ | | | | |

See notes on pages 164, 171 and 172.

All dimensions in inches.

On extra heavy anchorage tees the "Size" refers to the outside diameter of the fitting.

# Laying Dimensions of American Standard Flanged Fittings for 25 Pounds Steam Working Pressure Reducing Tees and Crosses (Short Body Patterns) [1,3,5]




## Table No. 63-A

| Nominal Pipe Size[1] | Size of Outlet and Smaller[2, 4] | Center to Face Run H | Face to Face Run HH | Center to Face Outlet J |
|---|---|---|---|---|
| | All reducing fittings sizes 16 inches and smaller have same center to face dimensions as straight size fittings. | | | |
| 18 | 12 | 13 | 26 | 15½ |
| 20 | 14 | 14 | 28 | 17 |
| 24 | 16 | 15 | 30 | 19 |
| 30 | 20 | 18 | 36 | 23 |
| 36 | 24 | 20 | 40 | 26 |
| 42 | 24 | 23 | 46 | 30 |
| 48 | 30 | 26 | 52 | 34 |
| 54 | 36 | 29 | 58 | 37 |
| 60 | 40 | 33 | 66 | 41 |
| 72 | 48 | 40 | 80 | 48 |

All dimensions given in inches.

[1] Short body patterns are used for sizes 18 inches and larger.

[2] Long body patterns are used when outlets are larger than given in above table, and, therefore, have the same dimensions as straight size fittings.

[3] Fittings 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 12 × 12 × 18 inch tee will be governed by the dimensions of the 18 inch long body tee, given in Table 63; namely 16½ inches center to face of all openings and 33 inches face to face.

[4] Side outlet tees, with outlet at 90 degrees or any other angle, straight or reducing, carry same dimensions center to face and face to face as regular tees having same reductions.

[5] In a side outlet tee the larger of the two side outlets govern the center to face dimensions "J."

# American Standard Flanged Fittings for 25, 125 and 250 Pounds Steam Working Pressure

*Marking.* All fittings must have marks cast on them, indicating the manufacturer and figures indicating the maximum working steam pressure for which the fittings are intended.

*Elbows.* There are two types of elbow, known as "Elbows" and "Long Radius Elbows"; unless long radius elbows are specifically ordered the former will be furnished.

*Reducing Fittings.* Reducing elbows and side outlet elbows carry same dimensions center to face as straight sized elbows corresponding with the size of the larger opening.

Tees, side outlet tees, crosses and laterals, sizes 16 inches and smaller, reducing on the outlet or branch have the same dimensions center to face and face to face as straight sized fittings corresponding to the size of the larger opening. Sizes 18 inches and larger, reducing on the outlet or branch, are made in two lengths depending on the size of the outlet as given in the tables of dimensions.

Tees, crosses and laterals, reducing on the run only, have the same dimensions center to face and face to face as straight sized fittings corresponding to the size of the larger opening.

Reducers and eccentric reducers for all reductions have the same face to face dimensions as given in the table for the larger opening.

Side outlet elbows and side outlet tees have all openings on intersecting center lines.

*Laterals.* Laterals, both straight and reducing, in sizes 8 inches and larger shall be reinforced for the inherent weakness in the casting design.

See notes page 164.

## AMERICAN 25 POUNDS STANDARD

*Size.* The term "size" is used to indicate the nominal inside diameter of port.

*Dimensions.* No dimensions are given in this Standard for sizes below 14 inches. For sizes 12 inches and smaller the regular American 125 Pound Standard Cast Iron Flanged Fittings are used; for sizes 14 inches and larger the flanged diameters, bolt circles and number of bolts are the same as the American 125 Pound Standard with a reduction in the thickness of flanges and bolt diameters as shown in Table 57, thereby maintaining interchangeability between the two Standards.

The center to face dimensions for fittings for sizes 14 inches to 48 inches inclusive are the same as the American 125 Pound Standard Cast Iron Flanged Fittings.

For standard flanges see page 155.
For standard dimensions of fittings see page 170.
For theoretical weights of fittings see page 185.

## AMERICAN 125 POUND STANDARD

*Size.* The term "size" is used to indicate the nominal inside diameter of port.

For standard flanges see page 147.
For standard dimensions of fittings see pages 166 to 169.
For theoretical weights of fittings see pages 173 to 178.

## AMERICAN 250 POUNDS STANDARD

*Size.* In sizes 14 inches and larger "Nominal size" refers to the outside diameter of fittings.

For standard flanges see page 149.
For standard dimensions of fittings see pages 167 to 169.
For theoretical weights of fittings see pages 179 to 184.

# Theoretical Weights in Pounds of American Standard Flanged Fittings for Maximum Saturated Steam Pressure of 125 Pounds per Square Inch

## Table No. 64

| Sizes | 90 Degree Elbow | 45 Degree Elbow | 90 Deg. Long Radius Elbow | Side Outlet Elbow | Tees | Cross and Side Outlet Tees | Laterals |
|---|---|---|---|---|---|---|---|
| 1 | 5 | 4 | 7 | 8 | 9 | 11 | 10 |
| 1 ¼ | 7 | 6 | 9 | 10 | 11 | 15 | 13 |
| 1 ½ | 9 | 8 | 11 | 13 | 15 | 19 | 17 |
| 2 | 14 | 12 | 16 | 20 | 21 | 28 | 25 |
| 2 ½ | 19 | 17 | 23 | 28 | 30 | 39 | 36 |
| 3 | 24 | 20 | 28 | 34 | 37 | 48 | 44 |
| 3 ½ | 31 | 27 | 37 | 46 | 49 | 63 | 59 |
| 4 | 41 | 36 | 48 | 59 | 64 | 82 | 75 |
| 5 | 52 | 45 | 62 | 74 | 81 | 105 | 96 |
| 6 | 68 | 60 | 85 | 96 | 105 | 135 | 125 |
| 8 | 110 | 94 | 145 | 150 | 165 | 210 | 210 |
| 10 | 175 | 145 | 230 | 240 | 270 | 330 | 340 |
| 12 | 250 | 220 | 350 | 340 | 380 | 470 | 520 |
| 14 | 350 | 270 | 470 | 470 | 530 | 650 | 680 |
| 16 | 470 | 360 | 670 | 620 | 700 | 850 | 950 |
| 18 | 580 | 420 | 840 | 760 | 860 | 1040 | 1150 |
| 20 | 740 | 540 | 1080 | 970 | 1100 | 1330 | 1480 |
| 24 | 1160 | 800 | 1640 | 1510 | 1730 | 2080 | 2080 |
| 30 | 1850 | 1430 | 2800 | 2350 | 2710 | 3210 | 3680 |
| 36 | 2800 | 2280 | 4450 | 3500 | 4050 | 4750 | |
| 42 | 4010 | 3380 | 6610 | 4930 | 5790 | 6710 | |
| 48 | 5400 | 4680 | 9250 | 6520 | 7620 | 8740 | |

For dimensions, see page 166.

All weights listed are for fittings faced and drilled, based upon minimum thicknesses and dimensions given in preceding table without allowances for variation. Cast iron is considered to weigh 0.26 pound per cubic inch.

Weights of laterals do not include reinforcing ribs.

# Theoretical Weights in Pounds of American Standard Flanged Fittings for Maximum Saturated Steam Pressure of 125 Pounds per Square Inch

## Table No. 65

| Sizes | Reducing Elbows | Reducers and Eccentric Reducers | Sizes | Reducing Elbows | Reducers and Eccentric Reducers |
|---|---|---|---|---|---|
| 3 x 1½ | 17 | | 14x 8 | 240 | 200 |
| 3 x 2 | 19 | 16 | 14x10 | 280 | 220 |
| 3 x 2½ | 22 | 19 | 14x12 | 320 | 250 |
| 3½x 2 | 24 | 20 | 16x 8 | 300 | 250 |
| 3½x 3 | 28 | 24 | 16x10 | 340 | 280 |
| 4 x 2 | 29 | 24 | 16x12 | 380 | 310 |
| 4 x 2½ | 31 | 26 | 16x14 | 420 | 340 |
| 4 x 3 | 33 | 28 | 18x10 | 390 | 320 |
| 4 x 3½ | 37 | 31 | 18x12 | 440 | 350 |
| 5 x 2½ | 37 | 31 | 18x14 | 480 | 380 |
| 5 x 3 | 40 | 32 | 18x16 | 540 | 430 |
| 5 x 4 | 48 | 39 | 20x12 | 520 | 410 |
| 6 x 3 | 47 | 39 | 20x14 | 570 | 450 |
| 6 x 3½ | 51 | 43 | 20x16 | 640 | 490 |
| 6 x 4 | 56 | 47 | 20x18 | 680 | 520 |
| 6 x 5 | 60 | 50 | 24x12 | 740 | 580 |
| 8 x 4 | 77 | 66 | 24x16 | 880 | 670 |
| 8 x 5 | 82 | 71 | 24x18 | 930 | 700 |
| 8 x 6 | 90 | 77 | 24x20 | 1010 | 760 |
| 10 x 5 | 115 | 95 | 24x22 | 1080 | 800 |
| 10 x 6 | 125 | 100 | | | |
| 10 x 8 | 150 | 120 | | | |
| 12 x 6 | 165 | 140 | | | |
| 12 x 8 | 190 | 155 | | | |
| 12 x10 | 220 | 180 | | | |

For dimensions, see page 166.

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.

# Theoretical Weights in Pounds of American Standard Flanged Fittings for Maximum Saturated Steam Pressure of 125 Pounds per Square Inch

## Table No. 66

| Sizes | Lateral Reducing Outlet (Not Ribbed) | Sizes | Lateral Reducing Outlet (Not Ribbed) |
|---|---|---|---|
| 3 x 3 x1 ½ | 36 | 12x12x 8 | 430 |
| 3 x 3 x2 | 39 | 12x12x10 | 470 |
| 3 x 3 x2 ½ | 42 | 14x14x 8 | 550 |
| 3 ½x 3 ½x2 | 49 | 14x14x10 | 590 |
| 3 ½x 3 ½x2 ½ | 52 | 14x14x12 | 640 |
| 3 ½x 3 ½x3 | 55 | 16x16x 8 | 740 |
| 4 x 4 x2 | 60 | 16x16x10 | 790 |
| 4 x 4 x2 ½ | 63 | 16x16x12 | 830 |
| 4 x 4 x3 | 66 | 16x16x14 | 880 |
| 4 x 4 x3 ½ | 70 | 18x18x10 | *930 |
| 5 x 5 x2 ½ | 79 | 18x18x12 | *980 |
| 5 x 5 x3 | 82 | 18x18x14 | 1030 |
| 5 x 5 x3 ½ | 86 | 18x18x16 | 1100 |
| 5 x 5 x4 | 93 | 20x20x10 | *840 |
| 6 x 6 x3 | 105 | 20x20x12 | *1220 |
| 6 x 6 x3 ½ | 105 | 20x20x14 | *1270 |
| 6 x 6 x4 | 115 | 20x20x16 | 1350 |
| 6 x 6 x5 | 120 | 20x20x18 | 1400 |
| 8 x 8 x4 | 175 | 24x24x12 | *1250 |
| 8 x 8 x5 | 180 | 24x24x14 | *1810 |
| 8 x 8 x6 | 195 | 24x24x16 | *1890 |
| 10 x10 x5 | 270 | 24x24x18 | 1950 |
| 10 x10 x6 | 280 | 24x24x20 | 2040 |
| 10 x10 x8 | 310 | 24x24x22 | 2120 |
| 12 x12 x6 | 400 | | |

For dimensions, see page 166.

Weights of laterals do not include reinforcing ribs.

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.

*These sizes made in the short body pattern only.

# Theoretical Weights in Pounds of American Standard Flanged Fittings for Maximum Saturated Steam Pressure of 125 Pounds per Square Inch

## Table No. 67

## Reducing Tees

| Sizes | Weight | Sizes | Weight | Sizes | Weight |
|---|---|---|---|---|---|
| 3 x3 x2 ½ | 36 | 4x3 x2 | 46 | 6x6x3 | 89 |
| 3 x3 x2 | 33 | 4x2 ½x4 | 56 | 6x5x6 | 100 |
| 3 x3 x1 ½ | 31 | 4x2 ½x3 | 49 | 6x5x5 | 95 |
| 3 x2 ½x3 | 35 | 4x2 ½x2 ½ | 47 | 6x5x4 | 92 |
| 3 x2 ½x2 ½ | 34 | 4x2 ½x2 | 45 | 6x5x3 | 84 |
| 3 x2 ½x2 | 31 | 4x2 x4 | 54 | 6x4x6 | 98 |
| 3 x2 ½x1 ½ | 29 | 4x2 x3 | 47 | 6x4x5 | 93 |
| 3 x2 x3 | 33 | 4x2 x2 ½ | 45 | 6x4x4 | 89 |
| 3 x2 x2 ½ | 32 | 4x2 x2 | 43 | 6x4x3 | 82 |
| 3 x2 x2 | 29 | 5x5 x4 | 78 | 6x3x6 | 92 |
| | | 5x5 x3 ½ | | | |
| 3 x2 x1 ½ | 27 | 5x6 x3 ½ | 74 | 6x3x5 | 86 |
| 3 x1 ½x3 | 32 | 5x5 x3 | 70 | 6x3x4 | 83 |
| 3 x1 ½x2 ½ | 30 | 5x5 x2 ½ | 68 | 6x3x3 | 76 |
| 3 x1 ½x2 | 27 | 5x4 x5 | 78 | 8x8x6 | 150 |
| 3 x1 ½x1 ½ | 25 | 5x4 x4 | 75 | 8x8x5 | 145 |
| 3 ½x3 ½x3 | 46 | 5x4 x3 | 68 | 8x8x4 | 145 |
| 3 ½x3 ½x2 ½ | 44 | 5x4 x2 ½ | 66 | 8x6x8 | 155 |
| 3 ½x3 ½x2 | 42 | 5x3 x5 | 72 | 8x6x6 | 140 |
| 4 x4 x3 ½ | 60 | 5x3 x4 | 68 | 8x6x5 | 135 |
| 4 x4 x3 | 57 | 5x3 x3 | 61 | 8x6x4 | 130 |
| 4 x4 x2 ½ | 55 | 5x3 x2 ½ | 59 | 8x5x8 | 150 |
| 4 x4 x2 | 53 | 5x2 ½x5 | 70 | 8x5x6 | 135 |
| 4 x3 x4 | 57 | 5x2 ½x4 | 67 | 8x5x5 | 130 |
| 4 x3 x3 | 50 | 5x2 ½x3 | 60 | 8x5x4 | 125 |
| 4 x3 x2 ½ | 49 | 5x2 ½x2 ½ | 58 | 8x4x8 | 150 |
| | | 6x6 x5 | 99 | | |
| | | 6x6 x4 | 96 | | |
| | | 6x6 x3 ½ | 92 | | |

For dimensions, see page 166.

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.

# Theoretical Weights in Pounds of American Standard Flanged Fittings for Maximum Saturated Steam Pressure of 125 Pounds per Square Inch

## Table No. 67 (continued)

## Reducing Tees

| Sizes | Weight | Sizes | Weight | Sizes | Weight |
|---|---|---|---|---|---|
| 8x 4x 6 | 135 | 14x14x10 | 480 | 16x12x12 | 620 |
| 8x 4x 5 | 130 | 14x14x 8 | 460 | 16x12x10 | 590 |
| 8x 4x 4 | 125 | 14x12x14 | 510 | 16x12x 8 | 570 |
| 10x10x 8 | 250 | 14x12x12 | 490 | 16x10x16 | 650 |
| 10x10x 6 | 240 | 14x12x10 | 460 | 16x10x14 | 620 |
| 10x10x 5 | 230 | 14x12x 8 | 440 | 16x10x12 | 600 |
| 10x 8x10 | 260 | 14x10x14 | 490 | 16x10x10 | 570 |
| 10x 8x 8 | 240 | 14x10x12 | 470 | 16x10x 8 | 550 |
| 10x 8x 6 | 220 | 14x10x10 | 450 | 16x 8x16 | 640 |
| 10x 6x10 | 250 | 14x10x 8 | 420 | 16x 8x14 | 610 |
| 10x 6x 8 | 230 | 14x 8x14 | 480 | 16x 8x12 | 580 |
| 10x 6x 6 | 210 | 14x 8x12 | 460 | 16x 8x10 | 560 |
| 12x12x10 | 360 | 14x 8x10 | 430 | 16x 8x 8 | 540 |
| 12x12x 8 | 340 | 14x 8x 8 | 410 | 18x18x16 | 860 |
| 12x12x 6 | 320 | 16x16x14 | 670 | 18x18x14 | 820 |
| 12x10x12 | 370 | 16x16x12 | 650 | 18x18x12 | *660 |
| 12x10x10 | 340 | 16x16x10 | 620 | 18x18x10 | *640 |
| 12x10x 8 | 320 | 16x16x 8 | 610 | 20x20x18 | 1060 |
| 12x10x 6 | 310 | 16x14x16 | 680 | 20x20x16 | 1040 |
| 12x 8x12 | 350 | 16x14x14 | 650 | 20x20x14 | *840 |
| 12x 8x10 | 330 | 16x14x12 | 630 | 20x20x12 | *820 |
| 12x 8x 8 | 310 | 16x14x10 | 600 | 20x20x10 | *790 |
| 12x 8x 6 | 300 | 16x14x 8 | 580 | 24x24x20 | 1640 |
| 12x 6x12 | 340 | 16x12x16 | 670 | 24x24x18 | 1600 |
| 12x 6x10 | 320 | 16x12x14 | 640 | 24x24x16 | *1170 |
| 12x 6x 8 | 300 | | | 24x24x14 | *1140 |
| 12x 6x 6 | 280 | | | 24x24x12 | *1110 |
| 14x14x12 | 500 | | | | |

For dimensions, see page 166.

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.

*These sizes made in short body pattern only.

# Theoretical Weights in Pounds of American Standard Flanged Fittings for Maximum Saturated Steam Pressure of 125 Pounds per Square Inch

## Table No. 68

## Reducing Crosses

| Sizes | Weight | Sizes | Weight |
|---|---|---|---|
| 3 x 3 x1 ½x1 ½ | 36 | 12x12x 8x 8 | 380 |
| 3 x 3 x2 x2 | 40 | 12x12x10x10 | 420 |
| 3 x 3 x2 ½x2 ½ | 44 | 14x14x 8x 8 | 500 |
| 3 ½x 3 ½x2 x2 | 47 | 14x14x10x10 | 550 |
| 3 ½x 3 ½x2 ½x2 ½ | 53 | 14x14x12x12 | 600 |
| 3 ½x 3 ½x3 x3 | 57 | 16x16x 8x 8 | 650 |
| 4 x 4 x2 x2 | 59 | 16x16x10x10 | 690 |
| 4 x 4 x2 ½x2 ½ | 64 | 16x16x12x12 | 740 |
| 4 x 4 x3 x3 | 68 | 16x16x14x14 | 790 |
| 4 x 4 x3 ½x3 ½ | 74 | *18x18x10x10 | 700 |
| 5 x 5 x2 ½x2 ½ | 78 | *18x18x12x12 | 750 |
| 5 x 5 x3 x3 | 82 | 18x18x14x14 | 930 |
| 5 x 5 x3 ½x3 ½ | 89 | 18x18x16x16 | 1000 |
| 5 x 5 x4 x4 | 96 | *20x20x10x10 | 860 |
| 6 x 6 x3 x3 | 100 | *20x20x12x12 | 910 |
| 6 x 6 x3 ½x3 ½ | 105 | *20x20x14x14 | 960 |
| 6 x 6 x4 x4 | 115 | 20x20x16x16 | 1200 |
| 6 x 6 x5 x5 | 120 | 20x20x18x18 | 1250 |
| 8 x 8 x4 x4 | 165 | *24x24x12x12 | 1210 |
| 8 x 8 x5 x5 | 175 | *24x24x14x14 | 1250 |
| 8 x 8 x6 x6 | 190 | *24x24x16x16 | 1310 |
| 10 x10 x5 x5 | 250 | 24x24x18x18 | 1810 |
| 10 x10 x6 x6 | 270 | 24x24x20x20 | 1900 |
| 10 x10 x8 x8 | 300 | 24x24x22x22 | 1980 |
| 12 x12 x6 x6 | 350 | | |

For dimensions, see page 166.

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.

*These sizes made in short body pattern only.

# Theoretical Weights in Pounds of American Standard Flanged Fittings for Maximum Saturated Steam Pressure of 250 Pounds per Square Inch

## Table No. 69

| Nominal Pipe Sizes | 90 Degree Elbow | 45 Degree Elbow | 90 Deg. Long Radius Elbow | Side Outlet Elbow | Regular and Single and Double Sweep Tees | Cross and Side Outlet Tees | Laterals (Not Ribbed) |
|---|---|---|---|---|---|---|---|
| 1 | 9 | 7 | 10 | 13 | 14 | 18 | 15 |
| 1¼ | 11 | 10 | 13 | 17 | 18 | 23 | 20 |
| 1½ | 16 | 15 | 18 | 24 | 25 | 32 | 30 |
| 2 | 20 | 18 | 23 | 30 | 32 | 41 | 37 |
| 2½ | 30 | 28 | 34 | 43 | 46 | 58 | 57 |
| 3 | 40 | 35 | 44 | 55 | 58 | 74 | 73 |
| 3½ | 49 | 44 | 55 | 71 | 76 | 94 | 91 |
| 4 | 65 | 58 | 72 | 94 | 99 | 130 | 120 |
| 5 | 87 | 76 | 98 | 125 | 135 | 170 | 165 |
| 6 | 115 | 105 | 135 | 170 | 180 | 230 | 230 |
| 8 | 185 | 155 | 220 | 260 | 280 | 350 | 360 |
| 10 | 290 | 240 | 350 | 400 | 430 | 540 | 570 |
| 12 | 410 | 340 | 510 | 560 | 620 | 770 | 820 |
| 14 O.D. | 560 | 440 | 710 | 790 | 870 | 1090 | 1180 |
| 16 O.D. | 750 | 620 | 960 | 1040 | 1150 | 1430 | 1610 |
| 18 O.D. | 970 | 780 | 1260 | 1330 | 1490 | 1840 | 2100 |
| 20 O.D. | 1220 | 960 | 1630 | 1670 | 1880 | 2320 | 2670 |
| 24 O.D. | 1840 | 1430 | 2470 | 2490 | 2800 | 3450 | 4020 |
| 30 O.D. | 3120 | 2230 | 4290 | 4150 | 4740 | 5760 | |

For dimensions, see page 167.

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.

Weights of laterals do not include reinforcing ribs.

# Theoretical Weights in Pounds of American Standard Flanged Fittings for Maximum Saturated Steam Pressure of 250 Pounds per Square Inch

## Table No. 70

| Nominal Pipe Sizes | Reducing Elbow | Reducers and Eccentric Reducers | Nominal Pipe Sizes | Reducing Elbow | Reducers and Eccentric Reducers |
|---|---|---|---|---|---|
| 3 x1 ½ | 28 | 24 | 12x 8 | 300 | 250 |
| 3 x2 | 30 | 25 | 12x10 | 360 | 290 |
| 3 x2 ½ | 35 | 29 | 14x 8 | 390 | 320 |
| 3 ½x2 | 35 | 29 | 14x10 | 440 | 360 |
| 3 ½x3 | 44 | 36 | 14x12 | 490 | 410 |
| 4 x2 | 43 | 36 | 16x 8 | 470 | 390 |
| 4 x2 ½ | 48 | 40 | 16x10 | 530 | 440 |
| 4 x3 | 52 | 44 | 16x12 | 600 | 490 |
| 4 x3 ½ | 56 | 48 | 16x14 | 670 | 550 |
| 5 x2 ½ | 60 | 50 | 18x10 | 650 | 520 |
| 5 x3 | 65 | 54 | 18x12 | 710 | 580 |
| 5 x4 | 78 | 63 | 18x14 | 790 | 640 |
| 6 x3 | 82 | 67 | 18x16 | 870 | 670 |
| 6 x3 ½ | 89 | 71 | 20x12 | 840 | 660 |
| 6 x4 | 93 | 77 | 20x14 | 930 | 730 |
| 6 x5 | 100 | 85 | 20x16 | 1020 | 800 |
| 8 x4 | 130 | 105 | 20x18 | 1120 | 880 |
| 8 x5 | 140 | 115 | 24x12 | 1150 | 920 |
| 8 x6 | 155 | 130 | 24x16 | 1350 | 1070 |
| 10 x5 | 190 | 155 | 24x18 | 1460 | 1170 |
| 10 x6 | 210 | 170 | 24x20 | 1590 | 1260 |
| 10 x8 | 240 | 190 | | | |
| 12 x6 | 280 | 220 | | | |

For dimensions, see page 167.

All weights listed are for fittings faced and drilled, based on minimum thicknesses and dimensions in preceding tables, without allowances for variation. Cast iron is assumed to weigh 0.26 pound per cubic inch.

# Theoretical Weights in Pounds of American Standard Flanged Fittings for Maximum Saturated Steam Pressure of 250 Pounds per Square Inch

## Table No. 71

| Nominal Pipe Sizes | Lateral Reducing Outlet (Not Ribbed) | Nominal Pipe Sizes | Lateral Reducing Outlet (Not Ribbed) |
|---|---|---|---|
| 3 x 3 x1 ½ | 58 | 12x12x 6 | 640 |
| 3 x 3 x2 | 60 | 12x12x 8 | 690 |
| 3 x 3 x2 ½ | 68 | 12x12x10 | 750 |
| 3 ½x 3 ½x2 | 73 | 14x14x 8 | 910 |
| 3 ½x 3 ½x2 ½ | 80 | 14x14x10 | 980 |
| 3 ½x 3 ½x3 | 85 | 14x14x12 | 1050 |
| 4 x 4 x2 | 92 | 16x16x 8 | 1190 |
| 4 x 4 x2 ½ | 98 | 16x16x10 | 1270 |
| 4 x 4 x3 | 105 | 16x16x12 | 1350 |
| 4 x 4 x3 ½ | 110 | 16x16x14 | 1440 |
| 5 x 5 x2 ½ | 130 | 18x18x10 | 1580 |
| 5 x 5 x3 | 135 | 18x18x12 | 1660 |
| 5 x 5 x3 ½ | 140 | 18x18x14 | 1760 |
| 5 x 5 x4 | 145 | 18x18x16 | 1870 |
| 6 x 6 x3 | 180 | 20x20x10 | *1620 |
| 6 x 6 x3 ½ | 185 | 20x20x12 | 2040 |
| 6 x 6 x4 | 195 | 20x20x14 | 2140 |
| 6 x 6 x5 | 210 | 20x20x16 | 2260 |
| 8 x 8 x4 | 290 | 20x20x18 | 2390 |
| 8 x 8 x5 | 300 | 24x24x12 | *2470 |
| 8 x 8 x6 | 320 | 24x24x14 | 3100 |
| 10 x10 x5 | 450 | 24x24x16 | 3200 |
| 10 x10 x6 | 470 | 24x24x18 | 3350 |
| 10 x10 x8 | 510 | 24x24x20 | 3520 |

For dimensions, see page 167.

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.

Weights of laterals do not include reinforcing ribs.

*These sizes made in the short body pattern only.

# Theoretical Weights in Pounds of American Standard Flanged Fittings for Maximum Saturated Steam Pressure of 250 Pounds per Square Inch

## Table No. 72

## Reducing Tees

| Nominal Pipe Sizes | Weight | Nominal Pipe Sizes | Weight | Nominal Pipe Sizes | Weight |
|---|---|---|---|---|---|
| 3 x3 x2 ½ | 58 | 4x3 x2 | 71 | 6x6x3 | 150 |
| 3 x3 x2 | 53 | 4x2 ½x4 | 86 | 6x5x6 | 175 |
| 3 x3 x1 ½ | 51 | 4x2 ½x3 | 76 | 6x5x5 | 160 |
| 3 x2 ½x3 | 58 | 4x2 ½x2 ½ | 72 | 6x5x4 | 155 |
| 3 x2 ½x2 ½ | 54 | 4x2 ½x2 | 68 | 6x5x3 | 145 |
| 3 x2 ½x2 | 50 | 4x2 x4 | 82 | 6x4x6 | 165 |
| 3 x2 ½x1 ½ | 48 | 4x2 x3 | 72 | 6x4x5 | 155 |
| 3 x2 x3 | 54 | 4x2 x2 ½ | 68 | 6x4x4 | 145 |
| 3 x2 x2 ½ | 50 | 4x2 x2 | 64 | 6x4x3 | 135 |
| 3 x2 x2 | 46 | 5x3 x4 | 125 | 6x3x6 | 155 |
| 3 x2 x1 ½ | 44 | 5x5 x3 ½ | 120 | 6x3x5 | 145 |
| 3 x1 ½x3 | 52 | 5x5 x3 | 115 | 6x3x4 | 140 |
| 3 x1 ½x2 ½ | 48 | 5x5 x2 ½ | 110 | 6x3x3 | 125 |
| 3 x1 ½x2 | 44 | 5x4 x5 | 125 | 8x8x6 | 260 |
| 3 x1 ½x1 ½ | 42 | 5x4 x4 | 120 | 8x8x5 | 240 |
| 3 ½x3 ½x3 | 72 | 5x4 x3 | 110 | 8x8x4 | 240 |
| 3 ½x3 ½x2 ½ | 68 | 5x4 x2 ½ | 105 | 8x6x8 | 260 |
| 3 ½x3 ½x2 | 63 | 5x3 x5 | 120 | 8x6x6 | 240 |
| 4 x4 x3 ½ | 93 | 5x3 x4 | 110 | 8x6x5 | 230 |
| 4 x4 x3 | 89 | 5x3 x3 | 100 | 8x6x4 | 220 |
| 4 x4 x2 ½ | 85 | 5x3 x2 ½ | 95 | 8x5x8 | 250 |
| 4 x4 x2 | 80 | 5x2 ½x5 | 115 | 8x5x6 | 230 |
| 4 x3 x4 | 90 | 5x2 ½x4 | 105 | 8x5x5 | 215 |
| 4 x3 x3 | 80 | 5x2 ½x3 | 96 | 8x5x4 | 210 |
| 4 x3 x2 ½ | 76 | 5x2 ½x2 ½ | 92 | 8x4x8 | 240 |
| | | 6x6 x5 | 170 | | |
| | | 6x6 x4 | 160 | | |
| | | 6x6 x3 ½ | 150 | | |

For dimensions, see page 167.

All weights 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.

# Theoretical Weights in Pounds of American Standard Flanged Fittings for Maximum Saturated Steam Pressure of 250 Pounds per Square Inch

## Table No. 72 (continued)

## Reducing Tees

| Nominal Pipe Sizes | Weight | Nominal Pipe Sizes | Weight | Nominal Pipe Sizes | Weight |
|---|---|---|---|---|---|
| 8x 4x 6 | 220 | 14x14x10 | 770 | 16x12x12 | 950 |
| 8x 4x 5 | 210 | 14x14x 8 | 730 | 16x12x10 | 900 |
| 8x 4x 4 | 200 | 14x12x14 | 820 | 16x12x 8 | 860 |
| 10x10x 8 | 400 | 14x12x12 | 770 | 16x10x16 | 1030 |
| 10x10x 6 | 370 | 14x12x10 | 730 | 16x10x14 | 970 |
| 10x10x 5 | 360 | 14x12x 8 | 690 | 16x10x12 | 900 |
| 10x 8x10 | 400 | 14x10x14 | 790 | 16x10x10 | 870 |
| 10x 8x 8 | 360 | 14x10x12 | 730 | 16x10x 8 | 830 |
| 10x 8x 6 | 340 | 14x10x10 | 690 | 16x 8x16 | 1000 |
| 10x 6x10 | 380 | 14x10x 8 | 650 | 16x 8x14 | 940 |
| 10x 6x 8 | 350 | 14x 8x14 | 760 | 16x 8x12 | 890 |
| 10x 6x 6 | 320 | 14x 8x12 | 710 | 16x 8x10 | 850 |
| 12x12x10 | 570 | 14x 8x10 | 660 | 16x 8x 8 | 800 |
| 12x12x 8 | 540 | 14x 8x 8 | 630 | 18x18x16 | 1420 |
| 12x12x 6 | 510 | 16x16x14 | 1090 | 18x18x14 | 1360 |
| 12x10x12 | 570 | 16x16x12 | 1040 | 18x18x12 | *1130 |
| 12x10x10 | 530 | 16x16x10 | 990 | 18x18x10 | *1080 |
| 12x10x 8 | 500 | 16x16x 8 | 950 | 20x20x18 | 1800 |
| 12x10x 6 | 470 | 16x14x16 | 1100 | 20x20x16 | 1730 |
| 12x 8x12 | 560 | 16x14x14 | 1040 | 20x20x14 | *1460 |
| 12x 8x10 | 510 | 16x14x12 | 990 | 20x20x12 | *1410 |
| 12x 8x 8 | 480 | 16x14x10 | 950 | 20x20x10 | *1360 |
| 12x 8x 6 | 450 | 16x14x 8 | 910 | 24x24x20 | 2620 |
| 12x 6x12 | 540 | 16x12x16 | 1050 | 24x24x18 | 2540 |
| 12x 6x10 | 500 | 16x12x14 | 1000 | 24x24x16 | *2090 |
| 12x 6x 8 | 460 | | | 24x24x14 | *2030 |
| 12x 6x 6 | 440 | | | 24x24x12 | *1970 |
| 14x14x12 | 820 | | | | |

For dimensions, see page 167.

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.

*These sizes made in short body pattern only.

# Theoretical Weights in Pounds of American Standard Flanged Fittings for Maximum Saturated Steam Pressure of 250 Pounds per Square Inch

## Table No. 73

## Reducing Crosses

| Nominal Pipe Sizes | Weight | Nominal Pipe Sizes | Weight |
|---|---|---|---|
| 3 x 3 x1 ¼x1 ½ | 59 | 12x12x 8x 8 | 620 |
| 3 x 3 x2 x2 | 63 | 12x12x10x10 | 690 |
| 3 x 3 x2 ½x2 ½ | 72 | 14x14x 8x 8 | 820 |
| 3 ½x 3 ½x2 x2 | 74 | 14x14x10x10 | 900 |
| 3 ½x 3 ½x2 ½x2 ½ | 82 | 14x14x12x12 | 990 |
| 3 ½x 3 ½x3 x3 | 89 | 16x16x 8x 8 | 1040 |
| 4 x 4 x2 x2 | 91 | 16x16x10x10 | 1120 |
| 4 x 4 x2 ½x2 ½ | 100 | 16x16x12x12 | 1210 |
| 4 x 4 x3 x3 | 110 | 16x16x14x14 | 1320 |
| 4 x 4 x3 ½x3 ½ | 115 | 18x18x10x10 | *1210 |
| 5 x 5 x2 ½x2 ½ | 125 | 18x18x12x12 | *1320 |
| 5 x 5 x3 x3 | 135 | 18x18x14x14 | 1590 |
| 5 x 5 x3 ½x3 ½ | 145 | 18x18x16x16 | 1710 |
| 5 x 5 x4 x4 | 155 | 20x20x10x10 | *1490 |
| 6 x 6 x3 x3 | 170 | 20x20x12x12 | *1580 |
| 6 x 6 x3 ½x3 ½ | 175 | 20x20x14x14 | *1680 |
| 6 x 6 x4 x4 | 190 | 20x20x16x16 | 2030 |
| 6 x 6 x5 x5 | 200 | 20x20x18x18 | 2170 |
| 8 x 8 x4 x4 | 270 | 24x24x12x12 | *2150 |
| 8 x 8 x5 x5 | 280 | 24x24x14x14 | *2270 |
| 8 x 8 x6 x6 | 310 | 24x24x16x16 | *2380 |
| 10 x10 x5 x5 | 400 | 24x24x18x18 | 2920 |
| 10 x10 x6 x6 | 420 | 24x24x20x20 | 3080 |
| 10 x10 x8 x8 | 470 | 24x24x22x22 | 3240 |
| 12 x12 x6 x6 | 570 | | |

For dimensions, see page 167.

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.

*These sizes made in the short body pattern only.

## Theoretical Weights in Pounds of American Standard Flanged Fittings for Maximum Saturated Steam Pressure of 25 Pounds per Square Inch

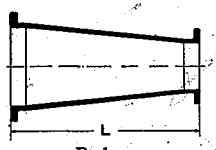
### Table No. 74

| Nominal Pipe Size | 90 Deg. Elbow | 45 Deg. Elbow | 90 Deg. Long Radius Elbow | Tees | Crosses |
|---|---|---|---|---|---|
| 4 | 35 | 30 | 45 | 50 | 65 |
| 5 | | | | | |
| 6 | 55 | 50 | 65 | 85 | 100 |
| 8 | 80 | 65 | 105 | 120 | 150 |
| 10 | 135 | 100 | 160 | 185 | 225 |
| 12 | 185 | 160 | 245 | 270 | 325 |
| 14 | 250 | 195 | 330 | 370 | 450 |
| 16 | 340 | 240 | 425 | 450 | 550 |
| 18 | 385 | 285 | 530 | 550 | 670 |
| 20 | 465 | 350 | 665 | 660 | 780 |
| 24 | 695 | 490 | 950 | 960 | 1130 |
| 30 | 1050 | 840 | 1550 | 1500 | 1750 |
| 36 | 1620 | 1350 | 2480 | 2275 | 2600 |
| 42 | 2325 | 2000 | 3620 | 3200 | 3675 |
| 48 | 3205 | 2850 | 5300 | 4300 | 4880 |
| 54 | 4565 | 3970 | 7500 | 6250 | 6880 |
| 60 | 6000 | 5140 | 9675 | 8000 | 10250 |
| 72 | 9320 | 7525 | 14175 | 12150 | 13450 |

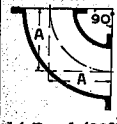
For dimensions see page 170.

NOTE: All weights listed are for fittings faced and drilled, based upon minimum thicknesses and dimensions given in preceding table without allowances for variation. Cast iron is considered to weigh 0.26 pound per cubic inch.

# Dimensions of Flanged Fittings for Water




Reducer




¼ Bend (90°)




⅛ Bend (45°)




1/16 Bend (22½°)




1/32 Bend (11¼°)




1/64 Bend (5⅝°)

## Table No. 75

| Size | A 90° Bends | A 45° Bends | A 22½° Bends | A 11¼° Bends | A 5⅝° Bends | A Long-Radius 90° Bends | L Short Pattern | L Long Pattern |
|---|---|---|---|---|---|---|---|---|
| 4 | 16 | 9.94 | 9.55 | ..... | ..... | 11 | .. | .. |
| 6 | 16 | 9.94 | 9.55 | ..... | ..... | 12 | 16 | 26 |
| 8 | 16 | 9.94 | 9.55 | ..... | ..... | 13 | 16 | 26 |
| 10 | 16 | 9.94 | 9.55 | ..... | ..... | 14 | 16 | 26 |
| 12 | 16 | 9.94 | 9.55 | ..... | ..... | 15 | 16 | 26 |
| 14 | 18 | 14.91 | 14.32 | ..... | ..... | 16 | 24 | 34 |
| 16 | 24 | 14.91 | 14.32 | ..... | ..... | 17 | 24 | 34 |
| 18 | 24 | 14.91 | 14.32 | ..... | ..... | 18 | 24 | 34 |
| 20 | 24 | 19.88 | 19.10 | 23.64 | 23.57 | 19 | 30 | 40 |
| 24 | 30 | 24.85 | 23.87 | 23.64 | 23.57 | 21 | 30 | 40 |
| 30 | 36 | 24.85 | 23.87 | 23.64 | 23.57 | .. | 34 | 74 |
| 36 | 48 | 37.28 | 35.80 | 23.64 | 23.57 | .. | 40 | 74 |
| 42 | 48 | 37.28 | 35.80 | 23.64 | 23.57 | .. | 40 | 74 |
| 48 | 48 | 37.28 | 35.80 | 23.64 | 23.57 | .. | 40 | 74 |
| 54 | [illegible] | 37.28 | 35.80 | 23.64 | 23.57 | .. | .. | .. |
| 60 | [illegible] | 37.28 | 35.80 | 23.64 | 23.57 | .. | .. | .. |

All dimensions in inches.

For standard flanges see page 147.

Fittings furnished with flanges faced plain unless otherwise specified.

Tees and crosses ribbed and bolted as necessary.

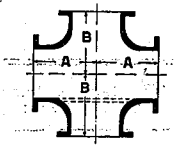
For bases see page 78.

For radii of bends see page 76.

Size of reducers, as well as tees and crosses 24 inches and under, given above represents opening at large end, laying length remains the same for all reductions.

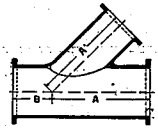
Radii and laying lengths in accordance with A. W. W. A. Specifications.

# Dimensions of Flanged Fittings for Water




Tee and Cross

## Table No. 76




Y Branch

| Tees and Crosses | | | Y Branches Type 2 | | | | | |
|---|---|---|---|---|---|---|---|---|
| Size | A | B | Size | A | B | Size | A | B |
| 4 | 11.0 | 11.0 | 4 | 14.5 | 9.50 | 30x20 | 54.0 | 15.50 |
| 6 | 12.0 | 12.0 | 6x4 | 16.0 | 10.00 | 30x24 | 54.0 | 15.50 |
| 8 | 13.0 | 13.0 | 6 | 17.0 | 11.00 | 30 | 57.0 | 21.25 |
| 10 | 14.0 | 14.0 | 8x4 | 18.0 | 12.00 | | | |
| 12 | 15.0 | 15.0 | 8x6 | 19.0 | 12.00 | 36x24 | 58.5 | 18.25 |
| | | | 8 | 20.0 | 12.00 | 36x30 | 60.5 | 18.25 |
| 14 | 16.0 | 16.0 | | | | 36 | 64.5 | 22.50 |
| 16 | 17.0 | 17.0 | 10x6 | 21.0 | 13.50 | | | |
| 18 | 18.0 | 18.0 | 10x8 | 22.0 | 13.50 | 42x24 | 65.0 | 15.25 |
| 20 | 19.0 | 19.0 | 10 | 22.5 | 13.50 | 42x30 | 68.0 | 15.25 |
| 24 | 21.0 | 21.0 | | | | 42x36 | 71.0 | 19.50 |
| | | | 12x6 | 23.0 | 13.50 | 42 | 74.0 | 23.75 |
| 30x12 | 19.5 | 24.0 | 12x8 | 25.5 | 13.50 | | | |
| 30x14 | 22.5 | 26.0 | 12x10 | 25.5 | 13.50 | 48x30 | 73.0 | 12.50 |
| 30x16 | 23.5 | 26.0 | 12 | 25.5 | 13.50 | 48x36 | 76.0 | 16.50 |
| 30x18 | 24.5 | 26.0 | | | | 48x42 | 79.0 | 20.75 |
| 30x20 | 25.5 | 26.0 | 14x6 | 26.0 | 11.00 | 48 | 82.0 | 25.00 |
| 30x24 | 27.5 | 26.0 | 14x8 | 26.5 | 11.75 | | | |
| 30 | 30.5 | 30.5 | 14x10 | 27.0 | 12.50 | | | |
| | | | 14x12 | 27.5 | 13.25 | | | |
| 36x12 | 19.5 | 27.0 | 14 | 28.0 | 14.00 | | | |
| 36x14 | 22.5 | 29.0 | | | | | | |
| 36x16 | 23.5 | 29.0 | 16x8 | 27.0 | 15.50 | | | |
| 36x18 | 24.5 | 29.0 | 16x10 | 29.0 | 15.50 | | | |
| 36x20 | 25.5 | 29.0 | 16x12 | 31.0 | 15.50 | | | |
| 36x24 | 27.5 | 29.0 | 16x14 | 33.0 | 15.50 | | | |
| 36x30 | 30.5 | 33.5 | 16 | 35.0 | 15.50 | | | |
| 36 | 33.5 | 33.5 | | | | | | |
| | | | 18x10 | 36.0 | 16.00 | | | |
| 42x12 | 20.0 | 30.0 | 18x12 | 36.0 | 16.00 | | | |
| 42x14 | 23.0 | 32.0 | 18x14 | 36.0 | 16.00 | | | |
| 42x16 | 24.0 | 32.0 | 18x16 | 38.0 | 16.00 | | | |
| 42x18 | 25.0 | 32.0 | 18 | 38.0 | 16.00 | | | |
| 42x20 | 26.0 | 32.0 | | | | | | |
| 42x24 | 28.0 | 32.0 | 20x12 | 41.0 | 16.75 | | | |
| 42x30 | 31.0 | 36.5 | 20x14 | 41.0 | 16.75 | | | |
| 42x36 | 34.0 | 36.5 | 20x16 | 41.0 | 16.75 | | | |
| 42 | 37.0 | 37.0 | 20x18 | 41.0 | 16.75 | | | |
| | | | 20 | 41.0 | 16.75 | | | |
| 48x16 | 24.0 | 35.0 | | | | | | |
| 48x18 | 25.0 | 35.0 | 24x16 | 44.0 | 10.75 | | | |
| 48x20 | 26.0 | 35.0 | 24x18 | 44.0 | 16.75 | | | |
| 48x24 | 28.0 | 35.0 | 24x20 | 44.0 | 16.75 | | | |
| 48x30 | 31.0 | 39.5 | 24 | 46.0 | 17.75 | | | |
| 48x36 | 34.0 | 39.5 | | | | | | |
| 48x42 | 37.0 | 40.0 | | | | | | |
| 48 | 40.0 | 40.0 | | | | | | |

See notes on previous page.

## Weights of Flanged Bends for Water

### Table No. 77

| Size | Class | 90° Bends | 45° Bends | 22 ½° Bends | 11 ¼° Bends | 5 ⅝° Bends | Short Long Radius 90° Bends |
|---|---|---|---|---|---|---|---|
| 4 | D | 70 | 58 | 58 | .... | .... | 61 |
| 6 | D | 102 | 84 | 84 | .... | .... | 90 |
| 8 | D | 151 | 125 | 125 | .... | .... | 140 |
| 10 | D | 211 | 172 | 172 | .... | .... | 202 |
| 12 | D | 287 | 238 | 238 | .... | .... | 285 |
| 14 | B | 337 | 363 | 363 | .... | .... | 319 |
| 14 | D | 388 | 420 | 420 | .... | .... | 377 |
| 16 | B | 496 | 444 | 444 | .... | .... | 416 |
| 16 | D | 602 | 526 | 526 | .... | .... | 490 |
| 18 | B | 589 | 515 | 515 | .... | .... | 505 |
| 18 | D | 706 | 611 | 611 | .... | .... | 601 |
| 20 | B | 712 | 712 | 712 | 841 | 841 | 631 |
| 20 | D | 853 | 853 | 853 | 1021 | 1021 | 749 |
| 24 | B | 1128 | 1127 | 1127 | 1131 | 1131 | 912 |
| 24 | D | 1377 | 1377 | 1377 | 1376 | 1376 | 1090 |
| 30 | A | 1682 | 1473 | 1473 | 1450 | 1450 | .... |
| 30 | B | 1887 | 1641 | 1641 | 1641 | 1641 | .... |
| 30 | C | 2121 | 1833 | 1833 | 1830 | 1830 | .... |
| 30 | D | 2357 | 2026 | 2026 | 2019 | 2019 | .... |
| 36 | A | 2892 | 2752 | 2752 | 2044 | 2044 | .... |
| 36 | B | 3243 | 3179 | 3179 | 2258 | 2258 | .... |
| 36 | C | 3706 | 3512 | 3512 | 2538 | 2538 | .... |
| 36 | D | 4198 | 3971 | 3971 | 2824 | 2824 | .... |
| 42 | A | 3785 | 3640 | 3640 | 2724 | 2724 | .... |
| 42 | B | 4394 | 4067 | 4067 | 3017 | 3017 | .... |
| 42 | C | 4960 | 4675 | 4675 | 3375 | 3375 | .... |
| 42 | D | .... | 5263 | 5263 | 3753 | 3753 | .... |
| 48 | A | 4730 | 4692 | 4692 | 3497 | 3497 | .... |
| 48 | B | 5393 | 5127 | 5127 | 3757 | 3757 | .... |
| 48 | C | 6247 | 5918 | 5918 | 4268 | 4268 | .... |
| 48 | D | 4981 | 6612 | 6612 | 4702 | 4702 | .... |
| 54 | A | 7192 | 5802 | 5802 | 4362 | 4362 | .... |
| 54 | B | 8011 | 6334 | 6334 | 4694 | 4694 | .... |
| 54 | C | 9460 | 7561 | 7561 | 5514 | 5514 | .... |
| 54 | D | 10845 | 8563 | 8563 | 6146 | 6146 | .... |
| 60 | A | 8342 | 7006 | 7006 | 5372 | 5372 | .... |
| 60 | B | 9605 | 7937 | 7937 | 5956 | 5956 | .... |
| 60 | C | 11141 | 8965 | 8965 | 6691 | 6691 | .... |
| 60 | D | 12872 | 10382 | 10382 | 7514 | 7514 | .... |

Weights given in pounds. All weights approximate.
For dimensions, see page 186.
For standard flanges, see page 147.
For standard bases, see page 78.

# Weights of Flanged Tees, Crosses and Y-Branches for Water
## Table No. 78

| Size | Class | Tees | Crosses | Y-Branches | Size | Class | Tees | Crosses | Y-Branches |
|---|---|---|---|---|---|---|---|---|---|
| 3 | .. | .... | .... | 68 | 18x4 | B | 593 | 620 | ..... |
| 4 | D | 89 | 115 | 117 | 18x4 | D | 707 | 733 | ..... |
| 6x4 | D | 126 | 152 | 164 | 18x6 | B | 607 | 647 | ..... |
| 6 | D | 139 | 179 | 185 | 18x6 | D | 725 | 770 | ..... |
| | | | | | 18x8 | B | 624 | 681 | ..... |
| | | | | | 18x8 | D | 743 | 805 | ..... |
| 8x4 | D | 183 | 210 | 228 | 18x10 | B | 640 | 713 | 1234 |
| 8x6 | D | 196 | 237 | 259 | 18x10 | D | 767 | 853 | 1502 |
| 8 | D | 215 | 276 | 293 | 18x12 | B | 668 | 770 | 1248 |
| | | | | | 18x12 | D | 782 | 884 | 1563 |
| | | | | | 18x14 | B | 685 | 804 | 1303 |
| 10x4 | D | 253 | 280 | ..... | 18x14 | D | 816 | 952 | 1624 |
| 10x6 | D | 272 | 306 | 367 | 18x16 | B | 730 | 893 | 1404 |
| 10x8 | D | 284 | 341 | 406 | 18x16 | D | 850 | 1019 | 1754 |
| 10 | D | 303 | 396 | 453 | 18 | B | 741 | 913 | 1464 |
| | | | | | 18 | D | 871 | 1061 | 1830 |
| 12x4 | D | 351 | 378 | ..... | 20x6 | B | 756 | 796 | ..... |
| 12x6 | D | 365 | 404 | 530 | 20x6 | D | 902 | 947 | ..... |
| 12x8 | D | 382 | 439 | 590 | 20x8 | B | 773 | 830 | ..... |
| 12x10 | D | 398 | 494 | 628 | 20x8 | D | 919 | 981 | ..... |
| 12 | D | 426 | 557 | 677 | 20x10 | B | 789 | 862 | ..... |
| | | | | | 20x10 | D | 944 | 1030 | ..... |
| | | | | | 20x12 | B | 821 | 927 | 1671 |
| 14x4 | B | 396 | 422 | ..... | 20x12 | D | 993 | 1129 | 1987 |
| 14x4 | D | 456 | 483 | ..... | 20x14 | B | 842 | 963 | 1676 |
| 14x6 | B | 409 | 449 | 584 | 20x14 | D | 1028 | 1199 | 2057 |
| 14x6 | D | 470 | 510 | 837 | 20x16 | B | 879 | 1042 | 1738 |
| 14x8 | B | 426 | 483 | 634 | 20x16 | D | 1056 | 1255 | 2138 |
| 14x8 | D | 487 | 544 | 882 | 20x18 | B | 896 | 1068 | 1774 |
| 14x10 | B | 454 | 538 | 685 | 20x18 | D | 1081 | 1303 | 2197 |
| 14x10 | D | 512 | 596 | 937 | 20 | B | 936 | 1156 | 1880 |
| 14x12 | B | 485 | 601 | 741 | 20 | D | 1110 | 1363 | 2317 |
| 14x12 | D | 544 | 659 | 1003 | | | | | |
| 14 | B | 498 | 627 | 773 | 24x6 | B | 1074 | 1114 | ..... |
| 14 | D | 573 | 717 | 1069 | 24x6 | D | 1301 | 1346 | ..... |
| | | | | | 24x8 | B | 1092 | 1149 | ..... |
| | | | | | 24x8 | D | 1318 | 1380 | ..... |
| 16x4 | B | 508 | 535 | ..... | 24x10 | B | 1108 | 1181 | ..... |
| 16x4 | D | 580 | 606 | ..... | 24x10 | D | 1342 | 1428 | ..... |
| 16x6 | B | 522 | 562 | ..... | 24x12 | B | 1140 | 1246 | ..... |
| 16x6 | D | 597 | 637 | ..... | 24x12 | D | 1391 | 1527 | ..... |
| 16x8 | B | 539 | 596 | 772 | 24x14 | B | 1163 | 1291 | ..... |
| 16x8 | D | 616 | 678 | 1110 | 24x14 | D | 1427 | 1597 | ..... |
| 16x10 | B | 555 | 628 | 840 | 24x16 | B | 1198 | 1361 | 2038 |
| 16x10 | D | 640 | 726 | 1186 | 24x16 | D | 1453 | 1652 | 2740 |
| 16x12 | B | 583 | 685 | 933 | 24x18 | B | 1211 | 1387 | 2182 |
| 16x12 | D | 672 | 788 | 1277 | 24x18 | D | 1574 | 1859 | 2845 |
| 16x14 | B | 596 | 730 | 980 | 24x20 | B | 1257 | 1479 | 2419 |
| 16x14 | D | 700 | 845 | 1378 | 24x20 | D | 1631 | 1971 | 3263 |
| 16 | B | 628 | 789 | 1065 | 24 | B | 1335 | 1635 | 2852 |
| 16 | D | 737 | 916 | 1512 | 24 | D | 1744 | 2189 | 3905 |

Weights given in pounds. All weights approximate.
For dimensions see page 187.
For standard flanges see page 147. For standard bases see page 78.

## Weights of Flanged Tees, Crosses and Y-Branches for Water

### Table No. 78 (continued)

| Size | Class | Tees | Crosses | Y-Branches | Size | Class | Tees | Crosses | Y-Branches |
|---|---|---|---|---|---|---|---|---|---|
| 30x12 | A | 1410 | 1526 | ..... | 36x18 | A | 2309 | 2513 | ..... |
| 30x12 | B | 1546 | 1661 | ..... | 36x18 | B | 2483 | 2688 | ..... |
| 30x12 | C | 1701 | 1817 | ..... | 36x18 | C | 2851 | 3088 | ..... |
| 30x12 | D | 1857 | 1973 | ..... | 36x18 | D | 3395 | 3795 | ..... |
| 30x14 | A | 1572 | 1717 | ..... | 36x20 | A | 2413 | 2663 | ..... |
| 30x14 | B | 1731 | 1876 | ..... | 36x20 | B | 2642 | 2892 | ..... |
| 30x14 | C | 1933 | 2098 | ..... | 36x20 | C | 3169 | 3585 | ..... |
| 30x14 | D | 2264 | 2532 | ..... | 36x20 | D | 3553 | 4015 | ..... |
| 30x16 | A | 1650 | 1828 | ..... | 36x24 | A | 2621 | 2957 | 4136 |
| 30x16 | B | 1816 | 1994 | ..... | 36x24 | B | 2869 | 3205 | 4801 |
| 30x16 | C | 2035 | 2239 | ..... | 36x24 | C | 3466 | 4006 | 5790 |
| 30x16 | D | 2388 | 2710 | ..... | 36x24 | D | 3961 | 4603 | 6283 |
| 30x18 | A | 1720 | 1924 | ..... | 36x30 | A | 3021 | 3580 | 4956 |
| 30x18 | B | 1895 | 2098 | ..... | 36x30 | B | 3544 | 4288 | 5469 |
| 30x18 | C | 2127 | 2363 | ..... | 36x30 | C | 4036 | 4883 | 6255 |
| 30x18 | D | 2502 | 2852 | ..... | 36x30 | D | 4674 | 5712 | 7018 |
| 30x20 | A | 1809 | 2059 | 3083 | 36 | A | 3426 | 4209 | 5660 |
| 30x20 | B | 1992 | 2241 | 3506 | 36 | B | 4003 | 4995 | 7176 |
| 30x20 | C | 2386 | 2773 | 4059 | 36 | C | 4596 | 5741 | 8504 |
| 30x20 | D | 2640 | 3061 | 4381 | 36 | D | 5379 | 6796 | 9686 |
| 30x24 | A | 1985 | 2322 | 3552 | 42x12 | A | 2564 | 2680 | ..... |
| 30x24 | B | 2183 | 2519 | 4289 | 42x12 | B | 2792 | 2907 | ..... |
| 30x24 | C | 2627 | 3130 | 4660 | 42x12 | C | 3113 | 3229 | ..... |
| 30x24 | D | 2899 | 3434 | 5144 | 42x12 | D | 3417 | 3533 | ..... |
| 30 | A | 2341 | 2899 | 3924 | 42x14 | A | 2826 | 2971 | ..... |
| 30 | B | 2614 | 3223 | 4810 | 42x14 | B | 3092 | 3236 | ..... |
| 30 | C | 3119 | 3923 | 4319 | 42x14 | C | 3491 | 3655 | ..... |
| 30 | D | 3509 | 4424 | 6045 | 42x14 | D | 4135 | 4500 | ..... |
| 36x12 | A | 1921 | 2037 | ..... | 42x16 | A | 2936 | 3115 | ..... |
| 36x12 | B | 2090 | 2206 | ..... | 42x16 | B | 3216 | 3394 | ..... |
| 36x12 | C | 2315 | 2431 | ..... | 42x16 | C | 3640 | 3844 | ..... |
| 36x12 | D | 2551 | 2667 | ..... | 42x16 | D | 4328 | 4752 | ..... |
| 36x14 | A | 2130 | 2275 | ..... | 42x18 | A | 3041 | 3245 | ..... |
| 36x14 | B | 2328 | 2473 | ..... | 42x18 | B | 3332 | 3537 | ..... |
| 36x14 | C | 2613 | 2778 | ..... | 42x18 | C | 4000 | 4389 | ..... |
| 36x14 | D | 3095 | 3403 | ..... | 42x18 | D | 4500 | 4966 | ..... |
| 36x16 | A | 2223 | 2401 | ..... | 42x20 | A | 3162 | 3412 | ..... |
| 36x16 | B | 2432 | 2610 | ..... | 42x20 | B | 3468 | 3717 | ..... |
| 36x16 | C | 2736 | 2940 | ..... | 42x20 | C | 4179 | 4633 | ..... |
| 36x16 | D | 3252 | 3615 | ..... | 42x20 | D | 4700 | 5231 | ..... |

See notes on previous page.

## Weights of Flanged Tees, Crosses and Y-Branches for Water

### Table No. 78 (continued)

| Size | Class | Tees | Crosses | Y-Branches | Size | Class | Tees | Crosses | Y-Branches |
|---|---|---|---|---|---|---|---|---|---|
| 42x24 | A | 3404 | 3741 | 5909 | 48x20 | A | 3998 | 4247 | ..... |
| 42x24 | B | 3735 | 4072 | 5645 | 48x20 | B | 4307 | 4556 | ..... |
| 42x24 | C | 4544 | 5130 | 8004 | 48x20 | C | 5239 | 5762 | ..... |
| 42x24 | D | 5163 | 5870 | 8735 | 48x20 | D | 5840 | 6437 | ..... |
| 42x30 | A | 3858 | 4416 | 6395 | 48x24 | A | 4287 | 4624 | ..... |
| 42x30 | B | 4501 | 5266 | 7646 | 48x24 | B | 4858 | 5357 | ..... |
| 42x30 | C | 5295 | 6260 | 8501 | 48x24 | C | 5650 | 6299 | ..... |
| 42x30 | D | 5999 | 7127 | 9638 | 48x24 | D | 6407 | 7211 | ..... |
| 42x36 | A | 4315 | 5098 | 8687 | 48x30 | A | 4814 | 5372 | 7703 |
| 42x36 | B | 5037 | 6058 | 8825 | 48x30 | B | 5507 | 6304 | 8972 |
| 42x36 | C | 5989 | 7291 | 10216 | 48x30 | C | 6505 | 7541 | 10359 |
| 42x36 | D | 6783 | 8280 | 11587 | 48x30 | D | 7356 | 8588 | 11552 |
| 42 | A | 4834 | 5903 | 8631 | 48x36 | A | 5343 | 6126 | 8999 |
| 42 | B | 5673 | 7042 | 10199 | 48x36 | B | 6232 | 7366 | 10583 |
| 42 | C | 6816 | 8569 | 12967 | 48x36 | C | 7263 | 8618 | 12242 |
| 42 | D | 7687 | 9664 | 15512 | 48x36 | D | 8202 | 9778 | 13738 |
| 48x16 | A | 3724 | 3903 | ..... | 48x42 | A | 5934 | 7003 | 10349 |
| 48x16 | B | 4006 | 4185 | ..... | 48x42 | B | 7031 | 8577 | 12082 |
| 48x16 | C | 4831 | 5236 | ..... | 48x42 | C | 8083 | 9825 | 14127 |
| 48x16 | D | 5383 | 5861 | ..... | 48x42 | D | 9211 | 11268 | 15969 |
| 48x18 | A | 3851 | 4056 | ..... | 48 | A | 6536 | 7903 | 11942 |
| 48x18 | B | 4148 | 4352 | ..... | 48 | B | 7844 | 9807 | 13822 |
| 48x18 | C | 5018 | 5466 | ..... | 48 | C | 9009 | 11206 | 16684 |
| 48x18 | D | 5600 | 6127 | ..... | 48 | D | 10223 | 12759 | 18954 |

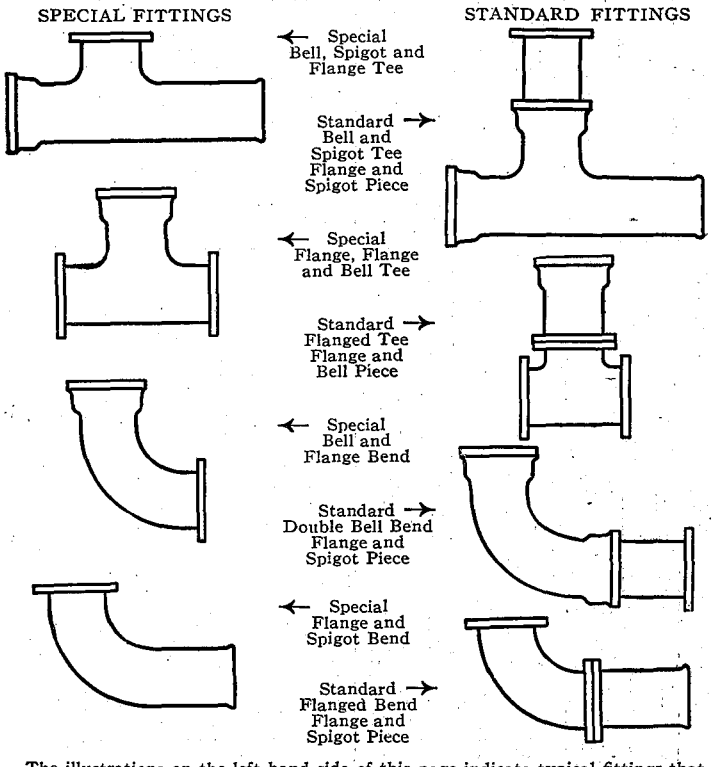
See notes on page 189.

## Weights of Flanged Reducers for Water—Table No. 79

| Size | Class | Reducers Long Pattern | Reducers Short Pattern | Size | Class | Reducers Long Pattern | Reducers Short Pattern |
|---|---|---|---|---|---|---|---|
| 6x4 | D | 89 | 68 | 30x18 | A | 1545 | 863 |
| 8x4 | D | 113 | 81 | 30x18 | B | 1672 | 923 |
| 8x6 | D | 127 | 94 | 30x18 | C | 1942 | 1036 |
| 10x4 | D | 143 | 104 | 30x18 | D | 2107 | 1105 |
| 10x6 | D | 162 | 117 | 30x20 | A | 1637 | 923 |
| 10x8 | D | 186 | 135 | 30x20 | B | 1755 | 973 |
| 12x4 | D | 183 | 123 | 30x20 | C | 2072 | 1109 |
| 12x6 | D | 201 | 148 | 30x20 | D | 2233 | 1175 |
| 12x8 | D | 225 | 165 | 30x24 | A | 1844 | 1034 |
| 12x10 | D | 257 | 188 | 30x24 | B | 1980 | 1095 |
| 14x6 | B | 254 | 201 | 30x24 | C | 2340 | 1250 |
| 14x6 | D | 289 | 218 | 30x24 | D | 2498 | 1305 |
| 14x8 | B | 285 | 225 | 36x20 | A | 2023 | 1288 |
| 14x8 | D | 319 | 243 | 36x20 | B | 2190 | 1374 |
| 14x10 | B | 325 | 256 | 36x20 | C | 2573 | 1567 |
| 14x10 | D | 360 | 276 | 36x20 | D | 2814 | 1690 |
| 14x12 | B | 371 | 293 | 36x24 | A | 2231 | 1416 |
| 14x12 | D | 408 | 314 | 36x24 | B | 2405 | 1503 |
| 16x6 | B | 300 | 234 | 36x24 | C | 2834 | 1726 |
| 16x6 | D | 320 | 257 | 36x24 | D | 3088 | 1853 |
| 16x8 | B | 330 | 259 | 36x30 | A | 2459 | 1574 |
| 16x8 | D | 376 | 284 | 36x30 | B | 2765 | 1731 |
| 16x10 | B | 370 | 290 | 36x30 | C | 3157 | 1930 |
| 16x10 | D | 415 | 317 | 36x30 | D | 3557 | 1997 |
| 16x12 | B | 418 | 328 | 42x20 | A | 2489 | 1597 |
| 16x12 | D | 464 | 354 | 42x20 | B | 2704 | 1709 |
| 16x14 | B | 426 | 340 | 42x20 | C | 3180 | 1945 |
| 16x14 | D | 505 | 390 | 42x20 | D | 3480 | 2095 |
| 18x8 | B | 365 | 285 | 42x24 | A | 2694 | 1726 |
| 18x8 | D | 417 | 315 | 42x24 | B | 2964 | 1862 |
| 18x10 | B | 409 | 318 | 42x24 | C | 3444 | 2104 |
| 18x10 | D | 457 | 348 | 42x24 | D | 3754 | 2254 |
| 18x12 | B | 455 | 356 | 42x30 | A | 3018 | 1883 |
| 18x12 | D | 505 | 387 | 42x30 | B | 3276 | 2134 |
| 18x14 | B | 461 | 367 | 42x30 | C | 3760 | 2305 |
| 18x14 | D | 548 | 424 | 42x30 | D | 4219 | 2537 |
| 18x16 | B | 510 | 404 | 42x36 | A | 3506 | 2139 |
| 18x16 | D | 603 | 467 | 42x36 | B | 3701 | 2341 |
| 20x10 | B | 525 | 422 | 42x36 | C | 4258 | 2618 |
| 20x10 | D | 599 | 481 | 42x36 | D | 4798 | 2893 |
| 20x12 | B | 579 | 467 | 48x30 | A | 3462 | 2230 |
| 20x12 | D | 652 | 524 | 48x30 | B | 3829 | 2414 |
| 20x14 | B | 585 | 485 | 48x30 | C | 4399 | 2703 |
| 20x14 | D | 700 | 559 | 48x30 | D | 4918 | 2924 |
| 20x16 | B | 636 | 521 | 48x36 | A | 3858 | 2488 |
| 20x16 | D | 764 | 614 | 48x36 | B | 4256 | 2589 |
| 20x18 | B | 721 | 588 | 48x36 | C | 4898 | 3013 |
| 20x18 | D | 812 | 657 | 48x36 | D | 5507 | 3342 |
| 24x14 | B | 717 | 582 | 48x42 | A | 4305 | 2794 |
| 24x14 | D | 842 | 676 | 48x42 | B | 4756 | 2923 |
| 24x16 | B | 768 | 623 | 48x42 | C | 5492 | 3388 |
| 24x16 | D | 909 | 730 | 48x42 | D | 6157 | 3722 |
| 24x18 | B | 810 | 655 | | | | |
| 24x18 | D | 968 | 775 | | | | |
| 24x20 | B | 875 | 710 | | | | |
| 24x20 | D | 1049 | 841 | | | | |

Weights given in pounds. All weights approximate. For dimensions see page 186.
For standard flanges see page 147.

## Comparison Between Special Bell and Spigot and Flanged Fittings and Combination of Standard Fittings



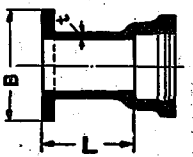

The illustrations on the left hand side of this page indicate typical fittings that are often required with a combination of bell, spigot, and flange outlets. The laying dimensions of these fittings are not covered by any standard and they are therefore usually named "Special" inasmuch as they are made to order to suit certain conditions in piping installations.

On the right hand side and opposite 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.

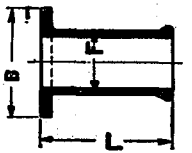
The use of standard fittings wherever possible is always recommended as the most economical and such fittings can usually be shipped out of stock. In sending inquiries for fittings of dimensions deviating from the standard, state specifically the type of outlets wanted, reading, size, etc., as shown on page 47, and give exact dimension from center line to outlet.

# Dimensions and Weights of Standard Flange and Bell, Flange and Spigot and Flange and Flare Fittings

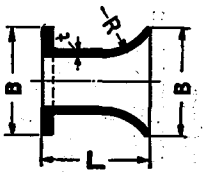
Table No. 80



Flange and Bell



Flange and Spigot

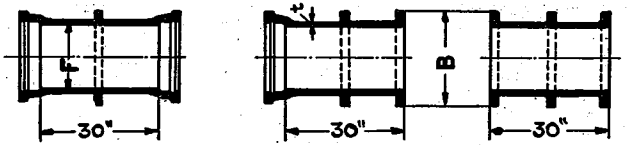


Flange and Flare

| Size | American Standard Flanges and Drilling | | | | | Class | Thickness of Body 't' | Outside Diam. Body F | Flange and Bell | | Flange and Spigot | | Flange and Flare | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Diameter of Flange 'B' | Thickness of Flange | Diam. Bolt Circle | Number of Bolts | Size of Bolts | | | | L | Approx. Weight | L | Approx. Weight | R | L | Approx. Weight |
| 3 | 7 ½ | ¾ | 6 | 4 | ⅝ | D | .48 | 3.96 | 10 | 42 | 16 | 30 | 6 | 8 | 25 |
| 4 | 9 | 15/16 | 7 ½ | 8 | ⅝ | D | .52 | 5.00 | 10 | 65 | 16 | 46 | 6 | 8 | 42 |
| 6 | 11 | 1 | 9 ½ | 8 | ¾ | D | .55 | 7.10 | 10 | 90 | 16 | 68 | 6 | 8 | 57 |
| 8 | 13 ½ | 1 1/16 | 11 ¾ | 8 | ¾ | D | .60 | 9.30 | 10 | 110 | 16 | 98 | 8 | 10 | 94 |
| 10 | 16 | 1 3/16 | 14 ¼ | 12 | ⅞ | D | .68 | 11.40 | 10 | 172 | 18 | 150 | 10 | 10 | 126 |
| 12 | 19 | 1 ¼ | 17 | 12 | ⅞ | D | .75 | 13.50 | 10 | 230 | 18 | 205 | 12 | 12 | 196 |
| 14 | 21 | 1 3/8 | 18 ¾ | 12 | 1 | B | .66 | 15.30 | 10 | 254 | 18 | 228 | 14 | 12 | 204 |
| 14 | 21 | 1 3/8 | 18 ¾ | 12 | 1 | D | .82 | 15.65 | 10 | 290 | 18 | 268 | .. | .. | ... |
| 16 | 23 ½ | 1 7/16 | 21 ¼ | 16 | 1 | B | .70 | 17.40 | 10 | 330 | 20 | 305 | 16 | 16 | 280 |
| 16 | 23 ½ | 1 7/16 | 21 ¼ | 16 | 1 | D | .89 | 17.80 | 10 | 375 | 20 | 348 | .. | .. | ... |
| 18 | 25 | 1 ½ | 22 ¾ | 16 | 1 1/8 | B | .75 | 19.50 | 10 | 384 | 20 | 352 | 18 | 16 | 345 |
| 18 | 25 | 1 ½ | 22 ¾ | 16 | 1 1/8 | D | .96 | 19.92 | 10 | 438 | 20 | 406 | .. | .. | ... |
| 20 | 27 ½ | 1 11/16 | 25 | 20 | 1 1/8 | B | .80 | 21.60 | 10 | 462 | 24 | 458 | 20 | 18 | 440 |
| 20 | 27 ½ | 1 11/16 | 25 | 20 | 1 1/8 | D | 1.03 | 22.06 | 10 | 535 | 24 | 532 | .. | .. | ... |
| 24 | 32 | 1 7/8 | 29 ½ | 20 | 1 ¼ | B | .89 | 25.80 | 10 | 630 | 24 | 628 | 24 | 18 | 600 |
| 24 | 32 | 1 7/8 | 29 ½ | 20 | 1 ¼ | D | 1.16 | 26.32 | 10 | 740 | 24 | 738 | .. | .. | ... |

For dimensions of Bells, see page 66.
Dimensions in inches.
Weights given in pounds. All weights approximate.
The above are standard lengths; other lengths can be furnished.

# Dimensions and Weights of Standard Wall Castings

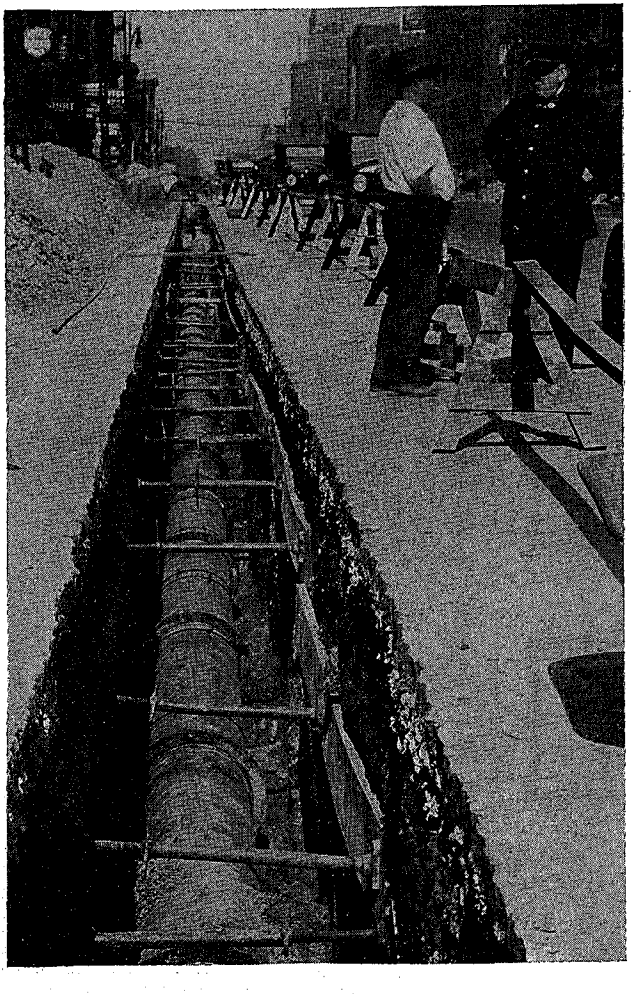



Bell and Bell | Bell and Flange | Flange and Flange

## Table No. 81

| Size | American Standard Flanges and Drilling | | | | | Class | Thickness of Body 't' | Outside Diam. Body F | Approximate Weights | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Diameter of Flange 'B' | Thickness of Flange | Diameter Bolt Circles | Number of Bolts | Size of Bolts | | | | Bell and Bell | Bell and Flange | Flange and Flange | One Bell | One Flange |
| 3 | 7 1/2 | 3/4 | 6 | 4 | 5/8 | D | .48 | 3.96 | 85 | 72 | 59 | 19.3 | 6.2 |
| 4 | 9 | 15/16 | 7 1/2 | 8 | 5/8 | D | .52 | 5.00 | 113 | 101 | 89 | 22.9 | 10.7 |
| 6 | 11 | 1 | 9 1/2 | 8 | 3/4 | D | .55 | 7.10 | 168 | 149 | 131 | 32.9 | 14.4 |
| 8 | 13 1/2 | 1 1/16 | 11 3/4 | 8 | 3/4 | D | .60 | 9.30 | 253 | 223 | 195 | 51.6 | 22.0 |
| 10 | 16 | 1 3/16 | 14 1/4 | 12 | 7/8 | D | .68 | 11.40 | 339 | 305 | 270 | 65.4 | 30.6 |
| 12 | 19 | 1 1/4 | 17 | 12 | 7/8 | D | .75 | 13.50 | 450 | 410 | 371 | 85.1 | 45.6 |
| 14 | 21 | 1 3/8 | 18 3/4 | 12 | 1 | B | .66 | 15.30 | 470 | 440 | 411 | 87.8 | 58.1 |
| 14 | 21 | 1 3/8 | 18 3/4 | 12 | 1 | D | .82 | 15.65 | 544 | 504 | 463 | 95.8 | 55.1 |
| 16 | 23 1/2 | 1 7/16 | 21 1/4 | 16 | 1 | B | .70 | 17.40 | 587 | 547 | 506 | 114.1 | 73.2 |
| 16 | 23 1/2 | 1 7/16 | 21 1/4 | 16 | 1 | D | .89 | 17.80 | 694 | 635 | 576 | 128.1 | 69.1 |
| 18 | 25 | 1 3/8 | 22 3/4 | 16 | 1 1/8 | B | .75 | 19.50 | 691 | 635 | 578 | 134.5 | 78.1 |
| 18 | 25 | 1 3/8 | 22 3/4 | 16 | 1 1/8 | D | .96 | 19.92 | 823 | 744 | 664 | 152.5 | 72.8 |
| 20 | 27 1/2 | 1 5/16 | 25 | 20 | 1 1/8 | B | .80 | 21.60 | 823 | 765 | 707 | 158.2 | 99.8 |
| 20 | 27 1/2 | 1 5/16 | 25 | 20 | 1 1/8 | D | 1.03 | 22.06 | 1002 | 905 | 809 | 189.2 | 92.9 |
| 24 | 32 | 1 7/8 | 29 1/2 | 20 | 1 1/4 | B | .89 | 25.80 | 1084 | 1019 | 954 | 202.0 | 137.0 |
| 24 | 32 | 1 7/8 | 29 1/2 | 20 | 1 1/4 | D | 1.16 | 26.32 | 1348 | 1222 | 1096 | 253.0 | 127.0 |

For dimensions of Bells, see page 66.
Dimensions in inches.
Weights given in pounds. All weights approximate.
The above are standard lengths; other lengths can be furnished.



Laying Cast Iron Pipe under City Streets

## SECTION 10

# PIPE LAYING

THERE seems to have been a tendency in the past to use less care in the laying of underground pipe lines than is ordinarily exercised in the construction of any other engineering structure. The reason probably was the fact that even though haphazard methods were used the failures were either not blamed on these methods or were so rare as not to be considered of great importance. Modern practice is along different lines and the tendency is to put more care into installing mains and in this way insure continuity of service and lower maintenance cost and to reduce the danger of damage from breaks. This step is consistent with the care taken by the pipe manufacturers in the making of pipe. There have been innumerable cases where the blame for a break was laid on the pipe, only upon investigation to find that the fault lay either with the way the pipe was handled after delivery or with some fault in the laying. In order to promote better pipe construction, an effort will be made to outline here the principal points of pipe laying with the hope that their adoption will eliminate some of the faults that have been relatively common heretofore.

*Unloading Pipe.* From the time the pipe is shaken out of the molds until it is loaded on the cars, the manufacturer exercises care to avoid injury to his product and each carload of pipe is inspected before leaving the foundry to determine whether or not any damage has been caused by rough handling during the loading process. Effort is also

made to load cars so that damage in transit will be reduced to a minimum. Damage due to rough handling of trains will occasionally occur and the buyer of pipe should inspect each length of pipe for cracks upon removing it from the cars and damaged pipe should be noted on the bill-of-lading and immediately called to the attention of the railroad agent to insure proper adjustment with the railroad company. In unloading the cars and in all subsequent handling of pipe, care should be exercised so that at no time will the pipe be dropped great distances or on



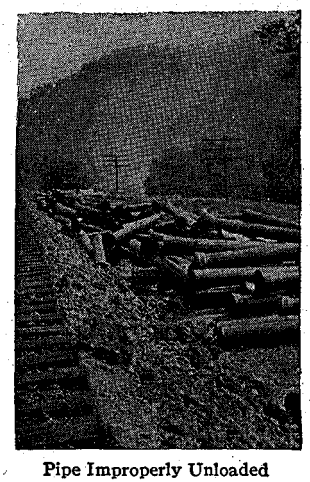
**Unloading Pipe from Truck with Skids**

hard ground. It is preferable to so arrange handling equipment that pipe is either unloaded by derrick or rolled off on skids.

Dropping pipe from trucks or cars to pavements is foolhardy, saves little time and is liable to cause damage that may not appear until after the pipe is installed in the line.

*Delivering Pipe on Ground.* In delivering pipe, economy requires that pipe of large diameters, particularly, be strung along the line with Bells facing the direction in which work is to proceed. Furthermore, the pipe should be so strung that each piece lies opposite its place in the ditch in order to avoid unnecessary handling.

When feasible, the pipe should be placed as close to the ditch as possible and on the side away from the dirt pile. Traffic conditions, digging machine operations and other



Pipe Improperly Unloaded

considerations will affect this procedure, but the general rule is to string the pipe in such a way as to cut down handling to a minimum and at the same time cause the least interference with traffic and reduce the danger of damage to the pipe from passing vehicles. Where Traveling Cranes are used for installing the pipe, it is sometimes possible to string the pipe on the same side of

the ditch as the dirt pile or occasionally on the opposite side of the street when the boom is long enough to pick the pipe up from these locations.

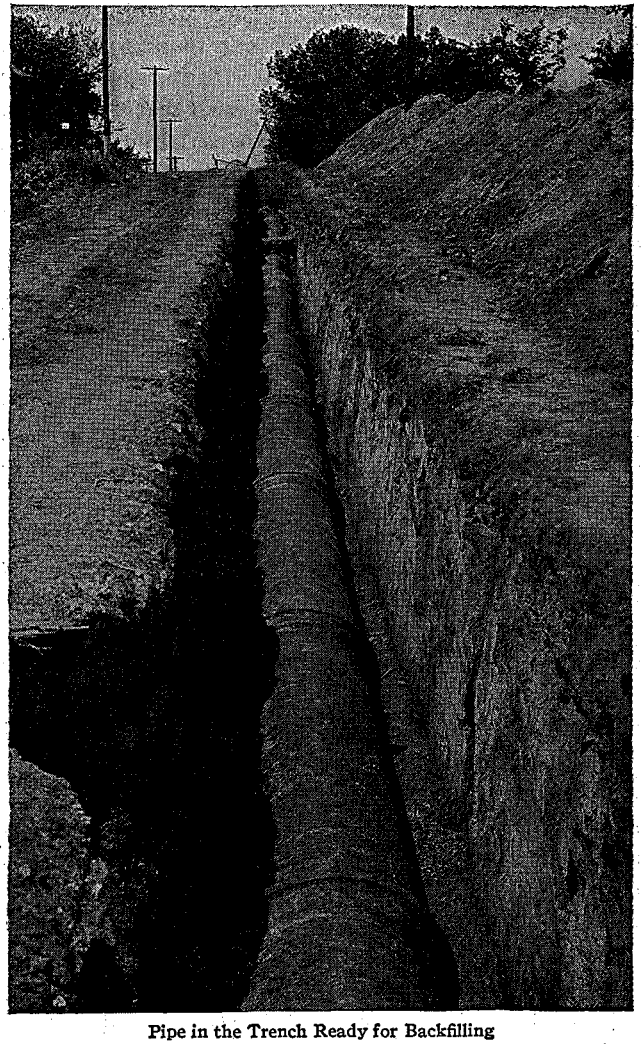
*Excavation.* The width of ditch for various sizes of pipe is determined more by the ability to properly back-fill than by any other consideration. It is conceivable to lay a 36-inch pipe, for instance, in a trench 48 inches wide



Pipe Strung Along Street Ready for Laying

dug in clay, but it would be a physical impossibility to properly back-fill under the pipe with the small clearance that would be available. On the other hand, a ditch dug in sand where flooding can be adopted in back-filling, can be much narrower than where tamping of fill is necessary. A fair average width of trench for various sizes of pipe is shown in the following table:

| Pipe Sizes Inches | Trench Widths Inches | Pipe Sizes Inches | Trench Widths Inches |
|---|---|---|---|
| 6 | 19 | 30 | 45 |
| 8 | 22 | 36 | 51 |
| 10 | 24 | 42 | 58 |
| 12 | 26 | 48 | 64 |
| 14 | 28 | 54 | 70 |
| 16 | 30 | 60 | 76 |
| 18 | 33 | 72 | 89 |
| 20 | 35 | 84 | 101 |
| 24 | 40 | .. | ... |



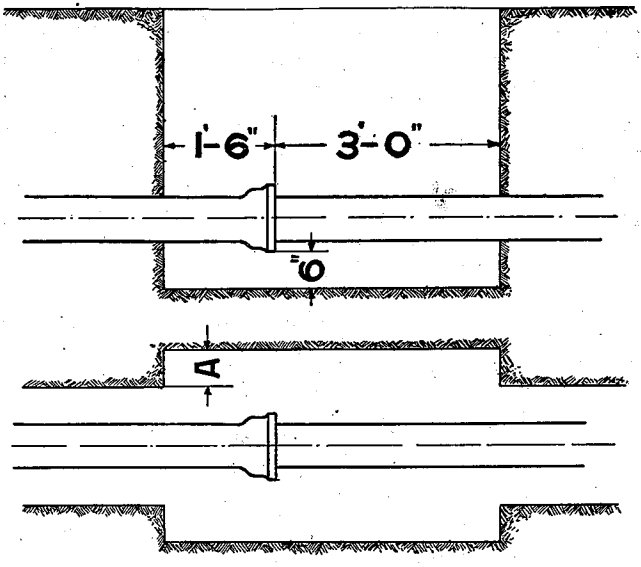
Pipe in the Trench Ready for Backfilling

The depth of trench in the case of water pipe of small diameter must be at least sufficient to bring the pipe below the maximum depth of frost. In the case of larger pipes, the minimum depth may be such that the bottom half of the pipe is always below frost. Large mains laid in heavy traffic streets, under railroad crossings, or in any place where shock might be transmitted to the pipe, should be laid deeper than the minimum requirements mentioned above. In some cases a minimum cover of 5 feet is required on mains of even the largest diameter in order to provide a cushion over the pipe to absorb shocks due to traffic.

At each joint a bell hole should be dug so as to make proper calking as easy as possible. The digging of bell-holes of such a size that the calker is unable to properly swing his calking hammer is poor economy. Proper care in bell-hole digging is a great help toward tight joints. The diagram opposite shows the proper dimensions for bell-holes.

In the case of rock excavation the only extra precaution necessary is to see that the rock is removed in such a way that at no place does it come closer than 6 inches to the finished pipe line. Failure to do this may result in pipe resting on a point of rock, a condition which is very liable to cause a break. In rock excavation the ditch should not be back-filled with the broken rock, but sand, clay or loam should be used, sand being preferable. In case sand is difficult to procure, at least that part of the ditch up to 6 inches above the pipe should be filled with loose material properly tamped, and the remainder of the trench may be filled with the broken rock.

Pipe lines should be carried around underground



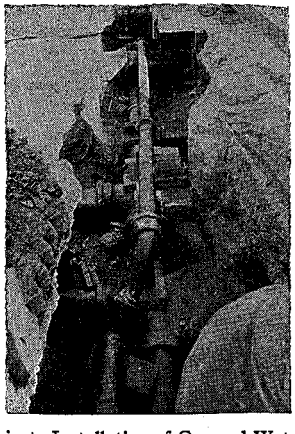

Dimension "A" varies from 6 inches to 10 inches, depending on kind of soil, calking material used and method of calking (hand or air). In smaller sizes of pipe bell holes may not extend to the surface of the ground in stiff material but may be dished out for about a foot and a half above the top of the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

obstructions, such as sewers, conduits, other pipe lines, subways and such like, using special castings if necessary. Care should be taken here as in the case of rock excavation to see to it that the pipe line does not rest on any unyielding structure and also that it is not called upon to support another structure by having it rest on the pipe.

The bottom of the trench should be made to conform to the grade to which the pipe is to be laid. Blocks should be placed immediately behind the bell and about two feet from the spigot. These blocks should be laid on undisturbed earth and set in slots in the bottom of the trench so that they project about ¾ of an inch above the trench

bottom. Where blocks are set in slots, care should be taken that the slot is not concave as in this case the middle portion of the block will be unsupported and the benefit to be derived by blocking is lost. They should be set so that they have bearing over the entire surface.

The primary purpose of blocking is to support and level the pipe during construction and while the earth in the



An Intricate Installation of Gas and Water Lines

ditch is settling. Its length and thickness depends on the nature of the soil and size of the pipe. In general, the following sizes of blocking will be found satisfactory:

BLOCKING

| Pipe Sizes Inches | Length Inches | Thickness Inches |
|---|---|---|
| 16 to 24 | 24 | 2 |
| 30 to 36 | 30 | 2 |
| 48 to 60 | 48 | 3 |
| 60 to 84 | 60 | 3 |

Cast Iron Pipe should be lowered into the trench with ropes and not dropped in from the bank. Small sizes up to 12-inch may be lowered by taking a turn of rope around each end of the pipe, standing on one end of each rope and paying out the other until the pipe rests on the bottom of the trench.



Lowering Small Pipe Into Trench by Hand

Larger sizes are best handled by means of derricks. These may be of the three-legged ditch type, Gantry type or Traveling Cranes. The use of a Traveling Crane simplifies construction in that it makes it possible to pick pipe directly from the trucks, from opposite sides of the roadway or to lift them over the dirt pile. It also makes it unnecessary to string the pipe with Bells all in one direc-

tion as they can easily be turned when being lifted by the derrick.

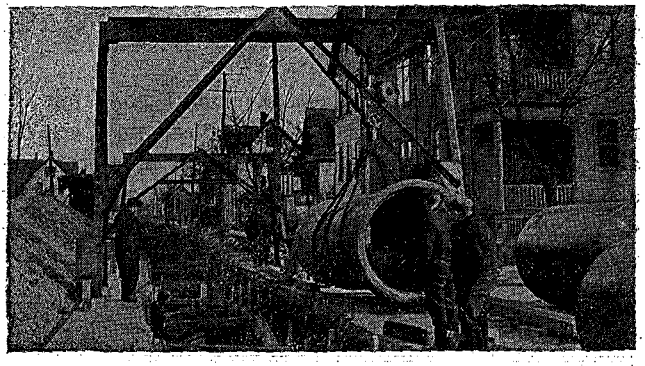
Before entering the Spigot into the Bell of the pipe already laid, the first strands of yarn are held in place on the Spigot end of the pipe by the yarner or yarners. This yarn enters with the Spigot end and centers it in the Bell. This is important, and if by chance when the derrick



Tripod for Lowering Large Pipe into Trench

"slacks off" on the pipe the joint space on the bottom is smaller than on the top, the pipe should again be raised either by the derrick or by means of wedges and additional yarn driven into the lower part of the Bell.

*Yarning.* Each strand of yarn should be cut somewhat longer than the circumference of the pipe so that the ends will overlap and the overlapped ends of successive strands



Special Gantry Crane for Laying Large Pipe

should be staggered. The separate strands should be driven home with the yarning iron and hammers and when the last one is in place, all strands should be thoroughly compacted. This is essential to a good joint as the yarn forms the compressible gasket that insures tight joints.



Handling Cast Iron Pipe with a Steam Shovel

Sufficient yarn should be used to fill a joint up to within 2 inches of the face of the Bell.

*Making the Joint.* The most common type of joint is made with Cast Lead, but joints using lead wool, cement and patent jointing compounds are used to a considerable extent. Plain end pipe with bronze welded joints or couplings is occasionally used, especially for the distribution of high pressure gas.

## LEAD JOINTS

| Size of Pipe | Approximate Pounds of Lead per Joint 2 in. Thick | | Approximate Pounds of Hemp per Joint | |
|---|---|---|---|---|
| | Water | Gas | Water | Gas |
| 3 | 6.00 | ..... | .18 | .... |
| 4 | 7.50 | 8.14 | .21 | .23 |
| 6 | 10.25 | 11.31 | .31 | .34 |
| 8 | 13.25 | 14.56 | .44 | .49 |
| 10 | 16.00 | 17.67 | .53 | .59 |
| 12 | 19.00 | 20.85 | .61 | .67 |
| 14 | 22.00 | ..... | .81 | .... |
| 16 | 30.00 | 27.20 | .94 | 1.03 |
| 18 | 33.80 | ..... | 1.00 | .... |
| 20 | 37.00 | 41.28 | 1.25 | 1.39 |
| 24 | 44.00 | 49.07 | 1.50 | 1.67 |
| 30 | 54.25 | 60.06 | 2.06 | 2.28 |
| 36 | 64.75 | 71.57 | 3.00 | 3.32 |
| 42 | 75.25 | 83.13 | 3.62 | 4.00 |
| 48 | 85.50 | 102.63 | 4.37 | 5.20 |
| 54 | 97.60 | ..... | 6.25 | .... |
| 60 | 108.30 | ..... | 8.25 | .... |
| 72 | 146.00 | ..... | 12.50 | .... |
| 84 | 170.00 | ..... | 15.00 | .... |

*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 should be built up with clay to a point at least 1 inch above the top of the

joint space. All joints should be poured from one ladle full of lead, or when more than one is used, no time should be allowed to elapse between pouring successive ladles. In the case of joints on pipe above 48 inches in diameter it is sometimes necessary to pour the joint in halves. When this is done, the runner is placed around the bottom half of the joint with a pouring gate on each side a little more than half way up on the pipe. Lead is then poured into both gates until it has reached a point just below the midpoint of the pipe. The bottom of the runner remains

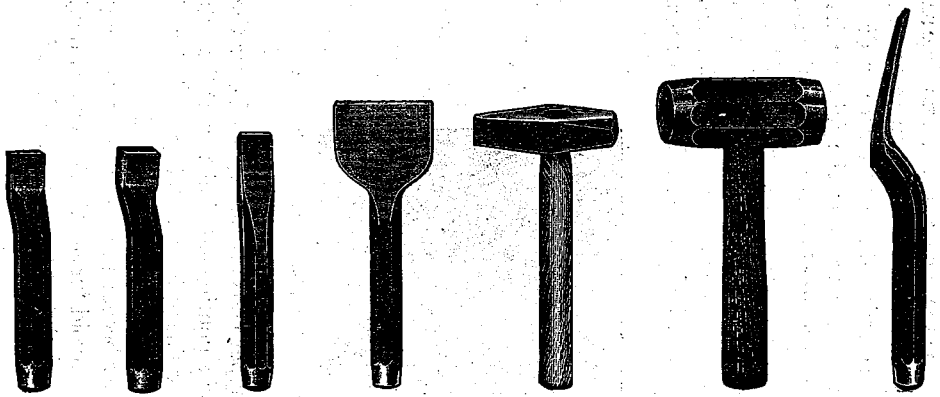


Pouring a Lead Joint, Showing Runner in Place

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. In extreme cold weather it sometimes becomes necessary to heat the joints of large size pipe to avoid "misses." As soon as the joint has cooled, the runner is removed and the joint is ready for calking.

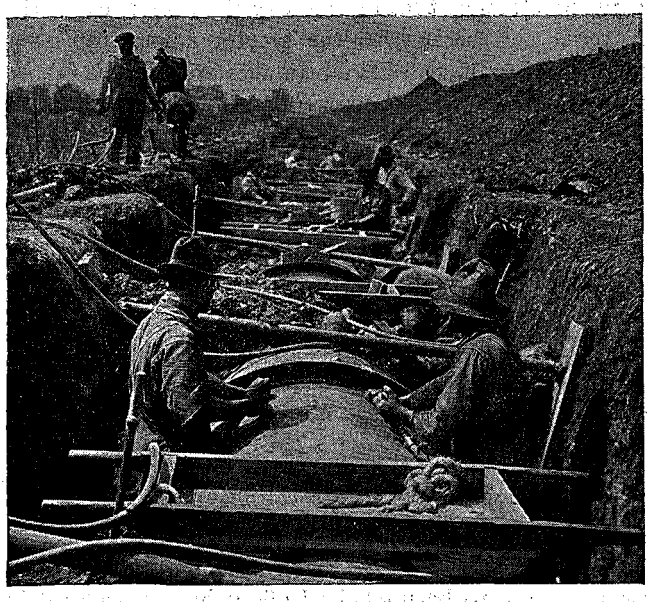
The best practice in calking joints requires that each calking tool be used from the smallest to the largest that

## Calking Tools




1. Regular pattern hand calking iron, ⅜-inch thick at point
2. Regular pattern hand calking iron, ⅝-inch thick at point
3. ¾-inch cold chisel
4. Lead cutting chisel, 3 inches wide at point
5. Pipe cutting chisel, with handle
6. 3½-pound calking hammer, with handle
7. Regular pattern yarning iron, ⅛-inch thick at point

will fit in the joint space and that the joint be calked completely around with each tool. This requires more work than would be necessary if only the larger tools were used but the joint that results is worth the additional effort. On large jobs the use of pneumatic calking hammers is recommended. They result in better calking and cut down the



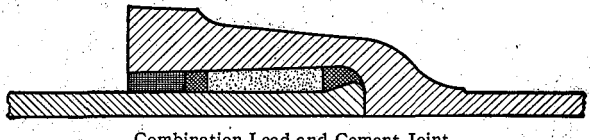
Pneumatic Calking with Lead Wool

cost of the work. Excessive calking should be avoided to prevent splitting bells of pipe.

*Lead Wool.* Lead wool is ordinary lead made into a shredded form and is furnished in the shape of loosely made rope. In making lead wool joints, the yarning is handled in the same manner as in cast lead joints, except

that the joint is yarned to within 1⅛ inches to 1⅜ inches of the face of the Bell. The lead wool is then placed in the joint, one strand at a time and each strand calked before inserting the next one. Each tool in the set should be used on each strand. The finished joint should be flush with the face of the Bell. This type of joint is more expensive than cast lead because of the higher cost of the material and because of the greater amount of labor necessary in calking. Its advantages are: That it can be made under water if necessary and it is claimed that it makes a tighter joint, particularly for gas mains.

*Lead Wool and Cement.* For medium gas pressures a combination cement and lead joint is sometimes used. This joint consists of layers of both cement and lead wool



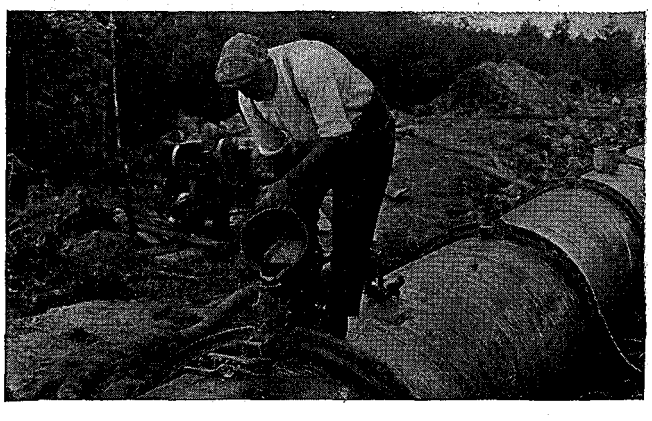
Combination Lead and Cement Joint

as shown in the above sketch. This forms a remarkably tight joint which offers considerable resistance to any tendency to blow out.

*Lead Alloys.* In some cases, where extremely high pressures are to be used, lead alloys have been used in place of commercial lead. The purpose in using an alloy is to get a material that is harder and consequently less liable to "flow" or flatten out if the pressure tends to blow 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%~~ 95% lead, ~~2%~~ 5% tin and 2% antimony. It was found that

this combination of metals gave a joint that calked relatively easily, was hard enough to resist blowing out and yet did not interfere with the flexibility of the joint. The manner of making this joint is similar to that of making the ordinary cast lead joint.

*Lead Substitutes.* Several kinds of self-calking substitutes for lead have been developed, some of which have been in service long enough to demonstrate that this type of material is well adapted for jointing purposes. The best known and oldest in common use is called "Leadite."



Pouring a Bell and Spigot Joint with Leadite

This material is a mixture of iron, sulphur, slag and other substances which, when melted and cooled, forms a hard slag-like mass. It is furnished in powdered form and is delivered in bags weighing 100 pounds. Less heat is required for melting it than in the case of lead and the best possible results are obtained when a gasoline fired

furnace is used although the ordinary coal burning lead kettle can be used by taking care to avoid overheating.

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. The use of tarred or oiled yarn causes the inside of the joint to become oily and is very apt to result in a poor joint. Braided hemp is even better than ordinary yarn as a uniform thickness of joint is insured. The runner is placed in the usual manner and the pouring gate built up with clay to a height of from 6 inches to 8 inches above the top of the Bell. The manufacturers furnish cone-shaped metallic runner heads that can be used in place of clay for this high pouring gate. It is important that a high gate be used. The joint is now ready for pouring. The Leadite is at a proper temperature when it flows freely, reflects one's image as in a mirror and is free from foam or bubbles. If it is too hot or too cold it will be somewhat thicker than the required consistency and it should be either heated or cooled as the case may require before pouring. The joint should be poured from one ladle full until the joint and pouring gate are completely full. As soon as jointing material has cooled, the runner should be removed, the joint inspected and the runner head cut off. In case of a missed joint the material should be cut out for several inches and all loose material removed. The missed part is then re-run. The joint requires no calking and is ready for use as soon as it has cooled. It is characteristic of this joint to sweat or seep a little at first. This should not be a cause for worry as it takes up and is tight in a short time. The principal advantage of this type of joint is a saving in labor that results from the fact that no calking is neces-

sary. There is also a saving due to the lower cost of material and to the fact that the bell holes may be considerably smaller as no room is necessary for swinging calking hammers.

*Cement Joints.* The use of cement for making joints in Cast Iron Pipe is fairly common practice in the gas industry and to a smaller extent for water distribution. A number of different schemes have been developed for making this type of joint, but the system described below seems to be the most common.

First of all the pipe should be properly supported before the joint is started so as to eliminate any possibility of movement of the pipe before the cement has set. The next step is to insert the yarn which has previously been dipped in a thin mixture of neat cement and water and to drive it home with hammers in the usual manner. Extreme care should be taken to be sure that the yarn is absolutely free from all oil and grease. Cement for the joint itself should be about ¾ cement to ¼ water and thoroughly mixed and kneaded by hand by workmen wearing rubber gloves while mixing the cement as well as while making up the joint. Experience shows that neat cement mixed with sufficient quantity of water and thoroughly kneaded in the hand to consistency so that no moisture will show when squeezed tightly in the hand will give proper results. Cement mortar should be made up in small batches so that no mortar shall stand more than three minutes before using. A wooden or iron tool similar in shape to a yarning iron but with a broader face is used for ramming the mortar into the joint. The joint is then finished off with cement and a filet formed at the face of the bell.

In extremely hot weather it is necessary to protect the joint from the direct rays of the sun and the joint kept moist until set (about 48 hours). In cold weather care must be taken to prevent freezing of mortar both before and after the joint is made.

*Rubber Rings for Bell and Spigot Gas Joints.* In Germany, France and England, where experiences with vulcanized rubber in bell and spigot joints range over periods of fifty years or more, the reports dealing with their durability draw the interesting conclusion that gas will not destroy vulcanized rubber in such joints.

Mr. Walter Hole has proved in England by rather complete and scientifically conducted tests (*) that when a rubber ring is put into a bell and spigot gas joint and sealed up, its life is rendered indefinitely long because the ingredients in the gas, consisting of such materials as benzol, toluol, solvent naphtha, petroleum, etc., can do no more than cause the rubber ring to swell or "get fat" and thereby more completely shut off any leakage of gas through the joint.

Several special shapes or designs for these rubber rings have been devised to be used in bell and spigot joints in combination with lead and jute, with cement and jute, and with such special materials as leadite.

One of the biggest problems that the gas industry is facing is the problem of preventing leakage or unaccounted for gas in the distribution systems. The development of a suitable vulcanized rubber ring to be used in bell and spigot joints promises to solve this problem in the most

(*) See article by Mr. Walter Hole on "The Utility and Durability of Rubber as a Jointing Material for Gas Mains" in Gas Journal (London), November 21, 1923, pages 504 to 5[illegible]

economical way and without altering present pipe standards or methods of field construction. Moreover, tests have revealed that this method of making gas joints is equally efficient for high pressure distribution as well as for medium and low pressure distribution. This factor makes it possible to throw into service at any later date an existing low pressure distribution system converted to



Dresser Type Couplings on Small Pipe

an intermediate system or high pressure system without any material increase in leakage from the joints that have been constructed to serve for low pressures.

*Coupled Joints.* For connecting plain end pipe several types of couplings have been developed, the best known of which is the Dresser Coupling.

This coupling consists of two flanges, two gaskets, a middle ring and the necessary bolts. The gaskets are made of plain rubber for water and natural gas lines and of lead or duck tipped rubber for manufactured gas lines. The use of lead or duck is necessary to avoid deterioration of the rubber due to contact with drip oils.

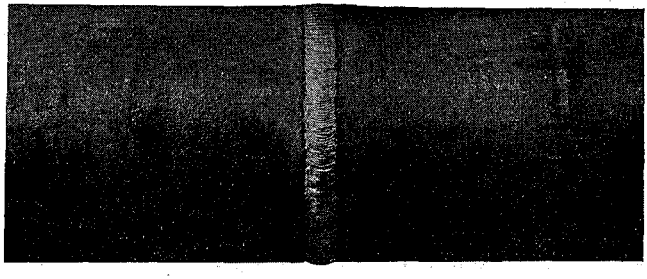
In making the joint, a flange and a gasket are slipped over the ends of the pipe to be connected, the middle ring is then placed on the pipe already installed. The end of the length being laid is then inserted in the middle ring and the flanges with their gaskets are drawn up evenly. To insure uniform compression of the gasket, bolts diametrically 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.

The advantages of this joint are flexibility, tightness, especially in the case of high pressure gas lines, and ability to withstand extremely high pressures in case of either gas or water. There is a saving in cost of pipe because the use of plain end pipe eliminates the extra metal in the bell.

*Bronze Welded Joints.* For high pressure gas distribution plain end pipe joined by a collar of tobin bronze may be used. With this type of joint expansion is usually taken care of by means of special couplings inserted at regular intervals.

The pipe ends are first thoroughly cleaned of all foreign matter and then butted together. The pipe is heated to a

dull red and tack welded in two or three places. The permanent weld is put on proceeding in one direction around the pipe until the joint is completed. Care should be taken to avoid excessive heat as too much heat will burn out the zinc, leaving gas bubbles in the bronze, causing a spongy and leaky joint. Too much oxygen should also be avoided, a neutral flame being necessary in order to avoid oxidizing the zinc and weakening the joint. A small amount of bronze welding flux is required. This is



Bronze Welded Joint on Cast Iron Pipe

applied by dipping the heated bronze rod in the flux from time to time during the welding operation. The general appearance of the joint is rippled, as can be seen in the accompanying photograph.

*Joints in Wet Ditches.* In wet excavations, the different kinds of joints require that certain precautions be taken to insure first class work. In the case of cast lead and lead alloys, it is important that the water be kept pumped out until the joint is finished. If the yarn has become wet due to flooding of the trench or from water standing in the pipe, a small amount of kerosene poured

into the joint prior to pouring the lead will do away with missed joints.

Lead wool joints can be made under water if necessary but even with this material it is advisable, wherever possible, to remove the water before making the joint. When it is impossible to pump out the water, as in the case of submarine lines, additional care is necessary because first it is more difficult to get the material itself to take a compact form when wet, and second, the unfavorable working conditions make first class work more difficult.

When making Leadite joints in wet trenches, the only precaution that should be taken is to leave a small opening at the bottom of the runner so that while the Leadite is being poured in it can force the water out. When Leadite starts to come through the opening in the bottom it should be stopped up with clay and the joint finished in the usual manner. Leadite can be poured into water without causing any explosion or disturbances.

In making up screwed joints or coupled joints in wet trenches, the only additional precaution necessary is to keep dirt out of the joint and to see to it that the workmen do not become careless in order to get through with the job.

*Calking.* The subject of calking has already been dealt with under lead and lead wool joints, but a little repetition may not be out of place. The best lead joint can only be obtained by carefully calking. In the case of cast lead, the shrinkage due to cooling causes the joint to open up around the circumference of the pipe, hence the necessity for calking. The depth to which calking is effective has been found to be about ¾ of an inch when calking is properly

done. By proper calking is meant using each tool, beginning with the cold chisel and using each successive size until the one occupying the entire joint space is used. Slip-shod work consists in using only the large tools. This method finishes off the face of the joint so it looks smooth, but has little effect below the surface. Although a reasonably heavy blow is necessary to properly calk a joint, too great force is to be avoided as it is liable to result in split bells.

In the case of lead wool joints it is equally essential that each tool be used, and on each strand of the material. Failure to follow this method will result in small voids in the joint that will eventually develop into leaks. The use of air hammers is almost a necessity in the case of lead wool joints if first class work is to be expected. Their use on cast lead joints, particularly on large diameter pipe, is also recommended. On page 194 (215) are shown typical calking tools for hand work.

*Submarine Pipe Laying.* In laying cast iron pipe lines under water, the type of joints to be used and the method of laying depend on the depth of the water, whether it is still or flowing, whether used for navigation or not, the nature of the bottom and other local conditions. It would be impossible in the short space allotted to this class of work to cover the method in detail, but a general outline will be given.

In shallow water it is often economy to construct coffer dams and, after pumping them out, to lay the pipe in the open just as on dry land. If the water is navigable the coffer dam should be constructed in sections, in order to provide a channel for boats. In still water the line may be laid on shore along the bank and floated by means of

large barrels attached to the pipe. When the entire length of pipe has been put together and calked one end is towed out until the pipe occupies the line proposed. It is then lowered by releasing the barrels, care being taken during the sinking process so that the joints do not become distorted. This requires that barrels throughout the entire length be released at the same time. Coffer dams 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 along a continuation of the proposed line 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 lay 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 chain hoists. The pipe is raised enough to release the platform upon which it was laid and then lowered gradually to the bottom of the water. It is not necessary that the entire line be lowered at once, but it should be lowered beginning at one end and proceeding to the other in such a way that the total deflection of the joints is kept down to about 2½ degrees.

Still another method is to join several lengths together on a barge, lower them into place by means of a derrick and make the joints between sections with lead wool, using a diver for the under water joints. In case it is not desirable to use lead wool, the end pipe in each section can be equipped with flanges and bell flange spigot pieces,

the under water joint then becomes a matter of making up a flanged joint.

For large lines in deep water an excellent method is to provide a laying cradle having a curved shape so that its lower part is in contact with and parallel to the bottom and its upper part at an angle of about 60° to the surface of the water. After each length of pipe is installed, the barge carrying the cradle is moved forward and the next length connected up until the entire line is laid. The use of this method requires a special joint. This joint, known as the Narrows Syphon Type, has a general appearance of a ball and socket and permits of a considerable deflection without causing joint leaks. The surface of the spigot is machined accurately on a spherical surface and in the case of large pipe polished to a high degree. The joint is run in the usual manner and, after cooling, slugs of lead are introduced into the joint through holes in the bell and forced into it by means of screw plugs. Grease is forced into the joint at the same time that the lead pellets are.

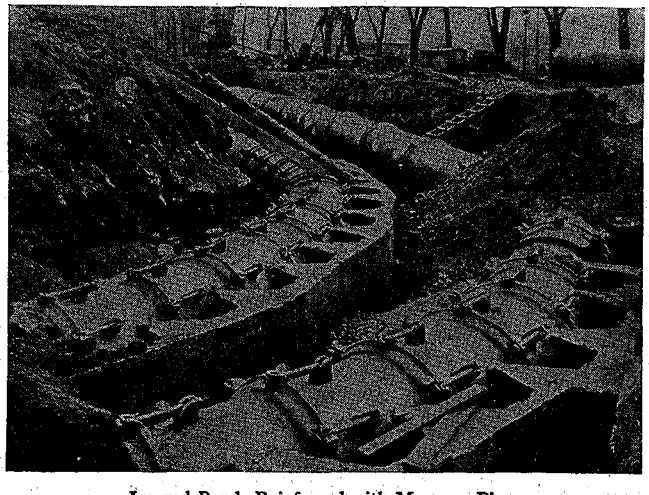
In laying submarine lines the necessity for the use of flexible joints should be considered, and while many lines may be laid with ordinary joints, when there is likely to be considerable change in direction either during the laying of pipe or after it is laid, it is advisable to provide some flexible joints. This can be done by providing at intervals a length of pipe with a standard bell on one end and the flexible spigot on the other, the next pipe having a flexible bell and a standard spigot or, if preferable, flanged joints can be provided where the flexible joint is to be used and a flexible joint provided with flanges inserted at these points. Submarine lines should be covered over particularly where there is navigation.

*Testing.* The best modern practice requires that all pipe lines be tested before back-filling. This applies to both water and gas mains. In the case of water mains the test pressure should be equal to the pressure under which the line will be called upon to operate or, preferably, twice this amount. Care should be taken to see that all caps and plugs are properly braced before the test pressure is applied and that all piers and masonry supports at bends are in place.

In the case of water lines, before attempting to raise the pressure in the line under test, all air must be expelled. This is best done by opening a fire hydrant near the high point of the line and by opening a corporation cock that has previously been inserted at the high point in order to expel air in that portion of the pipe above the hydrant branch. When all of 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 in the case of small lines, or small sections of large lines, or by use of a gasoline pump or fire engine in the case of larger lines. In any event a displacement meter should be so located in the discharge from the pump that when the pressure is up to the stated point, all the water may be caused to pass through this meter. In this way the actual amount of water lost can be measured. While the pipe is under pressure it should be thoroughly inspected from one end to the other. This inspection should cover the pipe itself and all of the joints. Leaking joints can be made tight in the case of lead and lead wool by additional calking. In the case of lead substitutes the pipe is usually not tested for several days after pressure has been applied

as it is known before hand that the joints will leak for a few days before taking up. After all leaks have been repaired the ditch should be back-filled.

In testing gas pipe air pressure is used and leaks are detected by applying soapsuds to each joint. In the case of leaks, bubbles will appear and the joint can be made tight by calking. As a rule in gas lines the actual leakage is not measured by a displacement meter, but the



Lugged Bends Reinforced with Masonry Piers

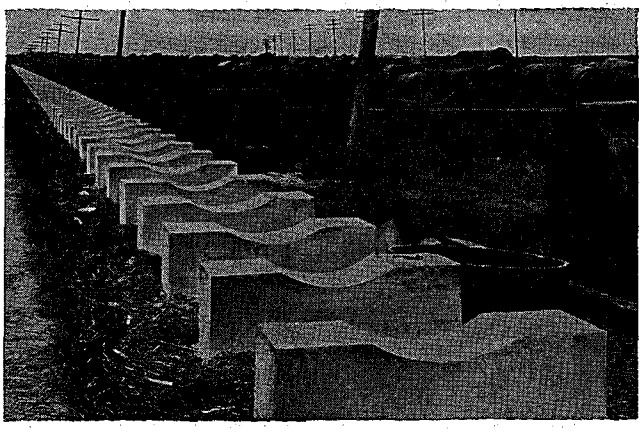
tightness of the pipe is determined by the fact that the pressure, when once built up remains stationary for a period of time.

*Piers.* Masonry piers should be constructed behind all bends, and in the case of large pipe behind caps and plugs. These piers 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, if at all possible, 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 piers behind bends refers to bends in the vertical plane as well as those used in changing direction. These piers should be so designed that they will not interfere with recalking joints if such work should become necessary.

*Back-Filling.* One part of pipe line construction work that is given too little attention is that of back-filling. The old-fashioned idea of tossing the dirt into the trench and leaving nature take its course, is a prolific source of trouble. The ideal system is one that replaces the excavated earth in such a way that future settlement is reduced to a minimum. When a ditch is poorly back-filled the pipe is very often called upon to act as a beam in supporting material directly over it. This introduces stresses in the pipe itself and at the joints that may cause breakage of the pipe or undue deflection of the joint. As mentioned under the subject of excavation, the width of the trench should be such that back-filling can be done properly, that is, there should be enough room between the pipe and the sides of the ditch so that the material can be placed under the lower quarters of the pipe, and if the material is such that tamping is necessary, there should be sufficient room for this work. In the case of excavation in sand, back-filling can be done efficiently by the proper use of flooding, although even in this case some care is necessary to see that no voids are left beneath the pipe. After the material has been tamped up to about the center of the pipe, as far as the pipe itself is concerned, there is little

trouble to be experienced as the remainder of the back-filling consists in merely filling the ditch. If the pipe, however, is in a city street or a travelled highway, the same care should be applied to the remainder of the trench as to the lower part. Some engineers require that the material shall be heaped over the trench to take care of a reasonable amount of settlement, while others claim that if back-filling is properly handled this is not necessary. All excess material should be removed in the case of pipe



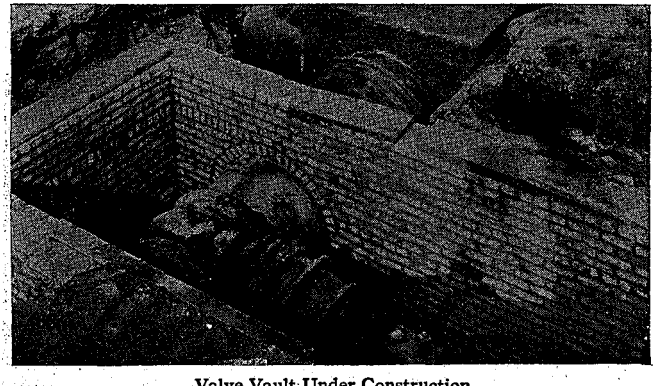
**Concrete Piers to Support Pipe Through Filled Ground**

in city streets as soon as possible, as the mere laying of pipe is often an annoyance to the people on the street and any effort on the part of those installing the pipe to minimize this annoyance is effort well spent.

The suggestions for back-filling mentioned heretofore apply to the average pipe job, but there are special cases where special precautions must be taken. In filled ground

and in swampy locations the best possible foundation is often so poor that it becomes advisable to use piers under each length of pipe, and this method should be followed rather than dependence placed on a material that obviously will not properly support the pipe.

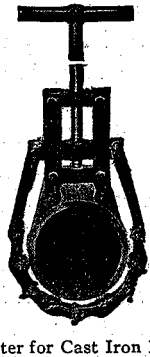
In the case of rock excavation, the ditch should not be filled with the excavated material, as all subsequent work is made considerably harder and more expensive, and the possibility of danger to the pipe due to back-filling with



Valve Vault Under Construction

broken rock is so great that it becomes advisable to use other material. Sand, if available, forms the best material for back-filling trenches in rock. In case it becomes necessary to lay a cast iron pipe through cinders, slag piles, garbage dumps or other material that is highly corrosive, the best results can be obtained if the trench is back-filled with clay. Back-filling with the excavated material is bound to cause trouble eventually and while hauling clay for the work may be expensive, it adds to the life of the pipe and results in a better job.

*Valve Basins, Vaults, Valve Boxes, Etc.* There is a difference of opinion among waterworks men as to whether valve boxes or valve vaults should be used. The argument in favor of building a vault over each valve is that it makes it possible to repack the valve, to replace broken stems, and to do any other work that may be necessary on the valve without the necessity of making an opening in the street. In the case of valves located in parkways, these arguments do not hold, and there are some who claim that it is cheaper to use a valve box and, when repairs



Cutter for Cast Iron Pipe

become necessary, to make the necessary excavation. In any event, either a valve vault or a valve box should be so constructed as to insure speedy closing of the valve in the event of emergencies. The exact location should be noted on the distribution atlas.

*Cutting Pipe.* There are two general methods used for cutting cast iron pipe. One by the use of a pipe cutting machine of some kind and the other by the use of hammers, diamond points, chisels, 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 necessary. For pipes above this size there are machines on the market that use a cutting tool (for making the cut) similar to the tools used in the ordinary machine shop. This machine is mounted on pipe concentrically and operated by means of crank handle, the feed being automatic. Cuts made with this machine are similar in nature to a cut made in a lathe and in addition to eliminating the possibility of a ragged cut or of cracking the pipe, this device makes it possible to salvage the cut piece. When pipe is cut by hand, a certain degree of skill and care is necessary. Small pipe can easily be cut by use of Cold Chisels and Hardys. The process consists in going around the pipe several times with the chisel and hammer until finally the piece breaks off. When cutting pipe in the trench or when cutting larger pipe on the bank, it becomes advisable to use a chisel with a diamond shaped point. This tool is used after the manner of a chisel, except that, due to its shape, it actually removes the iron in small chips instead of merely deforming it. After a groove has been completely cut around the pipe a hammer and chisels are used in much the same manner as when cutting pipe on the bank. It is possible, by striking hard blows with heavy hammers, to cause small cracks in the pipe that is being cut, which often do not show up for some time. Proper supervision should be exercised so that the pipe is not injured in the cutting process.

## SECTION 11

# SUBSTITUTES FOR CAST IRON PIPE

AT different times in the past there have appeared on the market various substitutes for bell and spigot cast iron pipe. Almost without exception manufacturers of these pipes have made no claim as to the superiority of their product over cast iron—their only claim has been that their product costs less. In speaking of cost, the figure that was stressed was the cost of the pipe—no attention was paid to the annual cost such as interest, sinking fund and maintenance. When annual costs have come in for consideration, the only salvation of the substitute pipe was to claim a long life for the material. This long life claim was enough in many instances to sell the first order of pipe, but in very few places was it considered when the second lot of pipe was bought. Some makers after experience had shown their product to be short-lived, attempted to hold their market by claiming that new methods of manufacture or new coatings had been developed that corrected the faults in the pipe that they had marketed previously. These claims worked in some cases, especially where the pipe was used in the installation of a new waterworks, where no local official had any experience with pipe of any kind. It is interesting to note that in very few if any cases where the substitute pipe has been replaced, anything but bell and spigot cast iron pipe has been considered for the replacement work.

The principal substitutes are wood pipe, steel pipe of various kinds, concrete pipe and cast iron pipe made by processes not conformable to the requirements of the standard specifications adopted by water works and gas associations.

Wood pipe for low heads is cheaper in the first cost than is cast iron. It fails, either by decay of the staves or by rusting out of the steel windings or bands that hold the staves together. After wood pipe had been in service long enough for these faults to develop, more rigid specifications concerning the stave material, steel banding and coatings were drawn up and enforced as far as possible. In spite of these rigid specifications failures have occurred repeatedly, and for water distribution purposes wood pipe is acknowledged to be only temporary and is not found where permanency is required.

Steel pipe, using various coatings, and manufactured by different processes, has been used somewhat spasmodically during the past forty years, and the consensus of opinion seems to be that the steel line is as good as its coatings, and that perfect coatings are still to be found. A small bubble or pin hole in the coating on the steel line will have the effect of concentrating corrosion at that point and will cause a pit to go through a pipe more quickly than if no coating had been used. Even where the greatest care is used in applying the coating the fact that the surface is certain to be marred in laying makes for the short life for steel pipe for underground use. Steel is readily attacked by soil corrosion and its thin shell is soon pierced by pits. Its life may be as much as thirty years under the most favorable conditions, and under unfavorable conditions may be as little as five years. Even if it were possible to

lay a steel main so cheaply that it could be replaced at the end of a reasonable life (basing cost on present prices of labor and material) it would be doubtful economy. There comes a time in the life of a steel pipe when maintenance costs become so great as to make it economy to replace the line. Unfortunately experience has shown that the line is often kept in service after this point is reached, and that considerable money is spent in repairing leaks and in damage to pavements that would have been avoided had cast iron pipe been used in the initial installation. Furthermore, the loss of water represents a loss of money and possibly lack of pressure to the consumer. Oftentimes the line is such that the waterworks operators would hesitate to raise the pressure in order to make up for the losses in the line, with the result that there is a period during which poor water service is rendered, during times of ordinary draft and during times of fire the supply is totally deficient. As said before, even if the saving in the first cost of steel over cast iron pipe would replace the line at the end of a reasonable life, using present day costs, if the price of labor and material during the next thirty years should advance in any where near the same proportion that they did in the past thirty years, this would be far from holding true.

Concrete pipe lends itself to a limited use in waterworks construction work. For local distribution it is entirely unfitted and has been used to only a small extent for larger gravity flow lines, particularly lines that work under relatively low heads. Its particular disadvantages are difficulty of making repairs in the event of break, lack of uniformity in product due to the manufacturing methods and the human element, difficulty in getting tight joints,

porousness, inability to make alterations readily and uncertain life.

As far as cast iron pipe manufactured by processes that have long since been abandoned by most of the waterworks pipe manufacturers, there is this much to be said: Prior to the time that the present day specifications were drawn up it was customary among all manufacturers of cast iron pipe to cast it on the flat or in an inclined position. It became evident to both the manufacturers and the users that these methods of casting were liable to cause the metal to be thick on one side of the pipe and thin on the other. This method of casting made it possible for the slag and impurities in the iron to collect in the wall of the pipe along top of the mold. For these reasons the present day specifications requiring that pipe shall be cast vertically in dry sand molds were drawn up. This method is now in common use and there are only a few makers of special type of pipe who cast their pipe in the old fashioned way.

**Since the above was written, equipment has been developed for casting pipe horizontally which makes it possible to cast it in this way sufficiently uniform in thickness. New methods of gating, also, practically avoid the danger of slag and other impurities in the iron collecting in the wall of the pipe along top of the mold.**

## SECTION 12

# PREVENTION OF LOSS OF CARRYING CAPACITY IN WATER MAINS

THE almost universal adoption of cast iron pipe for water mains makes the loss in carrying capacity which occurs in metal pipes in some sections of the country an important problem to all water works men. It is well known that in some localities water mains have lost an appreciable part of their capacity in the course of time and, for this reason, consideration of the causes of this trouble and the remedies that may be applied is of great interest. Obviously, this loss in carrying capacity results in increased operating expense, either because it necessitates greater pumping pressures or because of the necessity for installing additional mains. There are in all, four causes for the loss in carrying capacity in water mains.

1. Sedimentation.
2. Animal or vegetable growth.
3. Mineral deposit.
4. Tuberculation.

These various deposits may occur at the same time in a line; in fact it has been stated that the presence of animal or vegetable organisms in a main hastens tuberculation. On the other hand, a mineral deposit in the line may actually act as a protection and effectively prevent any other form of incrustation.

*Sedimentation.* There are two distinct types of sedimentation. The first type is commonly known as "red mud" and it is the result of a considerable percentage of clay or iron in the water. This mud is distributed evenly all around the inside surface of the pipe and cuts down the carrying capacity both by the reduction in effective area and by the increased friction which results therefrom. The ordinary form of sedimentation is the result of turbid water and consists of a deposit of mud on the bottom of



Sediment Almost Closing Old Wooden Mains

the pipe. This may cause serious trouble in cases where the deposit is heavy and may result in actually closing the pipe in low points along the line.

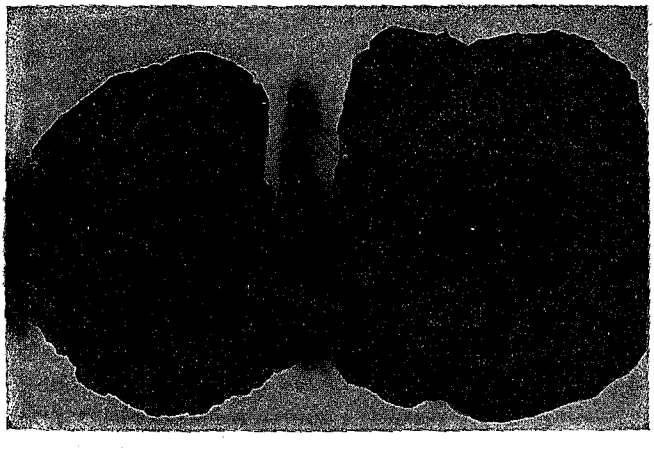
*Animal or Vegetable Growth.* The use of surface waters soft enough to make a satisfactory water supply often results in animal or vegetable growth on the inside of the pipe, although this trouble may also occur where ground water containing bacteria is used. One type of growth,

pipe sponge, may be identified by a tendency for large masses to break away from the surface of the pipe and float in the supply, resulting in the stoppage of service pipes. Unfortunately, pipe coating does not prevent this trouble and some other remedy must be found. Investigations show that iron in solution in the water is necessary for the growth of the sponge and mechanical filtration as well as the use of lime water as a coagulant are valuable remedies. Pipe moss, although somewhat similar in form, is not as serious in that it adheres closely to the surface of the pipe and is not liable to result in the stoppage of services. Unfortunately, pipe moss cannot be removed by flushing the mains, a valuable remedy for the sponge, and cleaning is necessary to remove the moss.

*Mineral Deposit.* Wherever a water supply flows over lime stone or shale, the water is liable to take up some of the minerals, which are later deposited on the inside of the pipe. This trouble occurs to a noticeable extent in the Middle West where ground water is used without filtration. A similar deposit may be obtained where excess lime is used in the preparation of the water This trouble also occurs where the water supply contains a very high percentage of other mineral salts. However, on pipe of large diameters it has been found that this type of deposit is very smooth and does not increase the friction loss to any appreciable extent.

*Tuberculation* By far the most serious cause of loss of carrying capacity in water mains is tuberculation. This trouble results from the formation on the inside of the pipe of small knobs or buttons of rust known as tubercules. These may occur at widely separated points on the inside of the pipe or, in some cases, successive layers of tubercules

may build up, resulting in the actual stoppage of small sized pipe. It would appear that tuberculation only forms at a point where there is some defect in the coating so that the water actually reaches the iron. Tuberculation is due principally to iron corrosion resulting from the presence of carbonic or some other acid in the water. Unfortunately, the waters which cause tuberculation are the desirable ones for household use, in that they are soft



Tubercules from a Steel Main Showing the Successive Layers of Growth

and low in total solids and alkalinity. Naturally a water of this kind contains more of the acids mentioned above.

It is interesting to note that this trouble is not limited to recent installations. In a book, "The Brooklyn Water Works," published in 1867, considerable attention is devoted to this question. However, even at that time it was known that tuberculation would not affect the purity of the water nor would it materially reduce the life of the

pipe. Investigations show that the actual pitting on cast iron under the tubercules is almost negligible.

*Prevalence.* It is well to note that the troubles above are not by any means universal. For instance, tuberculation is not found to any noticeable degree on the Pacific Coast, except in the case of some snow waters. The water of the Great Lakes does not affect cast iron pipe, and many of the Great Lake cities have had no trouble of this nature in the many years that their lines have been in service. Another example is the Mississippi River, which shows very little action throughout its length although some of its tributaries are so turbulent that they cause a great deal of sedimentation The surface waters of the New England States, in all probability, cause most of the trouble which occurs in this country. In a discussion of this question at the American Water Works Association Convention in 1908 it was brought out that no surface water in that section is entirely free from some form of incrustation.

The trouble resulting from tuberculation is most serious on small pipe and several reasons have been advanced to account for this. It has been suggested that small pipe is used in general for distribution systems and, for this reason, the flow of water in the pipe is less uniform. Other writers suggest that the eddy currents in small pipe bring proportionately more water in contact with the iron. The logical suggestion seems to be, however, that tubercules of the same height as are found in large pipe may practically cut off the flow in a pipe of small diameter. It has been found that on large pipe tubercules grow to an inch or an inch and a half in height before their growth is arrested.

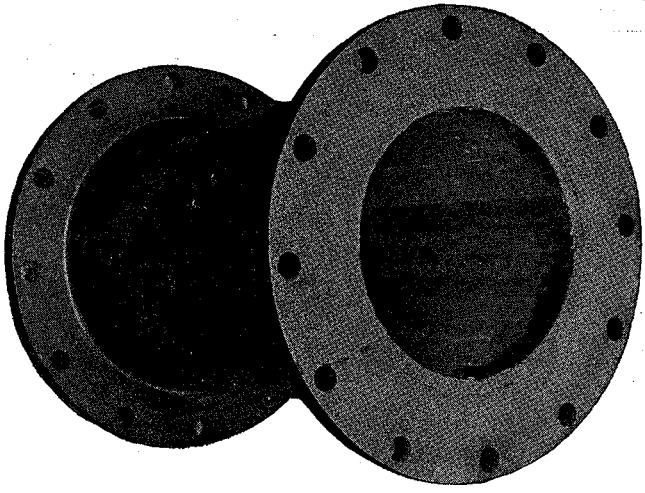
*Remedies.* Flushing mains is effective in improving the carrying capacity with some forms of incrustations. It is uniformly effective in the case of sedimentation, and with some types of animal or vegetable growth. In flushing mains it is customary to open several hydrants at a time, starting near the pumping plant and working out into the distribution system. The most satisfactory method is to start with the three hydrants next to the pumping plant open and as the first hydrant is closed opening the fourth hydrant on the line, continuing to work away from the pumping plant. In this way the sediment is blown out of the line and away from the pumping plant.

For tuberculation and the harder forms of incrustation the only remedy is cleaning the mains. Cleaning cast iron mains consists of inserting the scraper into the pipe, this machine is carried through the line and cuts the tubercules from the surface. The section to be cleaned is cut off from the main pipe system and a cut is made in the pipe at each end to receive the cleaner. One end of the line is sleeved after the cleaner is inserted and the pressure is turned on behind the machine. Once started the cleaner moves from three to four feet per second, coming out in the open end of the section and bringing with it all sediment and tubercules. Where the pressure is very low it may be necessary to pull the cleaner through the line with a cable. Cleaning not only removes the incrustation but any tools or foreign matter which may have been left in the pipe during construction. The method of cleaning mains discussed above has been in use for twenty-five years, and in many instances has been very successful,

resulting in from fifteen per cent. to eighty per cent. improvement in the carrying capacity of the line.

Unfortunately the passage of the cleaner may injure the coating to some extent and in a few localities it has been found that tuberculation occurs very rapidly following cleaning.

*Prevention.* Tuberculation in cast iron water pipe may be prevented by improvement in coating, and where



Wood Lined Cast Iron Flanged Pipe

trouble is expected it will probably pay to cover the pipe with some of the patented coatings now on the market. Unfortunately, most of the processes used for purification will not help in preventing the troubles we have mentioned although excess liming may eliminate tuberculation to a marked degree. The only definite prevention which has

been offered is the use of cement lined cast iron pipe.* This material combines maximum carrying capacity with the great durability found in cast iron pipe.

For conveying very corrosive liquids cast iron pipe may be lined with wood. This type of installation has found favor with the coal companies where the water may have a high percentage of sulphur, forming a corrosive acid. For the average installation cement lined cast iron pipe is not only cheaper but more satisfactory than the wood lined pipe.

*See page 243.

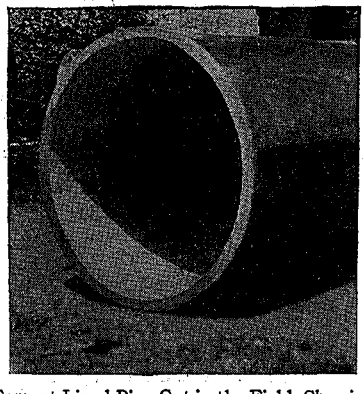
## SECTION 13

# CEMENT LINED PIPE

WHEN very soft waters are conveyed through iron pipes that are either uncoated or have a defective coating, nodules of rust will form on the walls of the pipe. Waters sufficiently soft to cause severe tuberculation are comparatively rare and are found principally in the East. In severe cases these rust nodules may finally reduce the carrying capacity of the pipe to such an extent that pressures are seriously affected. For their growth it is essential that the organisms causing the nodules or tubercules come in direct contact with the iron, and coatings, to be effective against tuberculation, must be free from even the smallest pin-holes. Tar coatings as now applied to cast iron pipe will prevent formation of tubercules except under the most severe conditions. Where these conditions exist a coating of Portland cement mortar has been found to be the most effective preventative.

Cement coatings have been in use for a number of years. The earliest were made of natural cement mortar and were applied to sheet metal pipes. These pipes fulfilled the expectation of their makers in that tuberculation was prevented, but, due to the rusting out of the steel and wrought sheets, the pipe failed in a relatively short time. In 1921 cement lining was first applied to cast iron pipe. The method of application was rather crude and consisted in standing the pipe on end, inserting a "bullet" to which a rope was attached, pouring in sufficient mortar for the

coating, and withdrawing the "bullet." As the "bullet" was withdrawn it spread the cement mortar fairly evenly over the walls of the pipe. The lining as applied by this process was usually from 3/16" to 1/4" in thickness. The pipe so manufactured were installed and the carrying capacity measured immediately after installation and again after the pipe had been in service one year. These tests were carried out at Charleston, South Carolina, where tuberculation conditions are unusually severe. The co-



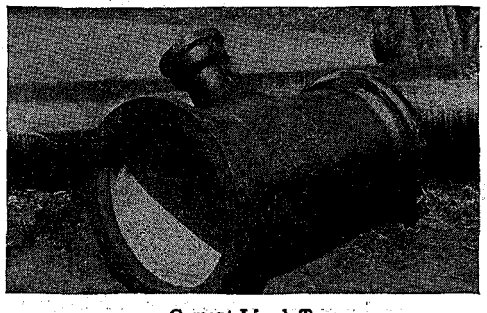
Cement Lined Pipe Cut in the Field, Showing the Adherence of Cement

efficient for the pipe when first laid was 135 and one year afterward was 128, under conditions where the ordinary pipe would have a co-efficient in the neighborhood of 100.

After these first lines were laid and proved successful, the method of lining the pipe was studied and improved upon. The method now used (and required by standard specifications) is to apply the lining centrifugally. In general, the process consists in supporting the pipe hori-

zontally on rollers, inserting a trough full of cement mortar, overturning the trough, revolving the pipe at a peripheral speed of 300′ per minute until the mortar is evenly spread, increasing the speed to 600′ per minute, and finally curing the coating.

The lining applied by the centrifugal method is very dense and has a porcelain-like surface. It adheres to the iron so tenaciously that the pipe can be cut or tapped



**Cement Lined Tee**

without danger of breaking off the coating adjacent to the cut or to the tap hole. The smooth surface makes for a high co-efficient, and due to the complete elimination of tuberculation, this high co-efficient is maintained throughout the life of the pipe.

The standard specifications for cement lined cast iron pipe are as follows:

# Tentative Specifications for Cement-Mortar Lined Cast Iron Pipe, and Fittings*

November, 1930

(In recommending these specifications, Sub-Committee 3C wishes to call attention to the fact that they are tentative only and subject to revision as additional information is obtained.)

## Cement

1. The cement used for making cement mortar shall be Portland cement, complying in all respects with the standard specifications of the American Society for Testing Materials, Serial designation 6-9-21.

## Sand

2. The sand for mortar shall consist of a clean, sharp, hard silicious sand, free from loam, clay, organic matter, or other foreign substance considered as deleterious for good mortar. The sand shall be well graded, and when tested by laboratory sieves, shall meet the following specifications:

Total passing 12 mesh sieve, 100%
Total passing 100 mesh sieve, not over 5%

*These *Tentative Specifications for Cement-Mortar Lined Cast Iron Pipe and Fittings* were adopted by Sub-Committee No. 3C (Inorganic Coatings) of the Sectional Committee on Specifications for Cast Iron Pipe (A-21) in March, 1930, except for the two amendments between triple star (***—***). These amendments were proposed at a meeting of Technical Committee 3, on March 25, 1930, were referred back to Sub-Committee 3C for consideration and were adopted by Sub-Committee 3C in November, 1930.

### Cement Mortar

3. The cement mortar used for lining pipe shall be a mixture of the above specified sand and cement in such proportions as to obtain a good, hard, dense lining, reasonably well bonded to the pipe, and with a smooth interior surface. (A mixture which has been found to give very satisfactory results consists of three parts cement to one part sand, by volume.)

4. The cement mortar shall be thoroughly mixed, only sufficient water being added to form a workable mixture for placing in the pipe.

5. Only sufficient cement mortar shall be mixed for the immediate requirements of lining.

6. The water for tempering the cement mortar shall be free from harmful amounts of oil, acid, alkali, organic or vegetable matter.

### Preparation of Pipe for Lining

7. Pipe to be lined with cement mortar shall not be coated inside with tar or other asphaltum products. Its interior surface shall be thoroughly cleaned of all core sand, mud, grease, foreign materials, or any sharp projections of iron which might project through the lining. Pipe shall be tested hydrostatically before being lined.

### Method of Applying the Cement Mortar Lining

8. Sufficient cement mortar shall be introduced to produce the required thickness of lining and spread evenly over the interior surface of the pipe, by any suitable means. A careful examination shall be made after this

operation is completed to see that the inner surface of the pipe is completely covered with cement mortar.

9. The shoulder of the bell and the end of the spigot may be covered with cement mortar by applying with a brush.

10. Surplus cement mortar shall be removed from the interior of the bell so as not to interfere with proper keying of the joint.

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

12. Patching of improperly lined pipe will not be permitted.

### * * * Smoothness of Lining

13. The lining of straight pipe shall be smooth and substantially free from noticeable ridges, corrugations, projections or depressions. The lining of fittings shall be as smooth as practicable * * *

### Outside Surface of Pipe

14. Unless otherwise specified, no coating shall be applied to the outside surface of cement mortar lined pipe and fittings.

### Lining Fittings

15. The interior surface of fittings shall be lined by applying cement mortar as specified in previous paragraphs, evenly and uniformly * * * and as nearly as

practicable of the thicknesses specified for the corresponding sizes of pipe * * *

### Thickness of Lining

16. The minimum thickness of lining for the various sizes pipe shall be as follows:

| Nominal Size of Pipe | Minimum Thickness of Cement-Mortar Lining |
|---|---|
| 4-inch | 1/8 of an inch |
| 6-inch | 1/8 of an inch |
| 8-inch | 1/8 of an inch |
| 10-inch | 1/8 of an inch |
| 12-inch | 1/8 of an inch |
| 14-inch | 5/16 of an inch |
| 16-inch | 5/16 of an inch |
| 18-inch | 5/16 of an inch |
| 20-inch | 5/16 of an inch |
| 24-inch | 5/16 of an inch |

17. A plus tolerance of 1/8″ in thickness of lining shall be permitted on all size pipe from 4″ to 24″. No minus tolerance to be allowed.

18. Linings of greater thickness will be furnished when specified.

19. The thickness of lining may be determined by means of spear measurement, using a hardened steel point not greater than 1/16″ in diameter. The inspector shall pierce the lining immediately after it is placed in the pipe, and before cement 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 greater than 4″ 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 obtained by reaching into the pipe without injuring the lining.

21. At the ends of the pipe where the lining naturally tends to taper off to a thin edge, the full thickness of lining shall extend to within one inch of end of pipe.

22. For linings of the above specified thickness, or of greater thickness, failure of the lining to completely adhere to the wall of the pipe shall not be cause of rejection, if the lining conforms to these specifications in all other respects (See Foot Notes).

### Curing Cement Mortar Lining

23. Immediately after pipe is lined with cement mortar, it shall be protected in a suitable manner to prevent the too rapid withdrawal of moisture from the cement mortar, and if necessary, suitable means shall be provided to keeping lining damp for a period of at least twenty-four hours after lining.

24. No pipe shall be shipped until the lining is thoroughly set.

## NOTES

The above tentative specification provides for thicker cement linings than have generally been used in American practice. In view of the unavoidable irregularities in the inner surface of cast iron pipe, of the known solvent action of many waters on the lime content of Portland cement, and the limited experience (only about seven years) with thin Portland cement linings in cast iron pipe, thicker linings are believed to be desirable as a matter of insurance.

In the present state of the art such thicker linings are

Committee believes that the thicker linings recommended will have longer life and will prevent tuberculation and maintain carrying capacity longer than thinner linings which may show somewhat less temporary separation from the pipe.

The Committee refrains from attempting, at this time, to specify the amount, or area, of the non-adherence of the lining which shall cause rejection. It is realized that the manufacturer will produce the best pipe he can and that it may require some little experimentation on each size and thickness of lining to secure the best adherence. The judgment and common sense of the inspector and the manufacturer's forces is relied upon to secure the best practicable results during this period of development, rather than an arbitrary limit to the permissible areas of non-adherence.

## SECTION 14

# FLOW TABLES

In attempting to compute the capacity of a pipe line or to figure the probable loss in head, after the pipe has reached a certain age, it is absolutely essential to know something about the water to be conveyed. In most cases the quality of the water is such that the carrying capacity is affected very little by the age of the pipe. In other cases, the water may be so soft as to cause tuberculation and consequent loss in carrying capacity or so turbid as to cause deposits of sand or mud with the same effect. Waters that cause tuberculation are the rare exception and outside of a few raw water conduits, muddy water is also unusual.

In spite of this fact, many of the books and articles on hydraulics and water supply, make the bold statement that a definite correction factor must be applied to flow formulae as the pipe increases in age. It is evident that this is incorrect, since first of all a large number of experiments have been made that show quite definitely that in many places, there is no change whatever in carrying capacity with age. Secondly, assume that a layer of tubercles 2 inches thick are produced as a result of many years use of a pipe, it is evident that the carrying capacity of a 12 inch pipe would be considerably more reduced than would a 48 inch pipe with the same thickness of tubercles, a fact that is not taken into consideration in the formulae in common use.

In presenting the flow tables, that follow, we are giving the values for new pipe. In most cases, it can be told beforehand whether or not the water to be conveyed will cause tuberculation. If tuberculation is not to be expected, ordinary Cast Iron Pipe should be used and the carrying capacity figured as shown in the tables. If it is known beforehand, the water is of such a nature as to cause tuberculation, cement lined Cast Iron Pipe should be

used and, as in previous case, the tables used without any correction factor.

The following tables represent the Flow of Water through Clean Cast Iron Pipe computed by the Formula derived after careful investigation by Edward Wegmann, C. E.[1] and Albert N. Aeryns, C. E.[2] The Wegmann-Aeryns Formula, which appeared in the Engineering News-Record for July 16, 1925, is as follows:

$$V = 182.5 \; R^{0.723} \; S^{0.539}$$

in which

V = Velocity in feet per second
R = Hydraulic radius in feet
S = Slope of the hydraulic gradient, or loss of head in feet per foot of pipe.

It should be remembered that the "loss of head," or friction head, given in feet per thousand feet of length, is also the fall in feet per thousand (the slope) required to produce the given velocity in pipe of the diameter given. The following examples illustrate the various uses of the table:

## EXAMPLE 1. MAXIMUM DELIVERY

To find the maximum delivery of an 8-inch pipe, 7,500 feet long under 150 foot head. The available head per thousand feet is $150 \div 7.5 = 20$ feet per thousand. The table for 8-inch pipe, under "loss of head," shows that for a loss of head of 15.7 feet per thousand the corresponding delivery at velocity of 5.32 feet per second is 1,200,000 gallons per day; the approximate value for a loss of 20 feet may then be calculated by interpolation.

## EXAMPLE 2. DETERMINATION OF DIAMETER

To find diameter of pipe necessary to deliver 3,000,000 gallons per day through a line 25,000 feet long under 150 foot head. The available head per thousand feet is $150 \div 25 = 6$ feet per thousand. Reading across table from discharge of 3,000,000 gallons, at the left, the first

[1] Consulting Engineer, New York City.
[2] Associate in Sanitary Engineering, Polytechnic Institute, Brooklyn, N. Y.

"loss of head" of 6 feet or less per thousand is 5.1 under 14-inch pipe. Hence the least diameter which will answer in regular commercial sizes is 14 inches.

### EXAMPLE 3. FRICTION LOSS

To find loss of head through a 10-inch line, 4,000 feet long delivering 1,000 gallons per minute. The table shows "loss of head" in a 10-inch pipe delivering 972 gallons per minute to be 6.8 feet per 1,000 feet of length; hence in 4,000 feet the loss will be 27.2 feet. If the water is delivered at a point 100 feet above pump, the total head pumped against is 100 feet (static) plus 27.2 feet (friction), or 127.2 feet total.

### EXAMPLE 4. DELIVERY DETERMINED FROM PRESSURE REDUCTION

Two accurate pressure gauges should be placed at a known distance apart, and measurement made of the difference in elevation of the points where readings are taken; thus, if in a 12-inch pipe the gauges are 500 feet apart and show a difference in pressure of 2 pounds (4.6 feet) while one gauge is 1.8 feet above the other, the actual loss of head will be 4.6 plus or minus 1.8=6.4 or 2.8 feet per 500 feet, or 12.8 or 5.6 feet per thousand feet. In the table for 12-inch pipe we find that a loss of head of 5.2 feet per thousand is due to velocity of 3.94 corresponding to discharge of 2,000,000 gallons per day.

### EXAMPLE 5

To find the pressure at any point in a water main when diameter, rate of delivery and static head are known. Assume that 1,200,000 gallons per day are to be pumped through 5,000 feet of 12-inch pipe laid on an incline to a total vertical height of 100 feet and that it is desired to learn the pressure in the pipe at each 1,000 feet from the pump. At the given delivery the loss of head in a 12-inch pipe is 2.0 per 1,000 feet or 10.0 for 5,000 feet; to this is added the static head, making total of 110. feet. The drop in pressure for each 1,000 feet will then be one-fifth of this quantity or 22 feet.

# FLOW OF WATER IN CAST IRON PIPE

## Frictional Heads, per Thousand Feet, at Given Rates of Discharge

| Discharge Gals. per Minute | Discharge Gals. per 24 Hours | 4″ Pipe | | 6″ Pipe | | 8″ Pipe | |
|---|---|---|---|---|---|---|---|
| | | Velocity ft. per Second | Loss of Head ft. per 1000 ft. of pipe | Velocity ft. per Second | Loss of Head ft. per 1000 ft. of pipe | Velocity ft. per Second | Loss of Head ft. per 1000 ft. of pipe |
| 35 | 50,000 | 0.89 | 1.4 | | | | |
| 69 | 100,000 | 1.78 | 5.2 | .79 | 0.7 | | |
| 104 | 150,000 | 2.68 | 11.0 | 1.18 | 1.4 | | |
| 139 | 200,000 | 3.56 | 18.7 | 1.58 | 2.4 | .89 | .6 |
| 153 | 220,000 | 3.91 | 22.3 | 1.73 | 2.9 | .98 | .7 |
| 167 | 240,000 | 4.27 | 26.2 | 1.89 | 3.4 | 1.06 | .8 |
| 181 | 260,000 | 4.63 | 30.4 | 2.05 | 3.9 | 1.15 | .9 |
| 194 | 280,000 | 4.99 | 34.9 | 2.21 | 4.5 | 1.24 | 1.1 |
| 208 | 300,000 | 5.34 | 39.7 | 2.36 | 5.1 | 1.33 | 1.2 |
| 243 | 350,000 | 6.23 | 52.9 | 2.76 | 6.8 | 1.55 | 1.6 |
| 278 | 400,000 | 7.12 | 67.7 | 3.15 | 8.7 | 1.77 | 2.0 |
| 312 | 450,000 | 8.00 | 84.2 | 3.55 | 10.9 | 1.99 | 2.5 |
| 347 | 500,000 | 8.90 | 102.0 | 3.94 | 13.2 | 2.22 | 3.1 |
| 417 | 600,000 | 10.68 | 144.0 | 4.73 | 18.5 | 2.66 | 4.3 |
| 486 | 700,000 | | | 5.52 | 24.7 | 3.10 | 5.8 |
| 556 | 800,000 | | | 6.30 | 31.6 | 3.55 | 7.4 |
| 625 | 900,000 | | | 7.09 | 39.3 | 3.99 | 9.2 |
| 694 | 1,000,000 | | | 7.89 | 47.8 | 4.43 | 11.2 |
| 833 | 1,200,000 | | | 9.46 | 67.0 | 5.32 | 15.7 |
| 972 | 1,400,000 | | | | | 6.20 | 20.8 |
| 1111 | 1,600,000 | | | | | 7.09 | 26.7 |
| 1250 | 1,800,000 | | | | | 7.98 | 33.2 |
| 1389 | 2,000,000 | | | | | 8.86 | 40.4 |
| 1528 | 2,200,000 | | | | | 9.75 | 48.2 |

Tables of Flow of Water through Clean Cast Iron Pipe Computed by the Wegmann-Aeryns Formula published in the Engineering News-Record, July 16, 1925.

## FLOW OF WATER IN CAST IRON PIPE (continued)

### Frictional Heads, per Thousand Feet, at Given Rates of Discharge

| Discharge Gals. per Minute | Discharge Gals. per 24 Hours | 10″ Pipe | | 12″ Pipe | | 14″ Pipe | |
|---|---|---|---|---|---|---|---|
| | | Velocity ft. per Second | Loss of Head ft. per 1000 ft. of pipe | Velocity ft. per Second | Loss of Head ft. per 1000 ft. of pipe | Velocity ft. per Second | Loss of Head ft. per 1000 ft. of pipe |
| 174 | 250,000 | 0.71 | 0.3 | 0.49 | 0.1 | | |
| 208 | 300,000 | 0.85 | 0.4 | 0.59 | 0.2 | | |
| 243 | 350,000 | 0.99 | 0.5 | 0.69 | 0.2 | 0.51 | 0.1 |
| 278 | 400,000 | 1.13 | 0.7 | 0.79 | 0.3 | 0.58 | 0.1 |
| 312 | 450,000 | 1.28 | 0.8 | 0.89 | 0.3 | 0.65 | 0.2 |
| 347 | 500,000 | 1.42 | 1.0 | 0.99 | 0.4 | 0.72 | 0.2 |
| 417 | 600,000 | 1.70 | 1.4 | 1.18 | 0.6 | 0.87 | 0.3 |
| 486 | 700,000 | 1.99 | 1.9 | 1.38 | 0.8 | 1.01 | 0.3 |
| 556 | 800,000 | 2.27 | 2.4 | 1.58 | 1.0 | 1.16 | 0.4 |
| 625 | 900,000 | 2.55 | 3.0 | 1.77 | 1.2 | 1.30 | 0.5 |
| 694 | 1,000,000 | 2.84 | 3.6 | 1.97 | 1.4 | 1.45 | 0.7 |
| 833 | 1,200,000 | 3.40 | 5.1 | 2.36 | 2.0 | 1.74 | 0.9 |
| 972 | 1,400,000 | 3.97 | 6.8 | 2.76 | 2.7 | 2.02 | 1.2 |
| 1111 | 1,600,000 | 4.54 | 8.7 | 3.15 | 3.4 | 2.32 | 1.6 |
| 1250 | 1,800,000 | 5.11 | 10.7 | 3.55 | 4.3 | 2.60 | 2.0 |
| 1389 | 2,000,000 | 5.67 | 13.1 | 3.94 | 5.2 | 2.90 | 2.4 |
| 1528 | 2,200,000 | 6.24 | 15.6 | 4.33 | 6.2 | 3.18 | 2.9 |
| 1667 | 2,400,000 | 6.81 | 18.4 | 4.73 | 7.3 | 3.48 | 3.4 |
| 1806 | 2,600,000 | 7.38 | 21.3 | 5.12 | 8.5 | 3.76 | 3.9 |
| 1944 | 2,800,000 | 7.94 | 24.4 | 5.52 | 9.7 | 4.05 | 4.5 |
| 2083 | 3,000,000 | 8.51 | 27.8 | 5.91 | 11.0 | 4.35 | 5.1 |
| 2222 | 3,200,000 | 9.08 | 31.3 | 6.30 | 12.5 | 4.63 | 5.7 |
| 2361 | 3,400,000 | 9.65 | 35.0 | 6.70 | 14.0 | 4.92 | 6.4 |
| 2500 | 3,600,000 | | | 7.09 | 15.5 | 5.21 | 7.1 |
| 2639 | 3,800,000 | | | 7.48 | 17.2 | 5.50 | 7.9 |
| 2778 | 4,000,000 | | | 7.88 | 18.8 | 5.79 | 8.7 |
| 2917 | 4,200,000 | | | 8.28 | 20.6 | 6.08 | 9.5 |
| 3056 | 4,400,000 | | | 8.67 | 22.5 | 6.37 | 10.3 |
| 3194 | 4,600,000 | | | 9.06 | 24.4 | 6.66 | 11.2 |
| 3333 | 4,800,000 | | | 9.45 | 26.4 | 6.95 | 12.1 |
| 3472 | 5,000,000 | | | 9.85 | 28.5 | 7.24 | 13.1 |

# FLOW OF WATER IN CAST IRON PIPE (continued)

## Frictional Heads, per Thousand Feet, at Given Rates of Discharge

| Discharge Gals. per Minute | Discharge Gals. per 24 Hours | 10″ Pipe | | 12″ Pipe | | 14″ Pipe | |
|---|---|---|---|---|---|---|---|
| | | Velocity ft. per Second | Loss of Head ft. per 1000 ft. of pipe | Velocity ft. per Second | Loss of Head ft. per 1000 ft. of pipe | Velocity ft. per Second | Loss of Head ft. per 1000 ft. of pipe |
| 174 | 250,000 | 0.71 | 0.3 | 0.49 | 0.1 | | |
| 208 | 300,000 | 0.85 | 0.4 | 0.59 | 0.2 | | |
| 243 | 350,000 | 0.99 | 0.5 | 0.69 | 0.2 | 0.51 | 0.1 |
| 278 | 400,000 | 1.13 | 0.7 | 0.79 | 0.3 | 0.58 | 0.1 |
| 312 | 450,000 | 1.28 | 0.8 | 0.89 | 0.3 | 0.65 | 0.2 |
| 347 | 500,000 | 1.42 | 1.0 | 0.99 | 0.4 | 0.72 | 0.2 |
| 417 | 600,000 | 1.70 | 1.4 | 1.18 | 0.6 | 0.87 | 0.3 |
| 486 | 700,000 | 1.99 | 1.9 | 1.38 | 0.8 | 1.01 | 0.3 |
| 556 | 800,000 | 2.27 | 2.4 | 1.58 | 1.0 | 1.16 | 0.4 |
| 625 | 900,000 | 2.55 | 3.0 | 1.77 | 1.2 | 1.30 | 0.5 |
| 694 | 1,000,000 | 2.84 | 3.6 | 1.97 | 1.4 | 1.45 | 0.7 |
| 833 | 1,200,000 | 3.40 | 5.1 | 2.36 | 2.0 | 1.74 | 0.9 |
| 972 | 1,400,000 | 3.97 | 6.8 | 2.76 | 2.7 | 2.02 | 1.2 |
| 1111 | 1,600,000 | 4.54 | 8.7 | 3.15 | 3.4 | 2.32 | 1.6 |
| 1250 | 1,800,000 | 5.11 | 10.7 | 3.55 | 4.3 | 2.60 | 2.0 |
| 1389 | 2,000,000 | 5.67 | 13.1 | 3.94 | 5.2 | 2.90 | 2.4 |
| 1528 | 2,200,000 | 6.24 | 15.6 | 4.33 | 6.2 | 3.18 | 2.9 |
| 1667 | 2,400,000 | 6.81 | 18.4 | 4.73 | 7.3 | 3.48 | 3.4 |
| 1806 | 2,600,000 | 7.38 | 21.3 | 5.12 | 8.5 | 3.76 | 3.9 |
| 1944 | 2,800,000 | 7.94 | 24.4 | 5.52 | 9.7 | 4.05 | 4.5 |
| 2083 | 3,000,000 | 8.51 | 27.8 | 5.91 | 11.0 | 4.35 | 5.1 |
| 2222 | 3,200,000 | 9.08 | 31.3 | 6.30 | 12.5 | 4.63 | 5.7 |
| 2361 | 3,400,000 | 9.65 | 35.0 | 6.70 | 14.0 | 4.92 | 6.4 |
| 2500 | 3,600,000 | | | 7.09 | 15.5 | 5.21 | 7.1 |
| 2639 | 3,800,000 | | | 7.48 | 17.2 | 5.50 | 7.9 |
| 2778 | 4,000,000 | | | 7.88 | 18.8 | 5.79 | 8.7 |
| 2917 | 4,200,000 | | | 8.28 | 20.6 | 6.08 | 9.5 |
| 3056 | 4,400,000 | | | 8.67 | 22.5 | 6.37 | 10.3 |
| 3194 | 4,600,000 | | | 9.06 | 24.4 | 6.66 | 11.2 |
| 3333 | 4,800,000 | | | 9.45 | 26.4 | 6.95 | 12.1 |
| 3472 | 5,000,000 | | | 9.85 | 28.5 | 7.24 | 13.1 |

# FLOW OF WATER IN CAST IRON PIPE (continued)

## Frictional Heads, per Thousand Feet, at Given Rates of Discharge

| Discharge Gals. per Minute | Discharge Gals. per 24 Hours | 16″ Pipe | | 18″ Pipe | | 20″ Pipe | |
|---|---|---|---|---|---|---|---|
| | | Velocity ft. per Second | Loss of Head ft. per 1000 ft. of pipe | Velocity ft. per Second | Loss of Head ft per 1000 ft. of pipe | Velocity ft. per Second | Loss of Head ft. per 1000 ft of pipe |
| 347 | 500,000 | 0.55 | 0.09 | 0.44 | 0.05 | | |
| 417 | 600,000 | 0.66 | 0.13 | 0.52 | 0.07 | | |
| 486 | 700,000 | 0.77 | 0.17 | 0.61 | 0.10 | | |
| 556 | 800,000 | 0.89 | 0.22 | 0.70 | 0.12 | | |
| 625 | 900,000 | 1.00 | 0.28 | 0.79 | 0.15 | | |
| 694 | 1,000,000 | 1.11 | 0.34 | 0.88 | 0.19 | 0.71 | 0.11 |
| 833 | 1,200,000 | 1.33 | 0.47 | 1.05 | 0.26 | 0.85 | 0.15 |
| 972 | 1,400,000 | 1.55 | 0.63 | 1.23 | 0.35 | 0.99 | 0.20 |
| 1111 | 1,600,000 | 1.77 | 0.80 | 1.40 | 0.44 | 1.13 | 0.26 |
| 1250 | 1,800,000 | 1.99 | 1.00 | 1.57 | 0.55 | 1.28 | 0.32 |
| 1389 | 2,000,000 | 2.22 | 1.22 | 1.75 | 0.67 | 1.42 | 0.39 |
| 1528 | 2,200,000 | 2.44 | 1.45 | 1.93 | 0.80 | 1.56 | 0.47 |
| 1667 | 2,400,000 | 2.66 | 1.71 | 2.10 | 0.94 | 1.70 | 0.55 |
| 1806 | 2,600,000 | 2.88 | 1.98 | 2.28 | 1.09 | 1.84 | 0.64 |
| 1944 | 2,800,000 | 3.10 | 2.28 | 2.45 | 1.26 | 1.99 | 0.74 |
| 2083 | 3,000,000 | 3.32 | 2.59 | 2.63 | 1.42 | 2.13 | 0.84 |
| 2222 | 3,200,000 | 3.55 | 2.91 | 2.80 | 1.61 | 2.27 | 0.94 |
| 2361 | 3,400,000 | 3.77 | 3.26 | 2.98 | 1.80 | 2.41 | 1.05 |
| 2500 | 3,600,000 | 3.99 | 3.63 | 3.15 | 2.00 | 2.55 | 1.17 |
| 2639 | 3,800,000 | 4.21 | 4.01 | 3.33 | 2.21 | 2.70 | 1.30 |
| 2778 | 4,000,000 | 4.43 | 4.41 | 3.50 | 2.43 | 2.84 | 1.43 |
| 3472 | 5,000,000 | 5.54 | 6.67 | 4.38 | 3.68 | 3.55 | 2.16 |
| 4167 | 6,000,000 | 6.65 | 9.35 | 5.25 | 5.16 | 4.26 | 3.03 |
| 4861 | 7,000,000 | 7.76 | 12.50 | 6.13 | 6.87 | 4.96 | 4.03 |
| 5556 | 8,000,000 | 8.86 | 16.00 | 7.01 | 8.80 | 5.67 | 5.17 |
| 6250 | 9,000,000 | 9.97 | 19.80 | 7.88 | 10.90 | 6.38 | 6.43 |
| 6944 | 10,000,000 | 11.08 | 24.10 | 8.76 | 13.30 | 7.09 | 7.82 |
| 7639 | 11,000,000 | 12.19 | 28.80 | 9.63 | 15.80 | 7.80 | 9.33 |
| 8333 | 12,000,000 | 13.30 | 33.80 | 10.51 | 18.70 | 8.51 | 11.00 |
| 9028 | 13,000,000 | | | | | 9.22 | 12.70 |
| 9722 | 14,000,000 | | | | | 9.93 | 14.60 |

# FLOW OF WATER IN CAST IRON PIPE (continued)

## Frictional Heads, per Thousand Feet, at Given Rates of Discharge

| Discharge Gals. per Minute | Discharge Gals. per 24 Hours | 24″ Pipe | | 30″ Pipe | | 36″ Pipe | |
|---|---|---|---|---|---|---|---|
| | | Velocity ft. per Second | Loss of Head ft. per 1000 ft. of pipe | Velocity ft. per Second | Loss of Head ft. per 1000 ft. of pipe | Velocity ft. per Second | Loss of Head ft. per 1000 ft. of pipe |
| 1389 | 2,000,000 | 0.98 | 0.16 | | | | |
| 2083 | 3,000,000 | 1.48 | 0.33 | 0.94 | 0.11 | | |
| 2778 | 4,000,000 | 1.97 | 0.57 | 1.26 | 0.18 | 0.88 | 0.07 |
| 3472 | 5,000,000 | 2.46 | 0.86 | 1.57 | 0.28 | 1.09 | 0.11 |
| 4167 | 6,000,000 | 2.96 | 1.21 | 1.89 | 0.39 | 1.31 | 0.16 |
| 4861 | 7,000,000 | 3.45 | 1.60 | 2.20 | 0.52 | 1.53 | 0.21 |
| 5556 | 8,000,000 | 3.94 | 2.06 | 2.52 | 0.66 | 1.75 | 0.27 |
| 6250 | 9,000,000 | 4.43 | 2.56 | 2.84 | 0.83 | 1.97 | 0.33 |
| 6944 | 10,000,000 | 4.92 | 3.11 | 3.15 | 1.01 | 2.19 | 0.40 |
| 7639 | 11,000,000 | 5.42 | 3.71 | 3.47 | 1.20 | 2.41 | 0.48 |
| 8333 | 12,000,000 | 5.91 | 4.36 | 3.78 | 1.41 | 2.63 | 0.56 |
| 9028 | 13,000,000 | 6.40 | 5.06 | 4.10 | 1.64 | 2.85 | 0.65 |
| 9722 | 14,000,000 | 6.89 | 5.81 | 4.41 | 1.88 | 3.06 | 0.75 |
| 10420 | 15,000,000 | 7.39 | 6.60 | 4.73 | 2.14 | 3.28 | 0.85 |
| 11110 | 16,000,000 | 7.88 | 7.44 | 5.04 | 2.41 | 3.50 | 0.96 |
| 11810 | 17,000,000 | 8.37 | 8.32 | 5.36 | 2.69 | 3.72 | 1.07 |
| 12500 | 18,000,000 | 8.86 | 9.26 | 5.67 | 3.00 | 3.94 | 1.20 |
| 13190 | 19,000,000 | 9.36 | 10.20 | 5.99 | 3.32 | 4.16 | 1.32 |
| 13890 | 20,000,000 | 9.85 | 11.30 | 6.30 | 3.65 | 4.38 | 1.45 |
| 15280 | 22,000,000 | 10.80 | 13.40 | 6.93 | 4.35 | 4.82 | 1.73 |
| 16670 | 24,000,000 | 11.80 | 15.80 | 7.56 | 5.12 | 5.25 | 2.04 |
| 18060 | 26,000,000 | 12.80 | 18.30 | 8.20 | 5.93 | 5.69 | 2.36 |
| 19440 | 28,000,000 | 13.80 | 21.00 | 8.83 | 6.81 | 6.13 | 2.71 |
| 20830 | 30,000,000 | | | | | 6.57 | 3.08 |
| 24310 | 35,000,000 | | | | | 7.66 | 4.10 |
| 27780 | 40,000,000 | | | | | 8.76 | 5.25 |

# FLOW OF WATER IN CAST IRON PIPE (continued)

## Frictional Heads, per Thousand Feet, at Given Rates of Discharge

| Discharge Gals. per Minute | Discharge Gals. per 24 Hours | 42″ Pipe | | 48″ Pipe | | 54″ Pipe | |
|---|---|---|---|---|---|---|---|
| | | Velocity ft. per Second | Loss of Head ft. per 1000 ft. of pipe | Velocity ft. per Second | Loss of Head ft. per 1000 ft. of pipe | Velocity ft. per Second | Loss of Head ft. per 1000 ft. of pipe |
| 2431 | 3,500,000 | 0.56 | 0.03 | | | | |
| 2778 | 4,000,000 | 0.64 | 0.03 | | | | |
| 3125 | 4,500,000 | 0.72 | 0.04 | | | | |
| 3472 | 5,000,000 | 0.80 | 0.05 | 0.62 | 0.03 | 0.48 | 0.01 |
| 4167 | 6,000,000 | 0.96 | 0.07 | 0.74 | 0.04 | 0.58 | 0.02 |
| 4861 | 7,000,000 | 1.13 | 0.09 | 0.86 | 0.05 | 0.68 | 0.03 |
| 5556 | 8,000,000 | 1.29 | 0.12 | 0.98 | 0.06 | 0.78 | 0.03 |
| 6250 | 9,000,000 | 1.45 | 0.15 | 1.10 | 0.08 | 0.88 | 0.04 |
| 6944 | 10,000,000 | 1.61 | 0.18 | 1.23 | 0.09 | 0.97 | 0.05 |
| 7639 | 11,000,000 | 1.77 | 0.22 | 1.35 | 0.11 | 1.07 | 0.06 |
| 8333 | 12,000,000 | 1.93 | 0.26 | 1.48 | 0.13 | 1.17 | 0.07 |
| 9028 | 13,000,000 | 2.09 | 0.30 | 1.60 | 0.15 | 1.27 | 0.08 |
| 9722 | 14,000,000 | 2.25 | 0.34 | 1.72 | 0.18 | 1.36 | 0.10 |
| 10420 | 15,000,000 | 2.41 | 0.38 | 1.84 | 0.20 | 1.46 | 0.11 |
| 11110 | 16,000,000 | 2.57 | 0.44 | 1.97 | 0.22 | 1.56 | 0.12 |
| 11810 | 17,000,000 | 2.73 | 0.49 | 2.09 | 0.25 | 1.66 | 0.14 |
| 12500 | 18,000,000 | 2.89 | 0.55 | 2.22 | 0.28 | 1.75 | 0.15 |
| 13190 | 19,000,000 | 3.05 | 0.61 | 2.34 | 0.31 | 1.85 | 0.17 |
| 13890 | 20,000,000 | 3.22 | 0.67 | 2.46 | 0.34 | 1.95 | 0.19 |
| 15280 | 22,000,000 | 3.54 | 0.79 | 2.71 | 0.40 | 2.14 | 0.22 |
| 16670 | 24,000,000 | 3.86 | 0.93 | 2.96 | 0.48 | 2.33 | 0.26 |
| 18060 | 26,000,000 | 4.18 | 1.08 | 3.20 | 0.55 | 2.53 | 0.30 |
| 19440 | 28,000,000 | 4.50 | 1.24 | 3.45 | 0.63 | 2.72 | 0.35 |
| 20830 | 30,000,000 | 4.82 | 1.41 | 3.69 | 0.72 | 2.92 | 0.40 |
| 24310 | 35,000,000 | 5.63 | 1.88 | 4.31 | 0.96 | 3.40 | 0.53 |
| 27780 | 40,000,000 | 6.44 | 2.41 | 4.92 | 1.23 | 3.89 | 0.68 |
| 34720 | 50,000,000 | 8.04 | 3.65 | 6.16 | 1.86 | 4.86 | 1.02 |
| 41670 | 60,000,000 | 9.65 | 5.11 | 7.39 | 2.61 | 5.84 | 1.44 |
| 48610 | 70,000,000 | | | 8.62 | 3.47 | 6.81 | 1.91 |

# FLOW OF WATER IN CAST IRON PIPE (continued)

## Frictional Heads, per Thousand Feet, at Given Rates of Discharge

| Discharge Gals. per Minute | Discharge Gals. per 24 Hours | 60″ Pipe | | 72″ Pipe | | 84″ Pipe | |
|---|---|---|---|---|---|---|---|
| | | Velocity ft. per Second | Loss of Head ft. per 1000 ft. of pipe | Velocity ft. per Second | Loss of Head ft. per 1000 ft. of pipe | Velocity ft. per Second | Loss of Head ft. per 1000 ft. of pipe |
| 5556 | 8,000,000 | 0.63 | 0.02 | | | | |
| 6250 | 9,000,000 | 0.71 | 0.02 | | | | |
| 6944 | 10,000,000 | 0.79 | 0.03 | | | | |
| 7639 | 11,000,000 | 0.87 | 0.04 | | | | |
| 8333 | 12,000,000 | 0.95 | 0.04 | | | | |
| 9028 | 13,000,000 | 1.03 | 0.05 | | | | |
| 9722 | 14,000,000 | 1.10 | 0.06 | 0.77 | 0.02 | | |
| 10420 | 15,000,000 | 1.18 | 0.06 | 0.82 | 0.02 | | |
| 11110 | 16,000,000 | 1.26 | 0.07 | 0.88 | 0.03 | | |
| 11810 | 17,000,000 | 1.34 | 0.08 | 0.93 | 0.03 | | |
| 12500 | 18,000,000 | 1.42 | 0.09 | 0.98 | 0.04 | | |
| 13190 | 19,000,000 | 1.50 | 0.10 | 1.04 | 0.04 | | |
| 13890 | 20,000,000 | 1.58 | 0.11 | 1.09 | 0.04 | | |
| 15280 | 22,000,000 | 1.73 | 0.13 | 1.20 | 0.05 | | |
| 16670 | 24,000,000 | 1.89 | 0.15 | 1.31 | 0.06 | | |
| 18060 | 26,000,000 | 2.05 | 0.18 | 1.42 | 0.07 | | |
| 19440 | 28,000,000 | 2.21 | 0.20 | 1.53 | 0.08 | | |
| 20830 | 30,000,000 | 2.36 | 0.23 | 1.64 | 0.09 | 0.78 1.21 | 0.04 |
| 24310 | 35,000,000 | 2.76 | 0.31 | 1.92 | 0.13 | 0.91 1.41 | 0.06 |
| 27780 | 40,000,000 | 3.15 | 0.40 | 2.19 | 0.16 | 1.04 1.61 | 0.07 |
| 31250 | 45,000,000 | 3.55 | 0.49 | 2.46 | 0.20 | 1.17 1.81 | 0.09 |
| 34720 | 50,000,000 | 3.94 | 0.60 | 2.74 | 0.24 | 1.30 2.01 | 0.11 |
| 41670 | 60,000,000 | 4.73 | 0.84 | 3.28 | 0.34 | 1.56 2.41 | 0.15 |
| 48610 | 70,000,000 | 5.52 | 1.12 | 3.83 | 0.45 | 1.82 2.82 | 0.20 |
| 55560 | 80,000,000 | 6.30 | 1.44 | 4.38 | 0.57 | 2.08 3.22 | 0.26 |
| 62500 | 90,000,000 | 7.09 | 1.79 | 4.92 | 0.71 | 2.34 3.65 | 0.33 |
| 69440 | 100,000,000 | 7.88 | 2.18 | 5.47 | 0.87 | 2.60 4.02 | 0.40 |
| 83330 | 120,000,000 | 9.46 | 3.05 | 6.57 | 1.22 | 3.12 4.92 | 0.56 |
| 97220 | 140,000,000 | | | 7.66 | 1.62 | 3.64 5.64 | 0.74 |
| 111100 | 160,000,000 | | | 8.76 | 2.07 | 4.16 6.44 | 0.95 |
| 125000 | 180,000,000 | | | | | 4.68 7.24 | 1.18 |
| 138900 | 200,000,000 | | | | | 5.20 8.04 | 1.44 |
| 152800 | 220,000,000 | | | | | 5.72 8.86 | 1.72 |
| 166700 | 240,000,000 | | | | | 6.24 9.64 | 2.02 |
| 180600 | 260,000,000 | | | | | 6.76 10.45 | 2.34 |

SECTION 15

# THE ELECTROLYSIS OF UNDERGROUND PIPE LINES AND ITS MITIGATION

ONE problem which may confront the engineer in charge of a pipe line is the prevention or mitigation of damage to the pipe due to stray electric currents in the ground. This trouble may occur where the pipe line at some point in its length passes near the rails of an electric railroad, and the prevalence of electrolytic corrosion has naturally increased with the growth of the street railway systems in this country. These roads use their tracks to carry the current which runs their cars back to the power house, and where these tracks are not kept in perfect condition a portion of this return current finds its way into the ground. If the various networks of pipe, which are so important to the life of the people of our cities, offer a path for this current it is natural that some of this stray current is carried by the pipe. At points where this current leaves the pipe there is serious danger from electrolysis, and as each ampere of current may remove from the pipe twenty pounds of iron in one year, should even a small amount of current be discharged from a limited area, the pipe will be badly damaged.

Unfortunately it is not always possible to tell from the condition of the pipe whether the trouble is electrolysis or due to some other form of corrosion. In some instances elaborate electrolysis surveys are necessary to determine

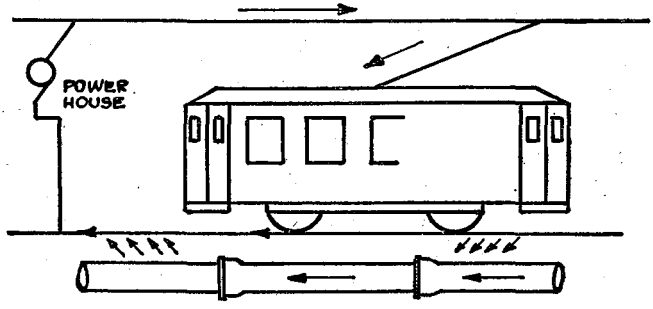
whether the cause of the trouble to the whole pipe system is electrolytic. Damage to pipe at any particular point may be shown by means of the Earth Current Meter, which measures the direction and approximate magnitude of a current entering upon or leaving a pipe line. Generally speaking, if the trouble is concentrated near the power stations of the street railway or occurs directly under a track leading to the power house, readings should be made with this instrument. Although most sections of the country are practically free from electrolysis troubles, in view of its importance in certain places it is worthy of some consideration here.

Many of the electric companies recognize their responsibility in this matter and we find that in some cities agreements have been signed between interested parties in which the electric railway company assumes the responsibility for damage by electrolysis where proven. Even where such agreements do not exist the courts have in certain instances ruled that it is the duty of the railway companies to keep their tracks in good condition so as to minimize the trouble.

Methods of entirely eliminating electrolysis generally necessitate elaborate changes in the railway system that are either expensive to install or costly to operate. There are, however, certain steps that the railroad company can take at a minimum of expense which are valuable in reducing electrolysis in underground mains to a minimum, and if co-operation between the two utilities has been established these steps are usually available.

In the figure following, the path of current in the usual type of electric railway is shown diagrammatically. The current leaves the power house on the overhead wire,

passes through the motors on the car and returns through the tracks to the power house. If the tracks offer much resistance to the flow of current an excessive amount of it leaks off the line and travels through the ground. If there is in the ground some good conductor of electricity, such as a pipe line, part of the current takes this easier path, leaving the pipe for the rails as it nears the power house. It is at this point that the greatest amount of trouble occurs, although part of the current will leave the

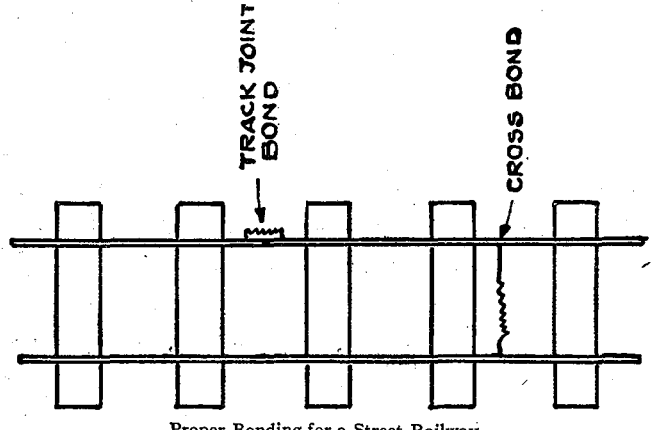



Single Track Electric Railway Showing the Path of Current.

pipe line at any point where it passes near a conductor offering less resistance in its return to the power house.

As long as the rails are kept in perfect condition there is little tendency for the current to leave them for the earth, and this is the most effective step that can be taken towards the prevention of electrolysis. The better the conductivity of the track the less the danger from stray currents, and for this reason it is important that the joints between two adjoining rails be kept in good condition. In fact the resistance of a rail joint should not be greater than the resistance of ten feet of rail. In a properly con-

structed track either the rails are welded together, forming a continuous line, or a heavy copper band is securely fastened to the ends of adjacent rails bridging the joints. As insurance against the temporary failure of one of these joints it is important to have at regular intervals cross bonds between the two lines of rails in a track. These bonds permit the interchange of current between the rails in case a high resistance joint occurs in one of them. In




Proper Bonding for a Street Railway.

a well maintained track these cross bonds are usually placed from 200 to 500 feet apart.

It is very important that heavy cables be laid around all track intersections or switches, which from their nature introduce resistance into the track. These cables should be large enough to carry all the current and should be carefully inspected at regular intervals to insure their being in perfect condition.

A properly constructed and drained road bed is very useful in preventing electrolysis. Dry rock ballast is a

very poor conductor of electricity and the use of this kind of material in track construction cuts down the amount of current leaking into the soil.

Whether it is possible to obtain the co-operation of the electric company or not there are certain steps in the prevention of electrolysis which may be applied to the pipe line itself. Much has been written as to the efficiency of insulating coatings applied to the line. It is true that if a perfectly water tight coating could be applied to the pipe electrolytic damage would be avoided. However, the difficulty in obtaining an absolutely continuous coating makes this method of mitigation unsatisfactory. In fact an effort to protect the line by means of special coatings may even be dangerous as it may serve to concentrate the corrosive action where the current leaves the pipe on small areas where the coating has failed, and this results in deep pitting. It has been suggested that the use of protective coatings in the areas where the pipe is picking up current might be of value as protective coatings on pipe at these points would increase the resistance of the path between the soil and the pipe and cuts down the amount of current picked up. However, the difficulty of definitely determining the right areas in which to use this protection makes it inadvisable to use any coating other than the regular tar coating furnished on pipe.

A method often suggested for eliminating electrolysis is pipe drainage. This consists of connecting the pipe line near the power house to the negative busbar or to the rails by means of a cable. At first glance this would seem to be a good method, but careful study shows that by making the path of the current along the pipe easy to follow the amount of current flowing on the line is in-

creased and trouble may result. This type of electrolysis mitigation should never be used except after a careful study of the situation by an expert and then only in conjunction with other mitigative measures.

For a new pipe line probably the best method of preventing electrolysis troubles is to use insulating joints for the pipe. To be satisfactory the joints must be insulating to such an extent that they prevent the line from being a good conductor. All joints should offer high resistance to the flow of current, as the introduction of one or two high resistance joints in a line may cause additional damage where the current leaves the pipe for the earth to pass around the joint. For this reason insulating jointing compounds should not be used for repairs in existing lines where the original joints were of lead. The use of insulating joints in making up lines which tie into existing networks usually will not of itself change the electrolytic condition of the system, as no current will flow over the new line.

Insulating joints may be made of cement or leadite. The first mentioned material is widely used for gas lines and gives very satisfactory results. It may, however, be necessary to use wooden rings in the base of the bell to prevent contact between the bell of one pipe and the spigot of the adjoining pipe. The gas company in one of the largest cities of the East uses this type of joint with marked success although the water company of the same city reports considerable trouble from electrolysis. Leadite is a useful insulating material and due to the ease with which it is handled as well as the satisfaction it affords for use with medium water pressures it deserves careful consideration in the installation of new lines.

In laying a pipe line it is very important to place the pipe as far away as possible from the street car tracks and other conductors. This has a very marked effect in preventing electrolysis and the reason is obvious when we consider that the resistance of the soil may be high and increases with the distance that the current has to flow through it. Care in locating pipe lines in regard to the tracks will invariably reduce electrolysis trouble.

The importance of electrolysis in certain sections is obvious when we consider that stray electric currents attack all the various types of pipe used for water and gas distribution. With metal pipe of the various kinds the resistance which they offer to this damage depends to a great extent on their thickness. At first glance it might appear that concrete pipe would be free from this trouble, but such is not the case, as the current working through the cement may attack the reinforcement, causing the cement to crack off and resulting in the early failure of the pipe.

From the above it will be seen that where there is a possibility of electrolytic trouble it is important that the railway company keep the track bonds in good condition and their road bed clean and dry. The man in charge of the pipe line can do his part in preventing electrolysis by the use of insulating joints with his pipe as well as by care in the location of new lines, good results being obtained by carefully locating pipe lines with regard to the various other conductors.

## SECTION 16

# FAILURES OF WATER CONDUITS IN SERVICE AND THEIR PREVENTION

NOTHING is more necessary to the comfort and health of any community than an ample supply of pure water. For this reason the failure of pipe lines carrying water is of vital importance to every person in a community and any step that will make this service more dependable is worth consideration. The results of an investigation of all breaks reported as having occurred in cast iron pipe lines carrying water are given in the following pages and we believe that a consideration of the causes of pipe failures described will enable those in charge of pipe lines to avoid breaks which might otherwise occur.

The importance of the water supply of a community lends to any break in this service a news value which far exceeds the actual importance of the failure. For this reason, newspaper clippings supply an accurate record of most of the breaks in water pipe lines occurring in this country. With these clippings as a basis, form letters have been sent out addressed to the Superintendent of Water Works in the cities where the breaks occurred asking for general information regarding these failures. The letter explains that the information requested will be of value in avoiding similar breaks in the future, and it

speaks well for the spirit of co-operation of this group of men that replies have been received to over 60% of these letters.

SUMMARY OF FAILURES IN CAST IRON WATER MAINS — Sept. 1, 1916 to Sept. 1, 1925

CAST IRON PIPE

| | | |
|---|---|---|
| Breaks in modern cast iron pipe | 285 | |
| Breaks in pipe made by old method, *i. e.*, cast on the side | 34 | |
| Breaks in pipe cast in local foundries without proper equipment | 16 | |
| Total Failures in Cast Iron Lines | | 335 |
| Failure Due to Blowing out of Lead Calking Material | | 89 |
| Failures Reported as Cast Iron, Actually Other Material | | 62 |
| Breaks Reported in Error; No Failure in Pipe | | 44 |
| Total Breaks Investigated | | 530 |

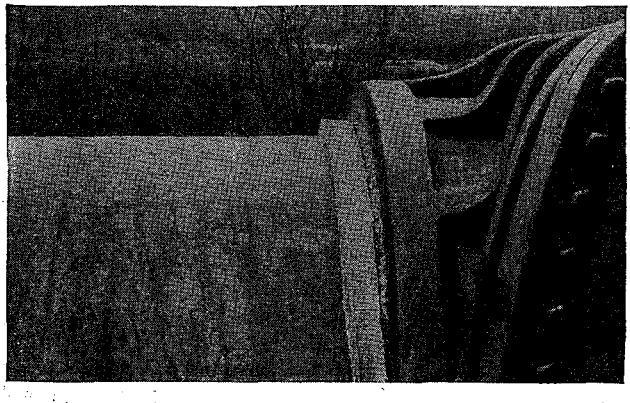
SUMMARY OF BREAKS IN MODERN CAST IRON PIPE

| Causes of Failures in Cast Iron Pipe Exclusive of Joint Failures | Distribution | Supply | Total |
|---|---|---|---|
| Settlement of earth under pipe | 58 | 19 | 77 |
| Settlement of walls, etc., on pipe | 4 | 1 | 5 |
| External blow | 32 | 30 | 62 |
| Longitudinal expansion of pipe | .. | 2 | 2 |
| Electrolysis | 10 | .. | 10 |
| Freezing | 25 | 2 | 27 |
| Pressure increase | 16 | 5 | 21 |
| Vibration | 11 | 4 | 15 |
| Poor construction | 1 | 4 | 5 |
| Water hammer | 7 | 3 | 10 |
| Resting on rock | 4 | 5 | 9 |
| Miscellaneous | 2 | .. | 2 |
| Defective pipe | 11 | 4 | 15 |
| Cause unknown | 22 | 3 | 25 |
| | 203 | 82 | 285 |

There is some difficulty in definitely classifying the cause of the various breaks. For instance, an old pipe may carry water for years in spite of a minor defect that only discloses itself when a nearby excavation causes the line to settle. In such a case it is reasonable to assume

that the pipe would have continued to give perfect service if the undue strain had not occurred. Therefore, wherever possible, the break is classified by the immediate cause of the failure.

*Joint Failures.* Undoubtedly the majority of leaks in water mains are due to the blowing out of the lead used for calking. Carelessness in laying pipe invariably results in a great deal of joint trouble, and even a line perfectly



**Lead Forced from the Bell of a Valve by Pulsation.**

installed may develop some leaks if the ground through which the line runs is not solid. One typical city of 150,000 inhabitants in the middle west reports an average of twenty leaks a year, and of this number 85% are joint failures.

On old lines it was sometimes customary to tie plugs or sharp bends into pipe lines by means of steel straps or to place wooden stakes back of the fittings to prevent shifting. Blow outs usually occur after these wooden stakes have rotted or the steel straps corroded and failed. Prob-

ably the safest method of holding a fitting in place is by means of a block of concrete.

We must expect to find occasional joints which fail due to poor calking, although these are usually discovered in the test of the line in the trench. If such poorly calked joints exist in an untested line they are almost certain to fail eventually under a sudden increase of pressure or even under the steady pulsation of the water. For this reason a service test after the pipe is in the trench and before back-filling is desirable on any pipe line.

*Cast Iron Pipe Breaks.* History has shown that cast iron pipe is literally "GOOD FOR CENTURIES," however, even cast iron pipe must be laid with a reasonable amount of care. Pipe are cast in twelve foot or longer lengths and are intended to carry water. They are not designed to act as beams, and most failures are the result of subjecting pipe to bending stresses.

*Settlement of Supports.* The number of conduits running under the streets of a modern city is really astonishing and it is not surprising that it is difficult to dig up one line without affecting several others. Careful excavation and sheeting will prevent trouble. However, as several utilities have conduits under the streets it is sometimes difficult to obtain the necessary co-operation. When excavations are being made near water lines it is important that a careful check on the work be made by the water department to see that proper precautions are taken to protect their lines.

Here again the tendency of unprotected wood to rot causes trouble. Many installations are laid temporarily on wood piles; later in the rush of work permanent supports are forgotten until at last the wooden supports give

way resulting in a serious break. Whenever it is necessary to place pipe on supports it is a real economy to make these supports of concrete or masonry and be sure that they are permanent.

Pipe lines must often be laid across shifting ground, and these lines are always subject to breaks. In fact, the tendency in modern pipe line construction is to support each length of pipe on concrete piers in passing through such ground and extending to solid earth.

There are a few cities in this country that are built over extensive coal mining operations and in these cities the



Pipe Supported on Concrete Piers

lines are subjected to continuous strains. Breaks become a part of the regular routine and no precautions will prevent their occurrence. One superintendent stated that they experienced several hundred breaks in distribution lines and services in one year and it is only by continuous effort that the lines in these localities are kept in repair.

Occasionally washouts, due to heavy rains, cause breaks by undermining the pipe. This can be avoided by careful construction. However the constantly changing channel in rivers and streams take a regular toll in breaks of the submerged supply lines. Better engineering practice in anchoring lines and in trenching for submerged pipe is gradually eliminating such breaks.

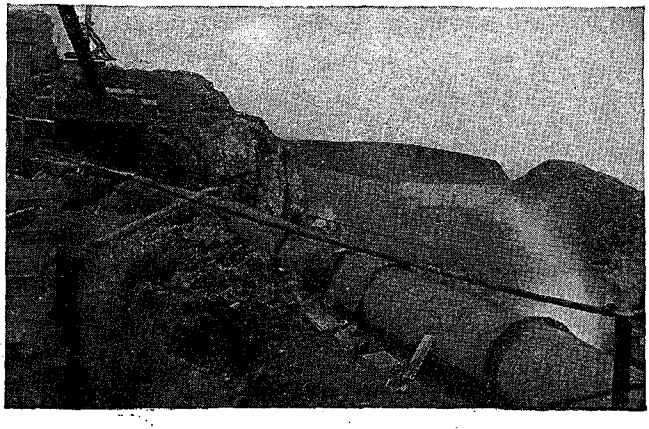
One of the most widely discussed breaks which has occurred in some years, that of the 42-inch line in Copley



Pipe Line Completely Exposed by Washout of the Supporting Fill

Square, Boston, was due primarily to settlement. Some time previous to the break, which occurred in 1916, a concrete sewer had been built under the pipe and the lower portion of the pipe embedded in the concrete. This held the pipe rigidly at one point so that a very slight settlement at the other end of the pipe resulted in severe strain and ultimately in the breaking of the pipe.

*External Blow.* Almost one-eighth of the breaks investigated were caused by subjecting the pipe to a heavy blow. The danger of such a blow is greatest before the pipe is covered. In back-filling it is important to avoid rolling heavy rocks into the trench so that they will strike the pipe. It is sometimes necessary to lay pipe without cover in crossing bridges. These lines are in constant danger from automobiles and trucks, and in several instances falling trees have broken such lines. Submerged



Cast Iron Pipe Exposed by Blasting

lines, unless laid in a trench, are often broken by anchors or dredge buckets.

Even with several feet of earth over the pipe they are not absolutely secure and pile drivers often pierce pipe lines when a careful record of their location is not kept. Blasting is sometimes carelessly done without sufficient protection being provided for nearby pipe lines, and in at

least two instances pipe lines were maliciously dynamited to injure the companies supplied.

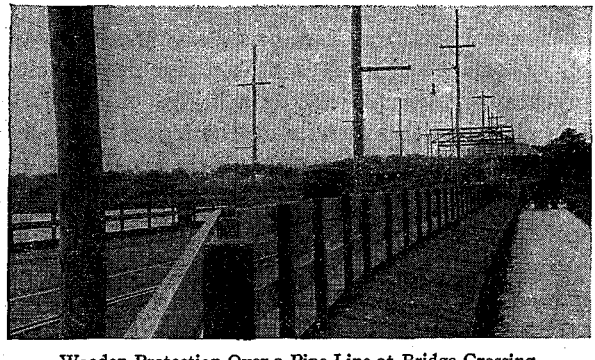
The most remarkable instance that has come to our attention happened in New York. A heavy machine was being lifted up the side of an office building. The machine slipped from the ropes eleven stories in the air. It crashed through the sidewalk and struck a six-inch cast iron pipe. It is probable that this pipe prevented the machine from plunging into the subway, which would undoubtedly have resulted in heavy loss of life.

*Settlement of Structure Crushing Pipe.* Another way in which settlement will result in broken pipe may be cited. If any heavy structure, such as a bridge or foundation wall, is placed so that it rests on the pipe a very slight settlement will be sufficient to crush the pipe no matter how carefully made.

Here again co-operation with other departments of the city is essential. It is not only necessary for the water superintendent to use care in the layout of his lines but also the sewer and even the highway department must be informed of the location of important lines so that they can be avoided when other work is being laid out.

*Longitudinal Expansion.* In laying cast iron pipe in cold weather it is better not to place the spigot end in contact with the bottom of the bell of the next pipe, as a small allowance is necessary to take care of the natural expansion of the pipe as the temperature rises. Few people realize that a pipe line expands over a foot in every mile during the change from winter to summer temperature. Under the conditions mentioned above a break may occur although ordinarily this change in length is easily taken care of in the regular bell and spigot joint.

*Freezing.* Except at points where water lines are carried across bridges or otherwise exposed there is little danger of breaks due to freezing. It is customary in the north to place pipe lines from five to six feet under the surface, and as frost seldom penetrates to this depth this affords ample protection from freezing. Investigations recently completed show that larger lines carried across bridges are immune from freezing if a constant flow through them is kept up. However, for smaller lines or



Wooden Protection Over a Pipe Line at Bridge Crossing

lines where the flow is intermittent it is better to enclose the pipe in a wooden box or with a sheet metal cover over a coating of felt.

*Vibration.* Unusual care should be taken where a pipe line passes under railroad tracks or highways subjected to heavy traffic. In some soils vibrations are transmitted many feet and these vibrations subject the pipe and joints to severe strains. By placing the lines at considerable depth under such crossings and by using care that the earth supporting the pipe is firm and level trouble can

often be avoided. However, it has been recommended that important lines under railroad tracks be placed in a tunnel or conduit of a larger size than the pipe, thus effectively eliminating the vibration.

*Contact With Rock.* In laying pipe it is very important to have the bottom of the trench level and free from rocks. Some of the worst breaks that have ever occurred have



Pipe Broken Directly Under a Rail Joint

been the result of allowing the pipe to rest on a stone. This may not cause an immediate failure, but during years of service the natural pulsation of the water in the line results in strains in the metal at the point of contact which finally causes a break.

*Water Hammer.* Careful engineering has reduced to a great extent the number of failures due to water hammer. The necessity for installing air valves at the high points of

any long line is now recognized as well as the advantages of an air chamber of sufficient size to control the surges. It is well to remember that air in any line is dangerous and wherever possible it should be removed in filling the pipe, care on this point reduces water hammer to a minimum.

There are several other minor causes of main failures which can be avoided by care in construction. Electrolysis

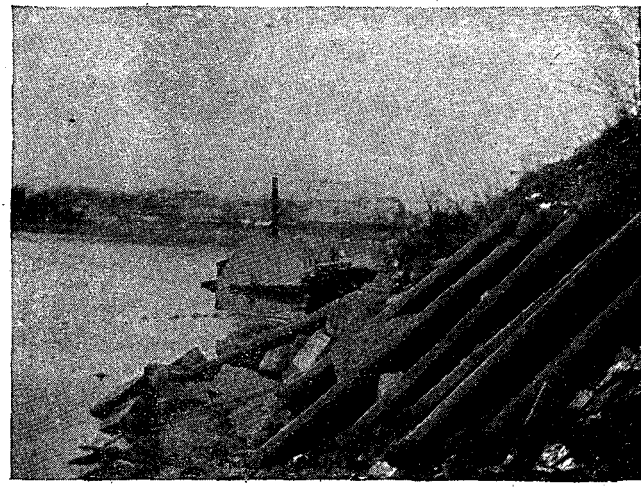


Large Rock Directly Under Break in Pipe

which is sometimes considered unavoidable may be minimized by the careful design and installation of a main. Electrolysis mitigation is discussed more in detail elsewhere.

*Injury to the Pipe Before Laying.* Occasionally the investigation of a break discloses the fact that the pipe

was injured before laying. This trouble can be avoided by exercising a reasonable amount of care in handling the pipe. All cast iron pipe is subjected to a hydraulic test at the foundry to at least twice the working pressure, and up to the time of shipment the pipe must be free from incipient cracks. However, if for any reason the pipe is transferred while en route it may be injured. For this reason it is important to inspect the pipe carefully when

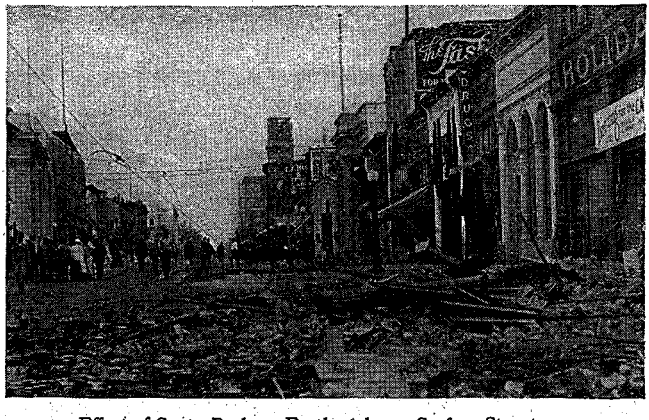


Careless Unloading Resulting in Serious Damage to Pipe

accepting it from the railroad. By order of the Interstate Commerce Commission carriers cannot pay claims for damage or loss unless the consignee immediately notifies the railroad agent at destination in writing in order to enable the railroad to check the final claim when presented. For this reason if damage in transit is found

a notation of breakage on the freight bill should be obtained from the agent. In unloading from the cars and trucking to the line a reasonable amount of care should be exercised to prevent injury and as a precaution each length should be "rung" before laying.

*Old Cast Iron Pipe.* The first cast iron pipe used in this country has been in service over one hundred years and there are many miles of this early pipe still in use. In view of the difficulties under which this pipe was made



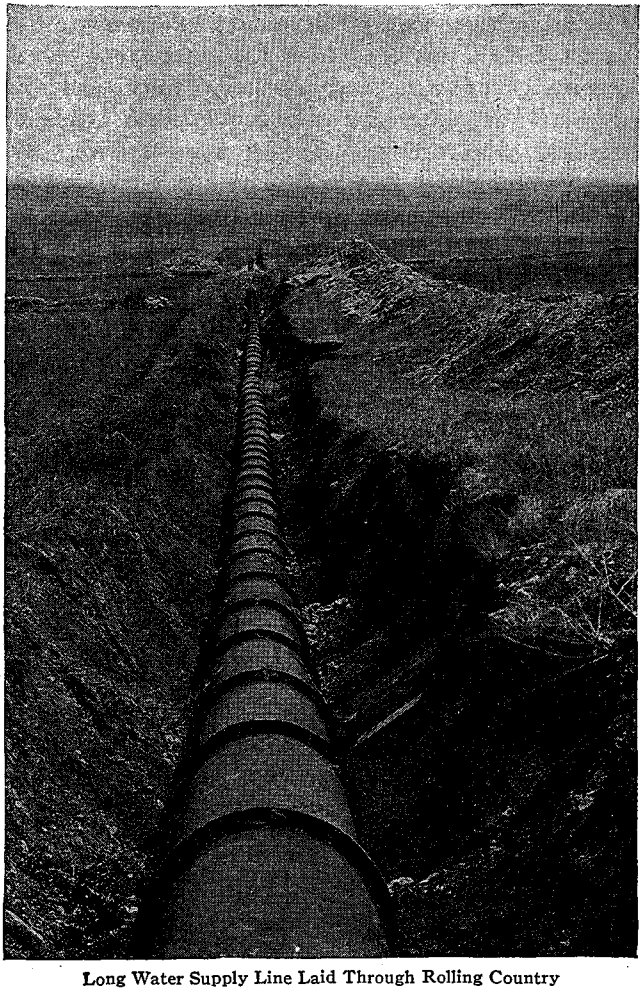
Effect of Santa Barbara Earthquake on Surface Structures

at that time it is not remarkable that it should sometimes fail under the increased strains of modern service. The remarkable record that this pipe has made amply justifies the judgment of those early city fathers that authorized its installation. Not so easy to understand, however, is the installation at this time, when standard pipe is available, of inferior pipe made in local foundries without adequate equipment for either the manufacture or the

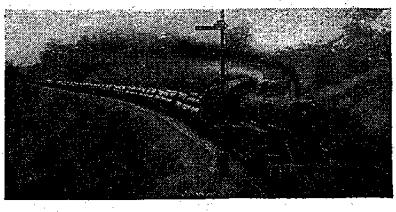
testing of the pipe. Yet the record of breaks shows that this is sometimes done. This record would be much worse except for the omission from the summary of breaks occurring in one well known pipe line. In two and a half miles of thirty-inch pipe over one hundred breaks are reported as occurring in twenty years' service. This pipe was purchased from a foundry which has since discontinued the manufacture of pipe, and this trouble was due to the high phosphorus content of the iron. Analysis shows that the pipe contains 1.33% of phosphorus, which is a far higher percentage than allowed by American Manufacturers today.

That cast iron pipe properly installed is permanent has been clearly shown by the way this pipe has withstood the strains set up by earthquakes. In the disastrous quake at Santa Barbara only three breaks, one of which was caused by a falling wall, occurred in the one hundred twenty-four miles of cast iron mains in use in the city.

Cast iron pipe with bell and spigot joints is amply durable to withstand the ordinary strains of service and, properly installed, it is good for centuries.

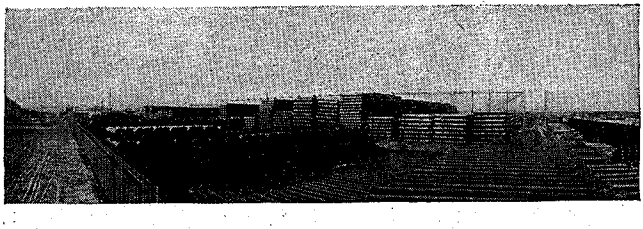


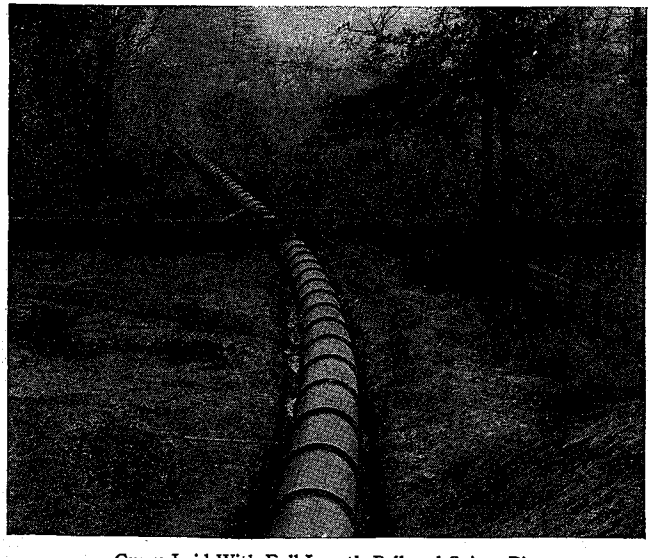
Long Water Supply Line Laid Through Rolling Country



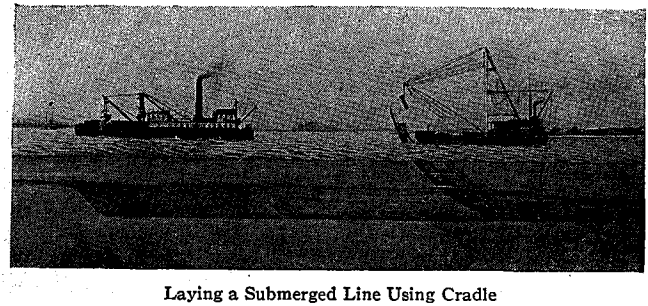
SECTION 17

# TYPICAL INSTALLATIONS

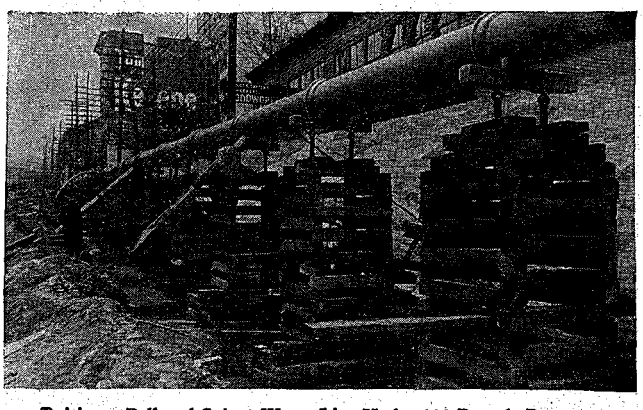




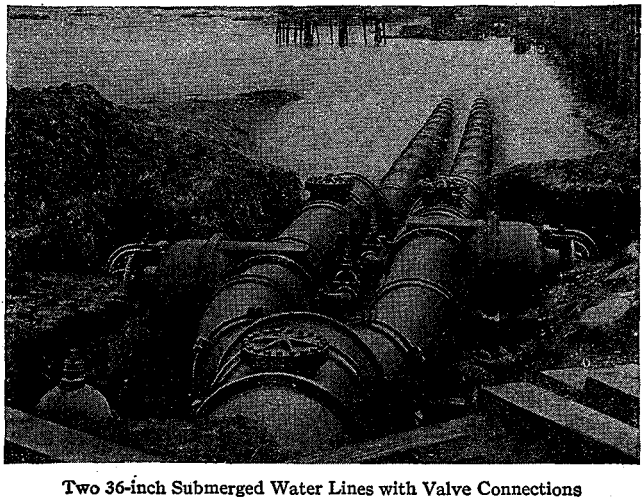
Curve Laid With Full Length Bell and Spigot Pipe



Laying a Submerged Line Using Cradle



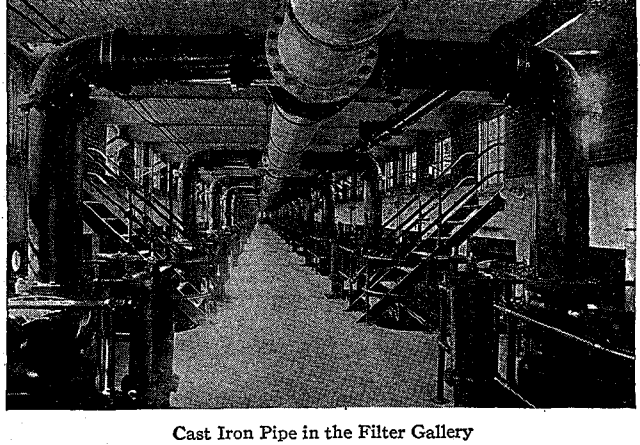
Raising a Bell and Spigot Water Line Under 120 Pounds Pressure



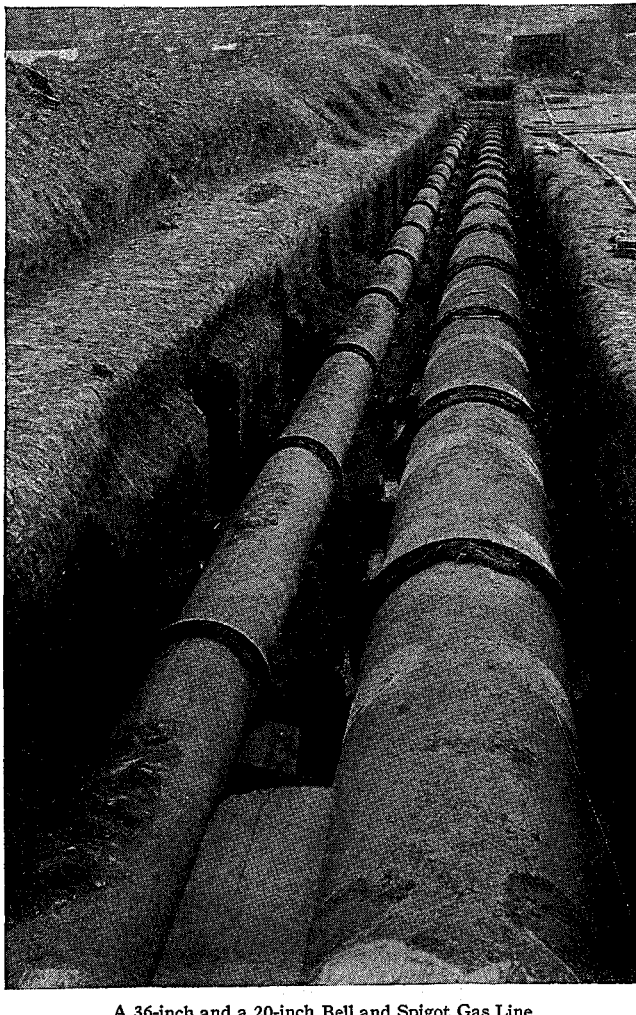
Two 36-inch Submerged Water Lines with Valve Connections



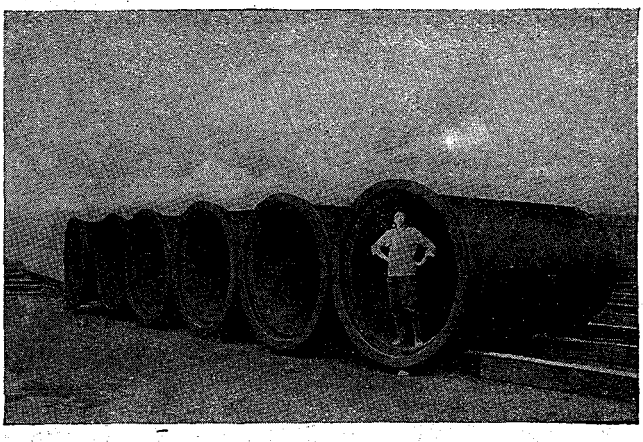
Cast Iron Pipe in the Pump Room



Cast Iron Pipe in the Filter Gallery



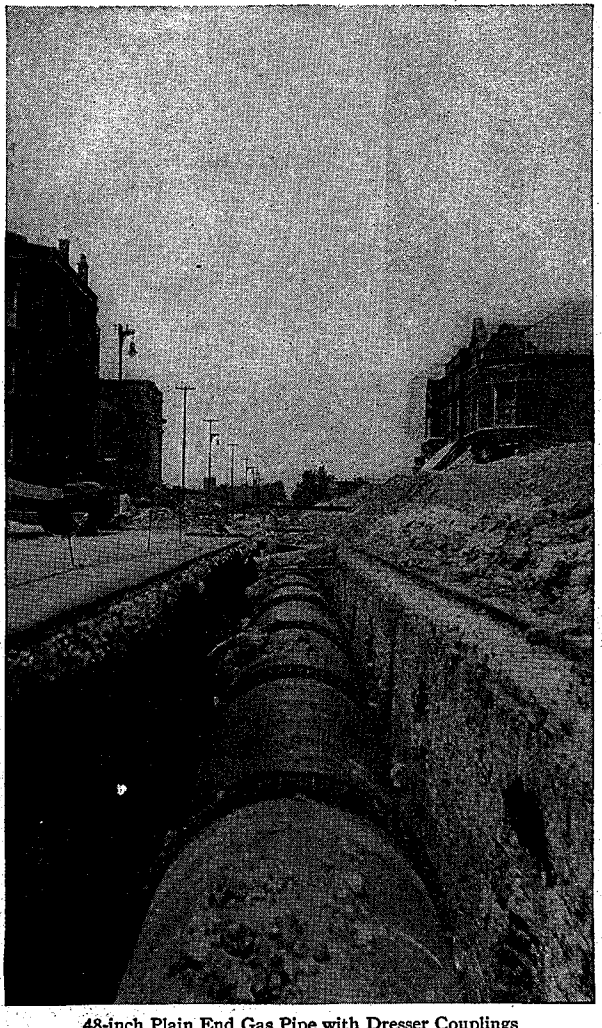
A 36-inch and a 20-inch Bell and Spigot Gas Line
in the Same Trench



72-inch Gas Pipe for the Astoria Tunnel



Valve House in a Large Gas Plant



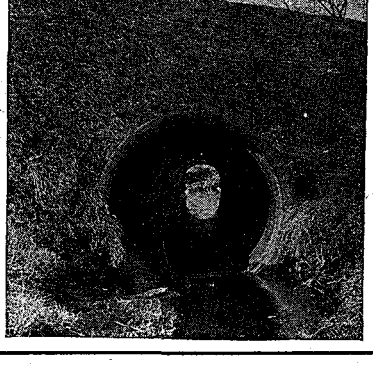
48-inch Plain End Gas Pipe with Dresser Couplings



High Pressure
Fire Line

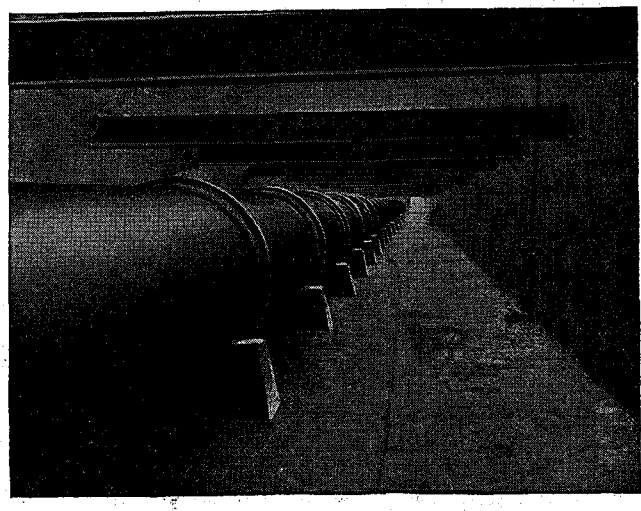


Cast Iron Pipe for Highway Culverts

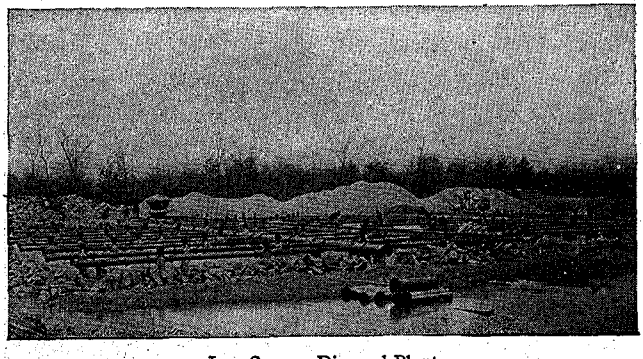


Railway Culvert
Under Deep Fill

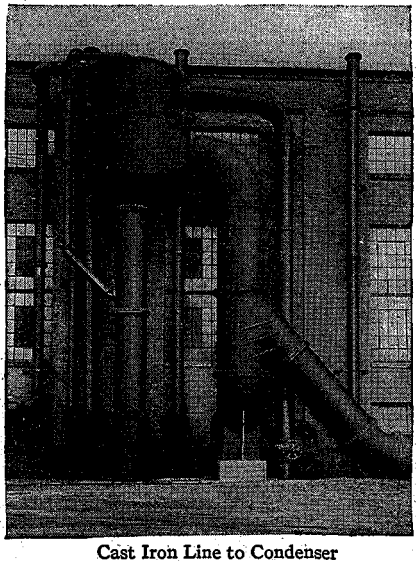
## MISCELLANEOUS USES FOR CAST IRON PIPE



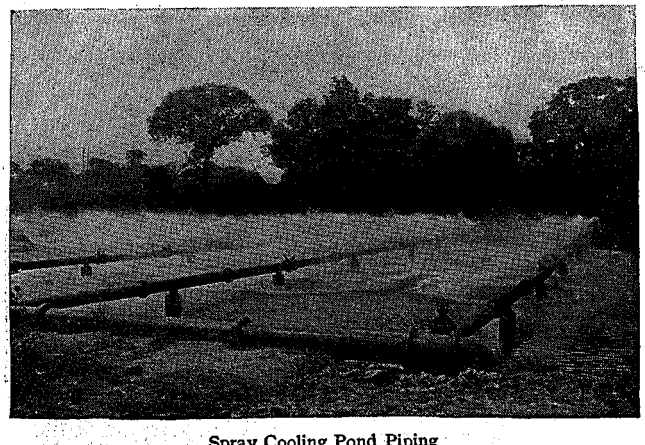
Large Sewer Siphon Line



In a Sewage Disposal Plant



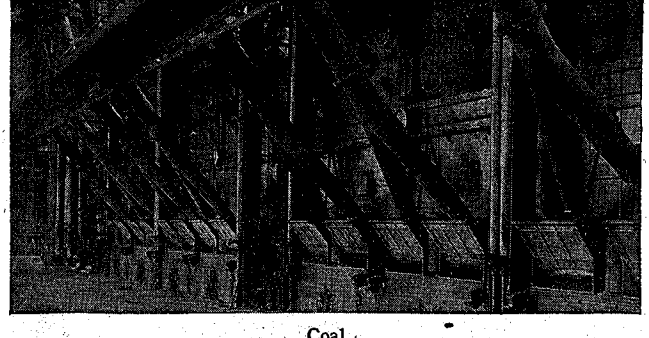
Cast Iron Line to Condenser



Spray Cooling Pond Piping

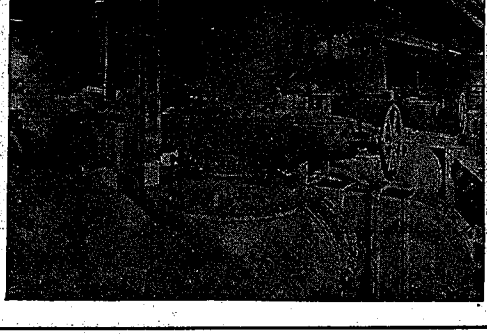


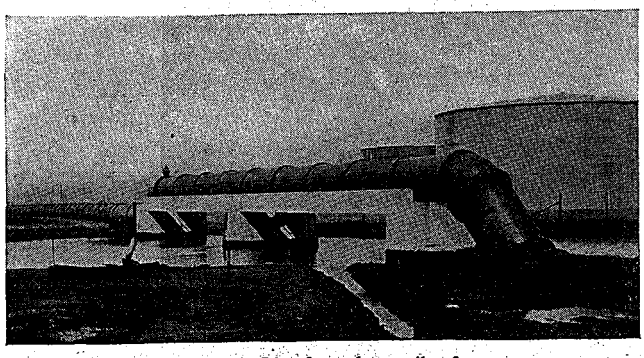
Water



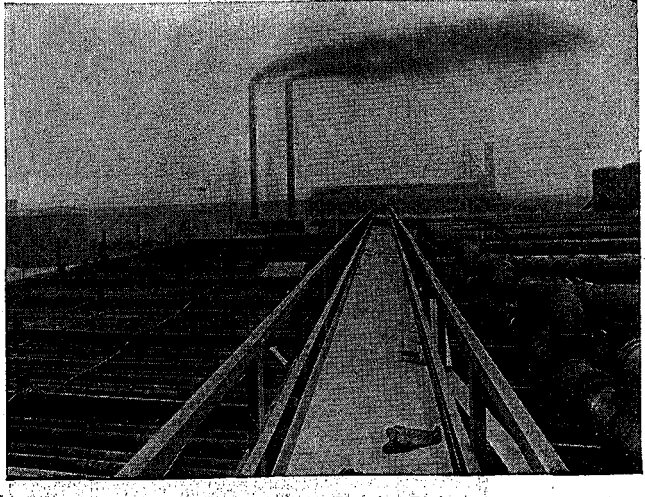
Coal

Steam





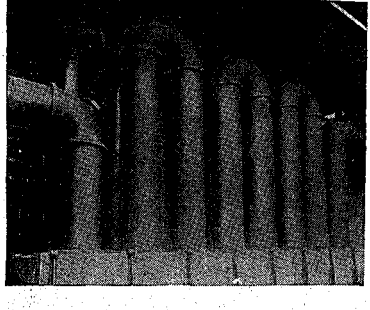
Water Supply Line for a large oil refinery



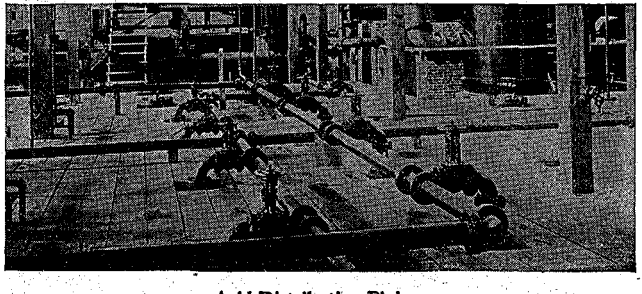
Condenser Boxes Showing Piping

$SO_2$ Gas Cooler

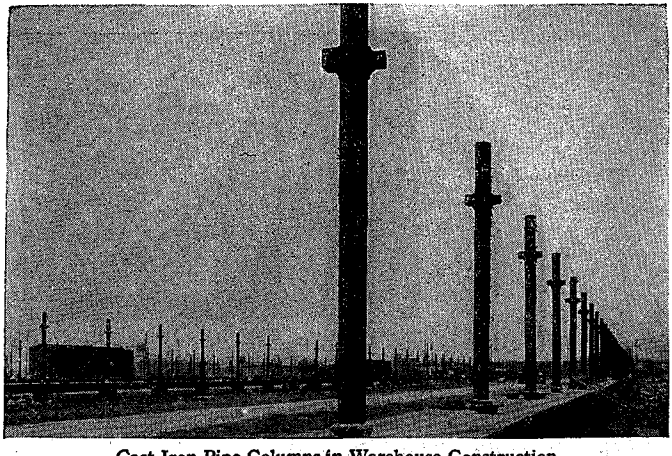




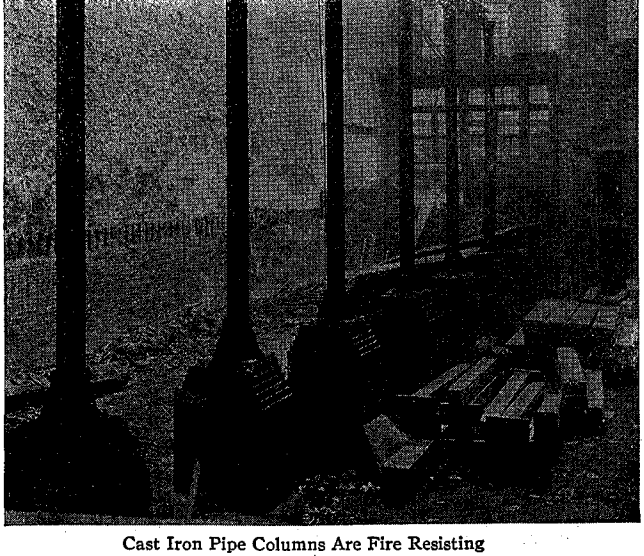
Sulphuric Acid Coils



Acid Distributing Piping



Cast Iron Pipe Columns in Warehouse Construction



Cast Iron Pipe Columns Are Fire Resisting

SECTION 18

# USEFUL ENGINEERING TABLES

## Equivalents of Fractions of an Inch

| Fractions | | | Decimals | Millimeters | Fractions | | | Decimals | Millimeters |
|---|---|---|---|---|---|---|---|---|---|
| | | 1/64 | .015625 | .3969 | | | 33/64 | .515625 | 13.0966 |
| | 1/32 | | .03125 | .7937 | | 17/32 | | .53125 | 13.4935 |
| | | 3/64 | .046875 | 1.1906 | | | 35/64 | .546875 | 13.8904 |
| 1/16 | | | .0625 | 1.5875 | 9/16 | | | .5625 | 14.2872 |
| | | 5/64 | .078125 | 1.9843 | | | 37/64 | .578125 | 14.6841 |
| | 3/32 | | .09375 | 2.3812 | | 19/32 | | .59375 | 15.0810 |
| | | 7/64 | .109375 | 2.7781 | | | 39/64 | .609375 | 15.4778 |
| 1/8 | | | .125 | 3.1749 | 5/8 | | | .625 | 15.8747 |
| | | 9/64 | .140625 | 3.5718 | | | 41/64 | .640625 | 16.2716 |
| | 5/32 | | .15625 | 3.9687 | | 21/32 | | .65625 | 16.6684 |
| | | 11/64 | .171875 | 4.3655 | | | 43/64 | .671875 | 17.0653 |
| 3/16 | | | .1875 | 4.7624 | 11/16 | | | .6875 | 17.4622 |
| | | 13/64 | .203125 | 5.1593 | | | 45/64 | .703125 | 17.8591 |
| | 7/32 | | .21875 | 5.5561 | | 23/32 | | .71875 | 18.2559 |
| | | 15/64 | .234375 | 5.9530 | | | 47/64 | .734375 | 18.6528 |
| 1/4 | | | .25 | 6.3499 | 3/4 | | | .75 | 19.0497 |
| | | 17/64 | .265625 | 6.7468 | | | 49/64 | .765625 | 19.4465 |
| | 9/32 | | .28125 | 7.1436 | | 25/32 | | .78125 | 19.8434 |
| | | 19/64 | .296875 | 7.5405 | | | 51/64 | .796875 | 20.2403 |
| 5/16 | | | .3125 | 7.9374 | 13/16 | | | .8125 | 20.6371 |
| | | 21/64 | .328125 | 8.3342 | | | 53/64 | .828125 | 21.0340 |
| | 11/32 | | .34375 | 8.7311 | | 27/32 | | .84375 | 21.4309 |
| | | 23/64 | .359375 | 9.1280 | | | 55/64 | .859375 | 21.8277 |
| 3/8 | | | .375 | 9.5248 | 7/8 | | | .875 | 22.2246 |
| | | 25/64 | .390625 | 9.9217 | | | 57/64 | .890625 | 22.6215 |
| | 13/32 | | .40625 | 10.3186 | | 29/32 | | .90625 | 23.0183 |
| | | 27/64 | .421875 | 10.7154 | | | 59/64 | .921875 | 23.4152 |
| 7/16 | | | .4375 | 11.1123 | 15/16 | | | .9375 | 23.8121 |
| | | 29/64 | .453125 | 11.5092 | | | 61/64 | .953125 | 24.2089 |
| | 15/32 | | .46875 | 11.9060 | | 31/32 | | .96875 | 24.6058 |
| | | 31/64 | .484375 | 12.3029 | | | 63/64 | .984375 | 25.0027 |
| 1/2 | | | .50 | 12.6998 | 1 | | | 1.00 | 25.3995 |

# Millimeters and Equivalent Decimals and Nearest Fractions of Inches

One Millimeter = .03937″ One Inch = 25.40 Mill.

| Millimeter | Inches | | Millimeter | Inches | |
|---|---|---|---|---|---|
| | Decimal | Nearest Fraction | | Decimal | Nearest Fraction |
| 1 | .03937 | 3/64 | 51 | 2.00787 | 2 1/64 |
| 2 | .07874 | 5/64 | 52 | 2.04724 | 2 3/64 |
| 3 | .11811 | 1/8 | 53 | 2.08661 | 2 5/64 |
| 4 | .15748 | 5/32 | 54 | 2.12598 | 2 1/8 |
| 5 | .19685 | 13/64 | 55 | 2.16535 | 2 5/32 |
| 6 | .23622 | 15/64 | 56 | 2.20472 | 2 13/64 |
| 7 | .27559 | 9/32 | 57 | 2.24409 | 2 1/4 |
| 8 | .31496 | 5/16 | 58 | 2.28346 | 2 9/32 |
| 9 | .35433 | 23/64 | 59 | 2.32283 | 2 21/64 |
| 10 | .39370 | 25/64 | 60 | 2.36220 | 2 23/64 |
| 11 | .43307 | 7/16 | 61 | 2.40157 | 2 13/32 |
| 12 | .47244 | 15/32 | 62 | 2.44094 | 2 7/16 |
| 13 | .51181 | 1/2 | 63 | 2.48031 | 2 31/64 |
| 14 | .55118 | 35/64 | 64 | 2.51968 | 2 33/64 |
| 15 | .59055 | 19/32 | 65 | 2.55905 | 2 9/16 |
| 16 | .62992 | 5/8 | 66 | 2.59842 | 2 19/32 |
| 17 | .66929 | 43/64 | 67 | 2.63779 | 2 41/64 |
| 18 | .70886 | 45/64 | 68 | 2.67716 | 2 43/64 |
| 19 | .74803 | 3/4 | 69 | 2.71653 | 2 23/32 |
| 20 | .78740 | 25/32 | 70 | 2.75590 | 2 3/4 |
| 21 | .82677 | 53/64 | 71 | 2.79527 | 2 51/64 |
| 22 | .86614 | 55/64 | 72 | 2.83464 | 2 53/64 |
| 23 | .90051 | 29/32 | 73 | 2.87401 | 2 7/8 |
| 24 | .94488 | 15/16 | 74 | 2.91338 | 2 29/32 |
| 25 | .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 9/64 | 79 | 3.11023 | 3 1/64 |
| 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 17/64 | 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 | 3 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.$_{6}$6214 | 0.$_{6}$5396 | 0.001 |
| 0.02540 | 1 | 0.08333 | 0.02778 | 0.$_{5}$5051 | 0.$_{6}$1263 | 0.$_{6}$1578 | 0.$_{6}$1371 | 0.$_{4}$2540 |
| 0.30480 | 12 | 1 | 0.33333 | 0.06061 | 0.01515 | 0.$_{5}$1894 | 0.$_{5}$1645 | 0.$_{4}$3048 |
| 0.91440 | 36 | 3 | 1 | 0.18182 | 0.04545 | 0.$_{5}$5682 | 0.$_{5}$4934 | 0.$_{4}$9144 |
| 5.02921 | 198 | 16.5 | 5.5 | 1 | 0.25 | 0.$_{4}$3125 | 0.$_{4}$2714 | 0.$_{3}$5029 |
| 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 = $\frac{1}{15}$° at equator = 7422 m
= 4.611808 U. S. statute miles.
1 international nautical mile = $\frac{1}{60}$° at meridian = 1852 m
= 0.999326 U. S. nautical miles.
1 U. S. nautical mile = $\frac{1}{60}$° 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.

## SURFACES AND AREAS

1 sq. meter, m² = 100 sq. decimeters, dm² = 10000 sq. centimeters, cm².
1 sq. meter, m² = 0.01 are, a = 0.0001 hectare, ha.
1 sq. millimeter, mm² = 0.01 cm² = 0.00155 sq. inch = 1973.5 circular mils.
1 are, a = 1 sq. decameter, dkm = 0.0247104 acre.

| Sq. Meters, m² | 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, km² |
|---|---|---|---|---|---|---|---|---|
| 1 | 1550.00 | 10.7639 | 1.19599 | 0.03954 | 0.$_{4}$2471 | 0.0001 | 0.$_{6}$3861 | 0.$_{6}$51 |
| 0.$_{4}$6452 | 1 | 0.$_{4}$6944 | 0.$_{4}$7716 | 0.$_{3}$2551 | 0.$_{4}$1594 | 0.$_{6}$6452 | 0.$_{6}$2491 | 0.$_{6}$6452 |
| 0.09290 | 144 | 1 | 0.11111 | 0.$_{3}$3673 | 0.$_{5}$2296 | 0.$_{6}$9290 | 0.$_{6}$3587 | 0.$_{6}$9290 |
| 0.83613 | 1296 | 9 | 1 | 0.03306 | 0.$_{4}$2066 | 0.$_{6}$8361 | 0.$_{6}$3228 | 0.$_{6}$8361 |
| 25.2930 | 39204 | 272.25 | 30.25 | 1 | 0.00625 | 0.$_{3}$2529 | 0.$_{6}$9766 | 0.$_{4}$2529 |
| 4046.87 | 6272640 | 43560 | 4840 | 160 | 1 | 0.40469 | 0.$_{3}$1563 | 0.$_{3}$4047 |
| 10000 | 15499969 | 107639 | 11959.9 | 395.366 | 2.47104 | 1 | 0.$_{3}$3861 | 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 = $\frac{1}{160}$ acre.
1 sq. chain, Gunter's = 16 sq. rods = $\frac{1}{10}$ acre.
1 acre = 4 sq. roods = 160 sq. rods. Square of 1 acre = 208.7103 feet square.

Notations $2_{6}$, $3_{6}$, $4_{6}$, etc., indicate that the 2, 3, 4, etc., are to be replaced by 2, 3, 4, etc., ciphers.

EXAMPLE—1 sq. rod = 0.$_{5}$9766 = 0.000009766 sq. miles.

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# Equivalents of Measure

## VOLUME AND CAPACITY

1 cu. meter, $m^3 = 1000$ cu. decimeter, $dm^3 = 1000000$ cu. centimeters, $cm^3$.
1 liter, 1 = 10 deciliters, dl = 100 centiliters, cl = 1000 milliliters, ml = 1000 cu. centimeters, $cm^3$, or cc.
1 liter, 1 = 0.1 decaliter, dkl = 0.01 hectoliter, hl = 1 cu. decimeter, $dm^3$.

| Cubic Decimeter, $dm^3$, l | Cubic Inches, cu. in. | Cubic Feet, cu. ft. | Cubic Yards, cu. yd. | U. S. Quarts | | U. S. Gallons | | U. S. Bushels, bu. |
|---|---|---|---|---|---|---|---|---|
| | | | | Liquid, l. qt. | Dry, d. qt. | Liquid, l. gal. | Dry, d. gal. | |
| 1 | 61.0234 | 0.03531 | 0.$\frac{1}{31}$308 | 1.05668 | 0.90808 | 0.26417 | 0.22702 | 0.02838 |
| 0.01639 | 1 | 0.$\frac{1}{0}$5787 | 0.$\frac{2}{1}$2143 | 0.01732 | 0.01488 | 0.$\frac{4}{3}$4329 | 0.$\frac{3}{3}$3720 | 0.$\frac{3}{0}$4650 |
| 28.3170 | 1728 | 1 | 0.03704 | 29.9221 | 25.7140 | 7.48055 | 6.42851 | 0.80356 |
| 764.559 | 46656 | 27 | 1 | 807.896 | 694.279 | 201.974 | 173.570 | 21.6962 |
| 0.94636 | 57.75 | 0.03342 | 0.$\frac{1}{3}$1238 | 1 | 0.85937 | 0.25 | 0.21484 | 0.02686 |
| 1.10123 | 67.2006 | 0.03889 | 0.$\frac{1}{2}$1440 | 1.16365 | 1 | 0.29091 | 0.25 | 0.03125 |
| 3.78543 | 231 | 0.13368 | 0.$\frac{4}{3}$4951 | 4 | 3.43747 | 1 | 0.85937 | 0.10742 |
| 4.40492 | 268.803 | 0.15556 | 0.$\frac{5}{0}$5761 | 4.65460 | 4 | 1.16365 | 1 | 0.125 |
| 35.2393 | 2150.42 | 1.24446 | 0.04609 | 37.2368 | 32 | 9.30920 | 8 | 1 |

U. S. Dry Measure: 1 bushel = 4 pecks = 8 gallons = 32 quarts = 64 pints.
U. S. Liquid Measure: 1 gallon = 4 quarts = 8 pints = 32 gills = 128 fluid ounces.
U. S. Apoth. Measure: 1 fl. ounce, f ℥ = 8 fl. drams, f ʒ = 480 minims, m = 29.574 cu. centimeter, $cm^3$.
British Imperial gallon dry and liquid measure = 1.03202 U. S. dry gal. = 1.20091 U. S. liquid gal.
British Imperial gallon = 277.410 cu. in. = 4545.9631 $cm^3$.
Weight of water at maximum density, 4°C, 45° Lat., and sea level.
1 cu. ft. = 62.4283 lbs. av. = 28.3170 kg. 1 cu. in. = 0.57804 oz. av. = 16.3872 g.
1 gal., U. S. liquid = 8.34545 lbs. = 3.78543 kg.
1 gal., British Imperial = 10.0221 lbs. = 4.5459631 kg.

## 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. | Avoir, oz. av. | Troy, lb. t. | Avoir, lb. av. | Net, Short, 2000lbs. | Gross, Long, 2240lbs. | Metric, 1000 kg. |
| 1 | 15432.4 | 32.1507 | 35.2740 | 2.67923 | 2.20462 | 0.$\frac{1}{0}$1102 | 0.$\frac{9}{8}$9842 | 0.001 |
| 0.$\frac{6}{4}$6480 | 1 | 0.$\frac{2}{3}$2083 | 0.$\frac{2}{2}$2286 | 0.$\frac{1}{3}$1736 | 0.$\frac{1}{3}$1429 | 0.$\frac{7}{6}$7143 | 0.$\frac{6}{3}$6378 | 0.$\frac{6}{4}$6480 |
| 0.03110 | 480 | 1 | 1.09714 | 0.08333 | 0.06857 | 0.$\frac{3}{4}$3429 | 0.$\frac{3}{3}$3061 | 0.$\frac{3}{0}$3110 |
| 0.02835 | 437.5 | 0.91146 | 1 | 0.07595 | 0.06250 | 0.$\frac{3}{4}$3125 | 0.$\frac{2}{3}$2790 | 0.$\frac{2}{0}$2835 |
| 0.37324 | 5760 | 12 | 13.1657 | 1 | 0.82286 | 0.$\frac{4}{3}$4114 | 0.$\frac{3}{3}$3674 | 0.$\frac{3}{0}$3732 |
| 0.45359 | 7000 | 14.5833 | 16 | 1.21528 | 1 | 0.00050 | 0.$\frac{4}{3}$4464 | 0.$\frac{4}{3}$4536 |
| 907.185 | 14000000 | 29166.7 | 32000 | 2430.56 | 2000 | 1 | 0.89286 | 0.90719 |
| 1016.05 | 15680000 | 32666.7 | 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 g.
1 hundredweight = 1/20 long ton = 4 quarters = 8 stone = 112 lbs. = 50.8024 kg.

Notations $\frac{2}{0}$, $\frac{3}{0}$, $\frac{4}{0}$, etc., indicate that the $\frac{2}{0}$, $\frac{3}{0}$, $\frac{4}{0}$, etc., are to be replaced by 2, 3, 4, etc., ciphers.

EXAMPLE—1 grain = 0.$\frac{2}{3}$2083 = 0.002083 oz. t. 1 grain = 0.$\frac{6}{4}$6480 = 0.00006480 kg.

Printed through the courtesy of the Carnegie Steel Company.

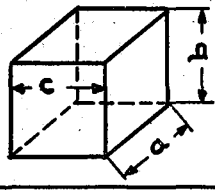
## Circumferences and Areas of Circles

| Diam. | Circum. | Area | Diam. | Circum. | Area | Diam. | Circum. | Area |
|---|---|---|---|---|---|---|---|---|
| 1/64 | .04909 | .00019 | 21 1/16 | 8.4430 | 5.6727 | 7 | 21.991 | 38.485 |
| 1/32 | .09818 | .00077 | 1/8 | 8.6394 | 5.9396 | 1/8 | 22.384 | 39.871 |
| 3/64 | .14726 | .00173 | 3/16 | 8.8357 | 6.2126 | 1/4 | 22.776 | 41.282 |
| 1/16 | .19635 | .00307 | 1/4 | 9.0321 | 6.4918 | 3/8 | 23.169 | 42.718 |
| 5/32 | .29452 | .00690 | 5/16 | 9.2284 | 6.7771 | 1/2 | 23.562 | 44.179 |
| 1/8 | .39270 | .01227 | 3 | 9.4248 | 7.0686 | 5/8 | 23.955 | 45.664 |
| 7/32 | .49087 | .01917 | 1/16 | 9.6211 | 7.3662 | 3/4 | 24.347 | 47.173 |
| 9/32 | .58905 | .02761 | 1/8 | 9.8175 | 7.6699 | 7/8 | 24.740 | 48.707 |
| 11/32 | .68722 | .03758 | 3/16 | 10.014 | 7.9798 | 8 | 25.133 | 50.265 |
| 1/4 | .78540 | .04909 | 1/4 | 10.210 | 8.2958 | 1/8 | 25.525 | 51.849 |
| 9/32 | .88357 | .06213 | 5/16 | 10.407 | 8.6179 | 1/4 | 25.918 | 53.456 |
| 5/16 | .98175 | .07670 | 3/8 | 10.603 | 8.9462 | 3/8 | 26.311 | 55.088 |
| 11/32 | 1.0799 | .09281 | 7/16 | 10.799 | 9.2806 | 1/2 | 26.704 | 56.745 |
| 3/8 | 1.1781 | .11045 | 1/2 | 10.996 | 9.6211 | 5/8 | 27.096 | 58.426 |
| 13/32 | 1.2763 | .12962 | 9/16 | 11.192 | 9.9678 | 3/4 | 27.489 | 60.132 |
| 7/16 | 1.3744 | .15033 | 5/8 | 11.388 | 10.321 | 7/8 | 27.882 | 61.862 |
| 15/32 | 1.4726 | .17257 | 11/16 | 11.585 | 10.680 | 9 | 28.274 | 63.617 |
| 1/2 | 1.5708 | .19635 | 3/4 | 11.781 | 11.045 | 1/8 | 28.667 | 65.397 |
| 17/32 | 1.6690 | .22166 | 13/16 | 11.977 | 11.416 | 1/4 | 29.060 | 67.201 |
| 9/16 | 1.7671 | .24850 | 7/8 | 12.174 | 11.793 | 3/8 | 29.452 | 69.029 |
| 19/32 | 1.8653 | .27688 | 15/16 | 12.370 | 12.177 | 1/2 | 29.845 | 70.882 |
| 5/8 | 1.9635 | .30680 | 4 | 12.566 | 12.566 | 5/8 | 30.238 | 72.760 |
| 21/32 | 2.0617 | .33824 | 1/16 | 12.763 | 12.962 | 3/4 | 30.631 | 74.662 |
| 11/16 | 2.1598 | .37122 | 1/8 | 12.959 | 13.364 | 7/8 | 31.023 | 76.589 |
| 23/32 | 2.2580 | .40574 | 3/16 | 13.155 | 13.772 | 10 | 31.416 | 78.540 |
| 3/4 | 2.3562 | .44179 | 1/4 | 13.352 | 14.186 | 1/4 | 32.201 | 82.516 |
| 25/32 | 2.4544 | .47937 | 5/16 | 13.548 | 14.607 | 1/2 | 32.987 | 86.590 |
| 13/16 | 2.5525 | .51849 | 3/8 | 13.744 | 15.033 | 3/4 | 33.772 | 90.763 |
| 27/32 | 2.6507 | .55914 | 7/16 | 13.941 | 15.466 | 11 | 34.558 | 95.033 |
| 7/8 | 2.7489 | .60132 | 1/2 | 14.137 | 15.904 | 1/4 | 35.343 | 99.402 |
| 29/32 | 2.8471 | .64504 | 9/16 | 14.334 | 16.349 | 1/2 | 36.128 | 103.87 |
| 15/16 | 2.9452 | .69029 | 5/8 | 14.530 | 16.800 | 3/4 | 36.914 | 108.43 |
| 31/32 | 3.0434 | .73708 | 11/16 | 14.726 | 17.257 | 12 | 37.699 | 113.10 |
| 1 | 3.1416 | .7854 | 3/4 | 14.923 | 17.721 | 1/4 | 38.485 | 117.86 |
| 1/16 | 3.3379 | .8866 | 13/16 | 15.119 | 18.190 | 1/2 | 39.270 | 122.72 |
| 1/8 | 3.5343 | .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 |
| 7/16 | 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 | 1/16 | 19.242 | 29.465 | 1/2 | 54.978 | 240.53 |
| 3/8 | 7.4613 | 4.4301 | 1/8 | 19.635 | 30.680 | 3/4 | 55.763 | 247.45 |
| 7/16 | 7.6576 | 4.6664 | 3/16 | 20.028 | 31.919 | 18 | 56.549 | 254.47 |
| 1/2 | 7.8540 | 4.9087 | 1/4 | 20.420 | 33.183 | 1/4 | 57.334 | 261.59 |
| 9/16 | 8.0503 | 5.1572 | 5/16 | 20.813 | 34.472 | 1/2 | 58.119 | 268.80 |
| 5/8 | 8.2467 | 5.4119 | 3/8 | 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 | 989.80 | 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 | | | |

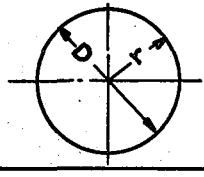
## USEFUL FORMULAE FOR ESTIMATING WEIGHTS OF CAST IRON PIPE AND PIPE FITTINGS




### PARALLELEPIPEDS

VOLUME IN CUB. INCHES = a X b X c

WEIGHT IN POUNDS = VOLUME X .26




### CIRCLE

r = RADIUS; D = DIAMETER

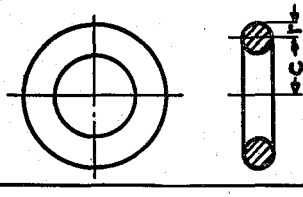
CIRCUMFERENCE = 3.14 X D

AREA = 3.14 X $r^2$

### SPHERE

AREA = 3.14 X $D^2$ VOLUME = $\frac{3.14 \times D^3}{6}$

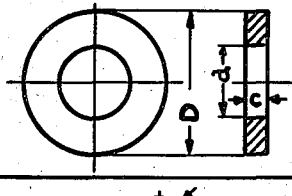
WEIGHT IN POUNDS = VOLUME X .26




### TORUS

VOLUME IN CUB. INCHES = 2 X $3.14^2$ X C X $r^2$ = 19.72 X C X $r^2$

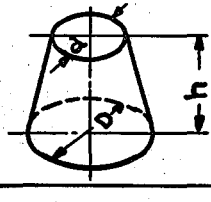
WEIGHT IN POUNDS = VOLUME X .26




### CIRCULAR RING

VOLUME IN CUB. INCHES = (AREA D — AREA d) X C

WEIGHT IN POUNDS = VOLUME X .26




### FRUSTUM OF CONE

VOLUME = $\frac{H}{3}$ X ( AREA [d] + AREA [D] + $\sqrt{\text{AREA[d] X AREA [D]}}$ )

WEIGHT IN POUNDS = VOLUME X .26

SPECIFIC GRAVITY OF IRON = 7.1

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. |
|---|---|---|
| **Ashlar Masonry** | | |
| Granite, syenite, gneiss | 2.3–3.0 | 165 |
| Limestone, marble | 2.3–2.8 | 160 |
| Sandstone, bluestone | 2.1–2.4 | 140 |
| **Mortar Rubble Masonry** | | |
| Granite, syenite, gneiss | 2.2–2.8 | 155 |
| Limestone, marble | 2.2–2.6 | 150 |
| Sandstone, bluestone | 2.0–2.2 | 130 |
| **Dry Rubble Masonry** | | |
| Granite, syenite, gneiss | 1.9–2.3 | 130 |
| Limestone, marble | 1.9–2.1 | 125 |
| Sandstone, bluestone | 1.8–1.9 | 110 |
| **Brick Masonry** | | |
| Pressed brick | 2.2–2.3 | 140 |
| Common brick | 1.8–2.0 | 120 |
| Soft brick | 1.5–1.7 | 100 |
| **Concrete Masonry** | | |
| Cement, stone, sand | 2.2–2.4 | 144 |
| Cement, slag, etc. | 1.9–2.3 | 130 |
| Cement, cinder, etc. | 1.5–1.7 | 100 |
| **Various Building Mat'l** | | |
| Ashes, cinders | | 40–45 |
| Cement, portland, loose | | 90 |
| Cement, portland, set | 2.7–3.2 | 183 |
| Lime, gypsum, loose | | 53–64 |
| Mortar, set | 1.4–1.9 | 103 |
| Slags, bank slag | | 67–72 |
| Slags, bank screenings | | 98–117 |
| Slags, machine slag | | 96 |
| Slags, slag sand | | 49–55 |
| **Earth, etc., Excavated** | | |
| Clay, dry | | 63 |
| Clay, damp, plastic | | 110 |
| Clay and gravel, dry | | 100 |
| Earth, dry, loose | | 76 |
| Earth, dry, packed | | 95 |
| Earth, moist, loose | | 78 |
| Earth, moist, packed | | 96 |
| Earth, mud, flowing | | 108 |
| Earth, mud, packed | | 115 |
| Riprap, limestone | | 80–85 |
| Riprap, sandstone | | 90 |
| Riprap, shale | | 105 |
| Sand, gravel, dry, loose | | 90–105 |
| Sand, gravel, dry, packed | | 100–120 |
| Sand, gravel, dry, wet | | 118–120 |
| **Excavations in Water** | | |
| Sand or gravel | | 60 |
| Sand or gravel and clay | | 65 |
| Clay | | 80 |
| River mud | | 90 |
| Soil | | 70 |
| Stone riprap | | 65 |

| Substance | Specific Gravity | Weight, Pounds per Cu. Ft. |
|---|---|---|
| **Minerals** | | |
| Asbestos | 2.1–2.8 | 153 |
| Barytes | 4.50 | 281 |
| Basalt | 2.7–3.2 | 184 |
| Bauxite | 2.55 | 159 |
| Borax | 1.7–1.8 | 109 |
| Chalk | 1.8–2.6 | 137 |
| Clay, marl | 1.8–2.6 | 137 |
| Dolomite | 2.9 | 181 |
| Feldspar, orthoclase | 2.5–2.6 | 159 |
| Gneiss, serpentine | 2.4–2.7 | 159 |
| Granite, syenite | 2.5–3.1 | 175 |
| Greenstone, trap | 2.8–3.2 | 187 |
| Gypsum, alabaster | 2.3–2.8 | 159 |
| Hornblende | 3.0 | 187 |
| Limestone, marble | 2.5–2.8 | 165 |
| Magnesite | 3.0 | 187 |
| Phosphate rock, apatite | 3.2 | 200 |
| Porphyry | 2.6–2.9 | 172 |
| Pumice, natural | 0.37–0.90 | 40 |
| Quartz, flint | 2.5–2.8 | 165 |
| Sandstone, bluestone | 2.2–2.5 | 147 |
| Shale, slate | 2.7–2.9 | 175 |
| Soapstone, talc | 2.6–2.8 | 169 |
| **Stone, Quarried, Piled** | | |
| Basalt, granite, gneiss | | 96 |
| Limestone, marble, quartz | | 95 |
| Sandstone | | 82 |
| Shale | | 92 |
| Greenstone, hornblende | | 107 |
| **Bituminous Substances** | | |
| Asphaltum | 1.1–1.5 | 81 |
| Coal, anthracite | 1.4–1.7 | 97 |
| Coal, bituminous | 1.2–1.5 | 84 |
| Coal, lignite | 1.1–1.4 | 78 |
| Coal, peat, turf, dry | 0.65–0.85 | 47 |
| Coal, charcoal, pine | 0.28–0.44 | 23 |
| Coal, charcoal, oak | 0.47–0.57 | 33 |
| Coal, coke | 1.0–1.4 | 75 |
| Graphite | 1.9–2.3 | 131 |
| Paraffine | 0.87–0.91 | 56 |
| Petroleum | 0.87 | 54 |
| Petroleum, refined | 0.79–0.82 | 50 |
| Petroleum, benzine | 0.73–0.75 | 46 |
| Petroleum, gasoline | 0.66–0.69 | 42 |
| Pitch | 1.07–1.15 | 69 |
| Tar, bituminous | 1.20 | 75 |
| **Coal and Coke, Piled** | | |
| Coal, anthracite | | 47–58 |
| Coal, bituminous, lignite | | 40–54 |
| Coal, peat, turf | | 20–26 |
| Coal, charcoal | | 10–14 |
| 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. |
|---|---|---|
| **Metals, Alloys, Ores** | | |
| Aluminum, cast-hammered | 2.55–2.75 | 165 |
| Aluminum, bronze | 7.7 | 481 |
| Brass, cast-rolled | 8.4–8.7 | 534 |
| Bronze, 7.9 to 14% Sn | 7.4–8.9 | 509 |
| Copper, cast-rolled | 8.8–9.0 | 556 |
| Copper, ore, pyrites | 4.1–4.3 | 262 |
| Gold, cast-hammered | 19.25–19.3 | 1205 |
| Iron, cast, pig | 7.2 | 450 |
| Iron, wrought | 7.6–7.9 | 485 |
| Iron, steel | 7.8–7.9 | 490 |
| Iron, spiegel-eisen | 7.5 | 468 |
| Iron, ferro-silicon | 6.7–7.3 | 437 |
| Iron ore, hematite | 5.2 | 325 |
| Iron ore, hematite in bank | | 160–180 |
| Iron ore, hematite, loose | | 130–160 |
| Iron ore, limonite | 3.6–4.0 | 237 |
| Iron ore, magnetite | 4.9–5.2 | 315 |
| Iron, slag | 2.5–3.0 | 172 |
| Lead | 11.37 | 710 |
| Lead ore, galena | 7.3–7.6 | 475 |
| Manganese | 7.2–8.0 | 500 |
| Manganese ore, pyrolusite | 3.7–4.6 | 259 |
| Mercury | 13.6 | 849 |
| Nickel | 8.9–9.2 | 565 |
| Nickel, monel metal | 8.8–9.0 | 556 |
| Platinum, cast-hammered | 21.1–21.5 | 1330 |
| Silver, cast-hammered | 10.4–10.6 | 656 |
| Tin, cast-hammered | 7.2–7.5 | 459 |
| Tin, ore, cassiterite | 6.4–7.0 | 418 |
| Zinc, cast-rolled | 6.9–7.2 | 440 |
| Zinc, ore, blende | 3.9–4.2 | 253 |
| **Various Solids** | | |
| Cereals, oats, bulk | | 32 |
| Cereals, barley, bulk | | 39 |
| Cereals, corn, rye, bulk | | 48 |
| Cereals, wheat, bulk | | 48 |
| Hay and Straw, bales | | 20 |
| Cotton, Flax, Hemp | 1.47–1.50 | 93 |
| Fats | 0.90–0.97 | 58 |
| Flour, loose | 0.40–0.50 | 28 |
| Flour, pressed | 0.70–0.80 | 47 |
| Glass, common | 2.40–2.60 | 156 |
| Glass, plate or crown | 2.45–2.72 | 161 |
| Glass, crystal | 2.90–3.00 | 184 |
| Leather | 0.86–1.02 | 59 |
| Paper | 0.70–1.15 | 58 |
| Potatoes, piled | | 42 |
| Rubber, caoutchouc | .092–0.96 | 59 |
| Rubber goods | 1.0–2.0 | 94 |
| Salt, granulated, piled | | 48 |
| Saltpeter | | 67 |
| Starch | 1.53 | 96 |
| Sulphur | 1.93–2.07 | 125 |
| Wool | 1.32 | 82 |

| Substance | Specific Gravity | Weight, Pounds per Cu. Ft. |
|---|---|---|
| **Timber, U. S. Seasoned** | | |
| Ash, white-red | 0.62–0.65 | 40 |
| Cedar, white-red | 0.32–0.38 | 22 |
| Chestnut | 0.66 | 41 |
| Cypress | 0.48 | 30 |
| Fir, Douglas spruce | 0.51 | 32 |
| Fir, eastern | 0.40 | 25 |
| Elm, white | 0.72 | 45 |
| Hemlock | 0.42–0.52 | 29 |
| Hickory | 0.74–0.84 | 49 |
| Locust | 0.73 | 46 |
| Maple, hard | 0.68 | 43 |
| Maple, white | 0.53 | 33 |
| Oak, chestnut | 0.86 | 54 |
| Oak, live | 0.95 | 59 |
| Oak, red, black | 0.65 | 41 |
| Oak, white | 0.74 | 46 |
| Pine, Oregon | 0.51 | 32 |
| Pine, red | 0.48 | 30 |
| Pine, white | 0 41 | 26 |
| Pine, yellow, long-leaf | 0.70 | 44 |
| Pine, yellow, short-leaf | 0.61 | 38 |
| Poplar | 0.48 | 30 |
| Redwood, California | 0.42 | 26 |
| Spruce, white, black | 0.40–0.46 | 27 |
| Walnut, black | 0.61 | 38 |
| Walnut, white | 0.41 | 26 |
| Moisture Contents: | | |
| Seasoned timber 15 to 20% | | |
| Green timber up to 50% | | |
| **Various Liquids** | | |
| Alcohol, 100% | 0.79 | 49 |
| Acids, muriatic, 40% | 1.20 | 75 |
| Acids, nitric, 91% | 1.50 | 94 |
| Acids, sulphuric, 87% | 1.80 | 112 |
| Lye, soda, 66% | 1.70 | 106 |
| Oils, vegetable | 0.91–0.94 | 58 |
| Oils, mineral, lubricants | 0.90–0.93 | 57 |
| Water, 4°C, max. denisty | 1.0 | 62.428 |
| Water, 100°C | 0.9584 | 59.830 |
| Water, ice | 0.88–0.92 | 56 |
| Water, snow, fresh fallen | .125 | 8 |
| Water, sea water | 1.02–1.03 | 64 |
| **Gases, Air = 1** | | |
| Air, 0°C, 760 mm | 1.0 | .08071 |
| Ammonia | 0.5920 | .0478 |
| Carbon dioxide | 1.5291 | .1234 |
| Carbon monoxide | 0.9673 | .0781 |
| Gas, illuminating | 0.35–0.45 | .028–.036 |
| Gas, natural | 0.47–0.48 | .038–.039 |
| Hydrogen | 0.0693 | .00559 |
| Nitrogen | 0.9714 | .0784 |
| 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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# Quantities of Material for Concrete
## Based on 3.8 Cubic Feet per Barrel of Cement (4 Sacks per Barrel), Sand and Stone Measured Loose

| Proportions by Parts | | | Quantities per Bbl. of Cement | | | Quantities of Material for 1 Yd. of Rammed Concrete | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 45% Voids Average Broken Stone | | | 40% Voids Average Gravel | | |
| Cement | Sand | Stone | Cement Bbl. | Loose Sand Cu. Ft. | Loose Stone Cu. Ft. | Cement Bbl. | Sand Cu. Yd. | Stone Cu. Yd. | Cement Bbl. | Sand Cu. Yd. | Gravel Cu. Yd. |
| 1 | 1 | 1½ | 1 | 3.8 | 5.7 | 3.08 | 0.43 | 0.65 | 2.97 | 0.42 | 0.63 |
| .. | ... | 2 | .. | ... | 7.6 | 2.73 | 0.38 | 0.77 | 2.62 | 0.37 | 0.74 |
| .. | ... | 2½ | .. | ... | 9.5 | 2.45 | 0.34 | 0.86 | 2.34 | 0.33 | 0.82 |
| .. | ... | 3 | .. | ... | 11.4 | 2.22 | 0.31 | 0.94 | 2.12 | 0.30 | 0.90 |
| 1 | 1½ | 2 | 1 | 5.7 | 7.6 | 2.40 | 0.51 | 0.68 | 2.31 | 0.49 | 0.65 |
| .. | ... | 2½ | .. | ... | 9.5 | 2.18 | 0.46 | 0.77 | 2.09 | 0.44 | 0.74 |
| .. | ... | 3 | .. | ... | 11.4 | 2.00 | 0.42 | 0.84 | 1.91 | 0.40 | 0.81 |
| .. | ... | 3½ | .. | ... | 13.3 | 1.84 | 0.39 | 0.91 | 1.76 | 0.37 | 0.87 |
| .. | ... | 4 | .. | ... | 15.2 | 1.71 | 0.36 | 0.96 | 1.63 | 0.34 | 0.92 |
| 1 | 2 | 3 | 1 | 7.6 | 11.4 | 1.81 | 0.51 | 0.76 | 1.74 | 0.49 | 0.74 |
| .. | ... | 3½ | .. | ... | 13.3 | 1.68 | 0.47 | 0.83 | 1.61 | 0.45 | 0.79 |
| .. | ... | 4 | .. | ... | 15.2 | 1.57 | 0.44 | 0.88 | 1.50 | 0.42 | 0.84 |
| .. | ... | 4½ | .. | ... | 17.1 | 1.48 | 0.42 | 0.94 | 1.41 | 0.40 | 0.89 |
| .. | ... | 5 | .. | ... | 19.0 | 1.39 | 0.39 | 0.98 | 1.32 | 0.37 | 0.93 |
| 1 | 2½ | 3½ | 1 | 9.5 | 13.3 | 1.55 | 0.55 | 0.76 | 1.49 | 0.52 | 0.73 |
| .. | ... | 4 | .. | ... | 15.2 | 1.46 | 0.51 | 0.82 | 1.40 | 0.49 | 0.79 |
| .. | ... | 4½ | .. | ... | 17.1 | 1.37 | 0.48 | 0.87 | 1.31 | 0.46 | 0.83 |
| .. | ... | 5 | .. | ... | 19.0 | 1.30 | 0.46 | 0.92 | 1.24 | 0.44 | 0.87 |
| .. | ... | 5½ | .. | ... | 20.9 | 1.23 | 0.43 | 0.95 | 1.17 | 0.41 | 0.91 |
| .. | ... | 6 | .. | ... | 22 8 | 1.17 | 0.41 | 0.99 | 1.11 | 0.39 | 0.94 |

## Quantities of Material for Concrete

### Based on 3.8 Cubic Feet per Barrel of Cement (4 Sacks per Barrel), Sand and Stone Measured Loose (continued)

| Proportions by Parts | | | Quantities per Bbl. of Cement | | | Quantities of Material for 1 Yd. of Rammed Concrete | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 45% Voids Average Broken Stone | | | 40% Voids Average Gravel | | |
| Cement | Sand | Stone | Cement Bbl. | Loose Sand Cu. Ft. | Loose Stone Cu. Ft. | Cement Bbl. | Sand Cu. Yd. | Stone Cu. Yd. | Cement Bbl. | Sand Cu. Yd. | Gravel Cu. Yd. |
| 1 | 3 | 4 | 1 | 11.4 | 15.2 | 1.36 | 0.57 | 0.77 | 1.30 | 0.55 | 0.73 |
| .. | ... | 4½ | .. | ... | 17.1 | 1.28 | 0.54 | 0.81 | 1.23 | 0.52 | 0.78 |
| .. | ... | 5 | .. | ... | 19.0 | 1.22 | 0.52 | 0.86 | 1.17 | 0.49 | 0.82 |
| .. | ... | 5½ | .. | ... | 20.9 | 1.16 | 0.49 | 0.90 | 1.11 | 0.47 | 0.86 |
| .. | ... | 6 | .. | ... | 22.8 | 1.11 | 0.47 | 0.94 | 1.05 | 0.44 | 0.89 |
| .. | ... | 6½ | .. | ... | 24.7 | 1.06 | 0.45 | 0.97 | 1.01 | 0.43 | 0.92 |
| .. | ... | 7 | .. | ... | 26.6 | 1.01 | 0.43 | 0.99 | 0.96 | 0.40 | 0.95 |
| 1 | 4 | 5 | 1 | 15.2 | 19.0 | 1.08 | 0.61 | 0.76 | 1.04 | 0.59 | 0.73 |
| .. | ... | 6 | .. | ... | 22.8 | 0.99 | 0.56 | 0.84 | 0.95 | 0.54 | 0.80 |
| .. | ... | 7 | .. | ... | 26.6 | 0.92 | 0.52 | 0.91 | 0.88 | 0.50 | 0.87 |
| .. | ... | 8 | .. | ... | 30.4 | 0.85 | 0.48 | 0.96 | 0.81 | 0.46 | 0.91 |
| .. | ... | 9 | .. | ... | 34.2 | 0.80 | 0.45 | 1.01 | 0.76 | 0.43 | 0.96 |

1 Bag of Cement..... =94 Lbs.
1 Bag of Cement..... = 1 Cu. Ft.

4 Bags of Cement..... =1 Bbl.
1 Bbl. of Cement..... =400 lb. Gross, 376 lb. Net

Printed through the courtesy of the Lehigh Portland Cement Company.

## Proportioning Concrete

| Proportions of Mixtures | | | Material for One Cubic Yard Concrete | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Gravel ¾-inch and Under | | | Stone 1-inch and Under Dust Screened Out | | | Stone 2 ½-inch and Under Dust Screened Out | | |
| Cement | Sand | Stone | Cement Bbls. | Sand Yards | Stone Yards | Cement Bbls. | Sand Yards | Stone Yards | Cement Bbls. | Sand Yards | Stone Yards |
| 1 | 2 | 3 | 1.54 | .47 | .73 | 1.70 | .52 | .77 | 1.73 | .53 | .79 |
| 1 | 2 | 4 | 1.34 | .41 | .81 | 1.46 | .44 | .89 | 1.48 | .45 | .90 |
| 1 | 2 | 5 | 1.17 | .36 | .89 | 1.27 | .39 | .97 | 1.29 | .39 | .98 |
| 1 | 2 ½ | 4 | 1.24 | .47 | .75 | 1.35 | .52 | .82 | 1.38 | .53 | .84 |
| 1 | 2 ½ | 5 | 1.10 | .42 | .83 | 1.19 | .46 | .91 | 1.21 | .46 | .92 |
| 1 | 2 ½ | 6 | .98 | .37 | .89 | 1.07 | .41 | .97 | 1.07 | .41 | .98 |
| 1 | 3 | 5 | 1.03 | .47 | .78 | 1.11 | .51 | .85 | 1.14 | .52 | .87 |
| 1 | 3 | 6 | .92 | .42 | .84 | 1.01 | .46 | .92 | 1.02 | .47 | .93 |
| 1 | 3 | 7 | .84 | .38 | .89 | .91 | .42 | .97 | .92 | .42 | .98 |
| 1 | 4 | 6 | .83 | .51 | .77 | .90 | .55 | .82 | .92 | .56 | .84 |
| 1 | 4 | 7 | .77 | .47 | .81 | .83 | .51 | .89 | .84 | .51 | .90 |
| 1 | 4 | 8 | .71 | .43 | .86 | .77 | .47 | .93 | .78 | .48 | .95 |
| 1 | 4 | 9 | .65 | .40 | .89 | .71 | .43 | .97 | .73 | .46 | 1.01 |

1 Bag of Cement..... =94 Lbs.
1 Bag of Cement..... = 1 Cu. Ft.

4 Bags of Cement..... = 1Bbl.
1 Bbl. of Cement..... =400 lb. Gross, 376 lb. Net

Printed through the courtesy of the Lehigh Portland Cement Company.

# Nominal Weight in Pounds per Foot of Cast Iron Cylinders or Pipe Without Flanges

(Based on cast iron weighing 450 lbs. per cu. ft.)

| Inside Dia. Inches | WEIGHT PER FOOT IN POUNDS<br>Thickness of Metal in Inches | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ¼ | ⅜ | ½ | ⅝ | ¾ | ⅞ | 1 | 1⅛ | 1¼ | 1⅜ | 1½ | 1⅝ | 1¾ | 1⅞ | 2 |
| 2 | 5.5 | 8.7 | 12.3 | 16.1 | 20.3 | 24.7 | 29.5 | 34.5 | 40.0 | | | | | | |
| 2½ | 6.8 | 10.6 | 14.7 | 19.2 | 24.0 | 29.0 | 34.4 | 40.0 | 46.0 | | | | | | |
| 3 | 7.9 | 12.4 | 17.2 | 22.2 | 27.6 | 32.3 | 39.3 | 45.6 | 52.2 | | | | | | |
| 3½ | 9.2 | 14.3 | 19.6 | 25.3 | 31.3 | 37.6 | 44.2 | 51.1 | 58.3 | | | | | | |
| 4 | 10.4 | 16.1 | 22.1 | 28.4 | 35.0 | 41.9 | 49.1 | 56.6 | 64.4 | 72.4 | | | | | |
| 4½ | 11.7 | 18.0 | 24.5 | 31.5 | 38.7 | 46.2 | 54.0 | 62.1 | 70.6 | 79.2 | | | | | |
| 5 | 12.9 | 19.8 | 27.0 | 34.5 | 42.3 | 50.5 | 58.9 | 67.7 | 76.7 | 85.9 | 95.6 | | | | |
| 5½ | 14.1 | 21.6 | 29.5 | 37.6 | 46.0 | 54.8 | 63.8 | 73.2 | 82.8 | 92.7 | 102.9 | | | | |
| 6 | 15.3 | 23.5 | 31.9 | 40.7 | 49.7 | 59.1 | 68.7 | 78.7 | 89.0 | 99.4 | 110.3 | 121.5 | | | |
| 7 | 17.8 | 27.2 | 36.8 | 46.8 | 57.1 | 67.7 | 78.5 | 89.7 | 101.0 | 112.9 | 125.0 | 137.4 | | | |
| 8 | 20.3 | 30.8 | 41.7 | 52.9 | 64.4 | 76.2 | 88.4 | 101.0 | 114.0 | 126.4 | 139.7 | 153.3 | 167.2 | | |
| 9 | 22.7 | 34.5 | 46.6 | 59.1 | 71.8 | 84.8 | 98.2 | 112.0 | 126.0 | 139.8 | 154.4 | 169.2 | 184.4 | | |
| 10 | 25.2 | 38.2 | 51.5 | 65.2 | 79.2 | 93.4 | 108.0 | 123.0 | 138.0 | 153.3 | 169.1 | 185.2 | 201.5 | 218.2 | |
| 11 | 27.6 | 41.9 | 56.5 | 71.3 | 86.5 | 102.0 | 118.0 | 134.0 | 150.0 | 166.8 | 183.8 | 201.1 | 218.7 | 236.6 | |
| 12 | 30.1 | 46.6 | 61.4 | 77.5 | 93.9 | 111.0 | 128.0 | 145.0 | 163.0 | 180.3 | 198.5 | 216.7 | 235.9 | 255.0 | 274.4 |
| 13 | 32.5 | 49.2 | 66.3 | 83.6 | 101.0 | 119.0 | 137.0 | 156.0 | 175.0 | 193.7 | 213.2 | 232.9 | 253.0 | 273.4 | 294.1 |
| 14 | 35.0 | 52.9 | 71.2 | 89.7 | 109.0 | 128.0 | 147.0 | 167.0 | 187.0 | 207.2 | 227.9 | 248.9 | 270.2 | 291.8 | 313.7 |
| 15 | | 56.6 | 76.1 | 95.9 | 116.0 | 136.0 | 157.0 | 178.0 | 199.0 | 220.7 | 242.6 | 264.8 | 287.3 | 310.1 | 333.3 |
| 16 | | 60.3 | 81.0 | 102.0 | 123.0 | 145.0 | 167.0 | 189.0 | 212.0 | 234.2 | 257.3 | 280.7 | 304.5 | 328.5 | 352.9 |
| 18 | | 67.7 | 90.8 | 114.0 | 138.0 | 162.0 | 187.0 | 211.0 | 236.0 | 261.1 | 286.7 | 312.6 | 338.8 | 365.3 | 392.1 |
| 20 | | | 101.0 | 127.0 | 153.0 | 179.0 | 206.0 | 233.0 | 261.0 | 288.1 | 316.1 | 344.4 | 373.1 | 402.0 | 431.3 |
| 22 | | | 110.0 | 139.0 | 168.0 | 197.0 | 226.0 | 255.0 | 285.0 | 315.0 | 345.5 | 376.3 | 407.4 | 438.8 | 470.9 |
| 24 | | | 120.0 | 151.0 | 182.0 | 214.0 | 245.0 | 278.0 | 310.0 | 342.0 | 374.9 | 408.2 | 441.7 | 475.5 | 509.7 |
| 26 | | | 130.0 | 163.0 | 197.0 | 231.0 | 265.0 | 299.0 | 334.0 | 368.9 | 404.3 | 440.0 | 476.0 | 512.3 | 548.9 |
| 28 | | | 140.0 | 175.0 | 211.0 | 248.0 | 284.0 | 321.0 | 358.0 | 395.9 | 433.7 | 471.9 | 510.3 | 549.1 | 588.1 |
| 30 | | | 149.0 | 188.0 | 226.0 | 265.0 | 304.0 | 343.0 | 383.0 | 422.9 | 463.1 | 503.7 | 544.6 | 585.8 | 627.3 |
| 32 | | | | 199.9 | 240.4 | 282.0 | 323.5 | 365.3 | 407.4 | 449.8 | 492.5 | 535.6 | 578.9 | 622.6 | 666.5 |
| 34 | | | | 212.1 | 255.5 | 299.1 | 343.1 | 387.3 | 431.9 | 476.8 | 521.9 | 567.4 | 613.2 | 659.3 | 705.7 |
| 36 | | | | 224.4 | 270.2 | 316.3 | 362.7 | 409.4 | 456.4 | 503.7 | 551.4 | 599.3 | 647.5 | 695.7 | 744.9 |
| 38 | | | | | 284.9 | 333.4 | 382.3 | 431.4 | 480.9 | 530.7 | 580.8 | 631.2 | 681.9 | 732.8 | 784.2 |
| 40 | | | | | 299.6 | 350.6 | 401.9 | 453.5 | 505.4 | 557.6 | 610.1 | 663.0 | 716.1 | 769.6 | 823.3 |
| 42 | | | | | | 367.7 | 421.5 | 475.5 | 530.0 | 584.6 | 639.4 | 694.9 | 750.4 | 806.3 | 862.6 |
| 44 | | | | | | 384.9 | 441.1 | 497.6 | 554.4 | 611.6 | 669.0 | 726.7 | 784.8 | 843.1 | 902.0 |
| 46 | | | | | | | 460.7 | 519.6 | 578.9 | 638.5 | 698.4 | 758.6 | 819.1 | 879.8 | 941.0 |
| 48 | | | | | | | 480.3 | 541.7 | 603.4 | 665.5 | 727.8 | 790.4 | 853.4 | 916.6 | 980.2 |

# Nominal Weight in Pounds per Foot of Cast Iron Cylinders or Pipe without Flanges

**Based on cast iron weighing 450 lbs. per cu. ft.**

| Inside Dia. Inches | WEIGHT PER FOOT IN POUNDS — Thickness of Metal in Inches | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 ¼ | 1 ⅜ | 1 ½ | 1 ⅝ | 1 ¾ | 1 ⅞ | 2 | 2 ⅛ | 2 ¼ | 2 ⅜ | 2 ½ | 2 ⅝ | 2 ¾ | 2 ⅞ | 3 |
| 50 | 627.9 | 692.4 | 757.2 | 822.3 | 887.7 | 953.4 | 1019.4 | 1085.7 | 1152.3 | 1219.3 | 1286.5 | 1354.0 | 1421.9 | 1490.0 | 1558.5 |
| 52 | 652.4 | 719.4 | 786.6 | 854.1 | 921.9 | 990.1 | 1058.6 | 1127.4 | 1196.4 | 1265.8 | 1335.5 | 1405.5 | 1475.8 | 1546.4 | 1617.3 |
| 54 | 676.9 | 746.3 | 816.0 | 886.0 | 956.3 | 1026.8 | 1097.8 | 1169.0 | 1240.5 | 1312.6 | 1384.7 | 1457.0 | 1529.4 | 1602.7 | 1666.7 |
| 56 | 701.5 | 773.4 | 845.4 | 917.9 | 990.6 | 1063.7 | 1137.0 | 1210.7 | 1284.7 | 1359.0 | 1433.6 | 1508.5 | 1583.7 | 1659.2 | 1735.0 |
| 58 | 725.9 | 800.2 | 874.8 | 949.7 | 1024.9 | 1100.4 | 1177.2 | 1252.3 | 1328.7 | 1405.5 | 1482.3 | 1559.7 | 1639.4 | 1715.4 | 1793.7 |
| 60 | 750.5 | 827.2 | 904.2 | 981.6 | 1059.2 | 1137.1 | 1215.4 | 1294.0 | 1372.9 | 1452.0 | 1531.5 | 1611.5 | 1691.7 | 1771.8 | 1852.7 |
| 62 | 774.9 | 854.1 | 933.6 | 1013.4 | 1093.5 | 1173.9 | 1254.6 | 1335.6 | 1417.0 | 1498.6 | 1580.5 | 1662.6 | 1745.3 | 1828.0 | 1911.3 |
| 64 | 799.5 | 881.1 | 961.5 | 1045.3 | 1127.8 | 1210.7 | 1293.8 | 1377.3 | 1461.1 | 1545.2 | 1629.5 | 1714.2 | 1799.3 | 1884.5 | 1970.3 |
| 66 | 824.0 | 908.0 | 992.4 | 1077.1 | 1162.1 | 1247.4 | 1333.1 | 1419.0 | 1505.2 | 1591.7 | 1678.6 | 1765.7 | 1853.3 | 1941.0 | 2028.9 |
| 68 | 848.5 | 935.0 | 1021.8 | 1108.9 | 1196.4 | 1284.2 | 1372.2 | 1460.6 | 1549.3 | 1638.3 | 1727.6 | 1817.2 | 1907.1 | 1997.1 | 2087.6 |
| 70 | 873.0 | 962.0 | 1051.3 | 1140.8 | 1230.7 | 1321.0 | 1411.5 | 1502.3 | 1592.4 | 1684.8 | 1776.6 | 1868.6 | 1959.0 | 2053.6 | 2146.6 |
| 72 | 897.6 | 989.0 | 1080.6 | 1175.8 | 1265.1 | 1357.7 | 1450.4 | 1543.9 | 1637.5 | 1731.4 | 1825.6 | 1920.1 | 2014.9 | 2110.0 | 2205.5 |
| 74 | 921.9 | 1015.9 | 1110.1 | 1204.5 | 1299.4 | 1394.5 | 1489.9 | 1585.6 | 1681.6 | 1778.0 | 1874.6 | 1971.5 | 2068.8 | 2166.3 | 2264.2 |
| 76 | 946.2 | 1042.7 | 1139.5 | 1236.4 | 1333.6 | 1431.2 | 1529.1 | 1627.3 | 1725.7 | 1824.5 | 1923.6 | 2023.0 | 2122.7 | 2222.7 | 2323.0 |
| 78 | 948.9 | 1069.5 | 1168.9 | 1268.3 | 1368.0 | 1468.0 | 1568.3 | 1668.9 | 1769.9 | 1871.1 | 1972.6 | 2074.5 | 2176.6 | 2279.1 | 2381.8 |
| 80 | 995.5 | 1096.9 | 1198.3 | 1300.1 | 1402.3 | 1504.7 | 1607.5 | 1710.6 | 1813.9 | 1917.6 | 2021.6 | 2125.9 | 2230.5 | 2335.4 | 2440.7 |
| 82 | 1019.9 | 1123.8 | 1227.7 | 1332.0 | 1436.6 | 1541.5 | 1646.7 | 1752.2 | 1858.1 | 1964.2 | 2070.6 | 2177.4 | 2284.4 | 2391.8 | 2499.5 |
| 84 | 1044.2 | 1150.6 | 1257.0 | 1363.7 | 1470.9 | 1578.3 | 1685.9 | 1793.9 | 1902.2 | 2010.8 | 2119.6 | 2228.8 | 2338.3 | 2448.2 | 2558.3 |
| 86 | 1068.9 | 1177.4 | 1286.3 | 1395.5 | 1505.2 | 1615.0 | 1725.1 | 1835.5 | 1946.3 | 2057.3 | 2168.7 | 2280.3 | 2392.2 | 2504.5 | 2617.1 |
| 88 | 1093.5 | 1204.6 | 1316.0 | 1427.7 | 1539.5 | 1651.8 | 1764.3 | 1877.2 | 1990.4 | 2105.8 | 2217.6 | 2328.6 | 2446.1 | 2560.9 | 2675.9 |
| 90 | 1118.2 | 1231.4 | 1345.3 | 1459.5 | 1573.7 | 1688.5 | 1803.4 | 1918.9 | 2034.5 | 2150.4 | 2266.7 | 2383.2 | 2500.1 | 2617.2 | 2734.7 |
| 92 | 1142.5 | 1258.6 | 1374.6 | 1491.3 | 1608.0 | 1724.2 | 1842.7 | 1960.5 | 2075.2 | 2197.0 | 2315.7 | 2433.6 | 2554.0 | 2673.6 | 2793.5 |
| 94 | 1166.8 | 1285.4 | 1404.0 | 1523.1 | 1642.3 | 1761.8 | 1882.0 | 2002.2 | 2122.7 | 2243.6 | 2364.7 | 2486.1 | 2607.9 | 2730.0 | 2852.3 |
| 96 | 1191.5 | 1312.5 | 1433.6 | 1555.0 | 1676.6 | 1798.9 | 1921.1 | 2043.5 | 2165.8 | 2290.1 | 2400.9 | 2529.8 | 2661.4 | 2790.8 | 2898.2 |
| 98 | 1213.8 | 1319.7 | 1449.6 | 1568.9 | 1697.9 | 1822.4 | 1946.4 | 2077.5 | 2197.8 | 2329.0 | 2449.5 | 2580.8 | 2702.4 | 2830.9 | 2956.4 |
| 100 | 1273.1 | 1347.8 | 1478.8 | 1600.2 | 1731.3 | 1868.7 | 1995.5 | 2118.7 | 2241.4 | 2374.7 | 2498.0 | 2631.8 | 2755.7 | 2890.2 | 3014.0 |

## Friction Heads for Elbows

**Heads Required to Overcome the Resistance of Ninety-Degree Circular Bends**

| Velocity in Feet per Second | Radius of Bend in Diameters of Pipe | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 0.5 | 0.75 | 1.00 | 1.25 | 1.5 | 2.0 | 3.0 | 5.0 |
| | Head, in Feet | | | | | | | |
| 1 | .016 | .005 | .002 | .002 | .001 | .001 | .001 | .001 |
| 2 | .062 | .018 | .009 | .007 | .005 | .005 | .004 | .004 |
| 3 | .140 | .041 | .020 | .015 | .012 | .011 | .010 | .009 |
| 4 | .245 | .072 | .036 | .026 | .021 | .019 | .017 | .016 |
| 5 | .388 | .113 | .056 | .041 | .033 | .029 | .027 | .025 |
| 6 | .559 | .162 | .081 | .059 | .048 | .042 | .038 | .036 |
| 7 | .761 | .221 | .110 | .080 | .066 | .057 | .052 | .050 |
| 8 | .994 | .288 | .144 | .104 | .086 | .074 | .069 | .065 |
| 9 | 1.260 | .365 | .182 | .132 | .108 | .094 | .086 | .082 |
| 10 | 1.550 | .450 | .225 | .163 | .134 | .116 | .106 | .101 |
| 12 | 2.340 | .649 | .324 | .236 | .192 | .167 | .153 | .145 |

The above table has been calculated by the well-known Weisbach formula for pipe or bends of circular cross section; i. e., round water-pipe specials.

Let R = radius of curve or bend in inches.
r = radius of section of pipe in inches.
K = coefficient of resistance.
v = velocity of flow in feet per second.
a° = angle embraced by curve or bend (a right-angle bend = 90°).
h = friction head in feet or decimal of foot.
g = acceleration due to gravity = 32.2.

Then $K = 0.131 + 1.847\left\{\frac{r}{R}\right\}^{\frac{7}{2}}$

And $h = K\frac{v^2}{2g} \times \frac{a^\circ}{180}$

Suppose a 90° bend of circular cross section, 20 inches diameter (r = 10) and 25 inches radius of curvature (= R). What friction head is developed by a velocity of flow of 2.7896 feet per second?

$$K = 0.131 + 1.847\left\{\frac{10}{25}\right\}^{\frac{7}{2}} = 0.206$$

And $$h = .206\frac{2.7896^2}{64.4} \times \frac{90}{180} = 0.01245 \text{ feet}$$

## Commercial Pipe Sizes for Fire Streams*

| Number of 1⅛-Inch Hose Nozzles | Ordinary Fire Streams | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 40 Pounds Pressure | | 50 Pounds Pressure | | 60 Pounds Pressure | | 70 Pounds Pressure | | 80 Pounds Pressure | | 90 Pounds Pressure | |
| | Required Size Pipe Ins. | Flow Cu. Ft. per Min. | Required Size Pipe Ins. | Flow Cu. Ft. per Min. | Required Size Pipe Ins. | Flow Cu. Ft. per Min. | Required Size Pipe Ins. | Flow Cu. Ft. per Min. | Required Size Pipe Ins. | Flow Cu. Ft. per Min. | Required Size Pipe Ins. | Flow Cu. Ft. per Min. |
| 1 | 4 | 20 | 6 | 23 | 6 | 25 | 6 | 27 | 6 | 29 | 6 | 30 |
| 2 | 6 | 40 | 8 | 45 | 8 | 50 | 8 | 53 | 8 | 57 | 8 | 61 |
| 3 | 8 | 61 | 8 | 68 | 10 | 74 | 10 | 80 | 10 | 86 | 10 | 91 |
| 4 | 10 | 81 | 10 | 90 | 10 | 99 | 10 | 107 | 12 | 114 | 12 | 121 |
| 5 | 10 | 101 | 12 | 113 | 12 | 124 | 12 | 134 | 12 | 143 | 12 | 152 |
| 6 | 12 | 121 | 12 | 135 | 12 | 149 | 14 | 160 | 14 | 172 | 14 | 182 |
| 7 | 12 | 141 | 14 | 158 | 14 | 174 | 14 | 187 | 14 | 200 | 16 | 212 |
| 8 | 12 | 162 | 14 | 181 | 14 | 199 | 16 | 214 | 16 | 229 | 16 | 242 |
| 9 | 14 | 182 | 14 | 203 | 16 | 223 | 16 | 241 | 16 | 257 | 18 | 273 |
| 10 | 14 | 202 | 16 | 226 | 16 | 248 | 16 | 267 | 18 | 286 | 18 | 303 |
| 11 | 16 | 222 | 16 | 248 | 18 | 273 | 18 | 294 | 18 | 314 | 18 | 333 |
| 12 | 16 | 243 | 18 | 271 | 18 | 298 | 18 | 321 | 20 | 343 | 20 | 364 |
| 13 | 16 | 263 | 18 | 293 | 18 | 323 | 20 | 348 | 20 | 372 | 20 | 394 |
| 14 | 18 | 283 | 18 | 316 | 20 | 348 | 20 | 374 | 20 | 400 | 20 | 424 |
| 15 | 18 | 303 | 20 | 339 | 20 | 372 | 20 | 401 | 20 | 429 | 24 | 455 |
| | High-Pressure Fire Streams | | | | | | | | | | | |
| | 100 Pounds Pressure | | 110 Pounds Pressure | | 120 Pounds Pressure | | 130 Pounds Pressure | | 140 Pounds Pressure | | 150 Pounds Pressure | |
| 1 | 6 | 32 | 6 | 33 | 6 | 35 | 6 | 36 | 6 | 38 | 6 | 39 |
| 2 | 8 | 64 | 8 | 67 | 10 | 70 | 10 | 73 | 10 | 75 | 10 | 78 |
| 3 | 10 | 96 | 10 | 100 | 10 | 105 | 10 | 109 | 12 | 113 | 12 | 117 |
| 4 | 12 | 128 | 12 | 134 | 12 | 140 | 12 | 145 | 12 | 151 | 14 | 156 |
| 5 | 14 | 160 | 14 | 167 | 14 | 174 | 14 | 181 | 14 | 188 | 14 | 195 |
| 6 | 14 | 191 | 14 | 200 | 14 | 209 | 16 | 218 | 16 | 226 | 16 | 234 |
| 7 | 16 | 223 | 16 | 234 | 16 | 244 | 16 | 254 | 16 | 264 | 18 | 273 |
| 8 | 16 | 255 | 16 | 267 | 18 | 279 | 18 | 290 | 18 | 301 | 18 | 313 |
| 9 | 18 | 287 | 18 | 301 | 18 | 314 | 18 | 326 | 18 | 339 | 20 | 352 |
| 10 | 18 | 319 | 18 | 334 | 20 | 349 | 20 | 363 | 20 | 377 | 20 | 391 |
| 11 | 20 | 351 | 20 | 367 | 20 | 384 | 20 | 399 | 20 | 414 | 20 | 430 |
| 12 | 20 | 383 | 20 | 401 | 20 | 419 | 20 | 435 | 24 | 452 | 24 | 469 |
| 13 | 20 | 415 | 20 | 424 | 24 | 454 | 24 | 472 | 24 | 490 | 24 | 508 |
| 14 | 24 | 447 | 24 | 467 | 24 | 488 | 24 | 508 | 24 | 528 | 24 | 547 |
| 15 | 24 | 479 | 24 | 501 | 24 | 523 | 24 | 544 | 24 | 565 | 24 | 586 |

To convert cubic feet to gallons, multiply by 7.4805.

In calculating above table, the following assumptions were made: Nozzles, 1⅛-inch smooth bore, playing simultaneously, and attached to 200 feet of best quality rubber-lined hose; pressures measured at hose connections; velocity of water in pipe approximately 3 feet per second.

*Reproduced by courtesy of N. S. Hill, Jr.

# Contents of Pipe

**Capacities in Cubic Feet and in United States Gallons (231 Cubic Inches) per Foot of Length**

| Diameter, Inches | Diameter, Feet | For 1 Foot Length | | Diameter, Inches | Diameter, Feet | For 1 Foot Length | | Diameter, Inches | Diameter, Feet | For 1 Foot Length | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Cubic Feet, Also Area in Sq. Ft. | U. S. Gals. (231 Cu. Ins.) | | | Cubic Feet, Also Area in Sq. Ft. | U. S. Gals. (231 Cu. Ins.) | | | Cubic Feet, Also Area in Sq. Ft. | U. S. Gals. (231 Cu. Ins.) |
| ¼ | .0208 | .0003 | .0026 | 6.75 | .5625 | .2485 | 1.859 | 19.0 | 1.583 | 1.969 | 14.73 |
| 5/16 | .0260 | .0005 | .0040 | 7.00 | .5833 | .2673 | 1.999 | 19.5 | 1.625 | 2.074 | 15.52 |
| ⅜ | .0313 | .0008 | .0057 | 7.25 | .6042 | .2868 | 2.144 | 20.0 | 1.666 | 2.182 | 16.32 |
| 7/16 | .0365 | .0010 | .0078 | 7.50 | .6250 | .3068 | 2.295 | 20.5 | 1.708 | 2.292 | 17.15 |
| ½ | .0417 | .0014 | .0102 | 7.75 | .6458 | .3275 | 2.450 | 21.0 | 1.750 | 2.405 | 17.99 |
| 9/16 | .0469 | .0017 | .0129 | 8.00 | .6667 | .3490 | 2.611 | 21.5 | 1.792 | 2.521 | 18.86 |
| ⅝ | .0521 | .0021 | .0159 | 8.25 | .6875 | .3713 | 2.777 | 22.0 | 1.833 | 2.640 | 19.75 |
| 11/16 | .0573 | .0026 | .0193 | 8.50 | .7083 | .3940 | 2.948 | 22.5 | 1.875 | 2.761 | 20.65 |
| ¾ | .0625 | .0031 | .0230 | 8.75 | .7292 | .4175 | 3.125 | 23.0 | 1.917 | 2.885 | 21.58 |
| 13/16 | .0677 | .0036 | .0270 | 9.00 | .7500 | .4418 | 3.305 | 23.5 | 1.958 | 3.012 | 22.53 |
| ⅞ | .0729 | .0042 | .0312 | 9.25 | .7708 | .4668 | 3.492 | 24.0 | 2.000 | 3.142 | 23.50 |
| 15/16 | .0781 | .0048 | .0359 | 9.50 | .7917 | .4923 | 3.682 | 25.0 | 2.083 | 3.409 | 25.50 |
| 1.00 | .0833 | .0055 | .0408 | 9.75 | .8125 | .5185 | 3.879 | 26.0 | 2.166 | 3.687 | 27.58 |
| 1.25 | .1042 | .0085 | .0638 | 10.00 | .8333 | .5455 | 4.081 | 27.0 | 2.250 | 3.976 | 29.74 |
| 1.50 | .1250 | .0123 | .0918 | 10.25 | .8542 | .5730 | 4.286 | 28.0 | 2.333 | 4.276 | 31.99 |
| 1.75 | .1458 | .0168 | .1250 | 10.50 | .8750 | .6013 | 4.498 | 29.0 | 2.416 | 4.587 | 34.31 |
| 2.00 | .1667 | .0218 | .1632 | 10.75 | .8958 | .6303 | 4.714 | 30.0 | 2.500 | 4.909 | 36.72 |
| 2.25 | .1875 | .0276 | .2066 | 11.00 | .9167 | .6600 | 4.937 | 31.0 | 2.583 | 5.241 | 39.21 |
| 2.50 | .2083 | .0341 | .2550 | 11.25 | .9375 | .6903 | 5.163 | 32.0 | 2.666 | 5.585 | 41.78 |
| 2.75 | .2292 | .0413 | .3085 | 11.50 | .9583 | .7213 | 5.395 | 33.0 | 2.750 | 5.940 | 44.43 |
| 3.00 | .2500 | .0491 | .3673 | 11.75 | .9792 | .7530 | 5.633 | 34.0 | 2.833 | 6.305 | 47.17 |
| 3.25 | .2708 | .0576 | .4310 | 12.00 | 1.000 | .7854 | 5.876 | 35.0 | 2.916 | 6.681 | 49.98 |
| 3.50 | .2917 | .0668 | .4998 | 12.50 | 1.042 | .8523 | 6.375 | 36.0 | 3.000 | 7.069 | 52.88 |
| 3.75 | .3125 | .0767 | .5738 | 13.00 | 1.083 | .9218 | 6.895 | 37.0 | 3.083 | 7.468 | 55.86 |
| 4.00 | .3333 | .0873 | .6528 | 13.50 | 1.125 | .9940 | 7.435 | 38.0 | 3.166 | 7.876 | 58.92 |
| 4.25 | .3542 | .0985 | .7370 | 14.00 | 1.167 | 1.069 | 7.997 | 39.0 | 3.250 | 8.296 | 62.06 |
| 4.50 | .3750 | .1105 | .8263 | 14.50 | 1.208 | 1.147 | 8.578 | 40.0 | 3.333 | 8.728 | 65.29 |
| 4.75 | .3958 | .1231 | .9205 | 15.00 | 1.250 | 1.227 | 9.180 | 41.0 | 3.416 | 9.168 | 68.58 |
| 5.00 | .4167 | .1364 | 1.020 | 15.50 | 1.292 | 1.310 | 9.801 | 42.0 | 3.500 | 9.620 | 71.96 |
| 5.25 | .4375 | .1503 | 1.124 | 16.00 | 1.333 | 1.396 | 10.44 | 43.0 | 3.583 | 10.084 | 75.43 |
| 5.50 | .4583 | .1650 | 1.234 | 16.50 | 1.375 | 1.485 | 11.11 | 44.0 | 3.666 | 10.560 | 79.00 |
| 5.75 | .4792 | .1803 | 1.349 | 17.00 | 1.417 | 1.576 | 11.79 | 45.0 | 3.750 | 11.044 | 82.62 |
| 6.00 | .5000 | .1963 | 1.469 | 17.50 | 1.458 | 1.670 | 12.50 | 46.0 | 3.833 | 11.540 | 86.32 |
| 6.25 | .5208 | .2130 | 1.594 | 18.00 | 1.500 | 1.767 | 13.22 | 47.0 | 3.916 | 12.048 | 90.12 |
| 6.50 | .5417 | .2305 | 1.724 | 18.50 | 1.542 | 1.867 | 13.97 | 48.0 | 4.000 | 12.566 | 94.02 |

1 Cubic foot of water weighs 62.35 pounds; 1 gallon (U. S.) weighs 8.335 pounds.

## Contents of Tanks and Cisterns per Foot of Depth

1 Gallon = 231 cubic inches = 1 cubic foot ÷ 7.4805 = 0.13368 cubic feet.

| Diam. Ft. In. | Area Sq. Ft. | Gals. 1 Foot Depth | Diam. Ft. In. | Area Sq. Ft. | Gals. 1 Foot Depth | Diam. Ft. In. | Area Sq. Ft. | Gals. 1 Foot Depth |
|---|---|---|---|---|---|---|---|---|
| 4— 0 | 12.57 | 94.00 | 10—3 | 82.52 | 617.26 | 20—3 | 322.06 | 2409.2 |
| 4— 1 | 13.10 | 97.96 | 10—6 | 86.59 | 647.74 | 20—6 | 330.06 | 2469.1 |
| 4— 2 | 13.64 | 102.00 | 10—9 | 90.76 | 678.95 | 20—9 | 338.16 | 2529.6 |
| 4— 3 | 14.19 | 106.12 | 11—0 | 95.03 | 710.90 | 21—0 | 346.36 | 2591.0 |
| 4— 4 | 14.75 | 110.32 | 11—3 | 99.40 | 743.58 | 21—3 | 354.66 | 2653.0 |
| 4— 5 | 15.32 | 114.61 | 11—6 | 103.87 | 776.99 | 21—6 | 363.05 | 2715.8 |
| 4— 6 | 15.90 | 118.97 | 11—9 | 108.43 | 811.14 | 21—9 | 371.54 | 2779.3 |
| 4— 7 | 16.50 | 123.42 | 12—0 | 113.10 | 846.03 | 22—0 | 380.13 | 2843.6 |
| 4— 8 | 17.10 | 127.95 | 12—3 | 117.86 | 881.65 | 22—3 | 388.82 | 2908.6 |
| 4— 9 | 17.72 | 132.56 | 12—6 | 122.72 | 918.00 | 22—6 | 397.61 | 2974.3 |
| 4—10 | 18.35 | 137.25 | 12—9 | 127.68 | 955.09 | 22—9 | 406.49 | 3040.8 |
| 4—11 | 18.99 | 142.02 | 13—0 | 132.73 | 992.91 | 23—0 | 415.48 | 3108.0 |
| 5— 0 | 19.63 | 146.88 | 13—3 | 137.89 | 1031.5 | 23—3 | 424.56 | 3175.9 |
| 5— 1 | 20.29 | 151.82 | 13—6 | 143.14 | 1070.8 | 23—6 | 433.74 | 3244.6 |
| 5— 2 | 20.97 | 156.83 | 13—9 | 148.49 | 1110.8 | 23—9 | 443.01 | 3314.0 |
| 5— 3 | 21.65 | 161.93 | 14—0 | 153.94 | 1151.5 | 24—0 | 452.39 | 3384.1 |
| 5— 4 | 22.34 | 167.12 | 14—3 | 159.48 | 1193.0 | 24—3 | 461.86 | 3455.0 |
| 5— 5 | 23.04 | 172.38 | 14—6 | 165.13 | 1235.3 | 24—6 | 471.44 | 3526.6 |
| 5— 6 | 23.76 | 177.72 | 14—9 | 170.87 | 1278.2 | 24—9 | 481.11 | 3598.9 |
| 5— 7 | 24.48 | 183.15 | 15—0 | 176.71 | 1321.9 | 25—0 | 490.87 | 3672.0 |
| 5— 8 | 25.22 | 188.66 | 15—3 | 182.65 | 1366.4 | 25—3 | 500.74 | 3745.8 |
| 5— 9 | 25.97 | 194.25 | 15—6 | 188.69 | 1411.5 | 25—6 | 510.71 | 3820.3 |
| 5—10 | 26.73 | 199.92 | 15—9 | 194.83 | 1457.4 | 25—9 | 520.77 | 3895.6 |
| 5—11 | 27.49 | 205.67 | 16—0 | 201.06 | 1504.1 | 26—0 | 530.93 | 3971.6 |
| 6— 0 | 28.27 | 211.51 | 16—3 | 207.39 | 1551.4 | 26—3 | 541.19 | 4048.4 |
| 6— 3 | 30.68 | 229.50 | 16—6 | 213.82 | 1599.5 | 26—6 | 551.55 | 4125.9 |
| 6— 6 | 33.18 | 248.23 | 16—9 | 220.35 | 1648.4 | 26—9 | 562.00 | 4204.1 |
| 6— 9 | 35.78 | 267.69 | 17—0 | 226.98 | 1697.9 | 27—0 | 572.56 | 4283.0 |
| 7— 0 | 38.48 | 287.88 | 17—3 | 233.71 | 1748.2 | 27—3 | 583.21 | 4362.7 |
| 7— 3 | 41.28 | 308.81 | 17—6 | 240.53 | 1799.3 | 27—6 | 593.96 | 4443.1 |
| 7— 6 | 44.18 | 330.48 | 17—9 | 247.45 | 1851.1 | 27—9 | 604.81 | 4524.3 |
| 7— 9 | 47.17 | 352.88 | 18—0 | 254.47 | 1903.6 | 28—0 | 615.75 | 4606.2 |
| 8— 0 | 50.27 | 376.01 | 18—3 | 261.59 | 1956.8 | 28—3 | 626.80 | 4688.8 |
| 8— 3 | 53.46 | 399.88 | 18—6 | 268.80 | 2010.8 | 28—6 | 637.94 | 4772.1 |
| 8— 6 | 56.75 | 424.48 | 18—9 | 276.12 | 2065.5 | 28—9 | 649.18 | 4856.2 |
| 8— 9 | 60.13 | 449.82 | 19—0 | 283.53 | 2120.9 | 29—0 | 660.52 | 4941.0 |
| 9— 0 | 63.62 | 475.89 | 19—3 | 291.04 | 2177.1 | 29—3 | 671.96 | 5026.6 |
| 9— 3 | 67.20 | 502.70 | 19—6 | 298.65 | 2234.0 | 29—6 | 683.49 | 5112.9 |
| 9— 6 | 70.88 | 530.24 | 19—9 | 306.35 | 2291.7 | 29—9 | 695.13 | 5199.9 |
| 9— 9 | 74.66 | 558.51 | 20—0 | 314.16 | 2350.1 | 30—0 | 706.86 | 5287.7 |
| 10— 0 | 78.54 | 587.52 | ..... | ..... | ..... | ..... | ..... | ..... |

## Relative Delivery of Water

| Nominal Diameter, Inches | Relative Flow Capacities of Full Smooth Pipe — Diameters in Inches | | | | | | | | | | | | | | | | | | Diameter Feet | Relative Flow Capacity |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 4 | 6 | 8 | 10 | 12 | 14 | 16 | 18 | 20 | 24 | 30 | 36 | 42 | 48 | 54 | 60 | 72 | 84 | | |
| 84 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 23.0 | 13.1 | 8.3 | 5.65 | 4.05 | 3.0 | 2.3 | 1.47 | 1.0 | 7.0 | 130.0 |
| 72 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 24.5 | 15.6 | 8.9 | 5.67 | 3.83 | 2.75 | 2.05 | 1.6 | 1.0 | ..... | 6.0 | 88.0 |
| 60 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 20.3 | 15.6 | 9.9 | 5.7 | 3.6 | 2.43 | 1.75 | 1.3 | 1.0 | ..... | ..... | 5.0 | 56.0 |
| 54 | ..... | ..... | ..... | ..... | ..... | ..... | 20.7 | 15.6 | 12.0 | 7.6 | 4.85 | 2.76 | 1.87 | 1.44 | 1.0 | ..... | ..... | ..... | 4.5 | 43.0 |
| 48 | ..... | ..... | ..... | ..... | ..... | 21.7 | 15.6 | 11.6 | 8.92 | 5.66 | 3.24 | 2.05 | 1.39 | 1.0 | ..... | ..... | ..... | ..... | 4.0 | 32.0 |
| 42 | ..... | ..... | ..... | ..... | 23.0 | 15.6 | 11.05 | 8.33 | 6.4 | 4.05 | 2.32 | 1.47 | 1.0 | ..... | ..... | ..... | ..... | ..... | 3.5 | 22.9 |
| 36 | ..... | ..... | ..... | 24.6 | 15.6 | 10.6 | 7.6 | 5.66 | 4.35 | 2.76 | 1.58 | 1.0 | ..... | ..... | ..... | ..... | ..... | ..... | 3.0 | 15.59 |
| 30 | ..... | ..... | 27.2 | 15.6 | 10.0 | 6.7 | 4.8 | 3.6 | 2.76 | 1.75 | 1.0 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 2.5 | 9.88 |
| 24 | ..... | 32.0 | 15.6 | 8.9 | 5.66 | 3.85 | 2.76 | 2.05 | 1.58 | 1.0 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 2.0 | 5.657 |
| 20 | 56.0 | 20.28 | 9.9 | 5.66 | 3.6 | 2.44 | 1.75 | 1.3 | 1.0 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 1.67 | 3.586 |
| 18 | 43.0 | 15.6 | 7.6 | 4.35 | 2.76 | 1.87 | 1.34 | 1.0 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 1.50 | 2.756 |
| 16 | 32.0 | 11.6 | 5.7 | 3.24 | 2.05 | 1.40 | 1.0 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 1.33 | 2.053 |
| 14 | 23.0 | 8.3 | 4.05 | 2.32 | 1.47 | 1.0 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 1.18 | 1.47 |
| 12 | 15.6 | 5.66 | 2.76 | 1.58 | 1.0 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 1.0 | 1.0 |
| 10 | 9.9 | 3.6 | 1.75 | 1.0 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 0.83 | 0.634 |
| 8 | 5.66 | 2.05 | 1.0 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 0.67 | 0.363 |
| 6 | 2.76 | 1.0 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 0.5 | 0.177 |
| 4 | 1.0 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 0.33 | 0.064 |

Right-hand column, Relative Flow Capacity, is based on arbitrary of 1.0 for 12-inch pipe.

Calculations for above table based on assumption that relative deliveries at same loss of head are to each other as $5/2$ power of the respective diameters.

Illustrative Example: How many 10-inch pipe will equal in total flow one 36-inch pipe?

Reading horizontally from 36 to intersection, table shows 24.6 10-inch pipe required—or, in practice, 25. Similarly 10 12-inch pipe = 1 30-inch pipe.

## 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 | 3.897 |
| 10 | 4.330 | 4.763 | 5.196 | 5.629 | 6.062 | 6.495 | 6.928 | 7.361 | 7.794 | 8.227 |
| 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 inch = 33.94 feet head.

# Discharge of Gas in Cubic Feet per Hour, Through Pipe of Different Diameters and Various Lengths, in Linear Yards

Pressure of Water in Inches, 1, 1.5, 2, 2.5. Specific Gravity, .400

| Length in Yards | 4-Inch Pipe | | | | 6-Inch Pipe | | | | 8-Inch Pipe | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 1.5 | 2 | 2.5 | 1 | 1.5 | 2 | 2.5 | 1 | 1.5 | 2 | 2.5 |
| 100 | 6,831 | 8,370 | 9,658 | 10,800 | 18,820 | 23,050 | 26,600 | 29,770 | 38,650 | 47,350 | 54,640 | 61,100 |
| 150 | 5,580 | 6,831 | 7,888 | 8,817 | 15,370 | 18,820 | 21,700 | 24,300 | 31,550 | 38,650 | 44,600 | 49,940 |
| 200 | 4,829 | 5,920 | 6,831 | 7,674 | 13,310 | 16,400 | 18,820 | 21,000 | 27,340 | 33,460 | 38,650 | 43,200 |
| 300 | 3,944 | 4,829 | 5,580 | 6,233 | 10,870 | 13,310 | 15,370 | 17,180 | 22,310 | 27,340 | 31,550 | 35,270 |
| 500 | 3,055 | 3,740 | 4,320 | 4,829 | 8,418 | 10,310 | 11,940 | 13,310 | 17,280 | 21,170 | 24,400 | 27,340 |
| 750 | 2,490 | 3,055 | 3,522 | 3,944 | 6,872 | 8,418 | 9,720 | 10,870 | 14,100 | 17,280 | 19,800 | 22,310 |
| 1,000 | 2,160 | 2,646 | 3,055 | 3,413 | 5,950 | 7,290 | 8,418 | 9,410 | 12,220 | 14,960 | 17,280 | 19,320 |
| 1,250 | 1,932 | 2,366 | 2,732 | 3,055 | 5,340 | 6,320 | 7,540 | 8,418 | 10,940 | 13,650 | 15,520 | 17,280 |
| 1,500 | 1,761 | 2,160 | 2,490 | 2,789 | 4,860 | 5,950 | 6,872 | 7,672 | 9,900 | 12,200 | 14,100 | 15,800 |
| 1,750 | 1,634 | 2,000 | 2,310 | 2,582 | 4,500 | 5,500 | 6,366 | 7,115 | 9,237 | 11,300 | 13,040 | 14,600 |
| 2,000 | 1,530 | 1,870 | 2,160 | 2,415 | 4,209 | 5,155 | 5,950 | 6,655 | 8,640 | 10,585 | 12,200 | 13,670 |
| | 10-Inch Pipe | | | | 12-Inch Pipe | | | | 16-Inch Pipe | | | |
| 500 | 30,100 | 37,100 | 42,600 | 47,700 | 47,600 | 58,320 | 67,200 | 75,240 | 98,000 | 120,200 | 138,240 | 154,560 |
| 750 | 24,650 | 30,190 | 34,800 | 39,000 | 38,800 | 47,600 | 55,000 | 61,470 | 79,770 | 97,740 | 113,200 | 128,020 |
| 1,000 | 21,640 | 26,150 | 30,100 | 33,750 | 33,660 | 41,200 | 47,600 | 53,240 | 69,120 | 84,670 | 98,000 | 109,260 |
| 1,500 | 17,400 | 21,300 | 24,760 | 27,560 | 27,500 | 33,600 | 38,880 | 43,515 | 56,600 | 69,120 | 79,800 | 89,230 |
| 2,000 | 15,050 | 18,500 | 21,300 | 23,850 | 23,800 | 29,250 | 33,600 | 37,620 | 49,000 | 60,100 | 69,120 | 77,280 |
| 2,500 | 13,175 | 16,136 | 18,632 | 20,880 | 21,190 | 26,100 | 30,116 | 33,631 | 43,680 | 53,540 | 61,824 | 69,120 |
| 3,000 | 12,027 | 14,561 | 17,008 | 19,016 | 19,440 | 23,800 | 27,500 | 30,740 | 39,885 | 48,870 | 56,600 | 64,000 |
| 4,000 | 10,413 | 12,756 | 14,729 | 16,468 | 16,830 | 20,600 | 23,800 | 26,620 | 34,560 | 42,340 | 49,000 | 54,630 |

# Discharge of Gas in Cubic Feet per Hour, Through Pipe of Different Diameters and Various Lengths in Linear Yards (continued)

Pressure of Water in Inches, 1, 1.5, 2, 2.5. Specific Gravity, .400

| Length in Yards | 20-Inch Pipe | | | | 24-Inch Pipe | | | | 30-Inch Pipe | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 1.5 | 2 | 2.5 | 1 | 1.5 | 2 | 2.5 | 1 | 1.5 | 2 | 2.5 |
| 500 | 170,600 | 204,600 | 241,000 | 270,000 | 271,200 | 326,000 | 375,000 | 425,800 | 468,000 | 574,000 | 664,000 | 744,200 |
| 750 | 139,600 | 170,600 | 197,600 | 222,400 | 217,200 | 271,200 | 310,000 | 344,000 | 384,000 | 468,000 | 558,900 | 607,600 |
| 1,000 | 120,744 | 147,900 | 170,600 | 191,000 | 189,200 | 233,280 | 271,200 | 301,160 | 332,000 | 406,000 | 468,000 | 526,000 |
| 1,500 | 98,800 | 120,700 | 139,600 | 155,800 | 155,000 | 190,500 | 217,200 | 245,800 | 272,070 | 332,760 | 384,140 | 457,600 |
| 2,000 | 85,300 | 102,300 | 124,500 | 135,000 | 134,600 | 163,000 | 187,600 | 212,900 | 234,000 | 287,000 | 332,000 | 372,100 |
| 2,500 | 76,500 | 93,500 | 108,000 | 120,744 | 119,000 | 145,500 | 168,000 | 194,400 | 210,000 | 257,000 | 298,000 | 332,000 |
| 3,000 | 69,800 | 85,300 | 98,800 | 110,200 | 108,600 | 135,600 | 155,000 | 172,000 | 192,000 | 234,000 | 270,000 | 303,800 |
| 4,000 | 60,370 | 73,950 | 85,300 | 95,500 | 95,350 | 116,640 | 135,600 | 150,580 | 166,000 | 203,000 | 234,000 | 263,000 |

| | 36-Inch Pipe | | | |
|---|---|---|---|---|
| 500 | 744,000 | 912,000 | 1,121,200 | 1,256,400 |
| 750 | 606,000 | 744,000 | 856,000 | 1,032,000 |
| 1,000 | 530,000 | 644,000 | 744,000 | 832,000 |
| 1,500 | 428,500 | 524,860 | 606,000 | 677,630 |
| 2,000 | 372,000 | 456,000 | 524,880 | 628,200 |
| 2,500 | 332,000 | 408,000 | 468,000 | 530,000 |
| 3,000 | 303,000 | 372,000 | 428,000 | 516,000 |
| 4,000 | 265,000 | 322,000 | 372,000 | 416,000 |

Above tables computed by Dr. Pole's formula:

$$Q = 1350\ D^2 \sqrt{\frac{H\ D}{G\ L}} \qquad D = .056 \sqrt[5]{\frac{Q^2\ G\ L}{H}}$$

in which

Q = quantity of gas, cubic feet per hour
D = diameter of pipe, inches
H = pressure by head of water in inches
L = length of pipe, linear yards
G = specific gravity of gas (taken as .400)

For other values of G, multiply quantities given in table by square root of .4 and divide by square root of new value. For lengths one-fourth those in table, discharge of gas is doubled; for lengths four times greater than table, the discharge equals one-half of quantities in table.

Four times the pressure doubles the discharge.

# Weight of Air at Different Temperatures and Pressures, in Pounds per Cubic Foot

Based on Atmospheric Pressure of 14.7 Lbs. per Square Inch

| Temp. of Air, in Degs. F. | Gauge Pressure, in Pounds | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | 5 | 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 |
| -20 | .0900 | .1205 | .1515 | .2125 | .2744 | .3360 | .3970 | .4580 | .5190 | .5800 | .6410 |
| -10 | .0882 | .1184 | .1485 | .2090 | .2685 | .3283 | .3880 | .4478 | .5076 | .5674 | .6272 |
| 0 | .0864 | .1160 | .1455 | .2040 | .2630 | .3215 | .3800 | .4385 | .4970 | .5555 | .6140 |
| 10 | .0846 | .1136 | .1425 | .1995 | .2568 | .3145 | .3720 | .4292 | .4863 | .5433 | .6006 |
| 20 | .0828 | .1112 | .1395 | .1955 | .2516 | .3071 | .3645 | .4205 | .4770 | .5330 | .5890 |
| 30 | .0811 | .1088 | .1366 | .1916 | .2465 | .3015 | .3570 | .4121 | .4672 | .5221 | .5771 |
| 40 | .0795 | .1067 | .1338 | .1876 | .2415 | .2954 | .3503 | .4038 | .4576 | .5114 | .5652 |
| 50 | .0780 | .1045 | .1310 | .1839 | .2367 | .2905 | .3432 | .3960 | .4487 | .5014 | .5541 |
| 60 | .0764 | .1025 | .1283 | .1803 | .2323 | .2840 | .3362 | .3882 | .4402 | .4927 | .5447 |
| 70 | .0750 | .1005 | .1260 | .1770 | .2280 | .2791 | .3302 | .3808 | .4316 | .4824 | .5332 |
| 80 | .0736 | .0988 | .1239 | .1738 | .2237 | .2739 | .3242 | .3738 | .4234 | .4729 | .5224 |
| 90 | .0723 | .0970 | .1218 | .1707 | .2195 | .2688 | .3182 | .3670 | .4154 | .4639 | .5122 |
| 100 | .0710 | .0954 | .1197 | .1676 | .2155 | .2638 | .3122 | .3602 | .4079 | .4555 | .5033 |
| 110 | .0698 | .0937 | .1176 | .1645 | .2115 | .2593 | .3070 | .3542 | .4011 | .4481 | .4950 |
| 120 | .0686 | .0921 | .1155 | .1618 | .2080 | .2549 | .3018 | .3481 | .3944 | .4403 | .4866 |
| 130 | .0674 | .0905 | .1135 | .1590 | .2045 | .2505 | .2966 | .3446 | .3924 | .4296 | .4770 |
| 140 | .0663 | .0889 | .1115 | .1565 | .2015 | .2465 | .2915 | .3364 | .3813 | .4262 | .4711 |
| 150 | .0652 | .0874 | .1096 | .1541 | .1985 | .2425 | .2865 | .3308 | .3751 | .4193 | .4636 |
| 175 | .0626 | .0840 | .1054 | .1482 | .1910 | .2335 | .2755 | .3181 | .3607 | .4033 | .4450 |
| 200 | .0603 | .0809 | .1014 | .1427 | .1840 | .2248 | .2655 | .3054 | .3473 | .3882 | .4291 |
| 225 | .0581 | .0779 | .0976 | .1373 | .1770 | .2163 | .2555 | .2949 | .3344 | .3738 | .4129 |
| 250 | .0560 | .0751 | .0941 | .1323 | .1705 | .2085 | .2466 | .2845 | .3223 | .3602 | .3981 |
| 275 | .0541 | .0726 | .0910 | .1278 | .1645 | .2011 | .2378 | .2745 | .3111 | .3478 | .3844 |
| 300 | .0523 | .0707 | .0881 | .1237 | .1592 | .1945 | .2300 | .2654 | .3008 | .3362 | .3716 |
| 350 | .0491 | .0658 | .0825 | .1160 | .1495 | .1828 | .2160 | .2492 | .2824 | .3156 | .3488 |
| 400 | .0463 | .0621 | .0779 | .1090 | .1405 | .1720 | .2035 | .2348 | .2661 | .2974 | .3287 |
| 450 | .0437 | .0586 | .0735 | .1033 | .1330 | .1628 | .1925 | .2220 | .2515 | .2810 | .3105 |
| 500 | .0414 | .0555 | .0696 | .0978 | .1260 | .1540 | .1820 | .2100 | .2380 | .2660 | .2940 |
| 550 | .0394 | .0528 | .0661 | .0930 | .1198 | .1464 | .1730 | .1996 | .2262 | .2528 | .2794 |
| 600 | .0376 | .0504 | .0631 | .0885 | .1140 | .1395 | .1650 | .1904 | .2158 | .2412 | .2668 |

## Properties of Aqueous Vapors

| Temperature in Degrees Fahrenheit | Weight of 1 Cubic Foot of Pure Dry Air, Pounds | Saturated Mixtures of Air and Water Vapor | | | | | |
|---|---|---|---|---|---|---|---|
| | | Elastic Force of Vapor, Inches of Mercury | Elastic Force of Air Alone, Saturated Inches of Mercury | Weight of Vapor in 1 Cubic Foot of Mixture, Pounds | Weight of Air in 1 Cubic Foot of Mixture, Pounds | Total Weight 1 Cubic Foot of Mixture, Pounds | Weight of Water Vapor Mixed with 1 Lb. of Air, Lbs. |
| 0 | .0864 | 0.044 | 29.877 | .00008 | .0862 | .0863 | .0009 |
| 12 | .0842 | 0.075 | 29.846 | .00013 | .0839 | .0841 | .0015 |
| 22 | .0824 | 0.117 | 29.804 | .00020 | .0821 | .0823 | .0024 |
| 32 | .0807 | 0.181 | 29.740 | .00030 | .0802 | .0805 | .0037 |
| 42 | .0791 | 0.267 | 29.654 | .00044 | .0784 | .0788 | .0056 |
| 52 | .0776 | 0.388 | 29.533 | .00062 | .0766 | .0772 | .0081 |
| 62 | .0761 | 0.556 | 29.365 | .00087 | .0747 | .0756 | .0117 |
| 72 | .0746 | 0.785 | 29.136 | .00121 | .0727 | .0740 | .0167 |
| 82 | .0733 | 1.092 | 28.829 | .00166 | .0706 | .0723 | .0235 |
| 92 | .0719 | 1.501 | 28.420 | .00225 | .0683 | .0706 | .0329 |
| 102 | .0707 | 2.036 | 27.885 | .00300 | .0659 | .0689 | .0456 |
| 112 | .0694 | 2.731 | 27.190 | .00396 | .0631 | .0670 | .0628 |
| 122 | .0682 | 3.621 | 26.300 | .00518 | .0600 | .0651 | .0863 |
| 132 | .0671 | 4.750 | 25.171 | .00669 | .0564 | .0631 | .1185 |
| 142 | .0660 | 6.167 | 23.754 | .00856 | .0524 | .0609 | .1635 |
| 152 | .0649 | 7.929 | 21.992 | .01085 | .0477 | .0585 | .2276 |
| 162 | .0638 | 10.097 | 19.824 | .01364 | .0423 | .0559 | .3224 |
| 172 | .0628 | 12.749 | 17.172 | .01699 | .0361 | .0530 | .4711 |
| 182 | .0618 | 15.965 | 13.956 | .02100 | .0288 | .0498 | .7280 |
| 192 | .0609 | 19.826 | 10.095 | .02575 | .0205 | .0463 | 1.2532 |
| 202 | .0600 | 24.442 | 5.479 | .03135 | .0110 | .0423 | 2.8851 |
| 212 | .0591 | 29.921 | .000 | .03792 | .0000 | .0379 | Infinite |

At atmospheric pressure, 29.921 inches of mercury or 14.6963 lbs. per sq. inch.

(From Kent's Mechanical Engineers' Pocket Book, Eighth Edition)

## Factors for Correction of Volume of Gas at Different Temperatures and Under Different Atmospheric Pressures

Volume, at 60° F. and 30.0 Inches Hg, =1.000.

| Temperature in Degrees Fahrenheit | Barometric Pressure, Inches of Mercury | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 28.6 | 28.7 | 28.8 | 28.9 | 29.0 | 29.1 | 29.2 | 29.3 |
| -30 | 1.173 | 1.177 | 1.181 | 1.186 | 1.190 | 1.194 | 1.198 | 1.202 |
| -25 | 1.160 | 1.164 | 1.168 | 1.172 | 1.176 | 1.180 | 1.184 | 1.188 |
| -20 | 1.147 | 1.151 | 1.155 | 1.159 | 1.163 | 1.166 | 1.170 | 1.175 |
| -15 | 1.134 | 1.138 | 1.142 | 1.146 | 1.150 | 1.154 | 1.158 | 1.161 |
| -10 | 1.121 | 1.125 | 1.129 | 1.133 | 1.137 | 1.141 | 1.145 | 1.149 |
| -5 | 1.109 | 1.113 | 1.117 | 1.120 | 1.124 | 1.128 | 1.132 | 1.136 |
| 0 | 1.095 | 1.099 | 1.103 | 1.107 | 1.111 | 1.114 | 1.117 | 1.122 |
| 5 | 1.083 | 1.087 | 1.090 | 1.093 | 1.098 | 1.102 | 1.105 | 1.109 |
| 10 | 1.071 | 1.075 | 1.078 | 1.082 | 1.086 | 1.090 | 1.093 | 1.097 |
| 15 | 1.059 | 1.063 | 1.066 | 1.069 | 1.074 | 1.077 | 1.081 | 1.085 |
| 20 | 1.047 | 1.051 | 1.055 | 1.058 | 1.062 | 1.065 | 1.069 | 1.073 |
| 25 | 1.035 | 1.039 | 1.043 | 1.046 | 1.050 | 1.054 | 1.057 | 1.061 |
| 30 | 1.023 | 1.027 | 1.031 | 1.034 | 1.038 | 1.042 | 1.045 | 1.049 |
| 35 | 1.012 | 1.015 | 1.018 | 1.022 | 1.026 | 1.030 | 1.033 | 1.037 |
| 40 | 1.001 | 1.004 | 1.007 | 1.011 | 1.014 | 1.018 | 1.021 | 1.025 |
| 42 | .995 | .999 | 1.003 | 1.006 | 1.010 | 1.013 | 1.017 | 1.020 |
| 44 | .991 | .994 | .998 | 1.001 | 1.004 | 1.008 | 1.012 | 1.015 |
| 46 | .986 | .990 | .993 | .997 | 1.000 | 1.004 | 1.007 | 1.011 |
| 48 | .981 | .985 | .988 | .992 | .995 | .999 | 1.002 | 1.006 |
| 50 | .977 | .980 | .984 | .987 | .990 | .994 | .997 | 1.001 |
| 52 | .972 | .975 | .979 | .982 | .986 | .989 | .992 | .996 |
| 54 | .967 | .970 | .974 | .977 | .981 | .984 | .988 | .991 |
| 56 | .962 | .966 | .969 | .973 | .976 | .979 | .982 | .986 |
| 58 | .958 | .961 | .964 | .968 | .971 | .975 | .978 | .981 |
| 60 | .953 | .956 | .959 | .963 | .966 | .969 | .973 | .976 |
| 62 | .947 | .951 | .954 | .958 | .961 | .964 | .968 | .971 |
| 64 | .943 | .946 | .949 | .953 | .956 | .959 | .963 | .966 |
| 66 | .938 | .941 | .944 | .948 | .951 | .954 | .958 | .961 |
| 68 | .932 | .936 | .939 | .942 | .946 | .949 | .952 | .956 |
| 70 | .927 | .931 | .934 | .937 | .941 | .944 | .947 | .950 |
| 72 | .922 | .925 | .929 | .932 | .935 | .939 | .942 | .945 |
| 74 | .917 | .920 | .924 | .927 | .930 | .933 | .937 | .940 |
| 76 | .912 | .915 | .918 | .921 | .925 | .928 | .931 | .935 |
| 78 | .906 | .909 | .913 | .916 | .919 | .923 | .926 | .929 |
| 80 | .901 | .904 | .907 | .910 | .914 | .917 | .920 | .923 |
| 82 | .895 | .898 | .901 | .905 | .908 | .911 | .914 | .918 |
| 84 | .889 | .893 | .896 | .899 | .903 | .906 | .909 | .912 |
| 85 | .887 | .890 | .893 | .896 | .900 | .903 | .906 | .909 |
| 90 | .872 | .875 | .878 | .881 | .885 | .888 | .892 | .895 |
| 95 | .857 | .860 | .863 | .866 | .870 | .873 | .876 | .879 |
| 100 | .840 | .843 | .846 | .850 | .853 | .856 | .859 | .862 |
| 105 | .823 | .827 | .830 | .833 | .836 | .839 | .842 | .845 |

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## Factors for Correction of Volume of Gas at Different Temperatures and Under Different Atmospheric Pressures (cont.)

Volume, at 60° F. and 30.0 Inches Hg, =1.000.

| Temperature in Degrees Fahrenheit | Barometric Pressure, Inches of Mercury. | | | | | | |
|---|---|---|---|---|---|---|---|
| | 29.4 | 29.5 | 29.6 | 29.7 | 29.8 | 29.9 | 30.0 |
| -30 | 1.206 | 1.210 | 1.214 | 1.218 | 1.222 | 1.227 | 1.231 |
| -25 | 1.192 | 1.196 | 1.200 | 1.204 | 1.208 | 1.212 | 1.217 |
| -20 | 1.179 | 1.183 | 1.187 | 1.191 | 1.195 | 1.199 | 1.203 |
| -15 | 1.165 | 1.169 | 1.173 | 1.177 | 1.181 | 1.185 | 1.189 |
| -10 | 1.152 | 1.156 | 1.160 | 1.164 | 1.166 | 1.172 | 1.176 |
| -5 | 1.140 | 1.144 | 1.148 | 1.151 | 1.155 | 1.159 | 1.163 |
| 0 | 1.126 | 1.130 | 1.133 | 1.137 | 1.141 | 1.145 | 1.149 |
| 5 | 1.113 | 1.117 | 1.120 | 1.124 | 1.128 | 1.132 | 1.136 |
| 10 | 1.101 | 1.105 | 1.108 | 1.112 | 1.116 | 1.120 | 1.123 |
| 15 | 1.088 | 1.092 | 1.096 | 1.100 | 1.103 | 1.107 | 1.111 |
| 20 | 1.076 | 1.080 | 1.084 | 1.087 | 1.091 | 1.095 | 1.099 |
| 25 | 1.065 | 1.068 | 1.072 | 1.075 | 1.079 | 1.083 | 1.086 |
| 30 | 1.053 | 1.056 | 1.060 | 1.063 | 1.067 | 1.071 | 1.074 |
| 35 | 1.041 | 1.044 | 1.048 | 1.051 | 1.055 | 1.058 | 1.062 |
| 40 | 1.028 | 1.032 | 1.036 | 1.039 | 1.043 | 1.046 | 1.050 |
| 42 | 1.024 | 1.027 | 1.031 | 1.034 | 1.038 | 1.041 | 1.045 |
| 44 | 1.019 | 1.022 | 1.026 | 1.029 | 1.033 | 1.036 | 1.040 |
| 46 | 1.014 | 1.018 | 1.021 | 1.025 | 1.028 | 1.031 | 1.035 |
| 48 | 1.009 | 1.013 | 1.016 | 1.019 | 1.023 | 1.026 | 1.030 |
| 50 | 1.004 | 1.008 | 1.011 | 1.015 | 1.018 | 1.022 | 1.025 |
| 52 | .999 | 1.003 | 1.006 | 1.010 | 1.013 | 1.017 | 1.020 |
| 54 | .995 | .998 | 1.001 | 1.005 | 1.008 | 1.012 | 1.015 |
| 56 | .990 | .993 | .996 | 1.000 | 1.003 | 1.007 | 1.010 |
| 58 | .985 | .988 | .992 | .995 | .998 | 1.002 | 1.005 |
| 60 | .980 | .983 | .986 | .990 | .993 | .997 | 1.000 |
| 62 | .975 | .978 | .981 | .985 | .988 | .991 | .995 |
| 64 | .969 | .973 | .976 | .980 | .983 | .986 | .990 |
| 66 | .964 | .968 | .971 | .974 | .978 | .981 | .985 |
| 68 | .959 | .962 | .966 | .969 | .972 | .976 | .979 |
| 70 | .954 | .957 | .960 | .964 | .967 | .970 | .974 |
| 72 | .949 | .952 | .955 | .959 | .962 | .965 | .968 |
| 74 | .943 | .947 | .950 | .953 | .957 | .960 | .963 |
| 76 | .938 | .941 | .944 | .948 | .951 | .954 | .958 |
| 78 | .932 | .936 | .939 | .942 | .946 | .949 | .952 |
| 80 | .927 | .930 | .933 | .937 | .940 | .943 | .946 |
| 82 | .921 | .924 | .927 | .931 | .934 | .937 | .941 |
| 84 | .915 | .919 | .922 | .925 | .928 | .932 | .935 |
| 85 | .913 | .916 | .919 | .922 | .926 | .929 | .932 |
| 90 | .898 | .901 | .905 | .908 | .911 | .914 | .917 |
| 95 | .882 | .885 | .889 | .892 | .895 | .898 | .901 |
| 100 | .865 | .868 | .872 | .875 | .878 | .881 | .885 |
| 105 | .848 | .851 | .855 | .858 | .861 | .864 | .867 |

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## Compound Interest Table

### Giving Value of $1 at End of Any Year, From 1 to 100

| Years | ¼% | 1% | 1¼% | 2% | 2¼% | 3% | 3¼% |
|---|---|---|---|---|---|---|---|
| 1 | 1.0050 | 1.0100 | 1.0150 | 1.0200 | 1.0250 | 1.0300 | 1.0350 |
| 2 | 1.0100 | 1.0201 | 1.0302 | 1.0404 | 1.0506 | 1.0609 | 1.0712 |
| 3 | 1.0151 | 1.0303 | 1.0457 | 1.0612 | 1.0769 | 1.0927 | 1.1087 |
| 4 | 1.0202 | 1.0406 | 1.0614 | 1.0824 | 1.1038 | 1.1255 | 1.1475 |
| 5 | 1.0253 | 1.0510 | 1.0773 | 1.1041 | 1.1314 | 1.1593 | 1.1877 |
| 6 | 1.0304 | 1.0615 | 1.0934 | 1.1262 | 1.1597 | 1.1941 | 1.2293 |
| 7 | 1.0355 | 1.0721 | 1.1098 | 1.1487 | 1.1887 | 1.2299 | 1.2723 |
| 8 | 1.0407 | 1.0829 | 1.1265 | 1.1717 | 1.2184 | 1.2668 | 1.3168 |
| 9 | 1.0459 | 1.0937 | 1.1434 | 1.1951 | 1.2489 | 1.3048 | 1.3629 |
| 10 | 1.0511 | 1.1046 | 1.1605 | 1.2190 | 1.2801 | 1.3439 | 1.4106 |
| 11 | 1.0564 | 1.1157 | 1.1779 | 1.2434 | 1.3121 | 1.3842 | 1.4600 |
| 12 | 1.0617 | 1.1268 | 1.1956 | 1.2682 | 1.3449 | 1.4258 | 1.5111 |
| 13 | 1.0670 | 1.1381 | 1.2136 | 1.2936 | 1.3785 | 1.4685 | 1.5640 |
| 14 | 1.0723 | 1.1495 | 1.2318 | 1.3195 | 1.4130 | 1.5126 | 1.6187 |
| 15 | 1.0777 | 1.1610 | 1.2502 | 1.3459 | 1.4483 | 1.5580 | 1.6753 |
| 16 | 1.0831 | 1.1726 | 1.2690 | 1.3728 | 1.4845 | 1.6047 | 1.7340 |
| 17 | 1.0885 | 1.1843 | 1.2880 | 1.4002 | 1.5216 | 1.6528 | 1.7947 |
| 18 | 1.0939 | 1.1961 | 1.3073 | 1.4282 | 1.5597 | 1.7024 | 1.8575 |
| 19 | 1.0994 | 1.2081 | 1.3270 | 1.4568 | 1.5987 | 1.7535 | 1.9225 |
| 20 | 1.1049 | 1.2202 | 1.3469 | 1.4859 | 1.6386 | 1.8061 | 1.9898 |
| 21 | 1.1104 | 1.2324 | 1.3671 | 1.5157 | 1.6796 | 1.8603 | 2.0594 |
| 22 | 1.1160 | 1.2447 | 1.3876 | 1.5460 | 1.7216 | 1.9161 | 2.1315 |
| 23 | 1.1216 | 1.2572 | 1.4084 | 1.5769 | 1.7646 | 1.9736 | 2.2061 |
| 24 | 1.1272 | 1.2697 | 1.4295 | 1.6084 | 1.8087 | 2.0328 | 2.2833 |
| 25 | 1.1328 | 1.2824 | 1.4509 | 1.6406 | 1.8539 | 2.0938 | 2.3632 |
| 26 | 1.1385 | 1.2953 | 1.4727 | 1.6734 | 1.9003 | 2.1566 | 2.4460 |
| 27 | 1.1442 | 1.3082 | 1.4948 | 1.7069 | 1.9478 | 2.2213 | 2.5316 |
| 28 | 1.1499 | 1.3213 | 1.5172 | 1.7410 | 1.9965 | 2.2879 | 2.6202 |
| 29 | 1.1556 | 1.3345 | 1.5400 | 1.7758 | 2.0464 | 2.3566 | 2.7119 |
| 30 | 1.1614 | 1.3478 | 1.5631 | 1.8114 | 2.0976 | 2.4273 | 2.8068 |
| 31 | 1.1672 | 1.3613 | 1.5865 | 1.8476 | 2.1500 | 2.5001 | 2.9050 |
| 32 | 1.1730 | 1.3749 | 1.6103 | 1.8845 | 2.2038 | 2.5751 | 3.0067 |
| 33 | 1.1789 | 1.3887 | 1.6345 | 1.9222 | 2.2589 | 2.6523 | 3.1119 |
| 34 | 1.1848 | 1.4026 | 1.6590 | 1.9607 | 2.3153 | 2.7319 | 3.2209 |
| 35 | 1.1907 | 1.4166 | 1.6839 | 1.9999 | 2.3732 | 2.8139 | 3.3336 |
| 36 | 1.1967 | 1.4308 | 1.7091 | 2.0399 | 2.4325 | 2.8983 | 3.4503 |
| 37 | 1.2027 | 1.4451 | 1.7348 | 2.0807 | 2.4933 | 2.9852 | 3.5710 |
| 38 | 1.2087 | 1.4595 | 1.7608 | 2.1223 | 2.5557 | 3.0748 | 3.6960 |
| 39 | 1.2147 | 1.4741 | 1.7872 | 2.1647 | 2.6196 | 3.1670 | 3.8254 |
| 40 | 1.2208 | 1.4889 | 1.8140 | 2.2080 | 2.6851 | 3.2620 | 3.9593 |
| 41 | 1.2269 | 1.5038 | 1.8412 | 2.2522 | 2.7522 | 3.3599 | 4.0978 |
| 42 | 1.2330 | 1.5188 | 1.8688 | 2.2972 | 2.8210 | 3.4607 | 4.2413 |
| 43 | 1.2392 | 1.5340 | 1.8969 | 2.3432 | 2.8915 | 3.5645 | 4.3897 |
| 44 | 1.2454 | 1.5493 | 1.9253 | 2.3901 | 2.9638 | 3.6715 | 4.5433 |
| 45 | 1.2516 | 1.5648 | 1.9542 | 2.4379 | 3.0379 | 3.7816 | 4.7024 |
| 46 | 1.2579 | 1.5805 | 1.9835 | 2.4866 | 3.1139 | 3.8950 | 4.8669 |
| 47 | 1.2642 | 1.5963 | 2.0133 | 2.5363 | 3.1917 | 4.0119 | 5.0373 |
| 48 | 1.2705 | 1.6122 | 2.0435 | 2.5871 | 3.2715 | 4.1323 | 5.2136 |
| 49 | 1.2768 | 1.6283 | 2.0741 | 2.6388 | 3.3533 | 4.2562 | 5.3961 |
| 50 | 1.2832 | 1.6446 | 2.1052 | 2.6916 | 3.4371 | 4.3839 | 5.5849 |

## Compound Interest Table

### Giving Value of $1 at End of Any Year, From 1 to 100

| Years | ½% | 1% | 1½% | 2% | 2½% | 3% | 3½% |
|---|---|---|---|---|---|---|---|
| 51 | 1.2896 | 1.6611 | 2.1368 | 2.7454 | 3.5230 | 4.5154 | 5.7804 |
| 52 | 1.2961 | 1.6777 | 2.1689 | 2.8003 | 3.6111 | 4.6509 | 5.9827 |
| 53 | 1.3026 | 1.6945 | 2.2014 | 2.8563 | 3.7014 | 4.7904 | 6.1921 |
| 54 | 1.3091 | 1.7114 | 2.2344 | 2.9135 | 3.7939 | 4.9341 | 6.4088 |
| 55 | 1.3156 | 1.7285 | 2.2679 | 2.9717 | 3.8888 | 5.0821 | 6.6331 |
| 56 | 1.3222 | 1.7458 | 2.3020 | 3.0312 | 3.9860 | 5.2346 | 6.8653 |
| 57 | 1.3288 | 1.7633 | 2.3365 | 3.0918 | 4.0856 | 5.3917 | 7.1056 |
| 58 | 1.3355 | 1.7809 | 2.3715 | 3.1536 | 4.1878 | 5.5534 | 7.3543 |
| 59 | 1.3421 | 1.7987 | 2.4071 | 3.2167 | 4.2925 | 5.7200 | 7.6017 |
| 60 | 1.3489 | 1.8167 | 2.4432 | 3.2810 | 4.3998 | 5.8916 | 7.8781 |
| 61 | 1.3556 | 1.8349 | 2.4799 | 3.3467 | 4.5098 | 6.0684 | 8.1538 |
| 62 | 1.3624 | 1.8532 | 2.5171 | 3.4136 | 4.6225 | 6.2504 | 8.4392 |
| 63 | 1.3692 | 1.8717 | 2.5548 | 3.4819 | 4.7381 | 6.4379 | 8.7346 |
| 64 | 1.3760 | 1.8905 | 2.5931 | 3.5515 | 4.8565 | 6.6311 | 9.0403 |
| 65 | 1.3829 | 1.9094 | 2.6320 | 3.6225 | 4.9780 | 6.8300 | 9.3567 |
| 66 | 1.3898 | 1.9285 | 2.6715 | 3.6950 | 5.1024 | 7.0349 | 9.6842 |
| 67 | 1.3968 | 1.9477 | 2.7116 | 3.7689 | 5.2300 | 7.2459 | 10.0231 |
| 68 | 1.4038 | 1.9672 | 2.7523 | 3.8443 | 5.3607 | 7.4633 | 10.3739 |
| 69 | 1.4108 | 1.9869 | 2.7936 | 3.9211 | 5.4947 | 7.6872 | 10.7370 |
| 70 | 1.4178 | 2.0068 | 2.8355 | 3.9996 | 5.6321 | 7.9178 | 11.1128 |
| 71 | 1.4249 | 2.0268 | 2.8780 | 4.0795 | 5.7729 | 8.1554 | 11.5018 |
| 72 | 1.4320 | 2.0471 | 2.9212 | 4.1611 | 5.9172 | 8.4000 | 11.9043 |
| 73 | 1.4392 | 2.0676 | 2.9650 | 4.2444 | 6.0652 | 8.6520 | 12.3210 |
| 74 | 1.4464 | 2.0882 | 3.0094 | 4.3293 | 6.2168 | 8.9116 | 12.7522 |
| 75 | 1.4536 | 2.1091 | 3.0546 | 4.4158 | 6.3722 | 9.1789 | 13.1986 |
| 76 | 1.4609 | 2.1302 | 3.1004 | 4.5042 | 6.5315 | 9.4543 | 13.6605 |
| 77 | 1.4682 | 2.1515 | 3.1469 | 4.5942 | 6.6948 | 9.7379 | 14.1386 |
| 78 | 1.4755 | 2.1730 | 3.1941 | 4.6861 | 6.8622 | 10.0301 | 14.6335 |
| 79 | 1.4829 | 2.1948 | 3.2420 | 4.7798 | 7.0337 | 10.3310 | 15.1456 |
| 80 | 1.4903 | 2.2167 | 3.2907 | 4.8754 | 7.2096 | 10.6409 | 15.6757 |
| 81 | 1.4978 | 2.2389 | 3.3400 | 4.9729 | 7.3898 | 10.9601 | 16.2244 |
| 82 | 1.5053 | 2.2613 | 3.3901 | 5.0724 | 7.5746 | 11.2889 | 16.7922 |
| 83 | 1.5128 | 2.2839 | 3.4410 | 5.1739 | 7.7639 | 11.6276 | 17.3800 |
| 84 | 1.5204 | 2.3067 | 3.4926 | 5.2773 | 7.9580 | 11.9764 | 17.9883 |
| 85 | 1.5280 | 2.3298 | 3.5450 | 5.3829 | 8.1570 | 12.3357 | 18.6179 |
| 86 | 1.5356 | 2.3531 | 3.5982 | 5.4905 | 8.3609 | 12.7058 | 19.2695 |
| 87 | 1.5433 | 2.3766 | 3.6521 | 5.6003 | 8.5699 | 13.0870 | 19.9439 |
| 88 | 1.5510 | 2.4004 | 3.7069 | 5.7124 | 8.7842 | 13.4796 | 20.6420 |
| 89 | 1.5588 | 2.4244 | 3.7625 | 5.8266 | 9.0038 | 13.8839 | 21.3644 |
| 90 | 1.5666 | 2.4486 | 3.8189 | 5.9431 | 9.2289 | 14.3005 | 22.1122 |
| 91 | 1.5744 | 2.4731 | 3.8762 | 6.0620 | 9.4596 | 14.7295 | 22.8861 |
| 92 | 1.5823 | 2.4979 | 3.9344 | 6.1832 | 9.6961 | 15.1714 | 23.6871 |
| 93 | 1.5902 | 2.5228 | 3.9934 | 6.3069 | 9.9385 | 15.6265 | 24.5162 |
| 94 | 1.5981 | 2.5481 | 4.0533 | 6.4330 | 10.1869 | 16.0953 | 25.3742 |
| 95 | 1.6061 | 2.5735 | 4.1141 | 6.5617 | 10.4416 | 16.5782 | 26.2623 |
| 96 | 1.6141 | 2.5993 | 4.1758 | 6.6929 | 10.7026 | 17.0755 | 27.1815 |
| 97 | 1.6222 | 2.6253 | 4.2384 | 6.8268 | 10.9702 | 17.5878 | 28.1329 |
| 98 | 1.6303 | 2.6515 | 4.3020 | 6.9633 | 11.2445 | 18.1154 | 29.1175 |
| 99 | 1.6385 | 2.6780 | 4.3665 | 7.1026 | 11.5256 | 18.6589 | 30.1366 |
| 100 | 1.6467 | 2.7048 | 4.4320 | 7.2446 | 11.8137 | 19.2186 | 31.1914 |

## Compound Interest Table

### Giving Value of $1 at End of Any Year, From 1 to 100

| Years | 4% | 4½% | 5% | 5½% | 6% | 6½% | 7% |
|---|---|---|---|---|---|---|---|
| 1 | 1.0400 | 1.0450 | 1.0500 | 1.0550 | 1.0600 | 1.0650 | 1.0700 |
| 2 | 1.0816 | 1.0920 | 1.1025 | 1.1130 | 1.1236 | 1.1342 | 1.1449 |
| 3 | 1.1249 | 1.1412 | 1.1576 | 1.1742 | 1.1910 | 1.2079 | 1.2250 |
| 4 | 1.1699 | 1.1925 | 1.2155 | 1.2388 | 1.2625 | 1.2865 | 1.3108 |
| 5 | 1.2167 | 1.2462 | 1.2763 | 1.3070 | 1.3382 | 1.3701 | 1.4026 |
| 6 | 1.2653 | 1.3023 | 1.3401 | 1.3788 | 1.4185 | 1.4591 | 1.5007 |
| 7 | 1.3159 | 1.3609 | 1.4071 | 1.4547 | 1.5036 | 1.5540 | 1.6058 |
| 8 | 1.3686 | 1.4221 | 1.4775 | 1.5347 | 1.5938 | 1.6550 | 1.7182 |
| 9 | 1.4233 | 1.4861 | 1.5513 | 1.6191 | 1.6895 | 1.7626 | 1.8385 |
| 10 | 1.4802 | 1.5530 | 1.6289 | 1.7081 | 1.7908 | 1.8771 | 1.9672 |
| 11 | 1.5395 | 1.6229 | 1.7103 | 1.8021 | 1.8983 | 1.9992 | 2.1049 |
| 12 | 1.6010 | 1.6959 | 1.7959 | 1.9012 | 2.0122 | 2.1291 | 2.2522 |
| 13 | 1.6651 | 1.7722 | 1.8856 | 2.0058 | 2.1329 | 2.2675 | 2.4098 |
| 14 | 1.7317 | 1.8519 | 1.9799 | 2.1161 | 2.2609 | 2.4149 | 2.5785 |
| 15 | 1.8009 | 1.9353 | 2.0789 | 2.2325 | 2.3966 | 2.5718 | 2.7590 |
| 16 | 1.8730 | 2.0224 | 2.1829 | 2.3553 | 2.5404 | 2.7390 | 2.9522 |
| 17 | 1.9479 | 2.1134 | 2.2920 | 2.4848 | 2.6928 | 2.9170 | 3.1588 |
| 18 | 2.0258 | 2.2085 | 2.4066 | 2.6215 | 2.8543 | 3.1067 | 3.3799 |
| 19 | 2.1068 | 2.3079 | 2.5270 | 2.7656 | 3.0256 | 3.3086 | 3.6165 |
| 20 | 2.1911 | 2.4117 | 2.6533 | 2.9178 | 3.2071 | 3.5236 | 3.8697 |
| 21 | 2.2788 | 2.5202 | 2.7860 | 3.0782 | 3.3996 | 3.7527 | 4.1406 |
| 22 | 2.3699 | 2.6337 | 2.9253 | 3.2475 | 3.6035 | 3.9966 | 4.4304 |
| 23 | 2.4647 | 2.7522 | 3.0715 | 3.4262 | 3.8197 | 4.2564 | 4.7405 |
| 24 | 2.5633 | 2.8760 | 3.2251 | 3.6146 | 4.0489 | 4.5331 | 5.0724 |
| 25 | 2.6658 | 3.0054 | 3.3864 | 3.8134 | 4.2919 | 4.8277 | 5.4274 |
| 26 | 2.7725 | 3.1407 | 3.5557 | 4.0231 | 4.5494 | 5.1415 | 5.8074 |
| 27 | 2.8834 | 3.2820 | 3.7335 | 4.2444 | 4.8223 | 5.4757 | 6.2139 |
| 28 | 2.9987 | 3.4297 | 3.9201 | 4.4778 | 5.1117 | 5.8316 | 6.6488 |
| 29 | 3.1187 | 3.5840 | 4.1161 | 4.7241 | 5.4184 | 6.2107 | 7.1143 |
| 30 | 3.2434 | 3.7453 | 4.3219 | 4.9840 | 5.7435 | 6.6144 | 7.6123 |
| 31 | 3.3731 | 3.9139 | 4.5380 | 5.2581 | 6.0881 | 7.0443 | 8.1451 |
| 32 | 3.5081 | 4.0900 | 4.7649 | 5.5473 | 6.4534 | 7.5022 | 8.7153 |
| 33 | 3.6484 | 4.2740 | 5.0032 | 5.8524 | 6.8406 | 7.9898 | 9.3253 |
| 34 | 3.7943 | 4.4664 | 5.2533 | 6.1742 | 7.2510 | 8.5092 | 9.9781 |
| 35 | 3.9461 | 4.6673 | 5.5160 | 6.5138 | 7.6861 | 9.0623 | 10.6766 |
| 36 | 4.1039 | 4.8774 | 5.7918 | 6.8721 | 8.1473 | 9.6513 | 11.4239 |
| 37 | 4.2681 | 5.0969 | 6.0814 | 7.2501 | 8.6361 | 10.2786 | 12.2236 |
| 38 | 4.4388 | 5.3262 | 6.3855 | 7.6488 | 9.1543 | 10.9467 | 13.0793 |
| 39 | 4.6164 | 5.5659 | 6.7048 | 8.0695 | 9.7035 | 11.6583 | 13.9948 |
| 40 | 4.8010 | 5.8164 | 7.0400 | 8.5133 | 10.2857 | 12.4161 | 14.9745 |
| 41 | 4.9931 | 6.0781 | 7.3920 | 8.9815 | 10.9029 | 13.2231 | 16.0227 |
| 42 | 5.1928 | 6.3516 | 7.7616 | 9.4755 | 11.5570 | 14.0826 | 17.1443 |
| 43 | 5.4005 | 6.6374 | 8.1497 | 9.9967 | 12.2505 | 14.9980 | 18.3444 |
| 44 | 5.6165 | 6.9361 | 8.5572 | 10.5465 | 12.9855 | 15.9729 | 19.6285 |
| 45 | 5.8412 | 7.2482 | 8.9850 | 11.1266 | 13.7646 | 17.0111 | 21.0025 |
| 46 | 6.0748 | 7.5744 | 9.4343 | 11.7385 | 14.5905 | 18.1168 | 22.4726 |
| 47 | 6.3178 | 7.9153 | 9.9060 | 12.3841 | 15.4659 | 19.2944 | 24.0457 |
| 48 | 6.5705 | 8.2715 | 10.4013 | 13.0653 | 16.3939 | 20.5485 | 25.7289 |
| 49 | 6.8333 | 8.6437 | 10.9213 | 13.7838 | 17.3775 | 21.8842 | 27.5299 |
| 50 | 7.1067 | 9.0326 | 11.4674 | 14.5420 | 18.4202 | 23.3067 | 29.4570 |

## Compound Interest Table

### Giving Value of $1 at End of Any Year, From 1 to 100

| Years | 4% | 4½% | 5% | 5½% | 6% | 6½% | 7% |
|---|---|---|---|---|---|---|---|
| 51 | 7.3910 | 9.4391 | 12.0408 | 15.3418 | 19.5254 | 24.8216 | 31.5190 |
| 52 | 7.6866 | 9.8639 | 12.6428 | 16.1856 | 20.6969 | 26.4350 | 33.7253 |
| 53 | 7.9941 | 10.3077 | 13.2749 | 17.0758 | 21.9387 | 28.1533 | 36.0861 |
| 54 | 8.3138 | 10.7716 | 13.9387 | 18.0149 | 23.2550 | 29.9833 | 38.6122 |
| 55 | 8.6464 | 11.2563 | 14.6356 | 19.0058 | 24.6503 | 31.9322 | 41.3150 |
| 56 | 8.9922 | 11.7628 | 15.3674 | 20.0511 | 26.1293 | 34.0078 | 44.2071 |
| 57 | 9.3519 | 12.2922 | 16.1358 | 21.1539 | 27.6971 | 36.2183 | 47.3015 |
| 58 | 9.7260 | 12.8455 | 16.9426 | 22.3174 | 29.3589 | 38.5725 | 50.6127 |
| 59 | 10.1150 | 13.4234 | 17.7897 | 23.5448 | 31.1205 | 41.0797 | 54.1555 |
| 60 | 10.5196 | 14.0274 | 18.6792 | 24.8398 | 32.9877 | 43.7498 | 57.9464 |
| 61 | 10.9404 | 14.6586 | 19.6131 | 26.2060 | 34.9670 | 46.5936 | 62.0027 |
| 62 | 11.3780 | 15.3183 | 20.5938 | 27.6473 | 37.0650 | 49.6222 | 66.3429 |
| 63 | 11.8332 | 16.0076 | 21.6235 | 29.1679 | 39.2889 | 52.8476 | 70.9869 |
| 64 | 12.3065 | 16.7279 | 22.7047 | 30.7721 | 41.6462 | 56.2827 | 75.9559 |
| 65 | 12.7987 | 17.4807 | 23.8399 | 32.4646 | 44.1450 | 59.9411 | 81.2729 |
| 66 | 13.3107 | 18.2673 | 25.0319 | 34.2501 | 46.7937 | 63.8372 | 86.9620 |
| 67 | 13.8431 | 19.0894 | 26.2835 | 36.1339 | 49.6013 | 67.9867 | 93.0493 |
| 68 | 14.3968 | 19.9484 | 27.5977 | 38.1213 | 52.5774 | 72.4058 | 99.5627 |
| 69 | 14.9727 | 20.8461 | 28.9775 | 40.2179 | 55.7320 | 77.1122 | 106.5321 |
| 70 | 15.5716 | 21.7841 | 30.4264 | 42.4299 | 59.0759 | 82.1245 | 113.9894 |
| 71 | 16.1945 | 22.7644 | 31.9477 | 44.7636 | 62.6205 | 87.4626 | 121.9686 |
| 72 | 16.8423 | 23.7888 | 33.5451 | 47.2256 | 66.3777 | 93.1476 | 130.5065 |
| 73 | 17.5160 | 24.8593 | 35.2224 | 49.8230 | 70.3604 | 99.2022 | 139.6419 |
| 74 | 18.2166 | 25.9780 | 36.9835 | 52.5632 | 74.5820 | 105.6504 | 149.4168 |
| 75 | 18.9453 | 27.1470 | 38.8327 | 55.4542 | 79.0569 | 112.5176 | 159.8760 |
| 76 | 19.7031 | 28.3686 | 40.7743 | 58.5042 | 83.8003 | 119.8313 | 171.0673 |
| 77 | 20.4912 | 29.6452 | 42.8130 | 61.7219 | 88.8284 | 127.6203 | 183.0421 |
| 78 | 21.3108 | 30.9792 | 44.9537 | 65.1166 | 94.1581 | 135.9156 | 195.8550 |
| 79 | 22.1633 | 32.3733 | 47.2014 | 68.6980 | 99.8075 | 144.7501 | 209.5648 |
| 80 | 23.0498 | 33.8301 | 49.5614 | 72.4764 | 105.7960 | 154.1589 | 224.2344 |
| 81 | 23.9718 | 35.3525 | 52.0395 | 76.4626 | 112.1438 | 164.1792 | 239.9308 |
| 82 | 24.9307 | 36.9433 | 54.6415 | 80.6681 | 118.8724 | 174.8509 | 256.7260 |
| 83 | 25.9279 | 38.6058 | 57.3736 | 85.1048 | 126.0047 | 186.2162 | 274.6968 |
| 84 | 26.9650 | 40.3430 | 60.2422 | 89.7856 | 133.5650 | 198.3202 | 293.9255 |
| 85 | 28.0436 | 42.1585 | 63.2544 | 94.7238 | 141.5789 | 211.2111 | 314.5003 |
| 86 | 29.1653 | 44.0556 | 66.4171 | 99.9336 | 150.0736 | 224.9398 | 336.5154 |
| 87 | 30.3320 | 46.0381 | 69.7379 | 105.4299 | 159.0781 | 239.5609 | 360.0714 |
| 88 | 31.5452 | 48.1098 | 73.2248 | 111.2286 | 168.6227 | 255.1323 | 385.2764 |
| 89 | 32.8071 | 50.2747 | 76.8861 | 117.3462 | 178.7401 | 271.7159 | 412.2458 |
| 90 | 34.1193 | 52.5371 | 80.7304 | 123.8002 | 189.4645 | 289.3775 | 441.1030 |
| 91 | 35.4841 | 54.9013 | 84.7669 | 130.6092 | 200.8324 | 308.1870 | 471.9802 |
| 92 | 36.9035 | 57.3718 | 89.0052 | 137.7927 | 212.8823 | 328.2191 | 505.0188 |
| 93 | 38.3796 | 59.9536 | 93.4555 | 145.3713 | 225.6553 | 349.5534 | 540.3701 |
| 94 | 39.9148 | 62.6515 | 98.1283 | 153.3667 | 239.1946 | 372.2744 | 578.1960 |
| 95 | 41.5114 | 65.4708 | 103.0347 | 161.8019 | 253.5463 | 396.4722 | 618.6697 |
| 96 | 43.1718 | 68.4170 | 108.1864 | 170.7010 | 268.7590 | 422.2429 | 661.9766 |
| 97 | 44.8987 | 71.4957 | 113.5957 | 180.0896 | 284.8846 | 449.6887 | 708.3150 |
| 98 | 46.6947 | 74.7130 | 119.2755 | 189.9945 | 301.9776 | 478.9184 | 757.8970 |
| 99 | 48.5625 | 78.0751 | 125.2393 | 200.4442 | 320.0963 | 510.0481 | 810.9498 |
| 100 | 50.5049 | 81.5885 | 131.5013 | 211.4686 | 339.3021 | 543.2013 | 867.7163 |

## 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% |
|---|---|---|---|---|
| 5 | 4,645.88 | 4,579.60 | 4,514.92 | 4,451.68 |
| 10 | 8,752.17 | 8,530.13 | 8,316.45 | 8,110.74 |
| 15 | 12,381.41 | 11,937.80 | 11,517.23 | 11,118.06 |
| 20 | 15,589.215 | 14,877.27 | 14,212.12 | 13,590.21 |
| 25 | 18,424.67 | 17,413.01 | 16,481.28 | 15,621.93 |
| 30 | 20,930.59 | 19,600.21 | 18,391.85 | 17,291.86 |
| 35 | 23,145.31 | 21,487.04 | 20,000.43 | 18,664.37 |
| 40 | 25,103.53 | 23,114.36 | 21,354.83 | 19,792.65 |
| 45 | 26,833.15 | 24,518.49 | 22,495.23 | 20,719.89 |
| 50 | 28,362.48 | 25,729.58 | 23,455.21 | 21,482.08 |
| 70 | 32,897.85 | 29,123.36 | 26,000.65 | 23,394.57 |
| 100 | 36,614.21 | 31,598.81 | 27,655.36 | 24,504.96 |

| Years | 4½% | 5% | 5½% | 6% |
|---|---|---|---|---|
| 5 | 4,389.91 | 4,329.45 | 4,268.09 | 4,212.40 |
| 10 | 7,912.67 | 7,721.73 | 7,537.54 | 7,360.19 |
| 15 | 10,739.42 | 10,379.53 | 10,037.48 | 9,712.30 |
| 20 | 13,007.88 | 12,462.13 | 11,950.26 | 11,469.96 |
| 25 | 14,828.12 | 14,093.86 | 13,413.82 | 12,783.38 |
| 30 | 16,288.77 | 15,372.36 | 14,533.63 | 13,764.85 |
| 35 | 17,460.89 | 16,374.36 | 15,390.48 | 14,488.65 |
| 40 | 18,401.49 | 17,159.01 | 16,044.92 | 15,046.31 |
| 45 | 19,156.24 | 17,773.99 | 16,547.65 | 15,455.85 |
| 50 | 19,761.93 | 18,255.86 | 16,931.97 | 15,761.87 |
| 70 | 21,202.16 | 19,342.74 | 17,752.90 | 16,384.51 |
| 100 | 21,949.21 | 19,847.90 | 18,095.83 | 16,612.64 |

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