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PLUMBING PRACTICE
and **DESIGN**

**PLUMBING PRACTICE
AND DESIGN**

VOLUME I. 308 pages; 6 × 9¹/₄; cloth.

VOLUME II. 329 pages, 6 × 9¹/₄; cloth.

PLUMBING PRACTICE
and DESIGN

Volume I

By
Svend Plum

NEW YORK • JOHN WILEY & SONS, INC.

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PREFACE

Plumbing, an ancient and useful craft, has had difficulty finding its proper place in a modern world of engineering technique. Treated as a stepchild, it has not been properly acknowledged by any particular group, whether architects or mechanical, sanitary, and civil engineers.

Good plumbing actually combines the sciences and arts of all these groups. Consequently, the technical data concerning plumbing are scattered among them and among the plumbers and the manufacturers, and have been interpreted by all in their particular language and for their individual benefit.

Every home, apartment, office building, institution, or work shop receives daily supplies for the sake of general conveniences and for the maintenance of food and sanitary services. To furnish these services, to handle them efficiently within the building, and to dispose of the wastes and refuse can be classified as the problem of domestic sanitation.

Plumbing is, more specifically, the domestic services which depend on supply and disposal through a system of pipes. In its more extensive phase as a pipe craft it includes, besides water piping and drains, various other systems, as piping for gas, air, etc.

This book is an attempt to consolidate the scattered data on the subject and to present them in a uniform terminology. Where data were available, no attempt has been made to alter their presentation. In many cases, however, for the sake of proper sequence and uniformity, it has been necessary to modify the information and fill in missing parts with new text.

I have tried to make this book, in so far as it is a handbook, usable for solving the many problems in design of plumbing systems. Certain practical limits, however, have to be adopted in all such work. A number of illustrative examples can be worked out, and yet only a small fraction of the possible cases can be analyzed. Rather than encourage the growth of any class of "handbook experts" or "catalog engineers," the users of this book are urged to adopt a spirit of intellectual pioneering by becoming interested in the underlying principles which govern the design and then, with this handbook as a guide, to use their own ingenuity in working out their ideas.

Even at this date plumbing practice and design can by no means be said to be an established and generally recognized set of rules. While much research has been done, we still cling to old notions. The old methods are often unscientific, and the new theories unfortunately are very often impractical. To bring these two extremes together is not an easy task, and I do not even pretend to have accomplished it. This book is only a wholehearted attempt to do so.

I found that to make this book complete in all details and to elaborate on all the necessary subjects would make it too large for convenient use. Specifications are included only where they aid in describing the particular mode of installation. Without a description of materials to be used and the methods of construction a good design may become nullified. The size of the book, however, placed limitations on this phase of the work. Because the specifications are not extensive, and also to overcome the difficulty in discussing work which is filled with an excess of terms overlapping each other or duplicating themselves, I have given a great number of definitions. The definitions also take the place of more extensive text on borderline subjects.

I am especially indebted to two men who initiated me into the mysteries of plumbing: Major Carl Richard Stephany of the firm of Gordon and Kaelber in Rochester, N. Y., and the late Oscar J. Miller, plumbing contractor's superintendent.

I also have a definite obligation to the many persons who assisted in the work on this book and in particular to the ones who have furnished text matter. The following have either written part of the text or assisted in writing or editing it: Richard T. Barnes, Jr., and John F. Mason, Jr., members of the Technical Service Group of the Development and Research Division of the International Nickel Company, who prepared the text for Chapter 1; Louis Shnidman, A.B., M.S., laboratory director of the Rochester Gas and Electric Corporation, Rochester, N. Y.; Mr. A. W. Loomis, engineer of Ingersoll-Rand Company, who assisted in the preparation of Chapters 6 and 8; and Mr. Robert S. Moulton, technical secretary of the National Fire Protection Association, who assisted with Chapter 7.

November 1, 1942

SVEND PLUM

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CHAPTER 1

CORROSION

ART. 1-A. CAUSES OF CORROSION

Types of Corrosion

Chemical or Normal Corrosion. Corrosion is a complex phenomenon which may take in one or more of several factors. It is most commonly understood today that the fundamental corrosion reaction is electrochemical in nature. By this is meant that both chemical and electrical changes are included in the corrosion reaction.

The fundamental corrosion reaction necessitates a transfer of electrons (or ions) in which some positively charged ions in the corroding solution—which are hydrogen ions usually—lose electrical charges to the metal or alloy which is going into solution or being corroded. The complete corrosion reaction then is divided into an anodic and cathodic portion, occurring simultaneously at separate points on the metal or alloy surface. The anodic reaction, which may be direct oxidation, represents an acquisition of charges by the corroding solution; whereas the cathodic reaction, which is a direct reduction, represents a loss of charges by the hydrogen ions which are being discharged from the solution. This flow of electricity between the anodic and cathodic areas may originate from local cells set up either on a single metal surface or between dissimilar metals. An electric current applied either by accident or by design may produce the same results.

Concentration-Cell Corrosion. The electrical effects caused by differences in the composition of the solution in contact with a single metal or alloy at different points will promote an accelerated form of corrosion known as concentration-cell corrosion. The differences in composition of a solution which may give rise to such effects may come from variations in the concentration of dissolved metal ions or dissolved oxygen. The first of these types will be called a metal ion concentration cell and the second an oxygen concentration cell. A metal ion concentration cell may be set up when a section of metal contacts a solution which contains a high concentration of its ions at one point and a low concentration at some other point. The form of an oxygen concentration cell is quite similar, with the exception that in the oxygen concentration cell the metal will be in contact at one point with a solution containing a relatively high concentration of dissolved oxygen and at some other point

with more of the same solution having a low concentration of dissolved oxygen.

Concentration cells are likely to be set up in practice where there are differences in the relative movement of the corroding solution at different points, or where there is movement at one point and stagnation at another, as in a crack, crevice, or open thread. Since the action of the concentration cell is that of accelerating corrosion at one point, the result will be that in the area so affected a deep pit or perforation will be formed. For this reason, cracks, crevices, and open threads should be avoided in the design and assembly of equipment intended for corrosion-resisting service.

Dezincification Corrosion. This form of corrosion occurs principally with alloys of copper and zinc (brasses) in which the zinc content is above about 15%. Brass which has undergone dezincification may retain its original shape, but under examination the structure will actually consist of a core of brass surrounded by a layer of porous copper. This copper layer has poor strength and ductility, and contributes very little to the load-carrying capacity of the remaining brass core.

Graphitic Corrosion. This form of corrosion is peculiar to gray cast iron and resembles dezincification. It is called graphitic corrosion because in many cases, in contact with corrosives, the iron in gray cast iron may be leached out by corrosion, leaving behind a porous layer of graphite over the remaining unattacked iron. This graphite layer may, and quite often does, contain oxides of iron or other iron-corrosion products. If this graphite layer that forms is continuous and free of pores, or if the conditions of service are such that the pores in the graphite layer fill with insoluble corrosion products, the graphite coating may serve to protect the cast iron from further attack. In substances where the graphite layer is porous (which most often is the case) the corrosion action will continue to proceed and might even become accelerated by complex galvanic corrosion effects between the relatively noble graphite layer and the underlying iron.

Stress-Accelerated Corrosion. This form of corrosion is known by the several names, stress-accelerated corrosion, corrosion fatigue, and corrosion cracking. It is confined to a limited number of alloys, of which the yellow brass alloys are the most susceptible. With certain of these materials in use under high stress, a relatively small amount of corrosion, as measured by the quantity of metal dissolved, may be accompanied by considerable mechanical weakening. As an example, yellow brass when stressed either internally or by applied loads may crack as a result of moderate corrosion in such solutions as sodium hydroxide or mercury salt.

Stress-accelerated corrosion quite often is complicated by such incidental factors as surface rupturing and fissuring, which if allowed to proceed will promote the formation of concentration cells. Where

such action has been noted, it is helpful to remove by mechanical finishing the layer of ruptured or fissured metal, followed by a stress-relief anneal of the overstressed part.

Galvanic Corrosion. In practice it frequently happens that two or more dissimilar metals or alloys may be used in direct contact with one another. In many cases this contact will promote an accelerated corrosion of one of the metals and a retarded corrosion of the other. This effect is called galvanic corrosion.

Pitting and Local Corrosion. Several of the forms of corrosion described above may make their effects known not only in the form of loss in metal or alloy weight but also in the development of pits, holes, or perforations. Where this pitting or other form of local attack proceeds at a high rate, its ultimate effect may be much more serious than that of the uniform corrosion which causes a simple loss in weight.

Pitting and local corrosion are caused usually either by breakdowns of the passive films which a metal or alloy may build up for itself in a corroding solution or as a result of accelerated corrosion at the point of a surface blemish or non-metallic inclusion. Concentration-cell corrosion, for example, usually causes pitting and local corrosion at points where the passive films are broken down, or where the differences in ion concentrations have caused a setting up of local anodic areas.

Controlling Factors in Corrosion

Solution Composition. In addition to the percentages of the several constituents which may be present in the corroding solution, it is important to know the alkalinity or acidity as recorded by pH (hydrogen-ion concentration) measurements.

Temperature. An increase in temperature may, but does not always, increase the rate of corrosion.

Velocity or Rate of Flow. An increase in the velocity or rate of flow of a solution through a pipe or by a metal section may affect the rate of corrosion because of the likelihood that rust scale or other partially protective films may be removed, exposing the underlying metal to further attack.

Aeration. The presence of oxygen or oxidizing impurities in the corroding solution may affect appreciably the severity of corrosion. The effects of oxygen or these oxidizing impurities may vary since under certain conditions they are conducive to the formation of protective films, whereas with other substances or with other metals they might serve to accelerate corrosion.

Film Effects. The presence or absence of protective films will bear directly on the extent of corrosion. In many cases these may be applied chemically, as for example with a protective paint or lacquer film, whereas with certain types of materials the presence of oxidizing agents in the corroding solution will promote the formation of protective films.

Inhibitors. In many cases corrosion inhibitors, such as the soda ash used in boiler-tube installations, may be added to reduce, or protect against, the ravages of corrosion. The action of these corrosion inhibitors is much like that of the protective films described above.

Galvanic Relationships. The extent of galvanic corrosion will be determined by three factors:

- Conductivity of the solution.
- Ratio of anodic and cathodic areas.
- Resistance to the circuit.

Galvanic corrosion will not result unless the corroding solution is a good conductor. The extent and distribution of galvanic corrosion will be governed directly by the ratio between the anodic and cathodic areas. Galvanic corrosion will proceed only if the several parts of the system are connected directly through metallic and liquid paths.

Expression of Corrosion Rates

Inch Penetration per Year (Ipy). This represents an average value calculated directly from weight loss data to correspond with that depth to which uniform corrosion would penetrate were the material exposed to corrosion from one side only, continuously, over a full year.

Milligrams Loss per Square Decimeter per Day (Mdd). This value is calculated directly from loss in weight data and corresponds with the average loss in weight in milligrams for one square decimeter area over one 24-hour day.

ART. 1-B. RESISTANCE OF METALS TO CORROSION

Cast Iron. Subject to both self- and galvanic corrosion. *Protection:* Coal tar or asphalt or cement lining. Most common form of rusting is "tuberculation."

Wrought-Iron and Steel Pipe. Usually rust by tuberculation. Additional cause of localized corrosion is mill scale.

Galvanized Iron Pipe. Concentration cell in crevices of the threads (cut after pipe has been galvanized.)

Lead and Lead-Lined Pipe. "Lead is quite low in electrochemical series and resists corrosion very well. In the absence of carbon dioxide, almost insoluble salts (lead oxide and hydroxide) are formed by corrosion, precipitate on the lead and protect it. In the presence of moderate amounts of carbon dioxide and oxygen another lead salt (lead oxycarbonate) is obtained. This tends, also, to precipitate, but is more soluble (less adherent) than lead hydroxide. When, however, carbon dioxide is present to excess, relatively soluble salts (probably lead carbonate and bicarbonate) are produced and in part carried away in solution. The

lead is not as well protected, is left bare to further attacks, and corrodes." (6)*

Tin and Tin-Lined Pipe. Tin has good corrosive-resisting properties. It is used for piping as pure tin (block tin) only to a limited extent and mostly as a lining. The same objections hold true for tin lining as for any other lining. Any imperfections in the lining may cause galvanic corrosion to act between the pipe material and the tin, thus corroding the pipe.

Brass and Copper Pipe. "The relative positions of zinc and copper in the electrochemical series expose brass more particularly to galvanic corrosion when the distribution of zinc and copper crystals is not even. . . . The flow of current in the water is from zinc to copper, the alloy going into solution, and the pipe material becoming spongy, permitting water to seep through and leave a white deposit of zinc salts (zinc hydrate or carbonate) on the outer surface of the pipe." (6)*

A brass which contains much zinc (as 35%, for example) corrodes more than one which contains less. Bronze corrodes less than brass, and copper corrodes less than bronze (1).

Brass pipe used for hot-water distribution should contain at least 67% copper. If it contains too large a percentage of zinc, the alloy is liable to dezincification. Some waters require 85% copper (red brass).

Galvanic currents are also set up where fittings are made of a different composition from the pipe, as bronze fittings with brass pipe and particularly brass fittings with iron pipe.

Copper is a slightly toxic metal if taken internally in excessive amounts, but the amount of copper dissolved from brass or copper pipe is usually so insignificant as to cause no harm (6).

Annealed copper pipe is more resistant than hard drawn copper pipe. The products of copper corrosion are largely insoluble salts which deposit upon the metal and protect it against solution (6).

Soldered Joints. Soldered seams in water-closet tanks are corroded by an acid water. This is often noticed in an alum-treated water. Covering the seams with a wash or paste of tar or asphalt mixed with cement should prove beneficial (1).

Kitchen Wastes. The possible corrosives added to water in kitchen wastes may be the fatty acids from grease, solvents used for grease removal, dishwashing compounds, and vegetable acids. Of these the fatty acids are not considered severe. Most cleaning compounds are largely composed of caustics which attack lead and brass but do not

* (6) From *Water Works Practice*, Abel Wolman, Editor, The Williams and Wilkins Co., Baltimore, Md. Reprinted by permission.

The numbers in parentheses throughout this book are bibliographical references to the list in the Appendix, page 298.

have much effect on iron. Likewise, the dishwashing compounds are largely alkaline, and where used in dishwashing machines reach the waste line at a high temperature. Vegetable acids, while exerting quite a corrosive power on some metals, are not severe on materials generally used for drainage systems.

Investigations made by Maxwell W. Smith for the Duriron Co., Inc., Dayton, Ohio, showed a common characteristic of pitting, typical of concentration cell. Analysis of some solvents widely used for cleaning drains showed them to be composed of caustic-containing flakes, probably of aluminum oxide. Apparently, when such a mixture would meet the water in the pipe, a sodium aluminate was formed which would coat the inside of the pipe in spots. A galvanic flow would take place from the bare spot to the adjacent coated spot, the soda solution being the electrolyte, the pipe material the positive pole, and the coated spot the negative pole. This is true with lead, brass, copper, cast-iron, wrought-iron, and steel pipe. When the same experiments were tried with high-silicon iron, the galvanic current flowed in the opposite direction, since the high-silicon iron is negative to most other metals used in plumbing. In such cases there would be no pitting of the pipe.

ART. 1-C. SOIL CORROSION

Characteristics of Soil Corrosion

(Abstracts of studies made by the National Bureau of Standards, *Soil Corrosion Studies*.)

Causes of Soil Corrosion. There is little doubt that underground corrosion is an electrochemical process and that strains and segregation cause potential differences which influence the rate of corrosion. Soil conductivity, soil acidity, moisture, and oxygen supply have been suggested as factors influencing corrosion. Whether these are the elementary factors or the results of more fundamental causes is not definitely known.

Rate of Corrosion. Only a small proportion, perhaps 5 or 10%, of the soil area of this country is decidedly corrosive.

There are indications that the rate of corrosion decreases with time in most soils because of more stable trench conditions or the formation of corrosion products.

Differences in the rate of penetration of different pipe-line materials by soil action in the same soil are much smaller than the differences in the rate of penetration of the same material in different soils. The type of soil rather than the variety of ferrous material is usually the controlling factor with respect to corrosion. In certain soils, however, one type of material may corrode much more rapidly than some other material, and for this reason the soil to which it is to be exposed should be considered in selecting material for a pipe line.

The rate of corrosion is initially high, as a rule decreasing rapidly, and

then more slowly, as time goes on. Considering this decreased rate of corrosion, slightly increasing the thickness of the pipe will prolong its life considerably. The corrosivity of different soils varies within a wide range.

Resistance of Materials to Soil Corrosion

(Abstracts of Studies made by National Bureau of Standards, *Soil Corrosion Studies.*)

Ferrous Metals.

1. All the rolled materials (Bessemer steel, wrought iron, open-hearth iron, open-hearth steel, and copper-steel) corrode at approximately the same rate.

2. Sand-cast iron shows a consistently higher rate of penetration than the rolled materials in these tests.

3. Centrifugally cast iron corroded initially at a slower rate than the rolled materials, but at the end of both of the 8- and 10-year periods was corroding at approximately the same rate as the rolled materials (8).

Non-ferrous Metals. Tests indicate that the rate of corrosion of copper and its alloys is generally low and nearly uniform. Pitting occurs on lead and zinc in some soils, and the corrosion of some alloys of aluminum is rapid under some soil conditions.

Copper and alloys high in copper corrode less rapidly than most ferrous materials in the soils investigated.

Metallic Coatings.

Galvanized iron or steel prepared by the hot-dip process includes an outer layer of nearly pure zinc, a middle zone of one or more alloys of zinc and iron, and, finally, the metal to which the zinc was applied.

A zinc coating weighing 1 oz per sq ft of exposed surface should extend the life of the coated material at least 6 years in very corrosive soils and much longer under more favorable conditions.

Over a 10-year period, the rates of loss of weight of galvanized steel were one-half to one-fifth the rates for bare steel.

Galvanized iron or steel corrodes most rapidly in poorly drained acid soils and in those high in salts.

For long periods of exposure, thick zinc coatings are superior to thin ones. A coating of 2.8 oz per sq ft of exposed surface prevented the formation of measurable pits in all but one soil for a period of 10 years.

The type of ferrous material to which the zinc is applied does not have an appreciable effect on the rate of corrosion of galvanized materials during the first 10 years of exposure.

The rate of corrosion of galvanized steel is lower than that of either zinc or steel alone.

Lead-coated pipe (average thickness 1 to 1.5 mils). Lead is sufficiently corrodible in most soils to result in perforation of lead coatings of the

thickness used in the tests within 10 years. After the lead has been punctured, accelerated corrosion may occur because of differences of potential between lead and steel.

Aluminum (calorized). A calorized coating is an alloy of aluminum with the base metal. There are two processes of calorizing, one known as the powder or dry process and the other as the dip or molten-metal process.

Specimens calorized by the powder process showed somewhat higher rates of loss of weight and somewhat lower rates of maximum penetration than those calorized by the dip process.

Mill and foundry scale. (Ferrous pipes made at the foundry or mill are covered with an oxide coating commonly called foundry or mill scale.) Foundry and mill scale do not protect ferrous materials against underground corrosion because of local corrosion in cracks and voids in the scale.

Non-metallic Coatings. Coatings of this sort tested consisted of synthetic rubber, vitreous enamel, rubber paint, oil paint, cashew nut oil-asbestos-fiber paint, hard rubber, loaded hard rubber, synthetic resin varnish, chlorinated rubber paint, China wood oil-mica plastic.

Of a group of non-metallic and non-bituminous coatings, vitreous-enamel and hard-rubber coatings afforded the best protection over a 2-year period of exposure. Thin coatings in this group permitted moisture to reach the pipe, with consequent rusting.

Bituminous Coatings.

Cutbacks. Bituminous materials reduced to a paintlike consistency by the addition of a volatile solvent are called cutbacks. They are applied to the pipe by spraying, brushing, or dipping. Cutbacks are made from two classes of materials—coal-tar pitches and asphalts.

Shielded cutbacks. Usually thin sheet metal. See also *Reinforced bituminous coatings.*

Emulsions. Asphalt emulsions are made from several kinds of asphalt and by the use of many emulsifying agents and methods.

Dip coatings. Bituminous coatings are frequently applied to pipe by dipping the latter in a tank of molten coal-tar pitch or asphalt.

Dip coatings for cast-iron pipe. For many years the specifications of the American Water Works Association have included a requirement that the pipe shall be coated inside and out with coal-tar pitch varnish to be applied by dipping the heated pipe in the heated varnish.

Thick unfilled coatings. Either asphalt-base or coal tar-pitch base coatings with or without a reinforcing by loosely woven cotton fabric somewhat heavier than cheesecloth.

Bituminous enamels. One of the characteristics of bitumens as protective coatings is their tendency to flow under low pressures. This tendency can be reduced by using a material of high softening point, but this usually makes a more brittle coating. A reduction in the tendency

to flow can also be accomplished by the addition of finely divided inert material commonly known as a filler. A bitumen to which a filler has been added is frequently called an enamel, although the term is also used to designate a bituminous varnish to which a pigment has been added. The term "enamel" is here used to designate a bitumen yielding between 15 and 50% of residue on ignition.

Reinforced bituminous coatings. It has been shown that asphalts and coal-tar pitches may have, in varying degree, four faults which detract from their value as protective-coating materials: absorption of water, low resistance to shock, susceptibility to changes in temperature, and cold flow under stress. The addition of finely divided inert materials improves the bitumens as coating materials, but does not result in products which are entirely satisfactory for use under severe soil conditions. Further improvements have been attempted through the use of reinforcing fabrics, either imbedded in the coating or placed over the coating as a shield. At first, various organic fabrics such as burlap and coarse cotton cloth were used as reinforcements. Later, bitumen-impregnated organic and asbestos felts similar to roofing felts were used extensively. The use of these materials not only results in coatings which are more resistant to shock and to soil stress, but also usually involves the application of more bitumen. It is generally agreed that the protection of the pipe against moisture depends upon the kind and amount of bitumen present. Most fabrics, even though impregnated with bitumen, absorb some moisture.

Mastic coatings. Made of a mixture of asphalt and graded mineral matter, applied by machine to a thickness of one-half inch.

Grease Coatings. Unreinforced grease coatings, grease coatings reinforced with cotton fabric or shielded by a wrapper or copper foil.

Conclusions Reached from Studies. The performance of a protective coating is controlled by the soil conditions to which it is subjected. The shrinkage and the relative density of the soils are important factors in the distortion of coatings.

Although no coating tested completely prevented corrosion under all soil conditions for as long as four years, almost all of them materially reduced the loss of metal during the period of test.

Coatings which are somewhat porous, such as cutbacks and asphalt emulsions, are effective in preventing pitting in well-aerated soils.

The thickness of the bitumen is an important factor in the effectiveness of the coating. Very thin bituminous coatings are unsuitable for severe soil conditions.

Thickness for thickness, coal-tar base coatings absorb less water and have better insulating qualities than coatings having asphalt as a base.

The coal-tar base coatings are, in general, more severely affected by soil stresses, sudden changes in temperature, and shocks.

Shields and reinforcements reduce the depth of the deepest pit to a

great extent during the first few years of exposure, probably because of their resistance to soil stress, although the relatively great thickness of reinforced and shielded coatings may be a factor.

Asbestos felt offers more permanent reinforcement to bituminous materials than rag felt.

No bituminous coating or coating material is inherently greatly superior to all others. It is possible to secure similar results by several methods.

ART. 1-D. CORROSION DUE TO FLUE GASES*

Causes of Corrosion

1. The condensation of vapors, which are formed during the combustion of fuel gases containing sulfur, results in the corrosion of combustion chambers and flue pipes.

2. Sulfur must be reduced considerably below two grains per 100 cu ft of fuel gas to eliminate corrosion problems.

3. Other constituents of the products of combustion do not appear to be significant with respect to corrosion (2).

Flue Pipes

That a certain amount of moisture will result in the efficient utilization of the heat from the products of combustion of gas fuels seems inevitable. The presence of traces of sulfur results in a corrosive medium, depending on the use of the fuel. To date the only method of avoiding trouble is to conduct the flue products to the outside atmosphere through corrosion-resistant conduits. The chief difficulty with this seems to be that no such universally suitable corrosion-resistant material is available (2).

The old-fashioned sheet-iron flue pipe is practically useless for the purpose, and the fact that a considerable amount of this kind of flue pipe was found to be in use in the natural-gas districts is proof in itself that the corrosion problem in those areas is not serious (2).

Galvanized pipe is the next cheapest material commonly available for the purpose. This was found to be in very general use everywhere. It will not, however, resist the attack of the sulfur-bearing flue gases and must be replaced in periods varying from a few months to 4 or 5 years, depending upon several conditions. In one property the claim was made that it had been found to be less expensive to replace this cheaper pipe than it was to install a more costly pipe which would eventually be destroyed anyway (2).

Asbestos-wrapped galvanized pipe has been tried and found to be

* Abstracts from *Corrosion of Metals and Alloys by Flue Gases*, by Louis Shnidman and Jesse S. Yeaw, Appendix I to *Organic Sulphur*, by R. E. Kruger, American Gas Association, New York, N. Y.

very little better than the bare pipe. A double-flue pipe which consists of two galvanized pipes, one inside the other with 1/2 to 3/4 in. of insulation between, is being tried in one city. The particular problem there was to conduct the flue gases a considerable distance away without condensation.

Another zinc-coated product, Wilder metal, was found in very common use for flue pipe in certain manufactured gas areas. This material seemed to give much better service than the ordinary galvanized pipe (2).

TABLE 1 (2)*
LIFE EXPECTANCY FOR 20 B.S. GAGE (0.032 in) METAL

Fuel Gas Burned	Sulfur-Free Natural Gas	Odorized Natural Gas	Purified Manufactured Gas		
Grains Sulfur per 100 Cu Ft. Fuel	0 0	0 4	9 0		
Commercial Lead	11	13	15	Years Service Exposure One Side Only	
Black Iron	6	5	1		
Commercial Zinc	100+	80	8†		
Chromium-Nickel Stainless Steel	100+	100+	100+		
Chromium Steel	100+	21	3		
Aluminum	46	29	8		
Aluminum-Magnesium Alloy	36	29	7		
Al-Cu Alloy, Al-Coated	—	—	3		
Silicon Bronze	64	21	10		
Silicon-Manganese Bronze	—	—	8		
85-15 Brass	64	29	8		
Commercial Copper	64	21	7		
Monel	100+	100+	—		
Lead	6	12	—		Years Service Continuous Exposure
Black Iron	4	4	—		
Zinc	100+	40	—		
Aluminum	36	29	—		
Copper	64	17	—		

* From *Corrosion of Metals and Alloys by Flue Gases*, by Louis Shnidman and Jesse S. Yeaw, Appendix I to *Organic Sulphur*, by R. E. Kruger, American Gas Association, New York, N. Y. Reprinted by permission.
† Galvanized iron used in test. Data refer to the zinc coating only.

Copper flue pipe was very abundantly found in one locality and in some other scattered locations also. It has been in use longer than any of the other common metals or alloys except the zinc-coated iron, and it seems to have given quite satisfactory service with the exception of some particular installations (2).

Aluminum flues were found in several scattered locations. They seemed to have given much better service than the cheaper materials, but whether the increased service overbalances the cost factor is in doubt. Aluminum too is eventually destroyed by the corrosive flue gases (2).

Among the more recently recommended materials are Transite, lead-lined copper, and chromium-nickel 18-8 stainless steel.* None of these has been in use long enough to show definite results. It is indicated that condensates soak right through Transite. These liquids leach out the binder, and a swelling and disintegration then take place. Preliminary observation appears to show that corrosion occurs in both lead-lined copper and stainless steel and it is therefore only a matter of time before these materials will be destroyed by the condensation products of the flue gases (2).

The problems of moisture and of the corrosion of flue pipe have been studied from the point of view of improving the method of installation. Most gas companies insist upon a more or less general supervision at the time of installation, but one insists upon placing the house heater close to the chimney and of actually changing it into that position if it has already been installed. In one locality all draft hoods usually supplied with the units have been removed and either installed in the line just as it enters the chimney or replaced with a modified diverter which is located at the same point. Some service departments adjust the burner settings to supply enough heat to the flue pipes to keep them well above the dew point, and thus avoid trouble (2).

The problem is far from settled anywhere, and doubt is expressed in some quarters that it can ever be satisfactorily settled until sulfur is removed from the fuel gas (2).

Chimney Linings

A situation similar to that in the flue pipe exists in the artificial chimney linings. *No chimney excels a properly constructed tile-lined chimney.* Lacking this, however, substitutes are necessary (2).

Various metals have been tried without much success. One or two aluminum chimney linings have been found which are very evidently badly attacked. Copper linings have been found to be in equally bad condition. Electrolytic lead on both sides of the usual copper flue pipe is being used in one city, but it is being attacked by the flue gases, particularly around the edges, bolt holes, and scratch marks. The same is true in the vitreous-enameled iron which is used almost exclusively in another city. High-chromium steel has been shown to be very actively attacked and destroyed, and the chromium-nickel stainless steel which

* In some tests type 316 with 2-3% molybdenum seems to be better than the regular 18-8 alloy. Tests are still being conducted on this.

has been recommended has yet to be given a fair trial. Laboratory tests on this material do not seem to have given consistent results (2).*

Transite has been used in some comparatively recent installations as a flue liner. A few were noted in the present survey, and they looked pretty badly messed up. Indications seem to show that moisture soaks through the Transite and destroys its usefulness.

No completely satisfactory method for the proper protection of chimneys which were not correctly tile-lined when they were constructed is available at the present time (2).

ART. 1-E. GENERAL CONCLUSIONS

Summary

The general conclusions reached by tests and observations on all types of corrosion seem to point to the following facts:

Metals exposed to corrosives disintegrate rapidly during the first stage and then, through the formation of protective coatings (oxides), at a slower rate.

Corrosion usually continues if this protective coating is removed. This happens in pipes carrying liquids. The more turbulent the flow, the quicker the removal.

Corrosion on the outside of pipes may be very slow if this protective coating is left undisturbed.

Metals protected in advance by lining or coatings pass through a preliminary stage during which the lining prevents corrosion. After the lining is worn down or pitted, corrosion starts. Where metal linings and coatings are used, corrosion may be accelerated through the electrolytic action between the two metals.

Metals with smooth and dense surfaces corrode slowly in the early stages. Notable in this class are the highly polished corrosion-resistant metals. After the polished surface becomes sufficiently pitted, the rate of corrosion increases and in some alloys, owing to the differences in electromotive series, at an aggravated rate. Tests showing low corrosion rate on some corrosive-resistant metals may therefore not necessarily prove that they will last indefinitely.

REFERENCES

Corrosion Resistance of Metals and Alloys, by R. J. MCKAY and ROBERT WORTHINGTON
Reinhold Publishing Corporation, New York, N. Y.

* See footnote on page 12.

CHAPTER 2

MATERIALS

ART. 2-A. STANDARDIZATION

Standards

Standardization of materials or products has been carried on by many organizations such as the American Society for Testing Materials (ASTM), the American Water Works Association (AWWA), the New England Water Works Association (NEWWA), the National Board of Fire Underwriters (NBFU), the National Fire Protection Association (NFPA), and the American Society of Mechanical Engineers (ASME).

Coordinating Work. Most of this work is now coordinated under the efforts of the American Standards Association (ASA), which sets up "American Standards" and "American Recommended Practice" for a great number of organizations representing manufacturers, underwriters, and engineers.

Federal Departments. In addition there are standards formulated by the United States Government and issued under "Federal Specifications" (Fed. Specs.), Standards of the National Bureau of Standards (NBS), Public Health Service (PHS), and the United States Navy.

ART. 2-B. SELECTION OF MATERIALS

Types of Materials

Importance of Proper Selection. Before the actual layout work begins it is important to make an analysis of the materials to be used, as the sizes of pipes, their installation, and their use depend greatly on the type of materials selected.

The materials used in plumbing are varied and many. They are listed here for the purpose of making the proper selection. Where there is no choice of selection or the proper material, alloy, or compound becomes purely a matter of the manufacturers' guarantee, no attempt is made to analyze them.

In most cases the architect or engineer is faced with the proper selection of pipe material for the project on hand and must then have knowledge of methods of making joints, the flow characteristics of pipes, etc.; he will, however, depend on the manufacturers' guarantee in the matter of many compounds of special alloys, machinery, etc., by having purchases based on a performance specification.

Proper selection of materials should be considered at the early stages of the work. They are determined by the nature of the building, its assumed length of life, the general cost, etc., and by the fluids or gases handled by the pipes and appurtenances.

Any such selection will, in turn, determine many factors in the actual design and layout, as the accessibility of piping, the general installations method, method of operations, service characteristics of the pipes, etc.

ART. 2-C. STEEL AND IRON

Mild Steel

Definition. Pipe Steel. A special grade of soft weldable pipe. This is nearly pure iron, very low in carbon, and is therefore not susceptible to heat treatment by sudden cooling (12).

Compositions.

1. Bessemer pipe steel

Iron	99 43%
Carbon	0.07%
Manganese	0.35%
Sulfur	0.05%
Phosphorus	0.10%

2. Open-hearth pipe steel

Iron	99 405%
Carbon	0.10 %
Manganese	0.40 %
Sulfur	0.035%
Phosphorus	0.02 %

Steel for range boilers, tanks, and heaters shall be best-quality homogenous flange steel, having a tensile strength of not less than 45,000 psi (20).

Wrought Iron. Iron refined in a puddle furnace below the melting point. It is characterized by the presence of about 2% of foreign material irregularly intermixed with ferrite or pure iron (12).

Carbon Steel

Definition. Steel containing 0.35 to 1.5% carbon.

Standards. Specifications for carbon-steel castings, for valves, flanges, and fittings, for high-temperature service, ASA G17-1, ASTM A95.

Specifications for carbon-steel and alloy-steel blooms, billets, and slabs for forgings, ASA G9-1, ASTM A17.

Cast Iron (Gray Iron)

Composition.

Iron	94 0%
Carbon	3 5%
Silicon	2 5%

Specification. Cast iron for heaters shall be best-quality gray cast iron and shall be free from imperfections (20).

Iron castings shall be pig iron, gray and tough. Coatings shall be coal-tar pitch varnish.

Malleable Iron

Definition. Cast iron made from pig iron of the proper kind, treated so as to render it capable of being bent or hammered to a limited extent without breaking; that is, it is malleable. Its strength is above that of cast iron. The treatment is known as annealing (12).

ART. 2-D. OTHER METALS AND BI-METALS**Copper**

Standards. Fed. Specs. QQ-C-501 (Class B).

Used for piping, tubes, fittings, gaskets, tanks, sheet metal, linings.

Tin

Standards. Pig tin, Fed. Specs. QQ-T-371; phosphor tin, Fed. Specs. QQ-T-351.

Used for piping, solder, coating, linings.

Lead

Standards. For calking, Fed. Specs. QQ-L-156; pig lead, Fed. Specs. QQ-L-171; sheet lead, Fed. Specs. QQ-L-201.

Corrosive-resistant. It is pliable and soft and is easily worked. Where greater strength is needed, a hard, or antimonial, lead is used.

Used for pipes, sheet metal, calking material, solders.

Zinc

Standards. Zinc, slab (spelter), Fed. Specs. QQ-Z-351; zinc, plates, and sheets, Fed. Specs. QQ-Z-301.

Aluminum

Standards. Plates and sheets, Fed. Specs. QQ-A-561.

Nickel

A typical chemical analysis of commercial pure nickel is 99.20% nickel, 0.20% copper, 0.40% iron, 0.10% carbon, 0.10% manganese, 0.10% silicon, and 0.005% sulfur.

Nickel-Clad Steel Plate

Nickel-clad steel plate is protected on one or both sides with a dense, homogeneous layer of pure nickel. It is firmly and permanently bonded to the steel-base plate and does not separate from it as a result of temperature change, pressure, vacuum, or deformation in forming. (This information from International Nickel Company, *Technical Bulletin T-4*.)

Standards. The composite plate, clad either on one or both sides, is obtainable with various thicknesses of nickel. Standards of 5, 10, 15, and 20% of the total thickness have been established, the most com-

mon being 10%. For example, the thickness of the nickel cladding on a ½-in. plate clad 10% is 0.05 in. The 5% cladding is produced only on plate ½ in. thick and heavier.

Characteristics. Nickel-clad steel can be welded. This is the preferred method of joining as it establishes a continuous nickel surface.

The nickel surface is furnished with a matte finish, nearly white in color.

Used for all types of tanks, vats, pressure kettles, etc.

ART. 2-E. IRON ALLOYS

Manufacturers' Standards

Although each manufacturer may use a different trade name, the American Iron and Steel Institute has assigned type numbers for all recognized standard grades and analyses. These numbers are referred to as A.I. and S.I. Type Numbers.

Stainless Steel

(May be either a chromium steel or a chromium-nickel steel.)

Standards. Ferro-chromium (iron chromium), Fed. Specs. QQ-F-151.

Compositions and Characteristics.

1. "17" stainless steel

Chromium	15-18%
Carbon	0.10% max.
Manganese	0.25-0.60%
Phosphorus	0.035% max.
Sulfur	0.035% max.
Silicon	0.50% max.

Can be drawn, welded, spun, soldered, and brazed. Heat-resistant up to 1550 F.

Highly corrosive-resistant.

2. "18-8" stainless steel (A.I. and S.I. Type 302)

Chromium	17.5-20%
Nickel	8-10%
Carbon	0.08% max. and 0.20% max.
Manganese	1.25% max. and 2.00% max.
Phosphorus	0.03% max.
Sulfur	0.03% max.
Silicon	0.75% max.

Variations of the above may be produced with small amounts of titanium, columbium, or molybdenum (A.I. and S.I. Types 321, 347, and 316 respectively).

Very ductile, practically non-corrosive (exception, muriatic acid). Used for seamless tubing, sheet metal (sinks). Can be forged, welded, brazed, soldered, machined, hot- or cold-rolled, stamped, spun, ground, and polished.

High Silicon-Iron (Ferro-Silicon)

Standards. Fed. Specs. QQ-F-181.

Composition.

Silicon	14.25 to 14.50%
Carbon	1.0 % max.
Manganese	} 85.0 %
Other Impurities	
Iron	

Characteristics. Very acid-resistant.

Used for cast pipes, fittings, and special castings.

Copper-Molybdenum Alloy Iron*Composition.*

Carbon	0.05% max.
Manganese	0.35% max.
Phosphorus	0.015% max.
Sulfur	0.04% max.
Copper	0.40% min.
Molybdenum	0.05% min.
Silicon	0.01% max.

Used for seamless tubing, fittings, tanks. Very corrosion-resistant.

Other Iron Alloys

Copper-Bearing Steel. A term used for many grades of steel with only a slight amount of copper. They are used for seamless tubing, plates, sheets, etc. They are rust-resisting but not rustproof.

Nickel steel, nickel chrome steel and chromium steel, silicon steel, and manganese steel contain relatively small amounts of the corrosion- or heat-resistant metals.

Nickel-Copper-Chromium Cast Iron. Standards by International Nickel Co.; corrosion-, erosion-, and heat-resisting. Used for castings.

*Ferro-nickel.**Compositions*

1. Castings

Iron	74.2%
Nickel	25.0%
Carbon	0.8%

2. Valve steel

Iron	67.8%
Nickel	32.0%
Carbon	0.2%

ART. 2-F. NON-FERROUS ALLOYS**Brass**

Definition. Brass is an alloy of copper and zinc in many different proportions, varying from 95% copper and 5% zinc to 58% copper and 42% zinc.

Standards. Fed. Specs. QQ-B-611, Compositions A and B, and QQ-B-621, Composition A.

Compositions

1. Red brass		4. Yellow brass	
Copper	85-90%	Copper	67%
Zinc	10-15%	Zinc	33%
2. Red brass, for fittings		5. For brazing	
Copper	80-86%	Copper	55%
Zinc	4-15%	Zinc	45%
Lead	2- 6%	6. For fixtures	
Tin	3- 6%	Copper	80% min.
3. Muntz metal		7. Castings (so-called manganese bronze)	
Copper	60%	Copper	66.7%
Zinc	40%	Zinc	33.3%

Used for seamless tubing and castings.

Bronze

Definition. Bronze has many different compositions. Common foundry formula: not less than 90% copper, not more than 8% tin, and the remainder lead or zinc. U.S. National Bureau of Standards: 85% copper, 5% lead, 5% zinc, and 5% spelter.

Standards.

Castings (red metal), Fed. Specs. QQ-B-691, Composition Z.

Manganese bronze, Fed. Specs. QQ-B-721a.

Phosphor bronze, Fed. Specs. QQ-B-746.

Compositions.

1. Drawn material		2. Bronze castings	
Copper	83-86%	Copper	85%
Lead	0.06% max.	Zinc	5%
Iron	0.05% max.	Tin	5%
Zinc	14-17%	Spelter	5%

White Metal (Nickel Silver or Nickel Bronze)

Standards by International Nickel Co. (nickel silver) and Fed. Specs. (white metal, German silver) QQ-N-321.

Compositions.

1. Cast white metal (Fed. Specs.)

Copper	62% min.	65% preferred
Nickel	19% min.	20% "
Tin	2.5% min.	4% "
Lead	6.0% max.	5.0% "
Zinc	10.0% max.	6.0% "
Manganese	1.0% max.	
Iron and other impurities	1.0% max.	

2. Drawn white metal (Fed. Specs.)

Copper	73.0–81.0%	75.0%	preferred
Nickel	19.0% min.	20.0%	"
Zinc	6.0% max.	5.0%	"
Iron and other impurities	2.0% max.		

3. Leaded white metal for machine parts (Fed. Specs.)

Copper	62.0% min.	65.0%	preferred
Nickel	17.0% min.	18.0%	"
Lead	1.5% max.		
Zinc	18.0% max.	17.0%	"
Manganese	0.5% max.		

4. Wrought, forged, or pressure die-cast white metal (Option for cast, drawn, or leaded, Fed. Specs.)

Copper	31.0–44.0%	41.75%	preferred
Nickel	15.0–20.0%	15.25%	"
Zinc	41.0–48.0%	42.5%	"
Manganese, iron, and other impurities	0.5% max.		

Copper Nickel Alloy (Nickel Copper, Monel)

Standards. International Nickel Co., Fed. Specs. QQ-C-541.

Composition.

Nickel	66.0%
Copper	34.0%

Characteristics. Highly corrosive-resistant. Can be welded, brazed, soldered, and forged. Used for piping, sheet metal, forgings, castings, valve seats.

Copper Silicon Alloy

Composition.

Copper	83.5% min.
Silicon	1.0–5.0%
Manganese	1.5% max.
Zinc	5.0% max.
Iron	2.5% max.
Tin	2.0% max.
Impurities	0.5% max.

Used for sheet metal (tanks).

Aluminum Alloys

Aluminum-Chromium-Magnesium-Silicon. Bars, rods, shapes, and wire, Fed. Specs. QQ-A-331. Plates and sheets, Fed. Specs. QQ-A-334.

Aluminum-Copper-Magnesium-Manganese. Bars, rods, shapes and wire, Fed. Specs. QQ-A-351a. Plates and sheets, Fed. Specs. QQ-A-353.

Aluminum-Manganese. Bars, rods, shapes, and wire, Fed. Specs. QQ-A-356a. Plates and sheets, Fed. Specs. QQ-A-359.

Aluminum-Base Alloys. Fed. Specs. QQ-A-601. Can be cast, forged, rolled, drawn, and extruded. Materials can be machined, soldered, and welded.

ART. 2-G. PLATINGS

Nickel

Standards. National Bureau of Standards: nickel plating on brass and bronze. The minimum average thickness of the nickel shall be 0.00018 in. on each piece (20).

Chromium

Standards. National Bureau of Standards: chromium plating on brass and bronze. Each piece shall be plated with nickel of a minimum average thickness of 0.00018 in., followed by chromium of a minimum average thickness of 0.000018 in. (20).

Chromium Plating on White Metal. Chromium shall be applied directly or over a coating of nickel and shall have a minimum average thickness of 0.00009 in. on each piece (20).

Zinc

Standards. Specifications for zinc coating of iron and steel, ASA G8, ASTM.

National Bureau of Standards Specifications: Zinc coating (galvanizing) shall be done thoroughly and evenly by the hot process, and shall be free from blisters and other defects. The average thickness of the coating shall be not less than 0.0033 in. or 2 oz per sq ft of surface covered. The zinc bath shall contain not more than 2% of elements other than zinc, as determined from samples taken at a point one-half the depth of the bath (20).

ART. 2-H. OTHER MATERIALS AND COMPOUNDS

Vitreous Ware

Standards. NBS.

Uses. Fixtures.

Enameled Ironware

Standards. NBS.

Uses. Finish on cast-iron fixtures; protective lining on pipes.

Cement

Standards. Portland cement, ASTM.

Uses. Concrete, cement mixes, cement compounds.

TABLE 2
LIST OF MATERIALS SPECIFICATIONS
 (American Tentative Standard, Code for Pressure Piping, ASA B31-1) (18)

Material	Specification	Maximum Service Temperature
<i>Bolts</i>		
Alloy steel		
Commercial steel (bar stock) for	ASTM A96	
Wrought iron (bar stock) for	ASTM A107	
<i>Fittings, Valves, and Flanges</i>		
Bronze (or brass) for	MSS SP20	500F
Cast iron for	ASTM A126	450F ¹
Malleable iron for	MSS SP22	500F
Steel (cast carbon) for	ASTM A105	
Steel (forged) for	ASTM A105	
<i>Pipe</i>		
Brass (seamless)	ASTM B43	406F
Cast iron (pit cast)	AWWA	450F ¹
Cast iron (centrifugally cast or cast horizontally in green sand molds)	FSB WW-P-421	450F ¹
Copper (seamless)	ASTM B42	406F
Steel (seamless and welded—ordinary use)	ASTM A120	
Steel (seamless and welded)	ASTM A53	
Steel (seamless and welded)	API 5L	
Steel (seamless and lap-welded, high press. and high temp. service)	ASTM A106	
Steel (electric-fusion-welded, 18 in. and larger for high press. and temp. service)	ASTM A155	
Steel (ordinary electric-fusion-welded)	ASTM A139	
Steel (ordinary electric-fusion-welded, large size)	ASTM A134	
Steel (electric-resistance-welded)	ASTM A135	
Steel (forge-welded)	ASTM A136	
Steel and wrought iron (riveted)	ASTM A138	750F
Wrought iron (welded)	ASTM A72	750F
<i>Tubing</i>		
Copper (seamless)	ASTM B75	406F ²
Copper (seamless water tube)	ASTM B88	406F

¹ For oil, not over 300 F.

² For wrought iron only.

Clay Products (See Art. 3. J for definitions).

Characteristics. Acid resistance.

Uses. Vitrified clay pipe, drain tile, earthenware, pipes, ducts, and containers.

Rubber

Uses. Gaskets, packings, mountings, piping, tubes, and hoses.

Sewer Brick

Standards. Hard brick, ASTM; hard burned shale.

Fine Aggregate for Concrete

Standards. Cement mortar bed for brick, stone-block, and wood-block pavements of ASTM.

Coarse Aggregate

Specifications. Crushed stone, gravel, or other inert material.

Gravel

Specifications. Unwashed gravel.

ART. 2-I. CHARACTERISTICS OF VARIOUS MATERIALS**Allowable Temperatures on Metals**

Temperature and Pressure
(Ref.: ASTM and ASA.)

Cast iron	459 F at 125 lb pressure
Malleable iron	450 300
Steam brass	500 200
Best cast brass	550 300
Cast Monel	750 400
Common bolts	500
Carbon cast steel	750 ASA pressures
Carbon cast steel	850 reduced ASA pressure
Alloy cast steel	850 ASA pressure
Alloy cast steel	1000 reduced ASA pressure
Forged steel	850 ASA pressure

Seating and disk materials made from special alloy steel up to 1000 F (*Valve World*, April, 1934; reprinted by courtesy of the Crane Company, Chicago, Ill.).

ART. 2-J. INSULATION MATERIALS**Organic Materials**

Cork, wood, hair and sponge.

Not suitable for high temperatures but used for refrigeration, condensing (sweating), and sound insulation.

Inorganic Materials

Asbestos: May lose its fibrous strength. Easily exposed to moisture.

Mineral wool: May shrink or sag.

Diatomaceous earth: In blocks. May become very fragile and brittle.

Sulfate of lime (plaster of Paris): May cause corrosion.

85% magnesia: Not affected by moisture.

CHAPTER 3

PIPES AND FITTINGS

PIPE MATERIALS

Too much emphasis cannot be placed on the proper selection of materials for pipes and fittings and their connections. As no chain is stronger than its weakest link, so no piping is better than its joints. With the selection of high-grade piping goes a most exacting and thorough analysis of the proper joints to be used.

Listing the various types of piping and corresponding types of fittings does not therefore necessarily imply that they are to be used together.

ART. 3-A. AMERICAN STANDARDS

Definitions

American (Briggs's) Standard. A list of pipe sizes, thicknesses, threads, etc., compiled by Robert Briggs about 1862 and subsequently adopted as standard (12).

Caliber. An expression which is often used to mean the inner diameter, or bore (12).

IP. Iron pipe, meaning American Standard size pipe. Also abbreviated IPS.

IPS. Iron pipe size, term used for pipes of all metals conforming in size to American Standard.

Nominal Size. The diameter listed for the various sizes of pipes which, of course, is subject to variation either way as permitted in specifications (12).

Size and Length. The given caliber or size of pipe is for a nominal internal diameter, except that other than iron-pipe size, brass-pipe size, for instance, is measured by its outside diameter. The developed length of a pipe is its length along the center line of pipe and fittings (12).

Standard Pipe. The standard adopted by the Wrought Pipe Makers in 1866. The Briggs's standard runs to 10-in. size in-

clusive, and by extension the pipe sizes embrace the nominal sizes 11-12-13-14 and 15 in. Because of changes in manufacturing processes, materials, and applications, the pipe wall thicknesses given in the standards adopted in 1866 have been varied as occasion demanded with little regard for national standardization.

In April, 1939, the American Standards Association approved a set of series or schedules of pipe wall thicknesses covering a wide range of pressure-stress ratios. The standards of 1939 have been approved by the ASTM and ASME and are generally based on the specifications of ASTM, ASME, and API.

The schedule numbers used in the 1939 Standard indicate approximate values for the expression $1000 \times \frac{P}{S}$, where P = internal pressure in pounds per square inch, and S = allowable fiber stress in pounds per square inch. Recommended values for S may be obtained by reference to the American Standard Code for Pressure Piping (ASA B31.1).

Specifications

Standardization of dimensions and materials of wrought-iron and wrought-steel pipe and tubing, ASA B36, ASME, ASTM A53.

Pipe thread, ASA B2, AGA, ASME.

Nipples, pipe, brass, steel, and wrought iron, Fed. Specs. WW-N-351.

Fire-hose coupling threads, ASA B26, ASME, AWWA, NBFU.

Screw threads for hose couplings, ASA B33, ASME.

Pipe flanges and fittings, ASA B16, ASME, MSS.

Face-to-face dimensions of ferrous flanged valves, ASA B16.10.

Welding fittings, ASA B16.9.

Cast-iron pipe flanges and flanged fittings, all sizes for maximum WSP of 250 psi, ASA B16b.

Cast-iron pipe flanges and flanged fittings, all sizes for maximum WSP of 25 psi.

Steel-flange fittings and companion flanges, ASA B16e.

American Tentative Code for Pressure Piping, ASA B31.1.

Wire and sheet-metal gages, ASME.

ART. 3-B. PIPE THREAD

Definitions

Common Thread. In machinery, an ordinary standard machine thread, as distinguished from a pipe thread (12).

Female Thread. A thread on the inside surface of a pipe or fitting, preferably called an inside thread (4).

Male and Female. Sometimes called recessed, usually written M. & F. It means that one flange of a pair is faced so as to produce a flat depressed face, extending from inside of pipe nearly to bolt holes. The other flange is faced so as to have a raised portion at same place and only slightly less diameter. The object is to prevent the gasket from blowing out (12). Also means male and female thread (12).

Male Thread. A thread on the outside of a pipe or fitting, preferably called an outside thread (4).

Pipe Thread. A thread employed in connection with wrought pipe. The standard thread is the Briggs's, which has an angle

of 60 deg between its sides, is slightly rounded at top and bottom, and has a taper. See American Standard (12).

Pitch (1). The distance measured on a line parallel to the axis, between two adjacent threads or convolutions of a screw (2). The distance between the centers of holes, as of rivet holes in boiler plates (12).

Pitch Diameter. The pitch diameter, which is also known as the "angle diameter" and as the "effective diameter," is equivalent to the outside diameter minus the depth of one thread. The pitch diameter of a screw having a single thread with angular sides is the distance between the points at which a line perpendicular to the axis of the screw intersects the sides or slopes of the thread (12).

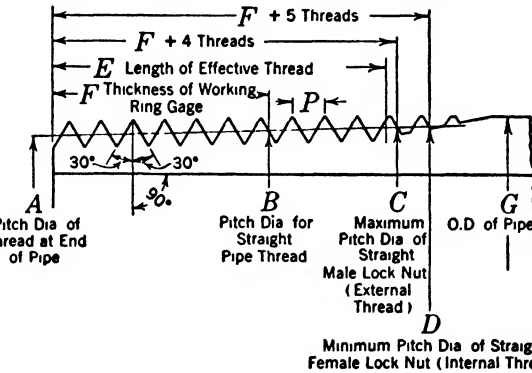
Threads per Inch. The number of threads per inch of linear measurement, as measured with a pitch gage. The reciprocal of the pitch (12).

Tables of Threads

Briggs's Standard, ASA B2 (see Table 3).

Hose Coupling Screw Threads, ASA B33.1; ASME. For all connections having nominal inside diameters of $\frac{1}{2}$, $\frac{5}{8}$, $\frac{3}{4}$, 1, $1\frac{1}{4}$, $1\frac{1}{2}$, and 2 in.

TABLE 3
AMERICAN STANDARD
FOR TAPER AND STRAIGHT PIPE THREADS AND LOCKNUT THREADS



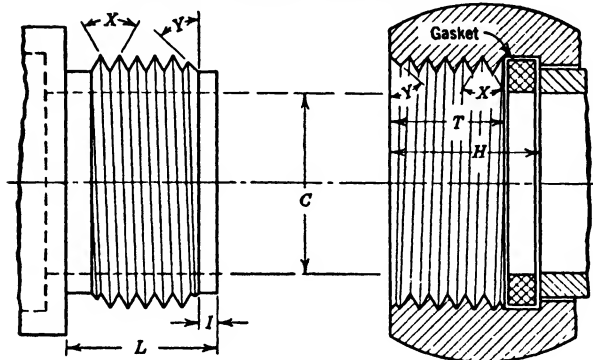
$A = G - (0.05G + 1.1)P$
 $B = A + 0.0625P$
 $C = B + (4P \times 0.0625)$
 $D = B + (5P \times 0.0625)$
 $E = (0.8G + 6.8)P$
 $F = \text{thickness of working ring gage}$
 $P = \text{pitch}$
 Total taper $\frac{3}{4}$ in. per ft
 Depth of thread $0.8P$

Tolerance for Male Threads:
 One turn large (max. size), one turn small (min. size), from face of ring gage.

Tolerance for Female Threads:
 One turn large (max. size), one turn small (min. size), from gaging notch.

Size	A	B	C	D	E	F	G	Depth of Thread	Pitch of Thread	Threads per Inch
$\frac{1}{4}$	0 36351	0 37476	0 38402	0 38633	0 2638	0 180	0 405	0 02963	0 03704	27
$\frac{1}{2}$	0 47739	0 48989	0 50378	0 50725	0 4018	0 200	0 540	0 04444	0 05556	18
$\frac{3}{4}$	0 61201	0 62701	0 64090	0 64437	0 4078	0 240	0 675	0 04444	0 05556	18
$\frac{1}{2}$	0 75843	0 77843	0 79628	0 80075	0 5337	0 320	0 840	0 05714	0 07143	14
$\frac{3}{4}$	0 96768	0 98886	1 00672	1 01118	0 5457	0 339	1 050	0 05714	0 07143	14
1	1 21363	1 23863	1 26037	1 26580	0 6828	0 400	1 315	0 06956	0 08696	11 $\frac{1}{2}$
1 $\frac{1}{4}$	1 55713	1 58338	1 60512	1 61055	0 7068	0 420	1 660	0 06956	0 08696	11 $\frac{1}{2}$
1 $\frac{1}{2}$	1 79609	1 82234	1 84407	1 84951	0 7235	0 420	1 900	0 06956	0 08696	11 $\frac{1}{2}$
2	2 26902	2 29627	2 31801	2 32344	0 7565	0 436	2 375	0 06956	0 08696	11 $\frac{1}{2}$
2 $\frac{1}{2}$	2 71953	2 76216	2 79341	2 80122	1 1375	0 682	2 875	0 100	0 12500	8
3	3 34063	3 38850	3 41975	3 42756	1 2000	0 766	3 500	0 100	0 12500	8
3 $\frac{1}{2}$	3 83750	3 88881	3 92006	3 92787	1 2500	0 821	4 000	0 100	0 12500	8
4	4 33438	4 38713	4 41838	4 42619	1 3000	0 844	4 500	0 100	0 12500	8
4 $\frac{1}{2}$	4 83125	4 88594	4 91719	4 92500	1 3500	0 875	5 000	0 100	0 12500	8
5	5 39073	5 44929	5 48054	5 48836	1 4063	0 937	5 563	0 100	0 12500	8
6	6 44609	6 50597	6 53722	6 54503	1 5125	0 958	6 625	0 100	0 12500	8
7	7 43984	7 50234	7 53359	7 54141	1 6125	1 000	7 625	0 100	0 12500	8
8	8 43359	8 50003	8 53128	8 53909	1 7125	1 063	8 625	0 100	0 12500	8
9	9 42734	9 49797	9 52922	9 53703	1 8125	1 130	9 625	0 100	0 12500	8
10	10 54531	10 62094	10 65219	10 66000	1 9250	1 210	10 750	0 100	0 12500	8
11	11 53906	11 61938	11 65063	11 65844	2 0250	1 285	11 750	0 100	0 12500	8
12	12 53281	12 61781	12 64906	12 65688	2 1250	1 360	12 750	0 100	0 12500	8
14 O.D.	13 77500	13 87262	13 90387	13 91168	2 250	1 562	14 00	0 100	0 12500	8
15 O.D.	14 76875	14 87419	14 90543	14 91324	2 350	1 687	15 00	0 100	0 12500	8
16 O.D.	15 76250	15 87575	15 90700	15 91481	2 450	1 812	16 00	0 100	0 12500	8
17 O.D.	15 75625	16 87500	16 90625	16 91406	2 550	1 900	17 00	0 100	0 12500	8
18 O.D.	17 75000	17 87500	17 90625	17 91406	2 650	2 000	18 00	0 100	0 12500	8
20 O.D.	19 73750	19 87031	19 90156	19 90937	2 850	2 125	20 00	0 100	0 12500	8
22 O.D.	21 72500	21 86562	21 89687	21 90468	3 050	2 250	22 00	0 100	0 12500	8
24 O.D.	23 71250	23 86094	23 89218	23 89999	3 250	2 375	24 00	0 100	0 12500	8

TABLE 4
HOSE COUPLING SCREW THREADS
FOR ALL CONNECTIONS HAVING NOMINAL INSIDE DIAMETERS OF
 $\frac{1}{2}$, $\frac{5}{8}$, $\frac{3}{4}$, 1, $1\frac{1}{4}$, $1\frac{1}{2}$, AND 2 INCHES
(American Standard ASA B33. 1-1935)



Length of Thread for Hose Couplings and Nipples

Service and Nominal Size	Threads per Inch	Length of Nipple L	Depth of Coupling H	Thread Length for Coupling T	Length of Pilot I	Inside Diameter of Nipple C	Approx. Number of Threads in Length T
Garden $\frac{1}{2}$, $\frac{5}{8}$, $\frac{3}{4}$	$11\frac{1}{2}$	$\frac{9}{16}$	$1\frac{7}{32}$	$\frac{3}{8}$	$\frac{1}{8}$	$2\frac{5}{32}$	$4\frac{1}{4}$
Chemical $\frac{3}{4}$, 1	8	$\frac{5}{8}$	$1\frac{9}{32}$	$1\frac{5}{32}$	$\frac{5}{32}$	$1\frac{1}{32}$	$3\frac{3}{4}$
Fire $1\frac{1}{2}$	9	$\frac{5}{8}$	$1\frac{9}{32}$	$1\frac{5}{32}$	$\frac{5}{32}$	$1\frac{17}{32}$	$4\frac{1}{4}$
Other Connections $\frac{1}{2}$	14	$\frac{1}{2}$	$1\frac{5}{32}$	$\frac{5}{16}$	$\frac{1}{8}$	$1\frac{7}{32}$	$4\frac{1}{4}$
$\frac{3}{4}$	14	$\frac{9}{16}$	$1\frac{7}{32}$	$\frac{3}{8}$	$\frac{1}{8}$	$2\frac{5}{32}$	$5\frac{1}{4}$
1—	$11\frac{1}{2}$	$\frac{9}{16}$	$1\frac{7}{32}$	$\frac{3}{8}$	$\frac{5}{32}$	$1\frac{1}{32}$	$4\frac{1}{4}$
$1\frac{1}{4}$	$11\frac{1}{2}$	$\frac{5}{8}$	$1\frac{9}{32}$	$1\frac{5}{32}$	$\frac{5}{32}$	$1\frac{9}{32}$	$5\frac{1}{2}$
$1\frac{1}{2}$	$11\frac{1}{2}$	$\frac{5}{8}$	$1\frac{9}{32}$	$1\frac{5}{32}$	$\frac{5}{32}$	$1\frac{17}{32}$	$5\frac{1}{2}$
2—	$11\frac{1}{2}$	$\frac{3}{4}$	$2\frac{3}{32}$	$1\frac{9}{32}$	$\frac{3}{16}$	$2\frac{1}{32}$	$6\frac{3}{4}$

All dimensions given in inches

Thread and chamfer angles: X equals 60 deg; Y equals 35 deg.

Fire-Hose Coupling Screw Threads, ASA B26. For all connections having nominal inside diameters of 2½, 3, 3½, and 4½ in., NBFU, AWWA, ASME. 2½-in. fire-hose couplings, American Marine Standard E34-36. Covering the threaded part of fire-hose couplings, hydrant outlets, stand-pipe connections, Siamese connections, and all other special fittings on fire lines where fittings of 2½, 3, 3½, and 4½ in. nominal diameter are used.

TABLE 5

Nominal Inside Diameter of Hose Coupling	Number of Threads per Inch
2½	7½
3	6
3½	6
4½	4

ART. 3-C. PIPES

Definitions

Butt-Weld. Welded along a seam that is butted and not scarfed or lapped (12).

Close Nipple. One whose length is about twice the length of a standard pipe thread and is without any shoulder (12).

Cold-Drawn. Refers to tubing drawn in the cold state through a hardened steel die, either with or without a mandrel on the inside, to give a smooth surface finish and to reduce the diameter or the diameter of the wall. The mandrel, more often used than not, is held stationary inside the die circle on the end of a long rod. The ratio of die diameter and the area remaining between the die circle and the mandrel to the original dimensions of the tube determines the character and degree of cold-drawn reduction obtained. A mandrel is usually used on all tubes except where the wall is heavy or where the diameter is very small (12).

Collapsing Pressure. A pressure which, when applied to the outside of a tube, causes it to cave in, or to fail by bending or buckling inwardly (12).

Double Extra Strong or, incorrectly, *Dou-*

ble Extra Heavy. A term used for very thick pipe.

Drawn. The term applied to that style of forging by which the thickness and also, at times, the diameter of a pipe are reduced by pushing or pulling the material through a die and over a mandrel or plug at the same time. In some cases, the mandrel is anchored so as to hold it within the die. When there is no inside mandrel, it is not called drawn product. See *Cold-Drawn*; *Hot-Drawn* (12).

Drifted. Having had a drift or short mandrel passed through the pipe in order to be certain that there are no inside irregularities or that they have thereby been removed (12).

Extension Piece. Usually a malleable iron nipple with male and female thread (12).

Extra Heavy. A term applied to valves and fittings good for a working steam pressure of 250 psi.

Extra Strong, or, incorrectly, *Extra Heavy Pipe.* A term used for pipe heavier than the "standard" pipe. Extra-strong pipe is iden-

tical in thickness with pipes listed under schedules 60 and 80 of present standards.

Ferrule. A short piece of steel or copper pipe placed between tubes and tube sheet of boiler. At times they are welded to tube (12).

Flanged Pipe. Pipe provided with flanges so that the ends can be held together by means of bolts (12).

Galvanizing. The process by which the surface of iron and steel is covered with a layer of zinc (12).

Hot-Drawn. A term used to signify the product of drawing, when the operation is performed on material that is hot, usually red hot, e.g., hot-drawn seamless tubes.

I.D. and O.D. (inside diameter and outside diameter). The outside diameter of all classes of pipe, casing, tubing, tubes, etc., heavier than standard is the same outside diameter as standard, the extra thickness always being on the outside (12).

Pipe and tubing are known and spoken of by their nominal inside diameter of $\frac{1}{8}$ in. to 12 in. inclusive (12). Pipe and tubing of more than 12-in. inside diameter are usually known and spoken of by their outside diameters, and, when ordering, thickness desired must be specified (12).

Lap-Weld. Welded along a scarfed longitudinal seam in which one part is overlapped by the other (12).

Medium Pressure. When applied to valves and fittings, mean good for a working pressure of 125 to 175 psi (12).

Nipple. (1) A tubular pipe fitting usually threaded on both ends and under 12 in. in length. Pipe over 12 in. in length is regarded as cut pipe (12).

Pipe. A long conducting passage, usually a line of tubes; any long tube or hollow body, especially one that is used as a conductor of water or other fluids, as a drain pipe, water pipe, etc. (12).

Pipe Bend. A bent pipe in contradistinction to a bend, which may be a casting (12). See *Bend*, page 35.

Seamless. Without seam; especially without a welded seam. Pipes and tubes are made seamless by the cupping, Mannesmann or Stiefel processes (12).

Sherardizing. A process in which clean surface of iron or steel is coated with zinc-iron alloy to protect against rust (12).

Short Nipple. One whose length is a little greater than that of two threaded lengths or somewhat longer than a close nipple. It always has some unthreaded shoulder between the two threads (12).

Shoulder Nipple. A nipple of any length, which has a shoulder of pipe between two pipe threads. As generally used, however, it is a nipple about halfway between the length of a close nipple and a short nipple (12)

Soil Pipe. In plumbing, a pipe which conveys away the waste from water closets, etc., usually made of cast iron (12).

Space Nipple. A nipple with a shoulder between the two threads. It may be of any length long enough to allow a shoulder (12).

Standard Pipe. A term used for low-pressure pipe. Standard pipe is identical in thickness with pipes listed under schedules 30 and 40 of present standards.

Standard Pressure. A term applied to valves and fittings good for a working steam pressure of 125 psi (12).

Tube. In America, means a boiler tube whose outside diameter is its nominal size. In England, tubes mean tubular goods, whether tubes, pipe, or casing. See also *Tubing*.

Tubing. A special grade of high-test pipe fitted with threads and couplings of special design. Tubing is made to the same outside diameters as standard pipe. It is similar to what is known in Europe as hydraulic pressure pipe (12).

Standard Specifications for Pipes, ASA B36.1, ASTM A53.

“Specifications cover black and hot-dipped-galvanized furnace-welded and seamless steel pipe. Pipe ordered under these specifications is intended for coiling, bending, flanging and other special purposes.

Butt-welded pipe is not intended for flanging. The purposes for which the pipe is intended should be stated in the purchase order. When seamless pipe is ordered for close coiling, cold bending, or for forge welding, the low-carbon grade should be specified rather than the medium-carbon grade.

“Manufacture. The steel for welded pipe shall be soft weldable quality made by one or more of the following processes: open-hearth, electric-furnace, or acid-bessemer. The steel for seamless pipe shall be made by the open-hearth or by the electric-furnace process.

“Welded pipe 3 inches or under in nominal diameter may be butt-welded, unless otherwise specified. Welded pipe over 3 inches in nominal diameter shall be lap-welded.”

TABLE 6
DIMENSIONS OF WELDED AND SEAMLESS STEEL PIPE
(American Standard B36.10-1939)

Nominal Pipe Size	Out-side Diam	Nominal Wall Thicknesses for Schedule Numbers										
		Sched 10	Sched 20	Sched 30	Sched 40	Sched 60	Sched 80	Sched 100	Sched 120	Sched 140	Sched 160	
3/8	0.405				0 068		0 095					
1/2	0.540				0 088		0 119					
5/8	0.675				0 091		0 126					
3/4	0.840				0 109		0 147					0.187
7/8	1.050				0 113		0 154					0.218
1	1.315				0 133		0 179					0.250
1 1/8	1.660				0 140		0 191					0.250
1 1/4	1.900				0 145		0 200					0.281
2	2.375				0 154		0 218					0.343
2 1/2	2.875				0 203		0 276					0.375
3	3.5				0 216		0 300					0.437
3 1/2	4.0				0 226		0 318					
4	4.5				0 237		0 337		0 437			0.531
5	5.563				0 258		0 375		0 500			0.625
6	6.625				0 280		0 432		0 562			0.718
8	8.625		0 250	0 277	0 322	0 406	0 500	0 593	0 718	0 812		0.906
10	10.75		0 250	0 307	0 365	0 500	0 593	0 718	0 843	1 000		1.125
12*	12.75		0 250	0 330	0 406*	0 562*	0 687	0 843	1 000	1 125		1.312
14 O.D.	14.0	0 250	0 312	0 375	0 437	0 593	0 750	0 937	1 062	1.250		1.406
16 O.D.	16.0	0 250	0 312	0 375	0 500	0 656	0 843	1 031	1.218	1.437		1.562
18 O.D.	18.0	0 250	0 312	0 437	0 552	0 718	0 937	1.156	1.343	1.562		1.750
20 O.D.	20.0	0 250	0 375	0 500	0 593	0 812	1 031	1 250	1 500	1.750		1.937
24 O.D.	24.0	0 250	0 375	0 562	0 687	0.937	1 218	1.500	1.750	2.062		2.312
30 O.D.	30.0	0 312	0.500	0 625								

All dimensions are given in inches.

The decimal thicknesses listed for the respective pipe sizes represent their nominal or average wall dimensions. For tolerances on wall thickness, see appropriate material specification.

Thicknesses shown in bold-face type in schedules 30 and 40 are identical with thicknesses for "standard weight" pipe in former lists, those in schedules 60 and 80 are identical with thicknesses for "extra strong" pipe in former lists.

The schedule numbers indicate approximate values of the expression $1000 \times P/S$.

* Owing to a necessary departure from the old "standard weight" and "extra strong" thicknesses in the 12-in. size, schedules 40 and 60, the new thicknesses are not as yet stocked by all manufacturers and jobbers. Hence, where agreeable to the purchaser and suitable for the service conditions, the old "standard-weight" 0.375-in. wall pipe corresponding to a $1000 P/S$ value of 37.7 is still available and can be substituted for the 0.406-in. wall, and the old "extra-strong" 0.500-in. wall pipe corresponding to a $1000 P/S$ value of 55 can be substituted for the 0.562-in. wall

TABLE 7
DIMENSIONS OF WELDED WROUGHT-IRON PIPE
(American Standard B36.10-1939)

Nominal Pipe Size	Outside Diam	Nominal Wall Thicknesses for Schedule Numbers					
		Sched 10	Sched 20	Sched 30	Sched 40	Sched 60	Sched 80
1/8	0.405				0.070		0.098
1/4	0.540				0.090		0.122
3/8	0.675				0.093		0.129
1/2	0.840				0.111		0.151
3/4	1.050				0.115		0.157
1	1.315				0.136		0.183
1 1/4	1.660				0.143		0.195
1 1/2	1.900				0.148		0.204
2	2.375				0.158		0.223
2 1/2	2.875				0.208		0.282
3	3.5				0.221		0.306
3 1/2	4.0				0.231		0.325
4	4.5				0.242		0.344
5	5.563				0.263		0.383
6	6.625				0.286		0.441
8	8.625			0.283	0.329		0.510
10	10.75			0.313	0.372	0.510	0.606
12*	12.75			0.336	0.414*	0.574*	0.702
14 O.D.	14.0	0.250	0.312	0.375	0.437	0.625	0.750
16 O.D.	16.0	0.250	0.312	0.375	0.500	0.687	
18 O.D.	18.0	0.250	0.312	0.437	0.562	0.750	
20 O.D.	20.0		0.375	0.500	0.562		

All dimensions are given in inches.

The decimal thicknesses listed for the respective pipe sizes represent their nominal or average wall dimensions. For tolerances on wall thickness, see appropriate material specification.

Thicknesses shown in bold-face type in schedules 30 and 40 are identical with thicknesses for "standard weight" pipe in former lists; those in schedules 60 and 80 are identical with thicknesses for "extra strong" pipe in former lists.

The schedule numbers indicate approximate values of the expression $1000 \times P/S$.

* Owing to a necessary departure from the old "standard weight" and "extra strong" thicknesses in the 12-in. size, schedules 40 and 60, the new thicknesses are not as yet stocked by all manufacturers and jobbers. Hence, where agreeable for the purchaser and suitable for the service conditions, the old "standard weight" 0.382-in. wall pipe corresponding to a 1000 P/S value of 38.7 is still available and can be substituted for the 0.414-in. wall, and the old "extra strong" 0.510-in. wall pipe corresponding to a 1000 P/S value of 56.3 can be substituted for the 0.574-in. wall.

TABLE 8
DOUBLE EXTRA STRONG PIPE*

Note: The following table of "double extra strong"* pipe sizes, although not a part of any American Standard, is appended for the convenience of the user, inasmuch as, at the present time, this pipe is commercially available in both wrought iron and steel.

Nominal Pipe Size	Outside Diameter	Nominal Wall Thickness		Weight per Foot, Plain Ends
		Wrought Iron	Steel	
½	0 840	0 307	0.294	1.714
¾	1.050	0 318	0 308	2.440
1	1 315	0 369	0 358	3 659
1¼	1 660	0 393	0.382	5 214
1½	1 900	0 411	0 400	6 408
2	2 375	0 447	0 436	9.029
2½	2 875	0 565	0 552	13 695
3	3 500	0 615	0 600	18 583
4	4 500	0 690	0 674	27 541
5	5 563	0 768	0 750	38 552
6	6 625	0 884	0 864	53.160
8	8 625	0.895	0 875	72 424

All dimensions are given in inches
Weights are given in pounds per linear foot.
* Obsolete terminology.

The bursting strength of pipe shall be determined on the basis of the following formula:

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

where

P = bursting pressure of pipe, pounds per square inch.

S = minimum specified tensile strength of the pipe material, pounds per square inch.

t = minimum pipe wall thickness, inches. For the purpose of this formula, minimum thickness is defined as 87½% of the nominal thickness according to schedule numbers in ASA B36.10.

D = outside diameter of pipe, inches.

Standards for Pipe Nipples. Brass, steel, and wrought iron; National Bureau of Standards, Commercial Standard CS5-40.

ASA Recommended Standard (1940) covers steel, ferrous-alloy, and wrought-iron pipe nipples, black and zinc-coated, in iron-pipe sizes of $\frac{1}{8}$ to 12 in., inclusive, of standard lengths, and brass and copper nipples in iron-pipe sizes of $\frac{1}{8}$ to 6 in. inclusive, of standard lengths. Ferrous pipe nipples are to be furnished in the following types: Type A, Standard Weight, Type B, Extra Strong, and Type C, Double Extra Strong. Brass and copper pipe nipples are to be furnished in the following weights: Standard and Extra Strong. According to the proposed stand-

TABLE 9

FERROUS PIPE NIPPLES, STANDARD WEIGHT, BLACK, IRON-PIPE SIZES AND LENGTHS
(National Bureau of Standards, Commercial Standard CS5-40. American Standards Association recommended standard)

Iron-Pipe Size	Lengths				
	Close	Special Short	Short	Long	Extra Long
	Inches	Inches	Inches	Inches	Inches
$\frac{1}{8}$	$\frac{3}{4}$	1	$1\frac{1}{2}$	2, $2\frac{1}{2}$, 3, $3\frac{1}{2}$	4, $4\frac{1}{2}$, 5, $5\frac{1}{2}$, 6, 7, 8, 9, 10, 11, 12
$\frac{1}{4}$	$\frac{7}{8}$	$1\frac{1}{4}$	$1\frac{1}{2}$	2, $2\frac{1}{2}$, 3, $3\frac{1}{2}$	4, $4\frac{1}{2}$, 5, $5\frac{1}{2}$, 6, 7, 8, 9, 10, 11, 12
$\frac{3}{8}$	1	...	$1\frac{1}{2}$	2, $2\frac{1}{2}$, 3, $3\frac{1}{2}$	4, $4\frac{1}{2}$, 5, $5\frac{1}{2}$, 6, 7, 8, 9, 10, 11, 12
$\frac{1}{2}$	$1\frac{1}{8}$	...	$1\frac{1}{2}$	2, $2\frac{1}{2}$, 3, $3\frac{1}{2}$	4, $4\frac{1}{2}$, 5, $5\frac{1}{2}$, 6, 7, 8, 9, 10, 11, 12
$\frac{3}{4}$	$1\frac{3}{8}$	$1\frac{1}{2}$	2	$2\frac{1}{2}$, 3, $3\frac{1}{2}$, 4	$4\frac{1}{2}$, 5, $5\frac{1}{2}$, 6, 7, 8, 9, 10, 11, 12
1	$1\frac{1}{2}$	...	2	$2\frac{1}{2}$, 3, $3\frac{1}{2}$, 4	$4\frac{1}{2}$, 5, $5\frac{1}{2}$, 6, 7, 8, 9, 10, 11, 12
$1\frac{1}{4}$	$1\frac{5}{8}$	2	$2\frac{1}{2}$	3, $3\frac{1}{2}$, 4, $4\frac{1}{2}$	5, $5\frac{1}{2}$, 6, 7, 8, 9, 10, 11, 12
$1\frac{1}{2}$	$1\frac{3}{4}$	2	$2\frac{1}{2}$	3, $3\frac{1}{2}$, 4, $4\frac{1}{2}$	5, $5\frac{1}{2}$, 6, 7, 8, 9, 10, 11, 12
2	2	...	$2\frac{1}{2}$	3, $3\frac{1}{2}$, 4, $4\frac{1}{2}$	5, $5\frac{1}{2}$, 6, 7, 8, 9, 10, 11, 12
$2\frac{1}{2}$	$2\frac{1}{2}$	...	3	$3\frac{1}{2}$, 4, $4\frac{1}{2}$, 5	$5\frac{1}{2}$, 6, 7, 8, 9, 10, 11, 12
3	$2\frac{5}{8}$	...	3	$3\frac{1}{2}$, 4, $4\frac{1}{2}$, 5	$5\frac{1}{2}$, 6, 7, 8, 9, 10, 11, 12
$3\frac{1}{2}$	$2\frac{3}{4}$	...	4	$4\frac{1}{2}$, 5, $5\frac{1}{2}$, 6	7, 8, 9, 10, 11, 12
4	$2\frac{7}{8}$	...	4	$4\frac{1}{2}$, 5, $5\frac{1}{2}$, 6	7, 8, 9, 10, 11, 12
5	3	4	$4\frac{1}{2}$	5, $5\frac{1}{2}$, 6	7, 8, 9, 10, 11, 12
6	$3\frac{1}{8}$	4	$4\frac{1}{2}$	5, $5\frac{1}{2}$, 6	7, 8, 9, 10, 11, 12
8	$3\frac{1}{2}$	...	5	6, 7, 8	10, 12
10	$3\frac{7}{8}$	...	5	6, 7, 8	10, 12
12	$4\frac{1}{4}$	...	6	8	10, 12

ard, pipe nipples are to be threaded on both ends with standard taper pipe threads conforming to the American Standards for Pipe Threads, ASA B2. (Fed. Specs. GGG-P-351.)

ART. 3-D. FITTINGS

Definitions

Ammonia Fitting. A fitting whose material is especially homogeneous, which usually has its mouth countersunk, and both the mouth and the thread tinned (12).

Back Outlet Ell. An ell with an outlet in the same place as the run and on the outside of the curve (12).

Ball Joint. A flexible or non-flexible joint made in the shape of a ball or sphere. Many forms of joints—unions for example—employ such spherical surfaces (12).

Ball-Joint Union. A union embodying the principles of a ball joint (12). See *Ball Joint*.

Bead. When applied to fittings means the slight reinforcing ring on the end.

A circular molding (12).

Bell. In pipe fitting, the recesses or enlarged female end of a pipe into which the male end of the pipe fits; also called hub (12).

Bell and Spigot Joint. The usual term for the joint in cast-iron pipe. Each pipe is made with an enlarged diameter, or bell, at one end into which the plain or spigot end of another piece is inserted when laying. The joint is then made tight by cement, oakum, lead, rubber, or other suitable substance which is driven in or calked into the bell and around the spigot.

Matheson joint is the name applied to a similar joint in wrought pipe which has the bell formed of the pipe.

Applied to fittings or valves means that one end of the run is a "bell" and the other end is a "spigot," similar to those used on regular cast-iron pipe (12).

Bend. A curved length of pipe struck to a larger radius than the elbow.

Pipe bent to 45, 90, or 180 deg is often specified as $\frac{1}{8}$, $\frac{1}{4}$, or $\frac{1}{2}$ bends (12).

Branch Ell. Used to designate an elbow having a back outlet in line with one of the outlets of the run. It is also at times called a heel outlet (12).

Bull Head Tee. A tee whose branch is larger than the run (12).

Bushing. A pipe fitting for the purpose of connecting a pipe with fitting of larger size, being a hollowed plug with internal and external threads to suit the different diameters (12).

Cap. A fitting that goes over the end of a pipe to close it, producing a dead end (12).

Cleanout Fitting. One that is equipped with hand hole and cover so that pipes may be cleaned (12).

Close Return Bend. A short cast or malleable U-shaped fitting for uniting two parallel pipes. It differs from the open return bend in having the arms joined together (12).

Coupling. A threaded sleeve used to connect two pipes. Commercial couplings are threaded inside to suit exterior thread of pipe (12).

Cross. A pipe fitting with four branches arranged in pairs, each pair on one axis and the axes at right angles. When outlets are otherwise arranged, the fittings are branch pipes or specials (12).

Cross-Over. A small fitting like a double offset or the letter U with ends turned out. It is made only in small sizes and used to pass the flow of one pipe past another when the pipes are in the same plane (12).

Double Bend. A pipe or fitting shaped like the letter S in outline (12).

Dresser Joint. A peculiar form of Normandy joint. There are various styles (12).

Drop Elbow. A small-sized ell that is frequently used where gas is put into a building. These fittings have wings cast on each side. The wings have small countersunk holes so that they may be fastened by wood screws to ceiling or wall or framing timbers (12).

Drop Tee. One having the same peculiar wings as the drop elbow (12).

Eccentric Fitting. One having its opening on center lines that are not concentric, usually arranged so that the interior walls of one side are in one plane. So arranged for drainage purposes (12).

Eighth Bend. A bent pipe whose curved portion deflects the line one-eighth of a circle, 45 deg.

At times applied to the cast fitting which is more properly called a 45-deg elbow.

Elbow. Ell. A fitting that makes an angle between adjacent pipes. The angle is always 90 deg unless other angle is stated (12).

Fittings. A term used to denote all those pieces that may be attached to pipes in order to connect them or provide outlets, etc., except that couplings and valves are not so designated (12).

Flush Bushing. A fitting intended to reduce the opening of a given fitting by screwing in flush with the face of the fitting (12).

Goose Neck. A return or 180-deg bend, having one leg shorter than the other (12).

Ground Joint. One with the abutting ends ground to make a perfect fit without the use of any gasket or packing.

Hub. Usually means a cast-iron outside ring or collar used to join two pipes.

Bell end of cast-iron pipe, or similar end in fitting or valve.

Collar of a flange (12).

Increaser. In plumbing, a fitting to join the female end of a small pipe to the male end of a large pipe (12).

Long-Turn Fitting. A term variously employed to mean long sweep, long radius, or an angular branch; e.g., a long-turn branch may be one whose branch makes about 45 deg with the run, but end of branch is sharply turned to 90 deg to run (12).

Normandy Joint. A joint by which the plain ends of two pipes are connected by means of a sleeve whose ends are made tight by rings of packing, compressed between bolting rings and sleeve. There are many similar joints or modifications such as Dayton, Dresser, Hammond, etc. (12).

Offset Pipe. A pipe bent so as to offset a line, i.e., move the line to a position parallel to, but not in alignment with, remainder of the pipe.

A fitting to accomplish the same (12).

Open Return Bend. A short cast or malleable iron U-shaped tube for uniting two parallel pipes. It differs from a close return

in having the arms separated from each other (12).

Pipe Clamp. A metallic strap or band, made to fit around a pipe, gripping it closely, for the purpose of stopping leaks, etc., a piece of jointing material being usually compressed between the clamp and the pipe (12).

Pipe Coupling. A sleeve or socket of cylindrical form with female threads, which receives the ends of two adjacent pipe lengths (12).

Pipe Fittings. Connections, appliances, and adjuncts designed to be used in connection with pipes such as elbows and bends to alter the direction of a pipe; tees and crosses to connect a branch with a main; plugs and caps to close an end, bushings, diminishers or reducing sockets to couple two pipes of different dimensions, etc. (12).

Reducer. A fitting having a larger size at one end than at the other. Some have tried to establish the term "increaser," thinking of direction of flow, but this has arisen from a misunderstanding of the trade custom of giving always a fitting's largest size first; hence, all fittings having more than one size are reducers. They are always inside thread unless specified flanged or for some special joint.

Threaded type is made with abrupt reduction.

Flanged pattern has taper body.

Flanged eccentric pattern has taper body, but flanges at 90 deg to one side of body.

Misapplied at times to a reducing coupling (12).

Reducing Taper Elbow. A reducing elbow whose curved body uniformly decreases in diameter towards the smaller end (12).

Reducing Tee. Any tee having two different sizes of openings. It may reduce on the run or the branch (12).

Return Bend. 180-deg bend. Usually a fitting having inside threads. Often applied to a bent pipe. Always means the fitting unless otherwise specified (12).

S-Pipe. In pipe fitting, a pipe whose outline is roughly that of the letter S (12).

Saddle. Strictly the saddle piece, which,

assembled with the strap, or straps, makes a service clamp (12).

Service Box. Small valve box. Service box is the name usually employed for those boxes used with corporation or curb cocks (12).

Service Ell. An elbow having an outside thread on one end. Also known as *Street Ell* (12).

Service Tee. A tee having inside thread on one end and on branch, but outside thread on other end of run. Also known as *Street Tee*.

Side Outlet Ell. An ell with an outlet at right angles to plane of run.

Slant. A branch inserted in a sewer for the purpose of making connection thereto (16).

Sleeve. A coupling, collar, or hub.

Socket. A recess, or piece furnished with a recess, into which some other piece may be inserted and securely held, as a socket in the ground for the reception of a post or pole (12).

The enlarged and recessed end of a cast-iron pipe into which the opposite end of another pipe is inserted (12).

Socket Pipe. In pipe fitting, a cast-iron pipe which is provided with a socket at one end and a spigot at the other. The sockets of wrought pipes are couplings and are screwed over the ends on the outside diameter (12).

Socket Plug. A plug with a recessed face, into which a wrench will fit to turn the plug (4).

Spigot. The end of a pipe, fitting, or valve that is inserted into the bell end (12).

The tapered male part of an inserted joint (12).

A cock, tap, or faucet used to draw water, etc. (12).

Sweep. A term used to convey the idea that the curvature is not abrupt, i.e., that the flow may take place easily and without the formation of eddies (12).

Tee. A fitting, either cast or wrought, that has one side outlet at right angles to the run. A single outlet branch pipe (12).

Templet. A gage ring for thread. A drilling jig for holes in flanges (12).

Trap. A trap is a fitting or device so constructed as to prevent the passage of air or gas through a pipe without materially affecting the flow of sewage or waste water through it (1).

Tucker Fitting. A cast-iron coupling, one opening of which is threaded for screw pipe and the other opening has a hub to receive the spigot end of a pipe (4).

Union. The usual trade term for a device used to connect pipes. It commonly consists of three pieces which are, first, the thread end fitted with exterior and interior threads; second, the bottom end fitted with interior threads and a small exterior shoulder; third, the ring which has an inside flange at one end, while the other end has an inside thread like that on the exterior of the thread end. In use a gasket is placed between the thread and bottom ends, which are drawn together by the ring. Unions are very extensively used because they permit connecting with little disturbance of the pipe positions.

Some types of unions are made with the thread ends of brass, and the thread and bottom ends are ground to a practically perfect contact, ground joint unions (12).

Union Coupling. A term sometimes applied to a right- and left-handed turnbuckle, or sleeve nut, whereby two parts might be connected and drawn together without turning anything but the coupling (12).

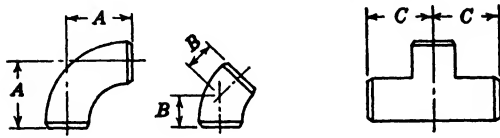
Union Ell. An ell with a male or female union at one end (12).

Union Tee. A tee with male or female union at connection on one end of run (12).

Wye (Y). A fitting either cast or wrought, that has one side outlet at any angle other than 90 deg. Usually set 45 deg, and always so set unless angle is specified. It is usually indicated by the letter Y (12).

Y-Branch (a Wye). Sometimes used to designate a fitting whose shape is nearly like that of a single sweep tee (12).

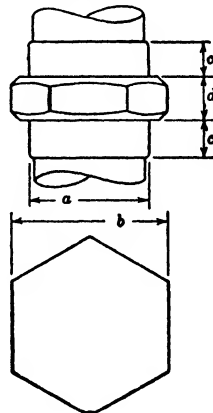
TABLE 10
 BUTT-WELDING FITTINGS
 (ASA B16 Tentative HPCNA, MSS, ASME)



	A	B	C
1	1½	7⁄8	1½
1¼	17⁄8	1	17⁄8
1½	2¼	1½	2¼
2	3	1¾	2½
2½	3¾	1¾	3
3	4½	2	3¾
3½	5¼	2¼	3¾
4	6	2½	4¾
5	7½	3¾	47⁄8
6	9	3¾	5¾
8	12	5	7
10	15	6¼	8½
12	18	7½	10

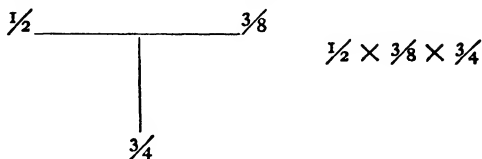
TABLE 11
 SCREWED PIPE UNIONS
 (Approximate Dimensions in Inches)

Size	a	b	c	d
¾	7⁄8	1½	¾	¾
½	1¼	1¾	¾	7⁄8
¾	1¾	2	¾	7⁄8
1	1¾	2½	7⁄8	1
1¼	2¼	27⁄8	1	1½
1½	2¾	3¼	1	1½
2	27⁄8	3¾	1½	1¼
2½	3¾	4¾	1¼	1¼
3	4	5¾	1¾	1¾
4	5¾	6¾	1½	17⁄8



Tees

In describing tees, the run is named first, then the outlet, thus:

**ART. 3-E. FLANGED CONNECTIONS****Definitions**

Blank Flange. A flange that is not drilled, but which is otherwise complete (12). (Not to be confused with a blind flange.)

Blind Flange. A flange used to close the end of a pipe (12).

Collar. The sleeve in the back of certain styles of flanges, such as a riveted flange, is called a collar (12).

Companion Flange. A flange suited to connect with a fitting, valve, screw on pipe, and conforming with the American Standard.

When specified to be drilled, the drilling will conform to the same standard unless otherwise specified (12).

Drilled. Used in connection with flanges to indicate that the bolt holes have been made by a drill, i.e., not made by cores (12).

Faced After. A term used on flanged work to mean that flanges are faced after they are attached to pipe and that ends of pipe are faced flush with flange, both being at right angles to general axis of pipe (12).

Flange. A projecting rim, edge, lip, or rib (12).

Flange Union. A fitting consisting of a pair of flanges and bolts to connect them for use on threaded pipe (12).

Flanged. When applied to a fitting it is used to distinguish it from screwed fittings which are always furnished unless flanges or other style of joint is specified.

When applied to pipe it means fitted with flanges (12).

Flanged Joint. A joint in pipes made by flanges bolted together (12).

Raised Face. A term used to indicate that flanges are faced $\frac{1}{16}$ in. or so higher inside the bolt circle (12).

Tongue and Groove. Usually applied to flange connections by forming a tongue on one flange and a groove on the other flange. Usually placed about midway between bolts and inside diameter of pipe. The gasket is placed in the groove. The depth of the groove should equal the thickness of the gasket plus $\frac{1}{16}$ in. (12).

Standards for Flanged Fittings

Flange dimensions, standard (Classes 125 and 250 cast-iron flanges, Classes 150 and 250 bronze flanges), Fed. Specs. WW-F-406.

American Standard, cast-iron pipe flanges and flanged fittings, Class 125, ASME, MSS, HPCNA, ASA B16a.

American Standard, cast-iron pipe flanges and flanged fittings, Class 25, ASME, MSS, HPCNA, ASA B16b2.

American Standard, steel pipe flanges and flanged fittings, ASME, MSS, HPCNA, ASA B16c.

CAST-IRON SOIL PIPE AND FITTINGS

(American Standard ASA A40.1)

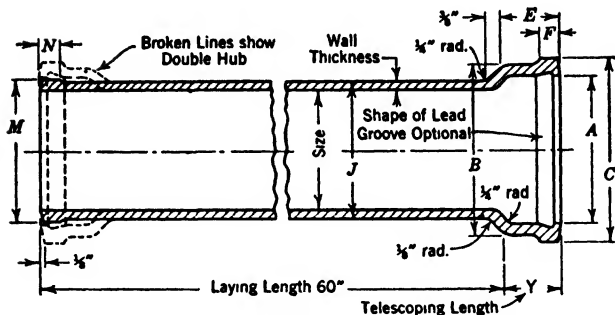
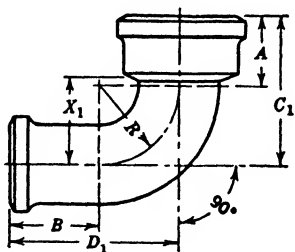


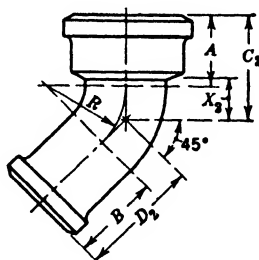
TABLE 12. HUBS AND SPIGOTS FOR EXTRA HEAVY SOIL PIPE AND FITTINGS

Size	Diam A	Diam B	Diam C	E	F	Apprx Wall Thickness	Diam J	Diam M	N	Y
2	3 1/4	3 3/4	3 13/16	2 1/4	3/4	3/16	2 1/8	2 1/4	1 1/4	2 3/4
3	4 1/4	4 13/16	5 1/8	2 11/16	1 1/8	3/8	3 3/4	3 7/8	3/4	2 3/4
4	5 1/4	5 13/16	6 3/8	2 15/16	1 3/8	1/2	4 1/4	4 7/8	1 1/4	3—
5	6 1/4	6 13/16	7 3/8	2 15/16	1 3/8	1/2	5 1/4	5 7/8	1 1/4	3—
6	7 1/4	7 13/16	8 3/8	2 15/16	1 3/8	1/2	6 1/4	6 7/8	1 1/4	3—
8	9 1/4	10 1/8	10 7/8	3 3/8	1 3/4	3/4	8 1/4	9	1 1/4	3 3/4
10	11 1/4	12 5/8	13 1/4	3 3/8	1 3/4	3/4	10 3/4	11 1/4	1 1/4	3 3/4
12	13 1/4	14 3/4	15 1/4	4 1/8	1 7/8	3/4	12 1/4	13 1/4	1 1/4	4 1/4
15	17	18 1/4	18 3/4	4 1/8	1 7/8	3/4	15 7/8	16 3/4	1 3/4	4 3/4

TABLE 13



1/4 BENDS



1/8 BENDS

Size	A	B	C ₁	C ₂	D ₁	D ₂	R	X ₁	X ₂
2	2 3/4	3—	5 1/4	4—	6—	4 1/4	3—	3 3/4	1 1/4
3	3 3/4	3 3/4	6 3/4	4 11/16	7—	4 13/16	3 3/4	4—	1 13/16
4	3 3/4	4—	7 1/4	5 3/16	8—	5 11/16	4—	4 3/4	2 3/16
5	3 3/4	4—	8—	5 3/8	9—	5 7/8	4 3/4	5—	2 3/8
6	3 3/4	4—	8 3/4	5 3/8	9—	5 7/8	4 3/4	5—	2 3/8
8	4 1/4	5 3/4	10 3/4	6 5/8	11 3/4	8 1/4	5—	5 3/4	2 3/4
10	4 1/4	5 3/4	11 1/4	7—	12 3/4	8 3/4	6—	6 3/4	3 3/4
12	5—	7—	13—	8 3/8	15—	10 3/4	7—	7 3/4	3 3/4
15	5—	7—	14 3/4	8 13/16	16 3/4	10 13/16	8 3/4	8 3/4	4 1/4

All dimensions given in inches.

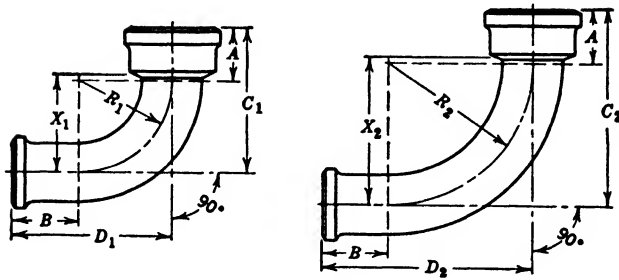
The length of a bend is the distance from the intersection of the hub and spigot center lines to the end of the spigot, shown as Dimension D.

Dimensions D and X are laying lengths.

CAST-IRON SOIL PIPE AND FITTINGS

(American Standards ASA A40.1)

TABLE 14

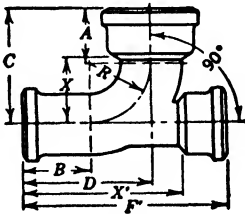


SHORT SWEEPS

LONG SWEEPS

Size	A	B	C ₁	C ₂	D ₁	D ₂	R ₁	R ₂	X ₁	X ₂
2	2 3/4	3—	7 3/4	10 3/4	8—	11—	5—	8—	5 1/4	8 3/4
3	3 3/4	3 3/4	8 3/4	11 3/4	9—	12—	5 1/2	8 1/2	6—	9—
4	3 3/4	4—	9 1/2	12 1/2	10—	13—	6—	9—	6 1/2	9 1/2
5	3 3/4	4—	10—	13—	10 1/2	13 1/2	6 1/2	9 1/2	7—	10—
6	3 3/4	4—	10 1/2	13 1/2	11—	14—	7—	10—	7 1/2	10 1/2
8	4 1/4	5 1/2	12 1/4	15 1/4	13 1/2	16 1/2	8—	11—	8 3/4	11 3/4
10	4 1/4	5 1/2	13 1/4	16 1/4	14 1/2	17 1/2	9—	12—	9 3/4	12 3/4
12	5—	7—	15—	18—	17—	20—	10—	13—	10 3/4	13 3/4
15	5—	7—	16 1/2	19 1/2	18 1/2	21 1/2	11 1/2	14 1/2	12 1/2	15 1/2

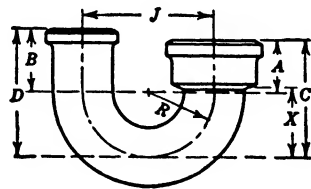
TABLE 15



1/4 BENDS WITH HEEL INLETS

Size	A	B	C	D	F'	R	X	X'
3 x 2	3 3/4	3 3/4	6 3/4	7—	11 3/4	3 3/4	4—	9—
4 x 2	3 3/4	4—	7 3/4	8—	13—	4—	4 3/4	10 1/2
4 x 3	3 3/4	4—	7 3/4	8—	13 3/4	4—	4 3/4	10 3/4
5 x 2	3 3/4	4—	8—	8 3/4	14 3/4	4 1/2	5—	11 1/4
5 x 3	3 3/4	4—	8—	8 3/4	14 3/4	4 1/2	5—	11 3/4
5 x 4	3 3/4	4—	8—	8 3/4	14 3/4	4 1/2	5—	11 3/4
6 x 2	3 3/4	4—	8 3/4	9—	15—	5—	5 3/4	12 3/4
6 x 3	3 3/4	4—	8 3/4	9—	15 3/4	5—	5 3/4	12 3/4
6 x 4	3 3/4	4—	8 3/4	9—	15 3/4	5—	5 3/4	12 3/4

TABLE 16



RETURN BENDS

Size	A	B	C ₁	D ₁	J	R ₁	X
2	2 3/4	3—	5 3/4	6—	6	3—	3 3/4
3	3 3/4	3 3/4	6 3/4	7—	7	3 3/4	4—
4	3 3/4	4—	7 3/4	8—	8	4—	4 3/4
5	3 3/4	4—	8—	8 3/4	9	4 3/4	5—
6	3 3/4	4—	8 3/4	9—	10	5—	5 3/4
8	4 1/2	5 1/2	10 1/4	11 1/4	12	6—	6 3/4

All dimensions given in inches.
 The length of a bend is the distance from the intersection of the hub and spigot center lines to the end of the spigot, shown as dimension D.
 Dimensions D and X are laying lengths.

CAST-IRON SOIL PIPE AND FITTINGS
(American Standard ASA A40.1)

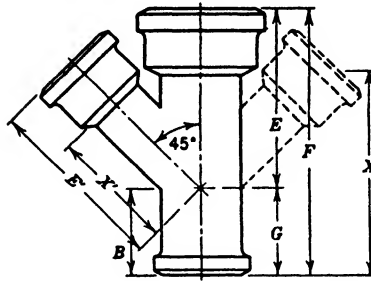


TABLE 17. SINGLE AND DOUBLE "Y" BRANCHES

Size	B (Min)	E	E'	F	G	X ¹	X' ¹
2	3 3/4	6 3/4	6 3/4	10 3/4	4—	8—	4—
3	4—	8 1/4	8 1/4	13 3/4	5—	10 3/4	5 3/4
4	4—	9 3/4	9 3/4	15—	5 1/2	12—	6 3/4
5	4—	11—	11—	16 3/4	5 3/4	13 3/4	8—
6	4—	12 1/4	12 1/4	18—	5 3/4	15—	9 1/4
8	5 3/4	15 5/8	15 5/8	23—	7 1/2	19 3/4	11 1/2
10	5 3/4	18—	18—	26—	8—	22 3/4	14 3/4
12	7—	21 1/4	21 1/4	31 3/4	10 3/8	27—	16 7/8
15	7—	25—	25—	35 3/4	10 3/4	31 3/4	20 3/4
3 x 2	4—	7 5/8	7 1/2	11 3/4	4 5/8	9—	5—
4 x 2	4—	8 3/8	8 3/4	12—	3 5/8	9—	5 3/4
4 x 3	4—	9 1/8	9—	13 3/4	4 1/8	10 3/4	6 3/4
5 x 2	4—	8 7/8	9—	12—	3 7/8	9—	6 3/4
5 x 3	4—	9 3/8	9 3/4	13 3/4	3 7/8	10 3/4	7—
5 x 4	4—	10 5/8	10 3/4	15—	4 1/8	12—	7 3/4
6 x 2	4—	9 7/8	9 3/4	12—	2 7/8	9—	7 3/4
6 x 3	4—	10 3/8	10 3/4	13 3/4	3 3/8	10 3/4	7 3/4
6 x 4	4—	10 7/8	11 3/4	15—	4 1/8	12—	8 3/4
6 x 5	4—	11 5/8	11 3/4	16 3/4	4 1/8	13 3/4	8 3/4
8 x 2	5 3/4	10 7/8	11—	14—	3 3/8	10 3/4	8 3/4
8 x 3	5 3/4	11 5/8	11 3/4	15 3/4	3 1/2	12—	9—
8 x 4	5 3/4	12 3/4	12 3/4	17—	4 3/8	13 3/4	9 3/4
8 x 5	5 3/4	13—	13—	18 3/4	5 3/8	15—	10—
8 x 6	5 3/4	13 1/8	13 3/4	20—	6 5/8	16 3/4	10 3/4
10 x 4	5 3/4	13 7/8	14 3/4	17—	3 7/8	13 3/4	11 3/4
10 x 5	5 3/4	14 3/8	14 3/4	18 3/4	4 3/8	15—	11 3/4
10 x 6	5 3/4	14 3/4	15 3/4	20—	5 3/8	16 3/4	12 3/4
10 x 8	5 3/4	16 3/4	16 3/4	23—	6 3/8	19 3/4	13 7/8
12 x 4	7—	15 3/4	15 3/4	19 3/4	4 3/8	15—	12 7/8
12 x 5	7—	15 7/8	15 3/4	20 3/4	4 7/8	16 3/4	12 7/8
12 x 6	7—	16 3/8	16 3/4	22 3/4	5 1/8	18—	13 7/8
12 x 8	7—	18 3/8	18 3/4	25 3/4	7 1/8	21—	14 3/4
12 x 10	7—	19 1/8	19 3/4	28 3/4	8 3/8	24—	15 3/4
15 x 6	7—	18 3/4	18 3/4	22 3/4	4—	18—	15 3/4
15 x 8	7—	19 3/4	20 3/4	25 3/4	5 3/8	21—	17 3/4
15 x 10	7—	21 3/4	21 3/4	28 3/4	6 3/8	24—	18 3/4
15 x 12	7—	22 3/8	23 3/4	31 3/4	8 3/8	27—	19 3/4

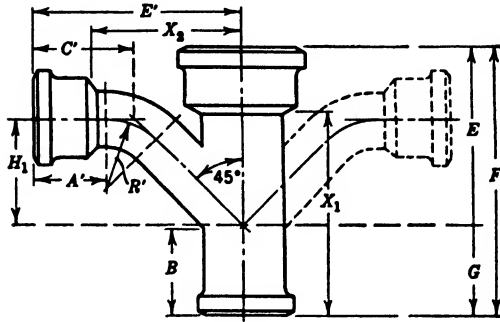
All dimensions given in inches.

¹ Dimensions X and X' are laying lengths.

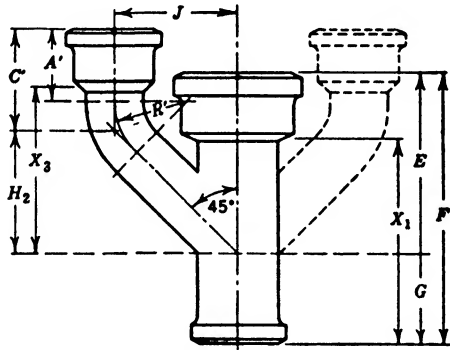
CAST-IRON SOIL PIPE AND FITTINGS

(American Standard ASA A40.1)

TABLE 18



SINGLE AND DOUBLE COMBINATION "Y" AND $\frac{1}{8}$ BENDS



SINGLE AND DOUBLE UPRIGHT "Y" BRANCHES

Size	A'	B (Min)	C'	E	E'	F	G	H ₁	H ₂	J	R'	X ₁	X ₂	X ₃
2	2 $\frac{3}{4}$	3 $\frac{3}{8}$	4—	6 $\frac{3}{8}$	7 $\frac{3}{8}$	10 $\frac{3}{8}$	4—	3 $\frac{3}{8}$	4 $\frac{3}{8}$	4 $\frac{3}{8}$	3—	8—	4 $\frac{7}{8}$	6—
3	3 $\frac{1}{2}$	4—	4 $\frac{11}{16}$	8 $\frac{3}{8}$	9 $\frac{3}{8}$	13 $\frac{3}{8}$	5—	5 $\frac{11}{16}$	5 $\frac{3}{8}$	5 $\frac{3}{8}$	3 $\frac{3}{8}$	10 $\frac{3}{8}$	7—	7 $\frac{7}{16}$
4	3 $\frac{3}{4}$	4—	5 $\frac{1}{16}$	9 $\frac{3}{8}$	12—	15—	5 $\frac{3}{8}$	6 $\frac{11}{16}$	6 $\frac{3}{8}$	6 $\frac{3}{8}$	4—	12—	9—	8 $\frac{11}{16}$
5	3 $\frac{1}{2}$	4—	5 $\frac{1}{8}$	11—	14—	16 $\frac{3}{8}$	5 $\frac{3}{8}$	8 $\frac{5}{16}$	7 $\frac{3}{8}$	7 $\frac{3}{8}$	4 $\frac{3}{8}$	13 $\frac{3}{8}$	11—	9 $\frac{7}{8}$
6	3 $\frac{3}{4}$	4—	5 $\frac{3}{8}$	12 $\frac{3}{8}$	15 $\frac{7}{8}$	18—	5 $\frac{3}{8}$	10 $\frac{5}{16}$	8 $\frac{3}{8}$	8 $\frac{3}{8}$	5—	15—	12 $\frac{3}{8}$	11 $\frac{3}{8}$
3 x 2	3—	4—	4 $\frac{3}{8}$	7 $\frac{7}{16}$	8 $\frac{3}{8}$	11 $\frac{3}{8}$	4 $\frac{3}{8}$	4—	5—	5—	3—	9—	5 $\frac{3}{8}$	6 $\frac{3}{8}$
4 x 2	3—	4—	4 $\frac{3}{8}$	8 $\frac{3}{8}$	8 $\frac{3}{8}$	12—	3 $\frac{11}{16}$	4 $\frac{3}{8}$	5 $\frac{3}{8}$	5 $\frac{3}{8}$	3—	9—	6 $\frac{3}{8}$	7 $\frac{3}{8}$
4 x 3	3 $\frac{3}{4}$	4—	4 $\frac{11}{16}$	9—	10 $\frac{3}{8}$	13 $\frac{3}{8}$	4 $\frac{3}{8}$	5 $\frac{3}{8}$	6—	6—	3 $\frac{3}{8}$	10 $\frac{3}{8}$	7 $\frac{3}{8}$	7 $\frac{3}{8}$
5 x 2	3—	4—	4 $\frac{3}{8}$	8 $\frac{3}{8}$	9 $\frac{3}{8}$	12—	3 $\frac{3}{8}$	5—	6—	6—	3—	9—	6 $\frac{3}{8}$	7 $\frac{3}{8}$
5 x 3	3 $\frac{3}{4}$	4—	4 $\frac{11}{16}$	9 $\frac{3}{8}$	10 $\frac{3}{8}$	13 $\frac{3}{8}$	4—	6 $\frac{1}{16}$	6 $\frac{3}{8}$	6 $\frac{3}{8}$	3 $\frac{3}{8}$	10 $\frac{3}{8}$	8—	8 $\frac{3}{8}$
5 x 4	3 $\frac{3}{4}$	4—	5 $\frac{1}{16}$	10 $\frac{3}{8}$	12 $\frac{3}{8}$	15—	4 $\frac{3}{8}$	7 $\frac{5}{16}$	7—	7—	4—	12—	9 $\frac{3}{8}$	9 $\frac{3}{8}$
6 x 2	3—	4—	4 $\frac{3}{8}$	9 $\frac{5}{16}$	9 $\frac{3}{8}$	12—	2 $\frac{11}{16}$	5 $\frac{3}{8}$	6 $\frac{3}{8}$	6 $\frac{3}{8}$	3—	9—	7 $\frac{3}{8}$	8 $\frac{3}{8}$
6 x 3	3 $\frac{3}{4}$	4—	4 $\frac{11}{16}$	10—	11 $\frac{3}{8}$	13 $\frac{3}{8}$	3 $\frac{3}{8}$	6 $\frac{1}{16}$	7—	7—	3 $\frac{3}{8}$	10 $\frac{3}{8}$	8 $\frac{3}{8}$	8 $\frac{3}{8}$
6 x 4	3 $\frac{3}{4}$	4—	5 $\frac{3}{16}$	10 $\frac{3}{8}$	13—	15—	4 $\frac{3}{8}$	7 $\frac{13}{16}$	7 $\frac{3}{8}$	7 $\frac{3}{8}$	4—	12—	10—	9 $\frac{11}{16}$
6 x 5	3 $\frac{3}{4}$	4—	5 $\frac{3}{8}$	11 $\frac{7}{16}$	14 $\frac{3}{8}$	16 $\frac{3}{8}$	5 $\frac{3}{8}$	9 $\frac{3}{8}$	8—	8—	4 $\frac{3}{8}$	13 $\frac{3}{8}$	11 $\frac{3}{8}$	10 $\frac{3}{8}$

All dimensions given in inches

Dimensions X₁ and X₂ are laying lengths.

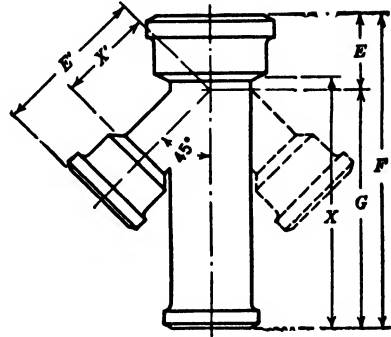
Position of branch inlets eliminates splash and direct passage.

CAST-IRON SOIL PIPE AND FITTINGS

(American Standard ASA A40.1)

TABLE 19

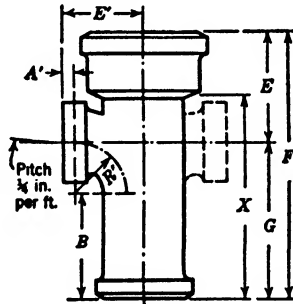
Size	E	E'	F	G	X ¹	X' ¹
2	3 3/4	5 7/8	12—	8 3/4	9 3/4	3 3/8
3	4—	7 3/8	15 1/4	11 1/4	12 3/8	4 3/8
4	4 3/4	8 7/8	17—	12 3/4	14—	5 3/8
5	4 3/4	10 3/8	18 3/4	13 3/4	15 3/8	7 3/8
6	5—	11 3/8	20—	15—	17—	8 3/8
3 x 2	3 3/4	6 3/8	13 3/4	10 3/4	11—	4 3/8
4 x 2	3 3/4	7 3/8	14—	10 15/16	11—	4 3/8
4 x 3	3 3/4	8 1/8	15 3/4	11 3/4	12 3/8	5 3/8
5 x 2	2 3/4	8 1/8	14—	11 3/4	11—	5 3/8
5 x 3	3 3/4	8 15/16	15 3/4	12 3/8	12 3/8	6 3/8
5 x 4	4—	9 3/8	17—	13—	14—	6 3/8
6 x 2	2 3/4	8 3/8	14—	11 15/16	11—	6 1/4
6 x 3	2 7/8	9 3/8	15 3/4	12 3/8	12 3/8	6 3/4
6 x 4	3 3/4	10 3/8	17—	13 3/8	14—	7 3/4
6 x 5	4 3/4	10 3/8	18 3/4	14 3/4	15 3/8	7 3/4



All dimensions given in inches.
¹ Dimensions X and X' are laying lengths.

SINGLE AND DOUBLE INVERTED "Y" BRANCHES

TABLE 20



SINGLE AND DOUBLE TAPPED SANITARY "T" BRANCHES

Size ¹	A'	B	E	E'	F	G	R'	X ²
2 x 2	1 1/2	4—	4 3/4	3 1/8	10 1/2	6 1/2	2 3/4	8
3 x 2	1 1/2	4 3/4	4 3/4	3 3/8	11 3/4	7—	2 3/4	9
4 x 2	1 1/2	4 3/4	5—	4 1/8	12—	7—	2 3/4	9
5 x 2	1 1/2	4 3/4	5—	4 3/8	12—	7—	2 3/4	9
6 x 2	1 1/2	4 3/4	5—	5 1/8	12—	7—	2 3/4	9

All dimensions given in inches.

- ¹ For 2-in. size with 1 1/4 in. or 1 3/8 in. tapping, B = 4 3/4 in. and R' = 1 3/4 in.
- For 3-in. size and larger with 1 1/4 in. or 1 3/8 in. tapping, B = 5 1/4 in. and R' = 1 3/4 in.
- For 2-in. size with 1 1/4 in. or 1 3/8 in. tapping, E' = 2 15/16 in.
- For 3-in. size with 1 1/4 in. or 1 3/8 in. tapping, E' = 3 3/8 in.
- For 4-in. size with 1 1/4 in. or 1 3/8 in. tapping, E' = 3 15/16 in.
- For 5-in. size with 1 1/4 in. or 1 3/8 in. tapping, E' = 4 3/8 in.
- For 6-in. size with 1 1/4 in. or 1 3/8 in. tapping, E' = 4 15/16 in.

Other dimensions same as above.

² Dimension X is the laying length.

³ Branches shall be tapped in accordance with the American Standard Taper Pipe Thread, ASA-B2.

CAST-IRON SOIL PIPE AND FITTINGS

(American Standard ASA A40.1)

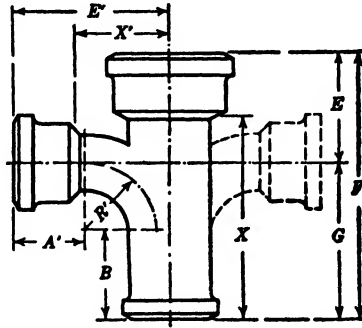


TABLE 21. SINGLE AND DOUBLE SANITARY "T" BRANCHES

Size	A'	B	E	E'	F	G	R'	X ¹	X' ¹
2	2 3/4	3 3/4	4 3/4	5 3/4	10 3/4	6 3/4	2 3/4	8—	2 3/4
3	3 3/4	4—	5 3/4	6 3/4	12 3/4	7 3/4	3 3/4	10—	4—
4	3 3/4	4—	6—	7 3/4	14—	8—	4—	11—	4 3/4
5	3 3/4	4—	6 3/4	8—	15—	8 3/4	4 3/4	12—	5—
6	3 3/4	4—	7—	8 3/4	16—	9—	5—	13—	5 3/4
8	4 1/4	5 3/4	8 3/4	10 1/4	20 3/4	11 3/4	6—	17—	6 3/4
10	4 1/4	5 3/4	9 3/4	11 1/4	22 3/4	12 3/4	7—	19—	7 3/4
12	5—	7—	11 3/4	13—	26 3/4	15—	8—	22 3/4	8 3/4
15	5—	7—	13 3/4	14 3/4	29 3/4	16 3/4	9 3/4	25 3/4	10 3/4
3 x 2	3—	4—	4 3/4	6 3/4	11 3/4	7—	3—	9—	4—
4 x 2	3—	4—	5—	7—	12—	7—	3—	9—	4 3/4
4 x 3	3 3/4	4—	5 3/4	7 3/4	13—	7 3/4	3 3/4	10—	4 3/4
5 x 2	3—	4—	5—	7 3/4	12—	7—	3—	9—	5—
5 x 3	3 3/4	4—	5 3/4	7 3/4	13—	7 3/4	3 3/4	10—	5—
5 x 4	3 3/4	4—	6—	8—	14—	8—	4—	11—	5—
6 x 2	3—	4—	5—	8—	12—	7—	3—	9—	5 3/4
6 x 3	3 3/4	4—	5 3/4	8 3/4	13—	7 3/4	3 3/4	10—	5 3/4
6 x 4	3 3/4	4—	6—	8 3/4	14—	8—	4—	11—	5 3/4
6 x 5	3 3/4	4—	6 3/4	8 3/4	15—	8 3/4	4 3/4	12—	5 3/4
8 x 2	3—	5 3/4	5 3/4	9—	14 3/4	8 3/4	3—	11—	6 3/4
8 x 3	3 3/4	5 3/4	6 3/4	9 3/4	15 3/4	9 3/4	3 3/4	12—	6 3/4
8 x 4	3 3/4	5 3/4	6 3/4	9 3/4	16 3/4	9 3/4	4—	13—	6 3/4
8 x 5	3 3/4	5 3/4	7 3/4	9 3/4	17 3/4	10 3/4	4 3/4	14—	6 3/4
8 x 6	3 3/4	5 3/4	7 3/4	9 3/4	18 3/4	10 3/4	5—	15—	6 3/4
10 x 4	3 3/4	5 3/4	6 3/4	10 3/4	16 3/4	9 3/4	4—	13—	7 3/4
10 x 5	3 3/4	5 3/4	7 3/4	10 3/4	17 3/4	10 3/4	4 3/4	14—	7 3/4
10 x 6	3 3/4	5 3/4	7 3/4	10 3/4	18 3/4	10 3/4	5—	15—	7 3/4
10 x 8	4 3/4	5 3/4	8 3/4	11 3/4	20 3/4	11 3/4	6—	17—	7 3/4
12 x 4	3 3/4	7—	7 3/4	11 3/4	18 3/4	11—	4—	14 3/4	8 3/4
12 x 5	3 3/4	7—	8 3/4	11 3/4	19 3/4	11 3/4	4 3/4	15 3/4	8 3/4
12 x 6	3 3/4	7—	8 3/4	11 3/4	20 3/4	12—	5—	16 3/4	8 3/4
12 x 8	4 3/4	7—	9 3/4	12 3/4	22 3/4	13—	6—	18 3/4	8 3/4
12 x 10	4 3/4	7—	10 3/4	12 3/4	24 3/4	14—	7—	20 3/4	8 3/4
15 x 6	3 3/4	7—	8 3/4	13—	20 3/4	12—	5—	16 3/4	10—
15 x 8	4 3/4	7—	9 3/4	13 3/4	22 3/4	13—	6—	18 3/4	10 3/4
15 x 10	4 3/4	7—	10 3/4	13 3/4	24 3/4	14—	7—	20 3/4	10 3/4
15 x 12	5—	7—	11 3/4	14 3/4	26 3/4	15—	8—	22 3/4	10 3/4

All dimensions given in inches.

¹ Dimensions X and X' are laying lengths.

CAST-IRON SOIL PIPE AND FITTINGS

(American Standard ASA A40.1)

TABLE 22. SINGLE AND DOUBLE TAPPED "T" BRANCHES¹

Size	E	E' ²	F	G	X ³	Weight, Single	Weight, Double
2 x 2	4 1/4	2	10 1/4	6 1/4	8	7	8
3 x 2	4 3/4	2 1/2	11 1/4	7	9	12	13
4 x 2	5	3	12	7	9	15	17
5 x 2	5	3 1/2	12	7	9	18	19
6 x 2	5	4	12	7	9	20	22

All dimensions given in inches.

¹ Tapped "T" Branches are approved for venting and cleanout purposes only and all tee openings are disapproved for use as waste inlets.

² Tapping boss may be tapped for 1 1/4-in. to 2-in. pipe threads, inclusive.

³ Branches shall be tapped in accordance with the American Standard Taper Pipe Thread, ASA-B2.

⁴ Dimension X is the laying length.

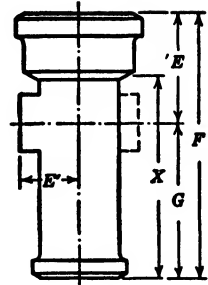
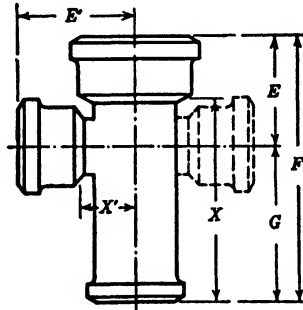


TABLE 23. SINGLE AND DOUBLE "T" BRANCHES¹



Size	E	E'	F	G	X ²	X' ²
2	4 1/4	4 1/4	10 1/4	6 1/4	8	1 1/4
3	5 1/4	5 1/4	12 1/4	7 1/4	10	2 1/4
4	6	6	14	8	11	3
5	6 1/2	6 1/2	15	8 1/2	12	3 1/2
6	7	7	16	9	13	4
8	8 1/2	8 1/2	20 1/2	11 1/2	17	5 1/2
10	9 1/2	9 1/2	22 1/2	12 1/2	19	6 1/2
12	11 1/2	11 1/2	26 1/2	15	22 1/2	7 1/2
15	13 1/2	13 1/2	29 1/2	16 1/2	25 1/2	9
3 x 2	4 3/4	5	11 1/4	7	9	2 1/2
4 x 2	5	5 1/2	12	7	9	3
4 x 3	5 1/2	5 1/2	13	7 1/2	10	3
5 x 2	5	6	12	7	9	3 1/2
5 x 3	5 1/2	6 1/2	13	7 1/2	10	3 1/2
5 x 4	6	6 1/2	14	8	11	3 1/2
6 x 2	5	6 1/2	12	7	9	4
6 x 3	5 1/2	6 1/2	13	7 1/2	10	4
6 x 4	6	7	14	8	11	4
6 x 5	6 1/2	7	15	8 1/2	12	4

Size	E	E'	F	G	X ²	X' ²
8 x 2	5 1/2	7 1/2	14 1/2	8 1/2	11	5 1/2
8 x 3	6 1/2	8	15 1/2	9 1/2	12	5 1/2
8 x 4	6 1/2	8 1/2	16 1/2	9 1/2	13	5 1/2
8 x 5	7 1/2	8 1/2	17 1/2	10 1/2	14	5 1/2
8 x 6	7 1/2	8 1/2	18 1/2	10 1/2	15	5 1/2
10 x 4	6 1/2	9 1/2	16 1/2	9 1/2	13	6 1/2
10 x 5	7 1/2	9 1/2	17 1/2	10 1/2	14	6 1/2
10 x 6	7 1/2	9 1/2	18 1/2	10 1/2	15	6 1/2
10 x 8	8 1/2	9 1/2	20 1/2	11 1/2	17	6 1/2
12 x 4	7 1/2	10 1/2	18 1/2	11 1/2	14 1/2	7 1/2
12 x 5	8	10 1/2	19 1/2	11 1/2	15 1/2	7 1/2
12 x 6	8 1/2	10 1/2	20 1/2	12 1/2	16 1/2	7 1/2
12 x 8	8 1/2	10 1/2	22 1/2	13	18 1/2	7 1/2
12 x 10	10 1/2	10 1/2	24 1/2	14	20 1/2	7 1/2
15 x 6	8 1/2	11 1/2	20 1/2	12 1/2	16 1/2	8 1/2
15 x 8	9 1/2	12 1/2	22 1/2	13	18 1/2	8 1/2
15 x 10	10 1/2	12 1/2	24 1/2	14	20 1/2	8 1/2
15 x 12	11 1/2	13 1/2	26 1/2	15	22 1/2	9

All dimensions given in inches.

¹ Tee branches are approved for venting and cleanout purposes only and all tee openings are disapproved for use as waste inlets.

² Dimensions X and X' are laying lengths.

CAST-IRON SOIL PIPE AND FITTINGS
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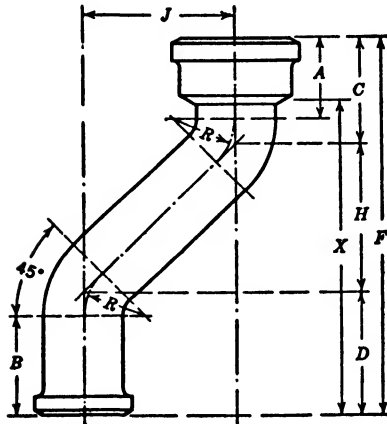


TABLE 24. 2-INCH 1/8 BEND OFFSETS

Size	A	B	C	D	F	H	J	R	X ¹
2 x 2	2 1/4	3 1/4	3 1/4	4 1/4	9 3/4	2	2	2	7 1/4
2 x 4	2 3/4	3 3/4	3 3/4	4 3/4	11 3/4	4	4	2	9 3/4
2 x 6	2 3/4	3 3/4	3 3/4	4 3/4	13 3/4	6	6	2	11 3/4
2 x 8	2 3/4	3 3/4	3 3/4	4 3/4	15 3/4	8	8	2	13 3/4
2 x 10	2 3/4	3 3/4	3 3/4	4 3/4	17 3/4	10	10	2	15 3/4
2 x 12	2 3/4	3 3/4	3 3/4	4 3/4	19 3/4	12	12	2	17 3/4
2 x 14	2 3/4	3 3/4	3 3/4	4 3/4	21 3/4	14	14	2	19 3/4
2 x 16	2 3/4	3 3/4	3 3/4	4 3/4	23 3/4	16	16	2	21 3/4
2 x 18	2 3/4	3 3/4	3 3/4	4 3/4	25 3/4	18	18	2	23 3/4
2 x 20	2 3/4	3 3/4	3 3/4	4 3/4	27 3/4	20	20	2	25 3/4
2 x 22	2 3/4	3 3/4	3 3/4	4 3/4	29 3/4	22	22	2	27 3/4
2 x 24	2 3/4	3 3/4	3 3/4	4 3/4	31 3/4	24	24	2	29 3/4

TABLE 25. 3-INCH 1/8 BEND OFFSETS

Size	A	B	C	D	F	H	J	R	X ¹
3 x 2	3 3/4	4	4 1/4	5	11 1/4	2	2	2 1/2	8 3/4
3 x 4	3 3/4	4	4 1/4	5	13 1/4	4	4	2 1/2	10 1/4
3 x 6	3 3/4	4	4 1/4	5	15 1/4	6	6	2 1/2	12 1/4
3 x 8	3 3/4	4	4 1/4	5	17 1/4	8	8	2 1/2	14 1/4
3 x 10	3 3/4	4	4 1/4	5	19 1/4	10	10	2 1/2	16 1/4
3 x 12	3 3/4	4	4 1/4	5	21 1/4	12	12	2 1/2	18 1/4
3 x 14	3 3/4	4	4 1/4	5	23 1/4	14	14	2 1/2	20 1/4
3 x 16	3 3/4	4	4 1/4	5	25 1/4	16	16	2 1/2	22 1/4
3 x 18	3 3/4	4	4 1/4	5	27 1/4	18	18	2 1/2	24 1/4
3 x 20	3 3/4	4	4 1/4	5	29 1/4	20	20	2 1/2	26 1/4
3 x 22	3 3/4	4	4 1/4	5	31 1/4	22	22	2 1/2	28 1/4
3 x 24	3 3/4	4	4 1/4	5	33 1/4	24	24	2 1/2	30 1/4

¹ Dimension X is the laying length. All dimensions given in inches.

CAST-IRON SOIL PIPE AND FITTINGS

(American Standard ASA A40.1)

TABLE 26. 4-INCH $\frac{1}{8}$ BEND OFFSETS

Size	A	B	C	D	F	H	J	R	X ¹
4 x 2	3½	4	4¾	5¼	12	2	2	3	9
4 x 4	3½	4	4¾	5¼	14	4	4	3	11
4 x 6	3½	4	4¾	5¼	16	6	6	3	13
4 x 8	3½	4	4¾	5¼	18	8	8	3	15
4 x 10	3½	4	4¾	5¼	20	10	10	3	17
4 x 12	3½	4	4¾	5¼	22	12	12	3	19
4 x 14	3½	4	4¾	5¼	24	14	14	3	21
4 x 16	3½	4	4¾	5¼	26	16	16	3	23
4 x 18	3½	4	4¾	5¼	28	18	18	3	25
4 x 20	3½	4	4¾	5¼	30	20	20	3	27
4 x 22	3½	4	4¾	5¼	32	22	22	3	29
4 x 24	3½	4	4¾	5¼	34	24	24	3	31

TABLE 27. 5-INCH $\frac{1}{8}$ BEND OFFSETS

Size	A	B	C	D	F	H	J	R	X ¹
5 x 2	3½	4½	4 ¹⁵ / ₁₆	5 ⁹ / ₁₆	12½	2	2	3½	9½
5 x 4	3½	4½	4 ¹⁵ / ₁₆	5 ⁹ / ₁₆	14½	4	4	3½	11½
5 x 6	3½	4½	4 ¹⁵ / ₁₆	5 ⁹ / ₁₆	16½	6	6	3½	13½
5 x 8	3½	4½	4 ¹⁵ / ₁₆	5 ⁹ / ₁₆	18½	8	8	3½	15½
5 x 10	3½	4½	4 ¹⁵ / ₁₆	5 ⁹ / ₁₆	20½	10	10	3½	17½
5 x 12	3½	4½	4 ¹⁵ / ₁₆	5 ⁹ / ₁₆	22½	12	12	3½	19½
5 x 14	3½	4½	4 ¹⁵ / ₁₆	5 ⁹ / ₁₆	24½	14	14	3½	21½
5 x 16	3½	4½	4 ¹⁵ / ₁₆	5 ⁹ / ₁₆	26½	16	16	3½	23½
5 x 18	3½	4½	4 ¹⁵ / ₁₆	5 ⁹ / ₁₆	28½	18	18	3½	25½
5 x 20	3½	4½	4 ¹⁵ / ₁₆	5 ⁹ / ₁₆	30½	20	20	3½	27½
5 x 22	3½	4½	4 ¹⁵ / ₁₆	5 ⁹ / ₁₆	32½	22	22	3½	29½
5 x 24	3½	4½	4 ¹⁵ / ₁₆	5 ⁹ / ₁₆	34½	24	24	3½	31½

TABLE 28. 6-INCH $\frac{1}{8}$ BEND OFFSETS

Size	A	B	C	D	F	H	J	R	X ¹
6 x 2	3½	4½	5—	5 ⁵ / ₈	13	2½	2	4	10
6 x 4	3½	4½	5 ⁵ / ₁₆	5 ¹³ / ₁₆	15	4—	4	4	12
6 x 6	3½	4½	5 ⁵ / ₁₆	5 ¹³ / ₁₆	17	6—	6	4	14
6 x 8	3½	4½	5 ⁵ / ₁₆	5 ¹³ / ₁₆	19	8—	8	4	16
6 x 10	3½	4½	5 ⁵ / ₁₆	5 ¹³ / ₁₆	21	10—	10	4	18
6 x 12	3½	4½	5 ⁵ / ₁₆	5 ¹³ / ₁₆	23	12—	12	4	20
6 x 14	3½	4½	5 ⁵ / ₁₆	5 ¹³ / ₁₆	25	14—	14	4	22
6 x 16	3½	4½	5 ⁵ / ₁₆	5 ¹³ / ₁₆	27	16—	16	4	24
6 x 18	3½	4½	5 ⁵ / ₁₆	5 ¹³ / ₁₆	29	18—	18	4	26
6 x 20	3½	4½	5 ⁵ / ₁₆	5 ¹³ / ₁₆	31	20—	20	4	28
6 x 22	3½	4½	5 ⁵ / ₁₆	5 ¹³ / ₁₆	33	22—	22	4	30
6 x 24	3½	4½	5 ⁵ / ₁₆	5 ¹³ / ₁₆	35	24—	24	4	32

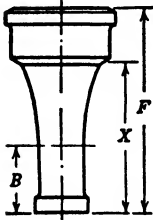
All dimensions given in inches.

¹ Dimension X is the laying length.

CAST-IRON SOIL PIPE AND FITTINGS

(American Standard ASA A40.1)

TABLE 29. TAPPED INCREASERS



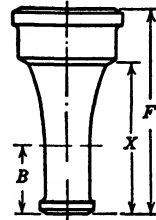
Size	B	F	X ¹
1½ x 2	4	10½	8
2 x 3	4	11¾	9
2 x 4	4	12—	9
2 x 5	4	12—	9
2 x 6	4	12—	9

Tapping boss on 1½ x 2-in. size may be tapped for 1¼-in. pipe threads and on sizes 2 x 3 in. and larger may be tapped for 1¼-in. to 2-in. pipe threads, inclusive.

Tapping shall be in accordance with the American Standard Taper Pipe Thread, ASA-B2

¹ Dimension X is the laying length.

TABLE 30. INCREASERS



Size	B	F	X ¹	Size	B	F	X ¹
2 x 3	4—	11¾	9	5 x 8	4—	15¾	12
2 x 4	4—	12—	9	5 x 10	4—	15¾	12
2 x 5	4—	12—	9	6 x 8	4—	15¾	12
2 x 6	4—	12—	9	6 x 10	4—	15¾	12
3 x 4	4—	12—	9	6 x 12	4—	16¾	12
3 x 5	4—	12—	9	8 x 10	5¾	15¾	12
3 x 6	4—	12—	9	8 x 12	5¾	16¾	12
4 x 5	4—	12—	9	8 x 15	5¾	16¾	12
4 x 6	4—	12—	9	10 x 12	5¾	16¾	12
4 x 8	4—	15¾	12	10 x 15	5¾	16¾	12
5 x 6	4—	12—	9	12 x 15	7—	16¾	12

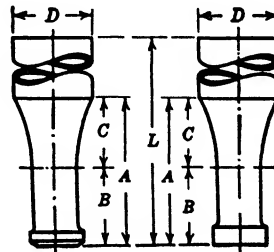
TABLE 31. SPIGOT AND TAPPED¹ LONG INCREASERS

Size	A	B	C ²	D	L
2 x 4 x 24	8½	4	4½	4½	24
2 x 4 x 30	8½	4	4½	4½	30
2 x 4 x 36	8½	4	4½	4½	36
2 x 4 x 48	8½	4	4½	4½	48
3 x 4 x 24	8½	4	4½	4½	24
3 x 4 x 30	8½	4	4½	4½	30
3 x 4 x 36	8½	4	4½	4½	36
3 x 4 x 48	8½	4	4½	4½	48
4 x 5 x 24	8½	4	4½	5½	24
4 x 5 x 30	8½	4	4½	5½	30
4 x 5 x 36	8½	4	4½	5½	36
5 x 5 x 48	8½	4	4½	5½	48
4 x 6 x 24	8½	4	4½	6½	24
4 x 6 x 30	8½	4	4½	6½	30
4 x 6 x 36	8½	4	4½	6½	36
4 x 6 x 48	8½	4	4½	6½	48

All dimensions given in inches.

¹ Tapping shall be in accordance with the American Standard Taper Pipe Thread ASA-B2.

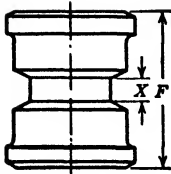
² All markings shall be on small end and in space indicated by dimension C.



CAST-IRON SOIL PIPE AND FITTINGS

(American Standard ASA A40.1)

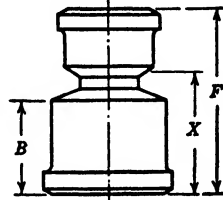
TABLE 32. DOUBLE HUBS



Size	F	X ¹
2	6—	1—
3	6½	1—
4	7—	1—
5	7—	1—
6	7—	1—
8	8¼	1¼
10	8¼	1¼
12	10—	1½
15	10—	1½

All dimensions given in inches.
¹ Dimension X is the laying length.

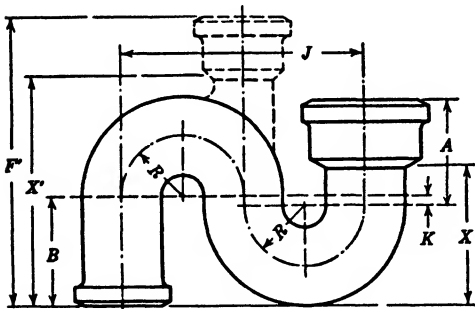
TABLE 33. REDUCERS



Size	B	F	X ¹
3 x 2	3¾	7¼	4¾
4 x 2	4—	7½	5—
4 x 3	4—	7¾	5—
5 x 2	4—	7½	5—
5 x 3	4—	7¾	5—
5 x 4	4—	8—	5—
6 x 2	4—	7½	5—
6 x 3	4—	7¾	5—
6 x 4	4—	8—	5—
6 x 5	4—	8—	5—
8 x 2	4½	8½	6—
8 x 3	4½	8¾	6—
8 x 4	4½	9—	6—
8 x 5	4½	9—	6—
8 x 6	4½	9—	6—
10 x 4	4½	9—	6—
10 x 5	4½	9—	6—
10 x 6	4½	9—	6—
10 x 8	4½	9½	6—
12 x 4	5¼	9½	6½
12 x 5	5¼	9½	6½
12 x 6	5¼	9½	6½
12 x 8	5¼	10—	6½
12 x 10	5¼	10—	6½
15 x 6	5¼	9½	6½
15 x 8	5¼	10—	6½
15 x 10	5¼	10—	6½
15 x 12	5¼	10¾	6½

All dimensions given in inches.
¹ Dimension X is the laying length.

TABLE 34. "S" TRAPS WITH OR WITHOUT HUB VENTS



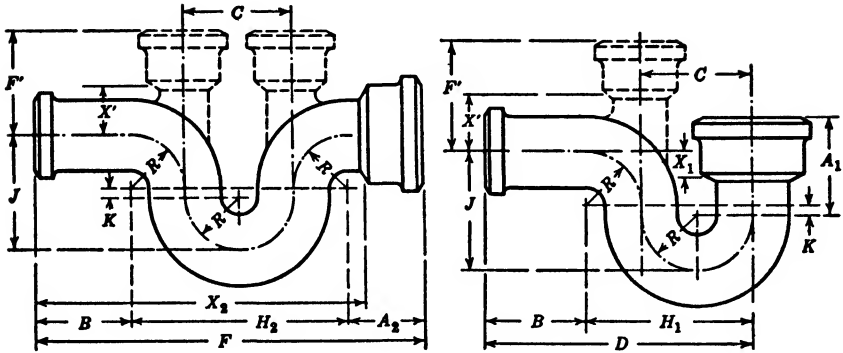
Size ¹	A	B	F'	J ²	K	R	X ³	X' ²
2 x 2	3—	3¾	10	8	0	2—	4	7¾
3 x 2	4¾	4¾	12	10	¾	2¾	5¾	9¾
3 x 3	4¾	4¾	12¾	10	¾	2¾	5¾	9¾
4 x 2	5¾	5¾	14	12	¾	3—	7¾	11¾
4 x 3	5¾	5¾	14¾	12	¾	3—	7¾	11¾
4 x 4	5¾	5¾	14¾	12	¾	3—	7¾	11¾
5 x 4	6¾	6¾	16¾	14	¾	3¾	9¾	13¾
5 x 5	6¾	6¾	16¾	14	¾	3¾	9¾	13¾
6 x 4	7¾	7¾	18¾	16	¾	4—	11¾	15¾
6 x 6	7¾	7¾	18¾	16	¾	4—	11¾	15¾

All dimensions given in inches.
¹ A minimum water seal of 2 in. for 2-in. size and 2½ in. seal for sizes 3 to 6 in., inclusive, is provided.
² Dimensions J, X, and X' are laying lengths.

CAST-IRON SOIL PIPE AND FITTINGS

(American Standard ASA A40.1)

TABLE 35



RUNNING TRAPS WITH SINGLE OR DOUBLE HUB VENTS OR WITHOUT HUB VENTS

1/2" "S" TRAPS WITH OR WITHOUT HUB VENTS

Size ¹	A ₁	A ₂	B	C	D ²	F	F'	H ₁	H ₂	J	K	R	X ₁ ³	X ₂ ³	X ₃ ³
2 x 2	3	3—	3 1/2	4—	9 1/2	14 1/2	4 1/2	6—	8	4	0	2—	1 1/2	12—	2—
3 x 2	4 1/2	3 3/4	4 1/2	5—	12	17 3/4	5—	7 1/2	10	5 1/2	1/2	2 1/2	1 3/4	15—	2 1/2
3 x 3	4 1/2	3 3/4	4 1/2	5—	12	17 3/4	5 1/4	7 1/2	10	5 1/2	1/2	2 1/2	1 3/4	15—	2 1/2
4 x 2	5 1/2	3 3/2	5—	6—	14	20 1/2	5 1/2	9—	12	6 1/2	1/2	3—	1	17 1/2	3—
4 x 3	5 1/2	3 3/2	5—	6—	14	20 1/2	5 3/4	9—	12	6 1/2	1/2	3—	1	17 1/2	3—
4 x 4	5 1/2	3 3/2	5—	6—	14	20 1/2	6—	9—	12	6 1/2	1/2	3—	1	17 1/2	3—
5 x 4	6 1/2	3 1/2	5—	7—	15 1/2	22 1/2	6 1/2	10 1/2	14	7 1/2	1/2	3 1/2	1 1/2	19 1/2	3 1/2
5 x 5	6 1/2	3 1/2	5—	7—	15 1/2	22 1/2	6 1/2	10 1/2	14	7 1/2	1/2	3 1/2	1 1/2	19 1/2	3 1/2
6 x 4	7 1/2	3 1/2	5—	8—	17	24 1/2	7—	12—	16	8 1/2	1/2	4—	0	21 1/2	4—
6 x 6	7 1/2	3 1/2	5—	8—	17	24 1/2	7—	12—	16	8 1/2	1/2	4—	0	21 1/2	4—
8 x 4	10—	4 3/8	7—	10—	22	31 5/8	8 1/4	15—	20	11—	1—	5—	+ 1/2	27 5/8	5 1/4
8 x 6	10—	4 3/8	7—	10—	22	31 5/8	8 1/4	15—	20	11—	1—	5—	+ 1/2	27 5/8	5 1/4
10 x 6	12—	4 3/8	7—	12—	25	35 5/8	9 1/4	18—	24	13—	1—	6—	+ 1 1/2	31 5/8	6 3/4
12 x 6	13 1/2	5—	8—	15—	30 1/2	43—	10 1/4	22 1/2	30	15—	0	7 1/2	+ 1 3/4	38 3/4	7 1/4
12 x 8	13 1/2	5—	8—	15—	30 1/2	43—	10 3/4	22 1/2	30	15—	0	7 1/2	+ 1 3/4	38 3/4	7 1/4
15 x 8	16 3/4	5—	8—	18 1/2	35 1/4	50—	12 1/4	27 3/4	37	18 1/2	0	9 1/4	+ 3 1/4	45 3/4	8 3/4

All dimensions given in inches.

¹ A minimum water seal of 2 in. for 2-in. size, 2 1/2 in. seal for sizes 3 to 6 in., inclusive, 3 in. seal for sizes 8 to 12 in., inclusive, and 3 1/2 in. seal for 15-in. size is provided.

² Dimensions D, X, and X' are laying lengths.

³ The dimension (X) preceded by the + sign indicates that the telescoping depth of hub above the horizontal center line is dimension given.

ART. 3-F. CAST FERROUS PIPES AND FITTINGS

Cast-Iron Soil Pipe and Fittings

Standards. American Standard, cast-iron soil or cast-iron soil pipe and fittings, ASA A40.1, ASTM, Fed. Specs. WW-P-401.

Coatings. Cast-iron pipe and fittings for underground use to be coated with asphaltum or coal-tar pitch.

Weights. Standard and Extra Heavy.

Joints. Hub or spigot ends, for calking.

Length of Pipes. 5 ft.

Uses. Used for drainage piping, underground soil pipe, and sewers. Grade required is usually Extra Heavy.

Cast-Iron Water Pipes and Fittings

Specifications. Cast-iron pipe and special castings, ASTM, AWWA, NEWWA, ASA A21.

Pipe, water, cast-iron (bell and spigot, and bolted joint), Fed. Specs. WW-P-421.

Socket fittings, Underwriters Laboratories and the Mutual Insurance Companies.

Pipes and Fittings. Cast-iron pit cast pipe for water or other liquids, ASA A21.2-1939.

Class (A)	50	for	50 lb	pressure	(115 ft	head)
" (B)	100	"	100	"	"	(231 " ")
" (C)	150	"	150	"	"	(346 " ")
" (D)	200	"	200	"	"	(462 " ")
" (E)	250	"	250	"	"	(577 " ")
" (F)	300	"	300	"	"	(693 " ")
" (G)	350	"	350	"	"	(808 " ")

Sizes 3, 4, 6, 8, 10, 12, 14, 16, 18, 20, 24, 30, 36, 42, 48, 54, and 60 in.; lengths 12 ft.

Class T Service, for 100, 150, 250, and 350 ft head; sizes 2, 3, and 4-in.; lengths 9 ft for 2-in. size and 12 ft for 3-in. and 4-in. sizes.

Bell and spigot fittings for Class T service pipes; tees, crosses, Y-branches, caps, plugs, 1/4 bends, 1/8 bends, 1/16 bends, and 1/32 bends; sizes 2, 3, and 4 in.

Short pattern "Socket Fittings," Class 150 (lb), Underwriters Laboratories approved fittings. (See pages 57-61)

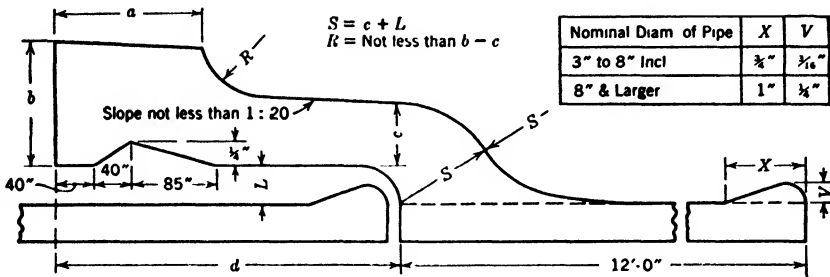
Joints. Bell and spigot ends for calking, "plain ends or such other type of ends as may be agreed upon at the time of purchase" (ASA A21.2).

Anchors. Where specified, the fittings shall be provided with cast lugs for anchors and furnished with steel clamps and anchors.

Coatings and Linings. Cement mortar lining (A21.4); coal-tar dip; bituminous enamel.

TABLE 36

STANDARD DIMENSIONS OF BELLS, SOCKETS, SPIGOT BEADS, AND OUTSIDE DIAMETERS OF PIT CAST PIPE



Nominal Diam	Thickness of Pipe		Outside Diam of Pipe	Dimensions of Bells					
	From	To		Diam of Socket	Thickness of Joint L	Depth of Socket d	a	b	c
3	0 37	0 45	3 80	4 60	0 40	3 50	1 25	1 30	0 65
	0 46	0 53	3 96	4 76	0 40	3 50	1 25	1 30	0 65
4	0 40	0 45	4 80	5 60	0 40	3 50	1 50	1 30	0 65
	0 46	0 55	5 00	5 80	0 40	3 50	1 50	1 30	0 65
6	0 43	0 50	6 90	7 70	0 40	3 50	1 50	1 40	0 70
	0 51	0 60	7 10	7 90	0 40	3 50	1 50	1 40	0 70
	0 61	0 66	7 22	8 02	0 40	4 00	1 50	1 75	0 75
	0 67	0 74	7 38	8 18	0 40	4 00	1 50	1 85	0 85
8	0 46	0 57	9 05	9 85	0 40	4 00	1 50	1 50	0 75
	0 58	0 70	9 30	10 10	0 40	4 00	1 50	1 50	0 75
	0 71	0 76	9 42	10 22	0 40	4 00	1 50	1 85	0 85
	0 77	0 85	9 60	10 40	0 40	4 00	1 50	1 95	0 95
10	0 50	0 60	11 10	11 90	0 40	4 00	1 50	1 50	0 75
	0 61	0 75	11 40	12 20	0 40	4 00	1 50	1 60	0 80
	0 76	0 85	11 60	12 40	0 40	4 50	1 75	1 95	0 95
	0 86	0 97	11 84	12 64	0 40	4.50	1 75	2 05	1 05
12	0 54	0 65	13 20	14 00	0 40	4 00	1 50	1 60	0 80
	0 66	0 80	13 50	14 30	0 40	4 00	1 50	1 70	0 85
	0 81	0 94	13 78	14 58	0 40	4 50	1 75	2 05	1 05
	0 95	1 09	14 08	14 88	0 40	4 50	1 75	2 20	1 20

All dimensions given in inches.
 From American Standard A21 2. Complete tables are available from American Water Works Association or American Standards Association.

TABLE 37
STANDARD THICKNESSES AND DIAMETERS OF PIT CAST PIPE
(Dimensions in Inches)

Nomi- nal Diam	Thick- ness Class	Thick- ness	Outside Diam	Inside Diam	Nomi- nal Diam	Thick- ness Class	Thick- ness	Outside Diam	Inside Diam
1	2	3	4	5	1	2	3	4	5
3	1	0 37	3 80	3 06	8	6	0.68	9 30	7.94
	2	0 40	3 80	3 00		7	0 73	9 42	7 96
	3	0 43	3 80	2 94		8	0 79	9 60	8.02
	4	0 46	3 96	3 04		9	0.85	9.60	7.90
	5	0.50	3.96	2 96		10	1	0.50	11 10	10.10
4	1	0.40	4 80	4.00	2		0 54	11.10	10.02
	2	0 43	4 80	3 94	3		0 58	11.10	9.94
	3	0.46	5.00	4 08	4		0 63	11 40	10.14
	4	0.50	5 00	4.00	5		0 68	11 40	10 04
	5	0.54	5.00	3.92	6		0 73	11 40	9 94
6	1	0.43	6.90	6 04	7		0 79	11 60	10 02
	2	0.46	6 90	5 98	8		0 85	11.60	9.90
	3	0.50	6.90	5.90	9		0 92	11 84	10.00
	4	0 54	7 10	6 02	12	1	0 54	13.20	12 12
	5	0 58	7 10	5 94		2	0 58	13 20	12 04
	6	0.63	7.22	5 96		3	0 63	13 20	11 94
	7	0.68	7 38	6 02		4	0.68	13.50	12 14
	8	0.73	7 38	5.92		5	0 73	13.50	12 04
8	1	0.46	9.05	8.13		6	0 79	13 50	11.92
	2	0 50	9 05	8.05		7	0 85	13.78	12.08
	3	0 54	9.05	7 97		8	0 92	13.78	11.94
	4	0.58	9.30	8 14	9	0.99	14 08	12.10	
	5	0.63	9.30	8.04	10	1.07	14.08	11.94	

From American Standard A21 2. Complete tables are available from American Water Works Association or American Standards Association.

TABLE 38
STANDARD THICKNESSES OF CAST-IRON PIT CAST PIPE

Note: These weights are for pipe laid without blocks, on flat-bottom trench, with tamped backfill, under 5 ft of cover. For other conditions, see Table 39.

Size Inches	Class 50	Class 100	Class 150	Class 200	Class 250	Class 300	Class 350
	50 Lb Pressure	100 Lb Pressure	150 Lb Pressure	200 Lb Pressure	250 Lb Pressure	300 Lb Pressure	350 Lb Pressure
	115 Ft Head	231 Ft Head	346 Ft Head	462 Ft Head	577 Ft Head	693 Ft Head	808 Ft Head
	Thickness Inches	Thickness Inches	Thickness Inches	Thickness Inches	Thickness Inches	Thickness Inches	Thickness Inches
3	0.37	0.37	0.37	0.37	0.37	0.37	0.37
4	0.40	0.40	0.40	0.40	0.40	0.40	0.40
6	0.43	0.43	0.43	0.43	0.43	0.46	0.50
8	0.46	0.46	0.46	0.46	0.50	0.54	0.58
10	0.50	0.50	0.54	0.58	0.63	0.68	0.73
12	0.54	0.54	0.58	0.63	0.68	0.73	0.79

TABLE 39

STANDARD THICKNESSES OF CAST-IRON PIT CAST PIPE

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

Laying Condition A—Flat-Bottom Trench, without Blocks, Untamped Backfill

Laying Condition B—Flat-Bottom Trench, without Blocks, Tamped Backfill

Laying Condition C—Pipe Laid on Blocks, Untamped Backfill

Laying Condition D—Pipe Laid on Blocks, Tamped Backfill

Size Inches	Working Pressure	3½ Ft of Cover				5 Ft of Cover				8 Ft of Cover			
		Laying Condition				Laying Condition				Laying Condition			
		A	B	C	D	A	B	C	D	A	B	C	D
3	50	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.43	0.37
	100	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.43	0.37
	150	0.37	0.37	0.37	0.37	0.37	0.37	0.40	0.37	0.37	0.37	0.43	0.37
	200	0.37	0.37	0.37	0.37	0.37	0.37	0.40	0.37	0.37	0.37	0.43	0.37
	250	0.37	0.37	0.37	0.37	0.37	0.37	0.40	0.37	0.37	0.37	0.46	0.37
	300	0.37	0.37	0.37	0.37	0.37	0.37	0.40	0.37	0.37	0.37	0.46	0.37
	350	0.37	0.37	0.40	0.37	0.37	0.37	0.40	0.37	0.37	0.37	0.46	0.37
4	50	0.40	0.40	0.40	0.40	0.40	0.40	0.43	0.40	0.40	0.40	0.50	0.40
	100	0.40	0.40	0.40	0.40	0.40	0.40	0.43	0.40	0.40	0.40	0.50	0.40
	150	0.40	0.40	0.40	0.40	0.40	0.40	0.43	0.40	0.40	0.40	0.50	0.40
	200	0.40	0.40	0.43	0.40	0.40	0.40	0.43	0.40	0.40	0.40	0.50	0.40
	250	0.40	0.40	0.43	0.40	0.40	0.40	0.46	0.40	0.40	0.40	0.50	0.40
	300	0.40	0.40	0.43	0.40	0.40	0.40	0.46	0.40	0.40	0.40	0.54	0.40
	350	0.40	0.40	0.46	0.40	0.40	0.40	0.46	0.40	0.40	0.40	0.54	0.40
6	50	0.43	0.43	0.46	0.43	0.43	0.43	0.50	0.43	0.43	0.43	0.58	0.43
	100	0.43	0.43	0.46	0.43	0.43	0.43	0.50	0.43	0.43	0.43	0.58	0.43
	150	0.43	0.43	0.50	0.43	0.43	0.43	0.50	0.43	0.43	0.43	0.58	0.43
	200	0.43	0.43	0.50	0.43	0.43	0.43	0.54	0.43	0.43	0.43	0.58	0.43
	250	0.43	0.43	0.50	0.43	0.43	0.43	0.54	0.43	0.46	0.46	0.63	0.46
	300	0.46	0.43	0.54	0.43	0.46	0.46	0.54	0.46	0.50	0.46	0.63	0.46
	350	0.50	0.50	0.54	0.46	0.50	0.50	0.58	0.50	0.50	0.50	0.63	0.50
8	50	0.46	0.46	0.54	0.46	0.46	0.46	0.54	0.46	0.46	0.46	0.63	0.46
	100	0.46	0.46	0.54	0.46	0.46	0.46	0.54	0.46	0.46	0.46	0.63	0.50
	150	0.46	0.46	0.58	0.46	0.46	0.46	0.58	0.46	0.50	0.50	0.68	0.50
	200	0.46	0.46	0.58	0.50	0.50	0.46	0.58	0.50	0.54	0.50	0.68	0.54
	250	0.50	0.50	0.63	0.50	0.54	0.50	0.63	0.54	0.54	0.54	0.68	0.58
	300	0.54	0.54	0.63	0.54	0.58	0.54	0.63	0.58	0.58	0.58	0.73	0.58
	350	0.58	0.58	0.63	0.58	0.58	0.58	0.68	0.58	0.63	0.63	0.73	0.63
10	50	0.50	0.50	0.58	0.50	0.50	0.50	0.58	0.50	0.54	0.50	0.68	0.54
	100	0.50	0.50	0.58	0.50	0.50	0.50	0.63	0.50	0.58	0.54	0.73	0.58
	150	0.50	0.50	0.58	0.50	0.54	0.54	0.63	0.54	0.58	0.58	0.73	0.58
	200	0.54	0.54	0.63	0.54	0.58	0.58	0.68	0.58	0.63	0.58	0.79	0.63
	250	0.58	0.58	0.63	0.58	0.63	0.63	0.68	0.63	0.68	0.63	0.79	0.68
	300	0.63	0.63	0.68	0.63	0.68	0.68	0.73	0.68	0.68	0.68	0.79	0.73
	350	0.68	0.68	0.73	0.68	0.73	0.73	0.79	0.73	0.73	0.73	0.85	0.73
12	50	0.54	0.54	0.58	0.54	0.54	0.54	0.63	0.54	0.58	0.58	0.73	0.63
	100	0.54	0.54	0.63	0.54	0.54	0.54	0.63	0.58	0.63	0.58	0.79	0.63
	150	0.58	0.54	0.63	0.58	0.58	0.58	0.68	0.63	0.68	0.68	0.79	0.68
	200	0.63	0.58	0.68	0.63	0.63	0.63	0.73	0.68	0.68	0.68	0.85	0.73
	250	0.68	0.68	0.73	0.68	0.68	0.68	0.79	0.73	0.73	0.73	0.85	0.73
	300	0.73	0.73	0.79	0.73	0.73	0.73	0.79	0.79	0.79	0.79	0.92	0.79
	350	0.79	0.79	0.85	0.79	0.79	0.79	0.85	0.85	0.85	0.85	0.92	0.85

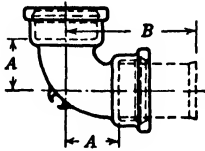
From American Standard A21 2 Complete tables are available from American Water Works Association or American Standards Association.

Bold-face numerals are Standard Thicknesses as given in Table 38.

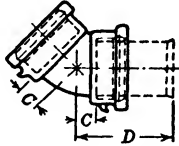
SOCKET BENDS
(150 lb Water Pressure)

All bells are 4 in. deep. Flanges are American Standard diameter and drilling—unless otherwise specified. Extra Heavy American flanges furnished on order for 151 to 173 lb pressure.

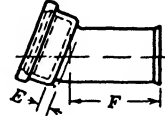
TABLE 40



SOCKET $\frac{1}{4}$ BENDS



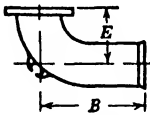
SOCKET $\frac{1}{8}$ BENDS



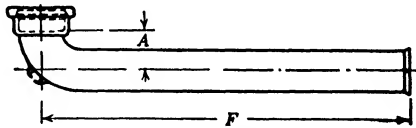
SOCKET $\frac{1}{16}$ BENDS

Size, In.	Dimensions, In.					
	A	B	C	D	E	F
4	5 $\frac{1}{4}$	15 $\frac{1}{4}$	2 $\frac{1}{4}$	12 $\frac{1}{4}$	1	11
6	6 $\frac{1}{4}$	16 $\frac{1}{4}$	2 $\frac{1}{4}$	12 $\frac{1}{4}$	1 $\frac{1}{2}$	11 $\frac{1}{2}$
8	8	18	3 $\frac{1}{4}$	13 $\frac{1}{4}$	1 $\frac{3}{4}$	11 $\frac{3}{4}$
10	9 $\frac{1}{4}$	19 $\frac{1}{4}$	4	14	2	12
12	10 $\frac{1}{4}$	20 $\frac{1}{4}$	4 $\frac{1}{4}$	14 $\frac{1}{4}$	2 $\frac{1}{4}$	12 $\frac{1}{4}$

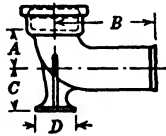
TABLE 41



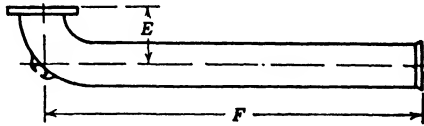
SOCKET $\frac{1}{4}$ BEND, F. S.



LONG SOCKET $\frac{1}{4}$ BEND, B. S.



SOCKET $\frac{1}{4}$ BEND WITH BASE

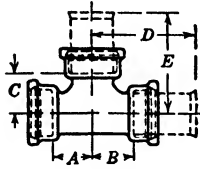


LONG SOCKET $\frac{1}{4}$ BEND, F. S.

Size, In.	Dimensions, In.					
	A	B	C	D	E	F
4	5 $\frac{1}{4}$	15 $\frac{1}{4}$	5 $\frac{1}{4}$	6	7	60
6	6 $\frac{1}{4}$	16 $\frac{1}{4}$	7	6	8 $\frac{1}{4}$	60
8	8	18	8 $\frac{1}{4}$	9	10	60
10	9 $\frac{1}{4}$	19 $\frac{1}{4}$	9 $\frac{1}{4}$	9	11 $\frac{1}{4}$	60
12	10 $\frac{1}{4}$	20 $\frac{1}{4}$	11 $\frac{1}{4}$	11	13	60

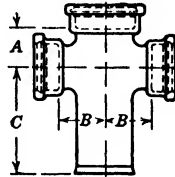
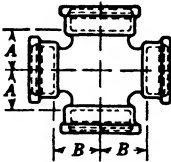
Courtesy of the Grinnell Co., Inc., Providence, R. I.

TABLE 42. SOCKET TEES
(150 lb Water Pressure)



Size, In.			Dimensions, In.					
			A	B	C	D	E	F
4	4	4	5½	5½	5½	15½	15½	1
6	6	6	6¾	6¾	6¾	16¾	16¾	
6	6	4	5½	5½	6¾	15½	16½	
8	8	8	8	8	8	18	18	
8	8	6	6¼	6¾	7¾	16¾	17¾	2
8	8	4	5½	5½	7¾	15½	17½	
8	6	8	8	7¾	8	17½	18	
8	6	6	6¾	6¾	7¾	16¾	17¾	
6	6	8	7¾	7¾	6¾	17½	16½	3
10	10	10	9½	9½	9½	19½	19½	
10	10	8	8	8	9	18	19	
10	10	6	6¼	6¾	8¼	16¾	18¾	
10	10	4	5½	5½	8¾	15½	18½	
12	12	12	10¾	10¾	10¾	20¾	20¾	
12	12	10	9½	9½	10¾	19½	20½	
12	12	8	8	8	10	18	20	
12	12	6	6¼	6¾	9¼	16¾	19¼	

TABLE 43. SOCKET CROSSES

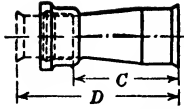


Size, In.				Dimensions, In.		
				A	B	C
4	4	4	4	5½	5½	15½
6	6	6	6	6¾	6¾	16¾
6	6	4	4	5½	6¾	15½
8	8	8	8	8	8	18
8	8	6	6	6¾	7¾	16¾
10	10	10	10	9½	9½	19½

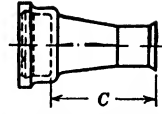
Size, In.				Dimensions, In.		
				A	B	C
10	10	8	8	8	9	18
10	10	6	6	6¾	8¾	16¾
12	12	12	12	10¾	10¾	20¾
12	12	10	10	9½	10½	19½
12	12	8	8	8	10	18
12	12	6	6	6¾	9¾	16¾

Courtesy of The Grinnell Co., Inc., Providence, R. I.

TABLE 44. SOCKET REDUCERS



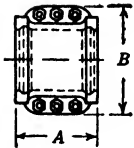
SMALL END BELL OR SPIGOT ENDS



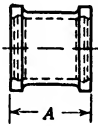
(INCREASER) LARGE END BELL

Size, In.		Dimensions, In.	
		C	D
6	4	14	20
8	6	14	20
8	4	14	20
10	8	14	20
10	6	14	20
10	4	18	24
12	10	14	20
12	8	14	20
12	6	18	24
12	4	22	28

TABLE 45



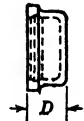
SOCKET SLEEVE



SPLIT SOCKET SLEEVE



SOCKET PLUG



SOCKET CAP

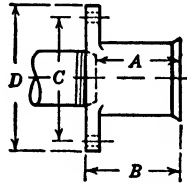
Size, In.	Dimensions, In.			
	A	B	C	D
4	10	11½	5½	4⅝
6	10	14½	5½	4¾
8	12	17¼	5½	4¾
10	12	20¼	6	4¾
12	14	22½	6	4¾

Bells for Caps are 4 in. deep.

Socket Plugs in 8-, 10-, and 12-in. sizes have two ribs.

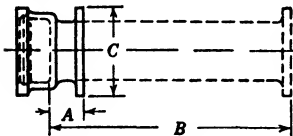
Courtesy of The Grinnell Co., Inc., Providence, R. I.

TABLE 46. WARREN COUPLINGS
(150 Lb Water Pressure)



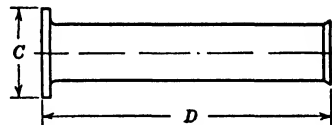
Size		Dimensions			
		A	B	C	D
3	3	8 1/16	9	8 3/4	10 3/4
3	2 1/2	8 3/8	9	8 3/4	10 3/4
3	2	8 5/16	9	8 3/4	10 3/4
4	4	7 15/16	9	9 3/4	11 3/4
4	3 1/2	8	9	9 3/4	11 3/4
4	3	8 1/8	9	9 3/4	11 3/4
4	2 1/2	8 3/8	9	9 3/4	11 3/4
4	2	8 5/16	9	9 3/4	11 3/4
6	6	7 3/4	9	12	14
6	5	7 15/16	9	12	14
6	4	7 15/16	9	12	14
6	3 1/2	8	9	12	14
6	3	8 1/8	9	12	14
8	8	7 3/8	9	14 1/4	16 3/4
8	6	7 3/4	9	14 1/4	16 3/4
10	10	7 3/4	9	16 3/4	18 3/4
12	12	7 3/4	9	18 3/4	20 3/4

TABLE 47. FLANGED SOCKETS



Size	Dimensions		
	A	B	C
4	4 3/4	30	9
6	4 3/4	30	11
8	4 3/4	30	13 1/2
10	4 3/4	30	16
12	4 3/4	30	19

TABLE 48. FLANGE AND SPIGOT PIECES

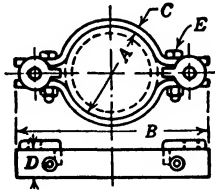


Size	Dimensions				
	C		D		
	150 lbs	173 lbs	Fig. No. 530	Fig. No. 531	Fig. No. 532
4	9	10	18	36	72
6	11	12 3/4	18	36	72
8	13 3/4	15	18	36	72
10	16	17 3/4	18	36	72
12	19	20 3/4	18	36	72

Notes: Bells of Flanged Sockets are 4 in. deep.
Flanges drilled American Standard drilling unless otherwise specified. Extra Heavy American Standard flanges furnished on order for 151 to 173 lb pressure.

Courtesy of The Grinnell Co., Inc., Providence, R. I.

TABLE 49. SOCKET CLAMPS



SOCKET CLAMP WASHER

Size, In.	Dimensions, In.				
	A	B	C	D	*Bolts E
4	5	12 $\frac{1}{8}$	$\frac{1}{2}$	2	$\frac{5}{8}$ x 3 $\frac{1}{2}$
6	7 $\frac{1}{16}$	14 $\frac{3}{8}$	$\frac{1}{2}$	2	$\frac{5}{8}$ x 3 $\frac{1}{2}$
8	9 $\frac{3}{16}$	16 $\frac{3}{8}$	$\frac{1}{2}$	2	$\frac{5}{8}$ x 3 $\frac{1}{2}$
10	11 $\frac{3}{8}$	18 $\frac{3}{8}$	$\frac{1}{2}$	2	$\frac{5}{8}$ x 3 $\frac{1}{2}$
12	13 $\frac{1}{2}$	21 $\frac{1}{4}$	$\frac{1}{2}$	2	$\frac{5}{8}$ x 3 $\frac{1}{2}$

* Bolts E have extra length thread to allow their use either on American Water Works Association Class "C" or "D" Pipe, or on Super-deLavaud Centrifugally Cast Pipe. (See Fig. 1, page 62.)

Courtesy of The Grinnell Co., Inc., Providence, R. I.

Cast-Iron Screwed Pipe (See Table 50, page 63.)

Standards. Fed. Specs. WW-P-356 (pipe, cast-iron, drainage, vent, and waste [threaded]).

Classes and Weights. Same dimensions as for Extra-Strong wrought iron.

Processes and Composition. Cast by either vertical or centrifugal method. May be cast iron or cast-iron alloy containing nickel, copper, molybdenum, or combinations of these metals.

Can be cut and threaded.

Lengths. Manufactured in 6-ft lengths and can be furnished welded together into 12-ft lengths. Delivered with couplings.

Uses. Drainage, vent, and water pipes.

Cast-Iron Screwed Fittings

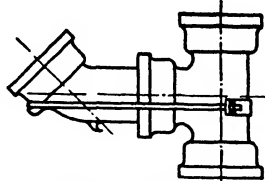
Standards. Pipe fittings, cast-iron (threaded), Fed. Specs. WW-P-501.

Cast-iron screwed fittings for maximum working steam pressures of 125 and 250 psi, ASA B16d, ASME, HPCNA, MSS (water working pressures up to 175 lb and 350 lb, respectively).

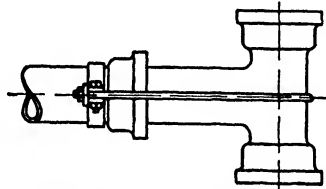
Pitch and Threading. Elbows can be procured in sizes $\frac{3}{4}$ in. to 6 in. with $\frac{1}{4}$ in. per ft pitch. Elbows can be procured with right- and left-hand threading.

Coatings. All fittings can be obtained black or galvanized.

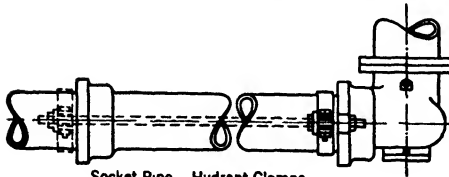
Uses. Water lines.



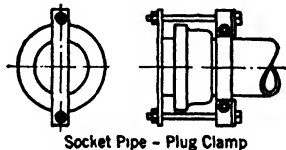
Socket Tee - $\frac{1}{2}$ Bend Clamp



Socket Tee Clamp for Spigot Outlet Tee



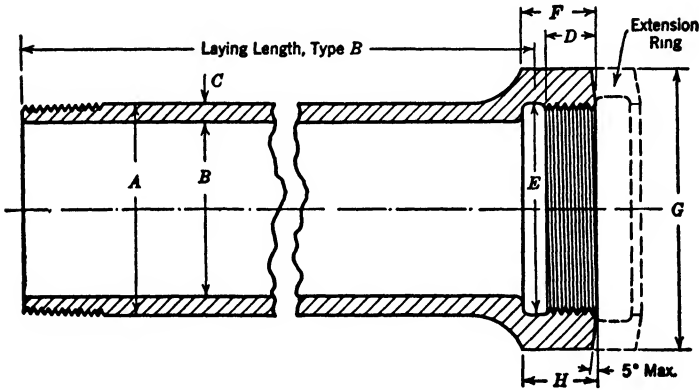
Socket Pipe - Hydrant Clamps



Socket Pipe - Plug Clamp

FIG. 1. Method of using Clamps. (Courtesy of The Grinnell Co., Inc., Providence, R. I.)

TABLE 50
 DIMENSIONS AND WEIGHTS OF CAST-IRON SCREWED PIPE
 (Fed. Specs. WW-P-356)



TYPE A. EXTERNAL THREAD ON BOTH ENDS.

TYPE B. EXTERNAL THREAD ON ONE END AND INTERNAL THREAD ON ONE END.

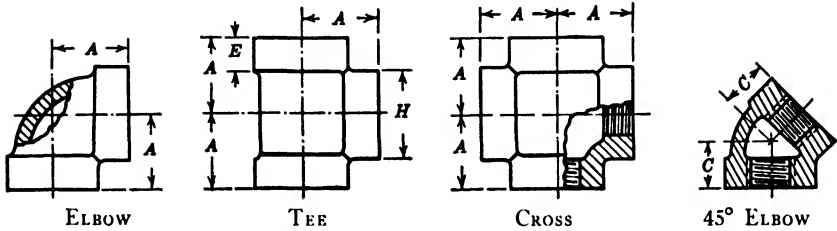
Nominal Pipe Size (Inches)	Nominal Diameter		Wall Thickness, Minimum (C)	Internal Thread Length, Minimum (D)	Diam of Groove, Maximum (E)	End to Shoulder, Minimum (F)	Band		Nominal Weights	
	Outside (Note 1) (A)	Inside (B)					Diam, Minimum (G)	Length, Minimum (H)	Type A and Barrel of Type B, per Foot Laying Length	Internally Threaded End (Type B)
1 1/4	1.660	1.232	0.187	0.42	1.73	0.71	2.39	0.71	3.033	0.60
1 1/2	1.900	1.454	0.195	0.42	1.97	0.72	2.68	0.72	3.666	0.90
2	2.375	1.893	0.211	0.43	2.44	0.76	3.28	0.76	5.041	1.00
2 1/2	2.875	2.323	0.241	0.68	2.97	1.14	3.86	1.14	7.031	1.35
3	3.500	2.900	0.263	0.76	3.60	1.20	4.62	1.20	9.410	2.80
4	4.500	3.826	0.294	0.84	4.60	1.30	5.79	1.30	13.750	3.48
5	5.563	4.813	0.328	0.93	5.66	1.41	7.05	1.41	19.050	5.00
6	6.625	5.761	0.378	0.95	6.72	1.51	8.28	1.51	26.224	6.60
8	8.625	7.625	0.438	1.06	8.72	1.71	10.63	1.71	39.817	10.00

Note 1. The nominal outside diameters are the same as for standard wrought-steel pipe.

125-LB CAST-IRON SCREWED FITTINGS

(American Standard B16d)

TABLE 51. DIMENSIONS OF ELBOWS, 45-DEG ELBOWS, TEES, AND CROSSES (STRAIGHT SIZES)



Nominal Pipe Size	<i>A</i>	<i>C</i>	<i>E</i>	<i>H</i>
	Center to End, Elbows, Tees, and Crosses	Center to End, 45-Deg Elbows	Width of Band, Min	Outside Diam of Band, Min
¼	0 81	0 73	0 38	0 93
⅜	0 95	0 80	0 44	1 12
½	1 12	0 88	0 50	1 34
¾	1 31	0 98	0 56	1 63
1	1 50	1 12	0 62	1 95
1¼	1 75	1 29	0 69	2 39
1½	1 94	1 43	0 75	2 68
2	2 25	1 68	0 84	3 28
2½	2 70	1 95	0 94	3 86
3	3 08	2 17	1 00	4 62
3½	3 42	2 39	1 06	5 20
4	3 79	2 61	1 12	5 79
5	4 50	3 05	1 18	7 05
6	5 13	3 46	1 28	8 28
8	6 56	4 28	1 47	10 63
10	8 08	5 16	1 68	13 12
12	9 50	5 97	1 88	15 47
14 O.D.	10 40		2 00	16 94
16 O.D.	11 82		2 20	19 30

All dimensions given in inches.

Dimensions for reducing elbows and reducing tees are given in Table 52 and Table 53, respectively.

125-LB CAST-IRON SCREWED FITTINGS

(American Standard B16d)

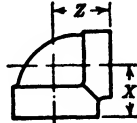


TABLE 52. DIMENSIONS OF ELBOWS (REDUCING SIZES)

Nominal Pipe Sizes	Center to End	
	X	Z
½ x ⅜	1 04	1 03
¾ x ½	1.20	1 22
1 x ¾	1 37	1 45
1 x ½	1 26	1 36
1¼ x 1	1 58	1 67
1¼ x ¾	1 45	1 62
1½ x 1¼	1.82	1 88
1½ x 1	1 65	1 80
2 x 1½	2 02	2 16
2 x 1¼	1 90	2 10
2 x 1	1 73	2 02
2½ x 2	2 39	2 60
2½ x 1½	2 16	2.51
3 x 2½	2 83	2 99
3 x 2	2.52	2 89
4 x 3	3 30	3.60
4 x 2	2.74	3.41
5 x 4	4.00	4 41
6 x 5	4 63	5 03
6 x 4	4.13	4.94
8 x 6	5.56	6 37
10 x 8	7 02	7 87

All dimensions given in inches.

125-LB CAST-IRON SCREWED FITTINGS
(American Standard B16d)

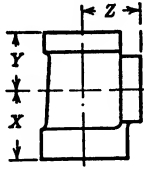


TABLE 53. DIMENSIONS OF T_{FES} (REDUCING SIZES)

Nominal Pipe Sizes	Center to End			Nominal Pipe Sizes	Center to End		
	X	Y	Z		X	Y	Z
1/4 x 1/4 x 3/8	1 22	1 22	1 20	1 1/2 x 3/4 x 1 1/4	1 94	1 75	1 94
1/4 x 1/2 x 3/8	1 04	1 04	1 03	1 1/2 x 1/2 x 1 1/4	1 82	1 62	1 88
1/4 x 1/2 x 1	1 45	1 45	1 37	1 1/2 x 1/2 x 1 1/2	1 94	1 66	1 94
1/4 x 3/4 x 1/2	1 20	1 20	1 22	2 x 2 x 3	2 89	2 89	2 52
1/4 x 3/4 x 3/8	1 12	1 12	1 13	2 x 2 x 2 1/2	2 60	2 60	2 39
1/4 x 3/4 x 3/4	1 31	1 22	1 31	2 x 2 x 1 1/2	2 02	2 02	2 16
1/4 x 3/4 x 1/2	1 20	1 12	1 22	2 x 2 x 1 1/4	1 90	1 90	2 10
1 x 1 x 1 1/4	1 80	1 80	1 65	2 x 2 x 1	1 73	1 73	2 02
1 x 1 x 1 1/2	1 67	1 67	1 58	2 x 2 x 3/4	1 60	1 60	1 97
1 x 1 x 3/4	1 37	1 37	1 45	2 x 2 x 1/2	1 49	1 49	1 88
1 x 1 x 1/2	1 26	1 26	1 36	2 x 1 1/2 x 2 1/2	2 60	2 51	2 39
1 x 1 x 3/8	1 18	1 18	1 27	2 x 1 1/2 x 2	2 25	2 16	2 25
1 x 3/4 x 1	1 50	1 45	1 50	2 x 1 1/2 x 1 1/2	2 02	1 94	2 16
1 x 3/4 x 3/4	1 37	1 31	1 15	2 x 1 1/2 x 1 1/4	1 90	1 82	2 10
1 x 3/4 x 1/2	1 26	1 20	1 36	2 x 1 1/2 x 1	1 73	1 65	2 02
1 x 3/4 x 1	1 50	1 36	1 50	2 x 1 1/2 x 3/4	1 60	1 52	1 97
1 x 3/4 x 3/4	1 37	1 22	1 45	2 x 1 1/2 x 1/2	1 49	1 41	1 88
1 x 3/8 x 1	1 50	1 27	1 50	2 x 1 1/2 x 2	2 25	2 10	2 25
1 1/4 x 1 1/4 x 2	2 10	2 10	1 90	2 x 1 1/2 x 1 1/2	2 02	1 88	2 16
1 1/4 x 1 1/4 x 1 1/2	1 88	1 88	1 82	2 x 1 1/2 x 1 1/4	1 90	1 75	2 10
1 1/4 x 1 1/4 x 1	1 58	1 58	1 67	2 x 1 1/2 x 1	1 73	1 58	2 02
1 1/4 x 1 1/4 x 3/4	1 45	1 45	1 62	2 x 1 x 2	2 25	2 02	2 25
1 1/4 x 1 1/4 x 1/2	1 34	1 34	1 53	2 x 1 x 1 1/2	2 02	1 80	2 16
1 1/4 x 1 x 1 1/2	1 88	1 80	1 82	2 x 3/4 x 2	2 25	1 97	2 25
1 1/4 x 1 x 1 1/4	1 75	1 67	1 75	2 1/2 x 2 1/2 x 4	3 51	3 51	3 05
1 1/4 x 1 x 1	1 58	1 50	1 67	2 1/2 x 2 1/2 x 3	2 99	2 99	2 83
1 1/4 x 1 x 3/4	1 45	1 37	1 62	2 1/2 x 2 1/2 x 2	2 39	2 39	2 60
1 1/4 x 1 x 1/2	1 34	1 26	1 53	2 1/2 x 2 1/2 x 1 1/2	2 16	2 16	2 51
1 1/4 x 3/4 x 1 1/2	1 75	1 62	1 75	2 1/2 x 2 1/2 x 1 1/4	2 04	2 04	2 45
1 1/4 x 3/4 x 1	1 58	1 45	1 67	2 1/2 x 2 1/2 x 1	1 87	1 87	2 37
1 1/4 x 3/4 x 1/2	1 75	1 53	1 75	2 1/2 x 2 1/2 x 3/4	1 74	1 74	2 32
1 1/4 x 1 1/2 x 2	2 16	2 16	2 02	2 1/2 x 2 x 2 1/2	2 70	2 60	2 70
1 1/4 x 1 1/2 x 1 1/4	1 82	1 82	1 88	2 1/2 x 2 x 2	2 39	2 25	2 60
1 1/4 x 1 1/2 x 1	1 65	1 65	1 80	2 1/2 x 2 x 1 1/2	2 16	2 02	2 51
1 1/4 x 1 1/2 x 3/4	1 52	1 52	1 75	2 1/2 x 2 x 1 1/4	2 04	1 90	2 45
1 1/4 x 1 1/2 x 1/2	1 41	1 41	1 66	2 1/2 x 2 x 1	1 87	1 73	2 37
1 1/4 x 1 1/4 x 1 1/2	1 94	1 88	1 94	2 1/2 x 2 x 3/4	1 74	1 60	2 32
1 1/4 x 1 1/4 x 1 1/4	1 82	1 75	1 88	2 1/2 x 2 x 1/2	1 63	1 49	2 23
1 1/4 x 1 1/4 x 1	1 65	1 58	1 80	2 1/2 x 1 1/2 x 2 1/2	2 70	2 51	2 70
1 1/4 x 1 1/4 x 3/4	1 52	1 45	1 75	2 1/2 x 1 1/2 x 1 1/2	2 39	2 16	2 60
1 1/4 x 1 1/4 x 1/2	1 41	1 34	1 66	2 1/2 x 1 1/2 x 1 1/4	2 16	1 94	2 51
1 1/4 x 1 x 2	2 16	2 02	2 02	2 1/2 x 1 x 2 1/2	2 70	2 37	2 70
1 1/2 x 1 x 1 1/2	1 94	1 80	1 94	3 x 3 x 4	3 60	3 60	3 30
1 1/2 x 1 x 1 1/4	1 82	1 67	1 88	3 x 3 x 3 1/2	3 33	3 33	3 18
1 1/2 x 1 x 1	1 65	1 50	1 80	3 x 3 x 2 1/2	2 83	2 83	2 99

(Table continued on next page)

TABLE 53 (Continued). DIMENSIONS OF TEES (REDUCING SIZES)

Nominal Pipe Sizes	Center to End			Nominal Pipe Sizes	Center to End		
	X	Y	Z		X	Y	Z
3 x 3 x 2	2 52	2 52	2 89	4 x 2 x 4	3 79	3 41	3 79
3 x 3 x 1½	2 29	2 29	2 80	4 x 1½ x 4	3 79	3 32	3 79
3 x 3 x 1¼	2 17	2 17	2 74	4 x 1¼ x 4	3.79	3 26	3 79
3 x 3 x 1	2 00	2.00	2 66	5 x 5 x 6	5 03	5 03	4 63
3 x 3 x ¾	1 87	1 87	2 61	5 x 5 x 4	4 00	4 00	4 41
3 x 2½ x 3	3 08	2 99	3 08	5 x 5 x 3½	3 75	3 75	4 31
3 x 2½ x 2½	2 83	2 70	2 99	5 x 5 x 3	3 51	3 51	4 22
3 x 2½ x 2	2 52	2 39	2 89	5 x 5 x 2½	3 26	3 26	4 13
3 x 2½ x 1½	2 29	2 16	2 80	5 x 5 x 2	2 95	2 95	4 03
3 x 2½ x 1¼	2 17	2 04	2 74	5 x 5 x 1½	2 72	2 72	3 94
3 x 2½ x 1	2 00	1 87	2 66	5 x 4 x 5	4 50	4 41	4 50
3 x 2 x 3	3 08	2 89	3 08	5 x 4 x 4	4 00	3 79	4 41
3 x 2 x 2½	2 83	2 60	2 99	5 x 4 x 3	3 51	3 30	4 22
3 x 2 x 2	2 52	2 25	2 89	5 x 4 x 2	2 95	2.74	4.03
3 x 2 x 1½	2 29	2 02	2 80	5 x 3 x 5	4 50	4 22	4 50
3 x 1½ x 3	3 08	2 80	3 08	5 x 3 x 4	4 00	3 60	4.41
3 x 1 x 3	3 08	2 66	3 08	5 x 3 x 3	3 51	3 08	4.22
3½ x 3½ x 3	3 18	3 18	3 33	5 x 2 x 5	4 50	4 03	4.50
3½ x 3½ x 2½	2 93	2 93	3 24	6 x 6 x 8	6 37	6 37	5 56
3½ x 3½ x 2	2 62	2 62	3 14	6 x 6 x 5	4 63	4 63	5 03
3½ x 3½ x 1½	2 39	2 39	3 05	6 x 6 x 4	4 13	4 13	4.94
3½ x 3½ x 1¼	2 27	2 27	2 99	6 x 6 x 3	3 64	3 64	4 75
3½ x 3 x 3	3 18	3 08	3 33	6 x 6 x 2½	3 39	3 39	4.66
3½ x 3 x 2½	2 93	2 83	3 24	6 x 6 x 2	3 08	3 08	4.56
3½ x 3 x 2	2 62	2 52	3 14	6 x 5 x 5	4.63	4 50	5.03
3½ x 3 x 1½	2 39	2 29	3 05	6 x 5 x 4	4 13	4 00	4.94
3½ x 2 x 3½	3 42	3 14	3 42	6 x 4 x 6	5.13	4 94	5.13
3½ x 1½ x 3½	3 42	3 05	3 42	6 x 4 x 4	4.13	3.79	4.94
4 x 4 x 6	4 94	4 94	4 13	6 x 3 x 6	5.13	4 75	5.13
4 x 4 x 5	4 41	4 41	4 00	6 x 2 x 6	5.13	4 56	5.13
4 x 4 x 3½	3 54	3 54	3 69	8 x 8 x 6	5 56	5 56	6 37
4 x 4 x 3	3 30	3 30	3 60	8 x 8 x 5	5 03	5 03	6 27
4 x 4 x 2½	3.05	3 05	3.51	8 x 8 x 4	4 50	4 50	6 17
4 x 4 x 2	2 74	2 74	3.41	8 x 8 x 3	4 00	4 00	6.07
4 x 4 x 1½	2 51	2 51	3 32	8 x 8 x 2½	3 69	3 69	6 01
4 x 4 x 1¼	2 39	2 39	3 26	8 x 8 x 2	3 44	3 44	5 84
4 x 4 x 1	2 22	2 22	3 18	8 x 6 x 8	6 56	6 37	6 56
4 x 3½ x 3	3 30	3 18	3 60	8 x 6 x 6	5 56	5 13	6 37
4 x 3½ x 2½	3 05	2 93	3 51	10 x 10 x 8	7 02	7 02	7 87
4 x 3½ x 2	2 74	2 62	3 41	10 x 10 x 6	6 02	6 02	7 68
4 x 3 x 4	3 79	3 60	3 79	10 x 10 x 4	4 96	4 96	7 48
4 x 3 x 3	3 30	3 08	3 60	12 x 12 x 8	7 44	7.44	9.09
4 x 3 x 2	2 74	2 52	3 41	12 x 12 x 6	6.44	6 44	8.90
4 x 2½ x 4	3.79	3 51	3 79				
4 x 2½ x 2½	3 05	2 70	3.51				

All dimensions given in inches.

250-LB CAST-IRON SCREWED FITTINGS
(American Standard B16d)

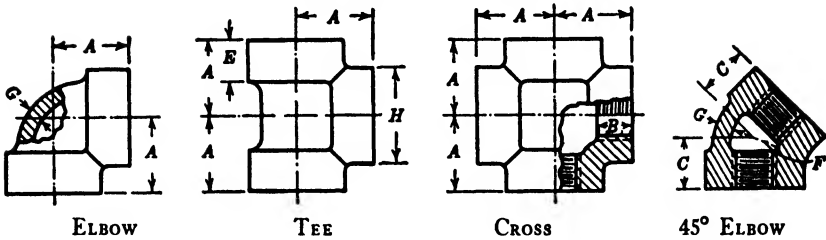


TABLE 54. DIMENSIONS OF ELBOWS, 45-DEG ELBOWS, TEES, AND CROSSES (STRAIGHT SIZES)

Nominal Pipe Size	A	C	B	E	F		G	H
	Center to End, Elbows, Tees, and Crosses	Center to End, 45-Deg Elbows	Length of Thread, Min	Width of Band, Min	Inside Diam of Fitting		Metal Thickness, Min	Outside Diam of Band, Min
					Min	Max		
3/8	0 94	0 81	0 43	0 49	0 540	0 584	0 18	1 17
1/2	1 06	0 88	0 47	0 55	0 675	0 719	0 18	1 36
3/4	1 25	1 00	0 57	0 60	0 840	0 897	0 20	1 59
1	1 44	1 13	0 64	0 68	1 050	1 107	0 23	1 88
1 1/8	1 63	1 31	0 75	0 76	1 315	1 385	0 28	2 24
1 1/4	1 94	1 50	0 84	0 88	1 660	1 730	0 33	2 73
1 1/2	2 13	1 69	0 87	0 97	1 900	1 970	0 35	3 07
2	2 50	2 00	1 00	1 12	2 375	2 445	0 39	3 74
2 1/2	2 94	2 25	1 17	1 30	2 875	2 975	0 43	4 60
3	3 38	2 50	1 23	1 40	3 500	3 600	0 48	5 36
3 1/2	3 75	2 63	1 28	1 49	4 000	4 100	0 52	5 98
4	4 13	2 81	1 33	1 57	4 500	4 600	0 56	6 61
5	4 88	3 19	1 43	1 74	5 563	5 663	0 66	7 92
6	5 63	3 50	1 53	1 91	6 625	6 725	0 74	9 24
8	7 00	4 31	1 72	2 24	8 625	8 725	0 90	11 73
10	8 63	5 19	1 93	2 58	10 750	10 850	1 08	14 37
12	10 00	6 00	2 13	2 91	12 750	12 850	1 24	16 84
14 O.D.	11 00		2 25	3 10	14 000	14 100	1 33	18 40
16 O.D.	12 50		2 45	3 45	16 000	16 100	1 50	20 88

All dimensions given in inches.

The 250-lb standard for screwed fittings covers only the straight sizes of 90- and 45-deg elbows, tees, and crosses.

Malleable-Iron Fittings

Standards. Malleable-iron screwed fittings for maximum WSP of 150 psi, ASA B16c.

Pipe fittings, malleable-iron (threaded), 150 lb, Fed. Specs. WW-P-521.

Unions, malleable-iron or steel, 250 lb, Fed. Specs. WW-U-531.

Patterns. Fittings are furnished with either flat band or beaded. (Flat-band pattern generally used for water lines and beaded pattern for gas lines.)

Coatings. Fittings furnished either black or galvanized.

Uses. Water and gas lines.

150-LB MALLEABLE-IRON SCREWED FITTINGS

(American Standard B16c)

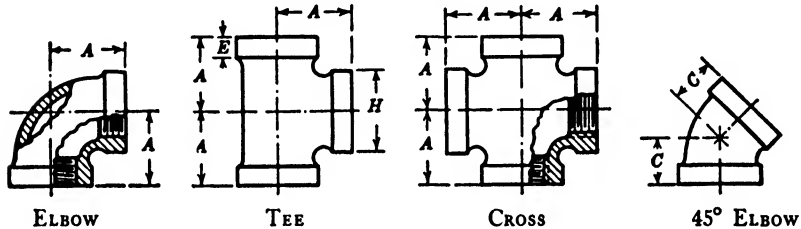


TABLE 55. DIMENSIONS OF ELBOWS, TEES, CROSSES, AND 45-DEG ELBOWS (STRAIGHT SIZES)

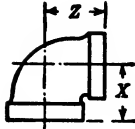
Nomi- nal Pipe Size	Center to End, Elbows, Tees, and Crosses* A	Center to End, 45-Deg Elbows C	Width of Band, Min E	Out- side Diam of Band, Min H	Nomi- nal Pipe Size	Center to End, Elbows, Tees, and Crosses* A	Center to End, 45-Deg Elbows C	Width of Band, Min E	Out- side Diam of Band, Min H
3/8	0.69		0.200	0.693	2	2.25	1.68	0.422	2.963
1/2	0.81	0.73	0.215	0.844	2 1/2	2.70	1.95	0.478	3.589
3/4	0.95	0.80	0.230	1.015	3	3.08	2.17	0.548	4.285
1/2	1.12	0.88	0.249	1.197	3 1/2	3.42	2.39	0.604	4.843
3/4	1.31	0.98	0.273	1.458	4	3.79	2.61	0.661	5.401
1	1.50	1.12	0.302	1.771	5	4.50	3.05	0.780	6.583
1 1/4	1.75	1.29	0.341	2.153	6	5.13	3.46	0.900	7.767
1 1/2	1.94	1.43	0.368	2.427					

All dimensions given in inches.

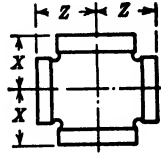
* Dimensions for reducing elbows and reducing crosses are given in Table 56, and dimensions for reducing tees in Table 57.

150-LB MALLEABLE-IRON SCREWED FITTINGS

(American Standard B16c)



ELBOW



CROSS

TABLE 56. DIMENSIONS OF ELBOWS AND CROSSES (REDUCING SIZES)*

Elbows			Crosses		
Nominal Pipe Size	Center to End		Nominal Pipe Size	Center to End	
	X	Z		X	Z
$\frac{3}{8}$ x $\frac{1}{4}$	0.88	0.90	$\frac{3}{4}$ x $\frac{1}{2}$	1.20	1.22
$\frac{1}{2}$ x $\frac{3}{8}$	1.04	1.03	1 x $\frac{3}{4}$	1.37	1.45
$\frac{3}{4}$ x $\frac{1}{2}$	1.20	1.22	1 x $\frac{1}{2}$	1.26	1.36
$\frac{3}{4}$ x $\frac{3}{8}$	1.12	1.13	$1\frac{1}{4}$ x 1	1.58	1.67
1 x $\frac{3}{4}$	1.37	1.45	$1\frac{1}{4}$ x $\frac{3}{4}$	1.45	1.62
1 x $\frac{1}{2}$	1.26	1.36	$1\frac{1}{2}$ x $1\frac{1}{4}$	1.82	1.88
$1\frac{1}{4}$ x 1	1.58	1.67	$1\frac{1}{2}$ x 1	1.65	1.80
$1\frac{1}{4}$ x $\frac{3}{4}$	1.45	1.62	$1\frac{1}{2}$ x $\frac{3}{4}$	1.52	1.75
$1\frac{1}{2}$ x $1\frac{1}{4}$	1.82	1.88	2 x $1\frac{1}{2}$	2.02	2.16
$1\frac{1}{2}$ x 1	1.65	1.80	2 x $1\frac{1}{4}$	1.90	2.10
$1\frac{1}{2}$ x $\frac{3}{4}$	1.52	1.75	2 x 1	1.73	2.02
2 x $1\frac{1}{2}$	2.02	2.16	2 x $\frac{3}{4}$	1.60	1.97
2 x $1\frac{1}{4}$	1.90	2.10	$2\frac{1}{2}$ x 2	2.39	2.60
2 x 1	1.73	2.02	3 x 2	2.52	2.89
$2\frac{1}{2}$ x 2	2.39	2.60			
3 x $2\frac{1}{2}$	2.83	2.99			
3 x 2	2.52	2.89			
4 x 3	3.30	3.60			

All dimensions given in inches.

* For dimensions not given see Table 55.

150-LB MALLEABLE-IRON SCREWED FITTINGS

(American Standard B16c)

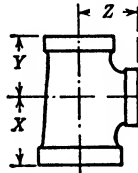


TABLE 57

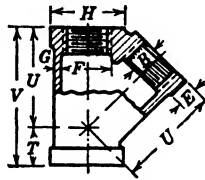
DIMENSIONS OF TEES (REDUCING SIZES)*

Nominal Pipe Size	Center to End			Nominal Pipe Size	Center to End		
	X	Y	Z		X	Y	Z
1/4 x 1/4 x 3/8	0 90	0 90	0 88	1 1/2 x 1 1/2 x 1 1/2	1 94	1 88	1 94
3/8 x 1/4 x 1/2	1 03	1 03	1 04	1 1/2 x 1 1/2 x 1 1/2	1 82	1 75	1 88
3/8 x 3/8 x 1/2	0 88	0 88	0 90	1 1/2 x 1 1/2 x 1	1 65	1 58	1 80
3/8 x 3/8 x 3/4	0 81	0 81	0 85	1 1/2 x 1 x 1 1/2	1 94	1 80	1 94
3/8 x 3/4 x 1/2	0 95	0 90	0 95	1 1/2 x 1 x 1	1 65	1 50	1 80
3/8 x 3/4 x 3/4	0 88	0 81	0 90	1 1/2 x 3/4 x 1 1/2	1 94	1 75	1 94
3/8 x 3/4 x 1	1 22	1 22	1 20	2 x 2 x 2 1/2	2 60	2 60	2 39
3/8 x 3/4 x 1 1/4	1 04	1 04	1 03	2 x 2 x 2 1/2	2 02	2 02	2 16
3/8 x 3/4 x 1 1/2	0 97	0 97	0 98	2 x 2 x 2 1/2	1 90	1 90	2 10
3/8 x 3/4 x 1 3/4	1 12	1 03	1 12	2 x 2 x 1 1/2	1 73	1 73	2 02
3/8 x 3/4 x 2	1 04	0 95	1 03	2 x 2 x 1 1/2	1 60	1 60	1 97
3/8 x 3/4 x 2 1/4	1 45	1 45	1 37	2 x 2 x 3/4	1 49	1 49	1 88
3/8 x 3/4 x 2 1/2	1 20	1 20	1 22	2 x 1 1/2 x 2	2 25	2 16	2 25
3/8 x 3/4 x 2 3/4	1 12	1 12	1 13	2 x 1 1/2 x 1 1/2	2 02	1 94	2 16
3/8 x 3/4 x 3	1 05	1 05	1 08	2 x 1 1/2 x 1 1/2	1 90	1 82	2 10
3/8 x 3/4 x 3 1/4	1 31	1 22	1 31	2 x 1 1/2 x 2	2 25	2 10	2 25
3/8 x 3/4 x 3 1/2	1 20	1 12	1 22	2 x 1 1/2 x 2	2 02	1 88	2 16
3/8 x 3/4 x 3 3/4	1 12	1 04	1 13	2 x 1 x 2	2 25	2 02	2 25
1 x 1 x 1 1/4	1 80	1 80	1 65	2 x 1 x 1 1/2	2 02	1 80	2 16
1 x 1 x 1 1/2	1 67	1 67	1 58	2 x 3/4 x 2	2 25	1 97	2 25
1 x 1 x 1 3/4	1 37	1 37	1 45	2 1/2 x 2 1/2 x 3	2 99	2 99	2 83
1 x 1 x 2	1 26	1 26	1 36	2 1/2 x 2 1/2 x 2	2 39	2 39	2 60
1 x 1 x 2 1/4	1 18	1 18	1 27	2 1/2 x 2 1/2 x 1 1/2	2 16	2 16	2 51
1 x 1 x 2 1/2	1 50	1 45	1 50	2 1/2 x 2 1/2 x 1 1/2	2 04	2 04	2 45
1 x 1 x 2 3/4	1 37	1 31	1 45	2 1/2 x 2 1/2 x 1	1 87	1 87	2 37
1 x 1 x 3	1 26	1 20	1 36	2 1/2 x 2 1/2 x 3/4	1 74	1 74	2 32
1 x 1 x 3 1/4	1 50	1 36	1 50	2 1/2 x 2 1/2 x 2 1/2	2 70	2 60	2 70
1 x 1 x 3 1/2	1 37	1 22	1 45	2 1/2 x 2 x 2	2 39	2 25	2 60
1 x 1 x 3 3/4	1 26	1 12	1 36	2 1/2 x 1 1/2 x 2 1/2	2 70	2 51	2 70
1 1/4 x 1 1/4 x 1 1/4	1 88	1 88	1 82	3 x 3 x 2 1/2	2 83	2 83	2 99
1 1/4 x 1 1/4 x 1 1/2	1 58	1 58	1 67	3 x 3 x 2	2 52	2 52	2 89
1 1/4 x 1 1/4 x 1 3/4	1 45	1 45	1 62	3 x 3 x 1 1/2	2 29	2 29	2 80
1 1/4 x 1 1/4 x 2	1 34	1 34	1 53	3 x 3 x 3/4	2 17	2 17	2 74
1 1/4 x 1 1/4 x 2 1/4	1 26	1 26	1 44	3 x 3 x 1	2 00	2 00	2 66
1 1/4 x 1 1/4 x 2 1/2	1 75	1 67	1 75	3 x 2 1/2 x 3	3 08	2 99	3 08
1 1/4 x 1 1/4 x 2 3/4	1 58	1 50	1 67	3 x 2 x 3	3 08	2 89	3 08
1 1/4 x 1 1/4 x 3	1 45	1 37	1 62	3 x 2 x 2	2 52	2 25	2 89
1 1/4 x 1 1/4 x 3 1/4	1 75	1 62	1 75	3 1/2 x 3 1/2 x 2 1/2	2 93	2 93	3 24
1 1/4 x 1 1/4 x 3 1/2	1 58	1 45	1 67	4 x 4 x 3	3 30	3 30	3 60
1 1/4 x 1 1/4 x 3 3/4	1 45	1 31	1 62	4 x 4 x 2 1/2	3 05	3 05	3 51
1 1/2 x 1 1/2 x 2	2 16	2 16	2 02	4 x 4 x 2	2 74	2 74	3 41
1 1/2 x 1 1/2 x 1 1/4	1 82	1 82	1 88	5 x 5 x 3	3 51	3 51	4 22
1 1/2 x 1 1/2 x 1 1/2	1 65	1 65	1 80	6 x 6 x 4	4 13	4 13	4 94
1 1/2 x 1 1/2 x 1 3/4	1 52	1 52	1 75	6 x 6 x 3	3 64	3 64	4 75
1 1/2 x 1 1/2 x 2	1 41	1 41	1 66	6 x 6 x 2 1/2	3 39	3 39	4 66
				6 x 6 x 2	3 08	3 08	4 56

All dimensions given in inches.
 * For dimensions not given see Table 55.

150-LB MALLEABLE-IRON SCREWED FITTINGS

(American Standard B16c)

**TABLE 58. DIMENSIONS OF 45-DEG Y-BRANCHES (STRAIGHT SIZES)**

Nominal Pipe Size	Width of Band, Min E	Outside Diam of Band, Min H	Center to End Inlet T	Center to End Outlet U	End to End V
$\frac{3}{8}$	0 230	1.015	0 50	1 43	1 93
$\frac{1}{2}$	0 249	1 197	0 61	1 71	2 32
$\frac{3}{4}$	0 273	1 458	0 72	2 05	2 77
1	0 302	1 771	0 85	2 43	3 28
$1\frac{1}{4}$	0 341	2 153	1 02	2 92	3 94
$1\frac{1}{2}$	0 368	2 427	1 10	3 28	4 38
2	0 422	2 963	1 24	3 93	5 17
$2\frac{1}{2}$	0 478	3 589	1 52	4 73	6 25
3	0 548	4 285	1 71	5 55	7 26
4	0 661	5 401	2 01	6 97	8 98

All dimensions given in inches.

150-LB MALLEABLE-IRON SCREWED FITTINGS

(American Standard B16c)

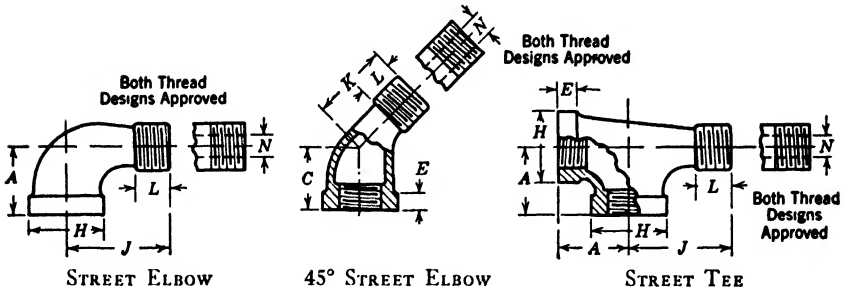


TABLE 59

DIMENSIONS OF SERVICE OR STREET TEES AND 90-DEG AND 45-DEG ELBOWS (STRAIGHT SIZES)

Nominal Pipe Size	Center to End, Elbows, Tees <i>A</i>	Center to End, 45-Deg Elbows <i>C</i>	Width of Band, Min <i>E</i>	Outside Diam of Band, Min <i>H</i>	Center to Male End Elbows, Tees <i>J</i>	Center to Male End 45-Deg Elbows <i>K</i>	Length of External Thread, Min <i>L</i>	Max Port Diam Male End <i>N</i>
1/8	*0.69		0 200	0 693	*1 00		0 2638	0 20
1/4	0.81	0 73	0 215	0 844	1 19	0 94	0 4018	0 26
3/8	0.95	0 80	0 230	1 015	1 44	1 03	0 4078	0 37
1/2	1 12	0 88	0 249	1 197	1 63	1 15	0 5337	0 51
3/4	1.31	0 98	0 273	1 458	1 89	1 29	0 5457	0 69
1	1 50	1 12	0 302	1 771	2 14	1.47	0 6828	0 91
1 1/4	1.75	1 29	0 341	2 153	2 45	1 71	0 7068	1.19
1 1/2	1 94	1.43	0 368	2 427	2 69	1 88	0.7235	1.39
2	2 25	1 68	0 422	2 963	3 26	2 22	0 7565	1.79
2 1/2	2.70	1 95	0 478	3 589	3 86	2 57	1.1375	2.20
3	3 08	2.17	0 548	4.285	4 51	3 00	1.2000	2.78
3 1/2	*3 42		0 604	4 843	*5 09		1.2500	3.24
4	3 79	2.61	0 661	5 401	5 69	3.70	1.3000	3.70
5	*4.50		0 780	6 583	*6.86		1 4063	4.69
6	*5.13		0 900	7.767	*8.03		1.5125	5.67

All dimensions given in inches.

* This dimension applies to street elbows only. Street tees are not made in these sizes.

150-LB MALLEABLE-IRON SCREWED FITTINGS
(American Standard B16c)

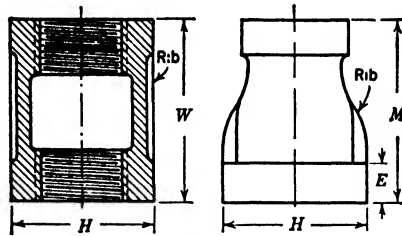


TABLE 60

DIMENSIONS OF COUPLINGS (STRAIGHT AND REDUCING SIZES)

Nominal Pipe Size	Width of Band, Min E	Outside Diam of Band, Min H	Thickness of Ribs*	Length of Straight Couplings W	Length of Reducing Couplings M
$\frac{1}{8}$	0.200	0.693	0.090	0.96	
$\frac{1}{4}$	0.215	0.844	0.095	1.06	1.00
$\frac{3}{8}$	0.230	1.015	0.100	1.16	1.13
$\frac{1}{2}$	0.249	1.197	0.105	1.34	1.25
$\frac{3}{4}$	0.273	1.458	0.120	1.52	1.44
1	0.302	1.771	0.134	1.67	1.69
$1\frac{1}{4}$	0.341	2.153	0.145	1.93	2.06
$1\frac{1}{2}$	0.368	2.427	0.155	2.15	2.31
2	0.422	2.963	0.173	2.53	2.81
$2\frac{1}{2}$	0.478	3.589	0.210	2.88	3.25
3	0.548	4.285	0.231	3.18	3.69
$3\frac{1}{2}$	0.604	4.843	0.248	3.43	4.00
4	0.661	5.401	0.265	3.69	4.38

All dimensions given in inches.

* Right-hand couplings have 2 ribs and right- and left-hand couplings have 4 or more ribs.

150-LB MALLEABLE-IRON SCREWED FITTINGS

(American Standard B16c)

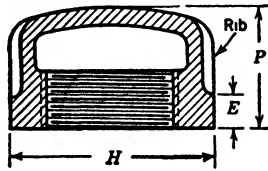


TABLE 61

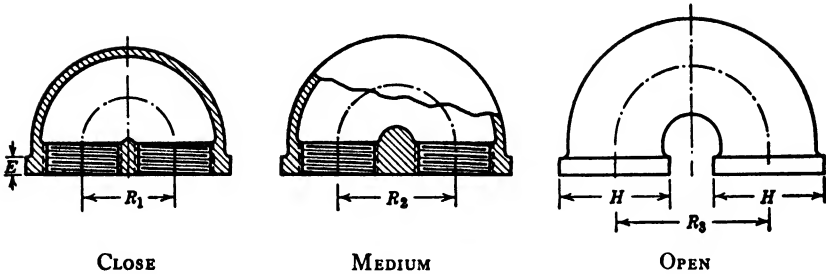
DIMENSIONS OF CAPS

Nominal Pipe Size	Width of Band, Min. <i>E</i>	Outside Diam of Band, Min. <i>H</i>	Height, Min. <i>P</i>	Thickness of Ribs
½	0 249	1.197	0.87	0.105
¾	0 273	1.458	0.97	0 120
1	0 302	1.771	1.16	0 134
1¼	0.341	2 153	1.28	0 145
1½	0.368	2.427	1.33	0 155
2	0 422	2.963	1.45	0 173
2½	0.478	3 589	1 70	0.210
3	0 548	4 285	1 80	0 231
3½	0.604	4.843	1 90	0 248
4	0.661	5 401	2 08	0 265
5	0 780	6.583	2 32	0 300
6	0.900	7.767	2 55	0 336

All dimensions given in inches.
The outside radius of top is equal to $3 \times P$.

150-LB MALLEABLE-IRON SCREWED FITTINGS

(American Standard B16c)



CLOSE

MEDIUM

OPEN

TABLE 62

DIMENSIONS OF CLOSE, MEDIUM, AND OPEN PATTERNS RETURN BENDS *

Nominal Pipe Size	Width of Band, Min. E	Outside Diameter of Band, Min. H	Center to Center (Close Pattern) R ₁	Center to Center (Medium Pattern) R ₂	Center to Center (Open Pattern) R ₃
½	0.249	1.197	1.000	1.250	1.50
¾	0.273	1.458	1.250	1.500	2.00
1	0.302	1.771	1.500	1.875	2.50
1¼	0.341	2.153	1.750	2.250	3.00
1½	0.368	2.427	2.188	2.500	3.50
2	0.422	2.963	2.625	3.000	4.00
2½	0.478	3.589			4.50
3	0.548	4.285			5.00

All dimensions in inches.

* It is permissible to furnish close pattern return bends not banded. Close pattern return bends will not make up parallel coils, as the distance center to center of two adjacent bends is greater than the center to center of openings of a single bend.

150-LB MALLEABLE-IRON SCREWED FITTINGS
(American Standard B16c)

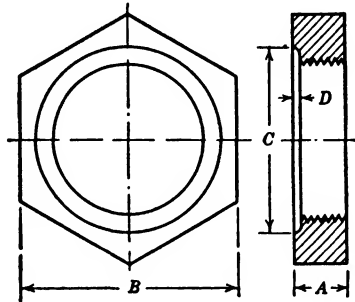


TABLE 63. DIMENSIONS OF LOCK-NUTS

Size*	Thickness, Min A	Diam Across Flats		Diam of Packing Recess, † Min C	Depth of Packing Recess, † Min D
		Malleable, Min B	Cast Iron, Min B		
¼	0 19	0 69		0 50	0 04
½	0 25	0 84		0 66	0 06
¾	0 28	1 00		0 77	0 06
1	0 31	1 18		0 97	0 06
1 ¼	0 34	1 43		1 23	0 06
1 ½	0 38	1 75		1 50	0 06
1 ¾	0 42	2 10		1 86	0 06
2	0 47	2 35		2 12	0 06
2 ¼	0 53	2 88		2 63	0 09
2 ½	0 59	3 50	3 86	3 18	0 09
3	0 67	4 27	4 62	3 84	0 09
3 ¼	0 73	4 84	5 20	4 38	0 13
4	0 80	5.38	5 79	5 00	0 13
5	0 94		7 05	6 06	0 13
6	1 09		8 28	7 13	0 13

All dimensions given in inches.
Reproduced from MSS Locknut Standard for Cast Iron and Malleable Iron, SP-17-1937.

Locknuts shall be threaded in accordance with the American Standard Internal Straight-Pipe Threads for Locknut Connections as specified in ASA B2.

* Sizes 3 ¼ in. and smaller are hexagonal; sizes 4 in. and larger may be either hexagonal or octagonal.

† The packing recess is cast finish (not tool finish).

Cast-Iron Drainage Fittings

Description. Screw-joint drainage fittings were developed about the year 1880 by the Durham House Drainage Company of New York. They are often referred to as Durham fittings.

These fittings are designed primarily for drainage systems using screw pipe. The fittings are provided with shoulders so that the ends of the pipe, when the joints are made up, practically meet the shoulders, thereby forming smooth passageways.

Standards. American Standard B16.12 (1942), ASME, HPCNA, MSS.

Material. The dimensions of the above standard are based upon gray iron castings of high quality (ASTM A126-30).

Pitch. All fittings having openings at 90 deg are tapped with a pitch of $\frac{1}{4}$ in. to the foot.

Coatings. Fittings are regularly coated with a black composition, uncoated, or galvanized. As a rule, code requirements call for galvanizing.

CAST-IRON SCREWED DRAINAGE FITTINGS

(American Standard B16.12)

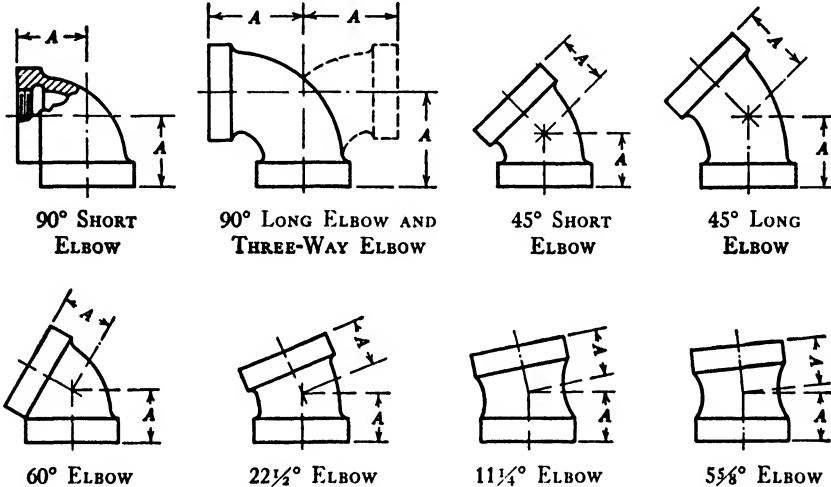


TABLE 64. CENTER TO END DIMENSIONS OF ELBOWS

Nominal Pipe Size	90-Deg Elbow		45-Deg Elbow		60-Deg Elbow A	22½-Deg Elbow A	11¼-Deg Elbow A	5¼-Deg Elbow A
	Short* A	Long† A	Short* A	Long A				
1	1½	1½½‡	1½	1½	1½	1	1	1½
1½	1¾	2¾	1¾	1¾	1¾	1¾	1¾	1¾
2	2	2¾	2	2	2	2	2	2
2½	2½	3½	2½	2½	2½	2½	2½	2½
3	3	4	3	3	3	3	3	3
4	3½	5	4	4	4	4	4	4
5	4	6	5	5	5	5	5	5
6	5	7	6	6	6	6	6	6

All dimensions are given in inches.

All drainage fittings having openings at 90 deg are tapped with the inlet opening pitched $\frac{1}{4}$ in. per ft.

* Same as adopted for 125-Lb Cast-Iron Screwed Fittings (ASA B16d-1927).

† Three-way elbows have same dimensions as 90-deg long radius elbows.

‡ This dimension applies to 90-deg long elbows only. Three-way elbows are not made in the 1-in. size.

CAST-IRON SCREWED DRAINAGE FITTINGS

(American Standard B16.12)

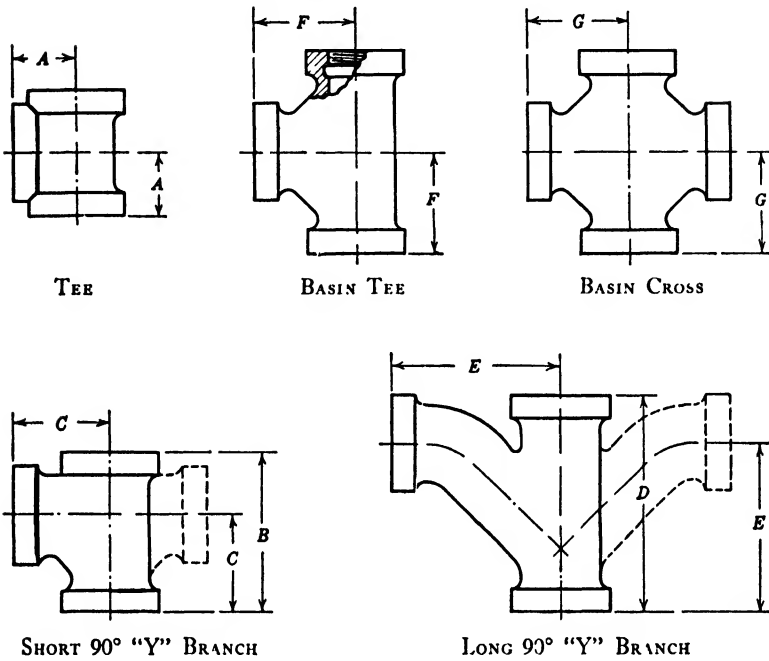


TABLE 65 DIMENSIONS OF TEES, CROSSES, AND Y-BRANCHES

Nominal Pipe Size	Center to End of Tee* A	90-Deg Short† Y-Branch		90-Deg Long† Y-Branch		Center to End of Basin Tee F	Center to End of Basin Cross G
		End to End B	Center to End C	End to End D	Center to End E		
1		3 1/4	1 13/16				
1 1/4	1 3/4	3 3/4	2 1/4	4 3/4	3 3/4	2 1/16	2 3/16
1 1/2	1 13/16	4 1/4	2 3/4	5 3/4	4 1/8	2 11/16	2 11/16
2	2 1/4	5 1/4	3 1/4	7	5 1/4	3 1/4	3 1/4
2 1/2	2 11/16	6 1/4	3 11/16	8 1/4	6 1/4	4 1/4	
3	3 1/4	7 1/4	4 1/4	9 7/8	7 3/4		
3 1/2	3 13/16	8 1/4	5 1/4	13	9 1/4		
4	4 1/4	10 1/16	6 1/8	15 3/4	12 1/4		
5	4 3/4	11 13/16	7 1/4	18 3/4	14 3/4		

All dimensions are given in inches.

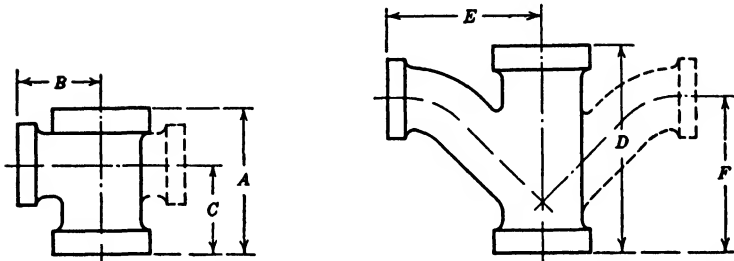
All drainage fittings having openings at 90-deg are tapped with the inlet opening pitched 1/4 in. per ft.

* Same dimensions as adopted for 125-lb Cast-Iron Screwed Fittings (ASA B16d-1927).

† Double Y-branches have same dimensions as single Y-branches.

CAST-IRON SCREWED DRAINAGE FITTINGS

(American Standard B16.12)



SHORT 90° "Y" BRANCH REDUCING

LONG 90° "Y" BRANCH REDUCING

TABLE 66. DIMENSIONS OF Y-BRANCHES (REDUCING SIZES)*

Nominal Pipe Size	90-Deg Short Y-Branch			90-Deg Long Y-Branch		
	End to End A	Center to End B	Center to End C	End to End D	Center to End E	Center to End F
1½ x 1¼	3 7⁄8	2 ½	2 ¾	5 1⁄8	3 7⁄8	3 13⁄16
2 x 1½	4 5⁄8	2 13⁄16	2 11⁄16	5 ¾	4 1⁄8	4 3⁄16
2½ x 1¾	4 7⁄8	3 1⁄16	2 11⁄16	5 ¾	4 9⁄16	4 1⁄16
2½ x 2	5 ¾	3 5⁄16	3 ¼	7 3⁄8	5 ¾	5 ¾
3 x 1¾	5 13⁄16	3 5⁄16	2 13⁄16	5 13⁄16	5	4 3⁄8
3 x 2	5 11⁄16	3 1⁄8	3 3⁄8	7 9⁄16	6 1⁄16	5 13⁄16
4 x 1¾	5 ¾	3 11⁄16	3	6 1⁄16	5 7⁄16	4 ¾
4 x 2	5 13⁄16	4 1⁄16	3 5⁄8	7 11⁄16	6 5⁄8	6 1⁄16
4 x 2½	6 5⁄8	4 7⁄16	3 11⁄16	8 5⁄8	7 1⁄16	6 ¾
4 x 3	7 3⁄8	4 3⁄4	4 5⁄8	10	8 13⁄16	7 3⁄8
5 x 1¾	5 9⁄16	4 1⁄8	3 7⁄8	6 5⁄8	6	4 13⁄16
5 x 2	6 1⁄8	4 5⁄8	3 9⁄8	7 3⁄8	7 3⁄8	6 1⁄8
5 x 3	7 3⁄8	5 ¾	4 ¾	10 ¾	8 5⁄8	7 7⁄8
5 x 4	9 3⁄8	5 11⁄16	5 ¾	13	10 7⁄16	10 1⁄8
6 x 2	6 ¾	5 1⁄8	3 5⁄8	7 13⁄16	7 ¾	6 5⁄16
6 x 3	7 3⁄8	5 ¾	4 9⁄8	10 1⁄8	9 3⁄8	8 1⁄16
6 x 4	9 3⁄8	6 1⁄16	5 7⁄8	13 1⁄16	11	10 3⁄16
6 x 5	10 9⁄16	6 ¾	6 ¾	16 1⁄16	12 13⁄16	12 3⁄16

All dimensions are given in inches.

All drainage fittings having openings at 90 deg are tapped with the inlet opening pitched ¼ in per ft.

* Double Y-branches have same dimensions as single Y-branches.

CAST-IRON SCREWED DRAINAGE FITTINGS

(American Standard B16.12)

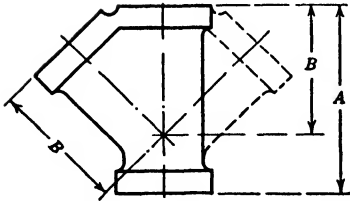


TABLE 67. DIMENSIONS OF 45-DEG Y-BRANCHES*

Nominal Pipe Size	End to End A	Center to End B	Nominal Pipe Size	End to End A	Center to End B
1	4	2 ¹¹ / ₁₆	3	9	6 ⁵ / ₁₆
1 ¹ / ₄	5	3 ³ / ₈	4	10 ⁷ / ₈	7 ¹¹ / ₁₆
1 ¹ / ₂	5 ³ / ₈	3 ⁵ / ₈	5	12 ¹⁵ / ₁₆	9 ⁹ / ₁₆
2	6 ³ / ₈	4 ³ / ₈	6	14 ⁷ / ₈	10 ³ / ₄
2 ¹ / ₂	7 ³ / ₈	5 ³ / ₈			

All dimensions are given in inches.
* Double Y-branches have same dimensions as single Y-branches.

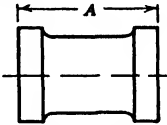


TABLE 69. DIMENSIONS OF COUPLINGS

Nominal Pipe Size	End to End A	Nominal Pipe Size	End to End A
1	2 ³ / ₈	3	4 ¹ / ₄
1 ¹ / ₄	3	4	4 ³ / ₈
1 ¹ / ₂	3 ¹ / ₈	5	4 ³ / ₄
2	3 ³ / ₈	6	5
2 ¹ / ₂	4		

All dimensions are given in inches.

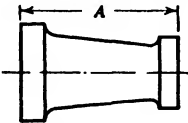


TABLE 70. DIMENSIONS OF INCREASERS

Nominal Pipe Size	End to End A	Nominal Pipe Size	End to End A
2 x 1 ¹ / ₄	9	5 x 2	9
2 ¹ / ₂ x 2	9	5 x 3	9
3 x 2	9	5 x 4	9
3 x 2 ¹ / ₂	9	6 x 4	9
4 x 2	9	6 x 5	9
4 x 3	9		

All dimensions are given in inches.

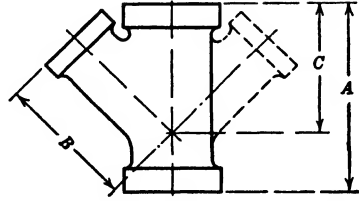


TABLE 68. DIMENSIONS OF 45-DEG Y-BRANCHES (REDUCING SIZES)*

Nominal Pipe Size	End to End A	Center to End B	Center to End C
1 ¹ / ₂ x 1 ¹ / ₂	5 ¹ / ₄	3 ⁷ / ₁₆	3 ³ / ₈
2 x 1 ¹ / ₂	5 ⁷ / ₈	4 ¹ / ₈	4 ¹ / ₁₆
2 ¹ / ₂ x 1 ¹ / ₂	6 ¹ / ₁₆	4 ⁵ / ₈	4 ⁹ / ₁₆
2 ¹ / ₂ x 2	7 ¹ / ₁₆	5 ¹ / ₈	4 ¹³ / ₁₆
3 x 1 ¹ / ₂	6 ⁵ / ₈	5 ¹ / ₁₆	4 ¹⁵ / ₁₆
3 x 2	7 ¹ / ₈	5 ³ / ₈	5 ⁵ / ₁₆
3 x 2 ¹ / ₂	8	5 ¹¹ / ₁₆	5 ¹¹ / ₁₆
4 x 1 ¹ / ₂	7 ³ / ₁₆	6 ¹ / ₁₆	5 ³ / ₄
4 x 2	7 ¹¹ / ₁₆	6 ⁵ / ₁₆	6
4 x 3	9 ¹ / ₁₆	7 ³ / ₁₆	6 ³ / ₈
5 x 2	8 ¹ / ₄	7 ¹ / ₁₆	6 ³ / ₈
5 x 3	9 ¹⁵ / ₁₆	7 ⁷ / ₈	7 ⁵ / ₈
5 x 4	11 ¹ / ₈	8 ³ / ₄	8 ¹ / ₁₆
6 x 2	8 ⁷ / ₁₆	8 ¹ / ₁₆	7 ⁹ / ₁₆
6 x 3	10	8 ⁵ / ₄	8 ⁵ / ₁₆
6 x 4	11 ³ / ₈	9 ³ / ₈	9 ¹ / ₁₆
6 x 5	13	10	9 ¹⁵ / ₁₆

All dimensions are given in inches.
* Double Y-branches have same dimension as single Y-branches.

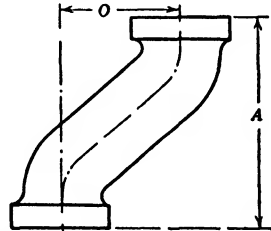


TABLE 71. DIMENSIONS OF OFFSETS

Nominal Pipe Size	Offset O	End to End A	Nominal Pipe Size	Offset O	End to End A
2	4	7 ¹ / ₂	4	10	15 ³ / ₄
2	6	9 ¹ / ₂	4	12	17 ³ / ₄
2	8	11 ¹ / ₂	5	6	12 ³ / ₈
2	10	13 ¹ / ₂	5	8	14 ³ / ₈
3	4	8 ³ / ₄	5	10	16 ³ / ₄
3	6	10 ³ / ₄	5	12	18 ³ / ₄
3	8	12 ³ / ₄	6	6	13 ³ / ₈
3	10	14 ³ / ₄	6	8	15 ³ / ₈
4	4	9 ³ / ₄	6	10	17 ³ / ₄
4	6	11 ³ / ₄	6	12	19 ³ / ₄
4	8	13 ³ / ₄			

All dimensions are given in inches.

Cast-Iron and Steel-Flanged Fittings

Standards are in use for Classes 25, 125, 250, and still higher pressure as listed below.

Coatings. Fittings are obtainable plain, asphaltum-covered, or galvanized.

Facing and Drilling. Fittings are usually furnished "faced" only, unless otherwise specified. If wanted "drilled," it should be especially mentioned. Extra Heavy used up to 250 lb WSP. Fittings can be ordered special to be made up of semi-steel. Furnished with raised faces, but not drilled unless so specified.

CLASS 125 CAST-IRON FLANGES AND FITTINGS

(American Standard B16a)

TABLE 72. DIMENSIONS OF CAST-IRON FLANGES, DRILLING FOR BOLTS AND THEIR LENGTHS

Nominal Pipe Size	Diam of Flange	Thick-ness* of Flange (Min)	Diam of Bolt Circle	Num-ber* of Bolts	Diam of Bolts	Diam* of Drilled Bolt Holes	Length of Bolts	Size of Ring Gasket
1	4¼	⅞	3⅞	4	⅜	⅝	1¾	1 x 2⅝
1¼	4⅝	½	3½	4	⅜	⅝	2	1¼ x 3
1½	5	⅞	3⅞	4	½	⅝	2	1½ x 3⅝
2	6	⅝	4¾	4	⅝	¾	2¼	2 x 4⅝
2½	7	1⅞	5½	4	⅝	¾	2½	2½ x 4⅞
3	7½	¾	6	4	⅝	¾	2½	3 x 5⅝
3½	8½	1⅞	7	8	⅝	¾	2¼	3½ x 6⅝
4	9	1⅞	7½	8	⅝	¾	3	4 x 6⅞
5	10	1⅞	8½	8	¾	⅞	3	5 x 7¾
6	11	1	9½	8	¾	⅞	3¼	6 x 8¾
8	13½	1⅞	11¾	8	¾	⅞	3½	8 11
10	16	1⅞	14¼	12	⅞	1	3¼	10 x 13⅞
12	19	1¼	17	12	⅞	1	3¼	12 x 16⅞
14 O.D.	21	1⅞	18¼	12	1	1⅞	4¼	14 x 17¾
16 O.D.	23½	1⅞	21¼	16	1	1⅞	4½	16 x 20¼

All dimensions given 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 1¼ in. the bolt holes shall be drilled ⅛ in. larger in diameter than the nominal diameter of the bolt. Holes for bolts 1¼ in. and larger shall be drilled ¼ in. larger than nominal diameter of bolts.

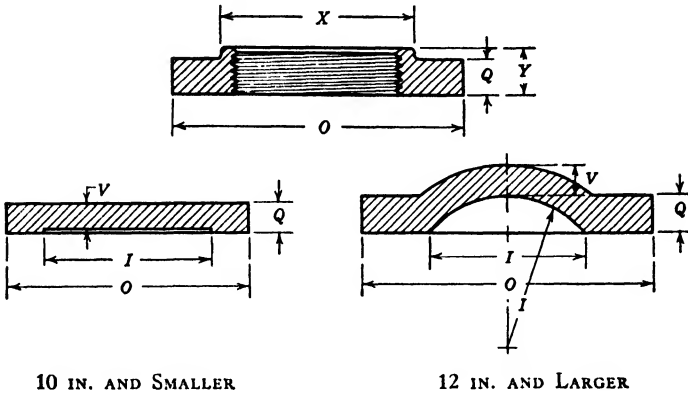
† All these cast-iron standard flanges have plain faces.

Bolts shall be of steel with American Standard Regular or Heavy Unfinished Square Heads and the nuts shall be of steel with American Standard Heavy Unfinished Hexagonal dimensions, all as specified in American Standard for Wrench-Head Bolts and Nuts and Wrench Openings (ASA B18 2-1933)

All bolts, or bolt-studs if used, and all nuts shall be threaded in accordance with American Standard for Screw Threads (ASA B1.1-1933) Coarse-Thread Series, Class 2 Fit.

CLASS 125 CAST-IRON FLANGES AND FITTINGS

(American Standard B16a)



10 IN. AND SMALLER

12 IN. AND LARGER

TABLE 73

DIMENSIONS OF SCREWED COMPANION AND BLIND FLANGES * †

Nominal‡ Pipe Size	Diam of Flange	Thickness of Flange (Min)	Wall‡ Thickness	Diam Hub (Min)	Length of Hub and Threads (Min)
<i>I</i>	<i>O</i>	<i>Q</i>	<i>V</i>	<i>X</i>	<i>Y</i>
1	4 1/4	7/16	3/8	1 15/16	1 1/8
1 1/4	4 5/8	3/8	7/16	2 3/8	1 3/8
1 1/2	5	9/16	3/8	2 9/16	7/8
2	6	5/8	7/16	3 1/8	1
2 1/2	7	11/16	3/8	3 9/16	1 1/8
3	7 3/4	3/4	11/16	4 1/4	1 3/8
3 1/2	8 3/4	13/16	3/4	4 13/16	1 1/4
4	9	15/16	7/8	5 1/8	1 3/8
5	10	15/16	7/8	6 1/8	1 3/8
6	11	1	15/16	7 1/8	1 3/8
8	13 3/4	1 1/8	1 1/16	9 11/16	1 3/4
10	16	1 1/16	1 1/8	11 13/16	1 13/16
12	19	1 1/4	1 3/8	14 1/8	2 3/8
14 O D.	21	1 3/8	7/8	15 3/8	2 3/4
16 O D.	23 3/4	1 7/8	1	17 3/8	2 3/4
18 O D.	25	1 9/8	1 1/16	19 5/8	2 13/16
20 O D.	27 3/4	1 11/16	1 1/8	21 3/4	2 7/8
24 O D.	32	1 7/8	1 3/8	26	3 3/4
30 O D.	38 1/4	2 1/8	1 7/16		
36 O D.	46	2 3/8	1 5/8		
42 O D.	53	2 5/8	1 11/16		
48 O D.	59 3/4	2 3/4	2		

All dimensions given in inches.

* For drilling templates refer to Table 72.

† All these standard flanges have plain faces.

‡ All blind flanges for sizes 12 in. (19 in. O D) and larger must be dished with inside radius equal to the port diameter. The wall thickness at no point shall be less than 87 1/2% of the dimensions given in the table.

CLASS 125 CAST-IRON FLANGES AND FITTINGS

(American Standard B16a)

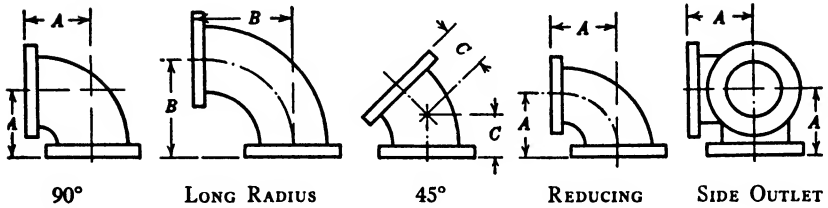


TABLE 74
DIMENSIONS OF ELBOWS*

Nominal Pipe Size	Inside Diam of Fittings	Center-†, ‡, § to-Face Elbow A	Center to Face Long Radius Elbow†, ‡, § B	Center-‡ to-Face 45-Deg Elbow C	Diam of Flange	Thickness of Flange (Min)	Wall || Thickness
1	1	3½	5	1¾	4¾	¾	¾
1¼	1¼	3¾	5½	2	4¾	¾	¾
1½	1½	4	6	2¼	5	¾	¾
2	2	4½	6½	2½	6	¾	¾
2½	2½	5	7	3	7	1¼	¾
3	3	5½	7½	3	7½	¾	¾
3½	3½	6	8½	3½	8½	1¼	¾
4	4	6½	9	4	9	1¼	¾
5	5	7½	10½	4½	10	1¼	¾
6	6	8	11½	5	11	1	¾
8	8	9	14	5½	13½	1¼	¾
10	10	11	16½	6½	16	1¼	¾
12	12	12	19	7½	19	1¼	1¼
14 O.D.	14	14	21½	7½	21	1¼	¾
16 O.D.	16	15	24	8	23½	1¼	1

All dimensions given in inches.

* For drilling templates refer to Table 72.

† Reducing elbows and side outlet elbows carry same dimensions center to face as straight-size elbows, corresponding to the size of the larger opening.

‡ Special-degree elbows, ranging from 1 to 45 deg, inclusive, have the same center to face dimensions given for 45-deg elbows and those over 45 deg and up to 90 deg, inclusive, shall have the same center-to-face dimensions given for 90-deg elbows. The angle designation of an elbow is its deflection from straight-line flow and is the angle between the flange faces.

§ Side outlet elbows shall have all openings on intersecting center lines.

|| Body thickness at no point shall be less than 87¾% of the dimensions given in the table.

CLASS 125 CAST-IRON FLANGES AND FITTINGS
(American Standard B16a)

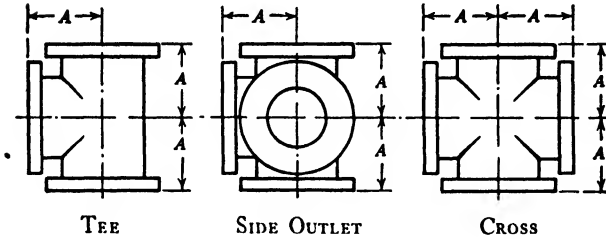


TABLE 75
DIMENSIONS OF TEES AND CROSSES (STRAIGHT SIZES)*

Nominal Pipe Size	Inside Diam of Fittings	Center-†, ‡ to-Face Tees and Crosses A	Face-†, ‡ to-Face Tees and Crosses AA	Diam of Flange	Thickness of Flange (Min)	Wall§ Thickness
1	1	3½	7	4¼	¾	⅜
1¼	1¼	3¾	7½	4¾	¾	⅜
1½	1½	4	8	5	¾	⅜
2	2	4½	9	6	¾	⅜
2½	2½	5	10	7	1½	⅜
3	3	5½	11	7½	¾	⅜
3½	3½	6	12	8½	1½	⅜
4	4	6½	13	9	1½	⅜
5	5	7½	15	10	1½	⅜
6	6	8	16	11	1	⅜
8	8	9	18	13½	1 ⅜	⅜
10	10	11	22	16	1 ⅜	⅜
12	12	12	24	19	1 ¼	1 ⅜
14 O.D.	14	14	28	21	1 ⅜	⅜
16 O.D.	16	15	30	23 ¼	1 ⅜	1

All dimensions given in inches.

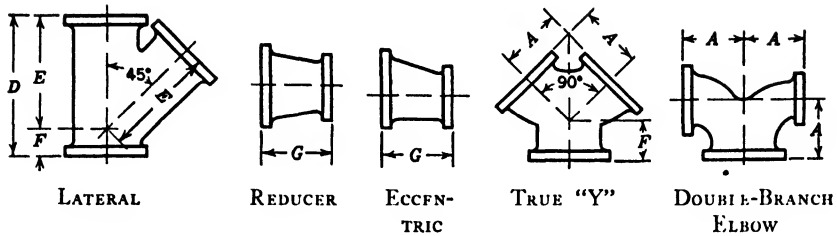
* For drilling templates refer to Table 72.

† Tees, side outlet tees, and crosses, 16 in. and smaller, reducing on the outlet, have the same dimensions center to face and face to face as straight-size fittings, corresponding to the size of the larger opening.

‡ Tees and crosses, reducing on run only, carry same dimensions center to face and face to face as a straight-size fitting of the larger opening.

§ Body thickness at no point shall be less than 87 ¼% of the dimensions given in the table.

CLASS 125 CAST-IRON FLANGES AND FITTINGS
(American Standard B16a)



**TABLE 76. DIMENSIONS OF LATERALS (STRAIGHT SIZES), REDUCERS, TRUE Y'S
DOUBLE-BRANCH ELBOWS***

Nomi- nal, † Pipe Size	Inside Diam of Fittings	Center- to-Face True Y and Double- Branch Elbow A	Face-‡, § to-Face Lateral D	Center-‡, § to-Face Lateral E	Center-‡, § to-Face True Y and Lateral F	Face-¶ to-Face Reducer G	Diam of Flange	Thick- ness of Flange (Min)	Wall || Thick- ness
1	1	3 1/2	7 1/2	5 1/4	1 3/4		4 1/4	7/16	5/16
1 1/2	1 1/2	3 3/4	8	6 1/4	1 3/4		4 5/8	3/8	5/16
1 1/2	1 1/2	4	9	7	2		5	5/16	5/16
2	2	4 1/2	10 1/2	8	2 1/2	5	6	3/8	5/16
2 1/2	2 1/2	5	12	9 1/2	2 1/2	5 1/2	7	11/16	5/16
3	3	5 1/2	13	10	3	6	7 1/2	3/4	3/8
3 1/2	3 1/2	6	14 1/2	11 1/2	3	6 1/2	8 1/2	13/16	7/16
4	4	6 1/2	15	12	3	7	9	15/16	3/4
5	5	7 1/2	17	13 1/2	3 1/2	8	10	15/16	3/4
6	6	8	18	14 1/2	3 1/2	9	11	1	3/4
8	8	9	22	17 1/2	4 1/2	11	13 1/2	1 1/8	3/4
10	10	11	25 1/2	20 1/2	5	12	16	1 1/4	3/4
12	12	12	30	24 1/2	5 1/2	14	19	1 1/2	13/16
14 O. D.	14	14	33	27	6	16	21	1 5/8	7/8
16 O. D.	16	15	36 1/2	30	6 1/2	18	23 1/2	1 7/8	1
18 O. D.	18	16 1/2	39	32	7	19	25	1 15/16	1 1/8
20 O. D.	20	18	43	35	8	20	27 1/2	1 11/16	1 1/8
24 O. D.	24	22	49 1/2	40 1/2	9	24	32	1 5/8	1 1/4
30 O. D.	30	25	59	49	10	30	38 1/2	2 1/8	1 7/8
36 O. D.	36					36	46	2 1/2	1 5/8
42 O. D.	42					42	53	2 5/8	1 13/16
48 O. D.	48					48	59 1/2	2 3/4	2

All dimensions given in inches.

* For drilling templates refer to Table 72.

† Laterals, both straight and reducing sizes 8 in. and larger, should be reinforced to compensate for the inherent weakness in the casting design.

‡ Laterals, 16 in. and smaller, reducing on the outlet or branch, use the same dimensions center to face and face to face as straight size fittings corresponding to size of the larger opening.

§ Laterals, 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.

¶ Body thickness at no point shall be less than 87 1/4% of the dimensions given in the table.

|| Reducers, and eccentric reducers, for all reductions, use the same face-to-face dimensions given in the above table of dimensions for the larger opening.

Gaskets. Rubber gaskets $\frac{1}{16}$ in. thick for cold water. Asbestos composition gaskets $\frac{1}{8}$ in. thick for hot water.

Class 25. Cast-iron pipe flanges and flanged fittings. All sizes for maximum working saturated steam pressure of 25 psi (gage). All sizes for a maximum gas-working pressure of 25 psi (gage). ASA B16b2, HPCNA, MSS, ASME.

All 25-lb cast-iron flanges and flanged fittings shall be plain-faced, i.e., without projection or raised face.

Class 125. Cast-iron pipe flanges and flanged fittings. ASA B16a, HPCNA, MSS, ASME.

For maximum saturated steam service pressures of:

125 psi (gage), sizes 1 to 5 in. incl.

100 psi (gage), sizes 6 to 12 in. incl.

80 psi (gage), sizes 4 to 24 in. incl.

For maximum water-service pressures at or near the ordinary range of air temperature:

175 psi (gage), sizes 1 to 12 in. incl.

150 psi (gage), sizes 14 to 48 in. incl., for flanges only.

These cast-iron flanges and flanged fittings shall be plain-faced, i.e., without projection or raised face.

Bolts shall be of steel with American regular unfinished square heads or American standard heavy unfinished hexagonal heads, and the nuts shall be of steel with American heavy hexagonal dimensions, all as specified in American Standard for Wrench Head Bolts and Nuts and Wrench Openings (ASA B18.2).

Class 250. Cast-iron pipe flanges and flanged fittings. All sizes for maximum working saturated steam pressure of 250 psi (gage). Sizes 10 in. and smaller for maximum non-shock fluids (other than steam) working hydraulic pressure of 325 psi (gage) at a temperature of 250 F.

Sizes 10 in. and smaller for maximum non-shock working hydraulic pressure of 400 psi (gage), at or near the ordinary range of air temperatures.

ASA B16b, HPCNA, MSS, ASME.

All 250-lb cast-iron flanges and flanged fittings shall have raised face $\frac{1}{8}$ in. high. The raised face is included in the minimum flange thickness and center-to-face dimensions.

Bolts shall be of steel with standard rough square heads, and the nuts shall be of steel with standard rough hexagonal dimensions, all as given in the American Standards on Wrench Head Bolts and Nuts and Wrench Openings, ASA B18.2.

Steel Flanges. Steel pipe flanges and flanged fittings, ASA B16c, HPCNA, MSS, ASME.

They cover the following classes known as American 150, 300, 400, 600, 900, 1500, and 2500-lb Steel Flange Standard.

The specifications also include standards for higher ratings and oil services.

TABLE 77
SERVICE PRESSURE RATINGS FOR STEEL FLANGES AND FLANGED FITTINGS
(American Standard B16e)

	Carbon Steel				Carbon-Molybdenum and Equivalent Alloy Steel	
	With Standard Facings		With Ring-Joint Facings		With Standard Facings	With Ring-Joint Facings
	Primary Service Pressure Ratings	150	300	150	300	300	300
Maximum Hydrostatic Shell Test Pressures	350	750	350	750	900	900
Service Temperature Degrees F	Maximum Non-Shock, Service Pressures Ratings at Temperatures from 100 to					
100	230	500	275	600	600	720
150	220	480	255	575	590	700
200	210	465	240	550	580	675
250	200	450	225	525	560	650
300	190	425	210	500	540	625

Cast-Iron Long-Turn Sprinkler Fittings, Screwed or Flanged

Standards. ASA B16g and B16g1.

Weights. Standard for 150-lb WP, Extra Heavy, for 250-lb WP

Ferro-Silicon Alloy Pipe

Characteristics. Not ductile or malleable. Cannot be forged or rolled into sheets or bars. Can be welded under favorable conditions. It is brittle or brash and must be handled carefully.

Machining is more difficult than gray iron or steel, owing to the fact that it is much harder and crumbles in front of the tool. It is not very practical for cutting standard threads because the tip of the thread crumbles, although a square thread can be cut if suitable for the service. Highly corrosive-resistant.

Uses. Acid conditions, chemistry laboratories, drain lines in canneries, photoengraving plants, chemical plants, acid mine water, tanneries, etc.

Uses. Pipes, fittings, blowers, fans, valves, cocks, plunger pumps, centrifugal pumps, acid ejectors, tanks (round and rectangular), evaporators, cascade pans, acid eggs, pots, kettles, etc.

ART. 3-G. WELDED FERROUS PIPES

Wrought-Iron Pipe

Definition. Butt-weld or lap-weld pipe made from soft weldable steel or iron (12).

Standards. Pipe, wrought-iron, welded, black, and galvanized, Fed. Specs. WW-P-441.

American Standard Specifications for Wrought-Iron and Wrought-Steel Pipe, ASTM A72, ASA B36.10.

Weight. According to Standard Specification for Pipes, ASA B36.1. (See Art. 3-C.)

Mild-Steel Pipe

Standards. Pipe, steel, seamless and welded, black and zinc-coated, Fed. Specs. WW-P-403.

Steel pipe (mild-steel pipe), Standard Specifications for Welded and Seamless Steel Pipe, ASTM A53, ASA B36.1.

Standard Specifications for Black and Hot-Dipped Zinc-Coated (Galvanized) Welded and Seamless Steel Pipe for Ordinary Uses, ASTM A120, ASA G8.7.

Iron-Alloy Pipes and Fittings

Most of the iron alloys listed in Chapter 2 are used in pipes of standard iron-pipe sizes and fittings of cast-iron-screwed malleable-iron or butt-welding pattern.

ART. 3-H. COPPER AND COPPER ALLOY PIPES AND FITTINGS

Copper Pipe

Standards. Pipe, copper, seamless, iron-pipe size, standard, Fed. Specs. WW-P-377.

Standard for copper pipe, standard sizes, ASTM B42.

Composition. 99.9% copper.

Weights. Iron-pipe size.

Tinned Copper Piping. Copper nickel alloy (salt-water pipes, 5 in. and under). Copper (salt-water pipes over 5 in.).

Copper Tubing and Fittings (See page 91.)

Standards. Pipe, tubing, copper, seamless, pipe (standard, iron-pipe size), tubing (for pressure up to 450 psi), Fed. Specs. WW-P-378.

Tubing, copper, seamless (for use with soldered or flared fittings), Fed. Specs. WW-T-799.

Tubing, copper, seamless (for general use with IPS flanged fittings), Fed. Specs. WW-T-797.

Composition. 99.9% copper or better.

Classes.

Types A	for	100	psi	WP	max.
"	B	"	200	"	"
"	C	"	300	"	"
"	D	"	450	"	"

Sizes correspond in outside diameter with iron-pipe sizes. To be used with IPS flanged fittings or with silver-brazed joints.

Type K, furnished either hard or soft. Used for underground services (250 lb WP max) and general plumbing purposes (for soldered or flared-type fittings).

Type L, furnished either hard or soft. Used for general plumbing purposes (for soldered fittings).

Type M, furnished only hard. Used for general plumbing purposes where water conditions are normal (for soldered fittings).

Type N, furnished soft. Used for fuel and lubrication tubes (for soldered or flared fittings).

Lengths. Hard tubes are furnished in straight lengths of 20 ft. Soft tubes are available in 20-ft lengths and for sizes up to 1¼ in., inclusive, in coils of 30, 45, and 60 ft, and in 100-ft coils in the 1-in. size and smaller.

Brass Pipe

Standards. Pipe, brass, seamless, iron-pipe size, standard, and extra strong, Fed. Specs. WW-P-351.

Standard Specifications for Brass Pipe, Standard Sizes, ASTM B43.

Tin-Lined Standard Brass IPS, ASTM B43.

Manufacture. Semi-annealed seamless brass IPS and weight. For pipes used for bends, spiral coils, etc., use "soft annealed."

Grades and Weight. Grades A, B, and C, each in two weights, Standard and Extra Strong.

Composition.

Grade A:	83-86%	copper
B:	65-68%	"
C:	59-68%	"

TABLE 79
BRASS PIPE

Names	Composition			Specifications	Uses
	Copper	Zinc	Tin		
Muntz	60	40		ASTM B-43 Federal: WW-P-351, Grade C U. S. Army: 83-5A, Grade C	Bends as easily when red hot as cold. For general good water conditions.
67%	65-68			ASTM B-43 Federal: WW-P-351, Grade B U. S. Army: 85-5A, Grade B U. S. Navy: 44 P-12, Grade B	Bends must be made when cold. For general good water conditions.
Admiralty	70	29	1	ASTM B-43 U. S. Navy: 44B-7E	Marine surface condenser tubes. Salt water conditions (Hot and Cold)
85% Red Brass	85	15		ASTM B-43 Federal: WW-P-351, Grade A U. S. Army: 35-5A, Grade A U. S. Navy: 44-P-12, Grade A	Salt water. Polluted water with mineral acids from mines or organic acids or chemicals used in purifi- cation or softening. Ground service.

Welding of Brass Pipe. Red brass can be welded by using a liquid or semi-paste flux and a standard braze welding rod.

The same flux can be used for welding galvanized pipe by coating the pipe for about 3 or 4 in. on each side of the weld. This leaves the galvanizing intact and will form a non-corrosive joint.

(Arthur N. Kugler, Air Reduction Sales Co., before the Annual Convention of the American Welding Society, October, 1939.)

Brass Tubing and Fittings

Standards. Tubing, brass, seamless, Fed. Specs. WW-T-791.

TABLE 78A

TYPE K SEAMLESS COPPER TUBING

Nominal Size, Inches	Actual Outside Diameter, Inches	Wall Thickness, Inches	Nominal Weight per Foot, Pounds	Minimum Test Pressure, Pounds per Square Inch (soft annealed)
3/8	0 500	0 049	0 269	1000
3/8	0 625	0 049	0 344	1000
3/8	0 875	0 065	0 641	1000
1	1 125	0 065	0 839	780
1 1/8	1 375	0 065	1 04	630
1 1/4	1 625	0 072	1 36	580
2	2 125	0 083	2 06	510
2 1/2	2 625	0 095	2 92	470
3	3 125	0 109	4 00	450
3 1/2	3 625	0 120	5 12	430
4	4 125	0 134	6 51	420
5	5 125	0 160	9 67	400
6	6 125	0 192	13 87	400

TABLE 78B

TYPE L HARD SEAMLESS COPPER TUBING

Nominal Size, Inches	Actual Outside Diameter, Inches	Wall Thickness, Inches	Nominal Weight per Foot, Pounds	Minimum Test Pressure, Pounds per Square Inch
3/8	0 500	0 035	0 198	1000
3/8	0 625	0 040	0 284	1000
3/8	0 875	0 045	0 454	1000
1	1 125	0 050	0 653	880
1 1/8	1 375	0 055	0 882	780
1 1/4	1 625	0 060	1 14	720
2	2 125	0 070	1 75	640
2 1/2	2 625	0 080	2 48	580
3	3 125	0 090	3 33	550
3 1/2	3 625	0 100	4 29	530
4	4 125	0 110	5 38	510
5	5 125	0 125	7 61	460
6	6 125	0 140	10 20	430

TABLE 78C

TYPE M HARD SEAMLESS COPPER TUBING

Nominal Size, Inches	Actual Outside Diameter, Inches	Wall Thickness, Inches	Nominal Weight per Foot, Pounds	Minimum Test Pressure, Pounds per Square Inch
3/8	0 500	0 025	0 144	1000
3/8	0 625	0 028	0 203	890
3/8	0 875	0 032	0 328	710
1	1 125	0 035	0 464	600
1 1/8	1 375	0 042	0 681	590
1 1/4	1 625	0 049	0 94	580
2	2 125	0 058	1 46	520
2 1/2	2 625	0 065	2 03	470
3	3 125	0 072	2 68	440
3 1/2	3 625	0 083	3 58	430
4	4 125	0 095	4 66	430
5	5 125	0 109	6 65	400
6	6 125	0 122	8 91	370

TABLE 78D

TYPE N SEAMLESS COPPER TUBING

Nominal Size, Inches	Actual Outside Diameter, Inches	Wall Thickness, Inches	Nominal Weight per Foot, Pounds	Minimum Test Pressure, Pounds per Square Inch (soft annealed)
3/8	0 125	0 035	0 038	1000
3/8	0 188	0 035	0 065	1000
3/8	0 250	0 035	0 092	1000
3/8	0 313	0 035	0 118	1000
3/8	0 375	0 035	0 145	1000
3/8	0 438	0 035	0 172	1000
3/8	0 500	0 035	0 198	980
3/8	0 625	0 035	0 251	790
3/8	0 750	0 049	0 418	920
3/8	0 875	0 049	0 493	790
1	1 000	0 049	0 567	690
1 1/8	1 125	0 049	0 642	610

Pipe fittings, brass or bronze (threaded), 125 lb, Fed. Specs. WW-P-448.

Unions, brass or bronze, 250 lb, Fed. Specs. WW-U-516.

Brass fittings for flared copper tubes for maximum cold-water service of 175 psi, ASA A40.2.

Fitting Patterns. Cast pattern similar to cast-iron screwed fittings (banded type) patterns.

Malleable pattern similar to beaded malleable fittings patterns.

Drainage fittings similar to cast-iron drainage fittings.

Weights. Fittings can be obtained screwed for 125 and 250 lb WSP, flanged for 150 and 250 lb WSP. For water: fittings on pipes 2 in. and less, standard pattern banded type; on pipes over 2 in., extra heavy pattern, banded type.

Other Brass Fittings.

(a) *Calking ferrules.* Brass calking ferrules shall be of the best quality red cast brass, with weights and dimensions in accordance with the following table:

Pipe Size (In.)	Actual Inside Diameter	Length	Lb	Oz
2	2¼	4½	1	
3	3¼	4½	1	12
4	4¼	4½	2	8

(b) *Soldering nipples and bushings.* Soldering nipples shall be of brass pipe, iron-pipe size, or of heavy, cast red brass not less than the following weights:

Diameters In.	Weights Oz	Diameters In.	Weights Lb Oz
1¼	6	2½	1 6
1½	8	3	2 0
2	14	4	3 8

Soldering bushings shall be of brass pipe, iron-pipe size, or of heavy, cast red brass.

(c) *Floor flanges for water closets.* Floor flanges for water closets shall be not less than 3/16 in. thick, and of brass or cast iron.

Soldered-Joint Fittings. Proposed American Standard. Fittings shall be made of wrought metal with 85% minimum copper content or of cast brass. (Composition: copper 85%, tin 5%, lead 5%, zinc 5%.)

White Metal Pipes, Tubing, and Fittings

White Metal Pipe. Annealed, seamless drawn polished, standard full weight IPS.

White Metal Tubing. Not less than 18 gage B and S.

White Metal Fittings. Cast white metal, malleable iron pattern, properly reinforced, finely finished and polished.

ART. 3-I. OTHER METAL PIPES AND FITTINGS

Aluminum and Aluminum-Alloy Tubing

Standards. Tubing, aluminum, round, seamless, Fed. Specs. WW-T-783a. (Continued on page 96.)

TABLE 80
LEAD-PIPE STANDARD

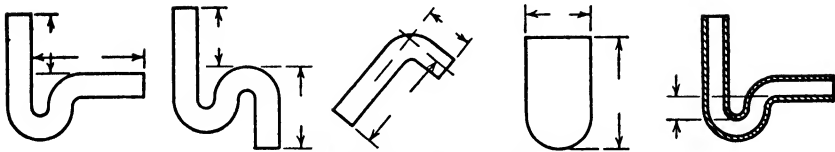
In- side Diam- eter In.	Classification		Out- side Diam- eter In.	Weight per Foot		In- side Diam- eter In.	Classification		Out- side Diam- eter In.	Weight per Foot			
	East	West		Lb	Oz		East	West		Lb	Oz		
3/8	D	XL	.549		10	1 1/4	A	S	1 670	4	12		
	C	L	.577		12		AA	XS	1 765	6			
	B	M	.631	1			AAA	XXS	1 889	7	12		
	A	S	.725	1	8		1 1/2	D	XL	1 776	3	8	
	AA	XS	.811	2				C	L	1 830	4	4	
	AAA	XXS	.888	2	8			B	M	1 882	5		
					A	S		1 984	6	8			
1/2	D	XL	.666		12	AA	XS	2 076	8				
	C	L	.712	1		AAA	XXS	2 272	11	4			
	B	M	.756	1	4	1 3/4	D	XL	2 024	4			
	A	S	.798	1	8		C	L	2 086	5			
	AA	XS	.876	2			B	M	2 146	6			
	AAA	XXS	1 012	3			A	S	2 193	6	12		
					AA		XS	2 404	10	8			
					AAA		XXS	2 624	14	12			
5/8	D	XL	.803	1		2	D	XL	2 284	4	12		
	C	L	.881	1	8		C	L	2 354	6			
	B	M	.953	2			B	M	2 410	7			
	A	S	1 019	2	8		A	S	2 503	8	12		
	AA	XS	1 082	3			AA	XS	2 751	13	12		
	AAA	XXS	1 137	3	8		AAA	XXS	3 008	19	8		
3/4	D	XL	.940	1	4	2 1/2			2 75	5			
	C	L	1 006	1	12				3 00	10	10		
	B	M	1 068	2	4		3			3 25	6		
	A	S	1 156	3						3 50	12	8	
	AA	XS	1 212	3	8			4			4 25	7	14
	AAA	XXS	1 336	4	12						4 50	16	6
					5					5 25	9	14	
										5 50	20	4	
						6				6 25	11	13	
										6 50	24	2	

Recommended Pipe Weights

Purposes	Classification	
	East	West
For plumbing soil, waste, and vent pipes	D or C	XL or L
For chemical waste pipes	B	M
For water pipes:		
Constant cold-water pressures up to 50 psi	A	S
Constant cold-water pressures up to 75 psi	AA	XS
Constant cold-water pressures up to 100 psi	AAA	XXS

In sizes above 2 in. inside diameter, there is no classification marking. The lighter of the two weights listed in each size is for plumbing soil, waste, and vent pipes, and the heavier weight for chemical wastes.

TABLE 81
LEAD TRAPS AND BENDS



Dimensions taken are shown by arrows

P-TRAP S-TRAP BEND DRUM TRAP SEAL

Wall thickness of all traps and bends is 0.125 in. Minimum trap seal is 2 in.

¼ S- or P-Traps

Inside Diameter In.	Short		Total Weight Lb Oz	Inside Diameter In.	Long	
	Dimensions In.				Dimensions In.	Total Weight Lb Oz
1½	4½ x 7	4	0	1½	4½ x 14	5 9
1¾	4½ x 7	4	15	1½	4½ x 14	6 12
2	4½ x 8	7	2	2	4½ x 14	9 3

Full S-Traps

1½	4½ x 7	4	9	1½	4½ x 19½	7	6
1¾	4½ x 7	5	10	1½	4½ x 19½	8	14
2	4½ x 8	8	5	2	4½ x 19½	12	4

Drum Traps

Inside Diameter In.	Inside Depth In.
4	8
4	9
4	10

Bends

Inside Diameter 1½ In.			Inside Diameter 3 In.			Inside Diameter 4 In.		
Dimensions In.	Total Weight Lb Oz		Dimensions In.	Total Weight Lb Oz		Dimensions In.	Total Weight Lb Oz	
4 x 7	2	12	5½ x 10	7	3	5½ x 10	9	5
4 x 12	4	1	5½ x 12	8	3	5½ x 12	10	10
4 x 15	4	13	5½ x 15	9	12	5½ x 15	12	10
4 x 18	5	10	5½ x 18	11	4	5½ x 18	14	10
4 x 20	6	2	5½ x 20	12	4	5½ x 20	16	0
7 x 7	3	8	10 x 10	9	8	10 x 10	12	5
7 x 12	4	13	10 x 12	10	8	10 x 12	13	10
7 x 15	5	10	10 x 15	12	0	10 x 15	15	10
7 x 18	6	6	10 x 18	13	8	10 x 18	17	10
7 x 20	6	15	10 x 20	14	8	10 x 20	18	15

Notes. Inlet dimensions listed first in all cases

Traps and bends meeting this standard in all other respects, but having greater nominal wall thickness than ¼ in., are considered as meeting the standard and may be stamped with the Lead Industries' Seal of Approval if they are clearly stamped with their wall thickness or weight per running foot.

Traps and bends meeting this standard in all other respects, but having dimensions different from those listed, are considered as meeting the standard and may be stamped with the Lead Industries' Seal of Approval if they are clearly stamped with their inlet and outlet dimensions.

S-traps are included in this standard to assure their quality when used, but their inclusion is not to be considered as an endorsement of this pattern of trap

TABLE 82
BLOCK TIN PIPE CALIBER LIST

Inside Diameter	Outside Diameter	Weight per Foot	Inside Diameter	Outside Diameter	Weight per Foot
1/16 in.	3/8 in.	1/2 oz	7/16 in.	5/8 in.	8 oz
1/8 "	3/16 "	1 "	1/2 "	19/32 " Scant	4 "
3/16 "	1/4 "	1 1/2 "	1/2 "	5/8 "	5 "
3/16 "	5/16 "	2 1/2 "	1/2 "	5/8 " Full	5 1/2 "
1/4 "	3/8 "	3 "	1/2 "	21/32 "	7 "
1/4 "	13/32 "	4 "	1/2 "	21/32 " Full	7 1/2 "
1/4 "	7/16 "	5 "	1/2 "	11/16 "	9 "
1/4 "	15/32 "	6 "	1/2 "	23/32 "	10 1/2 "
1/4 "	1/2 " Scant	7 "	1/2 "	3/4 "	12 1/2 "
1/4 "	1/2 " Full	8 "	5/8 "	3/4 "	7 "
5/16 "	7/16 " Full	4 "	5/8 "	25/32 "	9 "
5/16 "	1/2 " Scant	5 1/2 "	5/8 "	13/16 "	10 1/2 "
5/16 "	17/32 "	7 1/2 "	5/8 "	7/8 "	15 "
5/16 "	9/16 "	8 1/2 "	3/4 "	7/8 " Full	8 "
3/8 "	1/2 " Scant	4 "	3/4 "	29/32 "	10 "
3/8 "	1/2 " Full	4 1/2 "	3/4 "	29/32 " Full	11 "
3/8 "	17/32 "	5 "	3/4 "	15/16 "	12 1/2 "
3/8 "	9/16 " Scant	5 1/2 "	3/4 "	1 " Scant	17 "
3/8 "	9/16 " Full	6 1/2 "	3/4 "	1 1/32 "	20 "
3/8 "	19/32 "	7 1/2 "	3/4 "	1 1/16 "	22 1/2 "
3/8 "	5/8 " Scant	8 1/2 "	1 "	1 1/8 "	11 "
3/8 "	5/8 " Full	9 1/2 "	1 "	1 3/16 "	16 "
3/8 "	21/32 "	10 1/2 "	1 "	1 3/16 " Full	17 "
1/2 "	9/16 " Scant	12 "	1 "	1 7/32 "	19 1/2 "
1/2 "	19/32 "	4 1/2 "	1 "	1 1/4 "	22 "
1/2 "	19/32 "	6 1/2 "	1 "	1 5/16 "	28 "

Courtesy National Lead Co., New York, N.Y.

tubing, aluminum-alloy (aluminum-manganese), round, seamless, Fed. Specs. WW-T-788.

tubing, aluminum-alloy (aluminum-copper magnesium-manganese), round, seamless, Fed. Specs. WW-T-786.

Aluminum Tubing.

Temper: A : Soft.
1/2H: Half hard.
3/4H: Three-quarters hard.
H : Hard.

Weights: Standard and Extra Heavy.

Sizes: Outside diameters correspond to IPS fittings.

Composition: 99% aluminum, min.
1% iron plus silicon, max.

Lead Pipe

Standards adopted January, 1940, by Lead Industries Association, 420 Lexington Avenue, New York, N.Y. (Tables 80-81).

Pipe meeting the standard must be stamped at least every 24 in. with the manufacturers' name or identification mark and the seal of approval of the Lead Industries Association. (See pages 94-95.)

Block Tin Pipe

It is made of pure tin. Pipes are available in sizes $\frac{1}{16}$ in. to 1 in. in different weights. (See Table 82, page 96.)

Other Fittings

Definitions.

Railing Fittings. Those used on hand rails. There are various styles. To the trade, rail fittings are understood to be globe-shaped in the body, with ends reduced to take thread (12).

ART. 3-J. EARTHENWARE PIPES AND FITTINGS

Clay Materials

Definitions (from American Society for Testing Materials, Standard Specification for Drain Tile, C4).

Clay. An earthy or stony mineral aggregate consisting essentially of hydrous silicates of alumina, plastic when sufficiently pulverized and wetted, rigid when dry, and vitreous when fired at a sufficiently high temperature.

Fire Clay. A sedimentary clay of low flux content.

Shale. A thinly stratified, consolidated sedimentary clay with well-marked cleavage parallel to the bedding.

Surface Clay. An unconsolidated, unstratified clay, occurring on the surface.

Drain Tile

Standards. Drain tile, ASA A6, ASTM C4, U.S. Department of Agriculture.

Classes. There are three classes of drain tile: Farm drain tile, Standard drain tile, and Extra Quality drain tile.

Uses. Farm drain tile for ordinary private drainage work on farms; moderate sizes and depth.

Standard drain tile for ordinary district land drainage at moderate depths.

Extra Quality drain tile for district land drainage at considerable depths and where an extra quality is desired.

Sizes. Specifications cover sizes of 4, 5, 6, 8, 10, 12 in. and larger sizes in multiples of three.

Lengths. Drain tiles smaller than 12 in. shall have a minimum length of 12 in. Tiles of 12 to 30 in. in diameter, inclusive, shall have lengths not less than the diameter. Tiles larger than 30 in. in diameter shall have minimum lengths of 30 in.

Materials. The specifications apply to drain tile made of shale, fire clays, or surface clays and to drain tile made of concrete.

Clay Sewer Pipe and Fittings

Standards. Vitrified clay sewer pipe is manufactured commercially to conform with standard specifications of both the American Society for Testing Materials (Designation C-13) and the U. S. Government (Designation SS-P-361a). Specification SS-P-361a covers both Standard and Extra Strength pipe whereas ASTM specifications provide for a single class of pipe, the same as standard pipe included in Federal Specifications. Standard pipe is also commercially known as Double Strength pipe.

Standard Strength pipe is intended to be used for the conveyance of sewage, industrial wastes, and storm water.

Extra Strength pipe is intended especially for use in highway and railway culverts and in locations where high strength is required.

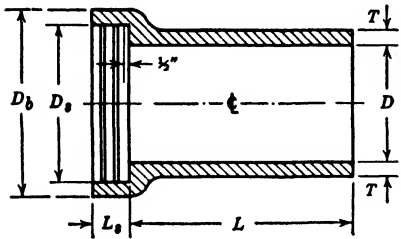
The *Handbook of Vitrified Clay Sewer Pipe and Kindred Clay Products* of the Clay Sewer Pipe Association, Inc., contains dimensions and weights of salt glazed vitrified clay sewer pipe and fittings, fire clay flue linings and fittings, stove pipe and fittings, wall coping and fittings, and other vitrified clay products. Tables 84 to 91 incl. are from

TABLE 83

REQUIRED STRENGTH OF STANDARD STRENGTH CLAY SEWER PIPE		REQUIRED STRENGTH OF EXTRA STRENGTH CLAY SEWER PIPE	
Size (Inches)	Req'd Strength (lb per lin ft, 3-edge Bearing)	Size (Inches)	Req'd Strength (lb per lin ft, 3-edge Bearing)
4	1000	6	2000
6	1000	8	2000
8	1000	10	2000
10	1100	12	2250
12	1200	15	2750
15	1370	18	3300
18	1665	21	3850
21	1995	24	4400
24	2400	30	5000
27	2765	36	6000
30	3170		
33	3535		
36	3900		

the *Handbook* and are reprinted here with the permission of the Clay Sewer Pipe Association, Inc. Special items not shown here are double T- and Y-branches in limited sizes, V-branches in sizes 4, 6, and 8 in., channel pipe, saddle hub tees, saddles, saddle hub curves, stoppers and strainers, increasers and reducers, half traps, P-traps, running traps, conductor elbows, grease traps, slop bowls, meter boxes, and flat and curved liner plates.

TABLE 84. SALT-GLAZED VITRIFIED CLAY DOUBLE STRENGTH SEWER PIPE
(Conforming to ASTM Standards)



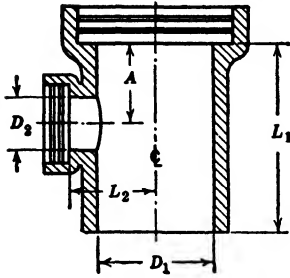
MINIMUM TAPER OF SOCKET 1:20

Dimension Schedule

Inside Diameter of Barrel (Inches)	Laying Length (feet)	Inside Diameter 1/2 in. above Base of Socket (Inches)	Depth of Socket (Inches)	Thickness of Barrel (Inches)	Maximum Outside Diameter of Socket (Inches)	Inside Diameter of Barrel (Inches)
<i>D</i>	<i>L</i>	<i>D_s</i>	<i>L_s</i>	<i>T</i>	<i>D_b</i>	<i>D</i>
12	1	15 7/8	2 3/4	1	17 1/4	12
	3					
15	1	18 3/4	2 3/4	1 1/4	21 1/4	15
	3					
18	1	22 1/4	3	1 1/2	25 1/4	18
	3					
21	1	25 7/8	3 3/4	1 3/4	29 3/8	21
	3					
24	1	29 3/8	3 3/8	2	33 5/16	24
	3					
27	1	33 3/8	3 1/2	2 1/4	37 1/2	27
	3					
30	1	36 5/8	3 1/2	2 1/2	41 3/8	30
	3					
36	1	43 1/4	4	2 3/4	48 9/16	36
	3					

For applicable dimension tolerances, see ASTM Standards: Designation C-13, and subsequent revisions.

TABLE 85. SALT-GLAZED VITRIFIED CLAY T-BRANCHES, DOUBLE STRENGTH
(Conforming to ASTM Standards)



For detail dimensions not shown, see

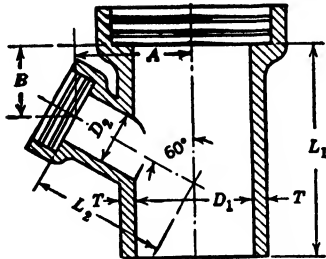
Table 84.

Dimension Schedule

Inside Diameter of Main Barrel (inches)	Inside Diameter of Branch (inches)	Laying Length of Main Barrel (feet)	Laying Length of Branch (inches)	Location of Branch (inches)
D_1	D_2	L_1	L_2	A
15	6	3	10 3/4	7
	8	3	11 1/4	8 1/4
	12	3	11 3/4	10 3/4
	15	3	11 3/4	12 3/4
18	6	3	12 3/4	7 3/4
	8	3	13	8 3/4
	12	3	13 3/4	10 3/4
	18	3	13 3/4	13 3/4
21	6	3	14 3/4	7 3/4
	8	3	14 3/4	8 3/4
	12	3	15	11
	18	3	15 3/4	14 3/4
	21	3	15 3/4	16
24	6	3	16	8
	8	3	16 3/4	9
	12	3	16 3/4	11 3/4
	18	3	17 3/4	14 3/4
	24	3 3/4	17 3/4	18
27	6	3	17 3/4	8 3/4
	12	3	18 3/4	11 3/4
	18	3	18 3/4	15
	24	3 3/4	19	18 3/4
30	6	3	19 3/4	8 3/4
	12	3	20 3/4	12
	18	3	21	15 3/4
	24	3 3/4	21 3/4	19
36	6	3	22 3/4	9 3/4
	12	3	23 3/4	12 3/4
	18	3	24 3/4	16
	24	3 3/4	25	19 3/4
Not listed in ASTM Standards				
5 in.	4 in. 5 in.	2 2	4 3/4 5	5 5 3/4

For applicable dimension tolerances see ASTM Standards: Designation C-13, and subsequent revisions. For branch sizes not shown, it is recommended that "Increasers" be used with standard fittings of branch fitting diameter next larger than the diameter of the branch line to be connected.

TABLE 86. SALT-GLAZED VITRIFIED CLAY Y-BRANCHES, DOUBLE STRENGTH
(Conforming to ASTM Standards)



For dimensions not shown see Table 84

Dimension Schedule

Inside Diameter of Main Barrel (inches)	Inside Diameter of Branch (inches)	Laying Length of Main Barrel (feet)	Laying Length of Branch (inches)	Center Line Projection of Branch (inches)	Offset Projection of Branch (inches)
D_1	D_2	L_1	L_2	A	B
4	4	2	6¾	5¾	3½
6	4	2	7¾	6¾	3¾
	6	2	8¾	7¾	4¾
8	4	2	8¾	7¾	4
	6	2	9¾	8¾	4¾
		3	11	9¾	5¾
10	6	3	11¾	9¾	5
	8	3	12	10¾	5¾
	10	3	13	11¾	6¾
12	6	3	12¾	11	4¾
	8	3	13¾	11¾	5¾
	10	3	14¾	12¾	6¾
	12	3	15	13	7¾
15	6	3	14¾	12¾	5
	8	3	15¾	13¾	6¾
	12	3	16¾	14¾	8¾
	15	3	17¾	15¾	9¾

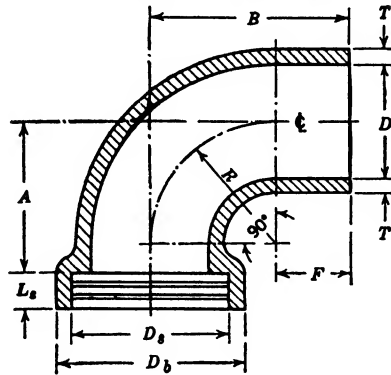
Inside Diameter of Main Barrel (inches)	Inside Diameter of Branch (inches)	Laying Length of Main Barrel (feet)	Laying Length of Branch (inches)	Center Line Projection of Branch (inches)	Offset Projection of Branch (inches)
D_1	D_2	L_1	L_2	A	B
18	6	3	16¾	14¾	5
	8	3	17¾	15	6¾
	12	3	18¾	16¾	8
	18	3	21	18¾	11
21	6	3	18¾	15¾	5¾
	8	3	19¾	17	6¾
	12	3	20¾	18	8¾
	18	3	23	20	11¾
24	6	3	24¾	21	12¾
	8	3	20¾	17¾	5¾
	12	3	21¾	18¾	6¾
	18	3	22¾	19¾	8¾
27	6	3	25	21¾	11¾
	8	3	25	21¾	11¾
	12	3	25	21¾	11¾
	18	3	25	21¾	11¾
30	6	3	27¾	23¾	14¾
	8	3	22¾	17¾	5¾
	12	3	23¾	18¾	6¾
	18	3	26¾	21¾	9¾
36	6	3	29	25	14¾
	8	3	24	20¾	6¾
	12	3	26¾	23	9¾
	18	3	28¾	25	12
36	6	3	31¾	27	15
	8	3	28¾	25	5¾
	12	3	30¾	26¾	9¾
	18	3	33¾	28¾	12¾
36	6	3	35¾	30¾	15¾
	12	3	30¾	26¾	9¾
	18	3	33¾	28¾	12¾
	24	4	35¾	30¾	15¾

(not listed in ASTM Standards)

5	4	2	7¾	6¾	3¾
	5	2	7¾	6¾	4

For applicable dimension tolerances see ASTM Standards: Designation C-13, and subsequent revisions. For branch sizes not shown, it is recommended that "Increasers" be used with standard fittings of branch fitting diameter next larger than the diameter of the branch line to be connected.

TABLE 87. SALT-GLAZED VITRIFIED CLAY, 90° ELBOWS, DOUBLE STRENGTH
(Conforming to ASTM Standards)

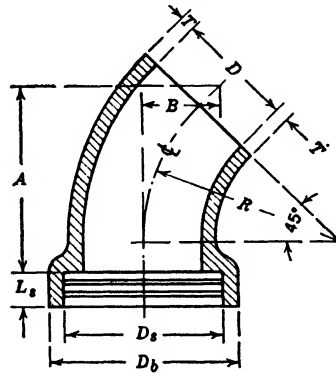


Dimension Schedule

Inside Diameter of Barrel (inches)	Inside Diameter 1/4 in. above Base of Socket (inches)	Depth of Socket (inches)	Thickness of Barrel (inches)	Maximum Outside Diameter of Socket (inches)	Center Line Projection (inches)	Offset Projection (inches)	Radius of Center Line (inches)	Spigot Length (inches)
D	D _s	L _s	T	D _b	A	B	R	F
Short Elbows								
4	5 3/4	1 3/4	3/4	6 13/16	5	6	4	2
*5	7	2	3/4	8 7/16	6	7 1/4	4 5/8	2 1/2
6	8 1/4	2 1/4	3/4	9 5/8	6 1/2	7 3/8	5 1/8	2 1/2
8	10 3/4	2 3/4	3/4	12 3/8	7 3/8	9	6 3/4	2 3/4
10	12 3/4	2 3/4	3/4	14 11/16	9	10 1/4	7 3/4	2 3/4
12	15 3/4	2 3/4	1	17 1/4	10 1/2	11 1/4	8 1/2	3
Medium Length Elbows								
4	5 3/4	1 3/4	3/4	6 13/16	7 1/4	8	6	2
*5	7	2	3/4	8 7/16	9	10	7 1/4	2 1/2
6	8 1/4	2 1/4	3/4	9 5/8	10 1/4	11 1/4	9	2 3/4
8	10 3/4	2 3/4	3/4	12 3/8	13 3/8	14 3/4	12	2 3/4
10	12 3/4	2 3/4	3/4	14 11/16	16 1/4	17 1/4	15	2 3/4
12	15 3/4	2 3/4	1	17 1/4	19 1/4	21	18	3
Long Elbows								
4	5 3/4	1 3/4	3/4	6 13/16	9 3/4	10	8	2
*5	7	2	3/4	8 7/16	11 1/4	12 1/2	10	2 1/2
6	8 1/4	2 1/4	3/4	9 5/8	13 3/8	14 1/2	12	2 1/2
8	10 3/4	2 3/4	3/4	12 3/8	17 1/4	18 3/4	16	2 3/4
10	12 3/4	2 3/4	3/4	14 11/16	21 1/4	22 3/4	20	2 3/4
12	15 3/4	2 3/4	1	17 1/4	25 1/4	27	24	3

* Not included in ASTM Standards.
For applicable dimension tolerances see Current ASTM Standards: Designation C-13, and subsequent revisions.

TABLE 88. SALT-GLAZED VITRIFIED CLAY CURVES 45°, DOUBLE STRENGTH
(Conforming to ASTM Standards)

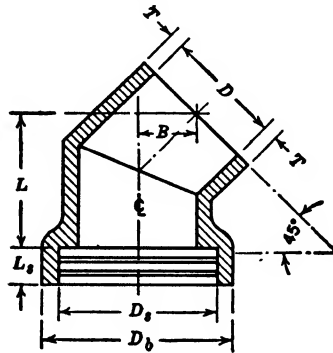


Dimension Schedule

Inside Diameter of Barrel (inches)	Inside Diameter $\frac{1}{4}$ in above Base of Socket (inches)	Depth of Socket (inches)	Thickness of Barrel (inches)	Maximum Outside Diameter of Socket (inches)	Center Line Projection (inches)	Offset Projection (inches)	Radius of Center Line (inches)
<i>D</i>	<i>D_s</i>	<i>L_s</i>	<i>T</i>	<i>D_b</i>	<i>A</i>	<i>B</i>	<i>R</i>
Short Curves							
4	5 $\frac{3}{4}$	1 $\frac{3}{4}$	$\frac{3}{8}$	6 $\frac{13}{16}$	11 $\frac{1}{4}$	3	10 $\frac{3}{4}$
5*	7	2	$\frac{3}{8}$	8 $\frac{3}{8}$	11 $\frac{1}{4}$	3	10 $\frac{3}{4}$
6	8 $\frac{1}{4}$	2 $\frac{1}{4}$	$\frac{3}{8}$	9 $\frac{5}{8}$	11 $\frac{1}{4}$	3	10 $\frac{3}{4}$
8	10 $\frac{1}{4}$	2 $\frac{3}{4}$	$\frac{3}{8}$	12 $\frac{3}{8}$	11 $\frac{1}{4}$	3	10 $\frac{3}{4}$
10	12 $\frac{3}{4}$	2 $\frac{3}{4}$	$\frac{3}{8}$	14 $\frac{11}{16}$	11 $\frac{1}{4}$	3	10 $\frac{3}{4}$
12	15 $\frac{3}{4}$	2 $\frac{3}{4}$	1	17 $\frac{1}{4}$	11 $\frac{1}{4}$	3	10 $\frac{3}{4}$
Medium Length Curves							
4	5 $\frac{3}{4}$	1 $\frac{3}{4}$	$\frac{3}{8}$	6 $\frac{13}{16}$	16 $\frac{3}{4}$	5 $\frac{1}{4}$	17 $\frac{3}{4}$
5*	7	2	$\frac{3}{8}$	8 $\frac{3}{8}$	16 $\frac{3}{4}$	5 $\frac{1}{4}$	17 $\frac{3}{4}$
6	8 $\frac{1}{4}$	2 $\frac{1}{4}$	$\frac{3}{8}$	9 $\frac{5}{8}$	16 $\frac{3}{4}$	5 $\frac{1}{4}$	17 $\frac{3}{4}$
8	10 $\frac{1}{4}$	2 $\frac{3}{4}$	$\frac{3}{8}$	12 $\frac{3}{8}$	16 $\frac{3}{4}$	5 $\frac{1}{4}$	17 $\frac{3}{4}$
10	12 $\frac{3}{4}$	2 $\frac{3}{4}$	$\frac{3}{8}$	14 $\frac{11}{16}$	16 $\frac{3}{4}$	5 $\frac{1}{4}$	17 $\frac{3}{4}$
12	15 $\frac{3}{4}$	2 $\frac{3}{4}$	1	17 $\frac{1}{4}$	16 $\frac{3}{4}$	5 $\frac{1}{4}$	17 $\frac{3}{4}$
Long Curves							
4	5 $\frac{3}{4}$	1 $\frac{3}{4}$	$\frac{3}{8}$	6 $\frac{13}{16}$	22	7 $\frac{3}{4}$	25 $\frac{3}{4}$
5*	7	2	$\frac{3}{8}$	8 $\frac{3}{8}$	22	7 $\frac{3}{4}$	25 $\frac{3}{4}$
6	8 $\frac{1}{4}$	2 $\frac{1}{4}$	$\frac{3}{8}$	9 $\frac{5}{8}$	22	7 $\frac{3}{4}$	25 $\frac{3}{4}$
8	10 $\frac{1}{4}$	2 $\frac{3}{4}$	$\frac{3}{8}$	12 $\frac{3}{8}$	22	7 $\frac{3}{4}$	25 $\frac{3}{4}$
10	12 $\frac{3}{4}$	2 $\frac{3}{4}$	$\frac{3}{8}$	14 $\frac{11}{16}$	22	7 $\frac{3}{4}$	25 $\frac{3}{4}$
12	15 $\frac{3}{4}$	2 $\frac{3}{4}$	1	17 $\frac{1}{4}$	22	7 $\frac{3}{4}$	25 $\frac{3}{4}$

* Not included in ASTM Standards.
For applicable dimension tolerances see Current ASTM Standards: Designation C-13, and subsequent revisions.

TABLE 89. SALT-GLAZED VITRIFIED CLAY CUT CURVES—45° DOUBLE STRENGTH
(Conforming to ASTM Standards)

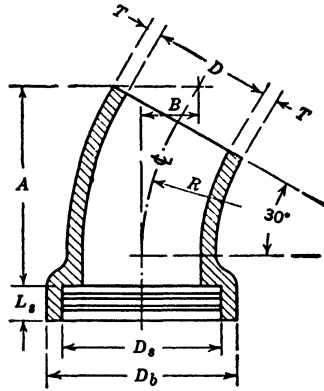


Dimension Schedule

Inside Diameter of Barrel (inches)	Inside Diameter $\frac{1}{2}$ in. above Base of Socket (inches)	Depth of Socket (inches)	Thick-ness of Barrel (inches)	Maximum Outside Diameter of Socket (inches)	Center Line Projection (inches)	Offset Projection (inches)
D	D_s	L_s	T	D_b	A	B
8	10 $\frac{1}{2}$	2 $\frac{1}{2}$	$\frac{3}{4}$	12 $\frac{3}{16}$	8 $\frac{9}{16}$	3 $\frac{1}{2}$
10	12 $\frac{3}{4}$	2 $\frac{1}{2}$	$\frac{7}{8}$	14 $\frac{1}{16}$	9	3 $\frac{7}{8}$
12	15 $\frac{1}{8}$	2 $\frac{3}{4}$	1	17 $\frac{1}{4}$	9 $\frac{15}{16}$	4 $\frac{5}{16}$
15	18 $\frac{3}{4}$	2 $\frac{3}{4}$	1 $\frac{1}{4}$	21 $\frac{1}{4}$	11 $\frac{1}{2}$	4 $\frac{7}{8}$
18	22 $\frac{1}{4}$	3	1 $\frac{1}{2}$	25 $\frac{1}{4}$	12 $\frac{15}{16}$	5 $\frac{9}{16}$
21	25 $\frac{7}{8}$	3 $\frac{1}{4}$	1 $\frac{3}{4}$	29 $\frac{3}{8}$	15	6 $\frac{1}{16}$
24	29 $\frac{3}{8}$	3 $\frac{3}{8}$	2	33 $\frac{3}{16}$	16 $\frac{3}{8}$	7 $\frac{5}{16}$
27	33 $\frac{3}{8}$	3 $\frac{1}{2}$	2 $\frac{1}{4}$	37 $\frac{1}{2}$	18 $\frac{1}{4}$	7 $\frac{3}{4}$
30	36 $\frac{5}{8}$	3 $\frac{1}{2}$	2 $\frac{1}{2}$	41 $\frac{3}{8}$	19 $\frac{1}{16}$	8 $\frac{1}{16}$
36	43 $\frac{1}{4}$	4	2 $\frac{3}{4}$	48 $\frac{9}{16}$	23 $\frac{1}{2}$	9 $\frac{15}{16}$

For applicable dimension tolerances see ASTM Standards: Designation C-13, and subsequent revisions.

TABLE 90. SALT-GLAZED VITRIFIED CLAY 30°—CURVES DOUBLE STRENGTH
(Conforming to ASTM Standards)



Dimension Schedule

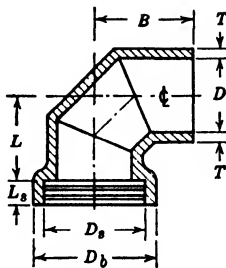
Inside Diameter of Barrel (inches)	Inside Diameter 1/2 in. above Base of Socket (inches)	Depth of Socket (inches)	Thickness of Barrel (inches)	Maximum Outside Diameter of Socket (inches)	Length of Center Line Projection (inches)	Offset Projection (inches)	Radius of Center Line (inches)
<i>D</i>	<i>D_s</i>	<i>L_s</i>	<i>T</i>	<i>D_b</i>	<i>A</i>	<i>B</i>	<i>R</i>
Short Curves							
4	5 3/4	1 3/4	1/2	6 13/16	11 5/8	2	21
5*	7	2	5/8	8 7/16	11 5/8	2	21
6	8 1/4	2 1/4	5/8	9 5/8	11 5/8	2	21
8	10 1/2	2 1/2	3/4	12 3/16	11 5/8	2	21
10	12 3/4	2 1/2	3/8	14 11/16	11 5/8	2	21
12	15 3/8	2 1/4	1	17 1/4	11 5/8	2	21
Medium Length Curves							
4	5 3/4	1 3/4	1/2	6 13/16	17 3/8	3 1/2	32
5*	7	2	5/8	8 7/16	17 3/8	3 1/2	32
6	8 1/4	2 1/4	5/8	9 5/8	17 3/8	3 1/2	32
8	10 1/2	2 1/2	3/4	12 3/16	17 3/8	3 1/2	32
10	12 3/4	2 1/2	3/8	14 11/16	17 3/8	3 1/2	32
12	15 3/8	2 1/4	1	17 1/4	17 3/8	3 1/2	32

* Not included in ASTM Standards.
For applicable dimension tolerances see Current ASTM Standards: Designation C-13, and subsequent revisions.

TABLE 91. SALT-GLAZED VITRIFIED CLAY, 90° CUT ELBOWS, DOUBLE STRENGTH
(Conforming to ASTM Standards)

Dimension Schedule

Inside Diameter of Barrel (inches)	Center Line Projection (inches)	Offset Projection (inches)
D	L	B
8	$7\frac{7}{8}$	$8\frac{3}{4}$
10	$8\frac{7}{8}$	$9\frac{3}{8}$
12	$10\frac{3}{8}$	$10\frac{3}{4}$
15	$12\frac{1}{2}$	$13\frac{1}{2}$



ART. 3-K. OTHER PIPES AND FITTINGS

Concrete Pipe and Fittings

Standards. Pipe, concrete, non-pressure, non-reinforced, and reinforced, Fed. Specs. SS-P-371.

Plain concrete pipe, ASTM C14.

Reinforced concrete pipe, ASTM C75.

Reinforced concrete culvert pipe, ASTM C76.

Plain concrete pipe (cement pipe) meets the same specifications as double-strength vitrified clay pipe. The sizes available are governed to a great extent by the competition with vitrified clay pipe. For this reason plain concrete pipes are available only in sizes above 12 in., except in localities where vitrified clay tile plants are located too far away (8, 10, 12, 15, 18, 21, 24 in.).

Reinforced concrete pipes are available in sizes 24 in. and over (24, 27, 30, 33, 36 in. etc.). In general dimensions they are equal to vitrified tile sewers.

Fittings. Made to order or can be assembled in the field by the use of slants.

Asbestos-Cement Pipes and Fittings

Material. Portland cement and asbestos fiber.

Characteristics. Can be cut with a saw, drilled, and tapped. Highly resistant to all forms of corrosion.

Uses. Water pipe, sewers, vents and stacks, chutes and ducts.

Pressure Pipe. Made in Classes 50, 100, 150, and 200; suited respectively for working pressure of 50, 100, 150, and 200 psi.

Made in diameter sizes of 2, 2½, 3, 3½, 4, 4½, 5, 6, 7, 8, 10, 12, 14, 16, 18, 20, 24, 30, and 36 in.

Lengths of 2- to 3½-in. pipe, inclusive, are 10 ft; and for 4-in. diameter and over, 13 ft.

Couplings furnished with each length are Simplex couplings, consisting of an asbestos cement sleeve with two rubber rings.

Service characteristics. Water $C_w = 140$.

Sewer Pipe. Made in Classes I and II, Class II having greater wall thickness.

Sizes. Class I: 4 in. to 36 in.; Class II: 20 in. to 36 in. in lengths of 13 ft.

Service characteristics. $C_w = 140$ (Williams-Hazen) or $n = 0.009$ (Kutter's Formula).

Joints. Floating sleeve type with asphalt compound.

Flue Pipe. Furnished in round cross-section in sizes 2 in. to 12 in. I.D. Sizes 2 in. to 5 in. are in 5-ft lengths. Sizes 6 in. and larger in 6-ft 6-in. lengths. Oval cross-sections in 3-in., 4-in., 5-in. and 6-in. nominal sizes, equal to round pipes of similar diameter; lengths 5 ft.

Joints. Round pipe is tapered at both ends and all fillings are tapered on all legs joined together by the use of a tapered coupling. For field cuts a duplex coupling is available with one tapered end and one bell end. Oval pipe is cut square.

Jointing cement is a ready-mixed material applied as a paste.

Stack Pipe. Sizes 2 in. to 36 in. Sizes 2-5 in., inclusive, 10-ft lengths. Sizes 6-36 in., inclusive, 13-ft lengths.

Pipe ends may be ordered machined for use with Simplex or split-and-bolted couplings. In pipe sizes 2 in. to 12 in., inclusive, the ends may be ordered tapered for use with tapered couplings. Coupling must be ordered separately, with the exception of tapered and split-and-bolted couplings. One such coupling is furnished with each section of pipe. Bolts, bolt-head putty, and ferro compound are included with split-and-bolted couplings.

Flue pipe cement, joint compounds, and asbestos yarn, where required in the assembly of the couplings, must also be ordered separately.

Hard-Rubber Pipe and Fittings

Definition. The term "hard rubber" is used to cover a large variety of compounds of rubber, sulfur, and other materials. Consequently there are wide variations in quality, the same as in soft rubber or alloys of metals.

Classes. Standard-weight pipe and screw fittings up to 50 lb WP and atmospheric temperatures.

Heavy-duty pipes and fittings up to 80 lb WP at atmospheric temperature or 50 lb WP up to 150 F temperature.

Sizes are available from ¼ in. to 4 in. on standard-weight pipe and from 1 in. to 6 in. in the heavy-duty type.

Joints can be made with hard-rubber screwed fittings or flanges using soft-rubber gaskets (except where soft rubber will not withstand the action of the liquids to be handled).

Characteristics. Hard-rubber pipes and fittings can be obtained in compositions to suit various kinds of service, for high internal strength, flexibility, expansion, moisture absorption, and resistance to chemicals and liquids, as sulfuric acid not over 50 Bé, acetic acid, nitric acid not over 16 Bé, citric acid, hydrochloric acid, hydrofluoric acid, hydrofluosilic acid, phosphoric acid, tannic acid, caustic soda and potash, copper sulfate, corrosive gases, hydrochloric acid gases, etc., solutions of calcium, zinc, ferric, ferrous, stannic, and stannous chlorides, oils and greases, kerosene, gasoline.

Among the few chemicals which do affect hard rubber are sulfuric acid over 50 Bé, nitric acid over 16 Bé, aniline benzol, carbon bisulfide, chloroform, ethylene dichloride.

Installation. Expansion and contraction are somewhat greater than for metal pipe. Distances between supports for hard-rubber pipe should not be greater than half those used for iron pipe. If warm liquids are used, continuous troughs may be necessary.

Stoneware Pipe and Fittings

Chemical stoneware is used for pipes, fittings, and various containers, receptacles, etc., where acids are used. The acid-resisting qualities rest in the material itself and are not dependent on any glazing.

Bell and spigot fittings are available in any size from 1 in. to 60 in., in any lengths to 5 ft. Flanged, plain ground ends, or special connections can be furnished.

The bell and spigot joints have pure asbestos wicking (one ring for vertical and two rings for horizontal joints), a poured bituminous compound, and a topping material.

ART. 3-L. LININGS AND COATINGS

Lead-Lined Pipe

A wrought pipe having a continuous interior lining of lead. When used on flanged pipe, the lining is often brought out over the face of the flanges. The lead lining is usually as thick as the same size of lead pipe. It is useful for conducting certain corrosive fluids.

Tin-Lined Pipe

A wrought pipe lined with block tin. Tin lining of lead pipe was introduced by Anderson in 1804 (12).

Linings for Steel and Iron Pipe

Cast-iron pipe with spun cement lining $\frac{1}{16}$ to $\frac{1}{8}$ in. thick, with additional coating of asphalt optional.

Spun bituminous (tar) enamel linings for cast-iron and steel pipe.

High-alumina cement lining for cast iron for highly corrosive waters.

Spun-cement lining for steel pipes.

Asphalt coating over the cement lining is being used more and more, especially for soft water and where the lining otherwise causes early causticity.

Rubber-Lined Pipe

Definition. Rubber attached directly to steel by patented methods.

Type of Pipe. Standard wrought steel or wrought iron, cast iron and copper-bearing steel spiral-welded. Flanges may be either cast iron or steel. If steel, flanges may be either welded or screwed on. Flanges on spiral-welded pipe shall be standard cast iron 125 lb, or spiral pipe flanges.

Lengths of Pipe. Pipes may be any specified length within the available range of the steel pipes used, and should be stated in "laying lengths." The maximum length for $\frac{1}{8}$ -in. lining is 20 ft.

Sizes of Pipes. Sizes may be $1\frac{1}{4}$ in. and up.

Joints. Pipes are flanged, with the rubber lining carried out over the face of the flanges. With plain end pipes, such as are used with the B. F. Goodrich Co. Flexlock coupling, the rubber is carried over the end of the pipe and back about 5 in. on the outside and the seal is made with rubber-lined steel split sleeves and Flexlock gaskets.

Soft-rubber lining is carried out to the inside rim of bolt holes on flanges. In addition, $\frac{3}{16}$ -in. thick asbestos gaskets are furnished for the bolt circle. The non-compressible asbestos gasket prevents excessive compression on the rubber. Hard-rubber lining is extended full face to the outer edge of the flanges.

Linings. The ordinary thickness is $\frac{1}{8}$ in. For special services, greater thicknesses may be used.

Linings may be of various plies and hardnesses. It is recommended that one specify the material to be handled and depend on the manufacturer's guarantee. If materials are abrasive, the material and temperature should be specified; if corrosive, the nature of liquid, concentration, and temperature should be specified.

Expansion Joints. Rubber expansion joints consist of two flat steel rings imbedded in a resilient pure gum rubber ring, 2 in. thick, made to attach between flanges of adjoining pipes. Each joint can take up $\frac{1}{2}$ in. stretch or compression.

Uses. For handling, purified water, acetic acid, muriatic acid, phosphoric acid, flue gas wash water, bleach liquids, mine water, chlorine solutions, acid wastes.

Coatings

Definitions.

Asphalted. Coated with asphalt literally, but usually some of the special compositions such as California oil (which has an asphaltic base), coal tar, mineral wax, Gilsonite, or Elaterite are added to give the right consistency to suit the average temperature which prevails when the coating is used (12).

Coal Tar. A by-product of the destructive distillation of soft or bituminous coal (12).

Steel Pipes. Bituminous tar enamel with or without asbestos felt wrapping. In markedly corrosive ground, gunite or a mortar wrapping bound on by cotton fabric (*Proceedings ASCE*, March 1939).

See also list of various coatings for underground pipes in Chapter 1.

Coating for Pipe. Usually a coal-tar composition, sometimes called asphalt. There are many on the market, such as Sarco, Mineral Rubber Asphalt, California Asphalt, Trinidad Asphalt, Elaterite, Gilsonite, and Dr. Angus Smith's Composition (12).

A well-refined coal-tar pitch, softening at 60 F and melting at about 110 F, is one of the best and most durable coatings known when properly applied (12).

ART. 3-M. INSULATION

Materials

Diatomaceous Earth. American Marine Standard E 32.

Asbestos. Fed. Specs. HH-a.

Air-Cell Sectional Pipe Covering. Composed of alternate layers of corrugated and flat asbestos paper. Furnished in 3-ft sections. Corrugations are about $\frac{1}{4}$ in. deep, making 4-ply to the inch. Regularly made in 3-ply and 4-ply. For greater durability, there is available air-cell covering with $\frac{1}{8}$ -in. corrugations, i.e., 8-ply to the inch, or $\frac{1}{6}$ in. corrugation, i.e., 6-ply to the inch.

Asbestos Gaskets.

Asbestos Rope and Wick Packings.

Cork. Fed. Spec. HH-c-571a, cork, granulated, insulating; HH-c-576, cork composition, gasket and sheet; HH-P-381, pipe covering, cork, molded.

Rock Wool. Fed. Spec. HH-P-386, pipe covering and cement, mineral or rock wool.

Hair-Felt Sectional Pipe Covering (Wool-Felt, Anti-Sweat).

Furnished in thickness $\frac{1}{2}$ in., $\frac{3}{4}$ in., and 1 in.

Styles. Asbestos-lined; tar-lined; alternate-layer tarred felt and wool felt.

Not to be used on pipes carrying heat.

Hair-felt insulation, in blanket form.

Magnesia. Fed. Specs. HH-M-61, magnesia, block, cement, pipe covering (molded).

85% magnesia sectional pipe covering. Furnished for pipe up to and including 12 in. in diameter. Made in semi-circular sections 3 ft long, and provided with canvas jackets.

85% *magnesia segmental insulation*. Furnished for pipe 12 in. in diameter and up.

85% *magnesia flat and curved blocks* for covering flat or larger curved surfaces, as ducts, breechings, tanks, and boilers. Made in thicknesses $\frac{7}{8}$ to 4 in.

85% *magnesia plastic cement* for covering irregular surfaces.

TABLE 92
STANDARD THICKNESS: 85% MAGNESIA

Nominal Inside Diameter of Pipe, Inches	Single-Standard Thickness	Double-Standard Inner Layer	Thickness Outer Layer
$\frac{1}{2}$ - $1\frac{1}{2}$ in.	$\frac{3}{8}$ in. thick min.	$\frac{3}{8}$	$1\frac{1}{32}$
2 - $3\frac{1}{2}$ in.	$1\frac{1}{32}$ in. thick min.	$1\frac{1}{32}$	$1\frac{1}{8}$
4 - 6 in.	$1\frac{1}{8}$ in. thick min.	$1\frac{1}{8}$	$1\frac{1}{8}$
7 - 10 in.	$1\frac{1}{4}$ in. thick min.	$1\frac{1}{4}$	$1\frac{1}{4}$
12 - 30 in.	$1\frac{1}{2}$ in. thick min.	$1\frac{1}{2}$	$1\frac{1}{2}$

ART. 3-N. PIPE ACCESSORIES

Hangers and Supports

Definition. Pipe hanger. A suspension link or band (often split) used to support a pipe without interfering with its expansion and contraction (12).

Hangers on copper tubing shall be copper bands or cast-brass rings with no steel or iron contacts to the copper.

Wood blocks and wedges are used for the support of underground cast-iron water pipe. They should be sound oak or pine timbers, not less than the following:

Size of Pipe	Size of Wood Blocks	Size of Wood Wedges
4-10 in.	2 x 12 x 12 in.	3 x 4 x 9 in.
12 in.	2 x 10 x 18 in.	3 x 4 x 9 in.

Wall, Floor and Ceiling Plates

Cast-iron solid and cast-iron split type with set screw, plated or unplated.

Aluminum pipe covering protectors for insulated pipes.

Expansion Bolts

Lead-calking type for heavy work; fiber-shell type for light work.

Special Castings

Specifications. Cast-iron pipe and special castings, ASTM, AWWA, NEWWA, ASA A21.

Manhole frames and covers, ASCE, ASA A35.

Manhole covers. Manhole frames not less than 20 in. in diameter in the clear. Frame to weigh not less than 240 lb. Cover to weigh not less than 110 lb (Fig. 2).

Vault covers. Nominal size 24 in. by 26 in., with covers in two sections; one section to be provided with lifting hooks; weight 480 lb; frame, 29 by 41 in. For use over large meter pits.

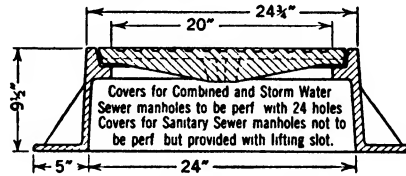


FIG. 2. Manhole Frame and Cover (Minimum weight of frame, 240 lb; minimum weight of perforated cover, 105 lb.)

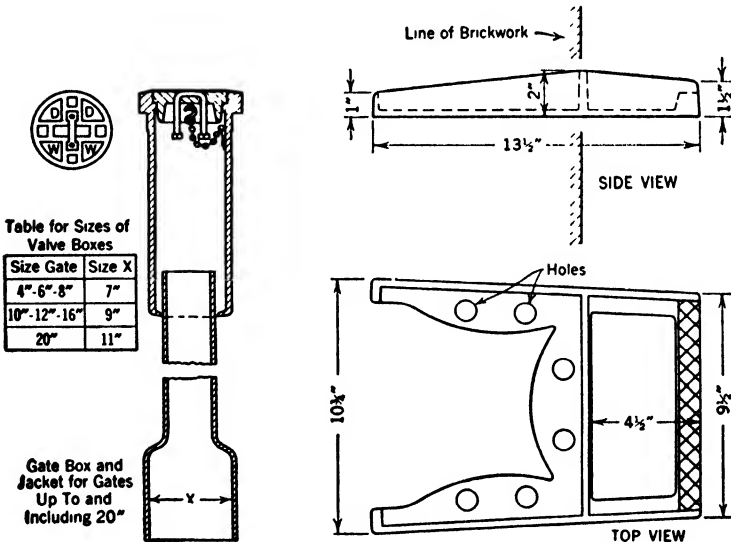


Table for Sizes of Valve Boxes

Size Gate	Size X
4"-6"-8"	7"
10"-12"-16"	9"
20"	11"

Gate Box and Jacket for Gates Up To and Including 20"

FIG. 3. Stop Gate Box.

FIG. 4. Cast-Iron Step for Manholes.

Sump pit covers. Cast-iron set in cast-iron frame, 24 by 24 in.

Cleanout covers. See Art. 4-A, Volume II.

Cast-iron steps for manholes. 9 1/2 in. wide by 1 in.; hatched patterned treads. Full overall length 13 1/2 in. (Fig. 4).

Stop gate boxes (Fig. 3).

ART. 3-O. SHEET METALS**Sheet Iron**

Standards. Specifications for zinc-coated (galvanized) wrought-iron sheets, ASA G8.8, ASTM A163.

Specifications for zinc-coated (galvanized) sheets, ASA G8b.1, ASTM A93.

Fed. Specs. QQ-1-696.

Weights Used. Galvanized sheet iron for piping shall be not lighter than the following (B and S gage):

No. 26 for 2- to 12-in. pipe.

No. 24 for 13- to 20-in. pipe.

No. 22 for 21- to 26-in. pipe.

Galvanized sheet iron for sinks shall be not less than 12 U.S. gage.

Other Sheet Metals

Sheet Lead. Fed. Specs. QQ-L-201.

Sheet lead shall be soft lead weighing not less than 4 lb per sq ft.

Sheet Copper or Brass. Fed. Specs. QQ-C-501.

Sheet copper for flashing shall be soft rolled 16-oz. copper.

Alloy Sheet Metals. Sheet metals used for sheet work (as sinks) shall be No. 14 U.S. gage minimum.

Stainless Steel Finishes

Sheet Finishes. The various sheet finishes are designated as follows:

No. 1—Hot rolled annealed and pickled.

No. 2-B—Full Finish (Bright cold rolled)

No. 2-D—Full Finish (Dull cold rolled).

No. 4—Standard Polish on one side or both sides.

No. 6—Standard Polish, Tampico Brushed on one or both sides.

No. 7—High Luster Polish on one or both sides.

No. 8—Mirror Finish on one or both sides.

No. 2B Finish and No. 2D Finish are the same as No. 1 except that they have a slightly higher finish due to cold roll processing.

No. 4 Finish, being ground and polished, is very satisfactory for exterior and interior application. It possesses a ground surface appearance with a medium luster and is considered the best commercial type of finish for such applications as bank vaults, restaurant and soda fountain equipment, sterilizers, laundry machinery, packing house refrigerators and equipment, cold storage, canning and preserving equipment, trim for cabinets, and numerous other places where a fairly high luster and ease of cleaning are desired. This is the finish most strongly recommended for all architectural applications.

No. 6 Finish has a silvery luster and does not have as high a reflectivity as No. 4. It can often be used to blend in conjunction with finishes of higher luster or other metals. Higher luster finishes, such as No. 7, are obtainable and are similar to No. 4 with the exception that the luster obtained by buffing is much brighter.

No. 8 Finish is the highest obtainable in commercial steel practice. All the grinding lines are removed, and a sheet of high reflectivity is obtained. Little need exists for this finish in architectural applications.

ART. 3-P. PACKINGS, GASKETS, COMPOUNDS, ETC.

Standards

Definitions.

Packing. A general term relating to yielding material employed to effect a tight joint. A common example is the sheet rubber used for gaskets. The term is also applied to the braided hemp or metallic rings used in some joints that allow considerable or incessant motion.

Any material used in packing stuffing boxes of valves (12).

Gasket. A thin sheet of composition or metal used in making a joint (12).

Packings. Fed. Specs. for Jute, Twisted, HH-P-117.

Gaskets. Fed. Specs. for Gaskets, Plumbing-Fixture-Setting, HH-G-116.

Gaskets may be of rubber, copper, Monel, iron, steel, aluminum, stainless steel, asbestos, etc.

Compounds. Fed. Specs. for Compound, Plumbing Fixture Setting, HH-C-536.

Various Compounds, etc.

Dope (for use on pipe threads).

Cement dopes. Litharge and glycerin mixed to a creamy paste (19).

Red lead mixed to a paste with linseed oil (19).

Calking Lead. Fed. Specs. QQ-L-156 and Lead Industries Association.

CALKING LEAD STANDARD

Lead for calking purposes shall contain not less than 99.73% pure lead. Impurities shall not exceed the following limits:

Arsenic, antimony, and tin together	0.015%
Copper	0.08 %
Zinc	0.002%
Iron	0.002%
Bismuth	0.25 %
Silver	0.02 %

Calking lead meeting the above standard must have the manufacturer's name or identification mark cast or stamped on each piece, or, in the case of lead wool, where impossible, it must appear on the package or tag.

Lead Wool. A material used in place of melted lead for making pipe joints. It is lead fiber, about as coarse as fine excelsior, and when made in a strand it can be calked into the joints, making them very solid (12).

Sulfur-Base Jointing Compound. Used in place of calking lead; is a patented product (Leadite).

Bituminous Compound for Sewer Joints. The compound shall preferably have a bituminous base, shall adhere firmly to the glazed surfaces of the pipes, shall melt and run freely at a temperature as low as 250 F, and, when set, shall be sufficiently elastic to permit a slight movement of the pipes without injury to the joints or without breaking the adhesion of the compound to the pipes. The compound shall not deteriorate when submerged in fresh or salt water or normal domestic sewage. It shall show no deterioration of any kind when immersed for a period of 5 days in 1% solution of hydrochloric acid or a 5% solution of caustic potash.

China cement for filling joints between china fixtures and building constructions is a mixture of one part portland cement and two parts fine sand.

Rubber Joints

For use in bell and spigot pipe conveying acids, alkalis, sewage, and other industrial wastes. Available at present only for ceramic pipes for maximum pressure of 15 psi and maximum temperature of 175 F.

After gaskets are inserted in the bell end of the pipe, the gasket and the outside of the spigot end are covered with a special lubricant. The spigot is inserted by hand on smaller pipes and forced into position with a screw-jack or yoke-type pulling device on larger pipes (B.F. Goodrich Co., Akron, Ohio).

Solders

Standards.

Brazing solder	F.S.B.	QQ-S-551
Silver solder	F.S.B.	QQ-S-561b
Tin-lead solder	F.S.B.	QQ-S-571
Borax (Sodium-borate)	F.S.B.	SS-B-611
Flux	F.S.B.	O-S

Specifications for solder metal, ASA H11, ASTM B32.

Definitions.

Autogenous or Copper Welding. Welding of copper using copper as the jointing material.

Brazed. Connected by hard solder, which usually is copper and zinc, half and half. Such solder requires a full red heat and is commonly used with borax flux (12).

Brazing spelter. Copper-zinc alloy; brass.

Bronze Welding. A jointing process between brazing and actual welding. The jointing material is either brass or bronze.

Flux. A flux is a substance, either liquid or solid, used to facilitate the fusing and uniting of two metals when soldering. They are resin, mutton tallow, muriatic acid, chloride of zinc, sal-ammoniac, etc. (Johnson [7]). It also protects the metal from oxidation.

Hard Solder. Brazing solder. It usually is copper and zinc, half and half by weight. Other alloys are used for special work; frequently pure copper is used. The usual flux is borax (12).

Hard Soldering and Brazing. Jointing with solder, either silver solder or brazing spelter. Work must be preheated.

Silver Solders. Solders composed of silver and copper, with silver ranging in proportions from 10 to 80%. The solders may also contain portions of zinc, cadmium, or phosphorus. The adding of the silver lowers the melting point so that the copper or brass alloy can be used in a similar way as soft solder. The flux is usually powdered borax.

Soft Solder. Tin and lead alloy. The first grade is half and half by weight, which melts at a lower temperature than either lead or tin (12).

Solder. An alloy used for connecting two pieces that are less easily melted (12).

Soldering. The uniting of metals by means of fusible alloys of lead and tin (soft solder).

Spelter. The commercial name for zinc; also used for an alloy composed of equal parts of zinc and copper.

Compositions of Solders. Tin increases the fusibility of a solder, but a solder made with tin is not as malleable and tenacious as one without tin (Johnson [7]).

The fusibility of solder is increased by adding bismuth.

For soldering lead, 1 tin, 2 lead.

For soldering tin, 1 tin, 1 lead, or all tin.

50-50 TIN-LEAD SOLDER FOR SOLDERED-JOINT FITTINGS
(ASTM Specifications for Soft Solder Metal, B32-40T.)

Composition	Percentage
Tin	50
Lead	50 (Approx.)
Impurities	
Bismuth	0.10 (max.)
Copper	0.08 "
Iron	0.01 "
Zinc	0.002 "
Aluminum	0.002 "
Antimony	0.12 "
Total other impurities	0.08 "

Spelters for brazing

Hardest	3 copper	1 zinc	
Hard	1 copper	1 zinc	
Soft	4 copper	3 zinc	1 tin
Very soft	1 antimony		2 tin

For brazing hard iron: silver solder, 7 brass, 1 zinc.

For brazing soft iron: 1 tin, 1 lead.

For brazing brass and copper (hard): brass mixed with $\frac{1}{2}$ to $\frac{1}{5}$, or $\frac{1}{2}$ of zinc.

For brazing brass and copper (soft): 1 tin, 1 lead.

For brazing pure tin: 4 parts pewter, 1 tin, 1 bismuth (7).

TABLE 93
SOLDFERS

Composition by Weight						Temperature of Fusion	Metals for Which It Is Used	Flux Commonly Used
Lead	Tin	Copper	Zinc	Silver	Gold			
1	1					188 C	Lead	Tallow
3	5					176 C	Zinc	Zinc chloride with 25% HCl
2	5					170 C	Copper Brass	Zinc chloride (neutral) or resin
							Iron	Zinc chloride or ammonium chloride (NH ₄ Cl)
		2	1				Iron Copper	Borax
		55	45			880 C	Iron Copper Brass	Borax
		4.5	0.5	15		1005 C	Iron Copper Gold	Borax
		6.5	2.0	11		983 C	Iron Copper Gold	Borax
		4		6	10		Gold	

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CHAPTER 4
VALVES AND CONTROLS
ART. 4-A. STANDARDS

Definitions

Bibb. A cock or valve with bent outlet; strictly the bent outlet (12).

Bleeder. A small cock or valve to draw off water of condensation from a range of piping (12).

Bonnet. That portion of a gate valve into which the disk rises when the valve is opened (4).

A cover used to guide and enclose the tail end of a valve spindle (12).

Brass-Mounted. When used to describe a globe, angle, or cross valve, it usually means that the valve has a brass bonnet, stem, seat, ring, and disk.

When used to describe gate valves, it usually means brass stem, seat, ring and wedge, or disk ring (12).

Mounted. When applied to pipe fittings, valves, etc., in such expressions as brass-mounted, nickel-mounted, etc., mounted means having the rubbing or wearing surfaces composed of the material named (12).

Valve. A device used for regulating or stopping flow in a pipe, etc. The form that allows an opening the full inside diameter of the pipe is usually known as a gate valve

or straight way valve. The same result is obtained in some forms of cocks. The essential difference between a valve and a cock is that the closure of the latter is invariably accomplished by rotating a taper plug, which has ports or holes in it that correspond to holes in the body (12).

Valve Box. A pipe placed over a buried valve to allow access to the valve stem or wheel for opening or closing. The top of the pipe is usually closed by a plate or cap to exclude dirt that would interfere with operation. There are many designs, the most usual being adjustable within limited range to suit the depth planted. They are called extension valve boxes, street boxes, or service boxes (12).

Valve Seat. A flat or conical fixed surface on which a valve rests, or against which it presses (12).

Valve Stem. A rod attached to a valve by which the latter is moved. It is also called a valve spindle (12).

Yoke. In a rising stem valve, the portion of the bonnet that supports the nut, hand-wheel, etc. (12).

Classifications

Valves and controls may be separated into operating controls and safety controls.

The operating controls are for the purpose of opening, partly opening, or closing pipe lines to permit the proper flow for operating purposes. They may be operated manually or automatically.

The safety controls are specially designed controls, usually fully automatic, to operate only in emergencies.

Automatic Controls

Automatic controls may operate by means of a liquid, a gas, electricity, or compressed air. They may be either self-contained or power-operated.

Self-contained controls do not require any outside means of operation. They are usually operated by a liquid which vaporizes or a gas which expands, a metal which expands, or through a hydraulic action, producing a movement towards a spring-loaded piston. Some relief valves operate against a spring or weight or by a float valve.

Power controls are usually operated by electricity (electric motors, relays, or solenoids) or by compressed air, or combinations of both.

Operation*

Two-position, on or off, snap action.

Floating Control. Static pressure regulator. Tank lever control.

Modulating Control. Gradual or graduated acting control. Proportional control.

Controls operated from temperature are called *Thermostats*. Thermostats are either self-contained (expansion type) or operated by electricity or compressed air. A "positive" thermostat is either "on" or "off," with no intermediate position (snap action). A "graduated" action thermostat moves from "on" to "off" in steps. (If electric, it is called a "potentiometer.")

Threading

Standards. The threading of standard valves (except the hose end of hose valves) conforms with that of standard wrought-iron and steel steam, gas, and water pipe as made in the United States and known as the American Briggs Standard.

All pipe threads are right-hand, unless left-hand is specified.

Direction of operation. All valves, hydrants, and indicator posts with threaded stems are made to open by turning the operating wheel or nut towards the left (counterclockwise), unless otherwise ordered.

Specifications

Valve Design. All valves for working pressures of less than 120 lb shall be tested at the factory to 250 lb hydrostatic pressure and shall be designed for a working pressure of 125 lb. Valves on fire lines shall be designed for a working pressure of 250 lb. The valves shall be provided with stuffing boxes and shall be permanently and properly packed. The valves shall be finished, machine-finished surfaces, except where polished surfaces are specifically called for. The polished surfaces shall

* These definitions are reprinted from *Air Conditioning Control Manual*, with the permission of the Minneapolis-Honeywell Regulator Co., Minneapolis, Minn.

show no tool marks and shall be highly polished. The rough surfaces shall be of rough cast brass free from flaws and uneven surfaces. The name or trade mark of the manufacturer shall be cast or stamped on all valves, stops, cocks, checks, etc. In general, valves, stops, cocks, checks, etc., on wrought-iron, steel, or standard brass pipe, 2 in. and under, shall be of (red) rough brass bodies with machine-finish trimmings and screwed ends; those 2½ in. and over shall be of iron bodies, bronze mountings, non-corrosive stem contacts, including bronze stems and faces; 2½-in. and 3-in. and 4-in. valves shall have screwed ends; those 5 in. and over shall be flanged. Valves, cocks, and checks on N.P. or chromium-plated brass pipe shall be rough-finished brass chromium-plated.

In general, unless otherwise specified, valves and cocks shall have key handles on pipes laid underground, or lever handles on stops and iron wheels on general control valves and cocks and brass-milled wheel handles at fixture controls, finished the same as the piping.

ART. 4-B. MANUAL OPERATING VALVES

Gate Valves

Definitions.

By-pass Valve. A small pilot valve used in connection with a larger valve to equalize the pressure on both sides of the disk of the larger valve before the larger valve is opened (12).

Gate Valve. A sluice valve; one having two inclined seats between which the valve wedges down in closing, the passage through the valve being in an uninterrupted line from one end to the other. The valve, when opened, is drawn up into a dome or recess, thus leaving a straight passage the full diameter of the pipe (12).

Wedge Gate Valve. A gate valve having inclined seats. Usually a wedge-shaped disk is pressed down between these inclined seats (12).

Standards. Valves, gate, 125-lb SWP (for land use). Fed. Specs. WW-V-76a.

Face-to-face dimensions of ferrous flanged and welding end valves, ASA B16.10, HPCNA, MSS, ASME.

Specifications. Gate valves shall be standard (125-lb SWP) bronze trimmings and stems of bronze or brass. All disks on valves 6 in. and less shall be solid bronze, above 6 in. shall be solid iron or steel with bronze face rings. All seat rings shall be square type.

Gate valves less than 3 in. shall have stationary stem, inside screw, and screwed bonnet.

Gate valves 3 in. and over shall have stationary stem, inside screw, and flanged bonnet.

Gate valve serving as main water shut-off shall be as specified above, except it shall be double-disk type.

STANDARD IRON-BODY DOUBLE-DISK GATE VALVES

Iron Body Bronze-Mounted or All-Iron

TABLE 94. NON-RISING STEM

Size, inches		2	2½	3	3½	4	5	6	8	10	12
Screwed	A	5	6	6¾	6¾	7	8	8½	10¼	11¾	13¾
Flanged	B	7	7½	8	8½	9	10	10½	11½	13	14
	D	6	7	7½	8½	9	10	11	13½	16	19
	E	¾	1¼	¾	1¼	1½	1½	1	1½	1¾	1¾
Number of bolts		4	4	4	8	8	8	8	8	12	12
Diameter of bolts		¾	¾	¾	¾	¾	¾	¾	¾	¾	¾
	M	10¼	11¼	12¾	14½	14½	17½	18½	22½	26¾	31½
	Y	6¾	6¾	7	8	8	9	10	12	14	16

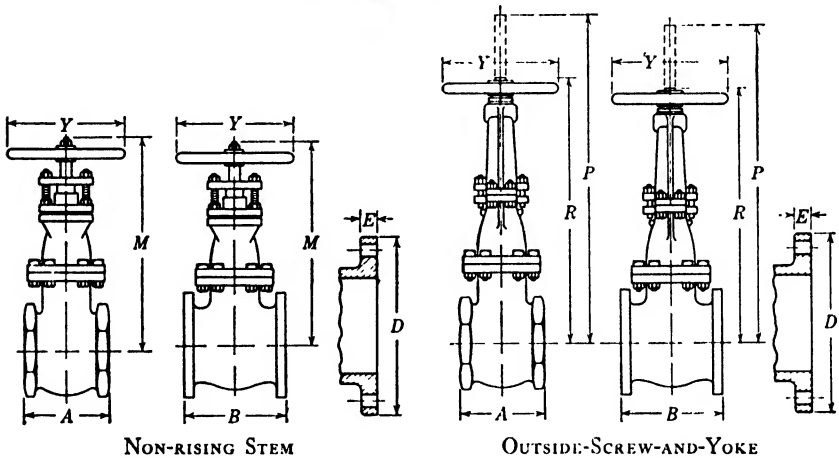


TABLE 95. OUTSIDE-SCREW-AND-YOKE

Size, inches		2	2½	3	3½	4	5	6	8	10	12
Screwed	A	5	6	6¾	6¾	7	8	8½	10¼	11¾	13¾
Flanged	B	7	7½	8	8½	9	10	10½	11½	13	14
	D	6	7	7½	8½	9	10	11	13½	16	19
	E	¾	1¼	¾	1¼	1½	1½	1	1½	1¾	1¾
Number of bolts		4	4	4	8	8	8	8	8	12	12
Diameter of bolts		¾	¾	¾	¾	¾	¾	¾	¾	¾	¾
	P	13¾	15½	17½	20½	21½	26½	30½	39½	45½	54½
	R	11¾	12¼	13¾	16½	17½	20¼	24½	31	34¾	42½
	Y	6¾	6¾	7	8	8	9	10	12	14	16

Courtesy Kennedy Valve Mfg. Co., Elmira, N.Y.

STANDARD IRON-BODY DOUBLE-DISK GATE VALVES

Iron Body Bronze-Mounted or All-Iron

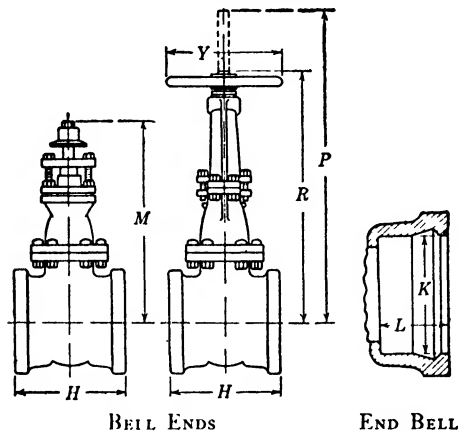


TABLE 96. NON-RISING STEM OR OUTSIDE-SCREW-AND-YOKE

Size, inches		2	3	4	5	6	8	10	12
Bell ends	H	7 7/8	9 1/2	11	10 3/4	11 1/4	13 1/4	14	14 3/4
	K	3 1/4	4 9/16	5 11/16	6 3/4	7 13/16	10	12 1/4	14 1/4
	L	2 1/2	2 3/4	3 1/4	3	3 1/2	4	4	4
	M	10 1/4	12 1/4	14 5/8	17 1/4	19 1/4	23 1/4	27 1/4	32 1/4
	P	13 7/8	17 1/8	21 5/8	26 3/8	30 5/8	39 5/8	45 3/8	54 3/8
	R	11 1/4	13 7/8	17 1/8	20 3/4	24 1/4	31	34 3/4	42 3/4
	Y	6 1/2	7	8	9	10	12	14	16

Courtesy Kennedy Valve Mfg. Co., Elmira, N.Y.

Globe and Angle Valves

Definitions.

Globe Valve. A valve having a round, ball-like shell. It is much in use for regulating or controlling the flow of gases or steam (12).

Angle Valve. A stop valve whose outlet is at right angles to its inlet branch, thus combining in itself a valve and an elbow (12).

Standards. Valves, brass or bronze, angle and globe, 150-lb SWP (for land use), Fed. Specs. WW-V-51.

Designs (Ref., *Valve World*, January, 1934).

- (a) Metal disk. Narrow conical seat.
- (b) Composition disk.
- (c) Plug disk.

Specifications.

Globe or angle valves shall be Standard 125-lb WSP.

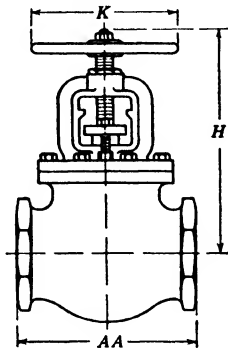
Globe valves 2 in. and less shall be heavy standard brass body, union bonnet, renewable composition disk. (Continued on page 125.)

STANDARD IRON-BODY GLOBE, ANGLE AND CROSS VALVES

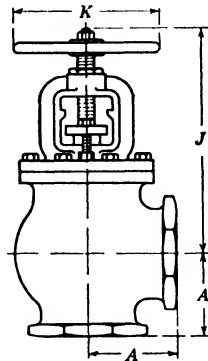
Iron-Body Bronze-Mounted or All-Iron

Bronze-Faced or All-Iron Disk

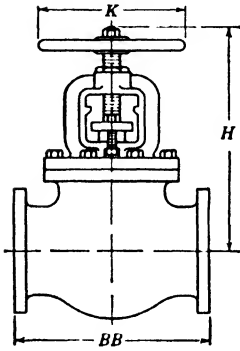
Yoke Bonnet



GLOBE, SCREWED



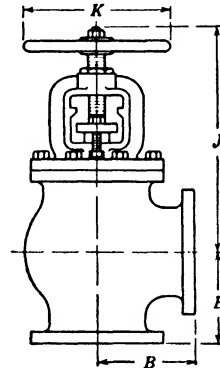
ANGLE, SCREWED



GLOBE, FLANGED



END FLANGE



ANGLE, FLANGED

TABLE 97

Size, inches		2	2½	3	3½	4	5	6	8	10	12
Globe	AA	6½	7	8	9	10	11½	13	18	22½	25½
	BB	8	8½	9½	10½	11½	13	14	19½	24½	27½
	H	10½	11	12	12½	14½	17	18	25½	32½	37½
Angle	A	3½	3½	4	4½	5	5½	6½	9	11½	12½
	B	4	4½	4½	5½	5½	6½	7	9½	12½	13½
	J	10½	11	12½	12½	14½	17	18	25½	33½	38½
Cross	AA	6½	7	8	9	10	11½	13	18	22½	25½
	A	3½	3½	4	4½	5	5½	6½	9	11½	12½
	BB	8	8½	9½	10½	11½	13	14	19½	24½	27½
	B	4	4½	4½	5½	5½	6½	7	9½	12½	13½
	J	10½	11	12½	12½	14½	17	18	25½	33½	38½
Flanges	D	6	7	7½	8½	9	10	11	13½	16	19
	E	¾	1½	¾	1½	1½	1½	1	1½	1½	1½
Number of bolts		4	4	4	8	8	8	8	8	12	12
	K	6½	6½	7	7	10	12	12	14	20	20

Courtesy Kennedy Valves Mfg. Co., Elmira, N.Y.

Globe valves 2½ in. and over shall be iron body, bronze mountings, outside screw and yoke, flanged bonnet, renewable bronze disk, hard metal brass seats.

Ground-Key Valves

Definitions.

Air and Gas Cocks. Air and gas cocks shall be in accordance with Specifications of the American Gas Association for Gas Fixture Cocks.

Cock. A device for regulating or stopping the flow in a pipe, made by a taper plug that may be rotated in a body having ports corresponding to those in the plug. See *Bibb, Bleeder, Corporation, Four-Way, Pet, Plug* (12).

Corporation Cock. A term usually applied to the cock attached to a street main, owned and operated by, or under the supervision of, a supply corporation. It is distinct from the more accessible curb cock which is placed in the service line for convenience.

Its essential peculiarities are usually that it has one threaded end, a heavy body, and a plug large enough to permit a drill to be operated through it, the diameter of the drill being the nominal size of the cock (12).

Four-Way cock. A cock so designed that the body has four passages and the plug has two passages (12).

Ground-Key Valve or Faucet. A valve or faucet through which the rate of water is

controlled by means of a circular plug or key which fits closely in a cylindrically ground seat. The plug has a hole bored through it as the water way (4).

This valve is same as *Plug Cock*.

Lubricated valves are specially designed cocks provided with grooves in the plug so that the contact surface between the ground seat and the plug may be kept lubricated. This feature is used on large cocks and cocks for special service. Smaller sizes are wrench-operated; the length of the wrench equals six times the nominal size of the valve. Larger sizes are worm-gear-operated.

Pet Cock. A small cock used to drain a cylinder, fitting, etc. The term means nearly the same as drip or drain cock (12).

Plug Cock. Usually called a cock. All cocks are essentially plug cocks (12).

Stop Cock. A valve with a ground key (4).

Stop-and-Waste Cock. A stop cock so designed that when the supply of water is shut off a drain is opened through which the water in the pipe, on the side of the cock opposite the supply line, is drained to waste (4).

Leak-Protector Valves

Definition. Leak-Protector Valves. Designed so as to divert to the outside, by means of leak grooves or otherwise, any leakage which attempts to pass the valve face.

Butterfly Valves

Definition. Butterfly. The name applied to certain valves made after design of a damper in a stovepipe (12).

Needle Valves

Definition. Needle Valve. At times called a needle-point valve. A valve provided with a long tapering point in place of the ordinary valve disk. The tapering point permits fine graduation of the opening.

Faucets

Definitions.

Compression Faucet (or Valve). A faucet or valve in which the flow of water is shut off by means of a flat disk (either with or without packing) which is screwed down onto its seat (4).

Drain Cocks. Drain cocks shall be $\frac{3}{4}$ in., rough brass hose end compression stop, wheel handle, and male I.P. thread.

Faucet. A device to control the flow of liquid. Originally a hollow plug with a transverse hole in which the spigot was placed. The spigot was later bored and equipped with a handle now made in a

great variety of forms. Commonly called a tap, and used in house plumbing to draw water.

Fuller Faucet. A faucet in which the flow of water is stopped by means of a rubber ball forced into the opening (4).

Hose Bibb. Usually the same as a "sill cock." Faucets on plumbing fixtures having threading for attaching of a hose should be specified as "spouts with hose ends."

Sill Cock. A faucet, used on the outside of a building, to which the garden hose is usually attached (4).

Rubber-Lined Valves

Types. Cast-iron body, 150 lb WP, rubber-lined, steel seat ring, molded hard rubber seat, bronze operating screw, bronze bushing. Sizes $1\frac{1}{2}$ to 8 in. Limited to temperatures up to 180 F.

35 lb WP, rubber-lined relinable valve operating by squeezing together the rubber tube inside the valve. Limited to use on non-oily fluids and temperatures up to 150 F. Sizes 1 to 6 in.

ART. 4-C. AUTOMATIC OPERATING CONTROLS

Check Valves

Definitions.

Back-Water gate. A device for preventing the backflow of sewage and water (16).

Check. To prevent flow in one direction; applied to valves (12).

Check Valve. An automatic non-return valve, or a valve which permits a fluid to pass in one direction but automatically closes when the fluid attempts to pass in the opposite direction (12). On sewer lines termed a back-water valve.

Specifications.

Check Valves. Check valves 2 in. and under shall be of red brass, 125 lb WSP, screwed, swing type, with regrinding feature and renewable disk.

Check valves over 2 in. shall have iron bodies, 125 lb WSP, bronze-mounted, swing type, bronze seat and disk, regrinding type.

On pneumatic water systems the check valve on the air compressor shall be bronze, spring-loaded-lift type with renewable disk. The check valve on the water pump discharge in sizes 2 in. and up shall be horizontal-swing type iron body with or without outside lever and weight, bronze-mounted, leather-faced disk.

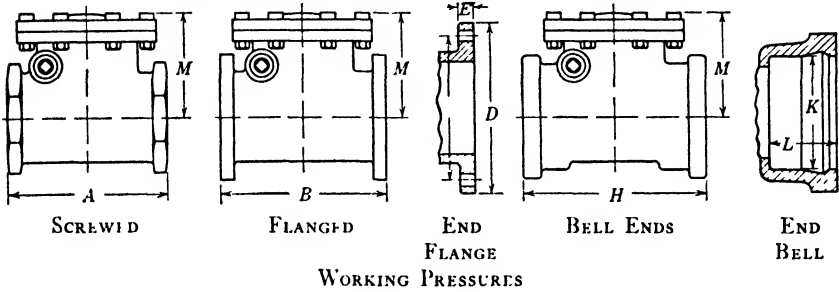
Sewer valves (back-water valves) shall have all bearing parts or balls

of non-corrodible metal and be constructed so as to insure a positive mechanical seal and shall remain closed except when discharging wastes. A 3/4-in. permanent opening of the flap at the bottom is sometimes allowed on flap-gate types.

STANDARD IRON-BODY SWING CHECK VALVES

Iron-Body Bronze-Mounted or All-Iron

Bronze-Faced, Leather-Faced or All-Iron Disk



2-in. to 12-in.: saturated steam, 125 lb; cold water, oil or gas, non-shock, 175 lb.

TABLE 98

Size, inches		2	2½	3	3½	4	5	6	8	10	12
Screwed	A	6¼	7½	8¼	8¾	9¾	11¼	13¼	15¼	19	22¼
Flanged	B	8	8¾	9¾	10¾	11¾	13	14	19¾	24¾	27¾
	D	6	7	7¾	8¾	9	10	11	13¾	16	19
	E	5/8	7/16	¾	13/16	15/16	1	1¼	1¾	19/16	1¾
Bell ends	H			12		13¾	15¼	15½	18¾	21¼	24¾
	K			4¾		5¾	6¾	7¾	10	12	14¾
	L			2¼		2¼	3¾	3¾	3¾	4	4
Center of opening to top of cap	M	4¾	5	6	6¾	6¾	8	9	10 7/8	12 7/8	14¾
Diameter of cap flange		5¼	6¼	7¼	7¾	8¾	10	11¾	14	16¾	19¾
By-pass valve—size											2

Courtesy Kennedy Valve Mfg Co., Elmira, N.Y.

Sewer valves at discharge end of sewers shall be flap-gate type, all brass or bronze (Palmer type). Where not installed at open ends of sewer, the valves shall be fully enclosed and provided with a brass screwed cleanout on top of a size one size larger than the pipe.

Float-Controlled Valves

Definitions.

Float Controls. Controls operating automatically by the rising or lowering of a float. Used in connection with electric motors for pumps, ejectors, etc.

Float Valve. A valve operating automatically by the rising or lowering of a float. Used in connection with the filling of water-storage tanks.

Float Valves. Float valves shall be equipped with gland stuffing box and swivel guide yokes; copper float adjustable for height, of approved make.

Pressure-Regulating and Pressure-Reducing Valves

Definition. Reducing Valve. A spring or lever loaded valve similar to a safety valve, whereby a lower and constant pressure may be maintained beyond the valve (12).

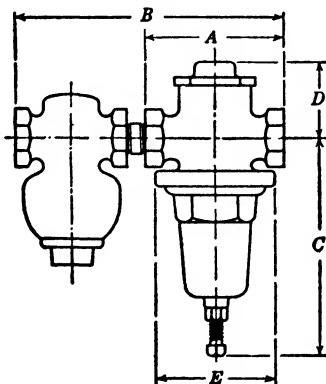
Specification. Pressure-regulating valves shall be of a type designed to prevent excessive pressure on the delivery side and shall be furnished set for initial and delivery pressures as specified. Valves shall be made entirely of brass or bronze, have full-size opening, composition reinforced diaphragm, composition disk, and a spring. Diaphragm and spring must be arranged to act directly on the valve stem, and the arrangement must be such that the delivery pressure will not vary more than 1 lb for each 10 lb variation of the inlet pressure. All parts subject to wear must be renewable.

Pressure-regulating valves 2 in. and smaller shall be brass; 2½ in. and larger shall have cast-iron bodies, brass-mounted.

All regulating valves shall be furnished with a galvanized iron body strainer of same nominal size as regulator, with phosphor bronze wire cloth basket screen.

TABLE 99

PRESSURE REDUCING AND REGULATING VALVE
(For Hot or Cold Water, Air, and Liquid Soap)



Size in.	A in.	B in.	C in.	D in.	E in.
¼	2⅝	5⅛	4⅛	1⅞	2⅝
⅜	3⅞	6⅜	5⅞	2⅞	2⅞
½	3⅞	7⅞	7⅞	2⅞	3⅞
¾	4⅜	8⅞	7⅞	3⅞	3⅞
1	3⅞	9⅞	8⅞	3⅞	5
1¼	4⅞	12⅞	10⅞	3⅞	7⅞
1½	5⅞	14⅞	10⅞	4⅞	9⅞
2	6⅞	17⅞	14⅞	4⅞	11⅞
2½	7⅞	20	16⅞	5⅞	14⅞

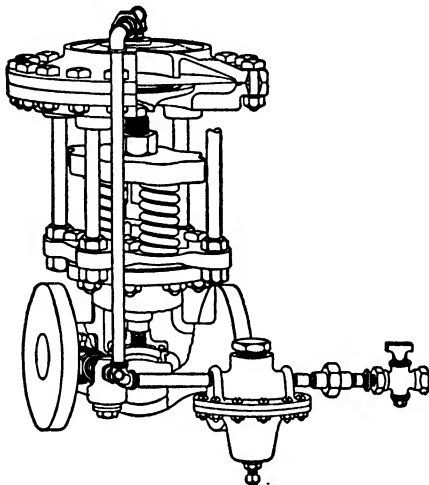
Sizes: ¼ in., ⅜ in., ½ in., ¾ in., 1 in., 1¼ in., 1½ in., 2 in., 2½ in.

Pressure Range: Valves are regularly stocked for initial pressures ranging from 40 to 250 and deliveries from 25 to 75. Valves can be furnished upon request for any initial up to 250 or delivery from 5 to 125 lbs. Special springs are necessary for the latter ranges.

All valves are set at 45 lb delivery, unless otherwise specified.

Courtesy Mueller Co., Decatur, Ill.

TABLE 100
 PRESSURE REDUCING AND REGULATING VALVE
 AUXILIARY-OPERATED
 (For Hot or Cold Water, Air, and Gas)



Screw End

	3/8	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3	4
End to end	2 1/8	2 11/16	4 7/8	6 3/8	7 7/8	8 1/2	10 9/16	7 1/2	8 3/16	10 3/8
C. to top	6 1/16	6 21/32	8 3/8	10 1/4	10 3/8	12 1/8	15 5/8	16 1/16	18 1/16	20 3/8
Diameter hood	6 1 1/2	6 1 3/4	6 7/8	8 5/8	8 3/4	10 1/8	12	14 7/8	14 7/8	16 1/2

Flange End

	2	2 1/2	3	4	5	6	8	10	12
Face-to-face std.	7 3/8	9	9 3/4	11	14	15 1/2	18	20	23 1/4
Face-to-face ex hvy.	9	10	10 3/4	12 1/8	14 1/2	16	20	25	28
C to top	15 3/8	16 1/16	18 3/16	20 1/4	20 29/32	23	24 1/4	31 1/2	34 3/8
Diameter hood	12	14 3/8	14 3/8	16 1/2	16 1/2	18	20	23 3/4	29 3/8

Courtesy Mueller Co., Decatur, Ill.

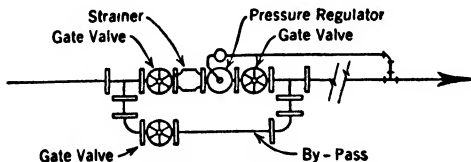


FIG. 5. Installation of Pressure Regulator.

TABLE 101

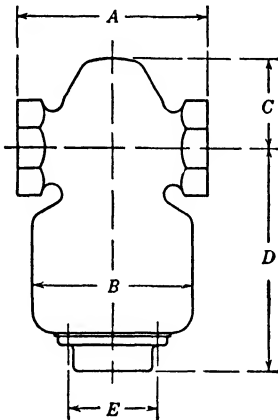
STRAINER

(For Water, Steam, Air, Gas, and Oil)

Size: 3/8 in., 1/2 in., 3/4 in., 1 in., 1 1/4 in., 1 3/4 in., 2 in., 2 1/2 in., 3 in., 4 in. **Note:** (All screw end).
Construction: 1/2 in. and 3/4 in. sizes of bronze, sizes 3/8 in. to 3 in. incl. of galvanized iron. Size 4 in. is iron with black japanned finish. Inverted basket screen of phosphor bronze wire cloth.

Installation: Strainer should be installed in service line with sediment chamber down, preceding meter and all plumbing fixtures.

Where strainers are used in cold climates care should be taken to install same in a warm and protected place.



Size in.	A in.	B in.	C in.	D in.	E in.
3/8	2 1/8	1 3/4	5/8	1 11/16	3/4 IP
1/2	2 1/8	1 3/4	5/8	1 11/16	3/4 "
3/4	3	2 11/16	1 15/32	3 13/16	1 1/4 "
1	3	2 11/16	1 15/32	3 13/16	1 1/4 "
1 1/4	3 5/8	3 3/16	1 15/32	4 3/16	1 1/4 "
1 3/4	4 1/2	3 13/16	1 29/32	5 13/16	1 1/2 "
2	5 7/8	4 5/8	2 5/16	5 13/16	2 "
2 1/2	6 3/8	5 1/8	2 3/4	6 3/8	2 1/2 "
3	7 1/2	6 1/4	3 3/16	7 3/8	3 "
3 1/2	9	6 5/8	3 1/2	9 1/16	3 "
4	10 5/8	7 1/2	3 7/8	10 3/16	3 1/2 "
4	12 7/8	9 5/8	6	12	1 1/2 "

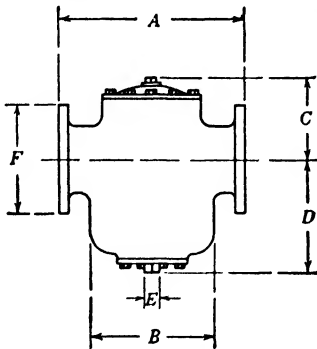
Note: E represents IPS of cleanout plug connection.

Size: 3 in., 4 in., 5 in., 6 in., 8 in., 10 in., 12 in. **Note:** (All flange end)

Construction: The strainer is of cast-iron body with black japanned finish. The basket screen is of the inverted type and of phosphor bronze screen wire

Installation: Strainers should always be installed with sediment chamber down and with flow in direction of arrow cast on body.

If unit is to be placed on line to pump make installation on suction side.



Size in.	A in.	B in.	C in.	D in.	E in.	F in.
3	12	7 1/2	3 7/8	10 3/16	3 1/2	8 3/4
4	17 1/2	9 5/8	6	12	1 1/2	10
5	20 3/4	12	6 3/4	14 3/8	1 1/2	11
6	24 3/4	15 1/4	8 1/4	16 1/4	2	12 1/2
8	28 1/2	19 1/4	11 1/8	18 3/4	2	15
10	33 3/8	21 3/8	13 5/8	22	2	17 1/2
12	37	23 3/4	16 1/8	25	2	20

Note: E represents IPS of cleanout plug connection.

Semi-Automatic Valves

These valves are hand-operated but automatically regulated.

Flushing valves, or metered valves or Flush-o-meters, are devices which when turned on will deliver a definite amount of water and then shut off the supply. They can be obtained in many sizes for various purposes. They are used mostly in connection with flushing fixtures (as water closets), as mentioned in Chapter 5.

Hand-Regulated Flow, Automatic-Regulated Pressure Equalizers, or Temperature Regulators.

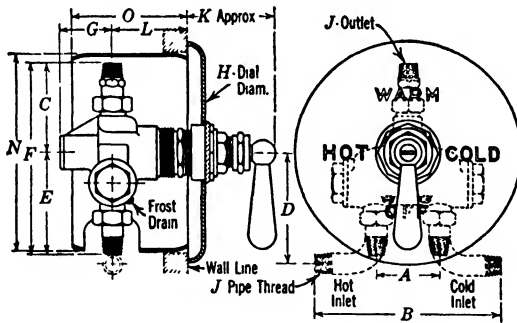
Mixing valve, pressure-equalizing type, for mixing hot and cold water. For use in connection with individual fixtures, 1/2 and 3/4 in. sizes, exposed and concealed types. Capacities 4 to 22 gpm (10-40 lb pressure), Table 102.

Steam and water mixer, capacities 2 to 24 gpm (10 to 40 lb pressure) sizes 1/2, 3/4, and 1 in., exposed type.

Thermostatic Mixing Valves (thermostatically and pressure-controlled).

Individual types, capacities 4 to 9 gpm on pressure from 10-40 lb, 1/2-in. size; exposed and concealed type.

TABLE 102
ROUGHING-IN DIMENSIONS
(Shower Mixer)

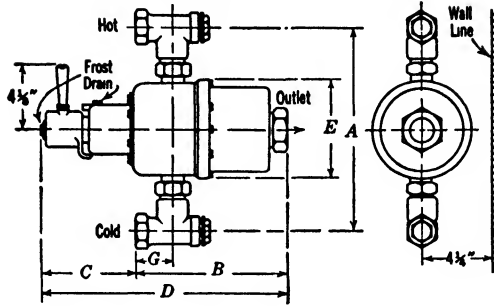


Size	A	B	C	D	E	F	G	Dial Dia H	J	K	L	M	N	O
1/2 in.	2 5/8	6 13/16	3 7/16	4 1/4	3 11/16	7 1/8	2	8 1/4	3/8	3 3/4	3	7 9/16	7 3/8	4 3/4
3/4 in.	3 5/8	8 9/16	4 1/2	6 13/16	6 1/16	10 9/16	2 3/4	10 7/8	3/4	3 3/8	3	10 3/4	10 7/16	5 3/4

Straight connections are standard. Elbow connections furnished only when specified at no extra cost. Wall box for thin partitions can be furnished at no extra cost when specified. Dimensions—L-1 3/4 in., O-2 7/8 in.

Courtesy The Powers Regulator Co., Chicago, Ill.

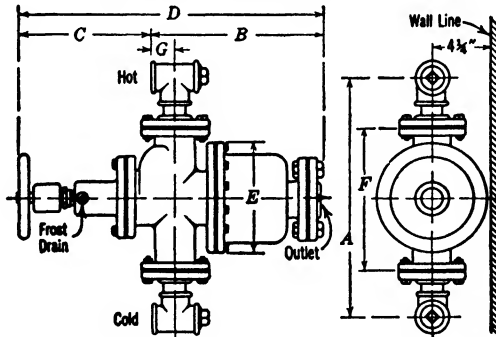
TABLE 103A
ROUGHING-IN DIMENSIONS
(Thermostatic Water Controllers)



Size	Inlet Size	Outlet Size	A	B	C	D	E	G
No. 1	3/4	3/4	9	6 7/8	6 5/8	13 3/8	6 3/8	1 3/8
No. 3	3/4	1	10 1/2	7 3/8	6 3/8	13 5/8	6 3/8	1 3/8
No. 4	1	1 1/4	12 1/4	8 5/8	6 1/8	14 11/16	6 3/8	2

Courtesy The Powers Regulator Co., Chicago, Ill.

TABLE 103B
ROUGHING-IN DIMENSIONS
(Thermostatic Water Controllers)

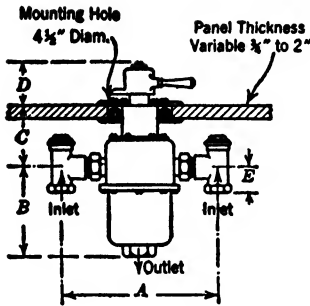


Size	Inlet Size	Outlet Size	A	B	C	D	E	F	G
No. 5	1 1/4	1 1/4	16	13 1/16	9 5/16	22 3/8	8 1/8	9	1 3/4
No. 6	1 1/2	2	16 3/4	13 3/4	9 3/8	22 3/8	8 1/8	9	1 15/16

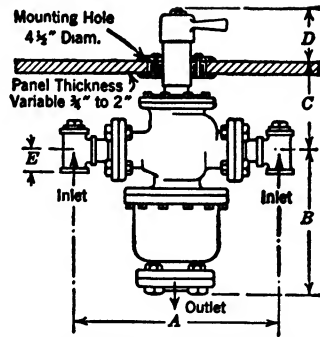
Courtesy The Powers Regulator Co., Chicago, Ill.

TABLE 103C

ROUGHING-IN DIMENSIONS

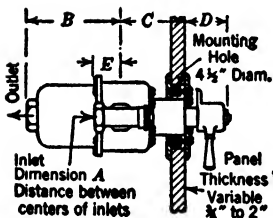


CONTROLLERS 1, 3, AND 4—
HORIZONTAL PANEL

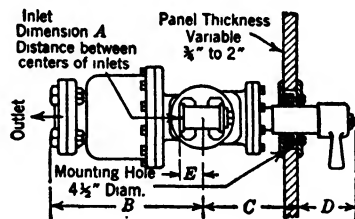


CONTROLLERS 5 AND 6—HORIZONTAL PANEL

Controller No.	1	3	4	5	6
Inlet Size	$\frac{1}{2}$	$\frac{3}{4}$	1	$1\frac{1}{4}$	$1\frac{1}{2}$
Outlet Size	$\frac{3}{4}$	1	$1\frac{1}{4}$	$1\frac{1}{2}$	2
A	9	$10\frac{1}{2}$	$12\frac{1}{4}$	16	$16\frac{3}{4}$
B	$5\frac{1}{2}$	$5\frac{1}{2}$	$6\frac{5}{8}$	$11\frac{5}{16}$	$11\frac{9}{16}$
C	$4\frac{15}{16}$	$4\frac{15}{16}$	$4\frac{15}{16}$	$7\frac{1}{16}$	$7\frac{1}{16}$
D	$3\frac{1}{8}$	$3\frac{1}{8}$	$3\frac{1}{8}$	4	4
E	$1\frac{3}{8}$	$1\frac{3}{8}$	2	$1\frac{3}{4}$	$1\frac{15}{16}$



CONTROLLERS 1, 3, AND 4—
VERTICAL PANEL



CONTROLLERS 5 AND 6—VERTICAL PANEL

Courtesy The Powers Regulator Co., Chicago, Ill.

Battery types, capacities 8 to 125 gpm on pressures from 20-40 lb. Sizes (on outlets) $\frac{3}{4}$, 1, $1\frac{1}{4}$, $1\frac{1}{2}$, 2 in.; exposed type, bronze body, rough finish or polished chromium- or nickel-plated (Table 103).

Mixing Valves. Thermostatic mixing valves for the purpose of regulating the temperature of water shall have all cast brass bodies, all parts to be either bronze or copper. The valve shall have solid metal thermostat with nickel base or be of the solid filled liquid expanding type. It

shall either be provided with pressure equalizer for the hot- and cold-water inlets or operate on the pressure regulating principles by having the plunger powerful enough to work directly against the supply inlets. Valves shall either have hand-operated regulator or be easily adjustable within 10 F, over and below the operating temperature specified.

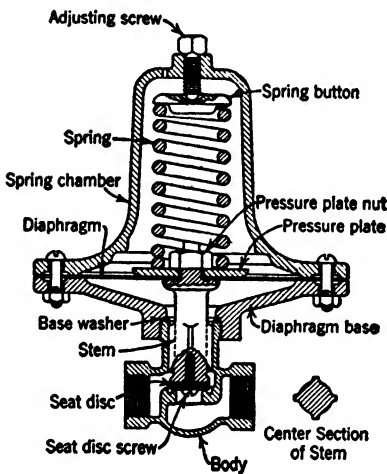
Air-Pressure Relief Valves

Definition.

Air Valve. A device that releases air from a pipe line automatically without permitting loss of water. It may also admit air to the pipe automatically if the internal pressure becomes less than atmospheric (14).

Air Relief Valves. Air relief valves shall be of the float type, to permit air to escape and stop water, heavy cast brass body, stainless steel float, stainless steel lever, valve pin, and seat.

TABLE 104
RELIEF VALVE
(For Hot or Cold Water, Air and Oil)



Size: $\frac{1}{2}$ in., $\frac{3}{4}$ in., 1 in., $1\frac{1}{4}$ in., $1\frac{1}{2}$ in., and 2 in.

Pressure Range: Valves are regularly carried in stock set at 30, 50, 75, 100, and 125 lb maximum relief pressure. Upon request valves will be furnished set at any pressure up to 125 lb. For prompt delivery order stock valve.

Valves size $\frac{1}{2}$ in., $\frac{3}{4}$ in., and 1 in. can be furnished of heavy construction for pressures between 125 and 250 lb. All valves for this range are made on order only and for maximum pressure indicated.

Construction: The relief valve is of straight-way body design with inside thread inlet and outlet connections. Standard construction for pressures up to 125 lb is bronze body

and stem, gray iron diaphragm base and spring chamber, and phosphorus bronze diaphragms. For pressures of 125 to 250 lb all parts are bronze.

Installation: Valves should be installed with spring chamber up, with flow in direction of arrow cast on body, and with outlet connected to suitable discharge. As to whether valve should be on cold- or hot-water side of boiler is optional.

Particular care should be taken to blow out pipes before connecting valve. The lodging of a particle of scale or pipe cutting will cause valve to seat improperly. This precaution saves many service calls.

Courtesy Mueller Co., Decatur, Ill.

Water-Pressure Relief Valves

Specifications. Water-pressure relief valves shall be of a design to relieve dangerous and excessive pressures of the water and shall be diaphragm-operated and of all bronze construction. The seat disk shall be easily removable and of non-corrosive, non-sticking steam-cured composition material and capable of withstanding extreme temperatures. Valves shall be installed with spring chamber up.

Mixing Valves

Automatic Thermostatic Mixing Valves. Automatic temperature control only; set for a fixed temperature to control hot-water line. Capacities 39 gpm to 300 gpm under pressure from 20–40 lb. Sizes 1, 1¼, 1½, and 2 in. (Fig. 6).

Automatic Power-Operated Control. Valve control, for instantaneous hot-water heaters, swimming-pool heaters, drinking-water systems, etc. Operated by compressed air or water at 15 lb pressure. Regulated by thermostatic bulb inserted in outlet line. Sizes ½, ¾, 1, 1¼, 1½, 2, 2½, 3, 4, 5, 6, 8, 10 in. (Fig. 7).

Equipped with three-way mixing valve. Capacities 30 to 2700 gpm at pressure from 20–40 lb. Sizes ¾, 1, 1¼, 1½, 2, 2½, 3, 4, 5, and 6 in. (Fig. 8).

Automatic Thermostatic Mixing Valve and Tank Regulator. For steam-heated hot-water heaters, tanks, etc. Sizes, ¼, ⅜, ½, ¾, 1, 1¼, 1½, 2, 2½, 3, 3½, 4, 5, 6 and 8 in. Valve controls the steam inlet. Thermostatic bulb inserted in the tank (Fig. 9).

Equipped with three-way mixing valve for tempering hot water. Three-way valve connects hot-water supply, cold-water supply, and tempered-water supply. Thermostatic bulb is inserted in tee on tempered water line. Sizes, ¼, ⅜, ½, ¾, 1, 1¼, 1½, 2, 2½, 3, 4 in. Capacities 5 to 12 gpm for pressures 20–40 lb. (Fig. 10)

Water Shock Absorbers

Types

- Air chamber, using air cushions.
- Diaphragm types.
- Bellows type.

Bellows Type. The device consists of a closed metal bellows or compression chamber which is filled with a special compressible emulsion. When any valve is opened in the water system, the bellows expand, owing to the decrease in pressure. When the valve is closed the bellows are compressed, allowing for the increase in pressure and additional shock.

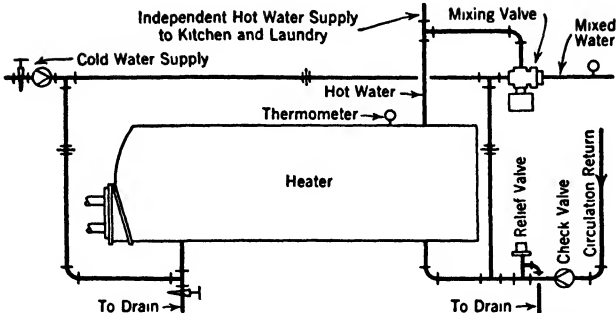


FIG. 6. Automatic Thermostatic Mixing Valve Mixing Hot Water from Storage Heater with Cold Water.

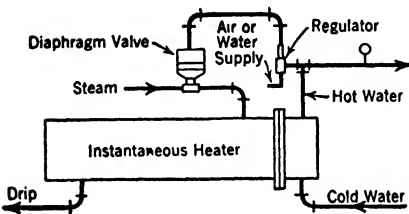


FIG. 7

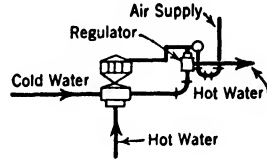


FIG. 8

Automatic Power-Operated Control

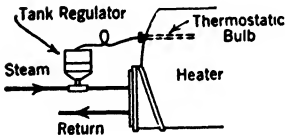


FIG. 9

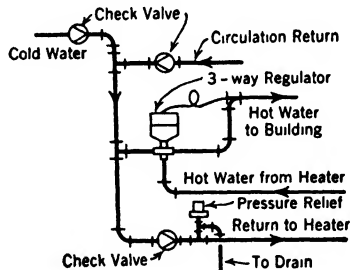


FIG. 10

Automatic Thermostatic Mixing Valve and Tank Regulator

ART. 4-D. CONTROL ACCESSORIES

Pressure and Vacuum Gages

Round dial-type indicating gages.

Standards. American Standard, ASA B40.1, ASME.

Definitions.

Pressure Gage. A gage designed to indicate, and having a scale graduated to show, pressures above atmospheric only.

Vacuum Gage. A gage designed to indicate, and having a scale graduated to show, pressures below atmospheric only.

Thermometers (ASA B44)

Rigid Bulb Dial Thermometers.

Remote Bulb Dial Thermometers.

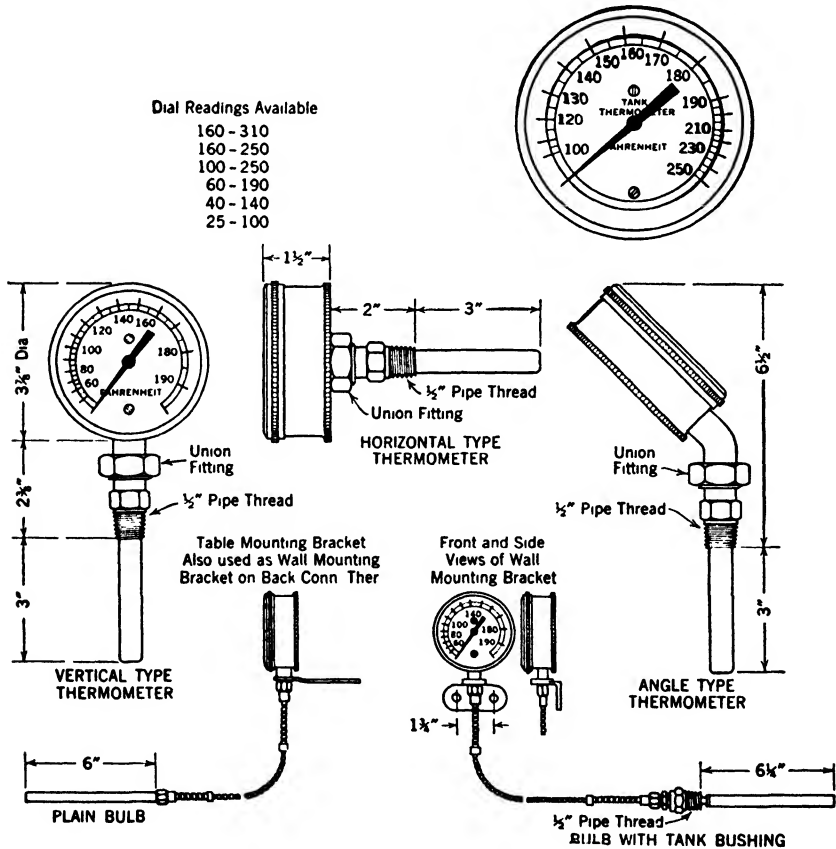


FIG. 11

CHAPTER 5

FIXTURES AND ACCESSORIES

The following articles contain information on the most common types of plumbing fixtures and general specifications for their use and installation.

ART. 5-A. DESIGN

Standards

Plumbing fixtures for shore purposes, Fed. Specs., WW-P-541.
Standardization of plumbing equipment, ASME, ASSE.

In addition, the manufacturers are guided by Federal "recommended simplified practices."

Definition

Plumbing fixtures are receptacles intended to receive and discharge water, liquid, or water-carried wastes into a drainage system with which they are connected (1).

Supply Requirements

Rate of Flow. A plumbing fixture is usually a vessel of some shape or other. Some fixtures, as sinks, tubs, and basins, are provided with a stopper to keep the water in the vessel for a certain period; others are left without stoppers or are built for flushing or through flow only.

The rate of flow desirable or necessary will, in the first instance, depend on the proper time to fill the vessel, and, in the second instance, for fixtures with flushing devices, upon the necessary velocity and quantity to perform the work and to clean the vessel. For fixtures with through flow, but without flushing devices, the rate of flow will in most cases be based on what might be called a "comfortable flow," as, e.g., in showers, rinsing sinks, etc.

The comfortable flow might be defined as a flow which will enter the vessel with a *quiet* velocity in a *non-splashing* stream and in *plentiful* volume to give the user satisfaction. For rinsing the hands under a faucet in a wash basin there is a certain volume of water which is satisfactory. Likewise, in a shower, there is a certain amount of water which gives the bather a feeling of being "showered." If these necessary volumes are discharged at a velocity not exceeding a certain rate, we have the quiet velocity combined with the plentiful volume. Where no other considera-

tion may determine the flow, the non-splashing stream is a desirable standard to use in determining it. For vessels with stoppers, there is also a time limit which could be set in each case. This time limit is based on a moderate idea of what constitutes a reasonable period of waiting before the vessel is filled. That this time can be combined with the factors mentioned above is perfectly feasible.

We can thus classify the fixtures under three headings: (a) fixtures operated for utility flow only and with through flow; (b) fixtures operated for convenient flow only and with through flow, and (c) fixtures operated for convenient flow only but not with through flow. The latter types (b and c) are really only one type, but used in two different ways; e.g., a lavatory belongs to type b if stopper is left open and hands rinsed under running faucet, but belongs to type c if stopper is used and hands washed in the bowl.

We shall therefore want to have the following information about fixtures: for type a the amount of gallons per minute needed for utility flow and the rate of discharge; for types b and c the gallons per minute needed for convenient flow, for filling, and the rate of discharge.

There are many and varied opinions as to what constitutes a proper rate of flow to fixtures, and no attempt is made here to conform to any particular authority. Neither will any distinction be made between various degrees of flow for any one fixture. Since the standards of rates of flow adopted for the fixtures are the predetermined factors from which the pipe sizes are calculated, such standards should be proper and adequate.

These same standards will be followed in this book for the determination of pipes and equipment.

Setting

Elbow Height. The normal height for an adult is 40 in., and it is an important dimension to keep in mind for all fixtures, in particular the ones used in connection with hand-washing. Forty inches to the elbow places the thumb about 43 in. above floor. The water starts running down the arms in disagreeable fashion when the wet hands are raised higher than elbow height in order to reach for soap or for a towel. For convenience all valves and faucets should be operated at a level not higher than 4 ft. On hospital fixtures where wing valves are used and where at times it is necessary to operate the valves with the elbows, this rule, of course, becomes even more important. Still it is just in such cases that the rule seems to be entirely overlooked.

Another offender is the paper-towel container, which for reasons unknown always is hung as far out of reach as possible.

Joints. A joint between a china fixture and a wall, floor, or other china fixtures or parts should be filled with a cement which does not expand. Under no circumstances should a cement with a plaster of paris (gyp-

TABLE 105

SUMMARY OF INFORMATION ON FIXTURES

FIXTURE		WATER				SUPPLY FIXT.			WASTE			REMARKS
TRAP SIZE	TYPE	Capacity of Fixt. with Stopper, cu ft	Max Hot Water Temp. °F	Average Mix. Temp. °F	Desired Minimum Pressure, lbs./sq. in.	Rate of Flow		Total Time of Flow in Seconds	Average Rate of Discharge cu ft per min.	Total time of Discharge Seconds	Disch. Velocity Feet per sec.	
						Gallons per min.	Cu ft per min.					
1	2	3	4	5	6	7	8	9	10	11	12	13
in.	Water Closet Blow-out Siphon-jet Wash down Tank				20	40	5 3	6-10	5-6	6-10	2	
					15	30	4 0					
					10	30	4 0					
					10	18	2 4					
3	Urinal Stall Siphon-jet Blow-out Tank				10	7	95					pr. Tank
					15	25	3 3					
					15	30	4 0					
	Service Sink				10	5	.67					
2-3	Showers 2 1/2 in 4 in 5 in. 6 in 8 in.			100 to 110	20	4	53	Contin-uous	.53	Contin-uous		
						5 1/2	.73					
						6 1/2	.87					
						7 1/2	.97					
					9	1 20		1 20				
2	Urinal—Wall hung				10	7	95					
	Bath Tub 5 ft 0 in	5 3	140	100 to 110	5	15	2	160	3 5	90	2	
	Sink	75			5	7	95	45	1 7	26		
1 1/2	Bath Tub 5 ft 0 in.	5 3	140	100 to 110	5	15	2	160	2	160	2.7	
	Sink	Contin. Flow		140		5	7	.95	Cont.	1 5	Cont.	
			.75	140		5	7	.95	45	1 5	30	2
	Laundry Tray	1	140		5	9	1 20	50	3	20	4	
	Combin. Sinks or Tray on One Trap	2	140		5	9	1 20	50	3	40 for two	4	
1 1/4	Lavatory 18 x 20 Lavatory 21 x 24	.13	140		5	5	67	12	1	8	1 9	
		23	140		5	9	1 20	12	1	14	1.9	

Column

- 1 Trap size.
- 2 Type of fixture.
- 3 Capacity of vessel (if used with a stopper) if filled for ordinary use (not necessarily to the overflow). cu ft.
- 4 Maximum hot-water temperature needed in supply pipe. Information to serve as a general guide.
- 5 Average mixing temperature—to determine maximum hot-water and cold-water requirements.
- 6 Desired minimum pressure of water at outlet to operate fixture properly.
- 7 Rate of flow necessary for proper action or service, expressed in gpm (combined hot and cold water).
- 8 Same as column 7, expressed in cubic feet per minute.
- 9 Total time of flow in seconds. Not important except to determine standards. Usually should be about the same as column 13. Time to flush a fixture or (for vessels) time to fill the fixture.
- 10 Average rate of discharge in cubic feet per minute. Corresponds to code "Fixture Unit."
- 11 Total time of discharge in seconds.
- 12 Discharge velocity in feet per second. Attempt to keep within limits of quiet action, yet sufficient to scour trap clean.

sum) base be used. Where portland cement is used the mixture should be one part gray portland cement and two parts fine sand. All joints should be raked and then pointed with a white portland cement.

A joint filler is no better than the setting and the adjoining materials. If there is any doubt that the setting is not absolutely stable, a portland cement joint cannot be depended on. More flexible joint fillers are litharge and glycerin or putty. It is desirable in all cases that the outer finish be as hard and impervious as possible.

ART. 5-B. SUPPLY FIXTURES

Faucets

Supply fixtures on all lavatories, slop sinks, showers, bathtubs, and sinks should be of the compression type.

This type has a metal seat, and the valve stem is provided with a removable composition washer which presses against the seat when the valve is closed. On all better types of faucets this washer is set so that it rotates in order to avoid a grinding effect against the metal seat.

Some faucets are made to close by the action of a spring, the valve stem pushing the composition seat against the spring. These valves have the advantage of closing with the current of water, and they produce no rotating effect on the disk.

Handles should be marked for hot or cold water, the hot water being placed to the left of the user and the cold water to the right. The handles should preferably be of metal. China faucets, no matter what the manufacturer may claim, are decidedly dangerous. They have caused permanent injury to the hands when they cracked.

Faucets should be adequate for the fixture which they serve.

The rules regarding cross-connections should be rigidly observed. All spouts should clear the rim level by a distance equal to twice the nominal size of the spout. Where "under-the-rim" supplies are necessary the supplies must be provided with vacuum breakers. For hand-washing fixtures the spout should also clear the edge sufficiently to enable the user to hold the hand under the spout. The clearance should be not less than 2 in. For certain other types of sinks, the following specification will state minimum clearance whether for washing purpose, filling of bottles, etc.

Regular-Type Lavatory Compression Faucets. They shall have arm or ball style indexed metal handles, shanks, and tailpieces. The minimum net weight of each faucet, including the tailpiece, shall be $1\frac{3}{8}$ lb.

Self-Closing-Type Lavatory Compression Faucets. They shall have arm or ball style indexed metal handles, shanks, and tailpieces. The mechanism of faucets shall operate easily, and shall close with or against a water pressure of 100 psi. Springs shall be phosphor-bronze and provided with means of adjustment for wear. Faucets shall operate on ball or roller bearings, and suitable methods shall be provided to prevent

handles from making complete turns. The minimum net weight of each faucet, including the tailpiece, shall be $1\frac{5}{8}$ lb.

Double-Type Compression Faucets (for lavatories with single faucet hole). Faucets shall have lever indexed handles, shanks, and tailpieces. The minimum net weight of each faucet, including the tailpiece, shall be $3\frac{5}{8}$ lb.

For lavatories with two faucet holes. Faucets shall have metal spouts, arm or ball style indexed metal handles, metal escutcheons on valves, and renewable valve seats. Minimum weight of faucet, including tailpieces, shall be 5 lb.

For lavatories with two faucet holes and pop-up waste. Faucets shall be combination supply and pop-up waste type with metal spouts, arm or ball style indexed metal handles on the valves and wastes, and metal escutcheons on the valves. Minimum weight of faucet, including tailpieces, shall be 7 lb.

Self-Closing Faucet (for public comfort stations). Three-eighths inch push-button type, self-closing lavatory faucet, operated by a flushing valve or metering device by which the stream can be adjusted to run a definite time up to at least 10 sec and then automatically shut off. The time of the closing movement is to be regulated from the exterior of the valve without shutting off the supply. Faucet shall be absolutely tamper-proof. Push button shall be of solid cast metal.

For recessed and corner tubs. Faucets shall be the concealed-type heavy pattern over-the-rim spout supply combination fittings with $\frac{1}{2}$ -in. valves connected to the spouts by brass pipes (iron-pipe size) and cast fittings, or by special castings. Bonnets shall be removable from the front for repairs or renewals. Faucets shall have ground joint unions for connections to $\frac{1}{2}$ -in. diameter hot- and cold-water supplies. The valves shall have arm or ball style indexed metal handles and metal escutcheons. Escutcheons shall cover all metal parts except the stems, and they shall be held in place by adjustable threaded nuts. The minimum net weight of each faucet, not including the escutcheons, shall be $6\frac{1}{2}$ lb.

For free-standing tubs. Faucets shall be combination type, provided with elevated spouts, arm, ball, or lever style indexed metal handles, and elbows with ground joint unions. Minimum weight of faucet, not including the elbows, shall be $3\frac{1}{2}$ lb.

For kitchen sinks. Faucets shall be combination type; swinging spouts; indexed metal lever handles; metal soap dish; renewable valve seats, and $\frac{1}{2}$ -in. iron-pipe-size flanged female inlet. Minimum net weight of faucet, not including soap dish, shall be 4 lb.

For service sinks. Faucets shall have extended spouts and indexed metal handle control valves. Minimum net weight of faucet shall be 4 lb. Hose ends shall be provided where flushing of floor or filling of tanks is required.

Shoulder-Type Sink Compression Faucets. They shall be $\frac{1}{2}$ or $\frac{3}{4}$ in.

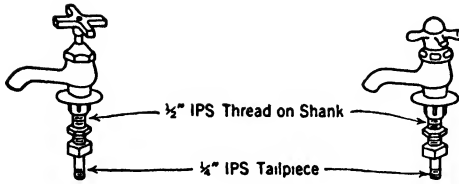


FIG. 12



FIG. 13

FIG. 12. Single Lavatory Faucet.
FIG. 13. Double Lavatory Faucet.

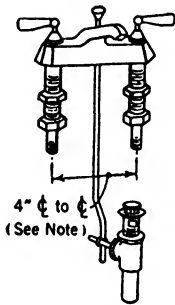


FIG. 14

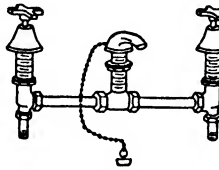


FIG. 15

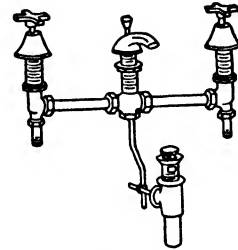


FIG. 16

FIG. 14. Double Lavatory Faucet and Drain Fitting. (Note: Body may be concealed if accessible for rewashing above slab. Tailpiece may be off-set.)

FIG. 15. Combination Lavatory Supply Fitting.
FIG. 16. Combination Lavatory Supply and Drain Fitting.

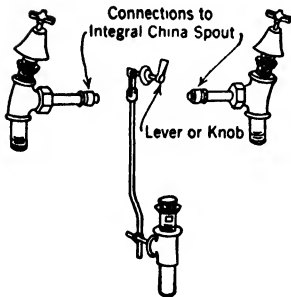


FIG. 17

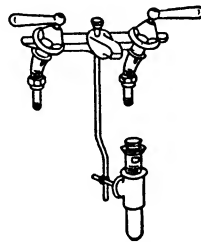


FIG. 18

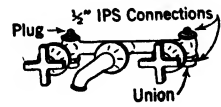


FIG. 19

FIG. 17. Combination Lavatory Supply and Drain Fitting.
FIG. 18. Combination Lavatory Supply and Drain Fitting. (For enameled shelf-back lavatories.)

FIG. 19. Bath Supply Fitting for Recessed and Corner Tubs.

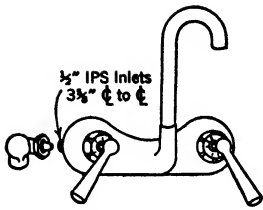


FIG. 20. Faucet for Free-Standing Tubs.

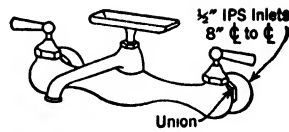


FIG. 21. Double Kitchen Sink Faucet.

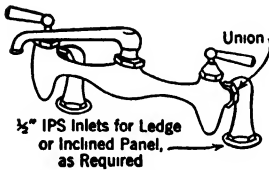


FIG. 22

FIG. 22. Double Kitchen Sink Faucet.

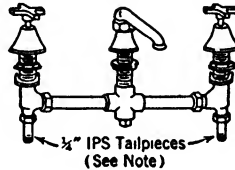


FIG. 23

FIG. 23. Combination Kitchen Sink Supply Fitting. (Note: Fitting may be above or below ledge and may be adapted to inclined panel. Inlets may be as shown or may be threaded internally 1/2 in. IPS.)

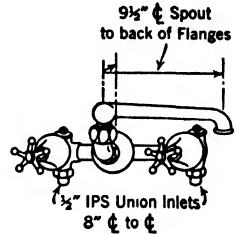


FIG. 24

FIG. 24. Scullery Sink Faucet.

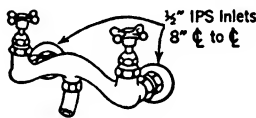


FIG. 25

FIG. 25. Service Sink Faucet. (Rough finish.)

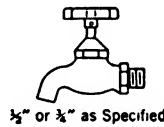


FIG. 26

FIG. 26. Single Faucet. (Shoulder type.)

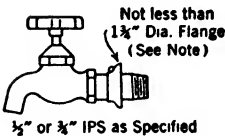


FIG. 27

FIG. 27. Single Faucet. (Shank and flange type.) (Note: Flange may have set screw or may be threaded to shank with concealed threads.)

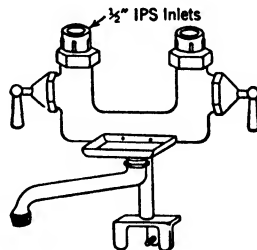


FIG. 28

FIG. 28. Double Laundry Tray Faucet. (Rough finish) (Soap dish shall be located approximately as shown and shall be fastened to faucet or bracket.)

as specified, with arm or ball style indexed metal handles, and standard male threads. Where hose threads are specified, they shall be for $\frac{3}{4}$ -in. diameter hose. Minimum net weight of each $\frac{1}{2}$ - and $\frac{3}{4}$ -in. faucet shall be $\frac{7}{8}$ and 1 lb, respectively.

Shank- and Flange-Type Sink Compression Faucets. They shall be $\frac{1}{2}$ or $\frac{3}{4}$ in., as specified, with arm or ball style indexed metal handles, shanks with adjustable flanges with set screws or with the flanges threaded on the shanks, and standard male thread. Where hose thread is specified, they shall be for $\frac{3}{4}$ -in. diameter hose. Minimum net weight of each $\frac{1}{2}$ - and $\frac{3}{4}$ -in. faucet, including flanges, shall be $1\frac{1}{16}$ and $1\frac{1}{4}$ lb, respectively.

Flushing Tanks

Ball cocks for flushing tanks shall be brass, automatic and float-operated; and shall close effectively against a water pressure of 100 psi. Top-supply pattern shall be provided for high tanks; bottom-supply pattern with fully elevated ball cocks, refill, and hush tube shall be provided for low tanks. All ball cocks shall be constructed to prevent backflow. Floats shall be of spun copper not less than 0.0108 in. thick, non-absorbent molded composition, or glass and shall have brass stems connected to the floats and cocks with set screws and screw threads. Cocks shall be constructed so that they can be taken apart readily for repairs. Pins or thumb screws forming bearings for levers shall be not less than $\frac{3}{16}$ in. in diameter. Supports for ball cocks and lever fulcrums on high tanks shall be secured with through bolts and nuts to lugs cast on the tanks; lead washers shall be provided between the tank lugs and supports. Connections to ball cocks shall be $\frac{3}{8}$ -in. pipe.

High-tank flushing trimmings shall consist of cast-brass gooseneck siphons with slotted guide sleeves and rubber washers. Siphons for urinal flush tanks shall be $1\frac{1}{8}$ in. in diameter; siphons for water-closet flush tanks shall be $1\frac{1}{2}$ in. in diameter. Siphons shall be secured properly to the operating levers and shall be balanced and guided properly to secure a straight lift and proper reseating. Lever post shall be provided with adjustable stud bolts or other fittings that shall limit the pull on the levers and prevent the guides on the gooseneck siphons from being pulled out of the sleeve. The flushing trimmings shall be operated by means of chains with hardwood pull handles. Handles shall have rods passing through them with ring nuts and bottom nuts sweated thereon. Chains shall be fastened to the operating levers and ring nuts by rings.

Low-tank flushing trimmings shall include rubber balls not less than 2 in. in diameter reinforced at top and center, stems, guides, and levers. Operation shall be quiet, and shall be controlled by lever handles set at the front of the tanks. Brass standpipes shall be tubing not less than 1 in. in diameter and not less than 0.045 in. thick. They shall be installed

properly for overflows. Each discharge shall be succeeded by an after-flush or refill that shall fill the fixture trap to its overflow weir.

Flushing Valves

Flushing valves, unless otherwise specified, shall conform to these requirements. They shall be operated by a single motion of a one-piece metal oscillating handle (push button is sometimes accepted on urinals). The valves shall be designed to cause no water hammer in the piping systems. After being set in operation, the valve shall complete the operation automatically, opening fully and closing positively under service pressures. The volume of water delivered and the rate of flow shall give a successful flush of the particular fixture on which it is installed and a refill of the fixture trap.

The discharge of water at each operation under any pressure between 10 and 100 lb shall be not more than 2 gal for stall urinals and 4 gal for pedestal urinals and water closets.

Where regulating devices are provided for the control of the volume or of the rate of flow, they shall be positive in their control and readily accessible for adjustment. All concealed metal parts shall be of corrosion-resisting metal that will withstand frequent operation without breakage or excessive wear. Each flushing valve shall be provided with a cut-off cock or valve which shall be an integral part of the flushing valve or connected immediately adjacent thereto. A metal union joint shall be provided between the flushing valve and the supply pipe. Threaded connections for supply pipes shall be not smaller than $\frac{1}{2}$ -in. nor larger than $\frac{3}{4}$ in. for stall urinals and not smaller than 1 in. nor larger than $1\frac{1}{4}$ in. for water closets and pedestal urinals. Flush pipes shall be not less than 1 in. in diameter for stall urinals and not less than $1\frac{1}{4}$ in. in diameter for water closets and pedestal urinals; they shall be tubing having a wall thickness of not less than 0.045 in. Cast wall escutcheons and cast flange for top supply. On public work the center of flush valve on water closets shall be 25 in. above the floor (for operation by elbow) and on pedestal urinals 45 in.

Exposed flushing valve, cast metal with solid metal oscillating handle; 1-in. capped angle stop; flush connection; cast metal wall escutcheon; spud coupling; nut and spud flange.

Concealed flush valve, rough cast metal plated, solid metal oscillating handle with wall extension and sleeve of length to suit installation, cast metal wall escutcheon, 1-in. capped angle or straight stop, elbow flush connection, cast metal wall escutcheon, spud coupling, nut and spud flange.

Supplies and Stops

Supplies (exposed) for lavatories, low flush tanks, and bathtubs shall be iron-pipe size to wall or floor, as specified, with compression stops and the necessary wall or floor plates.

Supply pipes shall be $\frac{3}{8}$ in. for lavatories and $\frac{1}{2}$ in. for bathtubs and low flush tanks.

Supply stops should be furnished for each and every fixture on both the hot- and cold-water lines.

They should be of the heavy compression type and provided with wheel or tee handle or loose key or screw-driver slots where conditions may warrant it. The stops may be straight or angle type as conditions require.

Where concealed stops become necessary they shall be of a type with seats removable from the front.

Compression stops shall be designed for 100-lb WP; shall be standard weight; and shall have full area openings; raised seats, composition disks and stuffing boxes. Angle pattern stops shall be used for wall connections and straightway stops to floor connections.

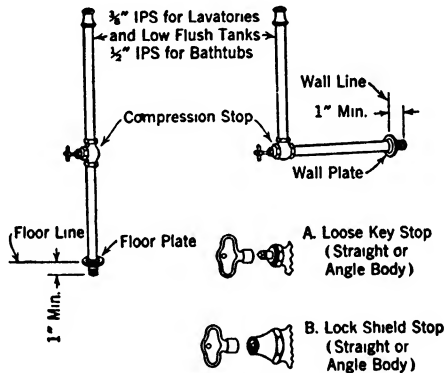


FIG. 29. Exposed Supplies to Floor and Wall. (For flush valve supplies, see illustration of fixture) (From Federal Specifications *WIV-P-541a.*)

ART. 5-C. WASTE CONNECTIONS

Plugs

Lavatory plugs shall be cast metal and shall have rod strainers, overflow openings, jam nuts, rubber gaskets, openings for $1\frac{1}{4}$ -in. diameter rubber stoppers, and $1\frac{1}{2}$ -in. tailpiece of tubing having a wall thickness of not less than 0.045 in.

Sink plugs shall be cast metal and shall have removable cast or stamped strainers, jam nuts, leather washers, couplings, and $1\frac{1}{2}$ -in. tailpiece of tubing having a wall thickness of not less than 0.045 in.

Tray plugs shall be cast metal and shall have rod strainers, ground openings for $1\frac{1}{4}$ -in. diameter metal stoppers, jam nuts, leather washers, couplings, and $1\frac{1}{2}$ -in. tailpiece of tubing having a wall thickness of not less than 0.045 in.

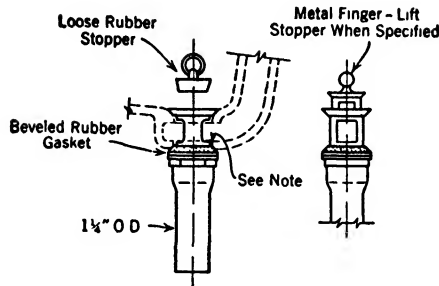


FIG. 30. Lavatory Drain Plug. (Rubber stopper unless metal stopper is specified.) (Note: When the waste plug is assembled to lavatory, the bottom edge of overflow opening in plug shall be below the bottom of overflow channel to prevent trapping of water.)

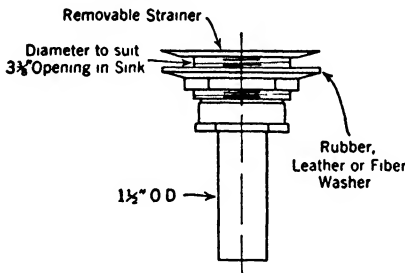


FIG. 31. Sink Drain Plug with Flat Strainer. (Minimum diameter of opening in sink, $3\frac{3}{8}$ in.)

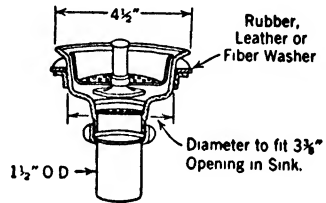


FIG. 32. Sink Drain Plug with Cup Strainer. (Minimum diameter of opening in sink, $3\frac{3}{8}$ in.)

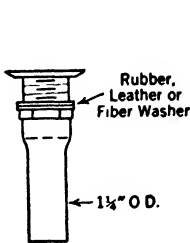


FIG. 33. Drinking Fountain Drain Plug.

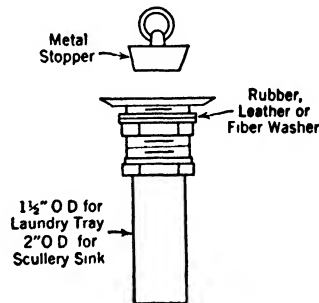


FIG. 34. Drain Plug for Laundry Tray and Scullery Sink.

Traps

Trap designs are many, but the most common in use are the New York Regulation P-trap or S-trap and the drum-type non-siphon trap. They are made of drawn metal but should be cast brass for public and institutional work.

They should be furnished with a cleanout plug.

The tailpiece on all traps is usually a 17-ga. tube.

P-traps shall be $1\frac{1}{2}$ in. in diameter, not less than 0.145 in. in wall thickness, and of cast metal with cast cleanout plugs. Traps shall have slip joints with nuts and rubber washers at inlets for connection to the plugs and with $\frac{1}{2}$ -in. standard pipe taps at outlets. The minimum water seal shall be 2 in.

Non-siphoning traps shall have cast bodies, not less than 0.145 in. in wall thickness, and cast cleanout plugs. Traps shall have slip joints with heavy nuts and rubber washers at inlets for connection to the plugs and with $\frac{1}{2}$ -in. standard pipe taps or union connections at outlets.

Wastes for lavatories, wash sinks, kitchen sinks, and laundry trays shall consist of connections to wall or floor, as specified, together with traps and the necessary wall or floor plates. Where connections are without bends, they shall be iron-pipe size pipe; otherwise they shall be tubing having a wall thickness of not less than 0.145 in. (Practically all traps can be obtained in such shapes that wall or floor connections can be iron-pipe size pipe.) Fittings shall be cast metal.

Wastes to floors shall be provided with non-siphoning traps, wastes to wall shall be provided with P-traps, except that continuous waste shall have non-siphoning traps.

Wastes for bathtubs, unless otherwise specified, shall be concealed for recessed and corner tubs and exposed for free-standing tubs. They shall consist of connected waste and overflow fixture of $1\frac{1}{2}$ -in. tubing having a wall thickness of not less than 0.045 in. and cast fittings with strainers on the waste, and strainers and chain stays on the overflow. Stoppers shall be $1\frac{1}{2}$ in. in diameter and of rubber and shall be supplied with chains. The waste tees on concealed wastes shall have standard male threads on the outside for $1\frac{1}{2}$ -in. pipe, and tees shall be reversible so that the outlets may be set parallel to the waste arms. The necessary floor plates shall be provided.

Pop-up type waste shall have lift rod operating through the overflow and all-metal operating handle. For public work the outlet shall have cast-metal bee-hive strainer. Pop-up waste may be constructed so that no access panel is required to gain access for repairs.

Traps for bathtubs shall be special cast-metal non-siphoning bath trap. (On institutional work it is preferable to fit the installation for the use of a P-trap.)

Traps for showers are listed in Art. 5-K.

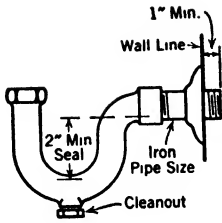


FIG. 35. Waste with P-Trap.

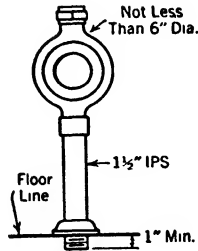


FIG. 36. Waste to Floor with Non-siphoning Trap.

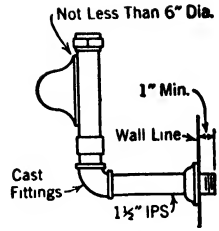


FIG. 37. Waste to Wall with Non-siphoning Trap.

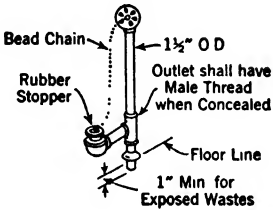


FIG. 38. Bathtub Waste with Rubber Stopper.

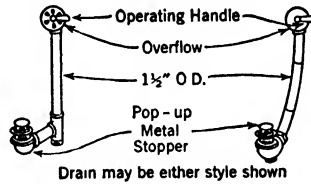


FIG. 39. Bathtub Waste with Pop-up Metal Stopper.

From Federal Specifications WW-P-541a

ART. 5-D. OTHER TRIMMINGS AND FINISHES

Trimmings

Chains. Chains for securing stoppers to chain stays and faucets and for high-tank operation shall be $\frac{3}{16}$ -in. bead type with $\frac{1}{8}$ -in. rings, soldered, at each end.

Lavatory-chain stays shall be provided with chains and $\frac{1}{4}$ -in. diameter rubber stopper to fit the lavatory plugs.

Soap dishes with chain stays for lavatories shall be provided with chains and $\frac{1}{4}$ -in. diameter rubber stoppers to fit the lavatory plugs.

Wall and Floor Plates. Wall and floor plates or escutcheons on tubing shall be stamped metal having a thickness not less than 0.045 in. and shall have integral clips for securing the plates to the pipes.

Wall and floor plates on iron-pipe pipes shall be cast or forged and shall have round-head set screws.

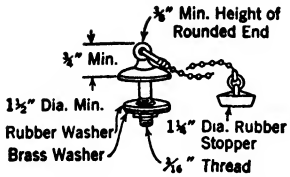


FIG. 40. Chain Stay for Lavatories.

From Federal Specifications WW-P-541a

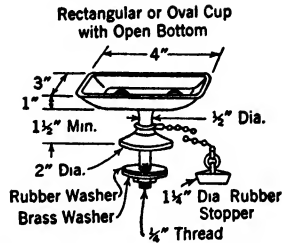


FIG. 41. Soap Dish with Chain Stay for Lavatories.

Finishes

General Considerations. In specifying finishes do not overlook all handles, push buttons, strainers, overflows, and strainer parts. These parts are either touched more than any other parts or rubbed. Finishes at these points will wear out more quickly than anywhere else. In public or institutional work these parts are often specified to be solid white metal.

Valve stems wear off the plating faster than any other part, and often become very unsightly.

Metal finishes on plumbing fixtures vary according to type of installation, the wear they will get, and to some degree on the current vogue.

For plain work polished brass is as good as anything. Where exposed to weather or acids a rough brass will look better in the long run. For laboratory work a rough nickel plating or rough chromium plating has been found very satisfactory.

In institutional work and public buildings, where solid brass is not used, a solid white metal is often substituted. This is a difficult metal to keep polished but at least offers the advantage that it can be polished forever.

Generally most fixtures are plated with nickel or chromium. Chromium being the harder has a longer life. Its disadvantages are an unpleasant sheen and vulnerability to certain cleansing powders. It needs no cleansing powder if polished regularly with plain soap.

All plating should be done in accordance with standards provided by the U.S. Bureau of Standards.

Specifications. The following shall be brass nickel plated except where brass unplated, bronze unplated, white metal unplated, white metal chromium plated, brass chromium plated, bronze nickel plated, or bronze chromium plated is specified:

- Exposed fixture supplies, including compression stops.
- Exposed wastes and traps.

Exposed parts of flush pipes, braces, and connections between tanks and fixtures.

Flushing chains and their fastenings.

Exposed parts of shower fixtures, including supply columns, valves, shower columns, shower heads, mixing valves; and supports and curtain frames, hooks, grommets, and hold-backs.

Exposed parts of flushing valves.

Urinal spreaders and strainers.

Strainers and strainer bars for lavatories, sinks, and laundry trays.

Rim guards and cleanout plugs for service sinks.

Flanges and strainers for shower, urinal, and floor drains.

Exposed metal parts of seat hinges.

Knee pieces and exposed brackets for lavatories and sinks.

Angle supports for flush tank.

Floor and wall escutcheons and plates.

Flanged covers for cleanout plugs in walls.

Faucet and bath nozzles.

Plugs and stoppers.

Soap dishes for bathtub and soap cups.

Tumbler holders and tumbler and toothbrush holders.

Chain stays, soap dishes and chain stays, and chains.

Toilet-paper holders.

Brackets for towel racks and for shelves.

Clothes hooks.

Exposed heads of bolts for supports and for fastenings of fixtures and accessories.

ART. 5-E. FLUSHING-TYPE FIXTURES

Water Closets

Definitions.

Blow-out-type water closets have the simplest type of trap and the smoothest discharge outlet. They are used a great deal in public and industrial toilets where misuses of the facilities are most likely. They are emptied solely by a strong discharge of water at a rate of about 36 gpm, and at a pressure of 15 to 25 lb. For this reason it is impractical to use a bowl of this type in connection with tanks; they are always equipped with flushing valves. The blow-out bowl is relatively inexpensive, easy to maintain but noisy in operation.

Siphon-Jet Water Closets operate by creating a siphon action in the trap. A jet at the bottom of the trap furnishes the initial push. It requires a flow of about 30 gpm with a pressure of about 10 lb. It is the most ex-

pensive type of bowl but the smoothest one in action. It is used on all high-grade installations and particularly in hospitals because of its quiet action.

Wash-down water closets function by filling the bowl to a sufficient level so that great enough head is formed to flush it. As the flushing action begins the rear column of the trap acts as a siphon and empties the bowl. The action is fairly easy and at times not sufficient. The pressure in the water main has no influence on the flushing action, except in so far as it fills the bowls faster or slower. It is the least expensive bowl and used mainly in residential work.

Reverse trap bowl is of the wash-down type with the trap reversed.

*Design.**Rate of Flow in Water Closets.**

"The most certain and efficient cleansing of the water closet bowl occurs when there is a strong siphon action in the first two or three seconds, followed by a period of weak or broken siphon action, during which the bowl is practically empty, and this in turn followed by a second siphon action. . . . It is impossible to fix a definite value for either the rate of supply or the total quantity of water required which will give the best results for all water closets. These will vary with different bowls and conditions. . . . For wash-down closets . . . a strong efficient flush was obtained when the mean rate of discharge and approximately the mean rate of supply was between 27 and 33 gpm. For siphon-jet closets the range is between 24 and 36 gpm. This gives a mean value of approximately 30 gpm as a rate of supply that, in general, will prove satisfactory for either type of closet bowl. The quantity of water required depends on the duration of the flush. The time varies from 6 to 10 sec. It is recommended to have a range of from 3 to 5 gal as the necessary quantity to flush a closet. Greater quantity than 5 gal and a mean rate greater than 36 gpm constitute an unnecessary waste of water."

Siphonproof Design. The water-closet bowls should be made of a

* *Recommended Minimum Requirements for Plumbing*, U. S. Department of Commerce, Elimination of Waste Series, Bureau of Standards, BH 13, Superintendent of Documents, Washington, D. C.

siphonproof design or the inlet connection should be provided with a vacuum breaker. Most authorities insist on a design having no moving parts in it and one which will meet this test:

Closet bowls must be thoroughly and positively flushed, and while the water is running the jet hole in the bowl shall be closed and there must be no leakage from the air vents in the breaker.

Vacuum breakers must be interchangeable in that the same type of breaker can be used on all closet bowls.

The vacuum breaker should be placed between the flush valve and the closet bowl.

Bowl Specifications.

All types. Material: vitreous chinaware. Design: integral flushing rim, top inlet (preferably), supply for 1½-in. (for flushing valves) or 2-in. (for tanks) spud connections; pedestal base with trap molded in the ware. Round or elongated fronts. Wall thickness not less than ½ in. Base not less than ¼ in. thick, recessed not less than ½ in. for the outlet flange; bolt holes. Bowl must be siphonproof or equipped with vacuum breakers. Action in bowl shall be practically instantaneous; water shall recede at practically the instant the flushing device is operated, and in no case shall water in the bowl be increased materially. Bolt caps, nickel plated brass, white metal, or china.

Blow-out type. Provided with jet. For public comfort stations, unheated in winter, provide drain plug on side to drain trap and jet. Trap to pass a 2⅝-in. solid ball.

Siphon-jet type. Provided with siphon jet. Bowl shall flush and refill with not more than 4 gal of water. Weight of bowl not less than 46 lb. Water surface not less than 10 by 12 in. and not more than 5 in. from top of rim on the bowl. Water seal, 3 in. Trap shall pass a solid ball 2⅝ in. in diameter.

Wash-down type. Bowl shall flush and refill with not more than 3½ gal of water. Weight of bowl not less than 34 lb. Water surface not less than 7 by 8 in. Water seal not less than 2½ in. Trap shall pass a solid ball 1½ in. in diameter.

Wall-hanging blow-out type, wall base. Bowl shall be provided with jet. Weight of bowl not less than 42 lb. Water surface approximately 90 sq in. Water seal 2½ in. Trap shall pass a solid ball 1½ in. in diameter. Top or back inlet, concealed rear outlet.

Wall-hanging siphon-jet type is similar to the blow-out type. Provided with siphon jet.

Prison type. Blow-out type with integral seat, oval bowl, wall base, concealed rear spud inlet, concealed outlet.

Spud connections for low-tank outfits shall be 2 in. in diameter and for high tanks and flushing-valve outfits shall be 1½ in.

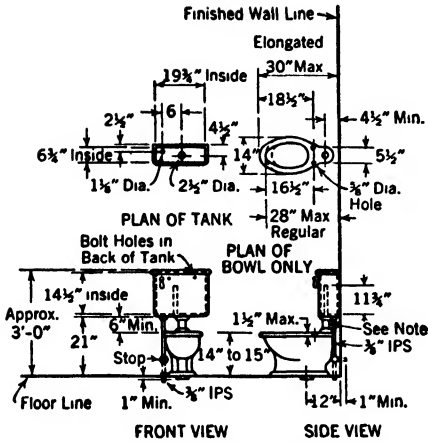


FIG. 42. Siphon-Jet Water Closet with Low Tank Supply and Floor Outlet. (Note: Flush pipe, 2 in. O.D., straight, or offset not over 1 1/2 in. Washer joint at tank.)

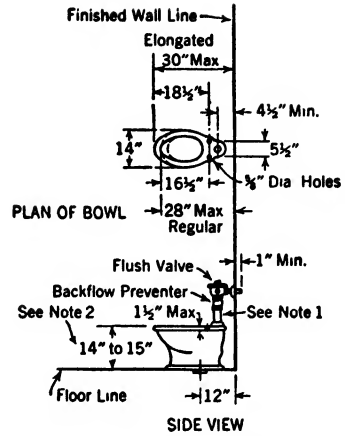


FIG. 43. Siphon-Jet Water Closet with Flush Valve Supply and Floor Outlet. (Note 1: Flush pipe, 1 1/2 in. O.D., straight, or offset not over 1 1/2 in. Note 2: Height of juvenile bowl, 13 in.)

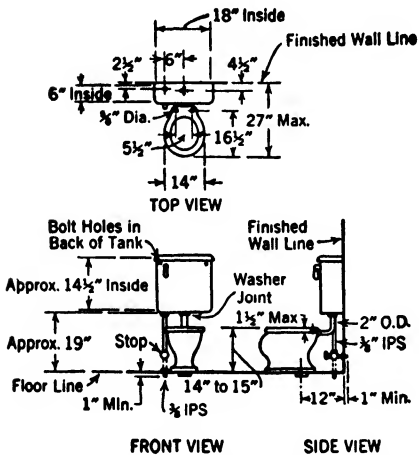


FIG. 44. Wash-Down Water Closet with Tank. (Fixture may be as shown, may be with concealed flush connection, or may be close-coupled.)

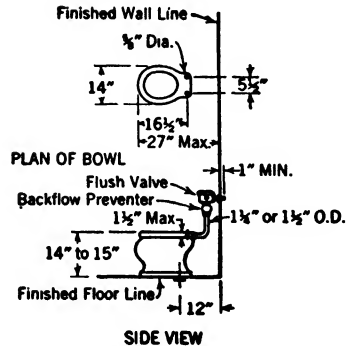


FIG. 45. Wash-Down Water Closet with Flush Valve.

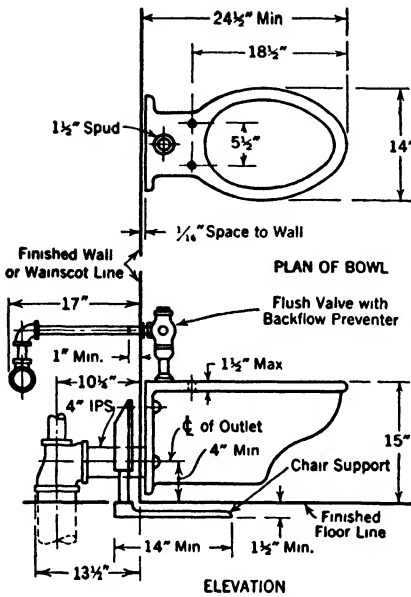


FIG. 46. Siphon-Jet Wall-Hanging Water Closet.

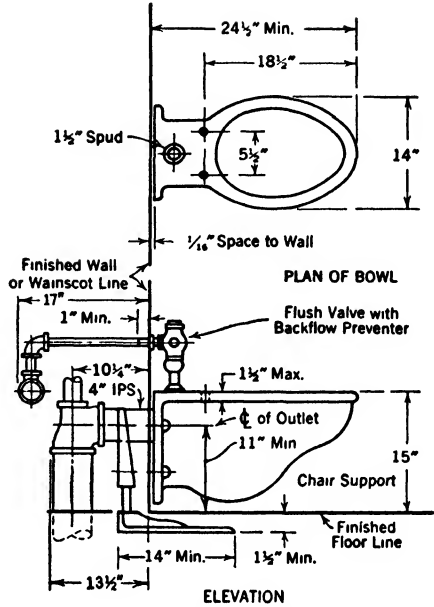


FIG. 47. Blow-Out Wall-Hanging Water Closet.

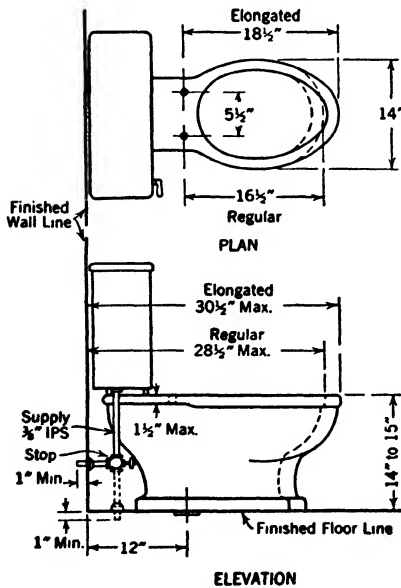


FIG. 48. Siphon-Jet Close-Coupled Combination Water Closet.

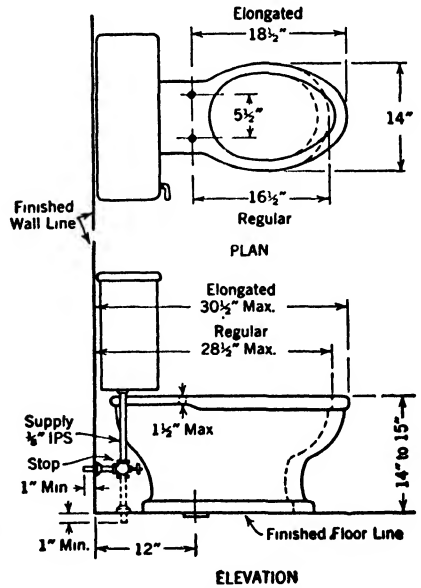


FIG. 49. Reverse-Trap Close-Coupled Combination Water Closet.

From Federal Specifications WW-P-541a

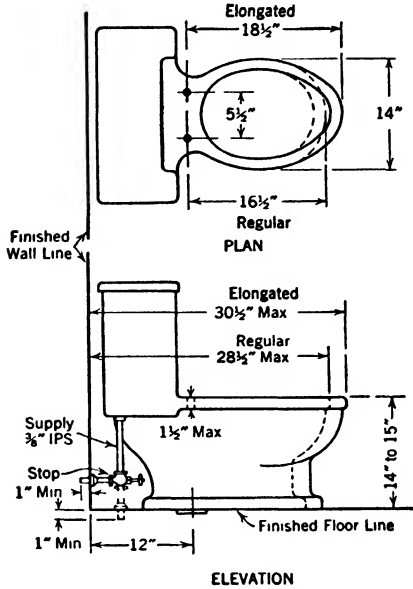


FIG. 50. Reverse-Trap Integral Water Closet and Tank Combination.
 From Federal Specifications WW-P-541a

Tanks.

Low tanks shall be of vitreous china, supplied with covers and flushing trimmings. Capacity not less than 1 cu ft. Each tank shall be provided with holes through back at the top for two bolts.

High tanks shall be of vitreous china and shall be supplied with flushing trimmings. Capacity not less than 3/4 cu ft. Each tank shall be provided with holes through the back at the top for two bolts, and at the bottom with two cast angles 2 by 2 by 1/4 in. and 1 1/4 in. wide.

Flushing pipes shall be tubing having a wall thickness of not less than 0.045 in. No pipe threads shall remain exposed. Flush pipes for high tanks shall be provided with cast wall braces for bolting them to the walls. If seats with covers are specified, the wall braces shall be provided with rubber seat bumpers. Bowl and tank spuds at flush pipes shall be cast and shall be concealed with cast escutcheons.

Supplies. Compression stops with connections for the ball cocks for high-tank outfits, supplies to wall or floor including compression stops for low-tank outfits, and supplies to wall to cut-off cocks on flushing-valve outfits shall be furnished, together with the necessary wall or floor plates.

Setting.

Pedestal type. Cast-iron or cast-brass floor flange with molded asbestos

graphite saturated gasket ring or flexible rubber gasket. Nickel-plated bolts.

Wall-hanging type. Connection and support shall be cast-iron or cast-brass wall flange with molded asbestos graphite saturated gasket ring; tamperproof nickel-plated carrier bolts and nuts.

Bowl shall be supported on a cast-iron combination carrier and stack support or cast-iron carrier.

All water closets should be placed on an impervious floor.

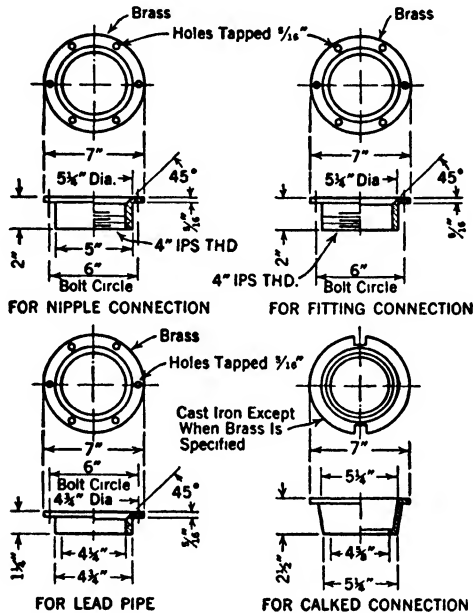


FIG. 51. Floor Flanges for Drain Connection.

From Federal Specifications WW-P-541a

Seat Specifications.

Composition seats and covers shall have hollow cores with shells of a good grade of hard rubber, or have solid cores with coverings of a good grade of hard rubber. The shell or covering shall be of the following minimum thickness, depending upon the core used: hollow core, hard shell $\frac{3}{16}$ in. thick, of which $\frac{1}{16}$ in. shall be hard rubber covering; and solid core, core of rubber composition or laminated wood with hard rubber cover $\frac{1}{16}$ in. thick, or core of other than rubber composition or laminated wood with hard rubber covering $\frac{3}{16}$ in. thick. Seats and covers shall be acidproof, impervious, well-polished, and without joints, openings, and crevices. Color shall be ebony unless mahogany is specified. Seats and covers shall not split or crack.

Hinges shall be attached to seat by concealed metal inserts. Hinge posts shall be provided with four rubber and two metal washers. Studs shall be not less than 2 in. in length below the flange post. The studs shall be threaded to within 1 in. of the flange. Nuts shall be not more than 1 in. in diameter. Hinges shall be covered with hard elongated rubber bumpers attached to the underside to give the seat a minimum of $\frac{3}{8}$ in. above the bowl. Suitable stops shall be provided on the hinges to prevent the seat's striking walls. Seats shall bear the name or the trademark of the manufacturer applied in a permanent manner.

Wood seats and covers shall be plain round staple pattern. Wood shall be high-grade, thoroughly seasoned hardwood free from knots, checks, wormholes, and other injurious defects. Seats shall be reinforced with steel or wood, the minimum total length of doweling shall be $\frac{1}{4}$ in., and for spiral wood dowels $\frac{3}{8}$ in. Hinges shall be of the bar-hinge type construction and shall weigh not less than 14 oz for a seat and cover and 12 oz for a seat. All wood screws for hinges shall be brass and not less than $\frac{3}{8}$ in. in length.

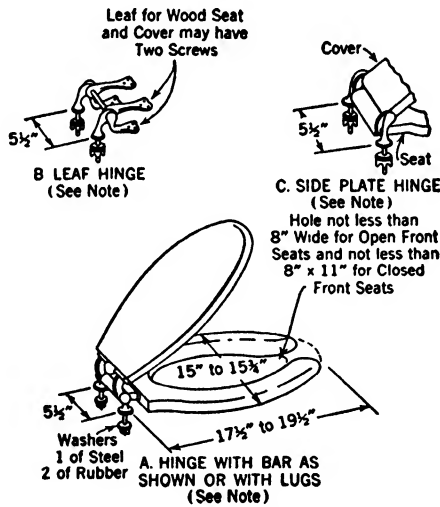


FIG. 52. Seat for Elongated Bowl. (Note: Hinge with lugs or bar approximately as shown at *A* for regular-weight composition seats; leaf hinge approximately as shown at *B* for lightweight composition seat and for square-back wood seat; side plate hinge approximately as shown at *C* for extended-back wood seat.) (From Federal Specifications *WW-P-541a*.)

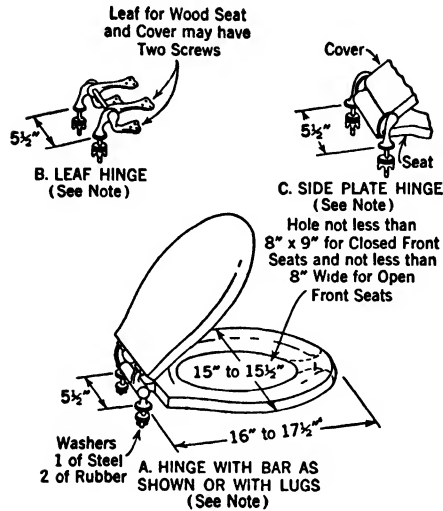


FIG. 53. Seat for Regular Bowl. (Note: Hinge with lugs or bar approximately as shown at *A* for regular-weight composition seat; leaf hinge approximately as shown at *B* for lightweight composition seat and for square-back wood seat; side plate hinge approximately as shown at *C* for extended-back wood seat.) (From *Federal Specifications WW-P-541a.*)

Urinals

Definitions.

There are three generally accepted types of urinals:

The wall-hanging urinal.

The stall urinal.

The pedestal urinal.

Built-up types of stone slabs or trough types are cheaper in first cost and may be acceptable for temporary work, but should not be used for permanent work.

Stall Urinal.

Stall, one-piece vitreous chinaware with integral flushing rim or metal spreader. Approximate size, 18 in. wide, with straight sides or wings; drip receptor to extend at least 5 in. from front face of side of stall; ground back; top drilled for 3/4-in. top inlet; 3-in. outlet with raised removable solid china cover fastened with brass bolts to outlet strainer.

Urinals set in batteries shall be matched and provided with straight-type continuous china covers to space urinals 23 in. (or according to manufacturers' standards) on centers, and covering the front and the top.

(Special china strainers are available for insertion of germicidal compound.)

Outlet connection shall be cast brass for 2-in. IPS calking, and connections between urinals and traps shall be a 2-in. cast-iron pipe calked with lead and oakum. Trap shall be a 3-in. cast-iron soil-pipe P-trap, for 3-in. cast-iron pipe, asbestos graphite saturated gasket ring, nickel-plated bolts, nuts and washers, or hub urinal connection with two

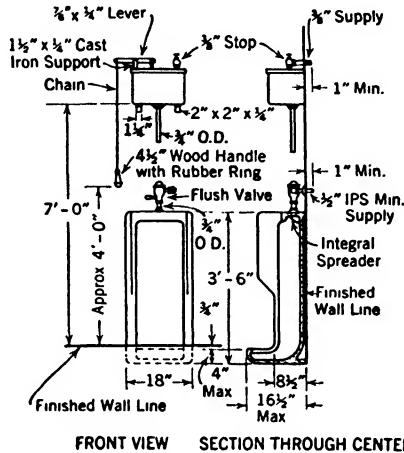


FIG. 54. Stall Urinal with High Tank or Flush Valve.

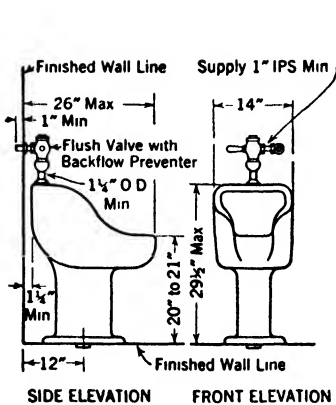


FIG. 55. Pedestal Urinal.

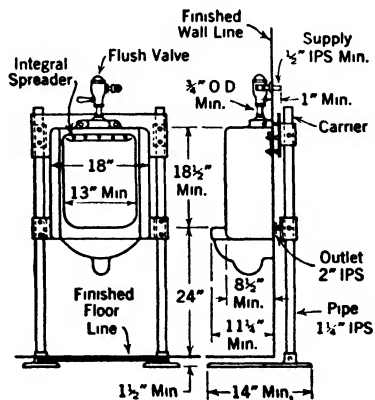
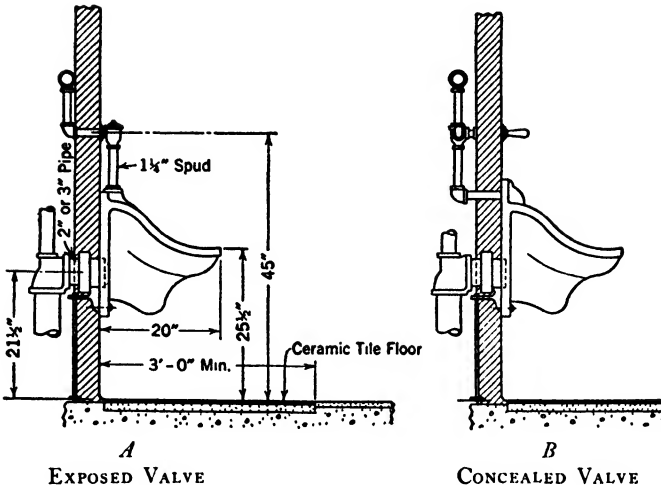


FIG. 56. Wall-Hanging Wash-Down Urinal.

From Federal Specifications WW-P-541a



EXPOSED VALVE

CONCEALED VALVE

FIG. 57. Wall-Hanging Blow-Out Urinal.

eccentric calking rings, one for holding lead pan and one threaded to receive strainer connection.

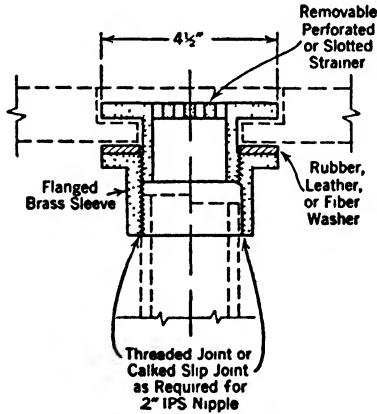


FIG. 58. Stall Urinal Drain Plug. (Waste strainer.) (From Federal Specifications WW-P-541a.)

Supply fixture shall be an integral flushing rim or cast-metal adjustable spreader of the fan type, designed to flush the stall thoroughly without spraying the floor. Metal spreader shall be finished.

Inlet connection shall be 3/4-in. IPS brass nipple, elbow and nipple to wall for concealed supply and cast-metal wall escutcheons and china escutcheons to urinal.

Lead Pan of sheet lead in 4-in. recess in floor.

Setting. Urinal shall be set with top of lip flush with floor (general contractor to provide 4½- or 5-in. depression). After lead pan is installed, urinal shall be set in a plastic compound to take up expansion, or the sides and base shall be covered with asphaltum paper at least ⅜ in. thick which shall be extended above floor level. The urinal shall be set in a bed of sand and have a space at least 1 in. at the sides and base. After urinals are set and before finished floor is laid, the asphaltum paper should be trimmed ⅛ in. below finished floor level. All joints shall be raked and pointed with white china cement.

Floor in front of urinal shall be of impervious material.

Tanks of vitreous china, provided with flushing trimmings. Capacity not less than given in Table 106. Each tank shall be provided with holes through the back at the top for two bolts and at the bottom with two cast angles. In public work, where possible, tanks shall be placed in a space inaccessible to the public.

TABLE 106
TANK SIZES

Number of Urinals on Tank	Tank Capacity, cu ft	Vertical Supply Pipe	Manifold
1	⅜	¾ in.	
2	¾	1 in.	1 in.
3	1⅛	1¼ in.	1 in.

Flush pipes shall be tubing having a wall thickness of not less than 0.045 in. No threads shall remain exposed.

Compression stops with connections to the ball cocks for tank outfits and supplies to the wall from the cut-off cocks for flushing-valve outfits shall be furnished, together with the necessary wall or floor plates.

Pedestal Urinal

Bowl of vitreous chinaware with integral flushing rim, siphon jet, top inlet, and pedestal base with trap molded in the ware. The action of urinal shall be practically instantaneous, and the water shall recede at practically the instant the flushing device is operated. In no case shall water in the bowl be increased materially. Bowl shall flush and refill properly with not more than 4 gal of water. The depth of the water seal shall be not less than 2 in. and the siphon trap way shall pass a solid ball not less than 1½ in. in diameter. China bolt caps.

Setting. Cast-iron or cast-brass floor flanges with asbestos gasket ring; nickel-plated bolts. Urinal shall be set on an impervious floor.

Wall-hanging Urinals

Vitreous chinaware, wall-hanging, blow-out, or siphon-jet type with integral trap to pass a 2 $\frac{1}{8}$ -in. solid ball; blow-out or siphon-jet; integral flushing rim; extended front lip; concealed back supply for 1 $\frac{1}{4}$ -in. spud connection; wall outlet to fit 3-in. or 2-in. pipe.

Outlet connection shall be cast-iron or cast-brass flange with concealed support to floor, and made to screw to a 3-in. or 2-in. IPS nipple; molded asbestos graphite saturated gasket ring; N.P. bolts, nuts, and washers.

ART. 5-F. WASHING FIXTURES

Lavatories

Design.

The lavatory is made in many and varied designs. It is the most commonly used fixture and subject more than any other to changes in style. It is also adaptable to more different uses. For this reason its hook-up and setting vary to a great extent.

The most common types are the 18- by 20-in. and 21- by 24-in. sizes. They may have a back and be set against a wall or have no back and be set 1 $\frac{1}{2}$ to 2 in. from the wall. They can be provided with depressions for soap dishes or toilet articles, surgical instruments, manicure instruments, etc. The slab and back may be drilled for various combinations, as single faucets and combination faucets of all sorts. The bowl is drilled for an 1 $\frac{1}{4}$ -in. outlet.

The capacity of the 18- by 20-in. bowl is about 0.13 cu ft; and the 21- by 24-in. bowl 0.23 cu ft.

Outlet connections may be open strainer, which is much to be preferred, or perforated strainer, with 17-ga tailpiece.

The trap should be 1 $\frac{1}{4}$ in., designed for a discharge rate of 1 cfm, which will empty the small bowl in 8 sec and the larger in 14 sec.

Supplies are usually $\frac{3}{8}$ in., on some installations $\frac{1}{2}$ in. IPS. They have angle stops and IPS nipple to the wall or straight stops with connections to the floor.

Supply fixture may be one of a multitude of designs, depending on the use of the basin. Convenient (non-splashing) flow velocity is 2.5 fps. Should fill basin in 10 to 12 sec (for small basin 5 to 6 gpm, for large basin 9 to 10 gpm), which requires a $\frac{3}{4}$ -in. pipe or spout of equal cross-sectional area (about 0.55 sq in.).

Setting. The setting of lavatories depends again on their use. For wall-hanging bowls they should be provided with concealed wall hanger. The usual height from floor to top of rim is 31 in. for domestic work. For work basins, doctors' lavatories, a height of 36 in. is preferable. In school work the setting depends on the age of the children; 26 in. for kindergarten and varying in height for intermediate grades up to 31 in. for high school.

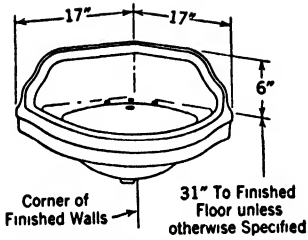


FIG. 59. Corner Lavatory.

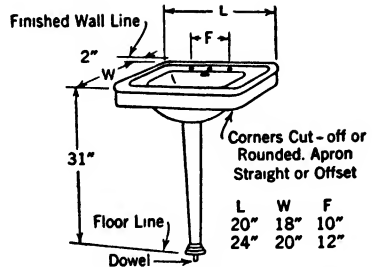


FIG. 60. Regular Lavatory without Back and with Leg.

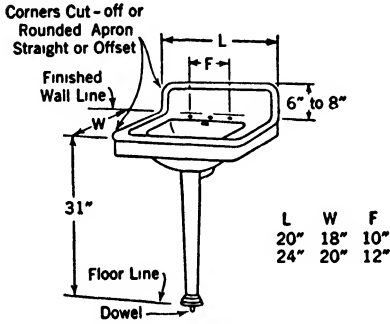


FIG. 61. Regular Lavatory with Back and with Leg.

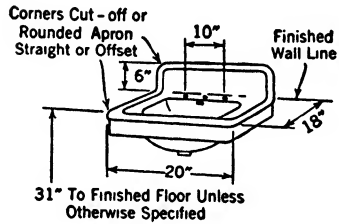


FIG. 62. Lavatory with Back.

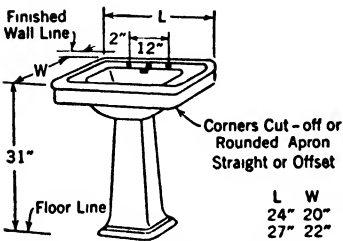


FIG. 63. Pedestal Lavatory.

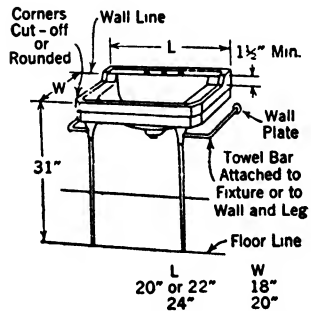


FIG. 64. Vitreous Lavatories with Low Shelf Back.

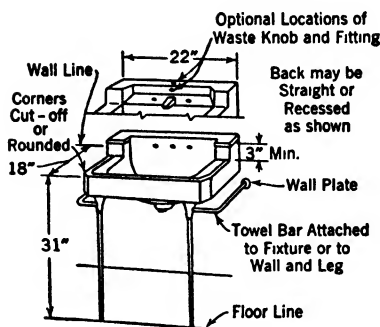


FIG. 65. Vitreous Lavatory with High Shelf Back. (Note: Spout may be an integral china part or of metal, and may be on angular panel or on back.)

From Federal Specifications WW-P-541a

Vitreous-China Lavatories

Bowl Specifications.

All types. Material, vitreous chinaware, one piece, with oval or rectangular bowl, apron, open or hooded integral overflow (and front anti-splash rims, if desired). Rims shall be roll or flat; apron and backs shall be flush or may have roll or flat rims. Overflow shall have cross-sectional area not less than $1\frac{1}{8}$ sq in. at every point. Slabs and backs shall be drilled to fit faucets and waste trimmings specified or have metal or china faucet hole covers for holes not needed. Slab shall be provided with depressed soap dish.

Corner lavatories. Bowl shall be approximately 11 by $14\frac{1}{2}$ in. (Fig. 59).

Regular 18- by 20-in. lavatory. Bowl shall be approximately 11 by 14 in. (Figs. 60-62).

Regular 20- by 24-in. lavatory. Bowl shall be approximately 12 by 15 in. (Figs. 60-62).

Pedestal lavatory. Bowl shall be approximately 13 by 17 in. (Fig. 63).

Small (space-saver) lavatory, approximately 25 by 14 in., with 5-in. integral back. Bowl approximately $15\frac{1}{2}$ by 10 in.

Prison-type lavatories. Size approximately 14 by 13 in. with 5-in. back, integral combination spout and drinking nozzle, integral soap dish, slow-draining integral china strainer, integral overflow. Back drilled for two openings for hot and cold water, one bolt support, and $1\frac{1}{2}$ -in. spud connection for waste.

Supports.

Corner lavatories shall have not less than two concealed hangers of suitable design or three suitable cast-metal brackets.

Regular lavatories with legs shall have leg supports and cast-metal knee pieces.

Regular lavatories in batteries shall have cast-iron standard or other approved standard or concealed wall supports.

Knee pieces shall be not less than $1\frac{1}{2}$ by $\frac{3}{16}$ in. thick.

Legs shall be vitreous chinaware and shall be provided with dowels to set into floor.

Prison-type lavatory bowl shall be fastened with one $\frac{3}{8}$ -in. bolt firmly secured in the back of lavatory and long enough to pass through wall (either $\frac{3}{16}$ -in. steel or brick) with large washer and nut on concealed side.

Wastes. Lavatory shall be provided with wastes complete with lavatory plug and trap; chain stay; faucet; or double type with pop-up waste; the necessary wall and/or floor plates; and, except for lavatories in batteries, supplies with compression stops.

Wastes for lavatories in batteries shall be continuous type.

Enameled Cast-Iron Lavatories

Bowl Specifications. Lavatories shall be one-piece cast iron with full aprons, oval or rectangular bowls, integral overflows and rims, and shall be enameled on the inside and over rims, aprons, and backs. Bowls shall be of these approximate sizes:

Corner lavatory: $10\frac{1}{2}$ by 15 in.

Regular 17- by 21-in. lavatory: $10\frac{1}{2}$ by 15 in.

Pedestal lavatory: 12 by 15 in.

Overflows shall have cross-sectional areas of not less than $1\frac{1}{2}$ sq in. at every point.

Supports. Corner lavatories shall have two concealed hangers of suitable design.

Regular lavatories shall have one-piece concealed hangers of suitable design. Pedestal lavatories shall have cast-iron pedestals enameled on the outside.

Wastes. Shall be similar to those specified for china lavatories.

Wash Sinks

Specifications.

Basins. Enameled cast-iron roll-rim wash sink 30, 48, or 60 in. long by 18 in. wide, 8-in. back, no apron; backs drilled for supply faucets; bottom drilled for $1\frac{1}{2}$ -in. outlet.

Outlet connection. $1\frac{1}{2}$ -in. open strainer; tailpiece; $1\frac{1}{2}$ -in. cast-brass trap with connection to floor or wall.

Supply fixture. Combination compression wash-sink faucets with gooseneck and rose-spray, reamed and countersunk on inside after casting and provided with strainer filters; four-arm indexed metal handles; $\frac{1}{2}$ -in. union shanks with cast-metal flanges.

There shall be one, two, and three supply fixtures on the 30-, 48-, and 60-in. sinks, respectively. In addition, sinks shall be provided with a set of all-metal soap dishes.

Drinking bubbler to be placed near rim, with slanting stream, self-closing hand valve, automatic stream regulator, and protecting guard.
Supports. Concealed wall hangers and exposed brackets.

Wash Fountains

Specifications.

Fountain. Monolithic bowl and pedestal, 54 or 36 in. diameter, circular or semi-circular, 28 in. to top of rim; made of precast stone ground, or not ground, and polished, non-absorbent and acid-resisting, or enameled iron acid resisting or stainless steel.

Outlet. Two-inch trap with or without 1½-in. vent connection.

Supplies. Top or bottom supplies; self-cleaning central spray head. Control of water by one hand operated mixing valve or foot ring with thermostatic mixing valve; volume control.

Accessories. Powdered or liquid soap dispenser or cake soap tray.

Average Water Consumption at 105 F:

54 in. circ.	5½-7 gpm.
36 in. circ.	3½-4½ gpm.
54 in. semi-circ.	3½-4½ gpm.
36 in. semi-circ.	2 -2½ gpm.

ART. 5-G. UTILITY SINKS

Service Sinks

Service sinks are for the use of janitors and building-maintenance workers. They are also referred to as *slop sinks* or *janitors' sinks*. They are used as a hopper for the discharge of dirty water. The sink receives a great deal of rough usage and not much is obtained by trying to make it fancy in appearance. If they are placed in special janitors' closets, their installation should be purely functional. Only in special cases, where exposed to view, should they be made of enameled iron or vitreous ware.

Vitreous-china sinks. Sinks shall have integral back, metal strainers with threaded shanks or not less than two flat-head machine screws and supported on and secured to trap standard.

Enameled cast-iron sink. Sink shall be one-piece and not less than 12 in. deep, roll rims and integral back. Enameled inside and over the rims and back. Outside painted one shop coat. (Finish coat to be three coats white paint and one coat enamel.)

Three-inch metal open strainer, rubber gasket threaded shanks to screw into 3-in. trap standard.

Supported on and secured to trap standard.

One-piece concealed hangers.

Galvanized cast-iron sinks are similar to enameled cast-iron except that they are galvanized all over.

Trap standard of cast-iron, open pattern, enameled inside and outside for cast-iron sinks. Diameter 3 in., without vent, and with screw cleanout

plug in the seal. Water seal not less than 2 in. Trap standard to have inlet to receive the threaded shanks, or tapped holes for the machine screws of the strainer. Trap standard for wall connection shall be tapped for 3-in. pipe, shall be adjustable for height, and shall have 3-in. IPS brass nipple (sanded for painting) to wall and cast-metal wall escutcheon. Trap standards for floor connection shall be provided with horns at outlet, cast-iron floor flanges (similar to Fig. 51) but for 3-in. pipe, and molded asbestos gaskets and bolts for fastening the fixture. Vitreous-china non-siphoning traps may be accepted in lieu of the traps above for vitreous-china sinks.

Rim guards shall be constructed of tubing $\frac{3}{8}$ in. in diameter, having a wall thickness of not less than 0.064 in., secured at both ends to holding bars which shall have brass spring plates or thumb screws for fastening the guards to the rim of the sink. Rim guards for vitreous-china sinks may be of sheet metal not less than 0.0625 in. thick and of the spring type formed to fit the rim of the sink.

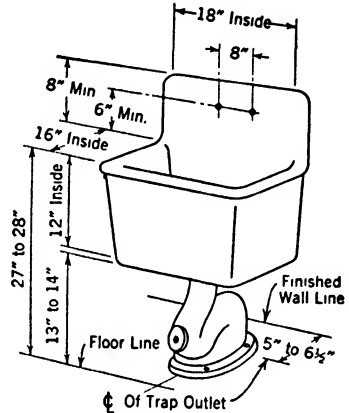


FIG. 66. Vitreous Service Sink. (Rim guards not shown.)

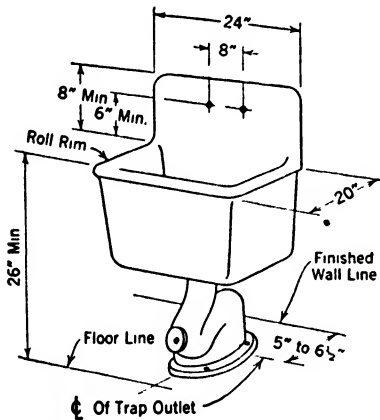


FIG. 67.A

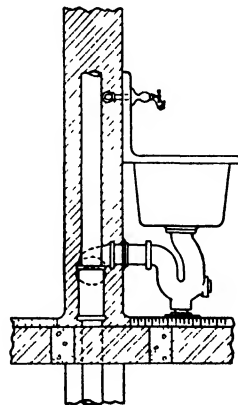


FIG. 67.B

Cast-Iron Service Sink. (Rim guards not shown.)

ART. 5-H. LABORATORY SINKS

Chemistry Sinks*Acid-Resisting Enameled Cast-Iron Sinks.*

Sink shall be acid-resisting enameled, flat rim, cast iron without back, 30 in. by 20 in.

Outlet connection: cast-metal strainer; 1½-in. tailpiece; 1½-in. cast-metal P-trap.

Supply fixture: exposed-type combination compression supply faucet, mounted on wall above sink with concealed supplies and stops, all-metal operating valves, four- or five-arm metal indexed handles, cast-metal wall escutcheons; gooseneck spout.

Supports: two 1½-in. structural steel angle brackets painted. When set in laboratory table top sink shall be supported on structural steel angles, painted, bolted to cabinet work (Fig. 68).

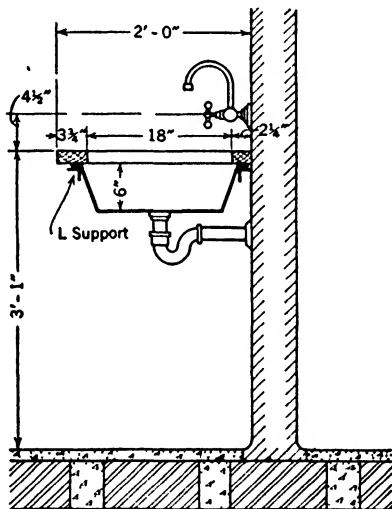


FIG. 68. Laboratory Sink.

Metal Sinks. See Art. 5-J.

Soapstone Sinks. For soapstone sinks, see specifications for domestic sinks, Art. 5-J.

Developing Tank*Hard-Rubber Composition Tank.*

Tank shall be hard-rubber composition approximately 30 by 18 by 22 in. deep, with drillings for ¾-in. intake near bottom, 1½-in. overflow near top and 1½-in. waste.

Trays: Tank shall be supplied with two loose, hard-rubber trays to fit into tank, approximately 5 gal capacity each.

Connections: Outlet connections shall be 1½-in. open-metal strainer overflow and waste, 1½-in. IPS overflow connection, 1½-in. cast-metal P-trap with wall connection and wall flange.

Supplies: Two ¾-in. supplies, two ¾-in. straight stops; floor and wall flanges.

Supply fixture shall be built up of two compression supply angle valves with cast escutcheons to wall, four-arm solid metal handles, IPS nipples and tee to form mixing chamber. Connection to tank shall be ¾-in. IPS with air break on the line.

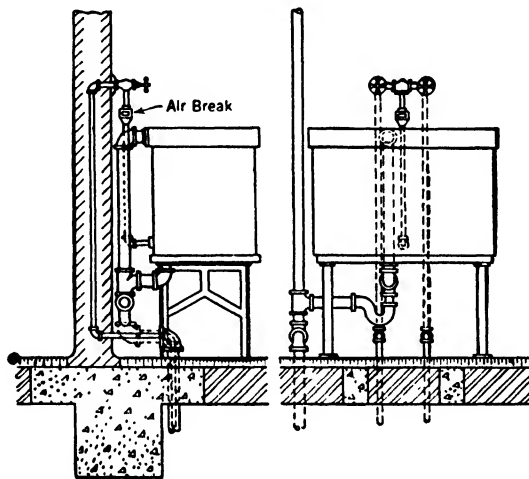


FIG. 69. Developing Tank.

ART. 5-I. DRINKING FIXTURES

Drinking Fountains

Design.

Drinking fountains shall be designed and constructed in such a manner that they comply with the rules and recommendations of the joint committee of the American Public Health Association and Conference of State Sanitary Engineers.

The committee agreed upon these ten features as essential to sanitary design:

- a. The fountain shall be constructed of impervious material, such as vitreous china, porcelain, enameled cast iron, other metals, or stoneware.
- b. The jet of the fountain shall issue from a nozzle of non-oxidizing, impervious material set at an angle from the vertical. The nozzle and every other opening

in the water pipe and conductor leading to the nozzle shall be above the edge of the bowl, so that such nozzle or opening will not be flooded in case a drain from the bowl of the fountain becomes clogged.

c. The end of the nozzle shall be protected by non-oxidizing guards to prevent persons using the fountain from coming into contact with the nozzle.

d. The inclined jet of water issuing from the nozzle shall not touch the guard, thereby causing splattering.

e. The bowl of the fountain shall be designed and proportioned so as to be free from corners which would be difficult to clean or would collect dirt.

f. The bowl shall be proportioned so as to prevent unnecessary splashing at a point where the jet falls into the bowl.

g. The drain from the fountain shall not have a direct physical connection to a waste pipe unless the drain is trapped.

h. The water-supply pipe shall be provided with an adjustable valve fitted with a loose key or an automatic valve permitting the regulation of the rate of flow of water to the fountain so that the valve manipulated by the users of the fountain will merely turn the water on or off.

i. The height of the fountain at the drinking level shall be such as to be most convenient to persons utilizing the fountain. The provision of several step-like elevations to the floor at fountains will permit children of various ages to utilize the fountain.

j. The waste opening and pipe shall be of sufficient size to carry off the water promptly. The opening shall be provided with a strainer.

Bowl. Drinking fountains can be obtained in enameled iron, china, and different metals. The greatest incentive to cleanliness is a clean appearance, and, as a drinking fountain is practically always a public fixture, a clean appearance and sanitary condition are important. No matter how much money may be spent on an ornamental bronze fountain, none of them will retain the fine appearance of a china bowl. It has been objected that china will not withstand hard usage in public; nevertheless they have been used for public work to a great extent with good results.

The bowl shall have an outlet for an 1¼-in. trap with china cap or cast-metal strainer.

Supply fixture should be a slanting stream with automatic stream control.

Setting. Drinking fountains shall be set with rim

26 in.	above floor	in kindergartens.
30 in.	" " "	all other parts of grade schools.
36 in.	" " "	junior high school.
42 in.	" " "	high school and for adults.

In public places, where both children and adults will use the fountain, a height of 30 in. is recommended, with steps provided to help smaller children.

Recessed-Type Drinking Fountain

Specifications.

Bowl. White vitreous china, recessed type, approximately 16 in. wide by 30 in. high, overall, receptor opening $12\frac{1}{2}$ in. wide by 20 in. high and 9 in. deep. Outlet for $1\frac{1}{4}$ -in. trap with china cap or cast-metal strainer.

Outlet connection. $1\frac{1}{4}$ -in. cast-metal P-trap with extension to face of wall with cast finished metal cleanout plug and wall escutcheon.

Supply. $\frac{3}{8}$ -in. IPS brass, concealed.

Supply fixture. Slanting stream with automatic stream control connected to concealed self-closing supply fitting, cast-metal four-arm drop-eared handle and cast-metal escutcheon; concealed stop valve on face of wall below fountain with cast-metal escutcheon.

In back of receptor, near top, shall be placed a cast-metal self-closing water bibb with cast-metal four-arm drop-eared handle with concealed IPS brass connection to water line.

Bracket-Type Drinking Fountain

Specifications.

Bowl. White vitreous china, circular, oval or square, approximately 12 in., with or without integral apron and integral protecting cowl. The body of the bowl shall conceal the trap and fittings. $1\frac{1}{4}$ -in. outlet with china cap or finished cast-metal strainer.

Outlet connection. $1\frac{1}{2}$ -in. cast-metal combined waste outlet and P-trap with nipple to wall.

Supply. $\frac{3}{8}$ -in. IPS brass pipe and elbow with compression stop.

Supply fixture. Slanting stream, automatic stream control, key socket adjustment, cast-metal self-closing control valve with four-arm drop-eared handle.

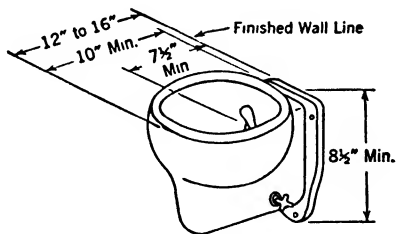


FIG. 70. Projecting Drinking Fountains.
(Note: Bowls may be oval or rectangular.)

From Federal Specifications WW-P-541a

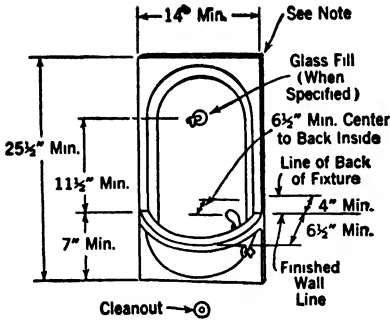


FIG. 71. Semi-recessed Drinking Fountain. (Note: Top may be square, unless otherwise specified.)

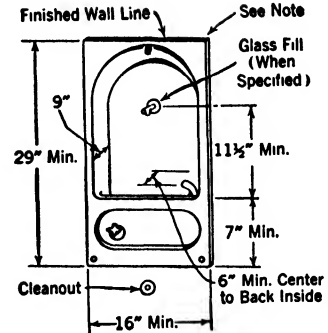


FIG. 72. Recessed Drinking Fountain. (Note: Top may be square, with or without mitered corners, or arched, and bottom shall be square, unless otherwise specified.)

From Federal Specifications WW-P-541a

Park Drinking Fountain

Specifications.

Bowl. White vitreous china or galvanized cast iron, approximately 9 in. in diameter, integral strainer or cast-metal strainer; $1\frac{1}{4}$ in. tailpiece to fit to a 2-in. IPS pedestal. Bowl to set 36 in. above grade.

Pedestal shall be 2-in. galvanized steel or wrought-iron pipe, fitted with a 7-in. long step rail set 9 in. above grade and a galvanized cast-iron flange at grade. Provide a 2-in. galvanized coupling and 2-in. galvanized steel or wrought-iron extension into ground, 24 in. long and open at the bottom.

Bubbler shall be of non-oxidizing, impervious material, set at an angle from the vertical and above the edge of the bowl, and shall be protected by a non-oxidizing guard.

Stream control. Automatic stream-control valve permitting the regulation of the rate of flow of water so that a uniform height of drinking stream will automatically be maintained. Valve shall be cast metal.

Self-closing valve. $\frac{3}{8}$ -in. self-closing valve, cast-metal and four-arm drop-eared handle.

Bibb on supply shall be one $\frac{3}{4}$ -in. cast-metal compression hose bibb with loose key stop, male-threaded inlet.

Shut-off on supply to be one $\frac{3}{4}$ -in. cast-metal compression loose-key stop valve.

Supply shall be $\frac{3}{4}$ -in. IPS brass with a brass union connection at grade. Supply is bushed down to $\frac{3}{8}$ -in. for branch to fountain and shall be provided with a $\frac{3}{8}$ -in. brass union at bowl inlet.

Base shall be made of concrete poured into a conical-shaped 22-ga galvanized iron form, 18 in. in diameter. Bottom of excavation shall be filled with crushed stone for drainage.

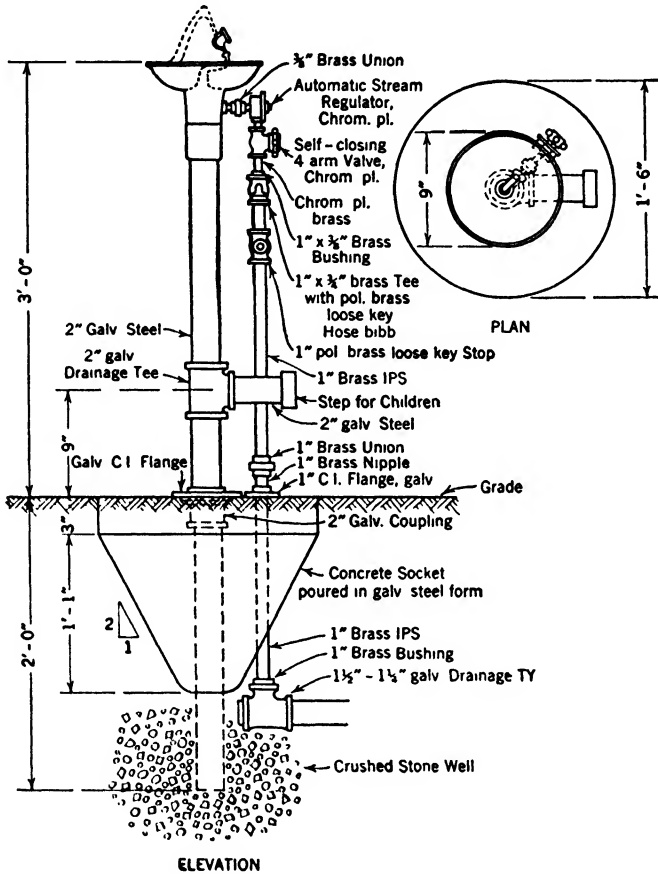


FIG. 73. Park Drinking Fountain.

Cuspidors

Definition. Cuspidors are china fixtures similar in construction to a wall-type drinking fountain, used mainly in gymnasiums.

Recessed-Type Cuspidor.

Bowl shall be white vitreous china, flat-faced recessed type, approximate size 17 by 26 in., and receptor approximately 12 1/2 by 20 by 9 in. deep. Receptacle shall be provided with outlet for 1 1/4-in. trap and 3/8-in. supply fixture. Strainer to be china or cast metal.

Outlet connection shall be 1¼-in. concealed cast-metal P-trap with nipple to face of wall and cast finished metal cleanout plug and wall escutcheon.

Supply fixture. Cast-metal adjustable spreader; cast-metal inlet connection; concealed brass piping to concealed self-closing valve with cast-metal drop-eared four-arm handle and cast-metal wall escutcheon.

Setting. Rim of cuspidor to be 36 in. above floor.

ART. 5-J. DOMESTIC SINKS

Kitchen Sinks

Enameled Cast-Iron Sinks.

Sink shall be one-piece cast iron and approximately 6 in. deep, and shall have integral back. Drainboard shall be integral. Sink shall be enameled on the inside and over the rims, back, apron, and drainboards.

Support. Apron sinks without drainboards and roll-rim sinks shall be supported on one-piece concealed metal hangers of suitable design; apron sinks with drainboards shall have two enameled cast-iron legs and two concealed metal hangers of suitable design.

Waste. Sink plug, trap, and the necessary wall or floor plates.

Supplies. Roll-rim sinks shall have ½-in. shank and flange-type sink compression faucets for hot and cold water, the cold-water faucets having hose threads. Apron sinks shall have double-type compression faucets.

Enameled Cast-Iron Combination Sink and Laundry Tray.

Fixture. One-piece cast iron with integral back and apron. Depth of sink not less than 6 in., and of tray approximately 14 in.

Enameled inside and over rims, backs, and apron.

Drainboard shall consist of not less than three strips of ash, of not less than ¾-in. finished thickness with all surfaces free from defects and finished smooth. The board shall be grooved; shall fit neatly; shall be reinforced with through brass rods and suitable wood cleats not less than ¾ by 2 in.; and shall be provided with suitable brass supports for holding them in position over the trays. Drainboard shall be easily removable.

Supports. Two enameled cast-iron adjustable legs and two concealed metal hangers of suitable design.

Waste. Complete waste, including strainer for sink compartment, waste plug with a chain and a metal stopper for the tray compartment, trap.

Supplies. Double-type compression sink faucet, supplies, and the necessary wall and/or floor plates.

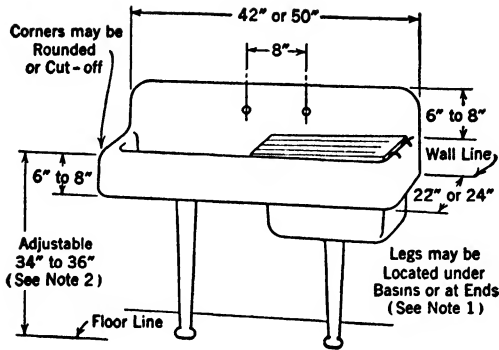


FIG. 74. Sink and Laundry Tray Combinations with Straight Back. (Note 1: Fixtures may have either straight or ledge back [see Fig. 75]. Illustration shows fixture with right-hand tray and apron; fixtures with roll rim shall have one leg only, located under tray. Note 2: Install at 36 in. height, unless otherwise specified.)

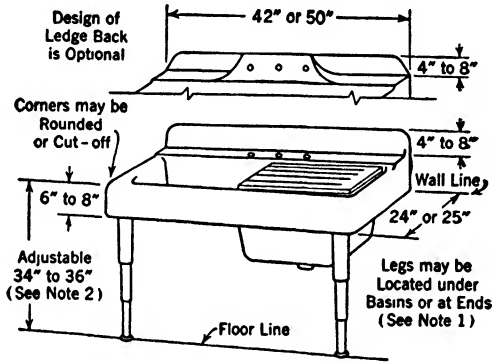


FIG. 75. Sink and Laundry Tray Combinations with Ledge Back. (Note 1: Fixture may have either straight or ledge back [see Fig. 74]. Illustration shows fixture with right-hand tray and apron; fixture with roll rim shall have one leg only, located under tray. Note 2: Install at 36 in. height, unless otherwise specified.)

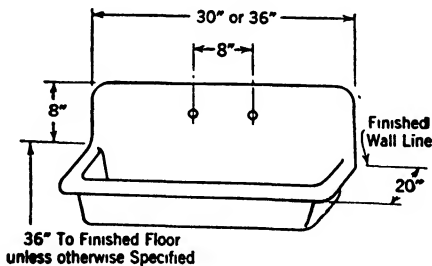


FIG. 76. Cast-Iron Kitchen Sink.

From Federal Specifications WW-P-541a

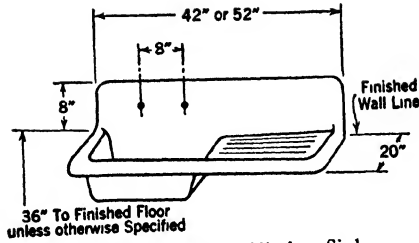


FIG. 77. Cast-Iron Kitchen Sink.

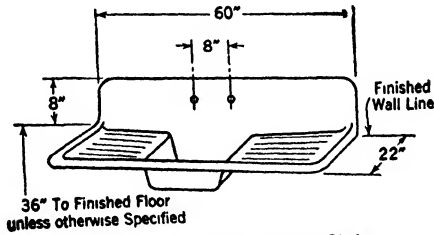


FIG. 78. Cast-Iron Kitchen Sink.

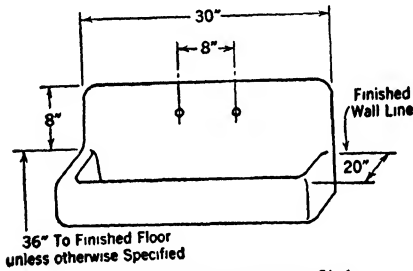


FIG. 79. Cast-Iron Kitchen Sink.

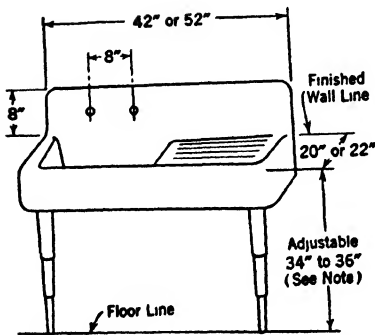


FIG. 80. Cast-Iron Kitchen Sink.
(Note: Install at 36 in. height, unless otherwise specified.)

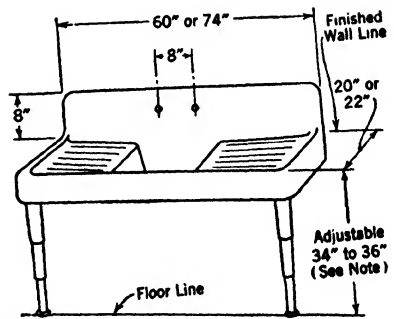


FIG. 81. Cast-Iron Kitchen Sink. (Note: Install at 36 in. height, unless otherwise specified.)

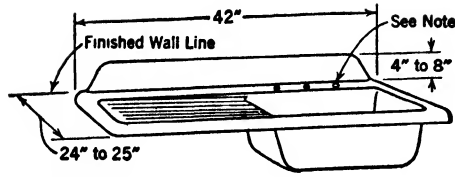


FIG. 82. Cast-Iron Kitchen Cabinet Sink. (Note: Holes for supply fitting shall be in ledge or in an angular panel. Corners may be rounded or cut off.)

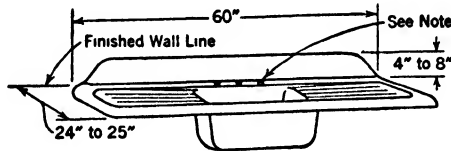


FIG. 83. Cast-Iron Kitchen Cabinet Sink. (Note: Holes for supply fitting shall be in ledge or in an angular panel. Corners may be rounded or cut off.)

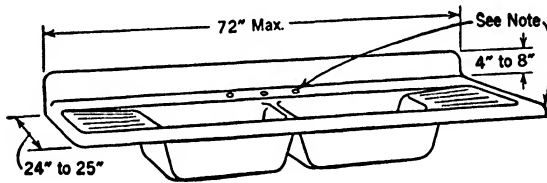


FIG. 84. Cast-Iron Kitchen Cabinet Sink. (Note: Holes for supply fitting shall be in ledge or in an angular panel. Corners may be rounded or cut off.)

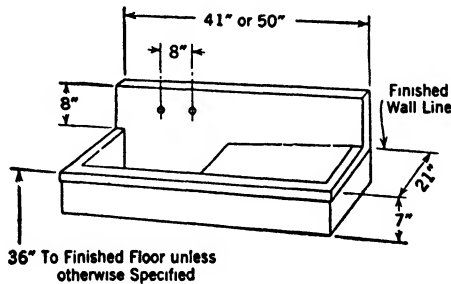


FIG. 85. Alloy Kitchen Sink. (Note: Alloy metal thickness 0.050 in. minimum.)

From Federal Specifications WW-P-541a

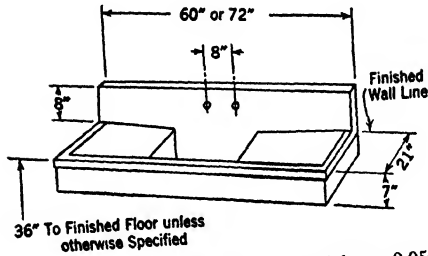


FIG. 86. Alloy Kitchen Sink. (Note: Alloy metal thickness 0.050 in. minimum.)

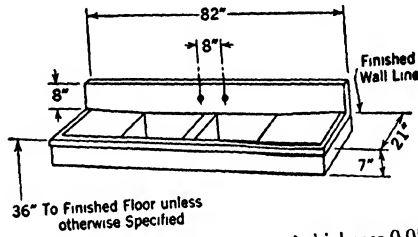


FIG. 87. Alloy Kitchen Sink. (Note: Alloy metal thickness 0.050 in. minimum.)

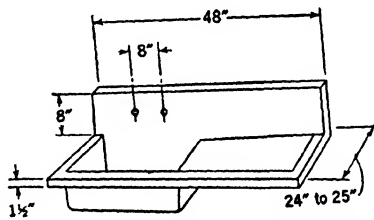


FIG. 88. Alloy Kitchen-Cabinet Sink. (Note: Alloy metal thickness, for bowl, 0.043 in. minimum; for top sheet and back, 0.037 in. minimum.)

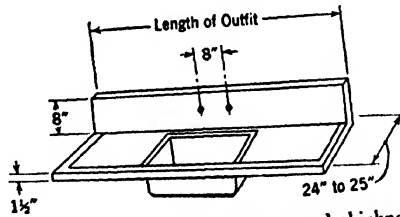


FIG. 89. Alloy Kitchen-Cabinet Sink. (Note: Alloy metal thickness, for bowl, 0.043 in. minimum; for top sheet and back, 0.037 in. minimum.)

From Federal Specifications WW-P-541a

DOMESTIC SINKS

Art. 5-J]

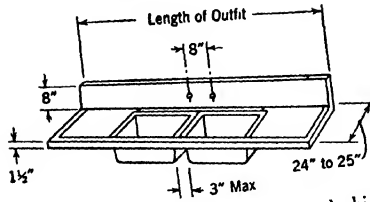


FIG. 90. Alloy Kitchen-Cabinet Sink. (Note: Alloy metal thickness, for bowl, 0.043 in. minimum; for top sheet and back, 0.037 in. minimum.)
From Federal Specifications WW-P-541a

Soapstone Sinks

Sinks shall be soapstone of clear structural type $1\frac{1}{4}$ in. thick. Joints shall be tongued and grooved, and shall be cemented with litharge and glycerin cement. Backs shall be integral.

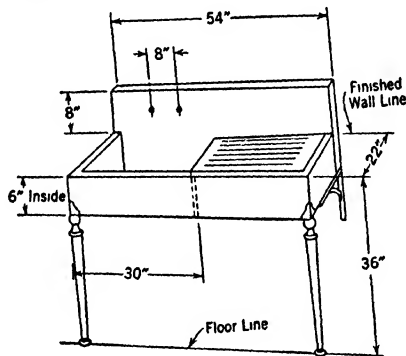


FIG. 91. Soapstone Sink.

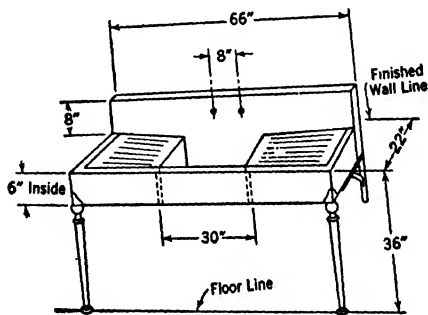


FIG. 92. Soapstone Sink.

Supports. Each sink shall be supported on two zinc-coated legs with apron supports and wall brackets.

Waste. Tray plugs and traps.

Supplies with the necessary wall or floor plates, brass stoppers with chains, and 1/2-in. shank and flange-type sink compression faucets. The cold-water faucet to have hose threads.

Metal Sinks

Specifications.

Sinks shall have integral backs and roll rims at fronts and backs, leaving space behind the backs for the supplies. Zinc-coated steel sinks shall be constructed of material not less than 0.109 in. thick (No. 12 U.S. ga) before being coated; alloy sinks shall be constructed of chromium-nickel-steel alloy (stainless steel) or copper-nickel alloy (Monel) not less than 0.078 in. thick (No. 14 U.S. ga). Zinc-coated steel sinks shall be welded or riveted; alloy sinks shall be welded. All interior corners shall be rounded and ground smooth. Partitions shall be bordered at the top with tubing 1/2 in. in diameter, having a wall thickness of not less than 0.05 in., spot-welded in place. Drainboards shall be integral with the backs.

Supports. Sinks shall be supported on zinc-coated steel angle legs, secured to the sink and with provision for being bolted to the floor.

Faucets. Each compartment shall have a 2-in. sink plug with strainer bars and a metal stopper with a chain. Each compartment of zinc-coated

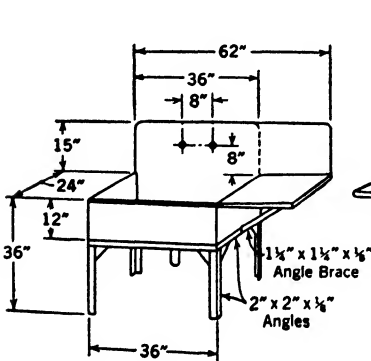


FIG. 93. Single-Compartment Scullery Sink.

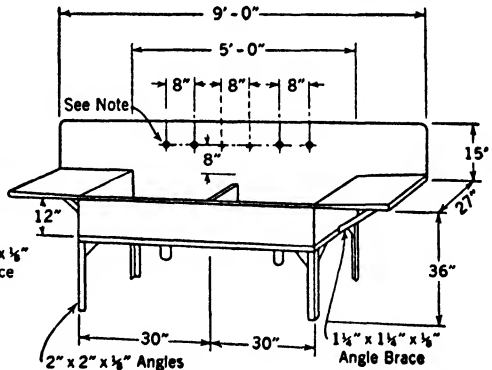


FIG. 94. Double-Compartment Scullery Sink. (Note: Furnish with four supply holes for pairs of single faucets centered over each compartment, unless combination faucet is specified. For combination faucet, furnish with one pair of supply holes centered over compartment partition.)

steel sinks shall be provided with $\frac{3}{4}$ -in. shank and flange-type sink compression faucets having hose threads. Each alloy sink shall be provided with a double-type compression faucet.

Each sink shall be provided with a $3\frac{1}{2}$ by 6-in. soap dish constructed of the same material as the sink and attached securely to the back.

Soapstone Laundry Trays

Specifications.

Trays shall be of soapstone of clear structural type $1\frac{1}{4}$ in. thick. Joints shall be tongued and grooved and shall be cemented with litharge and glycerin cement. Backs shall be integral.

Supports shall be continuous under all compartments and shall be formed of zinc-coated angles or $1\frac{1}{4}$ -in. galvanized pipe stands resting on galvanized floor flanges.

Waste. Each fixture shall be provided with waste complete with trap, wastes for double and triple compartment fixtures being of the continuous type. Each compartment shall be provided with a tray plug, a metal stopper with a chain.

Supplies. $\frac{1}{2}$ -in. faucets for hot and cold water, cold-water faucets having hose threads. Faucets shall be of the shoulder and flange type for trays with backs.

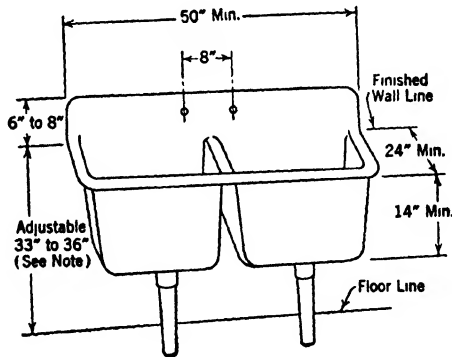


FIG. 95. Cast-Iron Laundry Tray. (Note: May be furnished with apron; legs may be located at corners. Install at 34 in. height, unless otherwise specified.)

From Federal Specifications WW-P-541a

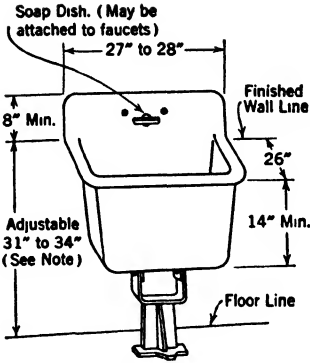


FIG. 96. Cast-Iron Laundry Tray.
(Note: Install at 34 in. height, unless otherwise specified.)

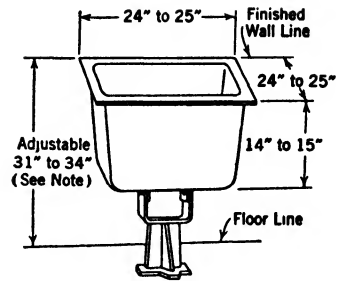


FIG. 97. Cast-Iron Laundry Tray.
(Note: Install at 34 in. height, unless otherwise specified.)

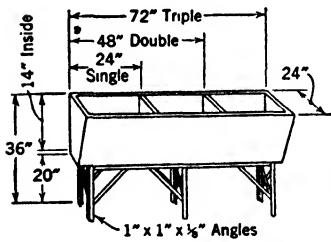


FIG. 98. Soapstone Laundry Trays without Back.

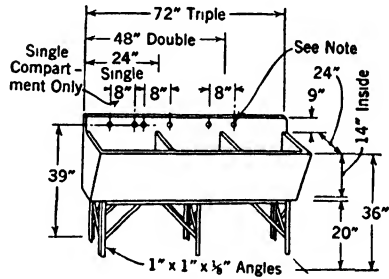


FIG. 99. Soapstone Laundry Trays with High Back. (Note: Furnish single and double trays with two supply holes and triple trays with four supply holes.)

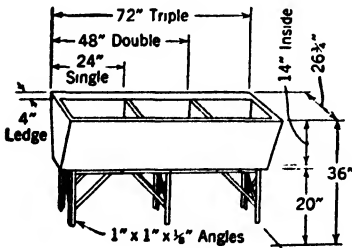


FIG. 100. Soapstone Laundry Trays with Ledge Back.

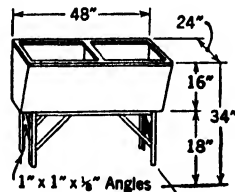


FIG. 101. Concrete Laundry Tray.

Domestic-Science Sinks

Specifications.

Sink. Acid-resisting enameled cast iron, flat rim, 24 by 18 in. by 6 in. deep, no back; outlet near side; cast-metal strainer.

Outlet connection. 1½-in. tailpiece; 1½-in. cast trap with connection to floor. (See also *Metal Sinks.*)

Supply fixture. Concealed (under table) type combination compression faucet, mounted on table top, concealed mixing column; exposed cast-metal handles, indexed; cast escutcheons; exposed ½-in. IPS metal gooseneck with cast escutcheon. Outlet of gooseneck to be 8 in. above top of table.

Supports. Sinks shall be supported by two 1½-in. structural steel angles, painted, and bolted under the rim to underside of wood table top. (See Fig. 68.)

ART. 5-K. BATH FIXTURES

Bathtubs

Enameled Cast-Iron Tubs. Bathtubs shall be one-piece cast iron. Tubs with 3-in. roll rims shall be enameled on the inside and over the rims. Tubs with apron shall be enameled on all exposed surfaces.

Recessed Tubs.

Tubs shall have flat rims at backs and at both ends, and shall be designed to be built into recesses, with or without apron.

Waste shall be of the concealed connected waste and overflow type, 1½ or 2 in.

Supplies. Faucets shall be double-type compression faucets. Hot- and cold-water supplies (iron-pipe size) fitted with ½-in. compression stops.

Corner Tubs.

Tubs shall have flat rims at back and at concealed ends and shall be designed to be built into the wall; with or without apron.

Waste. Same as for recessed tubs or exposed at the free end similar to free standing tubs, 1½ or 2 in.

Free-Standing Tubs.

Tubs shall be flat-bottom pattern with 3-in. roll rims and provided with four cast-iron feet or separate one-piece cast-iron bases.

Waste. Exposed connected overflow type.

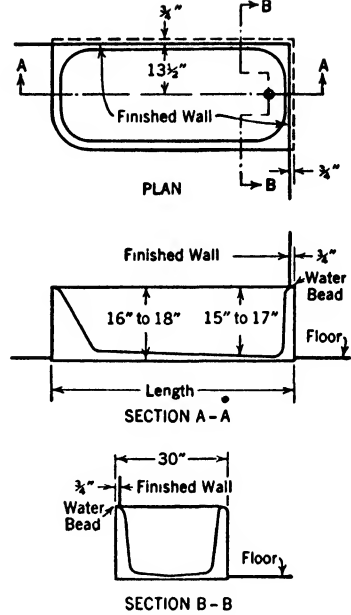
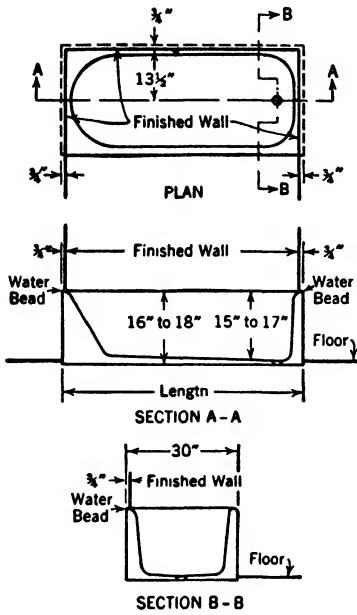


FIG. 102. Recessed Bathtubs, 54-, 60-, and 66-in. Lengths. (Drain at right or left end as specified.)

FIG. 103. Corner Bathtubs, 54-, 60-, and 66-in. Lengths.

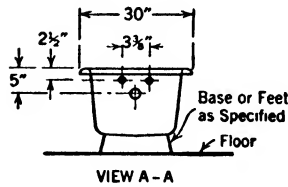
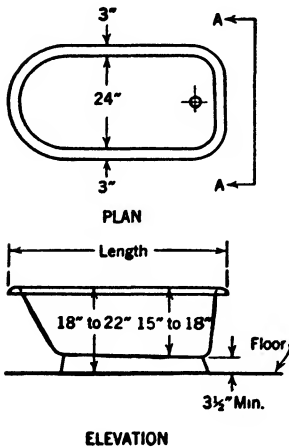


FIG. 104. Free-Standing Roll-Rim Bathtubs, 54-, 60-, and 66-in. Lengths.

From Federal Specifications WW-P-541a

Showers

Fixture Specifications.

Fixtures shall be of the combination compression valve type with union valves and supports. The union valves shall have indexed metal handles, except that, where mixing valves are used, they shall be of the lock shield type. All pipes and nipples shall be iron-pipe size.

Shower heads shall be of the rigid or ball type and shall have cast bodies and faces. The faces shall be threaded or fastened to the bodies with machine screws; shall be removable and approximately 4 in. in diameter; shall have round perforations not less than 0.042 in. in diameter (No. 58 drill), drilled and reamed after casting.

(For public work with a great number of showers in batteries, it is advisable to specify the maximum discharge desired at a certain pressure. Manufacturer can drill heads to permit a definite quantity of water.)

To keep perforations clear, heads should be provided with removable filter screen.

To prevent after dripping, heads may be provided with air valve.

Vandalproof heads. 4 in. in diameter vandalproof type, cast metal, equipped with removable strainer filter; removable face, bolt holes in wall flange. Holes in shower head shall be drilled and reamed after casting. Heads shall have top, back or bottom inlet supplies.

Self-cleaning adjustable heads shall be 2½-in. cast metal, adjustable type with ball joint; flanged elbow connection to wall and cast bent arm.

Concealed-type showers shall have plugged tee connection for concealed supplies and metal escutcheons.

Exposed showers. 36-in. supplies, wall supports.

Installation. Each exposed supply pipe shall have two supports and mixing column shall have one support. (For public work, the supplies and mixing column shall be arranged so that they will not be over ⅞ in. from wall to center.)

Shower Controls (see also Art. 4-C).

Shower controls shall conform to the specifications for thermostatic mixing valves.

Mixing valves shall be of a type that admits cold water first. Concealed mixing valves shall be of a type that will permit renewal of the washers from the front. When mixing valves are provided, the shower heads shall be equipped with volume regulators.

Individual controls shall be ½-in. concealed or exposed type, with a capacity of at least 6 gpm at 20 psi pressure; maximum temperature 115 F; brass body, bronze parts, chromium-plated seats, built-in check valves, union strainer tees. Exposed parts to be finished.

Battery controls shall be exposed type with a capacity of at least 5 gpm per shower head served at 20 psi pressure; maximum temperature 115

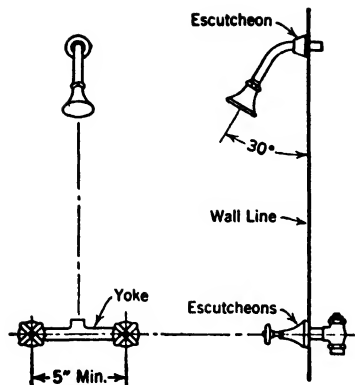


FIG. 105. Concealed Shower with Hand Valves.

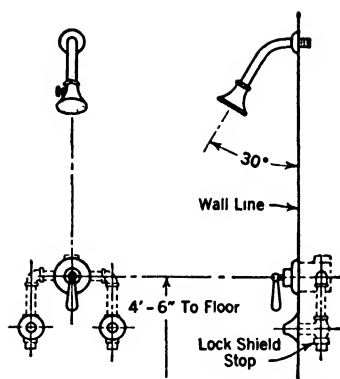


FIG. 106. Concealed Shower with Mixing Valve.

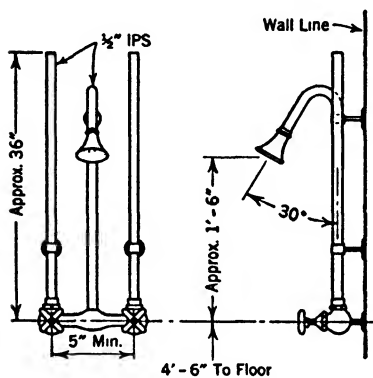


FIG. 107

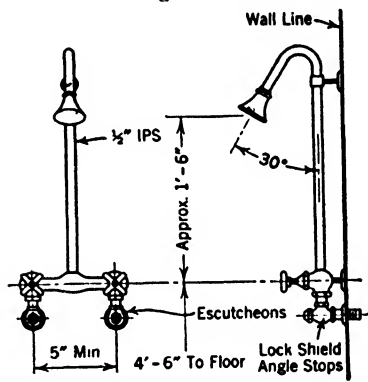


FIG. 108

Exposed Shower with Hand Valves.

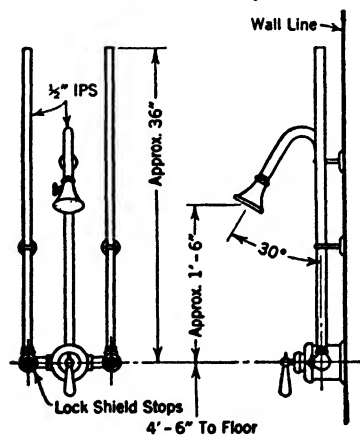


FIG. 109

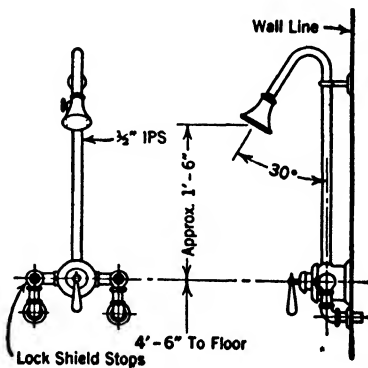


FIG. 110

Exposed Shower with Mixing Valve.

F; brass body, bronze parts, chromium-plated seats, inlet check valves, and filter screens. Exposed parts finished. Each mixing valve shall be furnished with a rigid bulb dial thermometer for liquid exposure, $\frac{1}{2}$ -in. union connection, vertical stem. Dial shall be at least 3-in. in diameter, with temperature indications from 40 to 140 F.

Shower Stalls.

Stall shower with gutters. Cast-metal strainer with gross surface of not less than 25 sq in. to fit into gutter 4 in. wide. Strainer to be calked or sweated into a cast-iron double-drainage floor drain having clamp for lead pan and 3-in. outlet for calking to a 3-in. cast-iron trap.

Shower receptors. 36 by 36 in. by $3\frac{3}{4}$ in. deep, porcelain enameled iron recessed type with 2-in. rim and apron. *Outlet.* 2-in. IPS with finished cast-metal strainer. Receptor shall be set tight against wall and all joints filled solid with china cement.

Curtains.

Curtains shall be not less than 10-oz white preshrunk duck conforming to Fed. Specs. CCC-D-771 (8-oz on residential work) and shall have grommets spaced not over 6 in. apart and a brass roller curtain hook for each grommet. Curtains shall be 6 ft long, and of widths suitable for the installation.

Curtain frames shall be straight pattern for recessed tubs and angle pattern for corner tubs; shall be of suitable length for tub; and shall be of tubing not less than 1 in. in diameter, having a wall thickness not less than 0.045 in., with cast flanges at walls. Holdbacks with screws shall be provided.

Foot Baths

Description. Foot baths are used in connection with pools. They are usually required by the state health authorities. Their first requisite is to rinse the feet of dirt gathered in the locker room. On bathing beaches foot baths for showers are installed to rinse the feet of sand. Foot baths, constructed as a depression in the floor, easily become collectors of dirt and slime, and so defeat their primary purpose. In many cases, such foot baths are provided with apparatus to disinfect the water and prevent the spread of infection of the feet.

Specifications.

Foot baths consist of a ceramic tile or concrete depression in the floor. If placed above the ground, they should be set in a steel pan or lead pan.

Steel pan shall be $\frac{1}{8}$ -in. thick (or No. 10 ga) sheet metal formed into a pan shape by welding. All welded joints shall be continuous and form perfectly tight joints. Pan shall be provided with openings for $\frac{3}{4}$ -in. supply, 2-in. waste, and $1\frac{1}{2}$ -in. overflow. Entire pan shall be covered inside and outside with black asphaltum pitch.

Supply fixture shall be concealed shower type of fixture with loose-key

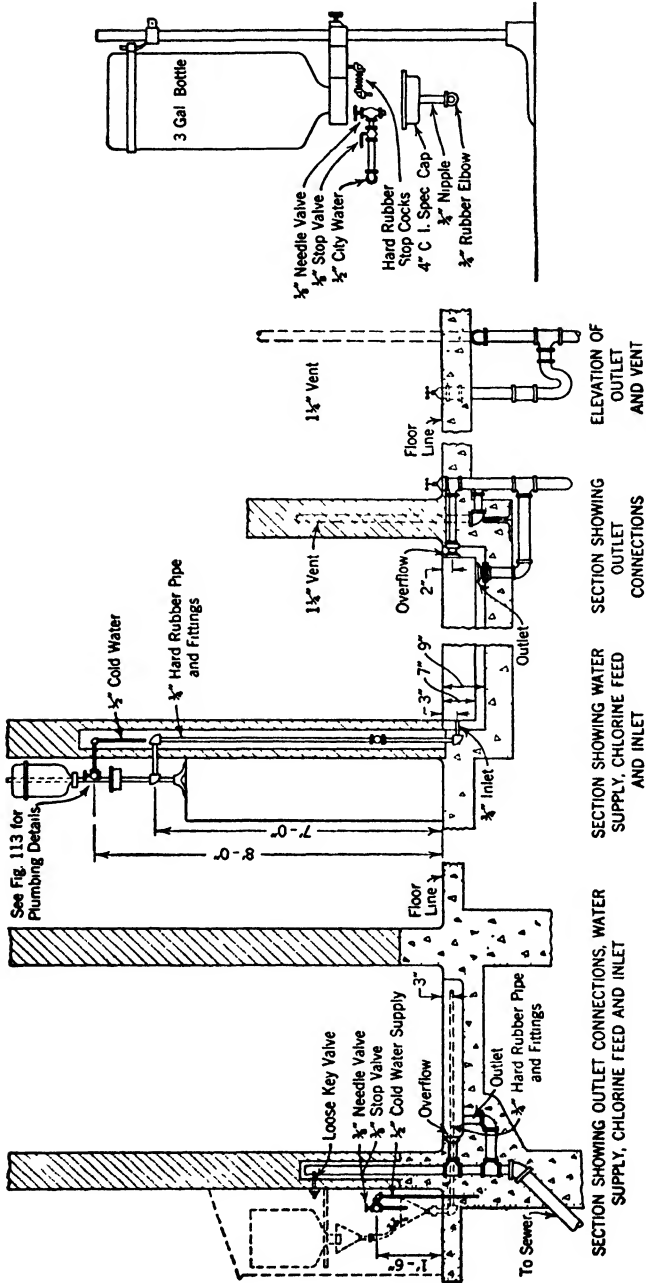


FIG. 113

FIG. 112

Foot Baths.

FIG. 111

finished metal valves; wall escutcheons. Outlet into foot bath shall be a 1½ in. short arm over-rim supply.

(Where foot bath is used only for rinsing sand off feet, outlet may be ½-in. cast metal with 2-in. rose sprays set at an angle with wall.)

Supply connection for chlorinated water shall be ½-in. IPS brass to a point about 8 ft. above floor level. At this point, place a ¾-in. stop valve and a ¾-in. needle valve. Water supply shall discharge from this valve into a glass funnel not less than 6 in. in diameter. This funnel shall be placed at the inlet of a ¾-in. hard-rubber pipe line which carries the chlorinated water to the foot bath. Where the hard rubber pipe passes through the steel pan, it shall be made waterproof by plastic waterproof cement. In some cases the water supply to the footbath is obtained from the treated water supplying the swimming pool.

Outlet fixture shall be a modified bathtub fixture with 2-in. cast-metal outlet and 3-in. cast-metal strainer, regular bathtub joint connection with rubber gaskets against the steel pan; concealed overflow and connection through wall; finished cast-metal strainer. Strainer shall be perforated only in upper half section. Waste connection; lock shield valve with loose metal handle, wall escutcheon. Trap to be 2-in. galvanized cast-iron P-trap drainage fitting.

Drainage connection from the foot bath may be carried into the drain line serving the scum gutters.

ART. 5-L. HOSPITAL FIXTURES

Standards

Types and Sizes.

Hospital plumbing fixtures (U.S. Department of Commerce, Simplified Practice Recommendations R106-30). Of the hospital plumbing fixtures covered by this recommendation, the types and sizes not specifically mentioned herein shall be considered as special.

Baby baths. All roll-rim single slab (porcelain, all-clay). Overall length, 42 in.; overall width, 28 in.; outside depth, 9 in.; sink with compartment at one end; drain shelf or slab shall be not less than 30 in. in length; shall be set on pedestals so that height from floor to top of rim will be 36 in.

Baby baths. All roll-rim, double-slab (porcelain, all-clay). Overall length, 60 in., 72 in.; overall width, 26 in.; center sink compartment, 21 by 14 in.; drain shelves or slabs shall be not less than 23 in. for the 60-in. bath and not less than 29 in. for the 72-in. bath; shall be set on pedestals so that height from floor to top of rim will be 37 in.

Baby baths. Single slab with integral back (porcelain, all-clay). Overall length, 42 in.; overall width, 30 in.; integral back, 9 in. height from rim; drain shelf or slab shall be not less than 30 in. in length; shall be set so that height from floor to top of rim will be 36 in.; can be furnished on pedestals or brackets.

Receiving baths. Roll rim with sloping head end (porcelain, all-clay). Overall length, 72 in.; overall width, 32 in.; inside depth, 8 in.; shall be set on pedestals so that height from floor to top of rim will be 34 in.

Prenatal bath. Roll rim with open end (porcelain, all-clay). Overall length, 72 in.; overall width, 32 in.; inside depth, 8 in.; shall be set on pedestals so that height from floor to top of rim will be 34 in.

Seat bath. Roll rim (porcelain, all-clay). Overall length, 30 in.; overall width, 26 in.; height of front, 14 in.; height of back, 21 in.

Continuous-flow bath (enameled ware or porcelain, all-clay). Overall length, 78 in.; overall width, 33 in.; minimum depth at outlet of tub shall be 20 in.

Portable bath (enameled ware). Overall length, 72 in.; overall width, 30 in.; depth at outlet shall be 17 in.; painted wrought-iron carriage; rubber-tired wheels; swiveled front axle; removable handle.

Surgeons' lavatory. Integral back (vitreous china). Overall length, 24 in.; overall width, 20 in.; integral back, 6 in. in height; no return ends; height from floor to top of rim, 31 in., with or without leg.

Surgeons' wash-up sink. Roll rim with integral back (vitreous china or porcelain, all-clay). Overall length, 30 in.; overall width, 21 in.; inside depth, 11 in.; integral back, 6 in. in height.

Medicine sink. Integral bowl (vitreous china). Overall length, 26 in.; overall width, 14 in.

Slop sinks. Wall-hanging, integral trap, blow-out type (vitreous china). Overall projection, 24 in.; overall width along wall, 21 in.; with top or back supply.

Slop sinks. Integral trap to floor, siphon-jet type (vitreous china). Overall length, 21 in.; overall width, 21 in.; height from floor to top of rim, 20 in.; with top supply.

Massage table. Slab (porcelain, all-clay). Overall length, 72 in.; overall width, 26 in.

Autopsy table (porcelain, all-clay). Overall length, 79 in.; overall width, 28 in.; overall height, 36 in.

In addition to the foregoing items especially designed for hospital use, there are available a number of regular commercial fixtures which are frequently purchased by hospitals for special uses. They include such items as the following, made in vitreous china, porcelain (all-clay), or enameled ware.

<i>Hospital use</i>	<i>Commercial description</i>
Surgeons' wash-up sink	Laundry trays
Baby bath	Kitchen sinks
Instrument washing lavatory	Laundry trays
Narrow lavatory	Lavatory
Pack sinks	Laundry trays
Plaster work sink	Kitchen sinks

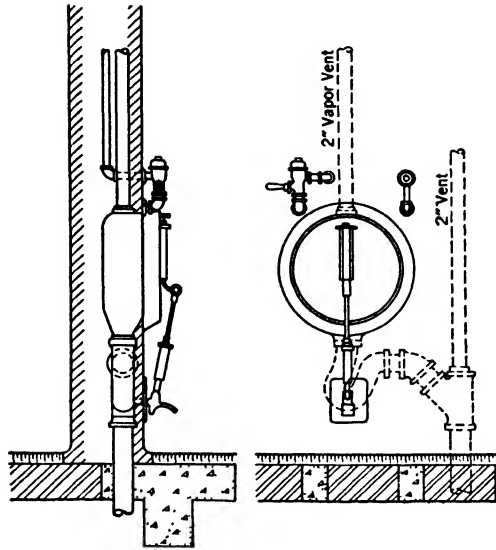


FIG. 114. Bed Pan Washer and Sterilizer.

Physicians' Lavatory

Specifications.

Supply fixture. Concealed under slab hot and cold combination compression supply fixture, 1/2-in. IPS gooseneck with 2-in. cast-metal rose-spray head with removable face and equipped with filter screen. Holes in spray face shall be reamed and drilled after casting. Underside of spray shall be 8 in. above top of lavatory slab. Two 3/8-in. cast-metal

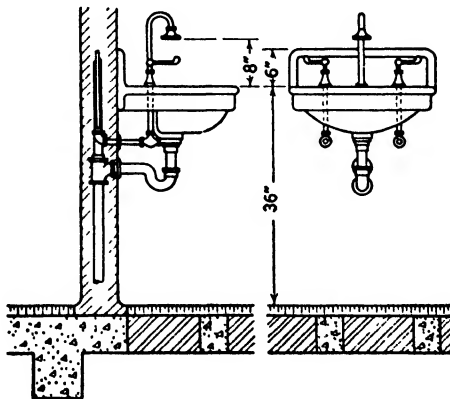


FIG. 115. Physician's Lavatory.

compression valves with wing-type lever arms at least 4 in. long. Center of wing lever shall be at least 4 in. above top of lavatory slab. Valves shall operate on one-quarter turn with definite stopping points. Cast-metal escutcheons.

Lavatories equipped with wing-type faucets, as described above, should, preferably, be set with top of slab 36 in. above floor.

ART. 5-M. DRAIN RECEPTACLES

Shower and Urinal Drains

All Types. Shower and urinal drains shall be cast and shall have top flanges and removable strainers. The bottom outlets of drains may be of the type designed for inside calking.

Shower Drain.

Strainer shall be approximately 6 in. in diameter, polished cast brass, fastened with screws into cast-brass collar with polished rim; male-threaded outlet.

Body shall be cast iron with double drainage feature with clamping device of shallow pattern; 4-in. drain trap with side outlet for 3-in. screwed connection.

Shower Drains for Use in Stalls.

Strainer shall be approximately 6 by 6 in. square, polished chromium-plated cast brass, fastened with screws into a cast-brass collar with polished chromium-plated rim; male-threaded strainer neck.

Body shall be cast-iron with double-drainage feature, flat clamping ring, clamps, and brass bolts for lead pan; 3-in. outlet for inside calking.

Trap shall be 3-in. cast-iron soil-pipe P-trap.

Shower Drain for Use in Boys' Battery Showers.

Strainer shall be approximately 5 by 10 in. rectangular, polished chromium-plated rim.

Body shall be cast-iron calking hub. Lead pan to be carried into calking ring, 3-in. outlet for inside calking.

Trap shall be 3-in. cast-iron soil-pipe P-trap.

Shower Drain for Use in Large Shower Rooms.

Strainer shall be approximately 8 in. in diameter, polished cast brass, fastened with screws into cast-brass collar with polished rim; male-threaded outlet.

Body shall be cast iron with double drainage feature, clamping device, 3-in. side outlet for screwed connection.

Trap shall be a 3-in. cast-iron galvanized drainage fitting P-trap.

Floor Drains

The Use of Floor Drains. It is becoming more and more recognized that the indiscriminate use of floor drains is unwarranted. It is too great an

investment and too unscientific a method to take care of what may be a very remote emergency, only to find, when such emergency arises, that the provision made is totally inadequate. As stated elsewhere, no floor drain should be installed without a back-water trap.

When floor drains are used, the floor, so to speak, becomes the vessel, and great thought should be given to the correct shape (or slope) of the floor and form of outlet basin.

Floor drains, particularly if installed in a proper manner, are a nuisance. They should preferably be placed along the walls with the center of the floor forming the high point and a gutter along the wall leading to the drains, or, if placed in the center, then in such a manner that no one has to walk over them (for example, under the benches of locker rooms, or close to partitions).

All Types. Floor drains shall be cast metal and shall have top flanges and removable strainers. The bottom outlets of drains may be of the type designed for inside calking.

Floor Drain, General Type.

Strainer shall be approximately 6 or 8 in. in diameter, polished cast-brass collar with polished rim; female-threaded outlet.

Body shall be cast iron with double drainage feature, 3-in. outlet for inside calking.

Trap shall be 3-in. cast-iron soil-pipe P-trap.

Floor Drains for Basements, Deep Seal Traps, Back-Water Valve.

Strainer shall be approximately 10-in. polished brass strainer fastened with screws into cast-brass collar with polished rim.

Body shall be 3-in. cast-iron deep seal floor drain and trap with automatic back-water valve, flap type, large brass taper threaded cleanout flush with floor.

Floor Drain for Use in Interior of Building on Floors with No Basement Below.

Strainer shall be polished extra-heavy cast brass or galvanized iron, 6 in. in diameter, screwed into a cast-brass or galvanized cast-iron strainer outlet piece; female-threaded outlet for 3-in. IPS brass nipple to calk into a 3-in. cast-iron hub.

Trap shall be a 3-in. cast-iron soil-pipe P-trap.

Floor Drains for Use in Interior of Building on Floors above Basement.

Strainer shall be polished chromium-plated extra-heavy cast brass, 5 in. in diameter, screwed into a cast-brass strainer outlet piece; male-threaded outlet for 3-in. IPS pipe.

Floor connection shall be japanned cast iron, with double drainage feature with outlet for inside calking to 3-in. soil pipe.

Trap shall be 3-in. cast-iron soil-pipe P-trap.

Floor Drains for General Use above Basement. (In Wet Places, near Sinks, Dishwashers, etc.).

Strainer shall be approximately 4 in. in diameter, polished cast brass fastened with screws into cast-brass collar with polished rim; male-threaded strainer neck. (In some cases it may be advisable to specify solid hinged covers in place of strainers.)

Body shall be cast iron with double-drainage feature, 3-in. outlet for inside calking.

Trap shall be 3-in. cast-iron soil-pipe P-trap.

Floor Drain for Use in Garage Floors (Car or Truck Storage Building and Similar-type Buildings).

Strainer shall be extra-heavy cast-iron galvanized, hinged, approximately 14-in. square.

Body shall be extra-heavy cast-iron galvanized, with galvanized cast-iron mud basket, integral trap with brass cleanout plug; hub outlet.

Area and Yard Drains

All Types. Area and yard drains shall be cast metal of extra-heavy pattern and shall have perforated cast-metal cover plates and connections for 3-in. cast-iron pipe.

Area Drains.

Strainer shall be approximately 9 in. in diameter, extra-heavy cast iron, loose anti-tilting or hinged.

Body shall be black cast iron with supplementary cast-iron strainer. Outlet shall be 3 in. for inside calking, deep hub.

Trap shall be 3 in. with cleanout, located inside the building. (One trap may serve several area drains on one branch.)

Drain for Exterior Work, in Gutters and Small Yards.

Strainer shall be approximately 5 by 10 in., cast iron or polished cast brass, screwed into a cast-iron body.

Body shall be galvanized cast iron, with 3-in. outlet for cast-iron calked connection.

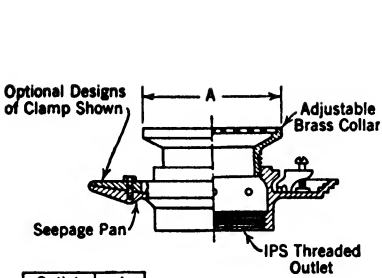
No trap.

Drain for Use on Exterior Work in Small Paved Areas.

Strainer shall be 8 in. in diameter, polished chromium-plated extra-heavy cast brass, placed with set screws into a cast-brass body with polished top edge.

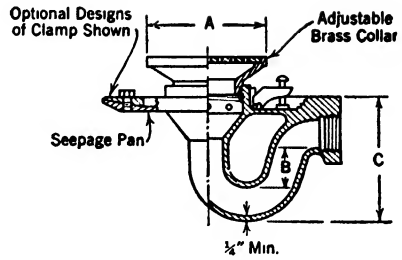
Body to be calked into 3-in. cast-iron hub.

No trap required.



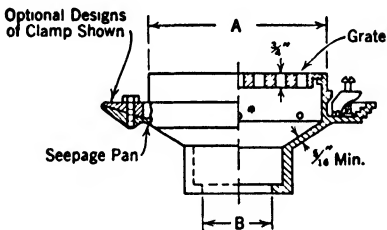
Outlet Size	A
2"	6"
3"	8"
4"	10"

FIG. 116. Adjustable Drain for Floor and Shower Stall.



Outlet Size	A	B Min.	C Max
2"	6"	2"	12 $\frac{1}{2}$ "
3"	8"	2"	14 $\frac{1}{2}$ "
4"	10"	2 $\frac{1}{2}$ "	16 $\frac{1}{2}$ "

FIG. 117. Adjustable Floor Drain with Trap and Side Outlet.



Outlet Size	A	B Min
3"	8"	3 $\frac{3}{8}$ "
4"	11"	4 $\frac{3}{8}$ "

FIG. 118. Floor and Area Drain with Bottom Outlet.

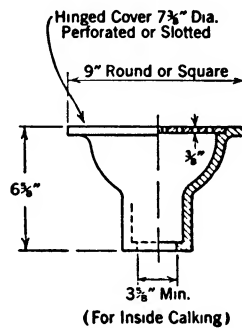


FIG. 119. Area Drain with Bottom Outlet.

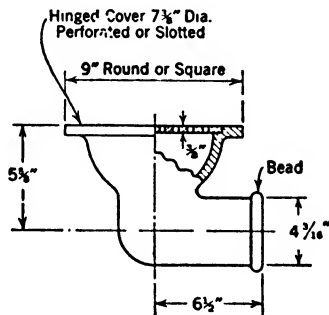


FIG. 120. Area Drain with Side Outlet.

Roof Drains

Roof Drains. Body shall be galvanized cast iron with female-threaded outlet and have clamping ring for roofing felt, anti-tilting removable dome strainer and large sediment chamber; gravel stop; bronze post, brass screws.

Roof Drain for General Use on All Types of Flat Roofs.

Description. Drains shall be cast iron, japanned, with slag stop, double-drainage feature, flashing rings, etc. Domes and flashing rings shall be secured with brass or bronze bolts.

Drains shall be of sizes as specified.

Roof Drains for Use in Cornice Gutters.

Description. Drains shall be cast iron japanned, with outlet for calking.

Roof Drains of Sheet Metal and Furnished and Set by Roofing Contractor. Plumbing contractor shall sweat to copper thimble on roof drain a brass ferrule for screw connection.

Expansion Joints. Each drain connection shall be provided with an expansion joint consisting of a heavy galvanized cast-iron sleeve, smooth turned heavy cast brass reinforced at threaded end; graphite saturated asbestos packing ring made tight by taper gland ring screwed down with brass bolts; male-threaded top and female-threaded bottom.

Installation.

Flashing. Drains shall be installed with a 24 by 24 in., 16-oz sheet copper flashing clamped to drain.

Downspouts

Description. Downspouts or downspout protectors are cast-iron units which form the lower part of metal downspouts. As they are usually not included in the sheet metal contract, they should be included in the plumbing contract.

Specifications. Downspouts shall be cast iron of sizes specified, 4 ft 6 in. long with outlet connection for 3-in. vitrified tile pipe. Downspouts shall have cast-iron eye hooks for fastening to masonry wall and shall be furnished with bolts and expansion shields. Downspouts shall be delivered to job with two coats of metallic paint.

Downspout nozzles are used where inside conductors are made to discharge outside the building line above grade.

Downspout nozzles shall be unfinished brass. Nozzles shall be threaded for pipe connection into drainage elbows at the bases of the downspouts (Fig. 121).

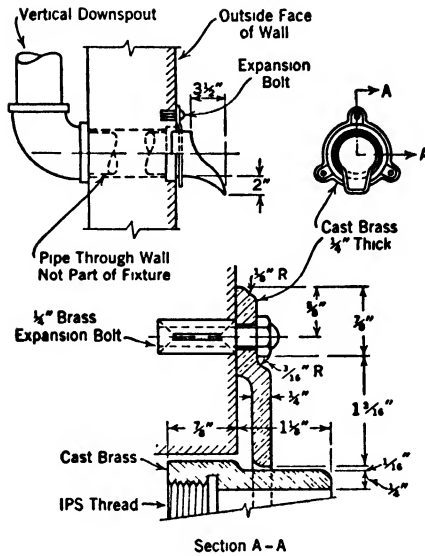


FIG. 121. Downspout Nozzle and Detail of Downspout Discharging at Grade.

ART. 5-N. HOSE BIBBS AND SMALL HYDRANTS

Street Washers

Specifications. Street washers shall have automatic non-freezing drains. Each valve shall be in a cast-iron box for installation not less than 36 in. below grade, being connected by two galvanized wrought-iron pipes not less than 1/2 in. in diameter to a cast-iron box having a hinged cover marked "water." One of the pipes shall be fitted at its upper end with a 3/4-in. cast-brass hose connection with jam nut; the other shall contain a brass operating rod. Each washer shall be provided with a short T-handle key (Fig. 122).

Wall Hydrants

Specifications. Wall hydrants shall have brass faces, detachable T-handles, and nozzles for 3/4-in. hose connections; shall be of length sufficient to go through walls 13, 18, 20, or 24 in. thick, as specified, placing the shut-off valve inside the buildings. Stems and seat washers shall be removable through the front of the hydrant. They shall have heavy brass couplings and union elbows for 3/4-in. pipe. The outer casing pipes shall be galvanized, and the inside operating rods shall be brass (Fig. 123).

Lawn Faucets

Specifications. Lawn faucets shall be brass, compression type, with integral flanges tapped for $\frac{3}{4}$ -in. pipes and detachable wheel or T-handle keys. Hose connections shall be for hose $\frac{3}{4}$ in. in diameter. Each faucet, excluding the handle, shall weigh not less than 1 lb (Fig. 124).

Fire-Hose Racks and Hose

Specifications. Racks shall be suitable for hanging hose $1\frac{1}{2}$ in. in diameter in vertical loops on non-detachable pins or supports. They shall be of the swinging type and of malleable iron or steel. Racks shall be of the following finishes, as specified: enameled red, nickel-plated, or chromium-plated.

Valves shall be $1\frac{1}{2}$ in. in diameter, of the angle globe pattern, with gland stuffing box, raised seat, elastic disk, wall plate, and brass hose rack nipples. Each valve shall weigh not less than 6 lb.

Hose and couplings shall be in accordance with Fed. Specs. JJ-H-571, and nozzles shall be finished castings of the composition specified therein for couplings.

Length of hose shall be as specified (Fig. 125).

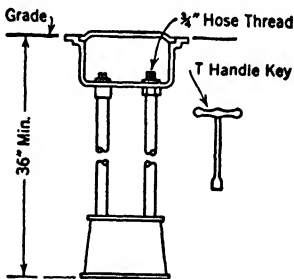


FIG. 122. Street Washer.

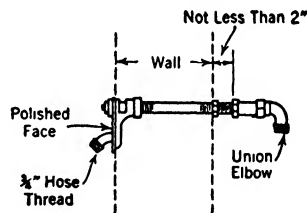


FIG. 123. Wall Hydrant.

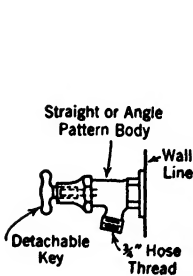


FIG. 124. Lawn Faucet.

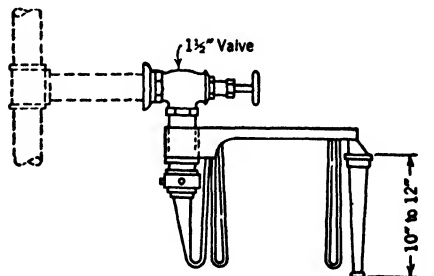


FIG. 125. Fire Hose Rack and Hose.

ART. 5-O. TOILET ROOM ACCESSORIES

While built-in accessories usually are included in the tile and marble contract, there are many articles which are not handled by other trades.

It is highly recommended to include in the plumbing contract at least these accessories:

- Toilet-paper containers.
- Soap containers or dispensers.
- Towel racks.
- Paper-towel containers and disposal cans.

Other accessories which may be furnished are:

- Soap cups.
- Soap dishes for tubs.
- Tumbler and toothbrush holders.
- Tumbler holders.
- Shelves.
- Clothes hooks.
- Sanitary-napkin dispensers.

In industrial work consideration should also be given to the installation of first-aid cabinets. Minimum requirements for such cabinets are furnished by most states.

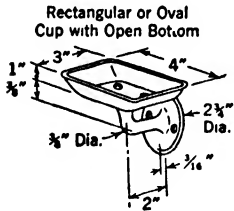


FIG. 126. Soap Dish.

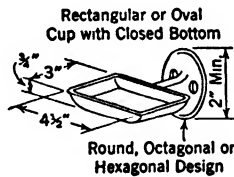


FIG. 127. Soap Dish.

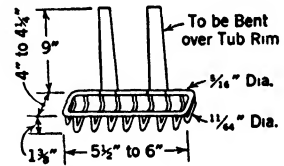


FIG. 128. Soap Dish for Rim of Bath tub.

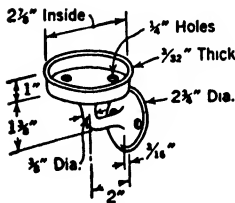


FIG. 129. Tumbler Holder.

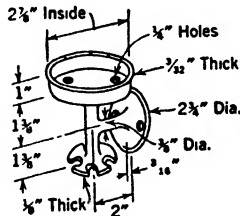


FIG. 130. Tumbler and Toothbrush Holder.

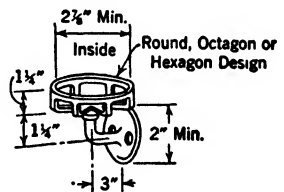


FIG. 131. Tumbler Holder.

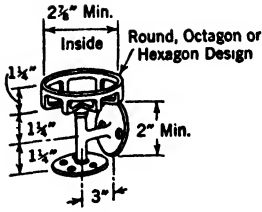


FIG. 132. Tumbler and Toothbrush Holder.

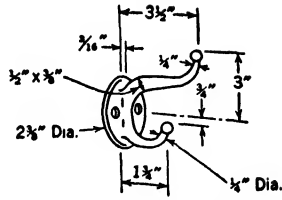


FIG. 133. Coat Hook.

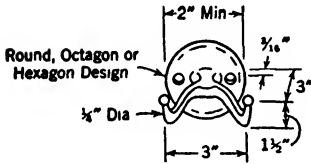


FIG. 134. Coat Hook.

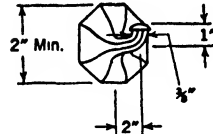


FIG. 135. Coat Hook.

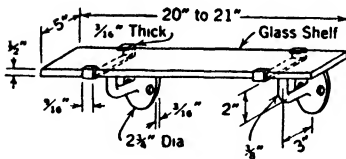


FIG. 136. Glass Shelf.

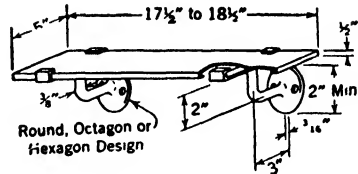


FIG. 137. Metal Shelf.

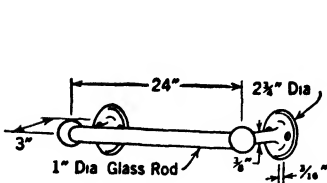


FIG. 138. Towel Rack with Glass Rod.

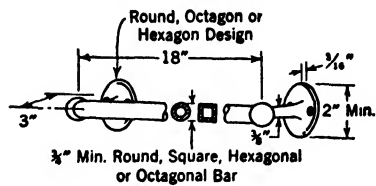


FIG. 139. Metal Towel Rack.

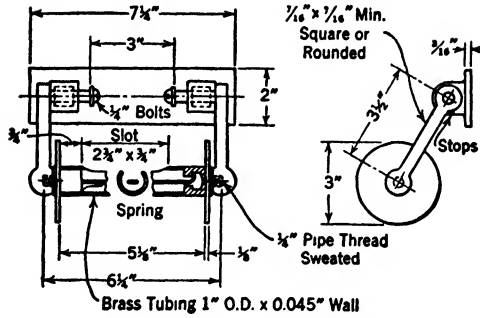


FIG. 140. Toilet Paper Holder.

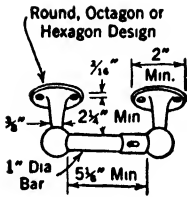


FIG. 141. Toilet Paper Holder.

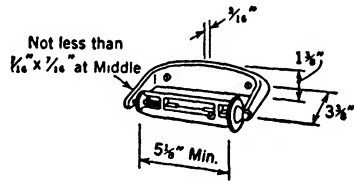


FIG. 142. Toilet Paper Holder.

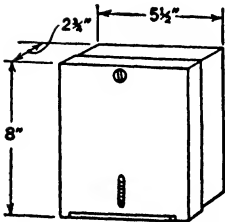


FIG. 143. Cabinet Toilet Paper Holder.

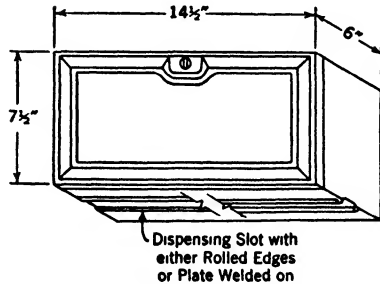


FIG. 144. Cabinet for Folded Paper Towels.

REFERENCES

Federal Specifications for Plumbing Fixtures WW-P-541a.

CHAPTER 6

PUMPS

By far the major part of this chapter is reprinted from the manual *Hydraulic Institute Standards* (24), with the permission of the Hydraulic Institute, 90 West Street, New York, N. Y.

ART. 6-A. CLASSIFICATION (24)

Manufacturers' Standards

Pumping machinery is divided, according to the Standards of the Hydraulic Institute, into four general classes. Each class is subdivided into types, differing in the design of the details but having features that are common to that type.

It is to the best interest of prospective purchasers and consulting engineers, when preparing specifications of pumping machinery, to consider the standard classification as applying to type only, leaving the manufacturer free to use such details as he has developed and standardized for that type of pump.

Class	Type	
Centrifugal	Centrifugal	
	Propeller	
	Mixed flow	
	Peripheral	
Rotary	Cam	
	Screw	
	Gear	
	Vane	
Reciprocating	Piston or Plunger	direct-acting-steam-single
		direct-acting-steam-duplex
		crank and flywheel
		power single
		power duplex
Deep well	Turbine	

Definitions of Types and Parts

Centrifugal Pump. A pump in which the pressure is developed principally by the action of centrifugal force. In pumps of this class the liquid enters the impeller at the hub and flows radially to the periphery.

Mixed-Flow Pump. A pump in which the head is developed partly by centrifugal force and partly by the lift of the vanes on the liquid. This type of pump has a single inlet impeller with the flow entering axially and discharging in an axial and radial direction, usually into a volute-type casing.

Propeller Pump. A pump of this type, sometimes called an axial-flow pump, develops most of its head by the propelling or lifting action of the vanes on the liquid. It has a single inlet impeller with the flow entering axially and discharging nearly axially into a guide case.

Peripheral Pump. A pump having an impeller which develops head by recirculating the liquid through a series of rotating vanes.

Single-Stage Pump. A pump having one impeller. (Single-stage pumps designed for low heads sometimes have two or more impellers working in parallel. These are commonly termed "Bi-rotor Pumps," when equipped with two impellers.)

Multi-stage Pump. A pump having two or more impellers acting in series in one casing.

Volute Pump. A pump having a casing made in the form of a spiral or volute.

Diffusion Vane or Turbine Pump. A pump equipped with removable diffusion vanes.

Vertical Pumps.

Suction type. A vertical-type pump located in a dry well.

Submerged type. A vertical-type pump located in a wet well.

Double-Suction Pump. A pump equipped with a double-suction impeller. (See *Impeller*.)

Single-Suction Pump. A pump equipped with a single-suction impeller. (See *Impeller*.)

Rotation of Pumps.

Horizontal pump. To determine rotation of a horizontal pump, stand at the driving end facing the pump.

Vertical pump. To determine the rotation of a vertical pump, look down upon the top of the pump.

Horizontal or vertical pumps. If the shaft revolves from left to right, the rotation is clockwise (CW). If the shaft revolves right to left, the rotation is counterclockwise (CCW). (Fig. 145.)

Impellers. (Figs. 146-147.)

Impeller, single-suction. An impeller with one suction inlet.

Impeller, double-suction. An impeller with two suction inlets, one on each side of the impeller.

Impeller, closed. An impeller having the side walls extended from the outer circumference of the suction opening to the vane tips.

Impeller, open. An impeller without attached side walls.

Impeller, sewage or non-clog. An impeller of the open, closed, or semi-enclosed type, designed with large passages for passing large solids.

Impeller, propeller type. An impeller of the straight axial-flow type.

Standard Fitted Pumps. The standard fitted centrifugal pump is bronze fitted (symbol B.F.). Casing of cast iron, shaft of steel, impeller of bronze, wearing rings and shaft sleeve, when used, of bronze.

Special Fitted Pumps. The following are considered special fitted pumps:

Acid-resisting pump (symbol A.R.). All parts of the pump in direct contact with the liquid pumped are to be constructed of such materials as will offer the maximum resistance to the corrosive action of the liquid. As the action of corrosive liquids upon the materials used in the construction of acid-resisting pumps is beyond the control of the manufacturer, no guarantee can be made of the life of the pumps.

All-bronze pump (symbol A.B.). All parts of the pump coming in direct contact with the liquid pumped are to be made of bronze.

All-iron pump (symbol A.I.). All parts of the pump coming in direct contact with the liquid pumped are to be made of iron or ferrous metal.

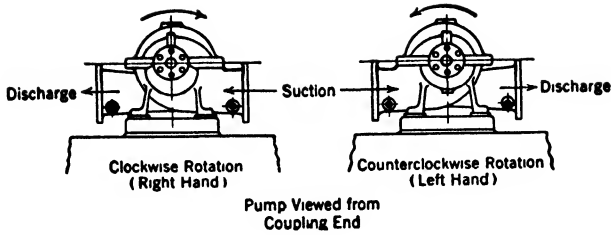


FIG. 145. Rotation of Pumps.

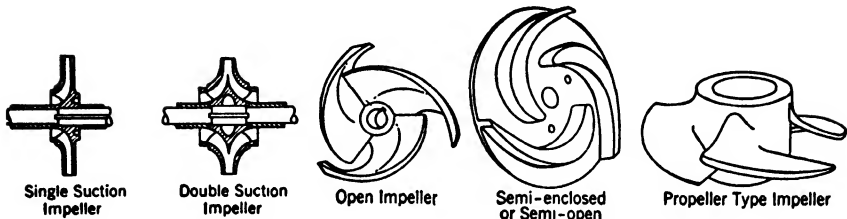


FIG. 146

FIG. 147

Size of Centrifugal Pumps. The practice of determining the nominal size of a centrifugal pump from its suction or discharge nozzle is misleading as to the pump's capacity and should be discouraged. The diameter of the discharge from a centrifugal pump determines its nominal size but does not definitely fix its capacity, and it is recommended that required capacity be stated rather than that the size be named.

Suction Lift

Suction Limitations. Among the most important factors affecting the operation of a centrifugal pump are the suction conditions. Abnormally high suction lifts usually cause serious reductions in the capacity and efficiency of the pump and often lead to serious troubles from vibration and cavitation.

Consequently standard centrifugal pump guarantees are made, unless otherwise specified, upon not more than 15 ft total dynamic suction lift when pumping the required capacity of water at not over 85 F at sea level. For suction lifts higher than this, the manufacturer must be consulted for specific recommendations.

Special Applications

Fire Pumps. Underwriters'. Underwriters' fire pumps of the single-stage and multi-stage type will be furnished in accordance with the specifications of the National Fire Protection Association.

ART. 6-C. ROTARY PUMPS (24)

Description

All types of rotary pumps have certain characteristics which are classified in the two following paragraphs.

They are positive displacement pumps, and therefore are suitable for handling thick and viscous liquids which are handled with difficulty by pumps of other types. They have close mechanical clearances or mechanical contact between parts which makes them most suitable for handling (a) liquids that lubricate, such as petroleum products, vegetable oils, greases, and soap, and (b) liquids having a high vapor pressure, such as gasoline and benzene. They are self-priming because of their positive displacement action and therefore find many applications where the pumping problem is on the suction side of the pump, such as priming units for centrifugal pumps, ice-plant core water units, and vacuum services of various kinds.

Rotary pump design permits of application where high vacuums are required, up to within one inch of barometer. This type of pump has been developed to cover all pressures up to 1000 psi and capacities to 35,000 gpm. They have been used successfully to handle materials having viscosities up to 500,000 S.S.U. and temperatures to 850 F.

Definitions of Types and Parts

Rotary Pump. A positive displacement pump with a fixed casing containing the rotating element or elements consisting of gears, cams, screws, vanes, or modifications of these elements.

Materials Used. Practically all types of rotary pumps are made with solid cast iron, solid bronze, bronze lined, bronze fitted, and cast steel construction. Special metals to suit the purchasers' requirements can be furnished by the manufacturer.

Capacity. The diameter of the discharge from a rotary pump determines its nominal size but does not fix its capacity. It is recommended that the required capacity be stated rather than that the size be named.

Pump Ratings. Practically all rotary-pump manufacturers list their product in catalogs by the displacement of the pump. This is necessary because of the wide variety of conditions encountered.

ART. 6-D. RECIPROCATING DISPLACEMENT PUMPS (24)

Definitions of Types and Parts

Direct-Acting Pump. A steam-driven reciprocating pump in which the steam piston is directly connected to the liquid piston or plunger through the piston rod. The length of the stroke is determined by the action of the steam in the steam cylinder.

Crank and Flywheel Pump. A steam-driven reciprocating pump with crankshaft

on which the flywheel is mounted for storing energy during the early part of the stroke and imparting this stored energy to the liquid piston or plunger during the latter part of the stroke, after the steam is cut off in the steam cylinder. The length of the stroke is determined by the throw of the main crank.

Power Pump. A reciprocating pump driven by power from an outside source applied to the crankshaft of the pump.

Single Pump. A reciprocating pump having one liquid piston or its equivalent single- or double-acting plunger.

Duplex Pump. A reciprocating pump having two liquid pistons or their equivalent single- or double-acting plungers.

Triples Pump. A reciprocating pump having three pistons or their equivalent single- or double-acting plungers.

Capacity Ratings

Terms Used. It is the general practice of manufacturers of reciprocating pumps to state capacities in terms of piston or plunger displacement without deduction for piston rods and slippage. When specifying the boiler horsepower for boiler feed pumps, it is recommended that 34.5 lb per hr evaporation be used as the basis for calculating the capacity of the pump per boiler horsepower.

Standard Equipment

Valve Service. The fitting of power pumps with liquid valve service other than the manufacturer's standard is not recommended. It is believed to be to the best interest of both the purchaser and the manufacturer, if any special liquid valve service is to be used, that such special valve service be furnished and installed by the purchaser after he has received the pump.

Gear Guard. Covering for the teeth of the pinion and the adjacent teeth of the gear will be furnished as a part of the standard equipment. Gear guards conforming to the laws of the various states will be furnished as extras, when such laws are quoted in the purchaser's inquiry or order.

Fire Pumps (Underwriters')

Duplex Steam-Driven. Underwriters' fire pumps of the duplex steam-driven type will be furnished in accordance with the specifications of the National Fire Protection Association.

ART. 6-E. DEEP-WELL PUMPS (24)

Definitions

Deep-Well Power Pump. This is a reciprocating pump, driven by power from an outside source applied to the pinion shaft of the pump, and consisting of three major parts: the power head, located at the surface of the ground; the cylinder (the pumping element), located under water in the well; and the drop pipe and rods, connecting the power head with the cylinder, forming a conducting pipe for the water from the cylinder to the surface of the ground.

Single-Stroke or Rod Pump. A deep-well single-stroke or rod power pump is a reciprocating power-driven pump having a single pump rod connecting the reciprocating mechanism of the power head with the cylinder plunger. This plunger may be either a single-acting or a double-acting type.

Double-Stroke or Rod Pump. A deep-well two-stroke or double-rod power pump is a reciprocating power-driven pump having two sets of pump rods connecting the re-

ciprocating mechanism of the power head with the cylinder plungers. One line of rod is hollow and the other is solid and works inside the hollow rods. The weight of one set of rods balances the weight of the other set. The cylinder plungers are the single-acting type and work one above the other in the same cylinder.

Triple-Stroke or Rod Pump. A deep-well three-stroke or triple-rod power pump is a reciprocating power-driven pump having three sets of pump rods connecting the reciprocating mechanism of the power head with the cylinder plungers. One line of rod is solid, the second line is hollow and works around the solid line, and the third line is also hollow and works around the other

two. All three lines are of equal weight. The cylinder plungers are single-acting and work one above the other in the same cylinder.

Deep-Well Turbine Pump. A vertical-shaft centrifugal pump with rotating impeller or impellers, suspended from the pump head by a column or eduction pipe which also serves as a support for the shaft and bearings. It is primarily designed for installation in bored wells, but it may also be used in ditches, dug wells, mine shafts, sumps, and many other applications.

Screw- or Propeller-Type Pumps. Primarily designed and used for low head installation, are not included in the classification of deep-well turbine pumps.

ART. 6-F. PUMP INSTALLATIONS (24)

Installations of All Types

Location of Unit. The pump should be as near the water supply as practical so that the static suction lift will be low and so that a short direct suction pipe may be used. The pump should be located so that a short direct discharge pipe with the least number of elbows and fittings may be used, to minimize head loss from friction. It should be placed so that it will be accessible for inspection during operation. Head room should be provided when it is necessary to use cranes. The pump should be protected against floods and a motor-driven unit should be installed in a dry place, if possible.

For a reciprocating pump sufficient room should be allowed for removal of piston or pistons, as well as rods, for repacking or replacement.

Installation. It is recommended that the services of a manufacturer's erecting engineer be employed in installing and starting up pumping equipment which is costly or of a precision type. This insures for the buyer that the machinery is properly installed and also affords the operators the privilege of receiving special instructions.

Foundation. The foundation should be sufficiently substantial to absorb any vibration and to form a permanent rigid support for the base plate. This is important in maintaining the alignment of a direct-connected unit. A concrete foundation on a solid base should be satisfactory. Foundation bolts of the proper size should be imbedded in the concrete, located by a drawing or template. Bolt sleeves should be about two and one-half diameters larger than the bolt ($2\frac{1}{2}$ -in. pipe for 1-in. bolt).

In steam pumps, the steam end should not be bolted down too tightly, but should be allowed to "float" to take care of expansion when hot.

Piping. Both suction and discharge pipes should be independently supported near the pump so that when the flange bolts are tightened no strain will be transmitted to the pump casing.

It is usually advisable to increase the size of both suction and discharge pipes at the pump nozzles in order to decrease the loss of head from friction, and for the same reason piping should be arranged with as few bends as possible and these should be made with a long radius wherever possible.

Suction Piping. The suction piping should be as direct and short as possible, and of a diameter at least one or two sizes larger than the pump connection, except when the lines are very short. Length and size of suction pipe are determined by the maximum allowable total suction lift, which should never exceed 22 ft, friction included.

Hot liquids must flow to the pump by gravity with a positive pressure in excess of the vapor pressure of the material handled.

Pipe should be laid out so that air pockets are eliminated.

It should be tested with pressure for leaks.

It must be perfectly air-tight. Suction strainers are recommended.

Foot Valve. When the suction lift is not very high, it is frequently advisable to install a foot valve to facilitate priming. Foot valves should not be used when the pump is operating against a high static head, as failure of the power would allow the water to rush back suddenly, causing a heavy water hammer. The foot valve should be of the flap type rather than of the multiple-spring type with a clear passage for water of at least the same area as that of the suction pipe. Care must be taken to prevent foreign substances from being drawn into the pump or choking the foot valve, and for this purpose an efficient strainer should be provided. When there is any refuse, such as sticks, twigs, and leaves, in the water, a larger outside screen should be placed around the suction inlet to prevent choking the strainer. This screen should have sufficient openings to keep the flow through it below 2 fps. The net area of the foot valve should be at least equal to the area of the suction pipe, preferably larger.

The net area of the strainer should be at least three or four times the area of the suction pipe.

Air Cocks. It sometimes happens that there is a considerable amount of air or gas in the water pumped. If there is much of this there may be a tendency for the gases to separate in the passages of the pump. For this reason air cocks placed on top of the casing should be opened occasionally to allow the air to escape. If there seems to be an unusual amount of air, these vents may be opened slightly at all times during operation of the pump, connecting them to drain pipes if desired.

Freezing. Care should be taken to prevent the pump from freezing during cold weather when it is not in operation. It may be necessary, when there is any possibility of this, to drain the pump casing of its

water during the shut-down period by removing the plugs in the bottom of the casing.

Raised-Face Flanges. Flange faces on pumps are cast integral with the cylinder and are usually milled, frequently on the same plane with other surfaces, so that, to provide raised-face flanges on a pump cylinder, it is necessary to change patterns and make up a special casting.

On pumps built with cast- or forged-steel bodies where it is necessary to use a joint having restricted gasket area, it is recommended that this be obtained by making the flange joint with a recess rather than a raised face.

Flanged fittings or unions should be used close to the pump in all pipe lines connecting to it, so as to facilitate removal of pump should this become necessary.

Centrifugal-Pump Installations

Discharge Piping. A check valve and a gate valve should be installed in the discharge line. The check valve, placed between the pump and the gate valve, is to protect the pump from excessive pressure and to prevent the water from running back through the pump if the driving machine fails. The gate valve is used in priming and starting and when the pump is to be shut down. It is advisable to close the gate valve before stopping the pump when a foot valve or check valve is installed to prevent water hammer. This is especially important when the pump is operated against a high static head. If reducers are used on the discharge side to increase the size of discharge piping, they should be placed between check valve and pump.

Suction Piping. The suction pipe must be kept free from air leaks. This is particularly important when the suction line is a long one or the static suction lift is high.

Trouble is often caused by the use of bell and spigot pipe in the suction line. Screwed or flanged pipe for the smaller sizes and flanged pipe for the larger sizes or for high suction lifts are recommended.

A horizontal suction line must have a gradual rise to the pump. If other piping is in the way, go under it. Any high point in the pipe will become filled with air and thus prevent proper operation of the pump. *A straight taper reducer should not be used in a horizontal suction line, as it forms an air pocket in the top of the reducer and the pipe.* Use an eccentric reducer instead. If an air pocket is left in the suction pipe when the pump is primed, it will often start up and pump properly for a time; but it is probable that a quantity of air will be drawn from the air pocket and up into the pump, causing the pump to lose its prime. This is especially true when the pump is primed by the use of a foot valve. But even when it is primed by ejector or vacuum pump, a small quantity of air is left in the pocket and this is added to, both from air in the water released by the partial vacuum in the suction pipe and from air admitted

through minute leaks in the pipe connections that ordinarily would not cause trouble. Small air pockets that may cause trouble are formed in the top of any gate valves installed vertically in the suction line. It is recommended that the gate valves in the suction line be laid so that the stems are horizontal. Trouble caused by an air pocket in the suction line can usually be stopped temporarily by priming and starting the pump several times. This will draw out enough of the air in the pocket so that the pump will operate properly, but the trouble is likely to recur, and such a pocket should be eliminated.

Check valves should ordinarily have no place in the suction line, although they are sometimes used in series-parallel operation to reduce the number of valves which are to be operated when changing from series to parallel operation. *The pump must not be throttled by the use of a valve on the suction side.*

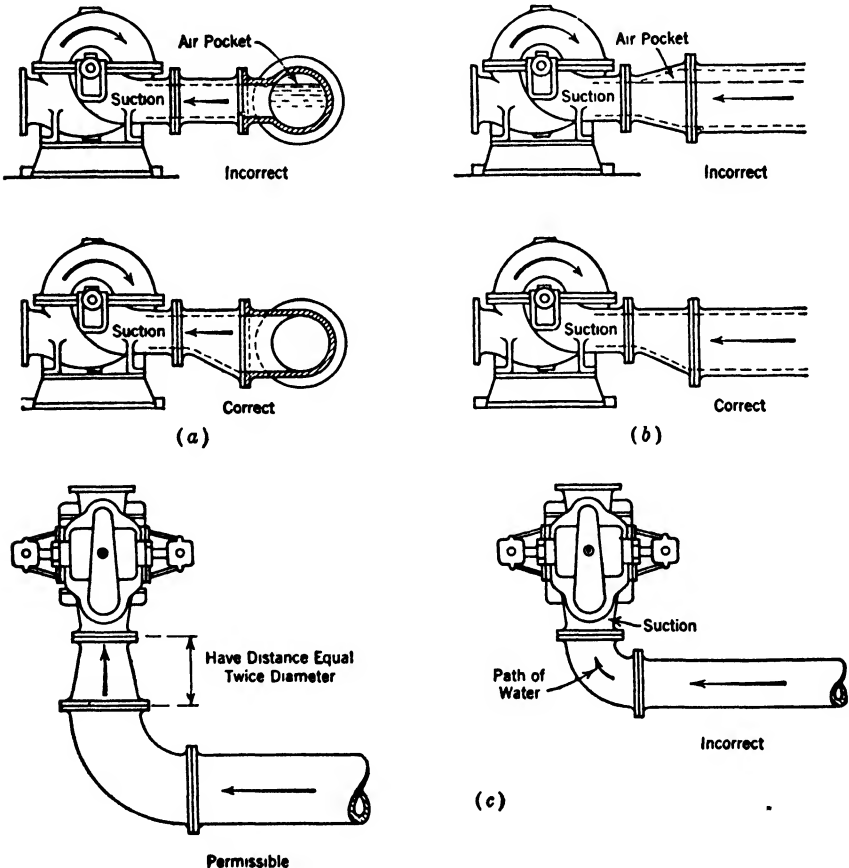


FIG. 148. Suction Piping on Centrifugal Pumps.

Elbow on Suction. Suction piping for double-suction pumps should not be installed so that there is an elbow close to the suction nozzle of the pump except when this elbow is in a vertical position; that is, an elbow bending either straight up or straight down is permissible, but one entering at another angle should not be used. There is always uneven flow around an elbow and when it is installed in any but a vertical position this unequal flow causes more water to enter one side of the runner than can enter the other side, thus causing a reduction in capacity and efficiency and a thrust which will heat the thrust bearing and possibly be of sufficient magnitude to cause rapid wear of the thrust bearing.

Rotary-Pump Installations

Discharge Piping. A by-pass line containing a relief valve should be installed between pump and discharge gate valve to protect pump in case of accidental closing of this valve. The by-pass line should be piped back to the source of supply. If conditions will not permit or warrant piping back to the source of supply, the by-pass line may be piped back to the suction line, but the line should be carried to a point as near the source of supply as possible. Piping back to the suction line is not recommended.

The relief valve should be set to a pressure slightly above the maximum desired at the pump discharge, and not more than 10% above pressure for which the pump is sold. A riser, approximately five times the pipe diameter, should be installed on the discharge side of pump to prevent gas or air pocketing in pump. (See Fig. 149.)

It has been found good practice to put a valve at top of riser to be used as a vent valve when starting pump. It has also been found, when handling hot oil, under some conditions, that a bleeder line from the top of the riser will improve pump operation by carrying off the gases which may come over in the material being pumped.

Drain Piping. When drains are used, pipe the drain connections from drip pocket to a waste line that can be readily cleaned.

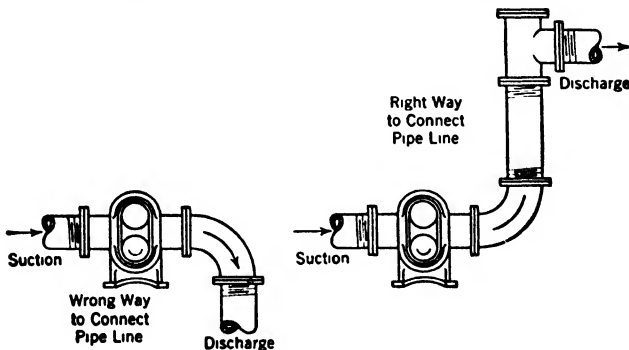


FIG. 149. Discharge Line on Rotary Pumps.

Reciprocating-Pump Installations

Discharge Piping. To protect the pump, a gate valve and check valve should be installed in the discharge pipe close to the pump. Check valve should be placed between pump and gate valve. If reducers are used on the discharge side to increase the size of discharge piping, they should be placed between check valve and pump.

Relief Valve. The insertion of a relief valve of suitable size for the capacity of the pump, set to open at a pressure slightly in excess of the maximum working pressure required of the pump, is highly recommended because of the added safety it affords. The relief valve should be placed in the discharge line as near to the pump as possible, and ahead of any other stop or check valve that may be located in the discharge line. In a steam pump, if the ratio of steam and fluid cylinders is such that an excessive discharge pressure cannot be produced, the relief valve is not absolutely essential, but one should always be installed in the discharge line from a power pump.

Air Chambers. The suction and discharge pipe layout for reciprocating steam and power pumps of conventional type is frequently such that no devices are necessary to compensate for normal variations in velocity of flow in the piping system.

Where the suction or discharge lines, or both, are of considerable length, where water comes to the pump under a static head, where the pump speed in revolutions per minute is high, or where the liquid handled is hot, air chamber of suitable size on the suction or discharge lines, or both, may be found necessary to insure smooth, quiet operation of the unit. The size of the chamber will depend upon the type of pump and the layout of the piping system. Recommendations of size and type of air chambers should be obtained from pump manufacturer, making sure to send full information as to piping installation to be used in any given case. Except in those special types of pumps where manufacturers' standards include such equipment, air chambers should be considered as a part of the piping system.

In general, suction air chambers are more frequently required than are discharge air chambers. Suitable air chambers can now be constructed cheaply of pipe and fittings by welding. In this list, pump types are arranged in order of their relative smoothness of flow, the type listed first most frequently requiring air-chamber compensation:

POWER PUMPS

Single—Single-acting
 Single—Double-acting
 Duplex—Single-acting
 Duplex—Double-acting
 Triplex—Single- and double-acting
 Quintuplex—Single- and double-acting

STEAM PUMPS

Single—Double-acting
 Duplex—Double-acting

Where air chambers are used, provision should be made to keep the chamber charged with air. An air chamber filled with liquid is of no value. A water-level gage is desirable to permit a check on the amount of air in the air chamber.

Air chambers, particularly on the suction, should be located as close as is possible to the pump, and in such position as will provide a direct continuation for the flow of water in the line. In such a position the air chamber will absorb the impact of the moving water column and thus cushion pulsations in the most efficient manner.

When a reciprocating deep-well pump is delivering water above the surface, a large air chamber should be placed between the pump and the check valve in the discharge line. This air chamber will relieve the pump rods of extreme loads caused by pulsating flow.

ART. 6-G. PUMP SERVICES IN BUILDINGS

Services

Pumps are generally used in buildings for the following purposes:

1. General water supply.
 - Overhead tank systems.
 - Pneumatic tank systems.
2. Booster service.
3. Domestic water supply.
4. Fire protection.
5. Circulating service.
 - Hot-water circulation.
 - Drinking-water circulation.
6. Sump drainage.
7. Sewage pumping.

General Water Supply

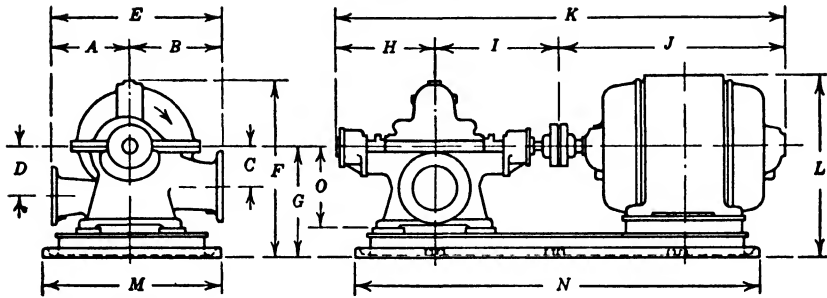
The various systems are described in Chapter 5 of Volume II. Where pump takes off directly from the city pressure main or where there is no suction lift a centrifugal pump can be used. Where there is a suction lift not over 15 ft a centrifugal pump with an automatic primer or a reciprocating pump must be used.

Booster Service

These are centrifugal pumps with intake pressures from the city main and operating only to boost this pressure. They may run continuously or automatically. When the automatic type is not operating the water flows by city pressure through the impellers.

Piston-type pumps can be used for booster service if mounted on a by-pass and take their supply from a tank.

TABLE 107



CENTRIFUGAL PUMPS

APPROXIMATE DIMENSIONS—FEET AND INCHES

(These dimensions are approximate only and are not to be used for construction of foundations.)

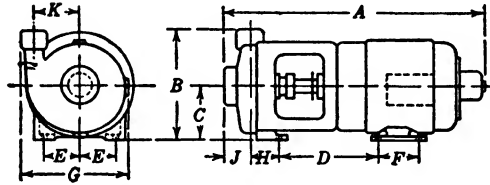
A *right-hand pump* is one whose rotation is *clockwise* when facing the driving end of the pump and having suction on the right and discharge on the left as shown above.

Either right- or left-hand rotation can be furnished. Specify definitely rotation desired when placing an order.

Size	Diam of Dis-charge	Diam of Suc-tion	A	B	C	D	E	F*	G*	H	I	J*	K*	L*	M*	N*	O
1½	1½	2	6½	7	3½	3½	13½	16	9½	10½	12	20	3-6	15	15½	3-3	6½
2	2	2½	7	9	3½	5½	16	18½	11½	10½	12	2-3½	4-1½	19½	19½	3-8½	8½
2½	2½	3	7¾	9½	3½	5½	16½	21½	14½	12	15½	2-2	4-3½	23½	21½	4-2½	9½
3	3	4	7¾	10½	4½	6	18½	22½	14½	12	15½	2-3	4-6½	23½	21½	4-2½	10½
4	4	5	8½	11	5	6½	19½	2-1	17	13½	18½	2-5	5-1½	2-2½	22½	4-8½	11½
5	5	6	11	15	6	9½	2-2	2-6½	19	14½	19½	3-3½	6-1	2-7½	2-½	5-8½	14½
6	6	8	15	19	8	11	2-10	3-0½	22½	19	23½	3-11½	7-6½	3-1½	3-2½	7-2	17
8	8	10	18	21	9½	11½	3-3	3-3½	2-0½	20½	2-1¾	4-1½	7-11½	3-5½	3-2½	7-5	19
10	10	12	19	21	11	12	3-4	3-6½	2-2½	23½	2 4½	4-7½	8-10½	3-7½	3-2½	8-3½	21
10	10	12	21½	20	11½	12½	3-5½	3-3½	2-3½	20½	2-1¾	4-0½	7-11	3-7½	3-6½	7-3	21½
12	12	16	2-2	2-1½	13½	15½	4-3½	4-2½	2-7½	2-0½	2-5½	4-10½	9-4	3-11½	3-2½	8-8	2-1½
14	14	18	2-2	2-3	16	18	4-5	4-7½	2-11	2-0½	2-5½	5-1½	9-7½	4-3½	3-8½	9-4	2-5

* Dimensions F, G, J, K, L, M, and N will vary with the size, type, and make of motor, turbine, or engine used. All dimensions in inches or feet and inches.
 Courtesy Ingersoll-Rand Co., Phillipsburg, N. J.

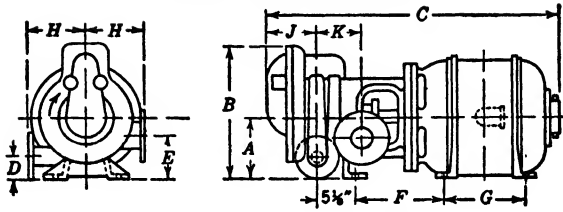
TABLE 108
 APPROXIMATE DIMENSIONS OF CLOSE-COUPLED CENTRIFUGAL PUMPS
 (Will vary with type and make)



Standard Type—Single-Stage

Hp	Disch	Suct	A	B	C	D	E	F	G	H	J	K
3/4	1	1 1/4	16 7/8	8 5/8	4 1/8	6 1/4	3 3/8	3 3/4	7 7/8	1 15/16	2	3 3/4
1 1/4		1 1/4	16 7/8	8 5/8	4 1/8	6 1/4	3 3/8	3 3/4	7 7/8	1 15/16	2	3 3/4
1 3/4		1 3/4	17 3/4	8 5/8	4 1/8	6 1/4	3 3/8	3 3/4	7 7/8	1 15/16	2	3 3/4
2		1 3/4	18 3/4	9	4 1/8	5 7/8	3 3/8	5	7 7/8	1 15/16	2	3 3/4
3		1 3/4	19 3/4	9	4 3/8	5 7/8	3 3/8	5 3/8	7 7/8	1 15/16	2	3 3/4
4		1 3/4	21 3/4	11 1/4	5	4	6 3/8	12 3/4	10 11/16	1 7/8	1 7/8	3 3/4
5		1 3/4	22 3/4	11 3/4	5 1/2	4 3/8	6 3/4	13 3/8	10 7/8	1 7/8	1 7/8	3 3/4
7 1/2		1 3/4	23 3/4	11 3/4	5 1/2	4 3/8	7 3/8	13 3/8	10 7/8	1 7/8	1 7/8	3 3/4
3/4	1 1/2	2	17 3/4	9 3/8	4 1/8	6 1/4	3 3/8	3 3/4	7 7/8	2 7/8	2 3/8	3 3/4
1 1/4		2	17 3/4	9 3/8	4 3/8	6 1/4	3 3/8	3 3/4	7 7/8	2 7/8	2 3/8	3 3/4
1 3/4		2	18 1/4	9 3/8	4 3/8	6 1/4	3 3/8	3 3/4	7 7/8	2 7/8	2 3/8	3 3/4
2		2	19 1/4	9 3/8	4 3/8	5 7/8	3 3/8	5	7 7/8	2 7/8	2 3/8	3 3/4
3		2	20 1/4	9 3/8	4 3/8	5 7/8	3 3/8	5 3/8	7 7/8	2 7/8	2 3/8	3 3/4
4		2	22 1/4	10	5	7 3/8	4	6 3/4	12 3/4	2 7/8	2 3/8	3 3/4
5		2	23 1/4	10 3/4	5 1/2	7 3/8	4 3/8	6 3/4	13 3/8	2 7/8	2 3/8	3 3/4
7 1/2		2	23 3/4	10 3/4	5 1/2	7 3/8	4 3/8	7 3/8	13 3/8	2 7/8	2 3/8	3 3/4
3/4	2	3	19 3/4	10 1/8	4 1/8	6 1/4	3 3/8	3 3/4	7 7/8	3 3/4	2 15/16	3 3/4
1 1/4		3	20	10 5/8	4 1/8	5 7/8	3 3/8	5	7 7/8	3 3/4	2 15/16	3 3/4
1 3/4		3	21	10 5/8	4 3/8	5 7/8	3 3/8	5 3/8	7 7/8	3 3/4	2 15/16	3 3/4
2		3	23	11	5	7 3/8	4	6 3/4	12 3/4	3 3/4	2 15/16	3 3/4
3		3	24	11 3/4	5 1/2	7 3/8	4 3/8	6 3/4	13 3/8	3 3/4	2 15/16	3 3/4
4		3	24	11 3/4	5 1/2	7 3/8	4 3/8	6 3/4	13 3/8	3 3/4	2 15/16	3 3/4
5		3	24 3/4	11 3/4	5 1/2	7 3/8	4 3/8	7 3/8	13 3/8	3 3/4	2 15/16	3 3/4
7 1/2		3	24 3/4	11 3/4	5 1/2	7 3/8	4 3/8	7 3/8	13 3/8	3 3/4	2 15/16	3 3/4

TABLE 108 (Continued)

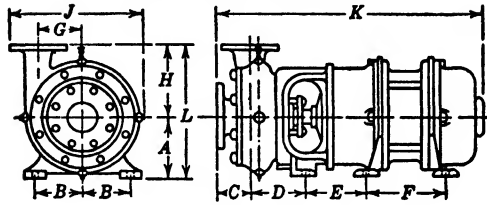


Heavy-Duty Type—Two-Stage

Hp	Disch	Suct	A	B	C	D	E	F	G	H	J	K
10	1 1/2	2 1/4	7	16 1/4	37 1/8	2 1/8	4 1/4	11 1/8	9 1/4	7 1/4	6 1/4	5 1/4
15		2 1/4	8	17 1/4	38 3/8	3 1/8	5 1/4	11 3/8	10 1/4	7 1/4	6 1/4	5 1/4
20		2 1/4	8	17 1/4	40 5/8	3 1/8	5 1/4	11 5/8	12	7 1/4	6 1/4	5 1/4
25		2 1/4	9	18 1/4	42 1/8	4 1/8	6 1/4	13 1/8	11 1/4	7 1/4	6 1/4	5 1/4
30		2 1/4	9	18 1/4	43 1/8	4 1/8	6 1/4	13 3/8	12 1/4	7 1/4	6 1/4	5 1/4
10	2	3	7	17 1/4	40 1/8	1 1/4	4 1/4	11 1/8	9 1/4	8	9 3/4	5 3/4
15		3	8	18 3/4	41 3/8	2 1/4	5 1/4	11 3/8	10 1/4	8	9 3/4	5 3/4
20		3	8	18 3/4	43 1/8	2 1/4	5 1/4	11 5/8	12	8	9 3/4	5 3/4
25		3	9	19 3/4	44 1/4	3 1/4	6 1/4	13 1/8	11 1/4	8	9 3/4	5 3/4
30		3	9	19 3/4	45 1/4	3 1/4	6 1/4	13 3/8	12 1/4	8	9 3/4	5 3/4
40		3	10	20 3/4	47 1/4	4 1/4	7 1/4	13 3/8	12 1/4	8	9 3/4	5 3/4

All dimensions in inches.
 Courtesy Ingersoll-Rand Co., Phillipsburg, N. J.

TABLE 108 (Continued)



Heavy-Duty Type—Single-Stage

Hp	Disch. Size	Suct. Size	A	B	C	D	E	F	G	H	J	K	
1	1 1/2	2 1/2	5	4	4	4 3/4	6 1/4	6 3/4	4 3/4	6 3/4	12 3/4	24 1/4	
1 1/4		2 1/2	5 1/2	4 1/4	4	4 3/4	6 5/8	6 3/4	4 3/4	6 3/4	13 3/8	25 1/4	
2		2 1/2	5 1/2	4 1/4	4	4 3/4	6 5/8	7 3/8	4 3/4	6 3/4	13 3/8	26	
3		2 1/2	5 1/2	4 1/4	4	4 3/4	6 5/8	7 3/8	4 3/4	6 3/4	13 3/8	26	
5		2 1/2	6 1/4	5	4	5	6 5/8	8 3/8	4 3/4	6 3/4	16 1/8	28	
7 1/2		2 1/2	7	5 1/2	4	5	7	9 3/8	4 3/4	6 3/4	17 3/8	30	
10		2 1/2	8	6 1/4	4	5	7 3/4	10 3/8	4 3/4	6 3/4	18 3/8	31 3/4	
15		2 1/2	8	6 1/4	4	4 3/4	7 3/4	10 3/4	4 3/4	6 3/4	20 3/8	33 3/4	
1	2	3	5 1/4	4 3/4	4 3/4	4 3/4	6 5/8	6 3/4	4 3/4	7 3/4	13 3/4	27 1/4	
1 1/4		3	5 1/4	4 3/4	4 3/4	4 3/4	6 5/8	6 3/4	4 3/4	7 3/4	13 3/4	27 1/4	
2		3	5 1/4	4 3/4	4 3/4	4 3/4	6 5/8	6 3/4	4 3/4	7 3/4	13 3/4	27 1/4	
3		3	5 1/4	4 3/4	4 3/4	4 3/4	6 5/8	6 3/4	4 3/4	7 3/4	13 3/4	27 1/4	
5		3	5 1/4	4 3/4	4 3/4	4 3/4	6 5/8	7 3/8	4 3/4	7 3/4	13 3/4	26 3/4	
7 1/2		3	6 1/4	5	4 3/4	4 3/4	5	6 5/8	8 3/8	4 3/4	7 3/4	16 1/8	28 1/4
10		3	7	5 1/2	4 3/4	4 3/4	4 3/4	7	9 3/8	4 3/4	7 3/4	17 3/8	30 1/4
15		3	8	6 1/4	4 3/4	4 3/4	4 3/4	7 3/4	10 3/8	4 3/4	7 3/4	19 3/8	31 3/4
20	3	8	6 1/4	4 3/4	4 3/4	4 3/4	7 3/4	12	4 3/4	7 3/4	20 3/4	33 3/4	
1 1/4	3	4	5 1/4	4 3/4	5 1/4	5 1/4	7	6 3/4	5 3/4	9 3/4	17 1/4	28 1/4	
2		4	5 1/4	4 3/4	5 1/4	5 1/4	7	7 3/8	5 3/4	9 3/4	17 3/4	29	
3		4	5 1/4	4 3/4	5 1/4	5 1/4	7	7 3/8	5 3/4	9 3/4	17 3/4	29	
5		4	7	5 1/4	5 1/4	6	7 3/8	9 3/8	5 3/4	9 3/4	17 3/4	33	
7 1/2		4	8	6 1/4	5 3/4	6	7 3/8	10 3/8	5 3/4	9 3/4	17 3/4	34 3/4	
10		4	8	6 1/4	5 3/4	6	7 3/8	10 3/8	5 3/4	9 3/4	18 3/8	34 3/4	
15		4	8	6 1/4	5 3/4	6	8 1/8	12	5 3/4	9 3/4	20 3/8	36 3/4	
20		4	9	7	5 3/4	5 3/4	8 5/8	11 3/8	5 3/4	9 3/4	21 3/8	36 3/4	
25	4	9	7	5 3/4	5 3/4	8 5/8	12 3/8	5 3/4	9 3/4	21 3/8	37 3/4		
3	4	5	5 1/4	4 3/4	6	5 5/8	7	7 3/4	6 3/4	10 3/4	19 3/4	29 3/4	
5		5	7	5 1/4	6	6	7 3/8	9 3/8	6 3/4	10 3/4	19 3/4	33 3/4	
7 1/2		5	8	6 1/4	6	6	7 3/8	10 3/8	6 3/4	10 3/4	19 3/4	35 3/4	
10		5	8	6 1/4	6	6	8 3/8	12	6 3/4	10 3/4	19 3/4	37 3/4	
15		5	8	6 1/4	6	6	8 3/8	12	6 3/4	10 3/4	19 3/4	37 3/4	
20		5	9	7	6	5 3/4	8 5/8	11 3/8	6 3/4	10 3/4	21 3/8	36 3/4	
25		5	9	7	6	5 3/4	8 5/8	12 3/8	6 3/4	10 3/4	21 3/8	37 3/4	
30		5	10	8	6	5 3/4	9 5/8	13 3/8	6 3/4	10 3/4	24 3/8	40 3/4	
40	5	11	9	6	5 3/4	10 5/8	14 3/8	6 3/4	10 3/4	26 3/8	43 3/4		
25	5	6	9	7	6 3/8	5 5/8	8 5/8	12 3/4	8 3/4	8 3/4	21 3/4	38 3/4	
40		6	11	9	6 3/8	5 7/8	10 7/8	14 3/4	8 3/4	8 3/4	26 3/4	43 3/4	

All dimensions in inches.
 Courtesy Ingersoll-Rand Co., Phillipsburg, N.J.

Domestic Water Supply

- Shallow well (suction lift not over 22 ft).
- Deep well (for greater depths than 22 ft).
- Complete pneumatic systems.
- Electric or gasoline motors.

Shallow Wells. Horizontal double-acting piston pumps for capacities of 250, 500, and 750 gph.

42-gal galvanized storage tank, or larger if desired; air-volume control.

Deep Wells. 4-, 6-, 8-, and 12-in. strokes, 42 gal galvanized tank, capacities up to 3750 gph.

Fire Protection

Fire pumps usually are the centrifugal type, either single- or multi-stage. They may be driven by electricity, steam, or gasoline. Whatever the power supply, it must be of a permanent type and, if steam, must have a constant minimum pressure of 50 lb steam. The pumps should be in accordance to the specifications of the NFPA.

Booster fire pumps are a low-head type to boost the pressure of the already available city supply.

See also Art. 7-D.

TABLE 109
SUMP DRAINAGE PUMPS
Vertical Centrifugal Pumps for Wet Pit
Goulds 3047—1750 rpm
Performance Charts

All ratings are for clear, cold water—Table shows size of pump and motor hp.

Gallons per Minute

Total Head in Feet	Gallons per Minute													
	10	20	30	40	50	60	75	100	150	200	250	300	400	500
60	3-3	3-3*	3-3*	3-3*	3-3*	3-3*	3-3*	4-5*	4-7½	4-7½	4-7½			
50	1½-1*	3-2*	3-2*	3-2*	3-2*	3-3	3-3	3-3	3-3*	3-5	4-5*	4-7½	4-7½	
40	1½-¾*	1½-1	1½-1	1½-1	1½-1½	2-1½	2-1½	3-2*	3-3	3-5	3-5	3-5	4-7½	4-7½
35	1½-¾	1½-¾	1½-¾	1½-¾*	1½-1	1½-1½	2-1½	2-1½	3-2*	3-3	3-3	3-5	4-5	4-7½
30	1½-¾*	1½-¾	1½-¾	1½-¾	1½-¾*	1½-1	1½-1½	2-1½	3-2	3-2*	3-3	3-5	4-5	4-5
25	1½-¾	1½-¾	1½-¾	1½-¾	1½-¾	1½-¾	1½-¾	2-1	2-1½	3-2	3-3	3-3	4-5	4-5
20	1½-¾	1½-¾	1½-¾	1½-¾	1½-¾	1½-¾	1½-¾	2-1	2-1½	3-2	3-2	3-3	4-3	4-5
15	1½-¾	1½-¾	1½-¾	1½-¾	1½-¾	1½-¾	1½-¾	2-¾	2-1½	3-2	3-2	3-3	4-3	4-5
10	1½-¾	1½-¾	1½-¾	1½-¾	1½-¾	1½-¾	1½-¾	2-¾	2-1	3-2	3-2	3-2	4-3	4-3

* If continued operation under reduced head likely, use next larger size motor.
Courtesy Goulds Pumps, Inc., Seneca Falls, N. Y.

TABLE 110
 SUMP DRAINAGE PUMPS
 Vertical Centrifugal Pumps for Dry Pit
 GOULDS 3047-F—1150 and 1750 rpm
 Performance Charts

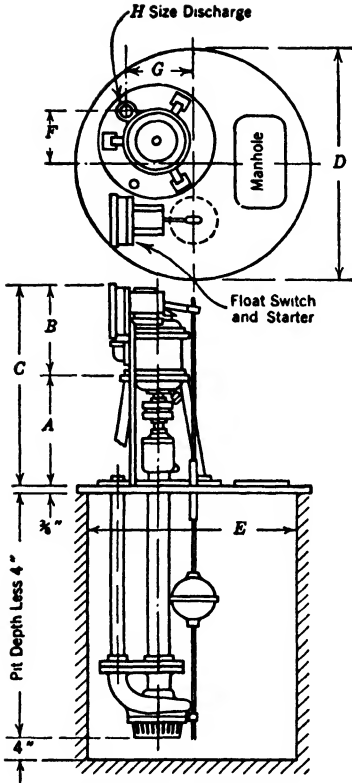
All ratings are for clear, cold water. Maximum suction lift is 15 ft. Table shows size of pump and motor hp. Bold-face type preceded by an X indicates 1150 rpm.

Gallons per Minute

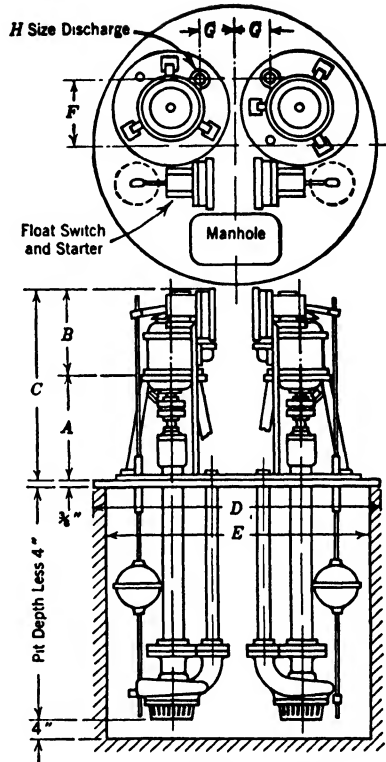
	10	20	30	40	50	60	75	100	150	200	250	300	400	500	
Total Head in Feet	60	2-2	2-2	2-2*	2-3	2-3	2-3	2-3	2-5	2-7½	3-7½	3-7½	4-10	4-15	
	50	1½-¾* x3-2	1½-1 x3-2	1½-1½ x3-2	2-2 x3-2	2-2 x3-2*	2-2 x3-2*	2-3 x3-3	2-3 x3-3	2-5	2-5* x4-5*	3-5 x4-5*	3-10	4-10	
	40	1½-¾ x2-1	1½-¾* x2-1	1½-¾* x2-1½	1½-1* x2-1½	1½-1* x3-1½	1½-1½ x3-1½	1½-1½ x3-2	2-2 x3-2	2-3	2-5 x3-5	3-5	3-5 x4-5*	3-10 x4-7½	4-10
	35	1½-¾ x2-¾*	1½-¾ x2-¾*	1½-¾ x2-1	1½-¾* x2-1½	1½-1* x2-1½	1½-1* x2-1½	1½-1½ x2-1½	2-2 x3-1½	2-3 x3-3	2-5 x3-3	3-5 x4-5	3-5 x4-5	3-7½ x4-5*	4-10 x4-7½
	30	1½-¾ x2-¾	1½-¾ x2-¾	1½-¾ x2-¾*	1½-¾ x2-1	1½-¾ x2-1	1½-1 x2-1*	1½-1½ x2-1½	1½-1½ x2-1½	2-3 x3-2	2-5 x3-3	3-5 x3-5	3-5 x4-5	3-7½ x4-5	4-10 x4-7½
	25	1½-¾ x2-¾	1½-¾ x2-¾	1½-¾ x2-¾	1½-¾ x2-¾	1½-¾ x2-¾*	1½-¾ x2-1	1½-1 x2-1*	1½-1½ x2-1½	2-3 x3-1½	2-5 x3-3	2-5 3-3	3-5 x4-3	3-7½ x4-5	4-10 x4-7½
	20	1½-¾ x2-¾	1½-¾ x2-¾	1½-¾ x2-¾	1½-¾ x2-¾	1½-¾ x2-¾	1½-¾ x2-¾	1½-1 x2-1	1½-1½ x2-1	2-2 x3-1½	2-3 x3-2	2-5 x3-3	3-5 x3-5	3-7½ x4-5	4-10 x4-5
	15					x2-¾	x2-¾	1½-1 x2-¾	1½-1½ x2-1	2-2 x2-2	2-3 x3-1½	3-3	3-5 x3-5	x4-5	x4-5
	10							1½-¾ x2-¾	1½-1½ x2-¾	x2-1½	x3-1½	x3-2	x3-3	x4-3	x4-5

* If continued operation under reduced head likely, use next larger size motor.
 Courtesy Goulds Pumps, Inc., Seneca Falls, N.Y.

TABLE 111
 SUMP DRAINAGE PUMPS
 DIMENSIONS
 (All dimensions in inches)



GOULDS 3047 AND 3047-F



GOULDS 3048 AND 3048-F

Figure Number	SINGLE								DUPLEX							
	Wet Pit 3047				Dry Pit 3047-F				Wet Pit 3048				Dry Pit 3048-F			
Size Pump	1½	2	3	4	1½	2	3	4	1½	2	3	4	1½	2	3	4
A	15	16½	17	19	17	19½	21½	24	15	16½	17	19	17	19½	21½	24
B	13½	12	12	14	11½	13½	17½	19	13½	12	12	14	11½	13½	17½	19
C	28½	28½	29	33	28½	33½	38	43	28½	28½	29	33	28½	33½	38	43
D	40	40	40	40	46	46	52	52	54	54	60	60	60	60	80	80
E (Standard)	36	36	36	36	42	42	48	48	48	48	54	54	54	54	74	74
F	6	6½	8	8½	3½	4	6	8	6	6½	8	8½	13½	14	6	8
G	7	7½	9	10	12½	14	13	8	4	4½	5	5½	10½	9½	13	11
H	1½	2	3	4	1½	2	3	4	1½	2	3	4	1½	2	3	4

Courtesy Gould Pump Co., Seneca Falls, N.Y.

Circulating Service

Hot-Water Circulating. These pumps are the centrifugal type. They are used to move water in a closed system and thus usually require only a low head, though the static pressure in the systems may be high. The pumps should be selected with attention to strength of casing, efficient stuffing box, freedom from air and vapor binding, and flexible mounting.

Sump-Drainage Service

Sump pumps are not classified as sewage pumps and should not be used for such purpose. They may be vertical or horizontal centrifugal type. The vertical type usually has the impeller submerged and the motor mounted above the pit. Units are equipped with float and an automatic switch operated by the float. They are available in single or duplex type.

Ejectors for dry-pit installations have a connection on the suction end of the pump which is piped to a separate wet pit.

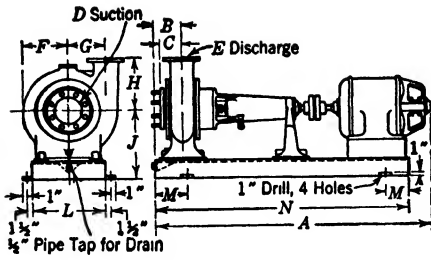
Sewage Pumps

Centrifugal type with non-clogging impellers.

Either horizontal or vertical with suction lift or placed in dry pit.

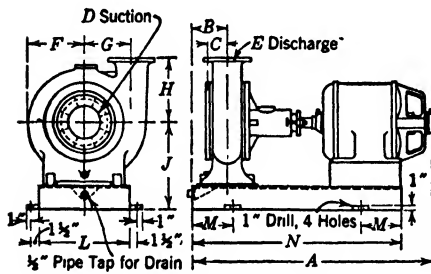
Float or diaphragm controls for automatic operation.

TABLE 112
SEWAGE PUMPS
TABLES OF DIMENSIONS



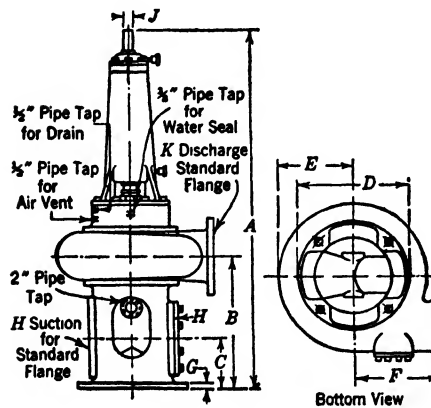
Pump	A	B	C	D	E	F
4	53	6	3 3/4	5	4	7 7/8
4	54	7 1/4	4 1/8	5	4	10
5	57	7 1/4	4 1/8	6	5	10 3/4
6	64	8 3/4	4 1/8	8	6	11 1/2
6	69	8 3/4	4 1/8	8	6	13
8	73	9 1/4	5 1/8	10	8	15
8	81	10 3/4	6 7/8	10	8	18

Pump	G	H	J	L	M	N
4	7	9	15	16 3/4	8 3/8	50 3/4
4	8 7/8	9 3/8	17	16 3/4	8 3/8	52 3/4
5	9 3/4	10 3/8	18	16 3/4	8 3/8	54 3/4
6	10	12	19 3/8	18 3/4	8 3/8	62 3/4
6	11	12 3/8	20 3/8	18 3/4	8 3/8	66 3/4
8	12	13	22	22 3/4	10 3/8	68 3/4
8	14 1/2	18	24 3/8	26 3/4	10 3/8	78 3/4



Pump	A	B	C	D	E	F
4	32	6	3 3/4	5	4	7 7/8
4	38	7 3/4	4 1/8	5	4	10
5	43	7 3/4	4 1/8	6	5	10 3/4
6	46	8 3/4	4 1/8	8	6	11 1/2
6	50	8 3/4	4 1/8	8	6	13
8	53	9 3/4	5 1/8	10	8	15
8	56	10 3/4	6 7/8	10	8	18

Pump	G	H	J	L	M	N
4	7	9	15	16 3/4	8 3/8	30 3/4
4	8 7/8	9 3/8	17	16 3/4	8 3/8	36 3/4
5	9 3/4	10 3/8	18	16 3/4	8 3/8	40 3/4
6	10	12	19 3/8	18 3/4	8 3/8	42 3/4
6	11	12 3/8	20 3/8	18 3/4	8 3/8	46 3/4
8	12	13	22	22 3/4	8 3/8	48 3/4
8	14 1/2	18	24 3/8	26 3/4	8 3/8	50 3/4



Pump	A	B	C	D	E
4	In.	In	In	In	In.
4	46 3/4	16 3/8	6 1/4	16	9
4	52 11/16	18 11/16	7 1/4	20	11 1/8
5	52 11/16	18 11/16	7 1/4	20	11 1/8
6	55 11/16	21 1/8	8 1/4	20	12 3/8
6	55 11/16	21 1/8	8 1/4	20	12 3/8
6	55 11/16	21 1/8	8 1/4	20	14 3/8
6	55 11/16	21 1/8	8 1/4	20	14 3/8
6	66 3/8	26 3/8	11	24	16 3/8
8	66 3/8	26 3/8	11	24	16 3/8

Pump	F	G	H	J	K
4	In.	In.	In.	In.	In.
4	11	3/8	5 & 4	1 3/4	4
4	11 3/4	1	6 & 4	1 3/4	4
5	11 3/4	1	6 & 4	1 3/4	5
6	14 3/4	1	8 & 6	1 3/4	6
6	14 3/4	1	8 & 6	1 3/4	8
6	14 3/4	1	8 & 6	1 3/4	6
6	14 3/4	1	8 & 6	1 3/4	8
6	16 1/4	1	10 & 8	1 11/16	8
8	16 1/4	1	10 & 8	1 11/16	10

Courtesy Chicago Pump Co., Chicago, Ill.

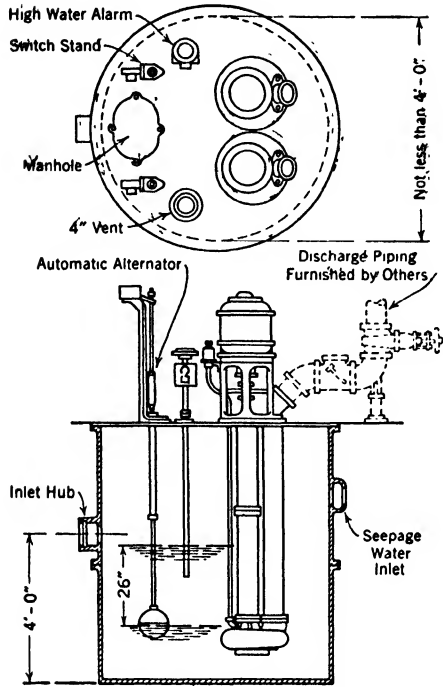


FIG. 150. Sewage Ejector, Wet-Basin Type. (Duplex wet basin non-clog sewage ejector. Equipment includes pumps and fittings, electric motors, float switches, automatic alternator, high-water alarm, motor switches, and automatic starters. Layout shows equipment with round cast-iron or steel basin. This layout is for 4-in. pumps.) (Courtesy Chicago Pump Co., Chicago, Ill.)

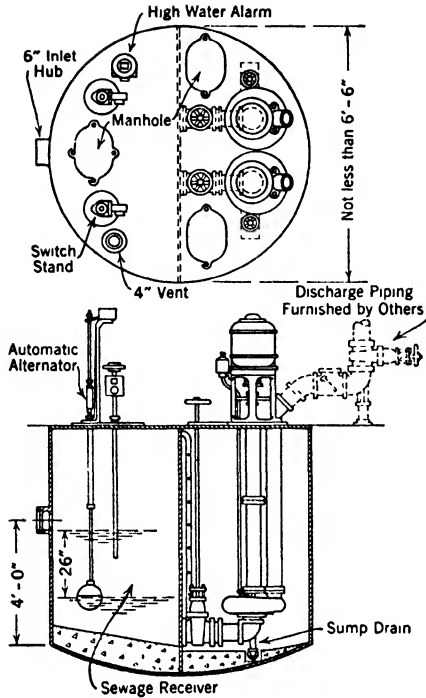


FIG. 151. Sewage Ejector, Dry-Basin Type. (Duplex dry-basin non-clog sewage ejector installation. Equipment includes pumps with suction and discharge piping up to floor plate, electric motors, steel ejector basin with separate sewage and pump compartments, high-water alarm, automatic alternator, float switches, floor-mounted control panel, motor switches, automatic starters, iron access ladder, and complete basin covers which are welded or riveted to basin. The following features make it the most popular dry-basin non-clog equipment. (1) It requires less space. (2) Pumps and piping connections of all equipment are accurately lined up at the factory. With this equipment no misalignment can occur at the time installation is made, because pumps, basin, basin cover, and connections are constructed as one complete unit. This greatly simplifies and expedites assembly of the equipment when it is erected on the job. (3) It makes a neat, compact, and clean-cut appearance. This layout is for 4-in. pumps.) (Courtesy Chicago Pump Co., Chicago, Ill.)

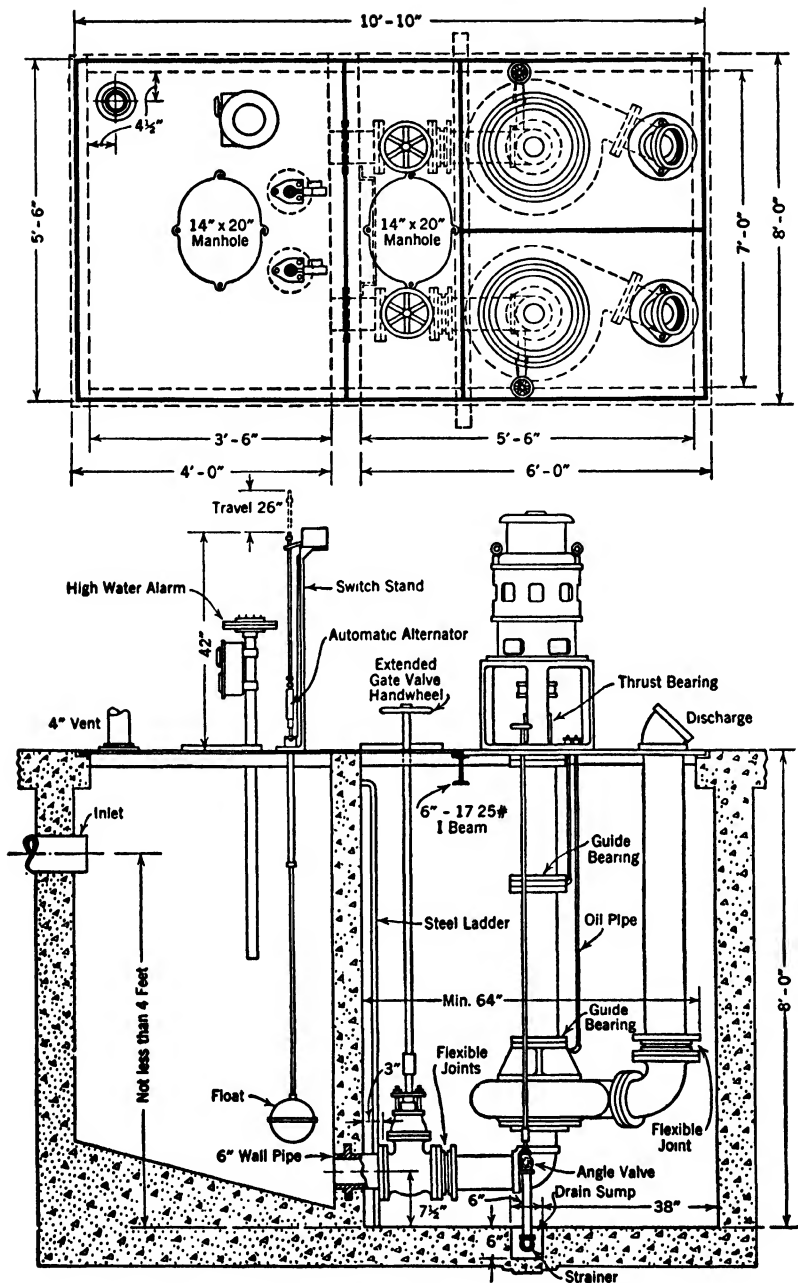


FIG. 152. Sewage Ejector, Dry-Basin Type. (Typical dry-basin non-clog sewage ejector, designed for municipal sewage-disposal plants and lift stations. These pumps are built in sizes 6 in. and larger. Float guide pipes are furnished where inflow interferes with flow action. This layout is for 6-in. pumps.) (Courtesy Chicago Pump Co., Chicago, Ill.)

Typical Pump Problem (reproduced courtesy of Ingersoll-Rand Co.)

Assume pump is to deliver 1500 gpm of clear cold water to an elevation 130 ft above the source of supply, using a total of 150 ft of piping; the pump to be located 10 ft above the source of supply, making the static suction lift (H_s) 10 ft and the static discharge head (H_d) 120 ft (See Fig. 153).

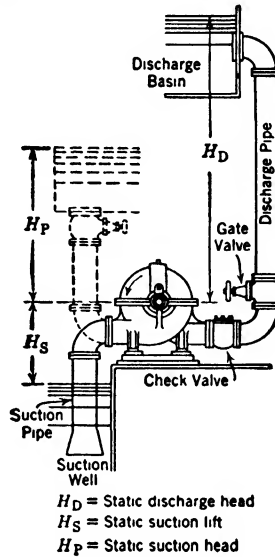


FIG. 153

The friction loss and velocity head may be obtained from Table 113. The suction pipe should be, and it is good practice for the discharge pipe to be, at least one pipe size larger than the connections on the pump.

The velocity head is the head required to accelerate the water in the discharge pipe, and should be included in the total head.

Using an 8-in. discharge pipe and a 10-in. suction pipe, the total head is as follows.

Static head ($H_d + H_s$)	130 ft
Friction (140 ft of 8-in. pipe) (disch.)	8.7 ft
Friction (10 ft of 10-in. pipe) (suction)	0.21 ft
Friction (3—8-in.—90-deg ells) (disch.)	3.75 ft
Friction (1—10-in.—90-deg ell) (suction)	0.53 ft
Friction (check valve and gate valve ordinarily negligible, say)	2.0 ft
Velocity head (8-in. pipe)	1.42 ft
Entrance loss (assume equal to velocity head for suction pipe)	0.58 ft
Total Head	147.19 ft

The suction lift is included in the above but must be checked separately to see that it does not exceed the limit for the pump (in most cases 15 ft). In this case the suction lift is as follows:

Suction	
Static lift (<i>H_s</i>)	10 ft
Friction (10 ft of 10-in. pipe)	0.21 ft
Friction (1—10-in.—90-deg ell)	0.53 ft
Velocity head (10-in. suction nozzle)	0.58 ft
Entrance loss (assume equal to velocity head for suction pipe)	0.58 ft
<hr/>	
Total Suction Lift	11.90 ft

The pump, therefore, must pump 1500 gpm against a total head of 147.2 ft including a suction lift of 11.9 ft.

TABLE 113
PIPE FRICTION*

(Corresponding to "17-year pipe." For new and smooth iron pipe the head loss will be 0.7 of that shown)

U.S. Gals. per Min	Velocity Head	Head Loss in Feet per 100 Ft	U.S. Gals. per Min	Velocity Head	Head Loss in Feet per 100 Ft	U.S. Gals. per Min	Velocity Head	Head Loss in Feet per 100 Ft	U.S. Gals. per Min	Velocity Head	Head Loss in Feet per 100 Ft
3-in. Pipe			4-in. Pipe			5-in. Pipe			6-in. Pipe		
35	0.04	0.71	50	0.03	0.34	80	0.03	0.27	100	0.02	0.17
40	0.05	0.91	60	0.04	0.47	90	0.03	0.34	110	0.02	0.21
50	0.08	1.38	70	0.05	0.63	100	0.04	0.41	125	0.03	0.26
60	0.12	1.92	80	0.06	0.81	120	0.06	0.58			
70	0.16	2.57	90	0.08	1.00	140	0.08	0.76	140	0.04	0.32
									160	0.05	0.40
80	0.20	3.28	100	0.10	1.22	160	0.11	0.98	180	0.07	0.50
90	0.26	4.08	120	0.15	1.71	180	0.13	1.22	190	0.07	0.55
100	0.32	4.96	140	0.20	2.28	200	0.17	1.48	200	0.08	0.61
120	0.46	7.0	160	0.26	2.91	220	0.20	1.77			
140	0.63	9.2	180	0.33	3.61	240	0.24	2.08	220	0.09	0.73
									240	0.11	0.87
160	0.82	11.8	200	0.41	4.4	260	0.28	2.41	260	0.13	1.00
180	1.04	14.8	220	0.49	5.2	280	0.33	2.77	280	0.16	1.14
200	1.28	17.8	240	0.58	6.2	300	0.37	3.14	300	0.18	1.30
220	1.55	21.3	260	0.69	7.2	320	0.42	3.54			
240	1.84	25.1	280	0.79	8.2	350	0.51	4.19	320	0.20	1.47
									350	0.24	1.70
260	2.16	29.1	300	0.91	9.3	400	0.66	5.4	380	0.28	2.00
280	2.51	33.4	320	1.04	10.5	450	0.84	6.7	400	0.32	2.20
300	2.88	38.0	340	1.17	11.7	500	1.04	8.1	450	0.40	2.74
320	3.28	42.8	360	1.31	13.1	550	1.26	9.6			
340	3.71	47.9	400	1.62	16.0	600	1.49	11.3	500	0.50	2.90
									550	0.60	3.96
360	4.15	53.0	450	2.05	19.8	650	1.75	13.2	600	0.72	4.65
380	4.62	59.0	500	2.53	24.0	700	2.03	15.1	700	0.98	6.21
400	5.11	65.0	550	3.06	28.7	750	2.34	17.2	800	1.28	7.96
420	5.64	71.0	600	3.65	33.7	800	2.66	19.4			
440	6.20	77.0	650	4.28	39.0	850	2.99	21.7	900	1.62	9.92
									1000	1.99	12.02

TABLE 113 (Continued)

U.S. Gals. per Min	Velocity Head	Head Loss in Feet per 100 Ft	U.S. Gals. per Min	Velocity Head	Head Loss in Feet per 100 Ft	U.S. Gals. per Min	Velocity Head	Head Loss in Feet per 100 Ft	U.S. Gals. per Min	Velocity Head	Head Loss in Feet per 100 Ft
8-in. Pipe			10-in. Pipe			12-in. Pipe			14-in. Pipe		
220	0.03	0.18	350	0.03	0.14	500	0.03	0.113	500	0.02	0.055
240	0.04	0.22	400	0.04	0.19	550	0.04	0.135	550	0.02	0.065
260	0.04	0.25	450	0.05	0.23	600	0.04	0.159			
						650	0.05	0.185	600	0.02	0.076
280	0.05	0.28	500	0.06	0.28				700	0.03	0.102
300	0.06	0.32	550	0.08	0.33	700	0.06	0.214	800	0.04	0.129
330	0.07	0.38	600	0.09	0.39	750	0.07	0.242	900	0.06	0.159
360	0.08	0.45	650	0.11	0.45	800	0.08	0.273	1000	0.07	0.195
390	0.10	0.52	700	0.13	0.52	900	0.10	0.339			
						950	0.11	0.372	1100	0.08	0.226
420	0.11	0.60	800	0.17	0.66				1200	0.10	0.274
460	0.13	0.70	900	0.21	0.96	1000	0.12	0.411	1300	0.11	0.317
500	0.16	0.82	1000	0.26	1.03	1100	0.15	0.487	1400	0.13	0.363
540	0.18	0.95	1100	0.31	1.19	1200	0.18	0.575	1500	0.15	0.416
580	0.21	1.07	1200	0.37	1.40	1300	0.21	0.667			
						1400	0.24	0.774	1600	0.17	0.470
620	0.24	1.20	1300	0.44	1.62				1700	0.20	0.519
680	0.29	1.45	1400	0.51	1.87	1500	0.28	0.876	1800	0.22	0.577
740	0.35	1.70	1500	0.58	2.13	1600	0.32	0.982	1900	0.24	0.635
800	0.40	1.97	1600	0.66	2.39	1800	0.40	1.21	2000	0.27	0.705
880	0.49	2.34	1700	0.75	2.65	2000	0.50	1.49			
						2200	0.60	1.81	2200	0.33	0.839
1000	0.63	2.97	1800	0.84	2.95				2400	0.39	0.985
1100	0.77	3.52	1900	0.94	3.32	2400	0.72	2.08	2800	0.53	1.32
1200	0.91	4.11	2000	1.02	3.59	2800	0.98	2.75	3200	0.69	1.67
1300	1.07	4.85	2200	1.25	4.24	3200	1.28	3.51	3500	0.83	1.97
1400	1.24	5.50	2400	1.50	5.04	3500	1.53	4.16			
						3800	1.81	4.90	4200	1.19	2.77
1500	1.42	6.24	2600	1.75	5.81				4900	1.61	3.70
1600	1.62	7.00	2800	2.02	6.70	4200	2.21	5.88	5600	2.12	4.75

The friction through a globe valve, tee or elbow is the same as that caused by the following additional lengths of straight pipe:

	Diameter of Pipe, Inches	1	1½	2	2½	3	3½	4	5	6	8	10	12	14
		Globe valves	Additional length, feet	29	45	58	69	86	98	113	142	170	224	281	336
Tee or long radius elbow	Additional length, feet	2	3	4	4	5	6	7	9	10	13	17	20	24
Standard elbow	Additional length, feet	3	4	5	6	8	9	10	13	15	20	25	30	35
Gate valve	Additional length, feet	.6	.9	1.1	1.3	1.6	1.9	2.1	2.7	3.2	4.3	5.3	6.4	7.5

* Reproduced courtesy of Ingersoll-Rand Co.

Efficiencies

Field Overall Efficiency. Or wire-to-water efficiency, takes into account the losses in both the pump and motor and is the ratio of energy converted into useful work, or water horse-power to energy supplied to the motor, or motor horsepower.

Kilowatt-hour Consumption per 1000 Gal.

$$\text{Kwhr per 1000 gal} = \frac{\text{Head in ft} \times 0.314}{\text{Overall efficiency}^*}$$

* Expressed in percentage and not as a decimal.

CHAPTER 7

FIRE PROTECTION

ART. 7-A. CODES AND REGULATIONS

General Scope

Fire Protection. This chapter describes methods for preventing and fighting fires. The plumbing contract may at times include these items although larger systems usually are handled by special contracts.

The regulations governing fire protection are issued through the local building codes and, in addition, for fire-insured property, through the fire underwriters.

Local laws and the fire underwriters' regulations will supersede any statements in this chapter, although they are all based on recommendations by the Federal Fire Council and the National Fire Protection Association.

As building codes may not be specific enough on the subject, this chapter will include general code definitions, like types of fires, methods for determining sizes and number of standpipes, general rules for location and sizes of water hydrants. Portable fire extinguishers are included as they form a component part of standpipes and sprinklers and should for that reason be included in the plumbing contract.

The location of hydrants, fire-engine connections, sprinkler alarms, shut-off valves, etc., should be checked with the local fire department, preferably with the battalion chief in charge of the district.

Definitions

Hydrant. An outlet placed at or near a main, and provided with a valve to control flow, and with an end suited to attach hose. Those made to serve fire hose or engines in cold climates usually have the valve below the frost line, and are so arranged that, when the flow is shut off, the hydrant will drain to prevent freezing (12).

Indicator. A device placed at a valve or a fire hydrant and arranged so that it shows whether the valve is open or closed (12).

Siamese Connection. A crotch fitting, usually arranged with union inlets for fire hose (12).

The term is gradually becoming obsolete.

Fire-engine connection.

ART. 7-B. CLASSES OF FIRE

Classification

(From *Manual of the Federal Fire Council* [23])

From the standpoint of extinguishment, fires can be divided into three general groups, designated as classes A, B, and C.

Class A Fires. Fires in ligneous or cellulosic materials like wood, paper, textiles, and animal and vegetable fibers generally come in this class, as well as fires in solid carbonaceous materials such as coal, coke, starch, sugar, cereals, and in bitumen, asphalts, and waxes that do not melt readily under heat. Fires in material containing nitrocellulose, such as photographic, X-ray, and motion-picture film and pyroxylin products can generally be placed in this class.

Class B Fires. Class B fires are those occurring in mineral, vegetable, and animal oils. Petroleum oils in the form of crude oil, gasoline, kerosene, fuel oil, transformer oil, lubricating oil and grease, and coal-tar oils, such as benzol, constitute the bulk of mineral-oil products. Among vegetable oils are the alcohols, acetone, turpentine, linseed oil, coconut oil, palm oil, olive oil, cottonseed oil, tung oil, and soybean oil. Some of them are contained in paints, varnishes, and lacquers. Animal oils include lard oil, oleo oil, red oil, menhaden oil, and whale oil.

Class C Fires. Class C fires are fires in electrical equipment for which the extinguishing medium should be a non-conductor of electricity if applied before the equipment is disconnected from the source of energy supply. Fires in insulation of motors, generators, transformers, switchboards, and electrical wiring generally are included in this class. Fires in the oil of oil-cooled electrical equipment should be regarded as class C fires while the equipment is energized, but after it is disconnected they can be regarded as class B fires.

ART. 7-C. EXTINGUISHING AGENTS

Types

The agents used in connection with plumbing systems are:

Water for class A fires (B and C).

Soda-acid for class A fires.

Foam for class A fires.

Carbon tetrachloride for class C fires.

Carbon dioxide for class B and C fires.

Steam for class B fires.

Water spray (fog systems) for various types of fires, such as oil.

Water. The extinguishing effects obtainable from water consist mainly in cooling the burning material to a temperature at which it will not support combustion or re-ignite, wetting it and surrounding material to reduce the rate of combustion and spread of fire, excluding oxygen by

surface films of water or steam or by immersion, and, as applied to some flammable liquids, diluting to a point where combustion is inhibited.

Water is well adapted for the extinguishment of class A fires, and to a limited extent for class B and class C fires (23).

Water should, in general, be applied to class C fires only after the equipment is disconnected from the power source (23).

Soda-Acid. In some types of portable fire-extinguishing equipment and in a few of those of the fixed type, a solution of sodium bicarbonate is employed that, in the operation of the equipment to extinguish fire, is mixed with sulfuric acid. This results in the formation of sodium sulfate, water, and carbon dioxide gas, the chemicals being proportioned to give an acid-free discharge. As held within a closed container, the gas serves to expel the liquid solution under a pressure calculated to give the desired range and duration of stream without rupture of the container (23).

The extinguishing effect is almost wholly from the water in the solution applied in a stream that can be directed at the seat of the fire. It is accordingly adapted for the extinguishment of class A fires. It has lower electrical resistivity than water and should not be applied to charged electrical equipment. The damage from staining, etc., is somewhat greater than for water. The freezing point of the bicarbonate solution is about -2 C or 28 F (23).

Foam for extinguishing fire is produced by a mixture of solutions of aluminum sulfate and sodium bicarbonate to which a foam-stabilizing ingredient has been added, and consists mainly of bubbles of carbon dioxide. In some foam systems, the materials in powder form are mixed with water in a foam generator (23).

Foam is best adapted for the extinguishment of class B fires.

Foam is as effective, weight for weight, on some class A fires as water. However, as applied to finely divided material, it will not penetrate the burning mass to the extent obtainable with water (23).

Carbon tetrachloride is a heavily volatile liquid. The pure form used in fire extinguishers is free from water, and, together with the other liquids added to depress its freezing point, it is a poor conductor of electricity. It can break an electric arc. Hence, it is adaptable for class C fires, although it is moderately effective for small class B fires (23).

Carbon dioxide is at normal pressure and temperatures a colorless, odorless, inert gas which extinguishes fire by smothering. It is non-damaging to most materials, non-corrosive, leaves no residue, is an electrical insulator, and does not deteriorate with age. It is suffocating in high concentrations. For fire extinguishing it is stored at high pressure in steel cylinders in liquid form. Special valves are needed to retain the carbon dioxide without leakage, and also to prevent freezing at the outlet. On emerging from the nozzle, it expands to about 425 times its stored volume. Once liberated, it cannot remain a liquid so that the amount of

inert gas produced by a given quantity of liquid is independent of the fire and is governed only by the quantity applied.

It is recommended for class B and C fires and is of limited value on class A fires (23).

Steam can be used for extinguishing class B fires where the surrounding space, or space above the oil, is enclosed or partly enclosed, provided the amount supplied is sufficient to reduce the oxygen content to the required degree (23).

Equipment

The general types of fire-extinguishing equipment comprise portable fire extinguishers, manually operated fixed equipments, and automatically operated fixed equipments. The choice in types will depend largely on the relation of cost of protection to the value of the property protected and the degree of fire hazard presented. It will also depend on particular structural and occupancy conditions and the environment. An occupancy unduly exposing or exposed by its surroundings may need a higher degree of protection than if its own hazards alone were considered (23).

Definitions.

Portable fire extinguishers are here taken to comprise hand and wheeled extinguishers.

The manually operated fixed equipments include mainly standpipe and hose systems arranged with small hose for the use of occupants or with outlets for the larger hose used by organized fire brigades, and outside systems of water mains and hydrants. Fixed equipments for discharging inert gas or foam by manual means would be included also.

Automatically operated fixed equipments discharge the extinguishing fluid through the medium of heat-actuated devices and comprise automatic sprinkler systems discharging water, and automatic carbon dioxide and foam fire-extinguishing systems (23).

ART. 7-D. STANDPIPE AND HOSE SYSTEMS

Scope of Application

The protection given by standpipe and hose systems in buildings below a certain height is augmented by hose streams supplied by street hydrants where public protection is present. For higher buildings, the standpipe system must furnish the whole supply needed for hose streams used in fire extinguishment. This will generally involve two systems of standpipe or standpipe outlets, one for small hose to be used by the occupants of the building and the other for the larger hose employed by the public fire brigade. The building height above which standpipe supply for large hose should be provided depends in part on local conditions, such as water pressure in the street mains, fire-department equipment, and the fire department's preferred method of fighting fire. The limit can be taken to be in the approximate range 45 to 65 ft height of roof above street level (23).

Water Supply for Standpipes

Source of Supply. The usual sources of supply for standpipes with large hose outlets are fire-department engines pumping water through outside fire-engine connections, city high-pressure water mains, pressure tanks, gravity tanks, fire pumps, or combinations of them. For standpipes supplying small hose the sources include city service mains, hose booster pumps, pressure tanks, gravity tanks, or combinations of pumps and tanks. The method of supplying water will determine some of the more important details of the systems.

Water Supplies for Large Hose. For standpipe systems supplying large hose (generally 2½-in. hose with 1½-in. nozzle) the requirements for water supply can be given as not less than 250 gpm for each standpipe riser at a pressure of not less than 50 psi at the top outlet (not including roof outlet) when discharging at the given (250 gpm) rate (22). Allowing for friction loss in pipes of the sizes herein recommended, this will be equivalent to a static pressure at the given outlet of 55 to 60 psi.

The minimum capacity of fire pumps used as a main source of supply should be 500 gpm, pressure tanks 4500 gal, gravity tanks 5000 gal, the latter with bottom elevated not less than 40 ft above topmost hose outlet. Gravity and pressure tanks should be considered as sources of supply only until other supplies, such as fire-department pumpers or fire pump, can be brought into service.

Where water for small hose is supplied from a separate source, pressure and gravity tanks for large standpipes can be omitted if they are supplied by any of the following: a city water system of adequate capacity and pressure, fire pump with duplicate power supply, fire pump supplemented by fire-department pumpers, or the pumpers alone if from a well-organized fire brigade, the response of which is not likely to be delayed by snow or other impediments. The quantity and pressure capacity of the separate sources are assumed adequate for the height and number of standpipes concerned. The standpipes should be kept primed by a small connection under pressure sufficient to keep them filled, with check valve against backflow provided in the connection. Dry standpipes should be used only where protection from freezing cannot be provided.

City water mains and their connections with standpipe systems should be of size and number adequate for supplying the quantity required, and connections should preferably be made outside water meters. If made inside the meter, the meter should be of a size and type not to introduce undue friction loss under conditions of maximum domestic and fire demand. Disk meters, while the most accurate, introduce the highest loss of head. Velocity meters of the same size as the connecting main are less objectionable. The fire-service meter is designed so that the friction loss is relatively small. Its cost is greater than that of the others and it should not be specified unless needed. Some cities permit connections for fire protection outside the meter. A by-pass should be provided around the meter in any case. It cannot, however, be promised that this

will be opened in emergency to permit flow around a meter of insufficient capacity unless it is in a convenient location with building personnel and public fire brigade fully informed on the necessity of so doing.

If the source of water supply is not adequate or the connection therewith is too small or too long to supply water at the required rate, recourse must be had to gravity or pressure tanks (21) or suction tanks or reservoirs for a fire pump. The amount of storage needed can be determined only from a study of the pertaining conditions. It will depend not only on the extent of the property to be protected but also on the type of construction, subdivision into fire areas, protection of openings, occupancy, and the exterior exposure. The quantity is determined by the number of hose streams estimated as necessary and the time they would need to be applied to control a fire under the more unfavorable conditions. Where an adequate water supply is present within reasonable distance, enlargement of the connection to the required size may be found more advantageous than provisions for storage in large amounts. It is occasionally possible to connect with a main of greater capacity or under higher pressure than that supplying the domestic demand of the building.

Where the city has a separate system of high-pressure fire-service mains, the connection to the standpipe system is made by hose from street hydrants to the fire-department connection on the outside of the building. A length of hose for the purpose might be kept within the building together with some lengths of fire hose on portable reels for use if for any reason the response of the fire brigade was prevented or delayed.

Water Supplies for Small Hose. For standpipe systems supplying small hose (preferably 1½-in. linen unlined fire hose with ½-in. or ⅝-in. nozzle) any source giving a minimum flow of 100 gpm at a pressure of 25 psi at the highest hose outlet is considered adequate (22). Allowing for friction loss in piping, this would require a minimum static pressure at the highest hose outlets of 30 to 35 psi. A more effective hose stream results from nozzle pressure of 40 psi, giving, with a ½-in. nozzle, discharge of little less than 50 gpm. With the friction loss in 75 ft of 1½-in. unlined hose and that in the pipes added, this represents a static pressure at the hose outlet of 60 to 65 psi, which it would be desirable to maintain at least as an average for the building.

The supply of 100 gpm can be taken from tanks connected with the domestic supply provided the pumps supplying them have the needed capacity for the combined demand. In this case it may be found advantageous to combine the distributing systems for the two purposes also, if the layout requires approximately the same pipe spacing. This may also assist in securing proper pressure distribution since the maximum and minimum pressures desirable for the domestic supply come within the range required for the hose streams.

If the area is covered with a wet-pipe system of automatic sprinklers,

the supply for small-hose streams can be taken from the sprinkler risers, with the limitations given in the installation rules for automatic-sprinkler equipments.

For supplies that are stored as in gravity or pressure tanks, the minimum carried for all but relatively small buildings should be 3000 gal, which allows for two hose streams for 30 min. If water from standpipes for large hose or from ground hydrants is also available, the above should be sufficient until extinguishment is begun with the larger hose.

Location of Pressure Tanks. When the water level in pressure tanks can be maintained by the pumps under conditions of maximum demand, the tank can generally be located at the most convenient point within the building unless the latter is of such height that the basement location would require excessive pressures to be carried. For moderate heights, the cost of providing support for them above the basement may exceed the added cost for a heavier tank construction in the basement location. Where pressure tanks are used for storage, location on the roof will generally be found necessary, since in order to maintain adequate pressure at the upper outlets with the tank empty, those in a lower location would be required to carry an excess pressure due to the difference in elevation.

Constant water level and pressure can be maintained by automatic regulation of air and water supply. Generally it may be sufficient to regulate only the pressure automatically by controls on either the air or the water supply. Alarm devices indicating low water level and pressure may under some conditions serve the purpose of automatic regulation.

Fire Pumps. The usual sizes are 500, 750, and 1000 gpm with discharge pressures of 100 to 175 psi (29), the centrifugal type being generally preferred. Any suction head from pressure in the supply main is generally neglected in rating the discharge capacity although it should be considered in providing pressure-reducing devices at hose outlets and other points. A relief valve should be provided at the pump with drainage for the discharge.

Where there will be an immediate demand on the pump in case of fire, the pump should have a combined manual and automatic starting panel, so that it can be started by the ringing of manual or automatic fire alarms, pressure drop in the standpipe system, or by manual switches. Where the initial demand is supplied from tanks, automatic start for the pump is less necessary. The relative cost and reliability of the two methods should be considered for each installation.

Fire pumps and pressure tanks should be placed within fire-resistive enclosures having curbs at door openings and floor drains.

Spacing and Location of Standpipes

Standpipes for large hose should be located in enclosed stairways. With adequate pressure, hose lengths of 200 ft or more can be employed, but

generally the spacing of stairways required for exit of occupants will enable shorter lengths to reach all portions of the building.

Standpipes for small hose should be spaced so that all portions of the building can be reached by a stream of 25-ft range at the end of not more than 75 ft of hose. Where pressures are adequate the hose length might be increased for isolated locations to 100 ft, although this length is less easily handled.

Standpipes or standpipe outlets for small hose should be located in corridors in preference to stairway enclosures, to prevent obstruction of stairways and admission of smoke during the initial stages of the fire fighting when the stairs are used for exit of occupants. Shorter lengths of hose will also then be required. Where standpipe risers supply both small and larger hose, the riser should be located in the stairway, and connections for the small hose with shut-off valve inside of stairway taken off to points outside the stairway enclosure. However, where no location presenting low fire hazard, such as a corridor, is present, it may be necessary to locate outlets for small hose in stairways, since otherwise it might not be possible to use them on account of fire in adjacent combustible materials. Standpipes may also have to be located with reference to protection against exterior fire exposure. Large standpipes should be extended to an outlet on the roof, portions exposed to freezing to be kept dry by means of a valve inside the building. Standpipes outside stairways should preferably be covered by the building construction to prevent direct exposure to fire, or be otherwise insulated.

Size of Standpipes

With the maximum demand and the water supply available known, the size of standpipes and distributing mains can be determined so that the quantity and pressures required at outlets will be obtained. Standpipes supplying large hose in buildings not over 75 ft or six stories high will generally be adequate if of 4-in. pipe. For high buildings, 6-in. standpipes are recommended (22). No increase in size for combined supply to large and small hose will usually be required.

For supplying small hose, standpipe risers and circulating mains should be not less than 2 in. for buildings not exceeding four stories, or 50 ft in height, and 2½ in. for higher buildings. Where the same pipe system is used as that for the domestic supply, it may be necessary to increase these sizes by ½ or 1 in. Generally, considerable economy and increased simplicity can be obtained by this combination of services. It assumes, however, that the water supply provided is adequate for both.

All standpipe risers should be connected through a gate valve with a main of size not smaller than the largest riser.

Hose Outlets, Hose, Nozzles, and Valves

Hose valves should be of the gate or angle type and have national standard fire-hose thread. If the fire-hose thread for the locality is not according to this standard, adapters should be provided. This is recommended on the assumption that the national standard thread will eventually be adopted. Generally large hose is not provided at the outlets. Small hose should preferably be 1½-in. linen unlined, fittings to be 11½ threads per in. The necessary length should be stored on racks at each outlet. The discharge side of hose outlet valves and all other outlets for fire hose should have male threads. Semi-automatic or one-man hose racks can be obtained with which water from the open hose valve is prevented from entering the hose until after it is extended, but are not in general considered necessary. Racks for hose should preferably be in cabinets flush with the supporting wall and fitted with glass doors. In correctional and similar institutions, steel doors prominently marked may have to be used in place of glass.

For small hose, nozzles should preferably be ½ in. Nozzles with a shut-off device should be provided only for locations where prevention of water damage is a prime consideration. One gate valve should be provided at the base of each standpipe riser.

Where standpipes are exposed to freezing, they can be kept dry with a control valve and drain. The valve may be manually operated or remotely controlled and operated by electrical or hydraulic means. One valve may be used to admit water to several standpipes.

Where standpipe systems or pressure tanks are supplied for initial fire fighting from the domestic or other source at lower pressure than that given by the fire pump or fire-department pumpers, a check valve should be placed in the connection to the low-pressure supply. Street (Siamese) inlets for pumpers or high-pressure fire-service connections should be provided at one or more accessible points to standpipe systems where such public protection is provided. For standpipes serving large hose, one such connection must be provided for each standpipe riser where the risers are not interconnected.

Allowable Pressures and Pressure-Reducing Devices

Continuous pressures exceeding 150 psi are usually considered undesirable on parts of standpipe systems from which hose outlets are taken. At the hose outlets, pressure-reducing devices should be provided so that the pressure with the stream flowing will not exceed about 55 psi immediately outside the outlet. Nozzle pressures of 40 psi should preferably not be exceeded. With a 1½-in. nozzle at the end of 100 ft of 2½-in. rubber-lined hose, or 75 ft of 1½-in. linen unlined hose with ½-in. nozzle, 55 psi at the hose valve would correspond to the given nozzle pressure. Allowing for friction losses in pipe and fittings, the

above rule would require reducing devices at hose outlets where the static pressure exceeds 60 or 65 psi.

Where the standpipe systems for small hose are combined with the domestic water-supply system, the pressure regulation required for the water-supply system may serve the purpose for the hose outlets, depending on the range in pressure obtaining. Pressures can be reduced by the insertion of a disk outside the hose valve, with an orifice A square inches in area, that can be determined approximately from the formula

$$A = 0.0425 \frac{Q}{\sqrt{P_1 - P_2}}$$

where Q is the discharge in gallons per minute and $P_1 - P_2$ is the difference in pressure on the two sides of the disk in pounds per square inch. The actual pressure obtaining on the outlet side of the disk should be determined in representative locations after installation.

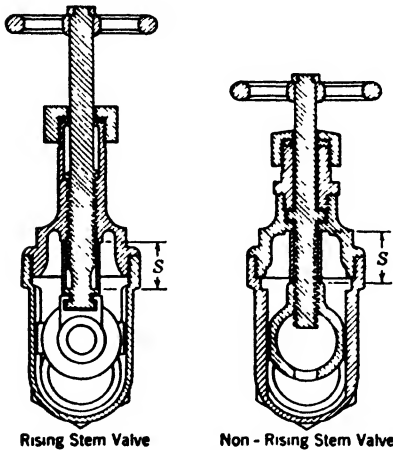


FIG. 154. Pressure-Reducing Device for Fire Hose Outlet Valves. (Length of sleeve $S = n \times p$ where n = turns of wheel from full-open position to that giving the desired pressure and p = gate movement per turn of wheel.) (From *Manual of the Federal Fire Council* [23].)

Another method consists of placing a brass sleeve over the lower threaded portion of the valve stem immediately above the gate, about $\frac{1}{16}$ in. thick and slightly larger than the thread on the valve stem. The length of the sleeve is so that it will stop the movement of the valve at the position giving the desired pressure. For rising-stem valves it is most conveniently determined by measuring the travel of the valve from the full open position to the position giving the desired pressure, the required length of sleeve being equal to this travel. For this type as also for the non-rising-stem type, this movement can be computed in terms of the number of turns required and gate movement per turn of wheel. (See Fig. 154.)

Adjustable pressure-reducing valves are obtainable involving restriction of flow through adjustable disks or diaphragms. The cost of the pressure regulation using these valves is much greater than with the devices outlined above, and whether, for a given installation, the added expense is warranted should be considered. The adjustable device has advantages where a standpipe may have to be used to fight an exposure fire requiring water at higher pressure than fires inside the building.

ART. 7-E. AUTOMATIC-SPRINKLER EQUIPMENTS**Scope of Application**

Automatic-sprinkler protection employing water is adapted in general for occupancies presenting hazards and values such that the cost of the protection can be justified on the score of expected reduction in loss from fire.

It will, in general, be found that only conditions representative of the higher values or hazards call for such protection. Some areas within buildings may not present values requiring the protection on that account alone, but a fire in them may cause damage to higher values in adjacent relatively non-hazardous areas to such extent as to justify the installation. Carpenter and paint shops, shipping rooms, and storage spaces for waste paper and miscellaneous items in fire-resistive public or office buildings are examples. The general types of occupancies for which the protection is adapted include manufacturing, handling, and storage presenting moderate to high hazards and values, and subject mainly to class A fires. Fires such as those in garages and airplane hangars that come in part under class B can generally be controlled satisfactorily also on account of the large volume of water applied. Other areas adaptable for automatic sprinkler protection include inaccessible spaces difficult to protect by other means. The absence of other forms of protection and requirements for isolation, such as in penal institutions, may also be determining factors.

Types

The types of automatic-sprinkler equipments employing water include wet-pipe, dry-pipe, thermostatically operated systems with either closed or open heads, and open systems for protection against exterior exposure.

In the *wet-pipe system* all portions are filled with water, and, without special precautions, such as maintenance of piping filled with non-freezing solution, the system is adapted only for areas not subject to freezing.

In the *dry-pipe system*, adaptable for areas subject to freezing temperatures, the piping beyond the dry valve is filled with air under pressure. The operation of a head lowers the air pressure which trips the dry valve, admitting water to the system. Exhausters or accelerators are installed to hasten the action of the valve. The air in the system slightly delays the issue of water, and the dry valve introduces an element of added initial cost and maintenance and a minor element of unreliability due to possible sticking of the dry valve on its seat. This deficiency is being largely overcome in recent types of valves.

In *thermostatically controlled systems* with closed heads, the piping beyond the control valve is filled with air at or near atmospheric pres-

sure. The thermostensitive elements are usually of the rate-of-rise type, and are suitably distributed on the ceiling over the area to be protected. The operation of one or more thermostensitive elements from fire in the area opens the valve and admits water to the system. No water, however, will issue until a sprinkler head opens. The thermostensitive elements, being more sensitive than the sprinkler heads, will give the alarm before the heads open, which, with prompt response may enable the fire to be extinguished with first-aid equipment before any water damage is done. On opening of the heads, water will issue a little more promptly than in systems controlled by dry-pipe valves because of the lower air pressure initially present in the pipes. A small difference in air pressure may be maintained between the atmosphere and the piping system as a means of detecting leaky or accidentally opened heads.

In thermostatically controlled systems with open heads, the water is admitted to the system when the control valve operates and issues through the full number of heads controlled by the valve, the heads being standard sprinkler heads with the thermostensitive element and cap removed. These are restricted by accepted regulations (28) to 75 per valve compared with 1000 permitted for closed heads.

Both types of thermostatically controlled systems are adapted for areas subject to freezing temperatures. The type with open heads can control fires that spread rapidly better than the other types. Possibility of water damage from both accidental operation and the excess applied in case of fire, must, however, be considered. The contents of buildings such as garages and airplane hangars are not likely to be damaged by water.

Open sprinklers used for protection against exterior exposure usually are manually controlled but may be operated automatically by heat-actuated devices.

Heads for Automatic-Sprinkler Systems

There are three common types of sprinkler heads. One type depends for operation on the fusion of a solder in the device that controls the issue of water from the head, the temperature of operation being controlled by the characteristics of the solder. A second type depends for operation on the fusion of a solid chemical in a similar device, the temperature of operation being controlled by the use of different solid chemicals for the fusible element. The third type operates by the fracture of a liquid-filled bulb, the temperature of operation being controlled mainly by varying the relation of the volume of liquid to that of an air bubble within the bulb. All three types can be obtained in models designed to operate at various temperatures which can be recognized by the color of the frame. The temperature ratings of the various heads and the corresponding frame colors are indicated in Table 114.

TABLE 114
TEMPERATURE RATINGS OF AUTOMATIC SPRINKLERS

Rated Operating Temp of Heads (F)	Max Permissible Temp at Ceiling Where Sprinklers to Be Used (F)	Designation	Color of Frame
135 to 165	80 to 100	Ordinary	Unpainted bronze *
175 to 212	101 to 150	Intermediate	White †
250 to 286	151 to 225	Hard	Blue
325 to 360	226 to 300	Extra hard	Red

* The 135-deg non-metallic (chemical) type has partial black marking on sides of frame.

† The 175-deg chemical and silica bulb types have yellow frames.

From *Manual of the Federal Fire Council* (23).

General Installation Details

Installation requirements for automatic-sprinkler systems have been given careful consideration, and systems installed according to accepted standards (28) should give good performance. These include such details as spacing of heads for different types of buildings or ceiling constructions, clearance above heads, size of branch lines, risers, distributing mains and connections, types of fittings, types and general locations for valves, gages, drains, test pipes, and fire-department connections.

The recommendations of the National Fire Protection Association (28) include installations in buildings housing one or more of the following or similar light-, ordinary-, or extra-hazard occupancies.

The following list gives a partial occupancy classification:

(a) *Light-Hazard Occupancies*. This class includes occupancies in such buildings as apartment houses, asylums, club houses, colleges, churches, dormitories, dwellings, hospitals, hotels, libraries, museums, office buildings, schools, and tenements.

(b) *Ordinary-Hazard Occupancies*. This class includes occupancies in such buildings as mercantile buildings, warehouses, manufacturing buildings and buildings not covered by paragraphs *a* and *c*.

(c) *Extra-Hazard Occupancies*. This class includes occupancies in only those buildings or portions of buildings where the hazard is severe as determined by the inspection department having jurisdiction.

A brief summary of requirements of interest to the designer of the building and its equipment may be pertinent. Check valves are required in connections to multiple sources of water supply to prevent backflow through one source from another source at higher pressure. A gate

valve is generally required on each side of the check valve to enable inspection and repair of the valve, except in street connection for fire-department pumpers. The water supply to the whole system or portion thereof served should be controlled by one gate valve in an accessible location. Floor valves should be used for shutting off portions of the system only where areas, heights, number of building subdivisions, or number of tenants served are large or where contents are very susceptible to water damage. This is to reduce possibility of shut valves. The types of valves, their supervision, and protection should be adapted for the location. This will need special consideration where tampering or similar interference is possible in order that the protection may be in operative condition at times when it may be most needed. Provision must be made for carrying off water from drains for standpipe risers and from test pipes.

Proper structural details will assist materially in increasing the effectiveness of the installation. A clear space of 24 in. between ceiling and top of permanent equipment and 10 to 12 in. between sprinkler piping and ceiling is desirable. This should be considered in fixing story heights. While smooth ceilings give the best distribution of water from sprinkler heads, beams or draft stops 12 in. or more deep at intervals not exceeding 100 ft assist in preventing the opening of heads beyond the area affected by a fire and increase the sensitiveness of the heads above the fire. This is particularly important where a floor or roof is supported on deep open trusses. At least some of the trusses should be made solid by fireproofing or other methods. For fire-resistive floor or roof construction, the best arrangement from the standpoint of sprinkler protection for ordinary-hazard occupancies is attained by making panels 20 by 20 ft to correspond with the 10-ft spacing required for the sprinklers with beams at all margins of the panels projecting 10 to 12 in. below the floor slab.

Vertical communications must be protected to prevent opening of heads on floors not affected by the fire and exterior openings should be protected for similar reasons. Small enclosures and concealed spaces in walls and ceilings of combustible construction are undesirable since they enable fire to originate and spread through channels that cannot be reached by the sprinklers. Segregation of portions of building not covered by the protection from those that are protected is required by the regulations. Floors should be watertight and slope on a grade of not less than 1 in. in 20 ft towards scuppers or floor drains.

Spacing of Sprinklers (28)

TABLE 115

SPRINKLERS

FIRE-RESISTIVE CONSTRUCTION

Note: where the construction is of a type making use of unprotected metal columns, girders, or beams, it should be treated as mill or semi-mill, depending upon the arrangement of the girders and beams.

	Light Hazard	Ordinary Hazard	Extra Hazard
Max protection area per sprinkler	196 sq ft	100 sq ft	90 sq ft
Max distance between lines and between sprinklers	14 ft	12 ft	10 ft

MILL CONSTRUCTION

Under ceilings of mill construction (smooth, solid plank and timber, or plank on steel construction, with bays 6 to 12 ft in width, center to center of beams or trusses) one line of sprinklers shall be placed in the center of each bay.

	Light Hazard	Ordinary Hazard	Extra Hazard
Max protection area per sprinkler	168 sq ft	100 sq ft	80 sq ft
Max distance between lines and between sprinklers	14 ft	12 ft 8 ft in 12-ft bays 9 ft in 11-ft bays 10 ft in 10-ft bays 11 ft in 9-ft bays 12 ft in 6- to 8-ft bays	10 ft

SEMI-MILL CONSTRUCTION

This is a modified form of standard mill construction in which the bays usually are 4 to 5 ft wide. Ceilings of modified mill construction having bays less than 3 ft wide should be treated as open-joist construction. Construction consisting of combustible flooring on steel-bar joists shall be treated as semi-mill construction.

Where girders and beams are framed into each other the construction is designated as panel. Under such construction sprinkler lines usually should be run at right angles to the beams or panels.

Where beams are not larger than 6 by 12 in., sprinklers may be placed under beams and in the bays, depending on the bay widths, occupancy, and other conditions. Where beams exceed 12 in. in depth sprinklers should be located in the bays.

TABLE 115 (Continued)

	Light Hazard	Ordinary Hazard	Extra Hazard
Max protection area per sprinkler	144 sq ft	90 sq ft	80 sq ft
Max distance between lines and between sprinklers	14 ft	10 ft*	10 ft

* Where lines are run in beam panels, sprinklers may be staggered not to exceed 12 ft apart on a line. Where beams are supported on top of girders and the sprinklers are spaced $1\frac{1}{4}$, $2\frac{1}{4}$, or 3 beam spaces apart, a progressive stagger should be used.

OPEN-JOIST CONSTRUCTION

Plank and beam construction with bays less than 3 ft wide, center to center, and construction consisting of combustible flooring on pressed steel joists shall be treated as open-joint construction.

Under open-finish joisted construction, ceilings, floors, decks, and roofs, the lines shall be run at right angles to the joists and the sprinklers shall be "staggered" so that they will be opposite a point one-half the distance between sprinklers on the adjacent lines.

	Light Hazard and Ordinary Hazard	Extra Hazard
Max protection area per sprinkler	80 sq ft	70 sq ft
Max distance between sprinklers on lines at right angles to the joists	8 ft †	7 ft
Max distance between sprinklers on lines parallel to the joists	10 ft †	10 ft

† End sprinklers on alternate lines to be not more than 2 ft from walls or partitions and the end heads on other lines not more than 4 ft from walls or partitions.

Open-joisted bays, with joists on top of girders, 10 ft 1 in. to 12 ft 6 in. in width, require two lines of sprinklers except where numerous bays of this width prevail, in which case two and one lines may be installed in adjoining bays, with two lines in the bays next to side or end walls.

TABLE 115 (Continued)

JOIST CONSTRUCTION WITH SHEATHED OR PLASTERED CEILING

	Light Hazard	Ordinary Hazard	Extra Hazard
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Under smooth sheathed ceilings with cement or gypsum plaster on metal lath or the equivalent.

Max protection area per sprinkler		100 sq ft	80 sq ft
Max distance between lines and between sprinklers		12 ft	10 ft

Under suspended ceilings of combustible construction provided there is a full complement of sprinklers immediately above such ceilings; also under top-floor ceilings of combustible construction provided there is a full complement of sprinklers immediately above such ceilings and the attic space is unfloored and unoccupied.

Max protection area per sprinkler		90 sq ft	Same as for open joists
Max distance between lines and between sprinklers		10 ft	

Under smooth sheathed ceilings of 1/2-in. plaster board, metal, wood lath, and plaster or the equivalent.

Max protection area per sprinkler	168 sq ft	80 sq ft	Same as for open joists
Max distance between lines and between sprinklers	14 ft	10 ft	

TABLE 115 (Continued)

	Light Hazard	Ordinary Hazard	Extra Hazard
Under combustible sheathing, such as matched boarding or combustible fiber board.			
Max protection area per sprinkler	120 sq ft	Same	Same
Max distance between lines and between sprinklers	12 ft for upper floors; 10 ft for basements	as for open joists	as for open joists

Under light combustible sheathing.

Same as for open joists

From *Automatic Sprinklers*, National Fire Protection Association, Boston, Mass. (28).

Pipe Schedules (28)

Definitions.

The vertical pipes supplying the sprinkler system shall be designated risers.

Bulk mains supplying risers or cross mains shall be designated feed mains.

Pipes directly supplying the lines in which the sprinklers are placed shall be designated cross-mains.

Lines of pipe in which the sprinklers are directly placed are designated branch lines.

The number of sprinklers on a pipe of given size on one floor of one fire section should not exceed the number given in the following schedule for a given occupancy.

Schedule for Light-Hazard Occupancies.

Branch lines should not exceed six sprinklers on either side of a cross-main. Pipe sizes should be:

TABLE 116A

1 -in. pipe	2 sprinklers
1¼-in. pipe	3 "
1½-in. pipe	5 "
2 -in. pipe	10 "
2½-in. pipe	40 "
3 -in. pipe	No limit

Where sprinklers are installed in an attic and where such sprinklers are supplied from the same piping which supplies sprinklers under the ceiling of the top floor, pipe sizes up to and including 2½ in. should be:

TABLE 116B

1 -in. pipe	2 sprinklers
1¼-in. pipe	4 "
1½-in. pipe	7 "
2 -in. pipe	14 "
2½-in. pipe	50 "

Where a larger number of sprinklers is required the sizing of pipe shall be treated as piping in a separate area.

Where loop cross-mains are used, see below under *Loop Cross-Mains*.

Connections to such systems from underground mains shall be not less than 4 in. in size.

Schedule for Ordinary-Hazard Occupancies.

Branch lines should not exceed eight sprinklers on either side of a cross-main. Pipe sizes should be:

TABLE 117A

1 -in. pipe	2 sprinklers
1¼-in. pipe	3 "
1½-in. pipe	5 "
2 -in. pipe	10 "
2½-in. pipe	20 "
3 -in. pipe	40 "
3½-in. pipe	65 "
4 -in. pipe	100 "
5 -in. pipe	160 "
6 -in. pipe	250 "

Where sprinklers are installed in an attic and where such sprinklers are supplied from the same piping which supplies sprinklers under the ceiling of the top floor, the pipe sizes up to and including 3 in. should be:

TABLE 117B

1 -in. pipe	2 sprinklers
1¼-in. pipe	4 "
1½-in. pipe	7 "
2 -in. pipe	14 "
2½-in. pipe	28 "
3 -in. pipe	48 "

Where a large number of sprinklers is required, the sizing of pipe shall be treated as piping in a separate area.

Where loop cross-mains are used, see below under *Loop Cross-Mains*.

Schedule for Extra-Hazard Occupancies.

Branch lines should not exceed six sprinklers on either side of a cross-main. Pipe sizes should be:

TABLE 118

1 -in. pipe	1 sprinkler
1¼-in. pipe	2 sprinklers
1½-in. pipe	5 "
2 -in. pipe	8 "
2¼-in. pipe	15 "
3 -in. pipe	27 "
3½-in. pipe	40 "
4 -in. pipe	55 "
5 -in. pipe	90 "
6 -in. pipe	150 "

Where loop cross-mains are used, see *Loop Cross-Mains*.

Loop Cross-Mains. The maximum size of cross-main may be reduced, if desired for reasons of appearance or convenience, below that called for by the regular piping schedules in these rules without reducing the quantity of water distribution from any or all heads, by using loop cross-mains according to the schedule below. The number of sprinklers includes all sprinklers fed from the cross-main, which shall be a complete loop of the size of pipe specified. The riser or other supply to the loop cross-main shall be of the size specified but may be connected into the loop at any point.

Branch lines shall be of the usual construction with pipe sizes as specified in the regular schedules.

TABLE 119
NUMBER OF SPRINKLERS AND SIZE OF FEED MAIN

Size of Loop Cross-Main	Light Hazard		Ordinary Hazard		Extra Hazard	
	No. of A.S.	Size of Supply	No. of A.S.	Size of Supply	No. of A.S.	Size of Supply
1	5	1½	5	1½	4	1½
1¼	9	2	9	2	8	2
1½	13	2½	13	2½	13	2½
2	30	2½	22	3	18	3
2½	80	3	40	3	27	3
					30	3½
3	No limit	3	65	3½	40	3½
			72	4	55	4
3½			100	4	80	5
			130	5		
4			130	5	90	5
			250	6	110	6
5					150	6

The intent of these piping schedules is to discourage the use of systems larger than 6-in., but, where conditions of construction, hazard, or occupancy warrant, an 8-in. system may be accepted. In no case shall the number of sprinklers on one floor of one fire section exceed 400 on 8-in. pipe.

Special Conditions (for lines fed one way).

Where cross-mains supply more than ten branch lines of only two sprinklers each, they should usually be centrally supplied, as the conditions approach those of long single branch lines. Branch lines up to fourteen in number may be fed from one end, provided that 2½-in. pipe does not supply more than sixteen sprinklers.

Not more than fourteen branch lines should be allowed on either side of the riser or feed main.

Larger pipe sizes than called for in the schedules may be required where the construction or conditions introduce unusually long runs of pipe or many angles.

Water Supplies for Sprinklers

The sources of supply include public water mains, the same reinforced by booster or fire pumps, fire-department pumper, and gravity and pressure tanks. There should preferably be two sources of supply. A public main giving adequate capacity and pressure is a satisfactory source of primary supply. Hydrant tests should be made at the building site to determine the available pressure with water flowing at the re-

quired rate. A static pressure of 25 psi on the topmost line of sprinklers or 10 to 15 psi minimum at this point, with water flowing at a rate equal to the consumption when all heads subject to one fire are opened, represents minimum requirements. The connection should be made outside the meter, or a meter should be placed in the connection that will not cause undue loss of head.

Gravity tanks are considered satisfactory primary supplies if the bottom of the tank is 20 or 25 ft above the topmost line of sprinklers. Capacity of tank has been recommended as not less than the consumption of 25% of the sprinkler heads within one undivided area for 20 min. Assuming 20 gpm per sprinkler, this is equivalent to 100 gal for each sprinkler within the area. For 50 or more heads within one area, the minimum capacity should be 5000 gal. The above assumes the presence of a secondary supply such as a public main supplying water through a fire pump or fire-department pumers. If an elevated tank supplies private hydrants also, the bottom should have an elevation above the highest buildings of not less than 25 ft and capacity of not less than 30,000 gal.

Pressure tanks generally carry only about half of the water specified for gravity tanks. The static pressure on the top line of sprinklers with the tank empty should be not less than 15 lb. Unless acting merely as a cushion tank for a fire pump, the pressure tank or tanks should be placed on the roof or other elevated position to avoid excessive pressure in the basement location, as explained in Art. 7-D and Art. 7-E above. A secondary supply such as was indicated for gravity tanks would be needed with the pressure tanks.

Fire pumps should preferably be provided with automatic-starting panels, even where an initial supply in gravity or pressure tanks is present. Fire-department connections on outside of buildings should be made to all sprinkler installations where public protection is present.

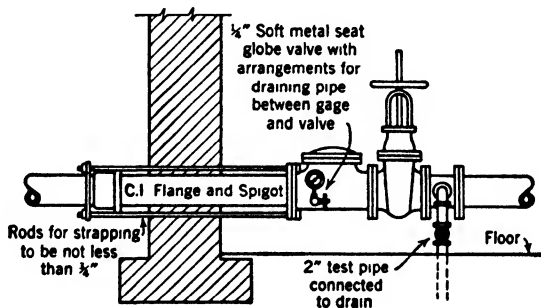


FIG. 155. Water-Supply Connection with Test Pipe. (Located on the system side of the gate valve, one test pipe may serve for more than one city connection. It will also indicate the condition of the gate valve. Located on the supply side of the check valve, it will serve to test out the check valve by closing the waterworks gate or other outside valve.)

(From "Automatic Sprinklers," National Fire Protection Association, Boston, Mass.)

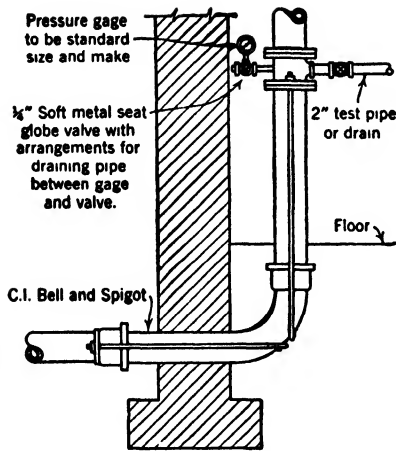


FIG. 156. Test Pipe on Water Supply with Outside Control. (Also applicable to an interior riser.) (From "Automatic Sprinklers," National Fire Protection Association, Boston, Mass.)

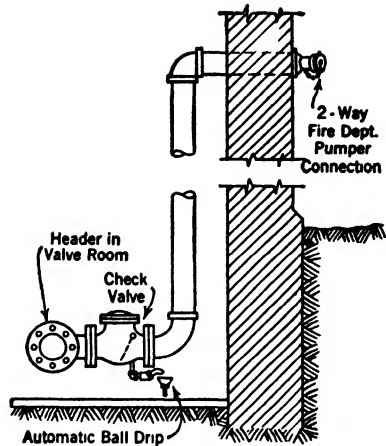


FIG. 157. Fire Department Connection.

For further details relating to water supply and water-supply equipment, reference is made to section above (23).

Fire-Alarm and Supervisory Equipment

Means for giving an alarm at locations where it will receive attention at all hours in case of water flow from opened sprinklers or other causes, tripping of alarm valve, low air pressure, or operation of thermosensitive elements should be provided. Exceptions to the rule might be made for small wet-pipe systems where provisions have been made for preventing decided water damage.

Sprinkler supervisory equipment checking position of supply valves, operative condition of alarm circuits, pressures at dry-pipe valves, and water level, pressure, and temperature in supply tanks are obtainable. The necessity for such equipment can be determined only with reference to the conditions surrounding each installation (23).

ART. 7-F. OTHER FIXED SYSTEMS

Fixed Carbon Dioxide Fire-Extinguishing Systems

Fixed carbon dioxide extinguishing equipment is adapted mainly for fires in materials and equipment in enclosed spaces that can be controlled by the reduction of the oxygen content of the air to a point where combustion will not continue. The limit varies for different materials.

This method is adaptable for the prevention or extinguishment of

class A, class B, or class C fires where an inclosure is present sufficient to maintain the inert gas mixture for the required period (23).

ART. 7-G. OUTSIDE PROTECTION

Private Water Supply

General Rules. Where a building or group of buildings is located beyond the range of protection from a public water supply, or where the latter is inadequate for the purpose, the installation of water mains covering the property may be necessary. The distance to the public or other supply beyond which this is necessary will depend on the extent of the property and the equipment of the public fire brigade. With good accessibility, fire engines in series can pump water through 1000 ft or more of 2½-in. hose, rubber-lined, to deliver streams at the required pressure on the fire, although operating at a decided disadvantage. Where the property is of considerable extent and the distance of any portion thereof from public fire hydrants is more than a few hundred feet, it is preferable to provide an underground distributing system.

Where a satisfactory distributing system for domestic supply is present and large extensions of the property are not expected, it may be best to make any new system for fire protection separate from other supplies. The advantage consists in fewer connections, less deterioration and obstruction within the piping, less possibility of drainage from connections broken by fire, and in some cases lower cost of water service. The latter would be true in general where no charge or only a nominal one is made for the fire-service connection. For new installations of any considerable extent, the universal practice in towns and small cities of combining all water service in one system will probably, in general, be found preferable. Where unpotable water must be used for fire protection, separate systems are required. No underground pipe that is a part of the system should be smaller than 6 in., and valves should be provided for shutting off the domestic connection outside all buildings served. A separate fire-service system should be provided where the supply for fire extinguishment is from a gravity tank or other limited source or where the pressure required is in excess of that suitable for domestic use. Separate systems should be employed also where an economy results from the avoidance of a meter installation, lower annual rate, service charge or meter rental, the use of a less expensive, non-potable water supply, or like conditions. In computing relative costs, interest in investment in the water systems, depreciation, and maintenance costs should be considered (23).

The amount and head of water required in storage and capacity of connections and pumps are determined by the maximum flow required for fire extinguishment and the length of time the flow would be needed under the more extreme conditions. This can be determined only from a study of local conditions. In general, the protection of an individual

dwelling or a building of corresponding size requires 500 gpm. Where dwellings are exposed within distance of 20 ft the requirement would be 1000 gpm; and where a district is closely built or buildings approach the dimensions of hotels, warehouses, or other structures two and three stories high or of large area, approximately 3000 gpm is required. Densely built sections of three-story buildings or extensive warehouses, pier sheds, and manufacturing sections require up to 6000 gpm.

Details of Private Systems.

General Rules. The details of the layout should follow accepted practice, the design to be based on a full study of present and possible future requirements. A complete plan of the installation and all subsequent additions and changes should be made and filed for reference. Supply

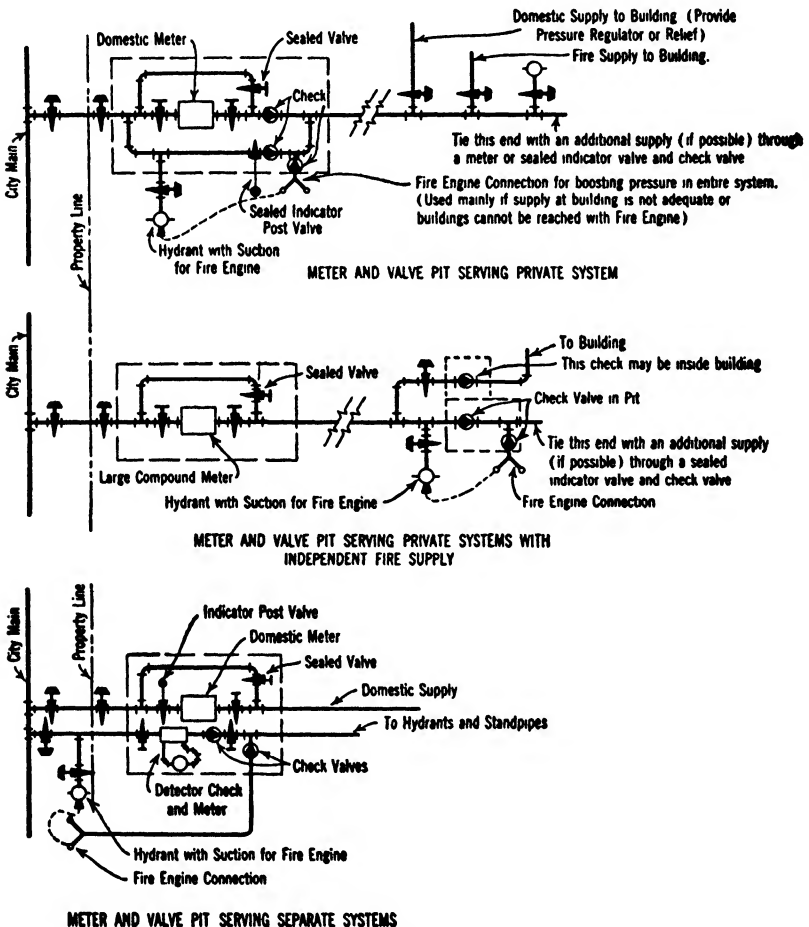


FIG. 158. Connections to Private Systems.

and distributing mains should be cast-iron pipe, preferably not less than 6 in. Distributing mains should be looped. Where buildings in considerable size or number are involved, the minimum size of mains used for hydrant supply should be 8 in. Six-inch mains should be used only where they complete a good gridiron, and their length without a cross-connection should not exceed 600 ft. Hydrants should be located to enable not fewer than two hose streams to be concentrated on any point in buildings without standpipe protection. No hose line should be required to be more than 500 ft long where streams are taken direct from hydrants nor more than 700 ft where pumpers are used (27). The average length of hose required should be much less. Hydrants in cold climates should be designed, installed, and drained to prevent freezing. Two 2½-in. outlets, with national standard fire-hose thread, are usual for private hydrants. They should be placed not nearer than 50 ft to non-fire-resistive buildings and be located on two or more sides thereof. Where supplying pumpers, they should have a suction connection of size and thread to fit the suction hose used and should be located not more than 20 ft from driveways or other location accessible to the fire engine. Where hydrants are on a system of mains supplying large automatic-sprinkler or standpipe systems, no suction connection for pumpers should be provided (23).

Mains. Supply and distributing mains should be cast-iron pipe, preferably not less than 6 in.

For purposes of standardization of pipe and valve sizes, 10, 14, 18 and 20 in. should be avoided.

Steel pipe is generally used on sizes above 30 in. Where no other considerations guide the location, the standard position in the street is 7 ft from the center line.

Joints on cast-iron pipe are poured lead 2½ in. deep. Sulfur-base jointing compound can be used. It should be handled properly and not overheated. Any initial leakage will seal itself. Sometimes a portland cement calked into the joints in a slightly moist condition is used. It is finished with a bead of plastic cement on the outside (6).

Tests of pipe should be made before backfilling the trenches. Leakage should not exceed 200 gal per day per inch of diameter per mile of pipe. With good workmanship it will average less than half of that.

Test pressure should be 100 ft (or 50 psi) above the operating pressure, but not over 150 psi (6).

Minimum size of mains for hydrant supply should be 6 in., gridironed with 6-in. cross-connecting mains at intervals not exceeding 600 ft; or, where initial pressures are high, a satisfactory gridiron may be obtained by a liberal percentage of larger mains cross-connecting the 6-in. at greater intervals (6).

In high-value districts, the minimum size to be 8-in. with cross-

connecting mains at distances given above; 12-in. or larger mains to be on principal streets, and for all long lines not cross-connected at frequent intervals.

Pipes shall be of class sufficient to withstand fire pressures.

Mains are calculated on the basis of peak demands or fire draft plus average daily domestic consumption. For smaller installation the latter usually gives the higher figure.

TABLE 120

Population	Required Maximum Fire Flow in gpm
1000	1000
2000	1500
4000	2000
6000	2500
10,000	3000

The sizes of water main shall also be checked against the following minimum flows:

For small dwellings, 500 gpm flow for one block.

Dwellings, 50 ft or less apart, 1000 gpm for one block.

High-value residences	} 1500 to 3000 gpm
Closely built sections	
Larger buildings	

Hydrants. Type. The hydrant most commonly used has two 2½-in. hose nozzles and one 4½-in. fire-engine nozzle, a 5-in. or slightly larger valve and a 6-in. inlet connection from the main. It discharges 500 gpm at a total maximum pressure loss of 2 psi.

The hydrants shall be installed so that they will not tear loose from the pipes due to high-velocity water streams. They should be either anchored securely against the side of the excavation or tied with steel-rod anchors to the piping. Hydrants may be specified to be provided with lugs for such anchorage.

All hydrant branches should be valved with a gate valve of same size as the branch.

Specifications for hydrants should be according to Standard Specifications for Hydrants and Valves adopted by the American Water Works Association.

Hydrants serving public buildings and institutions should be spaced not over 500 ft apart. The desirable spacing for direct hose streams is 300 to 400 ft.

The spacing of hydrant shall be checked against the maximum areas per hydrant in Table 121. The area per hydrant should be figured by multiplying the average distance in one direction with the average distance in another direction. The required fire flows refer to Table 120.

TABLE 121
MAXIMUM AREAS PER HYDRANT

(From *Standard Schedule for Grading Cities and Towns of the United States with Reference to Their Fire Defense and Physical Conditions*, National Board of Fire Underwriters, New York.)

Required fire flow in gallons per minute	Average area per hydrant in square feet	
	Engine streams	Direct hydrant streams
1000	120,000	100,000
1500		90,000
2000	110,000	85,000
2500		78,000
3000	100,000	70,000
4000	90,000	55,000

Where no engines are in service, direct hydrant stream spacing is to be required, regardless of the pressure. Where direct streams are used, four- or six-way hydrants with independent gates on outlets may be assumed as two hydrants in figuring area served. Where it is the practice of the fire department to connect two engines to a hydrant, those with two pumper outlets may be assumed as $1\frac{1}{2}$ hydrants. Cisterns with supply connections may be counted as hydrants.

For institutions and similar groups of buildings and where hydrants are difficult to reach for a fire engine, a booster connection should be provided. This connection should be near the entrance to the property and preferably in conjunction with the meter pit. It consists of an 8-in. hydrant with at least two $4\frac{1}{2}$ -in. fire-engine nozzles and an engine connection with two $4\frac{1}{2}$ -in. connections. The line between the hydrant and the engine connection shall be provided with a check valve, located in an accessible pit.

Fire-engine nozzles shall also be provided on all hydrants which may serve to feed or boost pressures in sprinkler lines and standpipes.

Gate valves shall be solid-wedge or double-disk type, the latter being preferred.

They shall be spaced not over 500 ft apart and so as to shut off sections for repair. Not more than five or six valves should be needed to shut off any one section.

Gates shall be on all branches from feeder mains and all hydrant branches. There shall be not less than two valves at any one intersection.

Cross-connections between two feeder mains should be gated at both ends.

All underground valves, including valves in pit, which are to be operated during fire emergencies should have indicator posts. This does not include valves on hydrant branches or sectional valves on mains.

Regulators. All domestic water connections beyond any booster con-

nection should be provided with pressure regulators capable of withstanding 250 psi pressure. All domestic lines likely to be affected by the suction from engine pumps should be provided with check valves located in pits or inside building lines.

Public Water Supply

The adequacy of the public water supply is of prime importance in determining the design and cost of private protection. The best possible utilization should be made of it for any form of protection. Its capacity and reliability for any purpose can be determined by flow and pressure tests at the building site. The plan of street mains, the reservoirs, and pumping equipment will disclose other conditions affecting reliability of the supply.

Connections of adequate size and number can usually be made with the street mains. Separate unmetered connections for fire-protection purposes are preferable. All credit that can conservatively be allowed should be given to supply of water by fire-department pumpers or high-pressure fire-service mains to standpipe and sprinkler systems through the street (Siamese) connections (23).

ART. 7-H. PORTABLE FIRE-EXTINGUISHING EQUIPMENT

Advantages and Limitations

The points in favor of portable equipments include relatively low cost, portability, which enables them to be carried to the vicinity of the fire, and ease of obtaining an extinguishing medium best adapted for particular conditions. Their effectiveness is limited by the small volume of extinguishing fluid that can be applied. Hence, for all but the larger units on trucks, they must be regarded as effective only on fires in their initial stages. To serve effectively as protection, the personnel within the space covered must be informed of the location and use of the equipment.

TABLE 122
APPLICATION OF HAND FIRE EXTINGUISHERS

Kind of Extinguisher	Capacity	Application		Weight, Each Lb	Protection from Freezing	How Operated*
		Class of Fire	Number per Unit			
Soda-acid	1¼ or 1½ gal	A	2	19 or 25	Yes	X
Soda-acid	2½ gal	A	1	35	Yes	X
Water, self-propelled	2½ gal	A	1	35 to 40	Yes	X
Calcium chloride	2½ gal	A	1	40	No	X
Loaded stream	1 gal	A	2		No	X
Loaded stream	1¾ gal	A	1		No	X
Pump tank	2½ gal	A	2	40	Yes†	P
Pump tank	5 gal	A	1	66	Yes†	P
Foam	1¼ or	A	2	19 to	Yes	X
	1½ gal	B	2	25		
Foam	2½ or	A	1	35 or	Yes	X
	5 gal	B	1	70		
Carbon tetrachloride	1, 1¼, 1½	B	2	7 for	No	P
	or 2 qt	C	2	1 qt		
Carbon dioxide	7½ or	B	2	35 for	No	S
	10 lb	C	1	7½ lb		
Carbon dioxide	15 or	B	1	50 or	No	S
	20 lb	C	1	77		

* P, hand-operated pump; S, stored pressure; X, internally generated pressure.

† "Yes" for plain water; "no" for non-freezing solution.

Rating of Hand Fire Extinguishers

Units of First Aid. As a convenience in rating and spacing hand fire extinguishers, a "unit of first aid" has been adopted, each unit consisting of one to five like appliances, depending on their effectiveness on the different classes of fires. The ratings for the more usual types, as applied by the Underwriters' Laboratories (26), together with other information, are given in Table 122. The tabulation indicates the classes of fires for which given extinguishers are adapted and the number required for each unit of first aid. Information on types of fires and on extinguishing action of the different media is given in Art. 7-B and Art. 7-C. The extinguishers listed are suitable for first-aid use generally except where women are depended on to use the extinguishers, in which case those with a weight of 30 lb or under should be available (23).

Types of Portable Extinguishers

Soda-Acid Type. In the loose-stopple type (Fed. Specs. O-F-355) the sulfuric acid is discharged into the solution by inverting the extinguisher. In the break-bottle type, used mainly only by fire brigades, the top must be bumped against the floor to liberate the acid.

The range of stream is from 30 to 40 ft, and the time of discharge about 1 min for the 2½-gal size.

Water Type (Self-Propelled). Two and one-half gallon capacity; water-propelled by a special cartridge containing sufficient carbon dioxide to produce the necessary pressure to propel the water.

Range 30-45 ft.

Discharge time about 50 sec.

Calcium Chloride and Loaded Stream Extinguishers. Similar to the soda-ash type but the solution is non-freezing.

Foam Extinguishers. Similar to the soda-ash type.

Range about 25 ft.

Discharge time about 45 sec for the 2½-gal size.

Carbon Tetrachloride Extinguishers (Fed. Specs. O-F-351).

Range 20 ft.

Discharge time 1½ min for 2 qt.

Carbon Dioxide Extinguishers. Range (for smaller sizes) about 4 ft.

Discharge time about 20 sec for the 7½ lb size and 40 sec for the 15-lb size.

Spacing of Portable Extinguishers

According to the recommendations of the National Fire Protection Association for light-hazard occupancies such as office, residential, institutional, and public buildings, units of first-aid fire protection should be provided so that not over 100 ft of travel is required to reach the nearest unit. One unit may be required for each 5000 sq ft of floor area (26).

For occupancies such as stores, warehouses, and manufacturing establishments of average hazard, units are recommended to be spaced so that the travel to reach the nearest unit will not exceed 50 ft. One unit may be required for each 2500 sq ft of area. For extra-hazardous occupancies the same general spacing is recommended, with provision of additional units for special hazards.

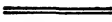
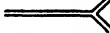
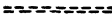


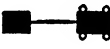


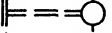

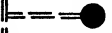

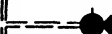

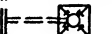

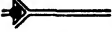



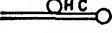





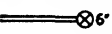

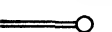

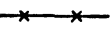

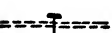
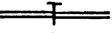
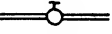
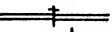
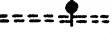




Where standpipe with hose or other fixed or large-sized portable extinguishing equipment appropriate to the hazard concerned is present, concentration of hand fire extinguishers greater than that required for light-hazard occupancies would not in general be necessary. Where a unit consists of several like pieces, all should preferably be grouped in the designated location for the unit.

Location and Supports

Portable fire extinguishers should be located at points readily accessible and not likely to be blocked. Where standpipes with hose for use of occupants are present, hose rack and extinguisher might be placed within the same cabinet, which can be recessed into the wall and fitted with glass doors. Metal doors with locks should be used only where proved to be a necessity, such as at some points in penal institutions and psychopathic hospitals. Where the occupancy of the building and general locations of hazards are known when it is designed, the type, size, and location of portable fire extinguishers should be determined and proper supports and enclosures provided during construction (23).

TABLE 123

SYMBOLS FOR FIRE-SURVEY PLANS

	Water pipe—exposed		Fire-dep't connection
	Water pipe—buried		Alarm gong with hood
	Suction pipe		Steam fire pump with hose connection—sample label: 1000-gal Knowles underwriter pump, 18 x 10 x 12 in., lift 4 ft to 8 ft.
	Foot valve and strainer		Centrifugal fire pump—sample label: 1000-gal Knowles centrifugal pump, 2 ft to 8 ft head
	Frostproof hydrant Two-way private		Rotary fire pump—sample label: 1000-gal National Standard Type B, Rodney Hunt rotary pump, 10 ft to 15 ft head
	Public chuck or flush hydrant		Sprinkler pressure tank—sample label: 6000-gal pressure tank, diameter 8 ft, length 18 ft, bottom 10 above top line of sprinklers
	Public hydrant—two outlets with suction connection		Sprinkler gravity tank—on section—sample label: 50,000-gal gravity tank on 100-ft steel trestle, diameter 21 ft, height 20 ft, bottom 30 ft above top line of sprinklers, protected from freezing by tank heater, filled by city water through 2-in. by-pass
	Private hydrant—four-way with independent valves and hose house		Sprinkler gravity tank—on plan—label as noted above on section
	Monitor nozzle		Reservoir or cistern—if for fire pump, indicate capacity and depth, also use to show mill use tanks
	Standpipe—label size		Meter—give size and name, show by-pass and valves
	Hose connection on pipe—label size		Valve in pit
	High-pressure hydrant		Automatic sprinklers on plan
	Deluge valve		Automatic sprinklers on sections
	Automatic-sprinkler riser—label size		Cotton rubber-lined hose—mark size
	Open sprinkler riser—Label size and "To O.S."		Linen unlined hose—mark size
	Open sprinklers		Fire escape
	Underground valve requiring key to open it		
	Ordinary gate valve		
	Globe valve		
	Indicator valve		
	Post-indicator valve		
	Check valve—arrow indicates direction of flow		
	Check valve with alarm attachment		
	Alarm valve		
	Dry-pipe valve		

REFERENCES

- Water Works Practice*, a manual issued by the American Water Works Association, ABEL WOLMAN, Editor. The Williams and Wilkins Co., Baltimore, Md.
- Manual of Fire Loss Prevention of the Federal Fire Council*, National Bureau of Standards Handbook, No. 19.
- Handbook of Fire Protection*, by CROSBY-FISKE-FORSTER, National Fire Protection Association, Boston, Mass.

CHAPTER 8

AIR PIPING AND EQUIPMENT

ART. 8-A. MACHINERY FOR COMPRESSING AIR

Definitions

Air-indicated horsepower is the horsepower calculated from the compressor indicator diagrams (25).

Brake horsepower is the measured horsepower input to the compressor (25).

It should be noted that horsepower, either indicated or brake, for any compressor varies with compression ratio as well as absolute intake and discharge pressures. Performance guarantees are expressed in terms of horsepower per cubic foot capacity. In comparing test results with performance guarantees, corrections should be made for any deviation from specified values of absolute intake pressures and ratio of compression (25)

Capacity (actual delivery) of an air or gas compressor is the actual quantity of air or gas compressed and delivered expressed in cubic feet per minute at conditions of temperature and pressure prevailing at the compressor intake (25).

The capacity of an air compressor is always expressed in terms of air at intake conditions rather than in terms of standard air. Therefore, the capacity of any particular compressor working under a given ratio of compression is not affected by barometric pressure or temperature at the compressor intake (25).

Compression efficiency is the ratio of the theoretical horsepower to the air- or gas-indicated horsepower (25).

Displacement of a compressor is the volume displaced per unit of time, and is usually expressed in cubic feet per minute. In a reciprocating compressor it equals the net area of the compressor piston multiplied by the length of stroke and by the number of strokes per minute. The displacement rating of a multi-stage compressor is the displacement of the low-pressure cylinder only (25).

Load factor is the ratio of the average compressor load during a given period of time to the maximum rated load of the compressor (25).

Mechanical efficiency is the ratio of the air- or gas-indicated horsepower to the indicated horsepower in the power cylinders in a steam-engine or internal-combustion-engine-driven compressor, and to the brake horsepower delivered to the shaft in the case of a power-driven compressor (25).

Theoretical horsepower (adiabatic base) is defined as the horsepower required to compress adiabatically the air or gas delivered by the compressor through the specified range of pressures. In the case of a multi-stage compressor, the theoretical horsepower is the sum of the theoretical horsepower calculated for each stage, assuming equal division of work between stages and perfect intercooling (25).

Volumetric efficiency is the ratio of the capacity of the compressor to the displacement of the compressor (25).

Classification

Compressors and Vacuum Pumps. These are machines for compressing air or gas from an initial intake pressure to a higher discharge pressure. They are made in various types or classes (25).

Turbo, Rotary, and Centrifugal Compressors and Blowers. These are machines in which the compressing element is of the rotating type (25).

Reciprocating Compressors. These are machines in which the compressing element is of the reciprocating type (25).

Types

In the early days of the industry, air compressors were used mainly for operating rock drills and pneumatic tools. Practically from the start, the manufacturers of air-power-operated equipment standardized on air-pressure requirements ranging from 70 to 100 lb. This practice, in turn, automatically fixed the standard discharge pressure ratings of air compressing equipment at 100 lb. In the early days, practically all compressing machinery was of the reciprocating type, and such parts as frames, running gears, and steam ends were gradually developed and standardized in various types in a range of sizes to meet the users' requirements. As other uses for compressed air developed, not necessarily in connection with air-power-driven equipment, air-compressing cylinders required for the pressures demanded were developed to load the standardized frames and running gears already available (25).

In addition to stationary reciprocating compressors and vacuum pumps, three general types of machines for compressing air or gas are built in this country at the present time:

Portable compressors.

Centrifugal compressors and exhausters.

Rotary compressors and vacuum pumps.

Portable Compressors

A portable compressor is a complete and compact air-power plant, with a self-contained cooling system, and is usually furnished complete with air receiver and an internal-combustion engine as a driver (sometimes an electric motor is used), all mounted on wheels or skids. It is almost always used as a source of power for air-driven tools (25).

Pressures. Single- and two-stage, water- or air-cooled, vertical or V-type single-acting portable compressors are available in standard sizes for pressures up to 125 lb discharge. Where a manufacturer's design and construction permit, high pressures may be used (25).

Standard Sizes. For the convenience of the user, portable compressors have been grouped into model classifications:

Model No.	Capacity in Cubic Feet of Free Air per Minute Delivered at 100 lb Gage at Sea Level
60	60 cu ft
85	61 cu ft to 85 cu ft inclusive
105	86 cu ft to 105 cu ft inclusive
130	106 cu ft to 130 cu ft inclusive
160	131 cu ft to 160 cu ft inclusive
210	161 cu ft to 210 cu ft inclusive
260	211 cu ft to 260 cu ft inclusive
315	261 cu ft to 315 cu ft inclusive
420	316 cu ft to 420 cu ft inclusive

For sizes larger than the model 420, no special designations have been established (25).

ART. 8-B. RECIPROCATING COMPRESSORS AND VACUUM PUMPS

Definitions

Aftercooler. Apparatus used for reducing the heat of compression generated in the final stage of compression. It provides one of the most effective methods of removing moisture from compressed air (25).

Air-Cooled Compressors. These are machines having radiating fins cast on the cylinder walls and in which the cooling of the compressor cylinders is obtained through the circulation of atmospheric air around them (25).

Air Filter. A device for removing dust and dirt from air before it enters the compressor (25).

Air Receiver. A tank into which a compressor discharges. It provides storage capacity and serves to dampen pulsations (25).

Angle Compressors and Vacuum Pumps. These are of the multi-cylinder type with one compressing element located horizontally and one located vertically (25).

Discharge Valve. A device for permitting the discharge of compressed air or gas from the compressor cylinder and for preventing its return to the cylinder (25).

Double-Acting Compressors and Vacuum Pumps. These consist of one or more compressing elements, compression taking place on both strokes per revolution in each cylinder (25).

Duplex Compressors and Vacuum Pumps. These consist of two straight-line units arranged parallel on one common crankshaft (25).

Horizontal Compressors and Vacuum Pumps. These have the compressing element in a horizontal position (25).

Inlet Valve. A device for admitting air or gas into the cylinder and for preventing its return when being compressed (25).

Intercooler. A device for removing the heat of compression between the stages of compression on compound or multiple-stage compressors (25).

Moisture Trap. A device for collecting and removing moisture, precipitated from the air or gas during the process of cooling (25).

Portable Compressors. These are complete air-compressor plants consisting of compressor, prime mover, air receiver, and cooling system, all mounted on a chassis so that it may be readily moved (25).

Reheater. A device for raising the temperature of compressed air (25).

Semi-Portable Compressors. These are complete machine-skidded, or units that can be moved about from place to place, but not on their own chassis (25).

Single-Acting Compressors and Vacuum Pumps. These consist of one or more com-

pressing elements, compression taking place on only one stroke per revolution in each cylinder (25).

Single-Stage Compressors and Vacuum Pumps. When air or gas is compressed in each cylinder from initial intake pressure to final discharge pressure on each working stroke of the piston, the machines are said to be of the single-stage type (25).

Straight-Line Compressors and Vacuum Pumps. In this class of machines the driving and compressing elements are placed in a horizontal position and in line with each other (25).

Two-Stage and Multi-Stage Compressors and Vacuum Pumps. When air or gas is compressed from initial intake pressure to

final discharge pressure in two distinct steps, the machines are said to be of the two-stage type (25).

More than two distinct steps can be used in compressing air or gas to its final pressure, and machines so constructed are spoken of as multi-stage machines, or three- or four-stage machines, depending on the number of distinct compressing stages (25).

Vertical Compressors and Vacuum Pumps. These have the compressing element in a vertical position (25).

Water-Cooled Compressors. These are machines in which the compressor cylinders are cooled by the circulation of water through jacketed spaces adjacent to them (25).

Classification

Reciprocating Compressors and Vacuum Pumps. These are machines in which air or gas is compressed by a piston which travels back and forth in a straight line. The *stationary type* is intended for installation on a more or less permanent foundation, as distinguished from the *portable type*, which can be moved about readily from one location to another (25).

Standard Types of Reciprocating Compressors. They may be classified as follows (25):

- Vertical and V-type single-acting.
- Single horizontal double-acting.
- Duplex double-acting.

Vertical and V-Type Single-Acting Compressors. They may be classified into two groups.

The first group includes single-cylinder and two-cylinder, single-stage and two-stage compressors in sizes varying from fractional horsepower to 15 hp, for maximum pressures usually limited to 250 lb. Such compressors are commonly used by filling stations and garages, and for starting internal-combustion engines, operating laundry presses, paint sprayers, etc.

In the second group are compressors of the multi-cylinder type in sizes of 15 to 125 hp, with pressures usually limited to 125 lb. This group is available either single-stage or two-stage, air-cooled and water-cooled.

These types of compressors may be belted or directly connected to the electric motor or other driver (25).

Single Horizontal Double-Acting Compressors. They are of the straight-line type, with all cylinders in tandem on a common piston rod. They are

built in approximately the same range of sizes as the second group of the vertical and V-type compressors, viz., 10 to 125 hp, but they are considerably heavier and operate at much lower speeds. The single-stage type is built for a maximum pressure of approximately 125 lb, the two-stage type for 2500 lb. The types of drive regularly employed include belt, direct-connected synchronous motor, and steam end in tandem with the compressor cylinder (25).

Duplex Double-Acting Compressors. They are built in standard sizes of 50 to 3000 hp for a wide range of pressures, with compressor cylinders arranged horizontally, vertically, or at an angle. They are also built for a wide variety of special conditions. Compressors of this type may be driven by steam, electric motors, or by internal-combustion engine (25).

Selection of Compressor

When planning a compressor installation prospective purchasers are urged to avail themselves of the standard sizes which manufacturers have developed in a variety of combinations to meet most operating needs, special machines being available for unusual conditions. Compressor manufacturers will gladly assist prospective purchasers in determining the size and type best adapted to their particular requirements, but the following general remarks may be of assistance (25).

Single vs. Two-Stage Compression. A choice between single- and two-stage compression depends upon many widely varying factors: size of compressor, ratio of compression, discharge temperature limitation, cost of power, continuity of service, relative permanence of installation, etc. In general, the dividing line between single- and two-stage compression may be drawn as follows, assuming sea-level atmospheric intake pressure: for pressures below 60 lb, single-stage; for pressures above 100 lb, two-stage; and for 60 to 100 lb, single-stage for capacities below 300 cfm and two-stage for larger sizes (25).

Determining Size of Compressor Required. Actual Capacity. Calculations for determining the size of compressor required for any specified purpose should be based on the *actual capacity* of the machine, which may be obtained from the manufacturer, rather than on the piston displacement, or nominal capacity, of the compressor. (See definitions of actual capacity and piston displacement.) (25)

Number of Units. Where large capacities are required and failure of the compressed-air supply would be costly, it may be desirable to install two machines of medium size instead of one large unit. Where reduction of the compressed-air supply cannot be tolerated, 100% spare compressor equipment should be installed (25).

Operation at Altitude. The rarefied air drawn into a compressor operating at a considerable altitude is compressed to a smaller volume than if intake were at the greater density prevailing at sea level, the reduction being approximately in the ratio of the absolute intake pressures. Due

allowance must be made for this smaller volume delivered by the compressor when calculating the size of compressor required at an altitude. It will be observed that *actual capacity* is always expressed in cubic feet per minute at intake pressure and temperature (25).

Cost of Power. This is a very important factor in determining the proper type of compressor to use, for the first cost of the equipment is paid but once, whereas the operating cost is paid many times during the life of the machine. Thus, with current at one cent per kilowatt hour and a load factor of 75%, the cost of the power consumed by a two-stage compressor would exceed the first cost of the machine within 3 years, if operated 8 hours per day, and in less than one year if operated 24 hours per day.

Prime Movers. The principal types of power used for driving compressors are:

- Steam.
- Electricity.
- Oil or gas.

Steam Drive. It is available for single and duplex horizontal double-acting compressors, with the steam engine usually built as an integral part of the compressor, although a separate steam engine may be used, attached to the compressor.

Electric Motor Drive. It is available for compressors of any capacity. For driving belted and high-speed direct-coupled compressors, the squirrel cage induction motor is usually used, but occasionally the synchronous motor is employed because of its capacity for power-factor correction.

Internal Combustion Engines. They are frequently used for driving compressors, where the cost of suitable fuel is favorable or other forms of power are not available. Small sizes may be driven by gasoline, fuel oil, or gas engine, belted or directly coupled; larger sizes by oil or gas engine built integral or directly coupled to the compressor.

Units Available. Reciprocating compressors and vacuum pumps:

Base-plate mounted units.

Receiver mounted units (mounted on top of air receiver).

Bare compressors (compressors without base plate).

Parts and Accessories:

Motor: Automatic start and stop control, for intermittent demands. Regulated by pressure switch.

Constant-speed control, for fairly constant demand. Regulated by hand control.

Dual control, a combination of both the above controls.

All electric equipment should, in addition, have a hand-operated cut-out.

Start and stop control; air receiver (optional); air filter and intake

muffler; ball-bearing compressor; centrifugal governor (for unloading compressor to prevent overload in starting); flat or V-belt wheel. Specify pressure setting.

Aftercoolers (used where discharge air should be free from oil or moisture). Maximum air pressure 250 lb. Recommended water flow to aftercoolers: For $\frac{3}{4}$ to 2 hp, $\frac{1}{2}$ gpm or less; for 3 and 5 hp, 1 gpm or less; for $7\frac{1}{2}$ and 10 hp compressors, 2 gpm or less. (See also Table 124, page 278.)

Pipe-line accessories: pressure-reducing valve (from 200 lb initial pressure reduced to 10 to 100 lb discharge pressure), $\frac{1}{4}$ -in. size will pass approx 40 cfm.

Pipe-line filters: horizontal swing-bolt type and vertical type; sizes $\frac{1}{2}$, $\frac{3}{4}$, 1, $1\frac{1}{2}$, 2, and 3 in. for 125 or 200 lb max pressure.

Safety valve (specify blow-off pressure), $\frac{1}{4}$ - and $\frac{1}{2}$ -in. thread.

Pressure switches, pressure gages, check valves.

ART. 8-C. CENTRIFUGAL COMPRESSORS AND EXHAUSTERS

Definitions

Centrifugal Blowers, Compressors, or Exhausters. These are machines in which air or gas is compressed by centrifugal force (25).

Centrifugal Blowers (or Turbo-Blowers). These are machines in which air or gas is compressed by centrifugal force to a final pressure not exceeding 35 lb. Machines of this type are generally not artificially cooled (25).

Centrifugal Compressors (or Turbo-

Compressors). These are machines in which air or gas is compressed by centrifugal force to a final pressure above 35 lb, but usually not over 125 lb. These machines are invariably water-cooled (25).

Centrifugal Exhausters (or Turbo-Exhausters). These are machines in which air or gas is compressed by centrifugal force, the pressure at the inlet being below atmospheric pressure (25).

Types

Centrifugal Compressors and Exhausters. This type of compressor has its principal application where comparatively large volumes of air or gas are required in a single unit.

While it is built by some manufacturers in the United States for air-discharge pressures up to 100 lb, it has a much broader application for pressure ranges below 100 lb. Generally speaking, this type of unit has not been exploited in the United States as a 100-lb discharge pressure machine except for special applications and then only in sizes of more than 5000 cfm capacity (25).

The field for the centrifugal machine is so broad that standardization work has proceeded slowly. For applications where this type of machine has been adopted as standard and where the pressure requirements are constant, regardless of size, ratings have been well standardized. For example, most manufacturers of centrifugal compressors have a standard line of units developed in convenient capacity steps for blowing blast furnaces, steel and copper converters and foundry cupolas, exhausting

and blowing water gas sets, exhausting coke ovens, and furnishing air for industrial oil burners. In addition, most manufacturers of this type of compressor have a well-standardized line of low-pressure centrifugal blowers for general application, in capacities up to approximately 10,000 cfm and discharge pressures up to 3 lb (25).

ART. 8-D. ROTARY COMPRESSORS AND VACUUM PUMPS

Definitions

Rotary Compressors and Vacuum Pumps. Rotary compressors, blowers, or vacuum pumps are machines in which compression is effected by the positive action of rotating elements (25).

Types

Rotary Compressors and Vacuum Pumps. In machines of this type compression is accomplished positively by rotating elements. Otherwise, all units of the rotary type have characteristics similar to the reciprocating compressor to the extent that the air or gas is compressed positively and not by centrifugal force (25).

Rotary Compressors of the Two-Impeller Type. They more or less parallel the reciprocating type as to capacity limitations but, generally speaking, have their broadest application where the pressure requirements do not exceed approximately 10 lb. This type of unit is well standardized in a wide range of sizes (25).

Rotary Compressors of the Sliding-Vane Type. They are built in single units for capacities up to approximately 2000 cfm and for any pressures up to 125 lb. They are usually built as two-stage machines for the higher pressure ranges and single-stage for lower pressures (25).

Rotary Liquid Piston Type Compressors and Blowers. Where the gas or air is compressed by a rotating body of confined water or other liquid, they are standardized in a convenient range of sizes for pressures up to approximately 75 lb, from small sizes up to large capacities in a single-stage machine. Two-stage units are also built for pressures above 75 lb (25).

Rotary compressors of the several types mentioned above are also adaptable as vacuum pumps (25).

ART. 8-E. MACHINERY FOR COMPRESSING GASES OTHER THAN AIR

Types

Machinery for Compressing Gases Other Than Air. Compressors are today essential in practically every plant where any form of gas is handled. Usually compressing equipment for gas service must be figured to fit the requirements of the individual application. Mechanically, aside from problems such as type of stuffing box, selection of materials suitable for the gas to be handled, regulation, etc., there is little differ-

ence between an air compressor and a gas compressor. Therefore a certain amount of standardization work has been done on the basis of using available parts of standardized air-compressing equipment when applying such machinery for handling gases other than air (25).

ART. 8-F. MANUFACTURERS' STANDARDS

Standards and Guarantees

The purchaser benefits from standardization. It is recommended that the prospective purchaser of compressor equipment and accessories consult the manufacturers about their standards before writing his specifications. Otherwise, he may specify something which, while suitable for his purpose, must be specially built, hence will be needlessly expensive and will involve delay in shipment. Manufacturers' standards have been set up after much study of consumers' requirements over a long period of years. A standard unit usually can be selected to fill the requirements of almost any application. Even in special cases, it is usually to the purchaser's advantage to adjust his requirements to a unit of standard rating.

Performance Guarantees. The performance of power-driven equipment, using air as a power medium, is usually stated in terms of air input against work output. The performance of machinery for compressing air is stated in terms of power input to the driving end against capacity output at rated pressure. Owing to the varying conditions affecting the operation of machinery handling air or gas, it is practically impossible to make tests with extreme accuracy. For this reason, the manufacturers of this class of equipment, in making guarantees, reserve a definite percentage of leeway, this percentage varying somewhat with different classes of equipment, depending on the accuracy with which it may be tested. In general, guarantees are not made subject to test after installation.

Reciprocating machinery for handling gases other than air can be guaranteed as to capacity and economy only on the basis of handling air. Any performance data based on handling other gases are submitted only as estimated performance since it is practically impossible to demonstrate, at the point of manufacture, the performance of such machinery when handling special gases (25).

ART. 8-G. INSTALLATION OF COMPRESSORS

Recommendations (by Compressed Air Institute)

Location. The compressor should be located in a clean, well-lighted area of sufficient size to permit cleaning, ready inspection, and any dismantling which may be necessary, such as removal of pistons, wheels, crankshaft, or intercooler tube nest (25).

In foundries, wood-working plants, and other dusty places the com-

pressor should be located in the main engine room or, where this is not possible, in a dust-tight room with provision made for drawing clean air from the outside to the compressor intake (25).

Foundation. Upon receipt of an order for a compressor, members of Compressed Air Institute regularly furnish drawings of required foundation of appropriate mass and base area for good subsoil, such as hard, dry clay or hard, dry clay mixed with gravel (hard pan) or coarse dry gravel. They also generally specify a certain concrete mixture such as a 1:2:4 ratio, the concrete to be poured while its temperature is between 40 and 120 F. The mixture may be modified when suitable stone or gravel, other than that specified, is available locally, but the proportion of cement to aggregate should not be reduced and a high-grade Portland cement must be used. In all cases the foundation must be carried to a depth below the frost line, which should never be assumed as less than 3 ft and often is as great as 6 ft when foundation is exposed (25).

Rotary and centrifugal compressors and vacuum pumps and exhausters require, as a rule, a foundation only sufficiently substantial to support the weight of the unit and of sufficient rigidity to insure permanent alignment.

Occasionally, subsoils are not as good as those mentioned above. The nature of the subsoil should be ascertained by borings on the site of the foundation. Such borings should be at least four in number, one near each corner of the proposed foundation. The borings should be made and judged by a competent foundation contractor, who should recommend suitable construction. The compressor builder cannot assume any responsibility on this account. In some cases, it may be necessary to spread the weight of the compressor and foundation over a larger subsoil area by providing a concrete mat below the foundation block. Where the subsoil is especially bad, water-bearing for example, the mat itself will have to be supported on piles, which should be braced against horizontal displacement (swaying) (25).

The foundation block should be cast in a single pour—and the mat, too, if used—but the mat and the block may be poured separately, in which case they should be anchored together by vertical bars (25).

The foundation should be cured for a period of ten days before the erection of the compressor is begun. Sprinkling the surface of the foundation with water and covering it with straw, burlap, or sand will improve curing (25).

To avoid transmission of vibration, concrete walls and floors of the compressor room should be insulated from the compressor foundation. It is well to surround the portion of the foundation that is below ground with 18 in. of coarse dry gravel and to separate it from the adjacent floor by a narrow gap, or by vibration insulation material, such as asphalt (25).

If the plant is designed without a basement, trenches for piping must be provided. These should be carefully planned before the piping layout

has been completed. The width and depth of pipe trenches should be given careful consideration in order that flanges, valves, unions, and joints will be accessible. The number of pipe trenches should be held to a minimum; therefore the piping layout should be such as to make possible the simplest and most accessible arrangement to facilitate proper operation and maintenance of the plant. The appearance of the plant may be very much improved by the use of simple pipe trench arrangement and cover design (25).

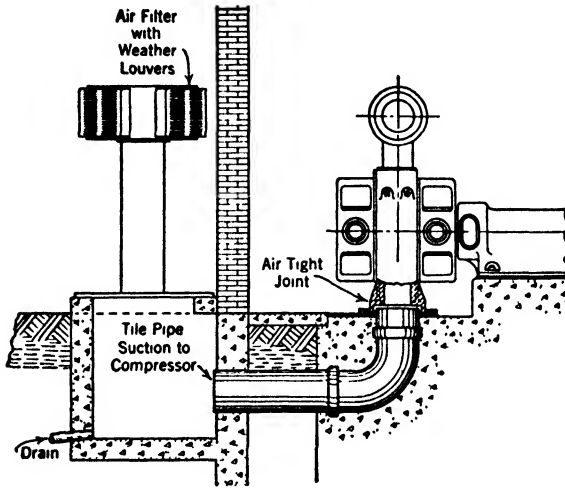


FIG. 159. Intake for Air Compressor.

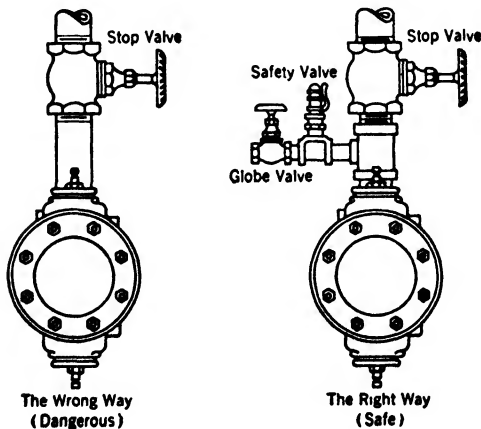


FIG. 160. Valves on Discharge Lines.

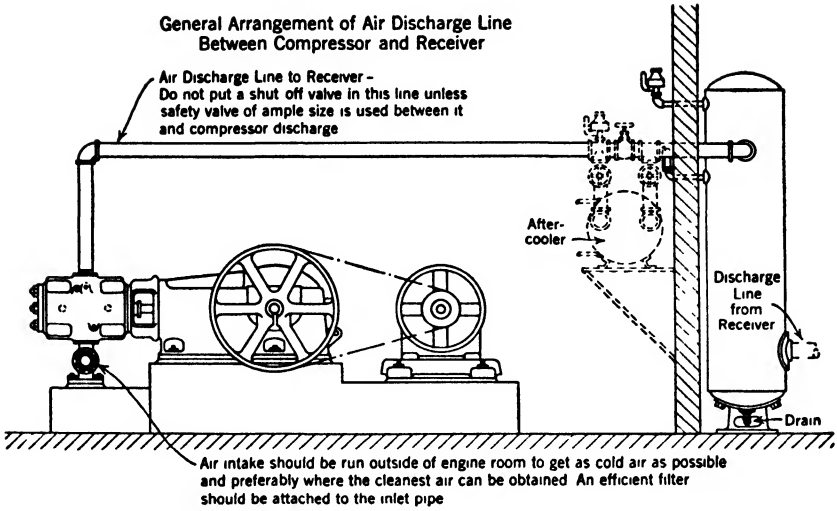


FIG. 161. Air Compressor Installation.

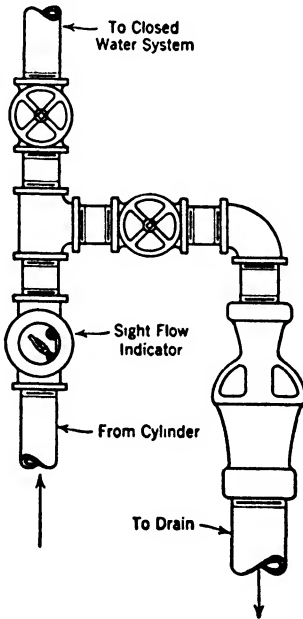


FIG. 162. Arrangement of Air Cylinder Water Piping When Closed System Is Used.

Air Intake. The intake of a compressor should be piped outside the buildings to obtain air as cool as possible. An actual increase in delivery of 1% is gained for every 5 deg reduction in intake temperature, since the density of air varies inversely as its absolute temperature (25).

Where local requirements call for a minimum of noise, the air intake should be provided with a muffler (25).

The air intake should be located as far away as possible from ash or coal bins, crushing plants, or other dusty places. If dust or foreign matter is continually sucked into a machine, it causes rapid wear of the working parts and forms a coating on the cylinders and valves. Where such conditions exist, an efficient air filter must be attached to the intake pipe (25).

The intake piping should be as short and direct as possible, using long radius elbows where bends are necessary. It should be the full diameter of the intake opening of the air cylinder or, if longer than 12 ft, the pipe of next larger size should be used (25).

If the air-intake pipe is above the floor, it is best to use standard steel pipe or sheet-metal pipe (25).

Glazed vitrified sewer pipe makes a convenient material to use for underground air intakes, as long sweep elbows of the same material can be obtained. All joints must be cemented to make them watertight, as any water seeping into the intake is carried into the low-pressure air cylinder, washing away the lubricant and causing the piston and cylinder to cut or wear (25).

If a concrete duct is used as an air intake, it must have a smooth, hard interior surface, for if the concrete crumbles or disintegrates it will be carried into the compressor cylinder and cause rapid wear. Painting the interior of a concrete duct with a good waterproof paint is advisable (25).

Where compressors are used in or adjacent to chemical plants, the air or gas taken into the compressor often contains acid fumes which attack iron and steel, causing corrosion and wear of the valves, pistons, and cylinders. If this condition is known to exist, the manufacturer of the compressor should be informed when the machine is purchased so that proper provision can be made to take care of it (25).

Air-Discharge Pipe. Drawings furnished by the manufacturer show the size and location of the discharge opening. Discharge piping should not be smaller than the full size of such outlets and should run directly to an aftercooler, if used. If no aftercooler is used, the discharge pipe should run directly to the air receiver, the latter to be set out of doors if possible but as close to the compressor as is practicable. The discharge pipe should be as short and direct as possible, employing a minimum number of fittings and using long radius elbows where bends are necessary. Unnecessary pockets should be avoided. If a pocket is formed between the compressor and the aftercooler or receiver, it should be provided with a drain valve or trap to avoid accumulation of oil. The hot

discharge line should not contact wood or other inflammable material. If the discharge line is more than 100 ft long, the diameter pipe of next larger size should be used (25).

Traps should be inserted in air lines at frequent intervals to remove condensed moisture. Automatic moisture traps can be purchased for this purpose, or traps may be used made of pipe fittings, consisting of tees having a pipe leg hanging down with a drain connected at the bottom. Traps, however, are effective only where the air already has been cooled and the moisture has precipitated. Where, as in the majority of installations, the air is not allowed to stand unused for any period of time and there is, therefore, little opportunity for it to cool by radiation, an aftercooler must be used to cool the air before its moisture can be precipitated and removed (25).

If an aftercooler is not employed, much of the trouble experienced with water in air lines can be overcome if small air receivers are put in the lines at frequent intervals to act as collecting tanks. Suitable piping must be provided to permit draining these vessels regularly (25).

Caution. A globe or gate valve may be placed in the discharge line between the compressor and aftercooler or receiver when more than one compressor discharges into a single aftercooler or receiver. When such a shut-off valve is used, a safety valve positively must be placed in the pipe line between the cylinder and the shut-off valve. This is very important, for the compressor may at some time be started with the stop valve closed and, if no safety valve is used, sufficient pressure may be built up to burst the cylinder. Figure 160 shows the wrong way and the right way of doing this, if a stop valve must be employed. The safety valve or valves should have a total capacity sufficient to accommodate the entire output of the compressor (25).

Figure 161, showing a straight-line belt-driven compressor, indicates in a general way how the discharge of a compressor should be connected to an aftercooler, if used, and to the air receiver. The receiver inlet should be near the top of the tank and the discharge near the bottom. The arrangement of air piping for large compressors is in general the same as shown here (25).

Circulating Water. A liberal supply of cooling water for cylinder jackets, cylinder heads, and intercoolers must be provided and must always be turned on before the compressor is started. The use of dirty water must be avoided, as it clogs the water jackets and reduces cooling efficiency (25).

When the cooling water is very cold, condensation may form in the air inlet passage of the high-pressure cylinder as the air passes through it coming from the cooler, because the air may be much warmer than the water. If condensation forms, it will be carried into the air cylinder and destroy the lubricant, causing rapid cylinder wear. To relieve this condition, it is advisable to pass the cold water through the intercooler

first, in order to increase its temperature before going to the cylinder jackets, or to reduce the supply to the cylinder jackets so that the temperature of the discharge therefrom will be between 100 and 115 F (25).

Outlet water should flow into open funnels, allowing frequent temperature readings to be made, an excessive rise in temperature indicating insufficient water, carbonized discharge valves, or leaking piston rings (25).

If it is necessary to use a closed water system, sight flow indicators should be put on the water discharge from each cylinder and intercooler to show positively that water is circulating and the discharge pipe should be by-passed to an open funnel so that the cylinders and coolers can be tested at frequent intervals to make sure that there are no leaks in the water jacket or in the intercooler tubes. If the water discharge is opened to the overflow funnel and the valve on the discharge line shut off, any leakage between the air and water spaces will be discovered at once by observing air blowing out with the water. Figure 162 shows how the water piping should be arranged when a closed system is used (25).

TABLE 124
COOLING WATER REQUIRED FOR INTERCOOLERS, CYLINDER JACKETS,
AND AFTERCOOLERS

Gallons of Water per Hundred Cubic Feet Actual Free Air for Different Water Temperatures				
	60 F	70 F	80 F	90 F
Aftercooler or intercooler separate (80–100 lb, 2-stage compression)	1.0	1.2	1.4	1.6
Intercooler and jackets in series (80–100 lb, 2-stage compression)	1.4	1.6	1.9	2.1
Aftercooler (80–100 lb, single-stage compression)	1.0	1.2	1.4	1.6
Both low- and high-pressure jackets with water supply separate from intercooler (80–100 lb, 2-stage compression)	0.85	1.0	1.2	1.4
Jacket for single-stage compression:				
40 lb air pressure	0.5	0.6	0.7	0.9
60 lb air pressure	0.6	0.7	0.8	1.0
80 lb air pressure	0.7	0.8	0.9	1.1
100 lb air pressure	0.8	0.9	1.0	1.2

With the amounts of water given in Table 124 it is expected that the temperature of the air leaving the intercooler or aftercooler will be within 20 deg of the temperature of the water entering the cooler for

ordinary working conditions, namely, when the cooler is handling air from a two-stage compressor operating at 100 lb discharge pressure (25).

Accessories

Air Receivers. The air receiver is an essential part of every air-compressor installation. It absorbs pulsations in the discharge line from the compressor, insuring a steady flow of air to the service line. It also acts as a reservoir for the storage of compressed air and furnishes reserve capacity to take care of sudden and unusual momentary demands in excess of the capacity of the compressor. Another of its functions is to precipitate or condense some of the moisture present in the air as it comes from the compressor, or which may be carried over from the after-cooler (25).

There is danger in the use of air receivers of unsound or questionable construction. In many states the ASME standards of construction of unfired pressure vessels are incorporated in the law. Therefore Compressed Air Institute endorses only air receivers that meet the requirements of the ASME code. Its standard sizes and capacities for air receivers for discharge pressures up to 125 psi are shown in Table 125 (25).

The use of special tanks of lighter constructions for pressures below 125 lb should be avoided, as the slight saving, if any, does not compensate for the risk that the lighter tank may be used inadvertently for higher pressures at some future time (25).

Aftercoolers. Compressed air or gas always contains moisture in some degree, depending on the condition of the air taken into the compressor and on the system of compression. This moisture, because of the heated condition of the air or gas as it leaves the compressor, is carried along as vapor, through the receiver, into the pipe line. Where the pipe lines are long, considerable heat loss takes place and the moisture-carrying capacity of the air or gas is reduced to such an extent that moisture is precipitated (25).

Water in compressed air often causes considerable annoyance and expense. Thus in pneumatic tools it washes away the lubricant, resulting in rapid wear, excessive air consumption and high maintenance cost, while frequently the water freezes at the exhaust of the tools, causing them to be sluggish and greatly retarding production. In paint spraying, air cleaning or blowing, air agitation of liquids, etc., the presence of water or oil vapor is obviously objectionable (25).

Water in compressed air or gas causes "water hammer" in pipe lines, reduces the capacity of the lines, and, freezing, may burst the pipe (25).

Expansion and contraction due to alternate heating and cooling of pipe lines, where the air is discharged directly from the compressor into a line without being cooled, produce strains and costly leaks (25).

In addition to water, some lubricating oil is carried by compressed air from the compressor cylinders. Like the water vapor, this oil vapor

TABLE 125
ASME STANDARD AIR RECEIVERS

Diameter, Inches	Length, Feet	* Actual Compressor Capacity for which Receiver Is Suited, Cu Ft Free Air per Minute	Volume, Cu Ft	Safety Valves		Size Drain Valves	Types of Opening for Cleaning
				No.	Diameter, Inches		
14	4	60	4½	1	¾	Sizes of drain to meet requirements of ASME Code for Unfired Pressure Vessels	Openings for inspection and cleaning are required and must meet specifications of ASME Code for Unfired Pressure Vessels
18	6	95	11	1	1		
24	6	185	19	1	1½		
30	7	305	34	1	2		
36	8	450	57	1	2½		
42	10	640	96	1	3		
48	12	1,275	151	2	3		
54	14	1,900	223	3	3		
60	14	3,000	275	3	3		
66	18	4,500	428	3	3		

* For automatic start-and-stop service, extra-large receivers are recommended to avoid starting too frequently.

All receivers up to 42 in. x 10 ft inclusive have screw openings—48 in x 12 ft and larger have flanged inlet and discharge openings with companion flanges.

Receivers are furnished complete with safety valves, pressure gage, hand holes or manhole, drain valve and nipple, and base for vertical receivers.

condenses when cooled and, unless removed, will collect in the air receiver and in the pipe lines, building up deposits there which under abnormal operating conditions may ignite and explode. Eliminating this oil vapor eliminates this hazard (25).

To remove water and oil vapor, they must be condensed and it is, therefore, necessary to cool the compressed air or gas. Aftercoolers are used to accomplish this. They consist essentially of steel shells containing a nest of tubes, water circulating through the tubes and the air or gas passing around the tubes. By cooling the air or gas to approximately the temperature at which it entered the compressor, most of the vapor is condensed and can be separated out of the air (25).

A moisture separator is an essential part of an efficient aftercooler. An automatic moisture trap is also recommended (25).

As water is used for cooling, an aftercooler always should be set indoors to avoid freezing. The aftercooler preferably should be set between the compressor and the air receiver so that any condensed moisture carried with the air after leaving the cooler can be collected in the air receiver and removed from there (25).

Air Filters. If dust or other foreign matter is continually sucked into a machine it causes rapid wear of the working parts and forms an obstructive coating on the cylinder, valves, etc. To avoid such a condition, an efficient air filter should be attached to the air-intake pipe. There are several standard makes of such filters now available, and recommendations to meet specific conditions can be obtained from compressor or filter manufacturers. The filter should be of ample size to prevent restriction of the air flow. (See Fig. 159.)

Air Silencers. Where the noise usually made by the suction of the compressor or the noise occasionally encountered in compressor discharge lines is objectionable, an air silencer should be used. Several makes of satisfactory silencers are now regularly available, and recommendations can be obtained from the compressor or silencer manufacturers. The silencer should not offer a resistance to the air flow exceeding 2 in. of water.

ART. 8-H. PIPING

Loss of Air Pressure in Piping Due to Friction

In all blower installations where a length of pipe is used to deliver air, either to the blower inlet or from the blower discharge or both, a certain amount of pressure is used up in forcing the air through these pipes. Ordinarily, when the combined length of the intake and discharge pipes is greater than ten pipe diameters, the drop in pressure is great enough to make a difference between the generated pressure and the pressure at the delivery end of the discharge pipe. This drop must be taken into consideration, especially if the pressure generated by the blower is to be very little in excess of that required to force the desired volume of air through the particular apparatus or system alone (25).

Table 126 shows factors for calculating loss of air pressure due to pipe friction applicable for any pressure.

For pipe systems with small pressure losses, where the compression ratio is practically equal to 1, the figure shown in Table 126 will, for all practical purposes, equal the pressure loss in pounds per square inch, per 1000 ft of pipe.

Table 127 shows loss of pressure through screw-pipe fittings, expressed in equivalent lengths of straight pipe.

Compressed Air Service for Laboratory Work

The machines usually are rotary compressors for smaller installations and reciprocating compressors with belt or silent chain device for larger installations. The motor should be provided with an automatic starter to cut in at 10 lb and cut out at 30 lb pressure. The storage tank should be of ample size and provided with a pressure-reducing valve at the outlet to reduce the air pressure to 4 to 5 lb.

The piping may be figured for a total pressure drop of 1 to 2 lb.

The discharge, measured in free air, per outlet may be found in Table 128.

The actual pressure drop can be read from Table 126. Consideration should be given to the fact that only a small percentage of outlets may be in use at any one time. This may not hold true, however, for school work.

Generally, these pipe sizes, based on not larger than $\frac{3}{16}$ -in. outlets, will prove satisfactory:

Piping.

1-in pipe will serve 25–35 outlets.

$\frac{3}{4}$ -in. pipe will serve 5–25 outlets.

$\frac{1}{2}$ -in. pipe will serve up to 5 outlets.

Short connections may be as small as $\frac{1}{4}$ -in. pipe.

TABLE 126

FACTORS FOR CALCULATING LOSS OF AIR PRESSURE DUE TO PIPE FRICTION APPLICABLE FOR ANY INITIAL PRESSURE

Cubic Feet Free Air per Minute	NOMINAL DIAMETER IN INCHES							
	½	¾	1	1¼	1½	2	2½	3
5	12.7	1.2	0.5					
10	50.7	7.8	2.2	0.5				
15	114.1	17.6	4.9	1.1				
20	202	30.4	8.7	2.0	0.9			
25	316	50.0	13.6	3.2	1.4			
30	456	70.4	19.6	4.5	2.0			
35	621	95.9	26.6	6.2	2.7			
40	811	125.3	34.8	8.1	3.6			
45		159	44.0	10.2	4.5	1.2		
50		196	54.4	12.6	5.6	1.5		
60		282	78.3	18.2	8.0	2.2		
70		385	106.6	24.7	10.9	2.9	1.1	
80		503	139.2	32.3	14.3	3.8	1.5	
90		646	176.2	40.9	18.1	4.8	1.9	
100		785	217.4	50.5	22.3	6.0	2.3	
110		950	263	61.1	27.0	7.2	2.8	
120			318	72.7	32.2	8.6	3.3	
130			369	85.3	37.8	10.1	3.9	1.2
140			426	98.9	43.8	11.7	4.6	1.4
150			490	113.6	50.3	13.4	5.2	1.6
160			570	129.3	57.2	15.3	5.9	1.9
170			628	145.8	64.6	17.6	6.7	2.1
180			705	163.3	72.6	19.4	7.5	2.4
190			785	177	80.7	21.5	8.4	2.6
200			870	202	89.4	23.9	9.3	2.9
220				244	108.2	28.9	11.3	3.5
240				291	128.7	34.4	13.4	4.2
260				341	151	40.3	15.7	4.9
280				395	175	46.8	18.2	5.7
300				454	201	53.7	20.9	6.6

From *Compressed Air Data*, by permission of Ingersoll-Rand Co.

TABLE 127
 LOSS OF PRESSURE THROUGH SCREW PIPE FITTINGS
 STEAM—AIR—GAS
 (Given in equivalent lengths of straight pipe)

Nominal Pipe Size, Inches	Actual Inside Diameter, Inches	Gate Valve	Long Radius Ell or on Run of Standard Tee	Medium Radius Ell or on Run of Tee Reduced in Size 25%	Standard Ell or on Run of Tee Reduced in Size 50%	Angle Valve	Close Return Bend	Tee Through Side Outlet	Globe Valve
Resistance Factor for Type of Fitting		0.25	0.33	0.42	0.67	0.90	1.00	1.33	2.00
3/8	0.622	0.31	0.41	0.52	0.84	1.1	1.3	1.7	2.5
1/2	0.824	0.44	0.57	0.73	1.2	1.6	1.8	2.3	3.5
1	1.049	0.57	0.77	0.98	1.6	2.1	2.3	3.1	4.7
1 1/4	1.380	0.82	1.1	1.4	2.2	2.9	3.3	4.4	6.5
1 1/2	1.610	0.98	1.3	1.6	2.6	3.5	3.9	5.2	7.8
2	2.067	1.3	1.7	2.2	3.6	4.8	5.3	7.1	10.6
2 1/2	2.469	1.6	2.2	2.8	4.4	5.9	6.6	8.7	13.1
3	3.068	2.1	2.8	3.6	5.7	7.7	8.5	11.4	17.1
4	4.026	3.0	3.9	5.0	7.9	10.7	11.8	15.8	23.7
5	5.047	3.9	5.1	6.5	10.4	13.9	15.5	20.7	31.0
6	6.065	4.8	6.4	8.1	12.9	17.4	19.3	25.6	38.5
8	7.981	6.7	8.9	11.2	17.9	24.1	26.8	35.6	53.8
10	10.020	8.8	11.5	14.7	23.4	31.5	35.0	46.6	70.0
12	12.000	10.9	14.4	18.4	29.3	39.3	43.7	58.1	87.4

Based on Foster's Formula $L = 43.7 r d^{(1.2)}$

In which L = equivalent length straight pipe in feet

r = resistance factor

d = diameter of fitting in feet

(ASME Trans., Vol. 42, p. 648, 1920.)

TABLE 128
DISCHARGE OF AIR THROUGH AN ORIFICE

(Cubic feet of air per minute measured at absolute pressure of 14.7 psi and 70 F.)

Gage Pressure Before Orifice in Pounds per Sq In.	DIAMETER OF ORIFICE, INCHES				
	1/64	1/32	1/16	1/8	1/4
	DISCHARGE IN CUBIC FEET OF FREE AIR PER MINUTE				
1	0.028	0 112	0 450	1 80	7.18
2	0 040	0.158	0.633	2 53	10 1
3	0.048	0 194	0.775	3 10	12 4
4	0 056	0.223	0 892	3 56	14 3
5	0 062	0 248	0.993	3 97	15.9
6	0 068	0 272	1 09	4 34	17 4
7	0 073	0 293	1 17	4 68	18.7
9	0 083	0 331	1 32	5.30	21.2
12	0 095	0.379	1.52	6.07	24.3
15	0.105	0 420	1 68	6 72	26.9
20	0.123	0 491	1 96	7.86	31 4
25	0.140	0 562	2.25	8.98	35.9
30	0 158	0.633	2 53	10 1	40.5
35	0 176	0 703	2 81	11 3	45.0
40	0.194	0.774	3.10	12.4	49.6
45	0 211	0 845	3 38	13 5	54.1
50	0 229	0 916	3 66	14.7	58.6
60	0.264	1 06	4.23	16.9	67.6

Table is based on 100% coefficient of flow. For well-rounded entrance, multiply values by 0.97. For sharp-edged orifices a multiplier of 0.65 may be used.

Values for pressures from 1 to 15 lb gage calculated by standard adiabatic formula.

Values for pressures above 15 lb gage calculated by approximate formula proposed by S. A. Moss:

Where:

$$W = 0.53033 \frac{ACP_1}{\sqrt{T_1}}$$

W = discharge in lbs per sec.
 A = area of orifice in sq. in.
 C = coefficient of flow.

P₁ = upstream pressure in lb per sq in. absolute.
 T₁ = upstream temperature in F absolute.

Values used in calculating above table were: C = 1.0, P₁ = gage pressure + 14.7 psi, T₁ = 530 F abs.

Weights (W) were converted to volumes using density factor of 0.07494 lb per cu ft. This is correct for dry air at 14.7 psi absolute pressure and 70 F.

Formula cannot be used where P₁ is less than two times the barometric pressure.

From *Compressed Air Data*.

ART. 8-I. VACUUM-CLEANING SYSTEMS

Vacuum-cleaning systems in buildings use a centrifugal or turbo-exhauster. The system looks very much like a compressed-air layout in reverse. From inlets distributed through the building, a system of pipes

connect to a receiver and exhauster from which the air is discharged into the regular building chimney or to the roof. The following data are from the *Spencer Vacuum Cleaner Data Book*, reprinted with the permission of the Spencer Turbine Company, Hartford, Conn.

Piping

All pipe fittings should be of the long-turn drainage type with recessed threads. Steam, gas, or water fittings are absolutely unsuitable for vacuum-cleaner piping. All pipes should be of black mild steel or wrought iron, and nothing smaller than 2-in. pipe should be used anywhere in the system. The only exception to this rule is that sometimes 1½-in. nipples and couplings may be used for connecting the inlet valves to the piping system. This procedure is not recommended, however, unless it is absolutely necessary on account of space limitations. Exhaust connections should be made to the chimney or flue and have no other openings above them.

Pipe Sizes

The correct size of pipe for a vacuum-cleaner installation may be determined from Fig. 163. This chart tells how to lay out a piping system for any building, whatever the size, in such a manner that the success of the installation may be assured. Of course a certain amount of judgment

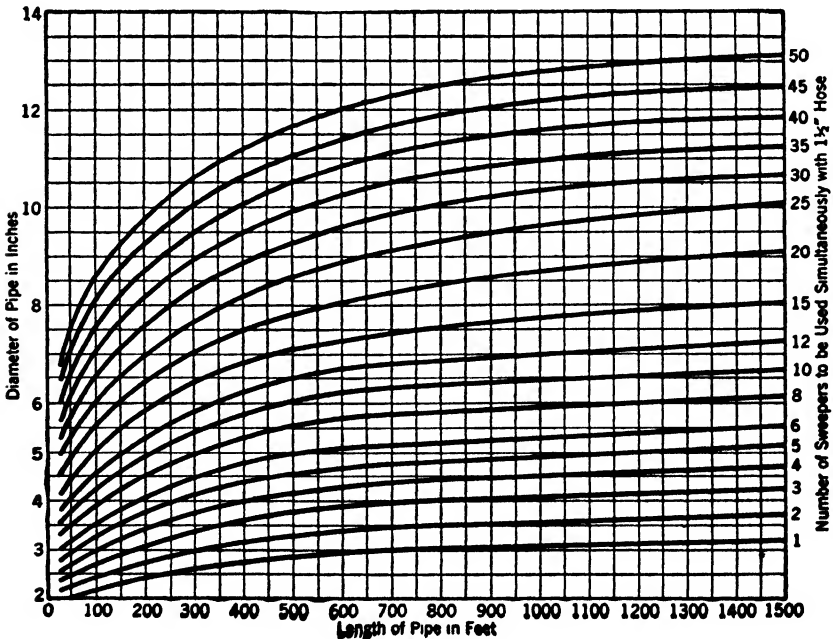


FIG. 163

must be used in laying out any piping system. Structural peculiarities of individual buildings must necessarily be taken into consideration, and often these peculiarities require a certain departure from the usual procedure. Standard practice specifies that there should be a drop in suction of not more than one inch of mercury between the most remote inlet valve and the vacuum producer. It is, therefore, well after the piping system has been laid out to check the pipe sizes against the resistance to flow, from the tables on pipe losses which are given in this section. This serves as a double check to assure the engineer that his system is properly proportioned for the work it is to do.

The size of pipe used for any vacuum-cleaner installation is given in Fig. 163. "Length of Pipe in Feet" is the total length of pipe from discharge end of the exhaust pipe to the most remote inlet valve in the building. Follow the vertical line indicating length of pipe to its intersection with the curve showing total number of sweepers to be operated simultaneously. The diameter of the pipe to be used is then found horizontally to the left.

If less than the full number of sweepers are to be operated simultaneously through part of the piping system, the pipe size may be reduced to that given in the diagram for the number of sweepers that will actually be used simultaneously through that part of the piping, based on the same total length of pipe from the discharge end of the exhaust pipe to the most remote valve in the building.

Note: In figuring total length of pipe, 10 ft must be added for each 90-deg elbow.

Example. The sample piping layout shown in Fig. 165 is based on a four-sweeper plant with not more than two sweepers in use simultaneously on any one riser, and not more than one sweeper at a time above the seventh floor on any riser.

To determine the pipe size required, first note that the total distance from the point where the exhaust pipe enters the chimney to the top of the most remote riser is 450 ft. Since there is only one sweeper above the seventh floor, we refer to the one sweeper curve on the diagram (Fig. 163) and find that this curve intersects the 450-ft vertical line about opposite the 2½-in. pipe figure at the left, showing that 2½ in. is the right pipe size above the seventh floor for all risers.

As two sweepers per riser are to be used below the seventh floor, we refer to the two-sweeper curve on the diagram and find that it intersects the 450-ft vertical line about opposite the 3-in. pipe figure, showing that 3-in. pipe will be required below the seventh floor on all risers, and as far on the horizontal main as it has to carry two sweepers only, which according to the above specification would be to riser C.

As two sweepers are to be used on a riser, the main pipe beyond riser C will have to carry four sweepers. Referring again to the diagram, we find that the four-sweeper curve intersects the 450-ft vertical line about opposite the 4-in. pipe figure, indicating that 4-in. pipe will be required for the remaining distance to the vacuum producer and for the exhaust to the chimney. In the use of the curve sheet, it is important to note that the vertical line on the curve sheet representing the total distance (from farthest inlet valve to end of exhaust in chimney) is held as the base or reference line.

Each 90-deg elbow is estimated as equal in frictional loss to about 10 ft of pipe of the same size.

TABLE 129

VACUUM IN INCHES OF MERCURY LOST BY FRICTION IN PIPES 100 FEET LONG

Cu Ft per Minute	1½ in.	2 in.	2½ in.	3 in.	4 in.	5 in.	6 in.	8 in.	10 in.	12 in.	14 in.
30	0.37	0.087	0.029	0.011	0.003						
40	0.65	0.160	0.051	0.021	0.005	0.0010					
50	1.02	0.24	0.079	0.032	0.008	0.0020					
60	1.47	0.35	0.114	0.045	0.011	0.0036	0.0014				
70	2.01	0.48	0.156	0.063	0.015	0.0049	0.0020				
80	2.62	0.62	0.204	0.082	0.020	0.0064	0.0025				
90	3.31	0.89	0.257	0.104	0.025	0.0081	0.003				
100	4.09	0.97	0.318	0.128	0.031	0.010	0.004				
150		2.18	0.715	0.288	0.069	0.023	0.009	0.0016			
200		3.73	1.39	0.510	0.120	0.039	0.016	0.004			
300			2.90	1.14	0.275	0.089	0.036	0.008	0.0028		
400			5.09	2.05	0.489	0.158	0.064	0.015	0.005		
500				3.20	0.775	0.250	0.100	0.024	0.008	0.0032	
600				4.60	1.10	0.357	0.145	0.034	0.011	0.0046	
700					1.52	0.490	0.196	0.046	0.015	0.006	0.002
800					1.85	0.634	0.258	0.061	0.020	0.008	0.003
900					2.51	0.810	0.324	0.077	0.025	0.010	0.004
1000					3.06	0.980	0.403	0.095	0.031	0.013	0.006
1200							0.581	0.137	0.045	0.018	0.008
1500								0.213	0.060	0.028	0.013
2000								0.390	0.125	0.050	0.023
2500									0.196	0.078	0.034
3000									0.270	0.115	0.052
3500										0.152	0.073
4000										0.200	0.094
4500										0.253	0.117
5000											0.145
5500											0.175
6000											0.208

Due to the variation in vacuum loss for various weights of hose this table is approximate only.

Courtesy Spencer Turbine Co., Hartford, Conn.

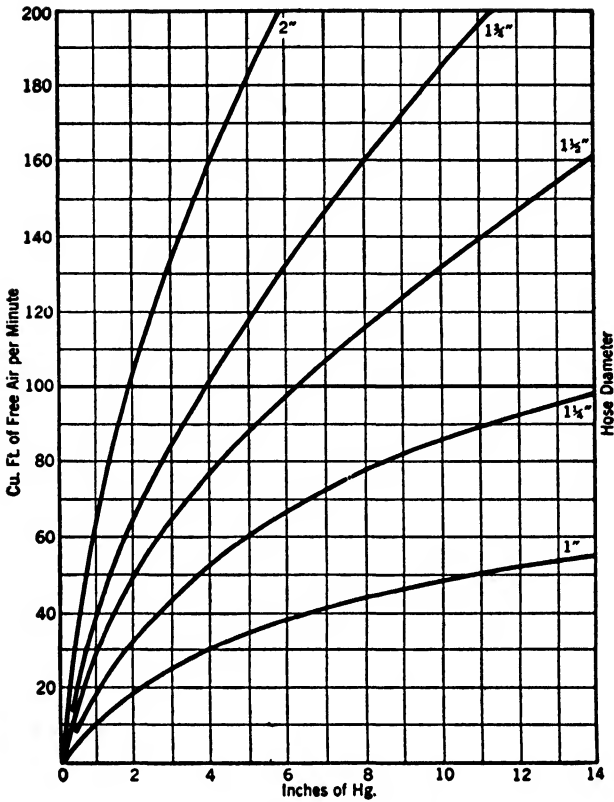


FIG. 164. Loss of Vacuum in Inches of Hg for 100 Feet of Hose. Pilot Tube Measurements.
 (By M. S. Coole.) (Courtesy Spencer Turbine Co., Hartford, Conn.)

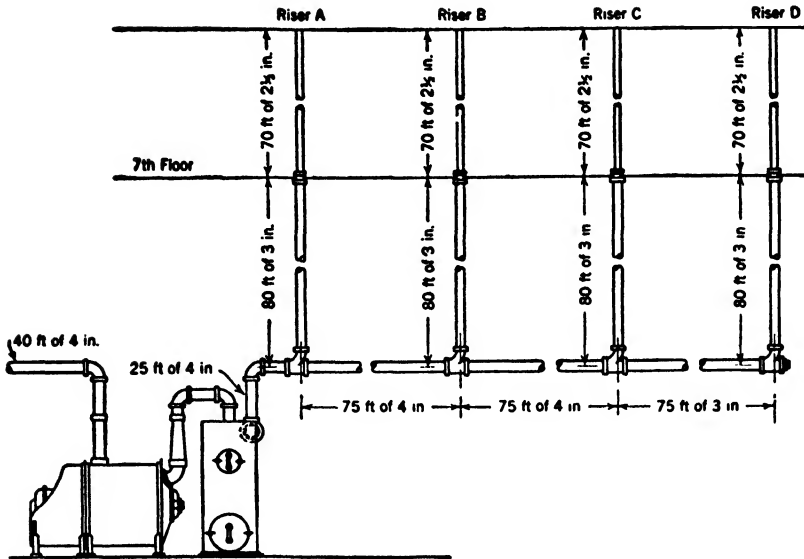


FIG. 165. Sample Piping Layout.

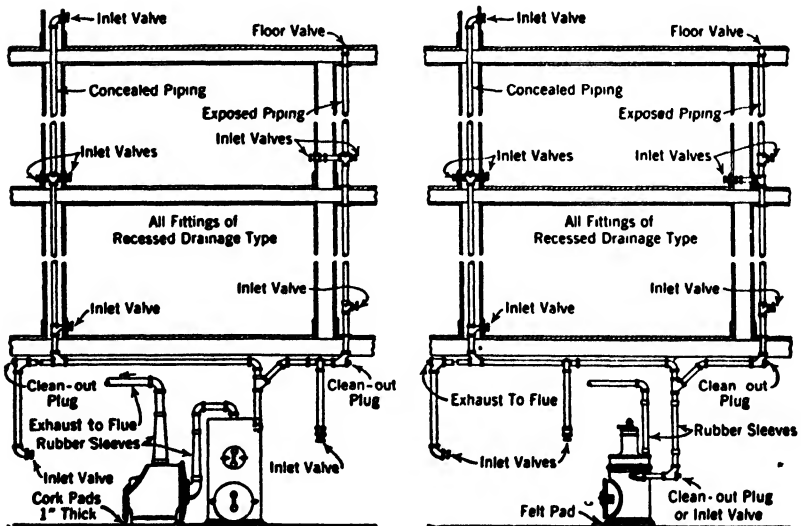


FIG. 166. Typical Piping Arrangements.

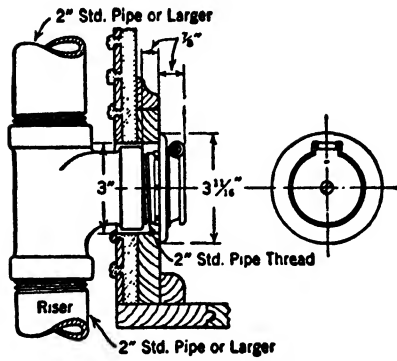


FIG. 167. Typical Inlet Valve.

APPENDIX

NATIONAL INSTITUTIONS

American Council on Education

744 Jackson Place, Washington, D. C.

American Public Health Association

1790 Broadway, New York, N. Y.

American Gas Association

420 Lexington Avenue, New York, N. Y.

American Standards Association

29 West 39th Street, New York, N. Y.

American Water Works Association

22 East 40th Street, New York, N. Y.

Manufacturers' Standardization Society of the Valve and
Fittings Industry

420 Lexington Avenue, New York, N. Y.

Lead Industries Association

420 Lexington Avenue, New York, N. Y.

National Fire Protection Association

60 Batterymarch Street, Boston, Mass.

ABBREVIATIONS AND SYMBOLS

A	Area
a	Minor areas
abs	Absolute
A.B.	All bronze (pumps)
A.I.	All iron (pumps)
A.R.	Acid resistant (pumps)
A.S.	Automatic sprinkler
AGA	American Gas Association
AI & SI	American Iron and Steel Institute
APHA	American Public Health Association
API	American Petroleum Institute
ASA	American Standards Association
ASCE	American Society of Civil Engineers
ASME	American Society of Mechanical Engineers
ASSE	American Society of Sanitary Engineers
ASTM	American Society for Testing Materials
AWWA	American Water Works Association
Al	Aluminum (Chem.)
Bé	Baumé degrees
Btu	British thermal unit
Bhp	Brake horsepower
B.F.	Bronze fitted (pumps)
C	Coefficient or constant
C	Allowance for loss of material (from threading, corrosion, etc.), in inches
C	Centigrade degrees
cfm	Cubic feet per minute
cfs	Cubic feet per second
cg	Centimeter-gram-second (system)
cu ft	Cubic feet
C	Center
C.I.	Cast iron
CCW	Counterclockwise (pump rotation)

CS	Commercial standard
CW	Clockwise (pump rotation)
Cl	Chlorides (Chem.)
Cu	Copper (Chem.)
<i>D</i>	Diameter
<i>d</i>	Diameter
<i>d</i>	Depth
deg	Degree
diam	Diameter
F	Fahrenheit degrees
ft	Foot
fps	Feet per second
F.U.	Fixture unit
FS	Federal Specifications
FSB	Federal Specification Board
Fe	Iron (Chem.)
<i>G</i>	Discharge in gallons per minute
ga	Gage
gal	Gallon
gph	Gallons per hour
gpm	Gallons per minute
<i>H</i>	Head, total
hp	Horsepower
HPCNA	Heating and Plumbing Contractors National Association
H	Hydrogen (Chem.)
Hg	Mercury (Chem.)
I. D.	Inside diameter
in.	Inch
ipy	Inch penetration per year, an expression of corrosion rate
IPS	Iron pipe size
kw	Kilowatt
kwhr	Kilowatt-hour

L	Length, in feet
lb	Pound
lin ft	Linear foot
M	Mille, thousand
max	Maximum
mdd	Milligrams per square decimeter per day, expression of loss in weight due to wear or corrosion
min	Minute
min	Minimum
M. & F.	Male and female
MSS	Manufacturers Standardization Society of the Valve and Fittings Industry
N.P.	Nickel-plated
NBFU	National Board of Fire Underwriters
NBS	National Bureau of Standards
NEWWA	New England Water Works Association
NFPA	National Fire Protection Association
N	Nitrogen (Chem.)
oz	Ounce
O.D.	Outside diameter
O	Oxygen (Chem.)
P	Pressure, in lb per sq in.
P_1	Maximum absolute air pressure
P_2	Minimum absolute air pressure
pH	Hydrogen-ion concentration
ppm	Parts per million
psi	Pounds per square inch
PHS	Public Health Service
P.E.	Plain ends (piping)
Q	Major discharge or flow, volume per unit of time
qt	Quart
S	Fiber strength of a material in pounds per square inch

sec	Second
sq ft	Square foot
sq in.	Square inch
S.S.U.	Saybolt Seconds Universal
SWP	Steam Working Pressure
<i>T</i>	Temperature
<i>t</i>	Thickness, in inches
WP	Working pressure
WSP	Working steam pressure
yr	Year

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