Pipe hanger design and engineering

Revised 1979

Grinnell®
SUPPLY SALES COMPANY

PIPE HANGER DESIGN
and
ENGINEERING

Weights of Piping Materials

The material in this booklet has been compiled to furnish pipe hanger engineers with the necessary data and procedures to determine pipe hanger loads and thermal movements of the pipe at each hanger location.

The tabulation of weights has been arranged for convenient selection of data that formerly consumed considerable time to develop. In many instances this information was not available for general distribution. This made it necessary to develop average or approximate weights that may be substituted with actual weights whenever practical.

The "Hanger Load Calculation Problem" is typical of the actual steps required in the solution of any pipe hanger installation. This method is used in our Pipe Hanger Division to solve the many unusual problems encountered by the Piping Industry.

Great care was taken in collecting and printing data in this booklet to assure accuracy throughout. However, no representation or warranty of accuracy of the contents of this booklet is made by Grinnell. The only warranties made by Grinnell are those contained in sales contracts for design services or products.

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INTRODUCTION

THE DESIGN OF PIPE HANGERS

It has become widely recognized that the selection and design of pipe hangers is an important part of the engineering study of any modern steam generating or process installation. Problems of pipe design for high temperature, high pressure installations have become critical to a point where it is imperative that such aspects of design as the effect of concentrated hanger loads on building structure, pipe weight loads on equipment connections, and physical clearances of the hanger components with piping and structure be taken into account at the early design stages of a project.

Problems presented in the design of hangers for nuclear power plants may vary substantially from those in fossil fuel generating plants. Temperatures are more moderate but the nature of nuclear energy demands fail safe hanger design as dictated by the Nuclear Regulatory Commission and in compliance with pertinent codes.

Engineers specializing in the design of pipe hangers have established efficient methods of performing the work required to arrive at appropriate hanger designs. However, the engineer who devotes varying portions of his time to the design of pipe hangers often must gather a considerable amount of reference data peculiar only to the hanger calculations for his current project.

It is the purpose of this article to present a compilation of all information necessary for the design of hangers, including a technical section devoted to the listing of piping material, weights, and thermal expansion data. Also, the discussions of the various steps involved in designing supports, presented here in their proper sequence, should serve as a good reference source for the engineer who only occasionally becomes involved in the essentials of hanger design.

The first of these steps is that of determining and obtaining the necessary amount of basic information before proceeding with calculations and detailing of the pipe supports. No design is complete unless the engineer has had the opportunity to review the equivalent of the following project data:

The pipe hanger specification, when available (A typical hanger specification is shown on pages 21 and 22).

A complete set of piping drawings.

A complete set of steel and structural drawings including equipment foundation and structure details.

A complete set of drawings showing the location of ventilating ducts, electrical trays, pumps, tanks, etc.

The appropriate piping specifications and data, which will include pipe sizes and composition identification, wall thicknesses, and operating temperatures.

A copy of the insulation specifications with densities.

Valve and special fittings lists, which will indicate weights.

The movements of all critical equipment connections such as boiler headers, steam drums, turbine connections, etc.

The results of the stress, flexibility and movement calculation performed for critical systems.

The steps in which the engineer will apply this basic information are as follows:

(1) The determination of hanger locations.
(2) The determination of the thermal movement of the piping at each hanger location.
(3) The calculation of hanger loads.
(4) The selection of hanger types, i.e., spring assembly, either of the constant support or variable spring type, rigid assembly, etc.
(5) The checking of clearance between the hanger components and nearby piping, electrical cable trays, conduits, ventilating ducts, and equipment.

The final step will not be discussed to any great degree. Obviously, this aspect of design is governed solely by the requirements and layouts of the individual job. Instead, attention will be devoted to steps 1 through 4, where the scope of good hanger practice can be generally defined for any installation.

Recognizing that each new piping design presents an abundance of new problems to the engineer, no attempt is made to state fixed rules and limits which would be applicable to every hanger design. Rather, the intention is to illustrate ideas which will serve as a guide to a simple, practical solution to any pipe support problem.

THE DETERMINATION OF HANGER LOCATIONS

Support locations are dependent on pipe size, piping configuration, the location of heavy valves and fittings, and the structure that is available for the support of the piping.

No firm rules or limits exist which will positively fix the location of each support on a piping system. Instead, the engineer must exercise his own judgement in each case to determine the appropriate hanger location.

The suggested maximum spans between hangers listed in table below reflect the practical considerations involved in determining support spacings on straight runs of standard wall pipe. They are normally used for the support spacings of critical systems.

The spans in table below are in accordance with MSS Standard Practice SP-69. They do not apply where concentrated weights such as valves or heavy fittings or where changes in direction of the piping system occur between hangers.

In case of concentrated loads the supports should be placed as close as possible to the load in order to keep bending stresses to a minimum.

Where changes in direction of the piping of any critical system occur between hangers, it is considered good practice to keep the total length of pipe between the supports less than three-fourths the full spans in table below.

When practical, a hanger should be located immediately adjacent to any change in direction of the piping.

In the sample problem, illustrated in Figure H-1 (page 4) seven supports are shown on the 12 inch line, and two on the 6 inch pipe.

Note that hanger H-1 has been placed adjacent to the valve weight concentration. The proximity of the hanger to the valve is helpful in keeping the load at terminal connection A to a minimum. Also, the bending stresses induced in the pipe by the valve weight are kept to a minimum.

The selection of the location for hanger H-2 entails a change in direction of the pipe between two hangers. In order to avoid excessive overhang of the pipe between hangers H-1 and H-2, the developed length of pipe between these hangers is made less than three-fourths the suggested maximum span in table below.

In considering the vertical section of the pipe on which H-3 and H-4 are shown, it should first be noted that this section of the pipe could be supported by one hanger rather than two as indicated. Two hangers, certainly, will provide greater stability than will a single hanger. Another deciding factor as to whether one hanger or a multiple of hangers should be used is the strength of the supporting steel members of the structure. The use of two hangers will permit the total riser weight to be proportioned to two elevations of the structure, avoiding the concentration of all the riser load at one building elevation.

The locations for hangers H-5 and H-6 are governed by the suggested maximum span as well as the position of the concentrated valve weight. Consequently, H-6 has been located adjacent to the valve, and H-5 at a convenient location between the valve and the 12 inch riser.

The location of hanger H-7 will be determined by calculation to satisfy the condition that no pipe load is to be applied to terminal connection C. It is obvious that by moving the hanger along the 12 foot section of pipe, the amount of load on connection C will vary. One support location exists where the entire section will be "balanced", and the load at C equal to zero.

The calculations performed in determining the exact location of H-7 are shown in the section entitled "The Calculation of Hanger Loads", page 11.

Consider next the 6 inch section of pipe on which H-8 and H-9 are shown. One of the requirements for this hanger problem is that the load at terminal connection B shall be zero. By placing H-9 directly over connection B, we can easily assure that this load will be zero. Also, this hanger location eliminates any bending stresses in the pipe that would be caused by the weight of the valve and vertical pipe at point B. If H-9 could not be located at this point due to structural limitations, it would be desirable to place it as close as possible to the vertical section of pipe to keep the cantilever effect to a minimum.

NOMINAL PIPE SIZE, IN.	1	1½	2	2½	3	3½	4	5	6	8	10	12	14	16	18	20	24	30
SPAN WATER, FT.	7	9	10	11	12	13	14	16	17	19	20	23	25	27	28	30	32	33
ST'M.. GAS, AIR FT.	9	12	13	14	15	16	17	19	21	24	26	30	32	35	37	39	42	44

Hanger H-8 is located at a convenient distance between H-9 and the intersection of the 6 inch and 12 inch pipes. In this instance, the location of adequate building structure will determine the hanger position.

The methods involved in locating hangers for this problem are typical of those employed by the hanger engineer in the design of pipe supports. Although the individual piping configurations and structure layout will vary in practically every instance, the general methods outlined above will apply for any critical piping system.

For economy in the support of low pressure, low temperature systems, and long outdoor transmission lines, hanger spans may be based on the allowable total stresses of the pipe and the amount of allowable deflection between supports.

In steam lines with long spans the deflection caused by the weight of the pipe may be large enough to cause an accumulation of condensate at the low points of the line. Water lines, unless properly drained, can be damaged by freezing. These conditions can be avoided by erecting the line with a downward pitch in such a manner that succeeding supports are lower than the points of maximum deflection in preceding spans as shown:

The stresses indicated in the Chart on page 61 and the Chart on page 62 are bending stresses resulting from the weight of the pipe between supports. It should be realized that this stress must be considered with other stresses in the piping, such as those due to the pressure of the fluid within the pipe, the bending and torsional stresses resulting from thermal expansion, etc., in order to design the system for *total* allowable stress.

The stresses and deflections indicated in the Charts on pages 60, 61 and 62 are based on a single span of pipe with free ends, and make no allowances for concentrated loads of valves, flanges, etc., between hangers.

The stress and deflection values shown in these Charts on pages 60, 61 and 62 are based on a free end beam formula and reflect a conservative analysis of the piping. Actually, the pipe line is a continuous structure partially restrained by the pipe supports, and the true stress and deflection values lie between those calculated for the free end beam and a fully restrained structure.

The deflections and bending stress values indicated represent safe values for any schedule pipe from Sch. 10 to XS pipe.

For fluids other than water, the bending stress can be found by first finding the added stress caused by water from the Charts on pages 61 and 62 and multiplying by the specific gravity of the fluid. Add this to the stress value of the pipe empty.

For lines which are thickly insulated, find the deflection or bending stress resulting from the weight of pipe bare and multiply by a ratio of the weight of pipe per foot plus insulation to the weight of bare pipe per foot.

To illustrate the use of the deflection and stress charts, consider the following examples:

Problem

Find: The maximum economical hanger spacing for a 10 inch non-insulated steam transmission line, 1200 feet long, which will provide sufficient drainage with minimum deflection within an allowable bending stress limit of 10,000 psi. The maximum difference in elevations of the ends of the line is 5 feet.

Solution: Maximum Slope — $\frac{5 \text{ ft. x } 12 \text{ in./ft.}}{1200 \text{ ft.}}$

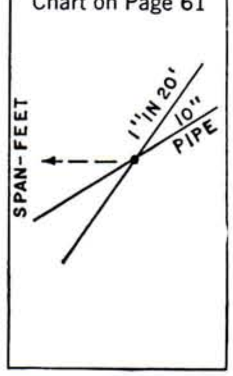
Maximum Slope — 1 in In 20 ft.

From the Chart on page 60, find the intersection of the Curve 1 inch in 20 feet, and 10 inch nominal pipe size. Read left to find the allowable pipe span of 40 feet.

From the Chart on page 61, the bending stress for 10 inch pipe with a support span of 40 feet is 3249 psi, which is below the allowable 10,000 psi.

Ans. Span — 40 ft.

Extract From Chart on Page 61



Problem:

Find: The maximum economical spacing to provide sufficient drainage for an 8 inch water filled line 600 feet long. The allowable bending stress is 6000 psi, and the difference in elevations between the ends of the pipe line is 5 feet.

Solution: Max. Slope = $\frac{5 \text{ ft. x } 12 \text{ in/ft.}}{600 \text{ ft.}}$ = 1 in. in 10 ft.

Problem:

From the Chart on page 60, find the intersection of the curve 1 inch in 10 feet and 8 inch pipe, and read left to a span of 43 feet.

From the Chart on page 62, for an 8 inch water filled line with a support span of 43 feet, the bending stress is 8289 psi, which is greater than the allowable 6000 psi. Therefore, the maximum span should be based on the allowable bending stress of 6000 psi.

Referring to the Chart on page 62, the maximum span for 8 inch pipe and an allowable bending stress of 6000 psi is 37 feet.

Ans. Span = 37 ft.

Problem:

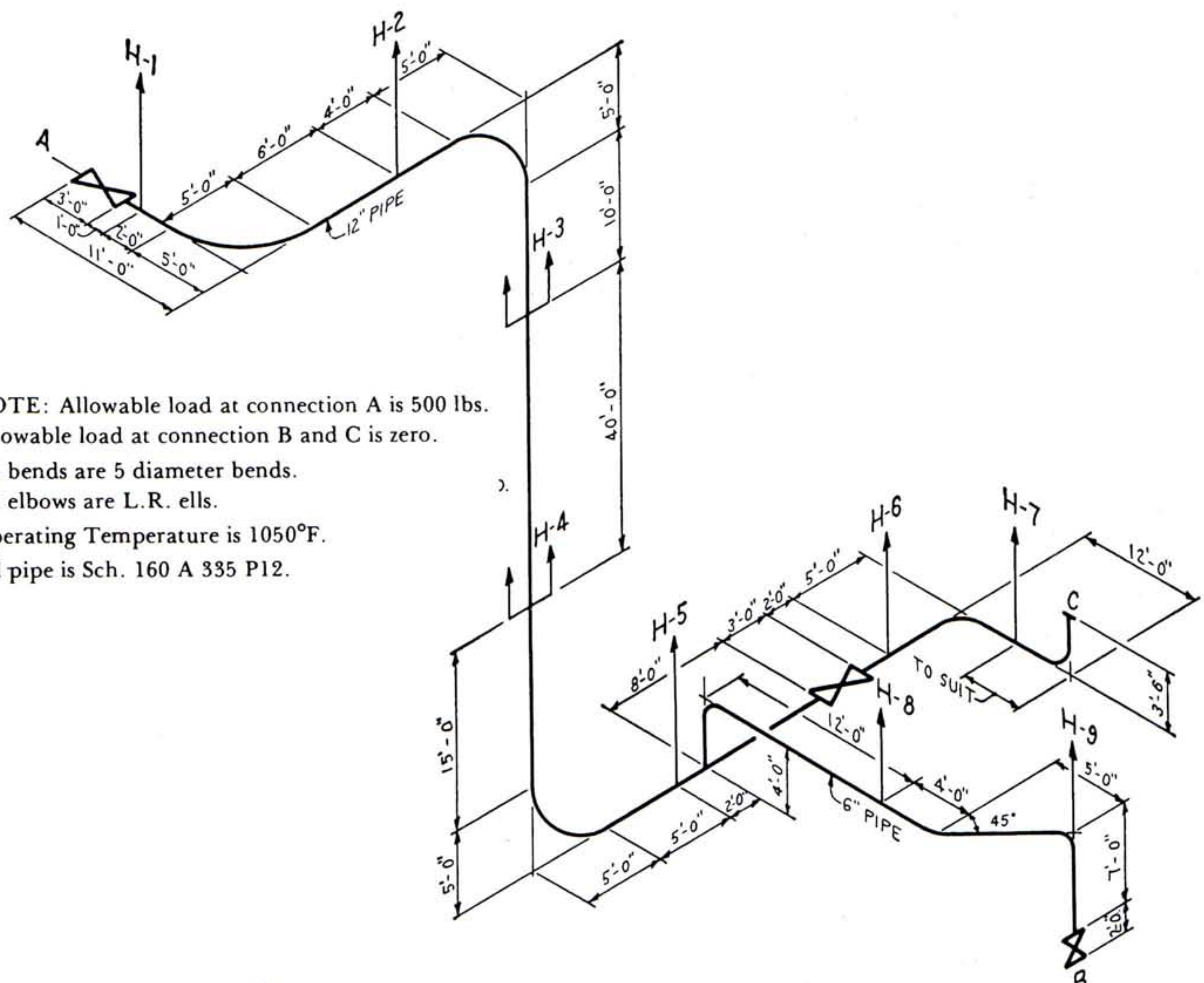
Find: The maximum spacing and slope for a 6 inch water filled line where the allowable bending stress is 10,000 psi. The difference in the elevations of the ends of the system is not limited.

From the Chart on page 62, the maximum span for a 6 inch water filled line with an allowable bending stress of 10,000 psi is 42 feet.

On the Chart on page 60, read from the 42 foot span value to the 6 inch pipe curve. Interpolating between the slope curves 1 inch in 10 feet and 1 inch in 5 feet, read the slope 1 inch in 6 feet.

Ans. Span = 42 ft.

Pipe is sloped at 1 inch in 6 feet. (A difference in elevation of 7 inch between supports.)



NOTE: Allowable load at connection A is 500 lbs.
Allowable load at connection B and C is zero.
All bends are 5 diameter bends.
All elbows are L.R. ells.
Operating Temperature is 1050°F.
All pipe is Sch. 160 A 335 P12.

Figure H-1

THERMAL MOVEMENT CALCULATIONS

The next step in the design of pipe hangers involves the calculation of the thermal movements of the pipe at each hanger location. Based on the amount of vertical movement and the supporting force required, the engineer can most economically select the proper type hanger (i.e. Constant Support, Variable Spring, or Rigid Assembly).

The determination of piping movements to a high degree of accuracy necessitates a highly complicated study of the piping system. The simplified method shown below is one which gives satisfactory approximations of the piping movements. Whenever differences occur between the approximations and actual movements, the approximation of the movement will always be the greater amount.

Step I

Draw the piping system of Figure H-1 and show all known vertical movements of the piping from its cold to hot, or operating, position (see Fig. H-1a). These movements will include those supplied by the equipment manufacturers for the terminal point connections. For the illustrated problem, the following vertical movements are known:

Point *A* — 2" up, cold to hot
Point *B* — 1/16" up, cold to hot
Point *C* — 1/8" down, cold to hot
H-4 — 0", cold to hot

The operating temperature of the system is given as 1050°F.

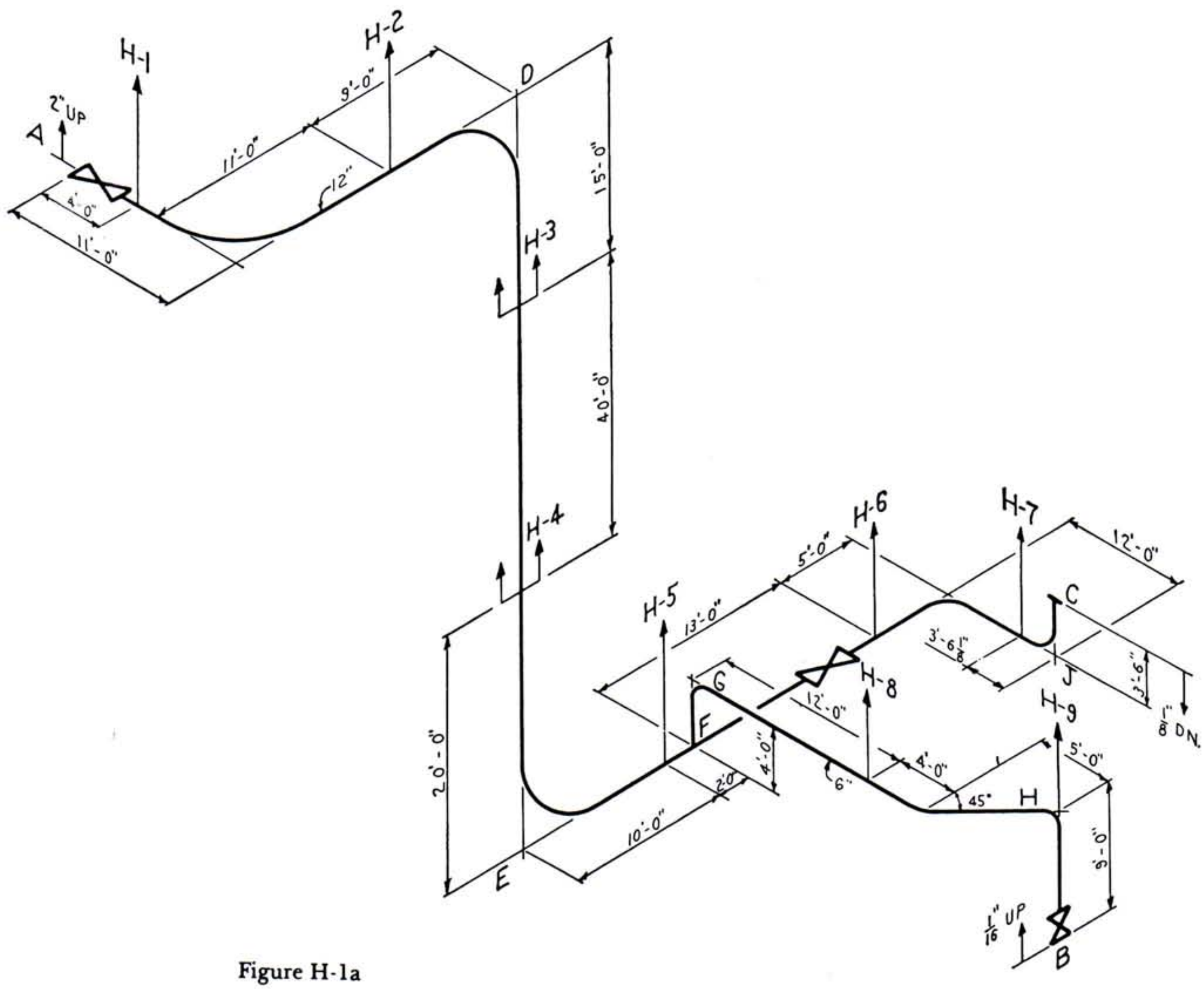


Figure H-1a

Referring to the thermal expansion table (page 65), the coefficient of expansion for low-chrome steel at 1050°F is .0946 inch/ft.

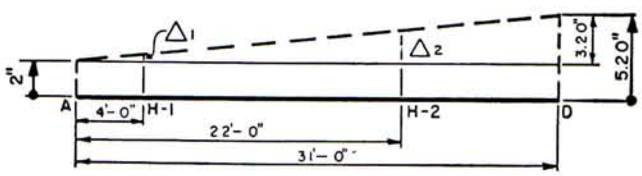
Calculate the movements at points *D* and *E* by multiplying the coefficient of expansion by the vertical distance of each point from the position of zero movement on the riser *DE*:

55 ft. x .0946 inch/ft = 5.20 inches *up* at *d*

20 ft. x .0946 inch/ft = 1.89 inches *down* at *E*

Step II

Make a simple drawing of the piping between two adjacent points of known movement, extending the piping into a single plane as shown for the portion of the system between *A* and *D*.



The vertical movement at any hanger location will be proportional to its distance from the end points:

$$\Delta_1 = \frac{4}{31} \times 3.20$$

$$\Delta_1 = .41''$$

The vertical movement at *H*-1 = .41" + 2"

$$\Delta H\text{-}1 = 2.41'' \text{ up}$$

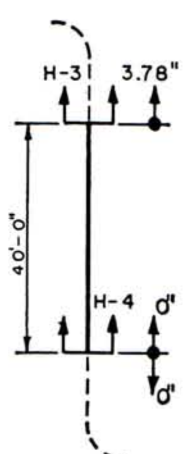
$$\Delta_2 = \frac{22}{31} \times 3.20$$

$$\Delta_2 = 2.27''$$

The vertical movement at *H*-2 = 2.27" + 2"

$$\Delta H\text{-}2 = 4.27'' \text{ up}$$

Step III

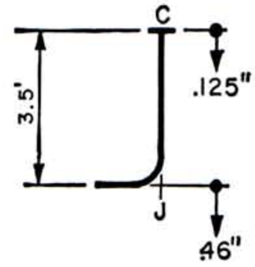


To calculate the vertical movement at *H*-3, multiply its distance from *H*-4 by the coefficient of expansion.

40 ft. × .0946 inch/ft = 3.78 inches

Δ*H*-3 = 3.78" up

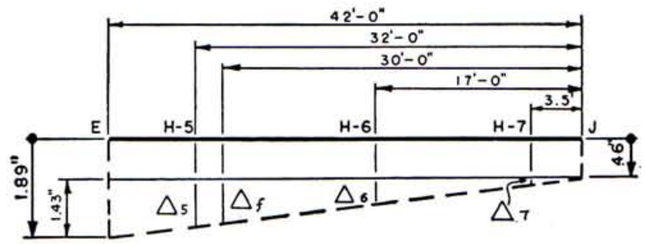
Step IV



The next section of pipe on which there are two points of known movement is the length *E*-*J*. The movement at *E* was calculated as 1.89" down. The movement at *J* is equal to the movement at the terminal point *C* (1/8" down) plus the amount of expansion of the leg *C*-*J*:

$$\Delta J = .125 \text{ inch} + 3.5 \text{ ft} \times .0946 \text{ inch/ft}$$

$$\Delta J = .46'' \text{ down}$$



$$\Delta_7 = \frac{3.5}{42} \times 1.43 = .12''$$

$$\Delta H\text{-}7 = .12'' + .46''$$

$$\Delta H\text{-}7 = .58'' \text{ down}$$

$$\Delta_6 = \frac{17}{42} \times 1.43 = .58''$$

$$\Delta H\text{-}6 = .58 + .46''$$

$$\Delta H\text{-}6 = 1.04'' \text{ down}$$

$$\Delta_f = \frac{30}{42} \times 1.43 = 1.02''$$

$$\Delta F = 1.02 + .46$$

$$\Delta F = 1.48'' \text{ down}$$

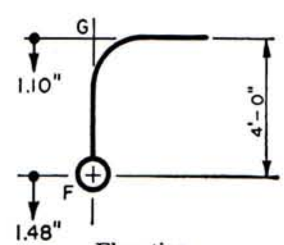
$$\Delta_5 = \frac{32}{42} \times 1.43 = 1.09''$$

$$\Delta H\text{-}5 = 1.09 + .46$$

$$\Delta H\text{-}5 = 1.55'' \text{ down}$$

Step V

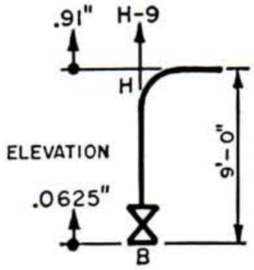
Draw the section *G*-*H*. The movement at *G* is equal to the movement at *F* *minus* the expansion of the leg *GF*:



Elevation

ΔG = 1.48" down
− 4 ft × .0946 inch/ft
ΔG = 1.10" down

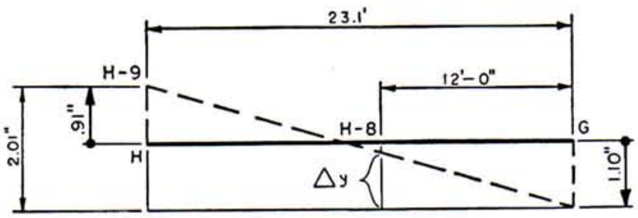
The movement at *H* is equal to the movement of the terminal point *B*(1/16" up) *plus* the expansion of the leg *B-H*:



ΔH = .0625" up + 9 ft × .0946 inch/ft
ΔH = .91" up

Since *H*-9 is located at point *H*,

ΔH-9 = ΔH = .91" up



$$\Delta_y = \frac{12}{23.1} \times 2.01 = 1.04"$$

ΔH-8 = 1.10 − 1.04
ΔH-8 = .06" down

After calculating the movement at each hanger location it is often helpful, for easy reference when selecting the appropriate type hanger, to make a simple table of hanger movements.

Hanger Number	Movement
H-1	2.41" up
H-2	4.27" up
H-3	3.78" up
H-4	0"
H-5	1.55" down
H-6	1.04" down
H-7	.58" down
H-8	.06" down
H-9	.91" up

HANGER LOAD CALCULATIONS

The thermal expansion of piping in modern high pressure and temperature installations makes it necessary for the designer to specify flexible supports, thereby requiring considerable thought to the calculation of hanger loads.

Turbine and boiler manufacturers are especially concerned about the pipe weight on their equipment and sometimes specify that the loads at pipe connections shall be zero. The hanger designer must be certain that the loads on the equipment connections of a piping system do not exceed the limits specified by the equipment manufacturers.

The majority of supports for a high temperature system are of the spring type. The designer must work to a high degree of accuracy in determining the supporting force required at each hanger location to assure balanced support, in order to select the appropriate size and type of spring support.

Many computer programs are available to help the pipe hanger engineer determine hanger loadings. The computer combines the determination of pipe stress with the hanger loadings and is the best approach to obtain the hanger loading. In the absence of this facility, manual calculations must be used.

We have prepared a sample problem, illustrated in Figure H-1, in which all of the hangers except *H*-7 have been located. This illustration is limited to as few pipe sections as possible but incorporates most of the problems encountered in hanger load calculations.

The calculation of loads for hangers involves dividing the system into convenient sections and isolating each section for study. A free body diagram of each section should be drawn to facilitate the calculations necessary for each hanger load. Most of the free body diagrams presented here are those which include as large a section of the piping system as is practical for a simple arithmetical solution to the problem.

The solution that follows is not intended to illustrate the only method which could be applied. Rather, it is intended to show a composite of various accepted methods which, for the problem under consideration, produce a well balanced system. Of the approaches that could be made to the solution of any problem, there will be one method that will produce the best balanced system. *Although the individual loads may vary, the total of all hanger loads would be the same in every case.*

The first step in the solution of a hanger load problem is to prepare a table of weights. For the pipe line shown in Figure H-1, the table on page 9 has been prepared.

Draw a free body diagram of the piping between point *A* and *H*-2, showing all supporting forces and all valve and pipe weights (Fig. 2). We will consider the loads and supporting forces between *A*, *H*-1 and *H*-2 acting about the axes *x*-*x*' and *y*-*y*'. We will apply the three equations $\Sigma M_{x\text{-}x'} = 0$; $\Sigma M_{y\text{-}y'} = 0$; and $\Sigma V = 0$.

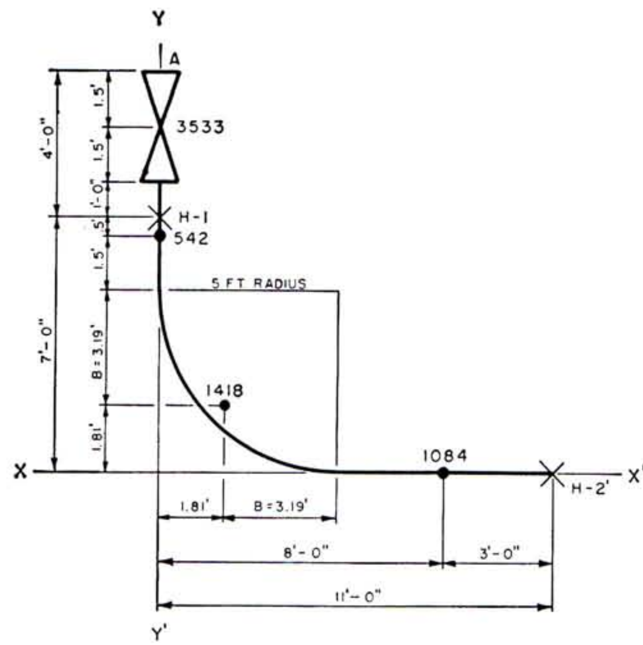
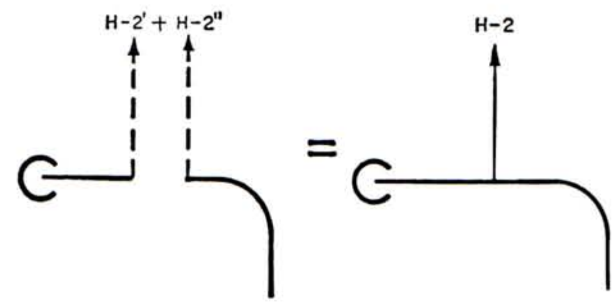


Figure H-2. Plan View

Note that the value for *H*-2 on this section of the piping system represents only a part of the total hanger force at *H*-2. For clarity, we have labelled this force *H*-2'. In the calculations for the next section of pipe beginning at *H*-2, we will call the hanger force at this point *H*-2''. That is:



Also, note that we have considered the weight of the 90° bend acting at the center of gravity of the bend. The distance *B* is determined from the Chart on page 59 which has been drawn for convenience:

$$B = \text{Radius} \times .637, \text{ or } 5' \times .637 = 3.185'$$

Step I

Taking moments about axis *y*-*y*', $\Sigma M_{y\text{-}y'} = 0$,

$$1.81\,(1418) + 8(1084) - 11\,(H\text{-}2') = 0$$

$$2567 + 8672 = 11\,(H\text{-}2')$$

$$H\text{-}2' = 1022 \text{ lb.}$$

Description	Weight	Insulation Weight (Ca-Si)	Total Weight	Weight Used in Calculations
12" Schedule 160 Pipe	160.3 lb/ft	20.4 lb/ft	180.7 lb/ft	180.7 lb/ft
12" Schedule 160 L. R. Elbow	375 lb	61.2 lb	436.2 lb	436 lb
12" 1500 lb Check Valve	3370 lb	163.2 lb	3533.2 lb	3533 lb
12" 1500 lb Gate Valve	4650 lb	163.2 lb	4813.2 lb	4813 lb
12" 1500 lb W. N. Flange	843 lb	30.6 lb	873.6 lb	874 lb
12" 5 Diameter Bend	1258 lb	160.2 lb	1418.2 lb	1418 lb
6" Schedule 160 Pipe	45.3 lb/ft	11.5 lb/ft	56.8 lb/ft	56.8 lb/ft
6" Schedule 160 90° L. R. Elbow	53 lb	17.2 lb	70.2 lb	70 lb
6" Schedule 160 45° Elbow	26 lb	6.9 lb	32.9 lb	33 lb
6" 1500 lb Gate Valve	1595 lb	80.5 lb	1675.5 lb	1676 lb

Step II

Taking moments about axis x-x', $\Sigma M_{x\text{-}x'} = 0$,

$$1.81\,(1418) + 6.5(542) - 7(H\text{-}1) + 9.5(3533) - 11(A) = 0$$
$$2567 + 3523 + 33564 = 7(H\text{-}1) + 11(A)$$
$$39654 = 7(H\text{-}1) + 11(A)$$

Step III

Adding forces, $\Sigma V = 0$,

$$A + H - 1 + H\text{-}2' - 3533 - 542 - 1418 - 1084 = 0$$
$$A + H\text{-}1 + H\text{-}2' = 6577\ \text{lb}$$

Substituting the value of H-2', calculated as 1022 lb in Step I,

$$A + H\text{-}1 + 1022 = 6577\ \text{lb}$$
$$A = 5555 - H\text{-}1$$

Step IV

List the three equations developed in the preceding steps:

(1) $H\text{-}2' = 1022$ — Step I
(2) $39654 = 7(H\text{-}1) + 11(A)$ — Step II
(3) $A = 5555 - H\text{-}1$ — Step III

Solving Equation (2) by substituting for $A = 5555$-H-1,

$$39654 = 7(H\text{-}1) + 11(5555 - H\text{-}1)$$
$$H\text{-}1 = 5363\ \text{lb}$$

Substituting for H-1 in Equation 3,

$$A = 5555\ \text{lb} - 5363\ \text{lb}$$
$$A = 192\ \text{lb}$$

which is below the allowable load at A of 500 lb.

Next, consider the section of pipe between H-2 and H-3 to determine the weight distribution, between these two points, of the four foot section of pipe and the five diameter bend.

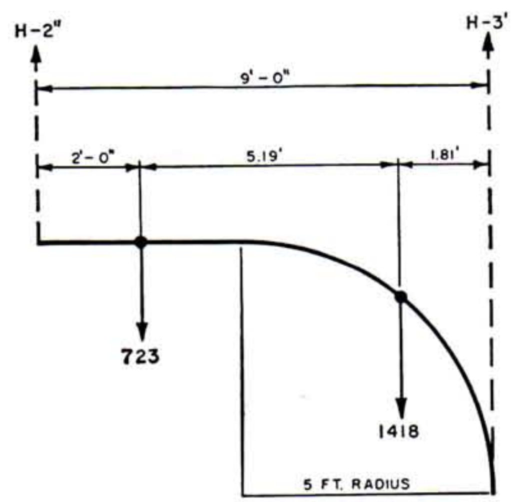


Figure H-3. Elevation View

$\Sigma M_{H\text{-}2''} = 0$,

$$2(723) + 7.19(1418) - 9(H\text{-}3') = 0$$
$$H\text{-}3' = 1293\ \text{lb}$$

$\Sigma M_{H\text{-}3'} = 0$,

$$1.81(1418) + 7(723) - 9(H\text{-}2'') = 0$$
$$H\text{-}2'' = 848\ \text{lb}$$

$H\text{-}2 = H\text{-}2' + H\text{-}2''$
$H\text{-}2 = 1022\ \text{lb} + 848\ \text{lb}$
$H\text{-}2 = 1870\ \text{lb}$

In the next free body diagram consider the 65 foot vertical section of the piping system to determine the supporting forces for *H*-3" and *H*-4'.

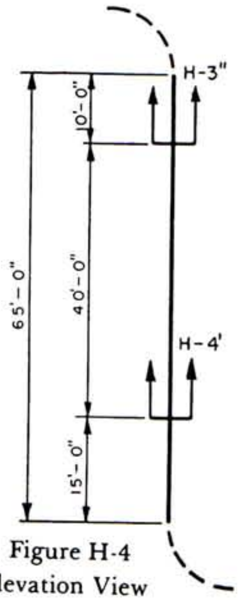


Figure H-4
Elevation View

It is apparent that the combined forces *H*-3" and *H*-4' will equal 65 ft X 180.7 lb/ft. Further, both *H*-3" and *H*-4' could be any value, provided the relationship *H*-3" + *H*-4' = 11746 lb is maintained. It is not recommended, however, to select arbitrary values for these two forces; instead, the load for each hanger should be such that the elevation of the pipe attachment is above the midpoint of the length of pipe supported by the hanger. Thus, the support will be located above the point where one could consider the weight of the pipe column acting, thereby avoiding a condition where the location of the support lends itself to the "tipping" tendency of the pipe when the support is located below this point.

Since there is 10 feet of vertical pipe above *H*-3", and 40 feet of pipe between *H*-3" and *H*-4', let *H*-3" support 10 feet plus 30 feet of pipe load:

$$H\text{-}3'' = (10 \text{ ft} + 30 \text{ ft})\,(180.7 \text{ lb/ft})$$
$$H\text{-}3'' = 7228 \text{ lb}$$

since $H\text{-}3 = H\text{-}3' + H\text{-}3''$
and $H\text{-}3' = 1293$ lb (See Fig. H-3),

$$H\text{-}3 = 1293 \text{ lb} + 7228 \text{ lb}$$
$$H\text{-}3 = 8521 \text{ lb}$$
$$H\text{-}4' = (10 \text{ ft} + 15 \text{ ft})(180.7 \text{ lb/ft})$$
$$H\text{-}4' = 4518 \text{ lb}$$

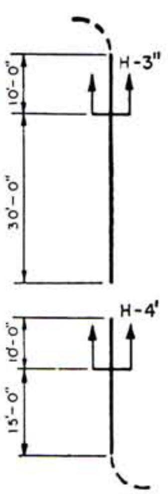


Figure H-5

Consider the piping between *H*-4' and *H*-5 to determine the weight distribution of the 5 diameter bend and the 5 feet of horizontal pipe:

$$\Sigma M_{H\text{-}4''} = 0,$$
$$1.81(1418) + 7.5(904) - 10(H\text{-}5') = 0$$
$$H\text{-}5' = 935 \text{ lb}$$

$$\Sigma M_{H\text{-}5'} = 0,$$
$$2.5(904) + 8.19(1418) - 10(H\text{-}4'') = 0$$
$$H\text{-}4'' = 1387 \text{ lb}$$

$$H\text{-}4 = H\text{-}4' + H\text{-}4'' = 4518 \text{ lb} + 1387 \text{ lb}$$
$$H\text{-}4 = 5905 \text{ lb}$$

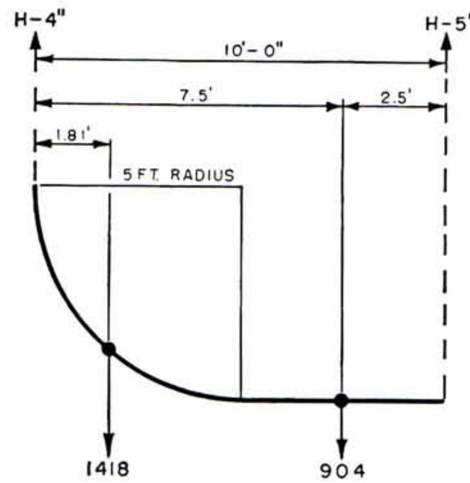


Figure H-6. Elevation View

It is obvious that some portion of the weight of the 6 inch pipe between the 12" line and H-8 must be supported by H-5" and H-6. Therefore, before proceeding thru H-5 and H-6, calculate this pipe weight load R_1, and introduce it into the free body diagram for H-5 and H-6.

$\Sigma M_{y\text{-}y'} = 0,$

$$.07(33) + 2.34(341) + 4.81(70) + 5(2031) - 5(H\text{-}9) = 0$$

$$H\text{-}9 = 2258 \text{ lb}$$

$\Sigma M_{x\text{-}x'} = 0,$

$$.19(70) + 2.66(341) + 5.03(33) - 9(H\text{-}8) + 12.78(849) + 20.73(70) - 21R_1 = 0$$

$$13387 = 9(H\text{-}8) + 21(R_1)$$

$\Sigma V = 0,$

$$R_1 + H\text{-}8 + H\text{-}9 - 2031 - 70 - 341 - 33 - 849 - 70 = 0$$

$$R_1 + H\text{-}8 + H\text{-}9 = 3394 \text{ lb}$$

Since H-9 has been calculated as 2258 lb,

$$R_1 + H\text{-}8 = 3394 \text{ lb} - 2258 \text{ lb} = 1136 \text{ lb}$$

$$H\text{-}8 = 1136 - R_1$$

Substituting this value for H-8 in the Equation $13387 = 9(H\text{-}8) + 21R_1$,

$$13387 = .9(1136 - R_1) + 21R_1$$

$$R_1 = 264 \text{ lb}$$

Since $H\text{-}8 = 1136 - R_1$,

$$H\text{-}8 = 1136 \text{ lb} - 264 \text{ lb}$$

$$H\text{-}8 = 872 \text{ lb}$$

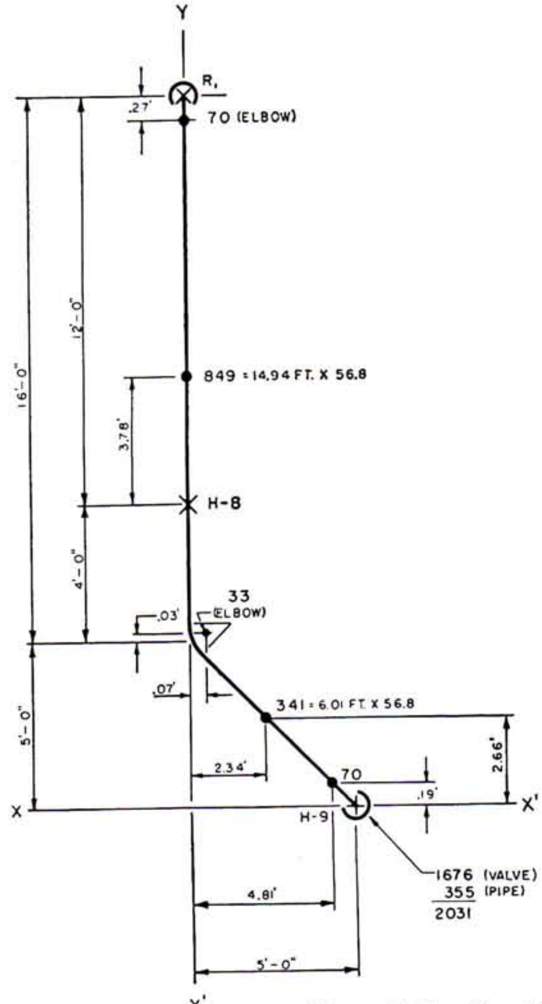


Figure H-7. Plan View

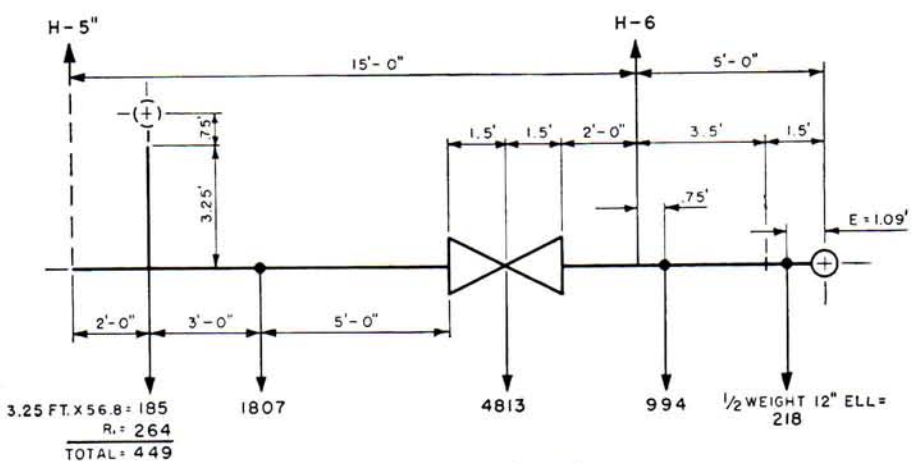


Figure H-8. Elevation View

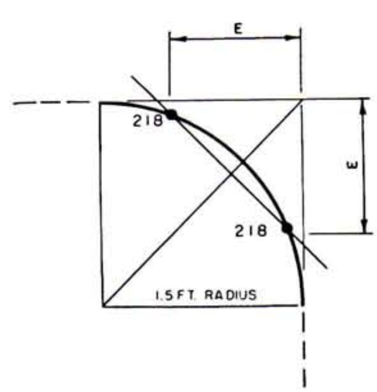


Figure H-9. Plan View

Dimension E is determined from the Chart on page 59. For the sample problem, $E = .726 \text{X} 1.5$ ft. = 1.09 ft.

The free body diagram shown in Figure H-8 extends from *H*-5 thru the 12"90° elbow. This is intended to illustrate that the weight of the 90° elbow may be considered as supported on a beam which passes thru the center of gravity of the elbow and rests on the extensions of the tangents, as shown in Figure H-9:

In Figure *H*-8, $\Sigma M_{H\text{-}5''} = 0$,

$2(449) + 5(1807) + 11.5(4813) - 15(H\text{-}6) + 15.75(994) + 18.91(218) = 0$

$$H\text{-}6 = 5671 \text{ lb}$$

$\Sigma M_{H\text{-}6} = 0$,

$3.5\,(4813) + 10(1807) + 13(449) - .75(994) - 3.91(218) - 15(H\text{-}5'') = 0$

$$H\text{-}5'' = 2610 \text{ lb}$$

$H\text{-}5 = H\text{-}5' + H\text{-}5'' = 935 \text{ lb} + 2610 \text{ lb}$

$H\text{-}5 = 3545 \text{ lb}$

The following diagram shows a method for arriving at the location of *H*-7 which will allow zero load on connection *C*.

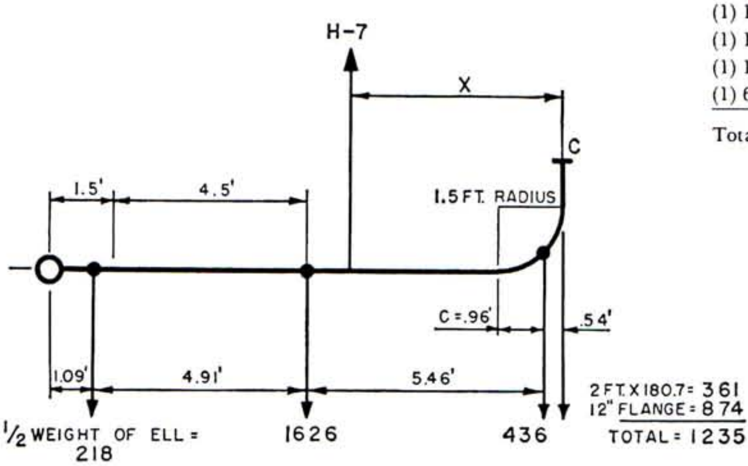


Figure H-10. Elevation View

The value, in pounds, for *H*-7, is equal to the weight of the piping section:

$H\text{-}7 = 218 \text{ lb} + 1626 \text{ lb} + 436 \text{ lb} + 1235 \text{ lb}$

$H\text{-}7 = 3515 \text{ lb}$

Solving for distance *X*, $\Sigma M_c = 0$

$$.54(436) - X(H\text{-}7) + 6(1626) + 10.91(218) = 0$$

$$X(H\text{-}7) = 12369$$

$$X(3515) = 12369$$

$$X = 3.52 \text{ feet}$$

As a final step, check to ensure that the weight of the entire piping system is equal to the total supporting forces of the hangers plus the pipe weight load to be supported by the equipment connections:

Weight of Piping System, lb		Support Forces Plus Terminal Point Loads, lb
109.5 ft of 12" Pipe @ 180.7 lb/ft	19787	A = 192
(3) 12" 5 Dia. Bends @ 1418 lb	4254	*H*-1 = 5363
(2) 12" 90° L.R. Ells @ 436 lb	872	*H*-2 = 1870
30.45 ft of 6" Pipe @ 56.8 lb/ft	1730	*H*-3 = 8521
(2) 6" 90° L. R. Ells @70 lb	140	*H*-4 = 5905
(1) 6" 45° Ell @33 lb	33	*H*-5 = 3545
(1) 12" 1500 lb Check Valve @ 3533 lb ...	3533	*H*-6 = 5671
(1) 12" 1500 lb Gate Valve @ 4813 lb. ...	4813	*H*-7 = 3515
(1) 12" 1500 lb WN Flange @ 874 lb	874	*H*-8 = 872
(1) 6" 1500 lb Gate Valve @ 1676 lb	1676	*H*-9 = 2258
Total Weight of Piping System	37712	Total = 37712

SELECTION OF THE PROPER HANGER

Selection of the appropriate type hanger for any given application is governed by the individual piping configuration and job requirements. Job specifications covering hanger types, however, are of necessity written in broad terms, and some emphasis is placed on the good judgement of the hanger engineer to ensure a satisfactory, yet economical, hanger system.

The type of hanger assemblies from which the hanger engineer selects the appropriate kind are generally classified as follows:

(1) Flexible hangers, which include hangers of the constant support and variable spring types.
(2) Rigid hangers, such as rod hangers and stanchions.
(3) Rollers

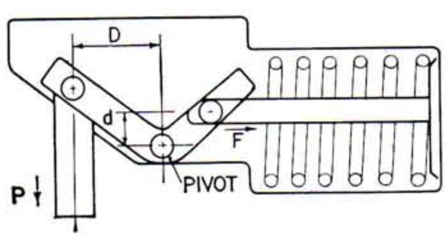
The location of anchors and restraints is not usually considered a responsibility of the hanger designer. Since it is necessary to determine the location of anchors and restraints before accurate and final stress analysis is possible, they are considered a part of piping design.

Flexible Hangers

When a pipe line expands vertically as a result of thermal expansion it is necessary to provide flexible pipe supports which apply supporting force throughout the expansion and contraction cycle of the system.

Flexible hangers are of two types: Variable Spring and Constant Support.

Constant Support hangers provide constant supporting force for piping throughout its full range of vertical expansion and contraction. This is accomplished through the use of a helical coil spring working in conjunction with a bell crank lever in such a way that the spring force times its distance to the lever pivot is always equal to the pipe load times its distance to the lever pivot.

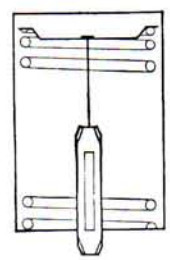


Fd = PD

CONSTANT SUPPORT

Because of its constancy in supporting effect the Constant Support hanger is used where it is desirable to prevent pipe weight load transfer to connected equipment or adjacent hangers. Consequently, they are used generally for the support of critical piping systems.

Variable Spring hangers are used to support piping subject to vertical movement where Constant Supports are not required. The inherent characteristic of a Variable Spring is such that its supporting force varies with spring deflection and spring scale. Therefore, vertical expansion of the piping causes a corresponding extension or compression of the spring and will cause a change in the actual supporting effect of the hanger. The variation in supporting force is equal to the product of the amount of vertical expansion and the spring scale of the hanger. Since the pipe weight is the same during any condition, cold or operating, the variation in supporting force results in pipe weight transfer to equipment and adjacent hangers and consequently additional stresses in the piping system. When Variable Spring hangers are used, the effect of this variation must be considered.



VARIABLE SPRING HANGER

Variable Spring hangers are recommended for general use on non-critical piping systems and where vertical movement is of small magnitude on critical systems. Accepted practice is to limit the amount of supporting force variation to 25% for critical system applications on horizontal piping.

To illustrate the difference in the effect of using a Variable Spring as compared with a Constant Support hanger, refer to the sample problem shown in Figure H-1, page 4.

The load for hanger H-1 was calculated as 5363 lb. The vertical movement at H-1 was calculated as 2.41 inches up, from the cold to the hot position of the pipe.

If a Variable Spring hanger were used at H-1, the effect of the variation in supporting force would have to be considered. The amount of variation can be determined by multiplying the spring scale in pounds per inch by the amount of vertical expansion in inches.

For example, if the Grinnell Figure B-268 Variable Spring hanger were considered, the proper spring size would be number 16 which has a spring scale of 1500 pounds per inch. (For convenience, neglect the weight of the pipe clamp, rod and hex nuts. In designing hangers for an actual problem, the weight of components should be added to the calculated load.)

The amount of variation is 1500 lb/in. X 2.41 in. = 3615 lb. Standard practice is to calibrate the hanger in such a way that when the piping is at its hot position the supporting force of the hanger is equal to the calculated load of the pipe. This means that the maximum variation in supporting force occurs when the piping is at its cold position, when stresses added to the piping as a result of variations in supporting forces are less critical.

The hot load for the variable spring, then is 5363 lb.

As the direction of movement from cold to hot is upward, the cold load is 5363 lb + 3615 lb, or 8978 lb. Fig. H-a shows the pipe and spring at the cold condition, and Fig. H-b at the hot condition.

The purpose of the considerations given to the variation in supporting effect is apparent when it is recalled that the pipe weight does not change throughout its cold to hot cycle, while the supporting force varies. In Fig. H-b, the supporting force is equal to the pipe weight. However, in Fig. H-a, the supporting force is 8978 lb while the pipe weight is 5363 lb. The hanger would exert an unbalanced force on the pipe equal to the amount of variation, or 3615 lb. Most of this force would be imposed directly on connection A, where limits are established for the force which may be applied.

Further, safe piping design must be based on *total* pipe stress which includes bending, torsional, shear, longitudinal, and circumferential stresses. The addition of large forces resulting from spring variations can cause stresses which will greatly reduce the factor of safety of the entire piping system.

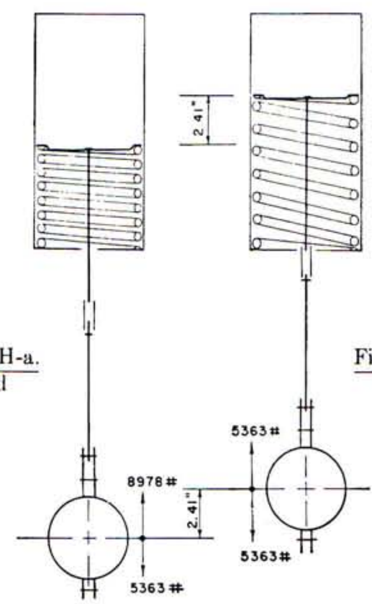


Figure H-a. Cold

Figure H-b. Hot

It is possible to reduce the amount of variability by using a variable spring which has a smaller spring scale, as a Grinnell Fig. 98 (Variable Spring Hanger).

The #16 Fig. 98 has a spring scale of 750 lb/in., one-half that of the B-268. The amount of variability would be reduced by one-half, or 2.41 X 750 = 1808 lb. However, it should be obvious that even this change in supporting force is too great for the critical location at H-1.

The appropriate hanger type for H-1 is a constant support hanger. This hanger would be calibrated to the calculated pipe weight. It would apply a constant supporting force, insuring complete support of the pipe throughout the piping expansion. That is, its supporting force would be 5363 lb when the pipe was at its cold position, and 5363 lb also when the pipe was at its hot position.

Hanger H-2 has a calculated load of 1870 lb. The vertical movement at this location is 4.27 inches up, cold to hot. Although the load may be considered slight, the magnitude of the vertical movement is great, and a considerable amount of supporting force change would occur if a variable spring were used.

For example, the appropriate size variable spring is a #12, Fig. 98 (the 4.27 inch travel is beyond the travel capacity of the Fig. B-268), which has a spring scale of 225 lb/in. The amount of variation equals 4.21 inches X 225 lb/in., or 947 lb.

This variation, expressed as a percentage, is

$\frac{947 \text{ lb}}{1870 \text{ lb}}$ X 100, or greater than 50%. Unless the hanger engineer were willing to perform some rather elaborate stress calculations to determine the effect of this variation, it would be safer to apply the accepted rule which limits variability to 25% for critical systems, and rule out the selection of a variable spring in favor of the constant support type hanger.

The vertical movement of the pipe at H-3 was calculated as 3.78 inches up, and the load as 8521 lb.

In selecting the spring type for this hanger assembly, it should be recognized that any variation in supporting force will not produce bending stresses in the piping system. As the supporting forces at H-3 and H-4 are concurrent, no bending is produced as a result of spring variation at H-3. Rather, any supporting force variation will merely result in a corresponding load change at the rigid hanger H-4.

The hanger type for H-3 may be a variable spring type. It is only necessary that the variable spring have a travel capacity which is some amount greater than the calculated pipe movement of 3.78 inches.

Such a variable spring hanger is the Fig. 98, which has a working travel range of 5 inches.

As this assembly is of a riser "trapeze" type, two spring units will be used, each supporting one-half the total load of 8521 lb, or 4261 lb. The appropriate size hanger is a #15 Fig. 98 with a spring scale of 540 lb/inch.

The amount of variation per spring is 3.78 inches X 540 lb/inch, or 2041 lb. The hot load setting for each hanger is equal to one-half the calculated load, or 4261 lb. As the direction of movement, cold to hot, is upward, the cold load setting will be 4261 lb + 2041 lb, or 6302 lb.

Figures H-c and H-d show the supporting forces at H-3 and H-4 when the pipe is at its cold and its hot position. The weight of riser clamps, rods, etc., are not included, for convenience.

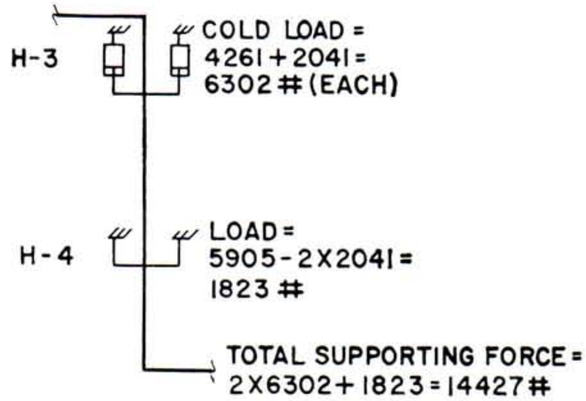


Figure H-c.

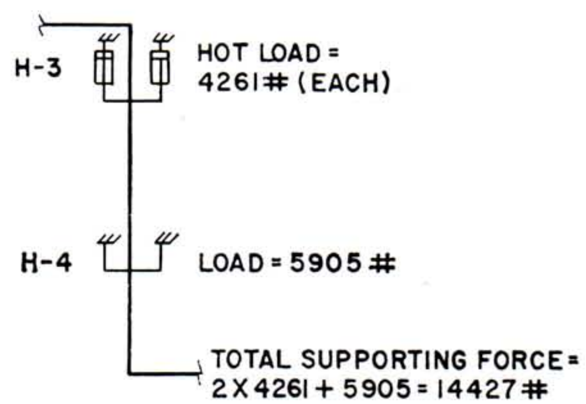


Figure H-d.

The design load for H-3 should allow for a calculated cold load of 6302 lb X 2, or 12,604 lb.

The load at rigid hanger H-4 is 1823 lb cold, 5905 lb hot. All hanger components should be designed for the larger load.

Variation in supporting forces at Hangers H-5, H-6, H-7 and H-9 will produce reactions at connections B and C. As one of the requirements of the problem under study is that weight loads at B and C shall be zero, these hangers must be of the constant support type.

Although it holds true that at H-8 any hanger force variation will cause weight loads at B and C, the load and movement at this hanger location are so slight that the spring variation effect can be considered negligible. The load was calculated as 872 lb, the movement as .06 inch down.

The amount of variability for a #8 Fig. B-268 is .06 inch X 150 lb/inch, or 9 lb. For practical purposes, a 9 lb change in supporting force could be neglected, and a variable spring selected for Hanger H-8.

The selection of hanger types for supports H-1 through H-9 in the sample problem illustrates the many considerations which should be given in selecting the appropriate flexible hanger at each support location for any major piping system.

In selecting flexible hanger types the engineer should consider that:

> Whenever constant support hangers are used, the supporting force equals the pipe weight throughout its entire expansion cycle, and no pipe weight reactions are imposed at equipment connections and anchors.
>
> Wherever variable spring hangers are used, the engineer must check to assure that the total variation in supporting effect does not result in harmful stresses and forces within the piping system.
>
> Where piping stresses and reactions are known to be close to allowable, the simplest and, in the long run, most economical type of flexible support is obviously the constant support hanger.
>
> Where piping stresses and end reactions are known to be low, variable spring hangers can be used satisfactorily for most non-critical piping support, and for the support of critical systems where vertical movements are of small magnitude.

Rigid Hangers

Rigid hangers are normally used at locations where no vertical movement of the piping occurs.

The design considerations for a rigid hanger are pipe temperature, for selection of appropriate pipe clamp material, and load, for selection of components suitable for the pipe weights involved.

Pipe clamp material is usually carbon steel for temperatures up to 750°F. and alloy steel for temperatures above 750°F. Malleable iron pipe clamps may be used at temperatures up to 450°F.

For piping systems of low operating temperature, where vertical expansion is usually not a factor, the rigid hanger assembly components are selected and designed on the basis of calculated or approximated loads.

In some instances, however, the rigid hanger is used in a manner where it does more than merely support the pipe weight, but acts as a restraint against vertical piping movements. It is in these cases that the engineer should exercise care in the location of the rigid hanger and the design load he uses in the selection of components.

The location and effect of any restraint, guide or anchor on a high temperature and high pressure system is of necessity a function of the stress analyst. The indiscriminate placing of a restraining device on a piping system could alter the piping stresses and end reactions to a serious degree, changing a conservatively designed system into one which exceeds the limits of good design practices.

The hanger engineer, though not as well acquainted with the total stress picture of a piping system as is the stress analyst, must usually decide if the problem is of this "critical" nature, or whether the system under study is such that the effect of adding a restraint for his convenience will be negligible. His decision is based on the factors of operating temperature, operating pressure, and the configuration of the system. Recognizing that pipe design is based on *total* pipe stress, he must determine whether the stresses produced by the addition of a rigid hanger, or vertical restraint, are critical.

This article is *not* intended to present a short-cut method for the stress analysis of a piping system. In any instance where it is not obvious to an engineer that he is dealing with a non-critical case, the problem should either be reviewed formally from a total stress viewpoint, or the decision to use a rigid hanger should be changed and a flexible support should be utilized.

This article *is* intended to provide the engineer with a simple and quick method of deciding how he can most economically treat vertical thermal movement on a long, horizontal section of a *non-critical* piping system. Often, his problem can be expressed in the simple terms of whether he will be able to use a rigid hanger rather than a flexible hanger without producing obviously harmful stresses in the system.

Consider a simple example, shown in Fig. H-e, where the hanger engineer is confronted with the problem of how he can best treat vertical movement resulting from thermal expansion of the riser. The horizontal sections at both the top and the bottom of the riser are of any considerable length. He must determine which of the hangers H-2, H-3, H-4, etc., should be spring hangers and which will be rigid hangers (vertical restraints in this instance). He must satisfy a condition that the bending stress produced by the restraining action of the hanger is no greater than some acceptable amount, say, in this instance, 10,000 psi.

For an operating temperature of 300°F, the expansion factor for carbon steel pipe is .0182 inch per foot.

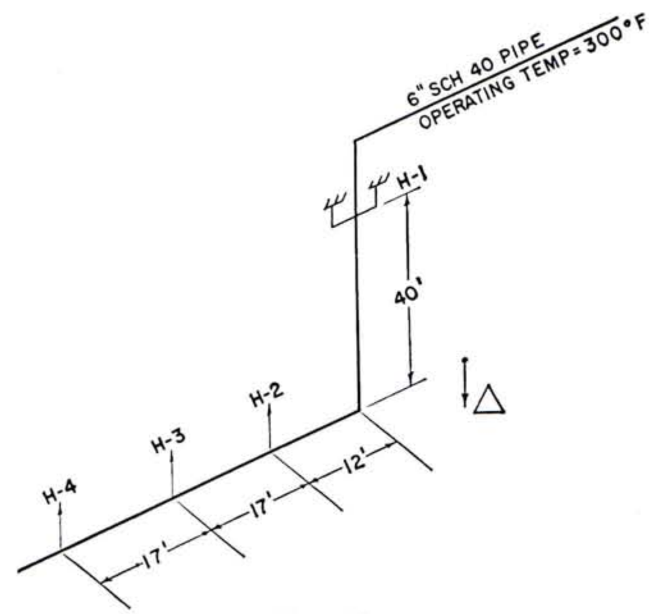


Figure H-e.

Δ = 40 feet X .0182 inch/ft.

Δ = .728 inch down.

(See "Thermal Movement Calculations", page 5)

From the Chart on Page 63, using values of 6 inch pipe and a deflection of ¾ inch, read 17.5 feet. This is the minimum distance from the riser where the first rigid hanger may be placed for this problem.

If the locations of the hangers are fixed, as they are for this case, then H-2 must be a spring hanger assembly because it is located only 12 feet from the riser. Therefore, the nearest rigid hanger will be hanger H-3, located 29 feet from the riser.

The amount of vertical movement at hanger H-2 will be proportional to its distance between H-3 and the riser, and can be approximated as shown in Fig. H-f:

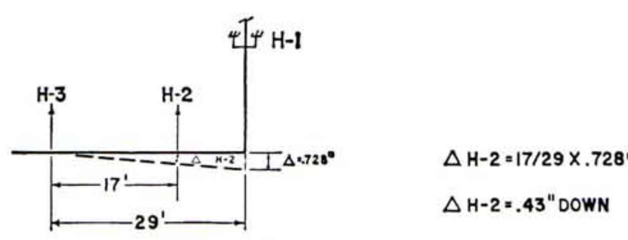


Figure H-f.

Thus, H-2 would be selected as a variable spring hanger for .43 inch of downward vertical movement, and H-3 would be designed as a rigid hanger.

In the above problem the hanger locations were fixed. If this were not the case, and the hangers could be placed at any convenient location subject to usual hanger span limits, then H-2 would be placed at any distance 17.5 feet or more from the riser. This would satisfy the condition that a maximum bending stress of 10,000 psi would result from the restraining effect of the hanger. If the allowable effect was given as a higher stress, then the hanger could be placed closer to the riser; if lower, the nearest rigid hanger would be placed a greater distance from the riser.

If the hanger were located closer to the riser, a greater restraining force would be applied to the pipe by the hanger. As the location is changed to a greater distance from the riser, a lesser force is required. As illustrated in the following sample problem, this force can be an important factor in the design load of the hanger.

Problem:

Given: 10-inch Sch. 40 pipe, and allowable bending stress of 10,000 psi produced by the restraining effect of the hangers.

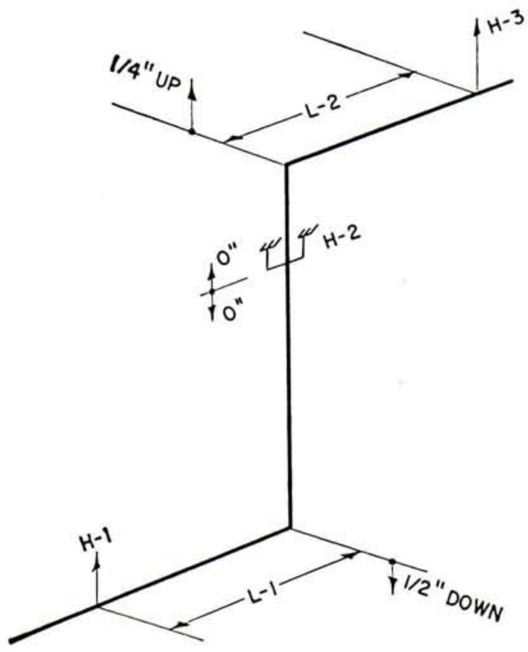


Figure H-g.

Find: (1) L_1 and L_2, the distances to the nearest rigid hangers H-1 and H-3, see Fig. H-g. (2) The forces which the hangers must apply to the pipe to allow the ¼-inch and ½-inch deflections resulting from the thermal expansion of the vertical pipe.

Solution: From the Chart on page 63, using values of ½-inch deflection and 10-inch pipe, read L_1 as 18.5 feet, the distance from the riser to the rigid hanger H-1. This means that at a distance of 18.5 feet, the hanger will exert sufficient force to deflect the pipe ½ inch, producing 10,000 psi bending stress. (See Fig. H-h).

To find the value of force P, refer to the Chart on page 64. For a pipe size of 10 inches and a span of 18.5 feet, read *P* as approximately 2700 lb.

This force is applied by the pipe hanger H-1, and, therefore, must be included in the design load for H-1.

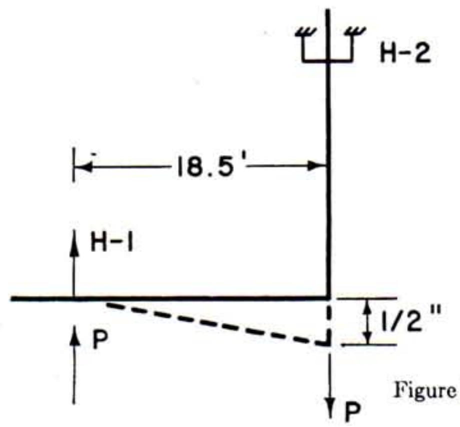


Figure H-h.

In this instance, where the piping movement is in the downward direction, the force P is added to the pipe weight to be supported by Hanger H-1. If the pipe weight for H-1 were calculated as 2000 lb, then the design load for the hanger components is 2000 lb plus 2700 lb, or 4700 lb, as shown in Fig. H-i.

To solve for L_2, refer to the Chart on page 63, and, using values of ¼-inch deflection and 10-inch pipe, read L_2 as 13 feet, the distance to the proposed rigid hanger H-3. As discussed for H-1 of this problem, hanger H-3

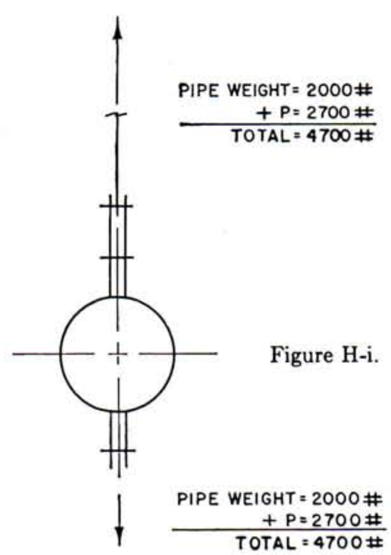
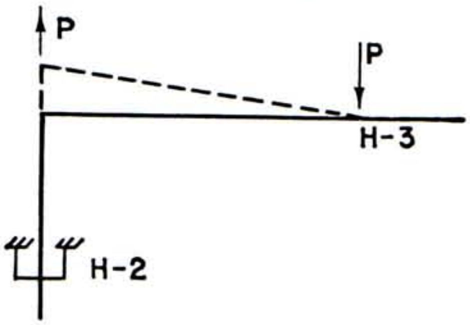


Figure H-i.

must apply sufficient force to restrain the pipe vertically against the force resulting from the thermal expansion of the vertical piping above H-2.

The force P which is required at H-3 can be determined from the Chart on page 64. Using values for 10-inch pipe and a 13-foot span, P is approximately 3800 lb. Since this force restrains the upward movement of



the pipe, it should be checked against the pipe weight load to assure that the hanger assembly can exert a force equal to the difference of the force P and the pipe weight load.

To illustrate, assume that the pipe load at H-3 were calculated as 5000 lb. The difference between the pipe weight and the force P would equal 5000 lb – 3800 lb, or 1200 lb, as shown in Fig. H-j.

The design load used for hanger H-3 should equal 5000 lb, or pipe weight only, in this instance. Where the vertical movement is in the upward direction, and the

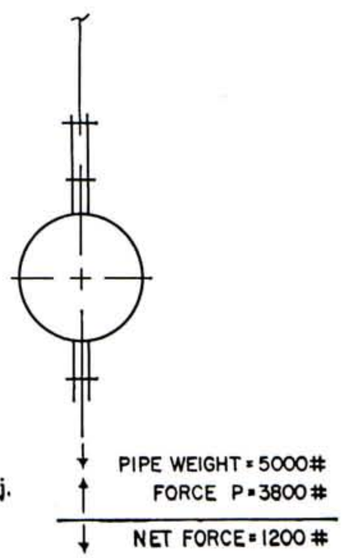


Figure H-j.

force P approaches the pipe weight load, the rigid hanger will tend to unload. That is, as the pipe expands upward the net force applied to the pipe by the hanger becomes less. If the force P becomes greater than the pipe weight at the hanger, the net force on the hanger becomes compressive rather than tensile. When the system has expanded its full amount, the pipe will tend to lift from the hanger, and the supporting effect of the hanger will be zero.

If the pipe weight for the sample problem had been calculated as 3000 lb, then the net force is 3000 lb - 3800 lb, or 800 lb upward, as shown in Fig. H-k.

The hanger, in this case, would not be considered as a support for the pipe, but a vertical restraint against

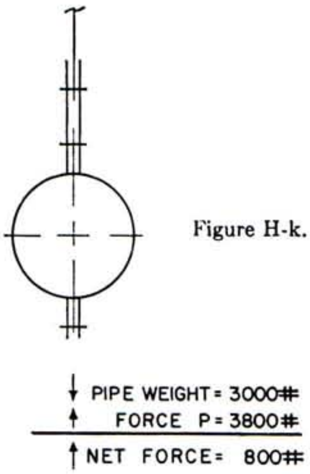


Figure H-k.

upward movement. Therefore, either a greater span should be used in order to reduce the force P, or a spring hanger should be used if L_2 is maintained as 13 feet, in order to provide support and allow the piping to move upward at this hanger location. Using the values of L_1 and L_2 as determined in the original problem, the forces P at each hanger are as shown in Fig. H-l.

The forces at H-1 and H-3 have been discussed in some detail, but it should also be noted that the design

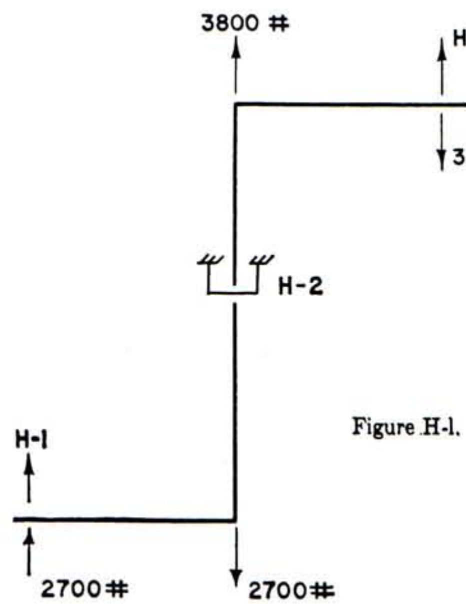


Figure H-l.

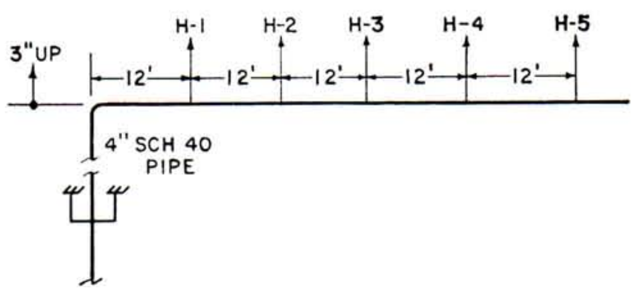
load for H-2 should include these forces as well. For this example, the design load for H-2 equals the pipe weight *plus* 3800 lb, *minus* 2700 lb, or design load = pipe weight load plus 1100 lb.

In the preceding problems, the allowable bending stress due to the restraining effect of the hanger was given as 10,000 psi. This allowable stress will, of course, vary with the individual case. Where the stress is other than 10,000 psi, use the Chart on page 63 to read the minimum span, and multiply the span in feet by the factor indicated in the Chart below for the specific stress.

Correction Factor for Stresses Other Than 10,000 psi

For Bending Stress Of:	Multiply Length By:
2000 psi	2.24
3000	1.83
4000	1.58
5000	1.41
6000	1.29
8000	1.12
10000	1.00
12000	.91
15000	.82
20000	.71

Illustrative Problem:



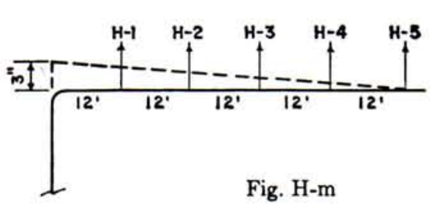
Given: 4-inch Sch. 40 pipe, Δ = 3 inches, and 3000 psi maximum bending stress through the restraining effect of the first rigid hanger.

Find: L, the distance from the riser to the first rigid support.

From the Chart on page 63, using values of 4-inch pipe and 3-inch deflection, read a span of 29 feet. This span is based on a stress of 10,000 psi, and, to correct for 3000 psi, refer to above Chart. For a stress of 3000 psi, the correction factor for spans is 1.83. Multiplying 29 feet by 1.83, the span for 4-inch pipe with 3-inch deflection at 3000 psi is 29 X 1.83, or 53 feet. Thus, L, the minimum distance to the first rigid hanger, is 53 feet.

The first rigid hanger in the above problem will be H-5, located 60 feet from the riser. The force P required to restrain the piping vertically can be determined from the equation on page 64 as about 27 pounds, using values of 4 inch pipe, 3000 psi and a span of 60 feet. The effect of this force will be considered negligible for this problem.

The vertical movements at hanger locations between H-5 and the riser are as shown in Fig. H-m.



ΔH-1 = 48/60 x3 = 2.4"
ΔH-2 = 36/60 x3 = 1.8"
ΔH-3 = 24/60 x3 = 1.2"
ΔH-4 = 12/60 x3 = .6"

Fig. H-m

The above results are based on an approximate but conservative analysis. Wherever the appropriate charts are used, the values listed should assist the engineer in arriving at an economical, safe design for any rigid hanger assembly.

The examples described represent situations not frequently encountered in pipe support design, but do point out that the rigid hanger in some instances is more than a simple pipe support, and that good design must allow for all applicable conditions.

Rollers

The pipe attachment and structural attachment of a hanger assembly should be such that they will permit the hanger rod to swing to allow for lateral movement of the piping where horizontal pipe expansion is anticipated.

In some instances, where piping expansion is slight and hanger rods are long, the swing permitted by the pivoting of the rod at the upper and lower connections is sufficient, as shown in Fig. H-n.

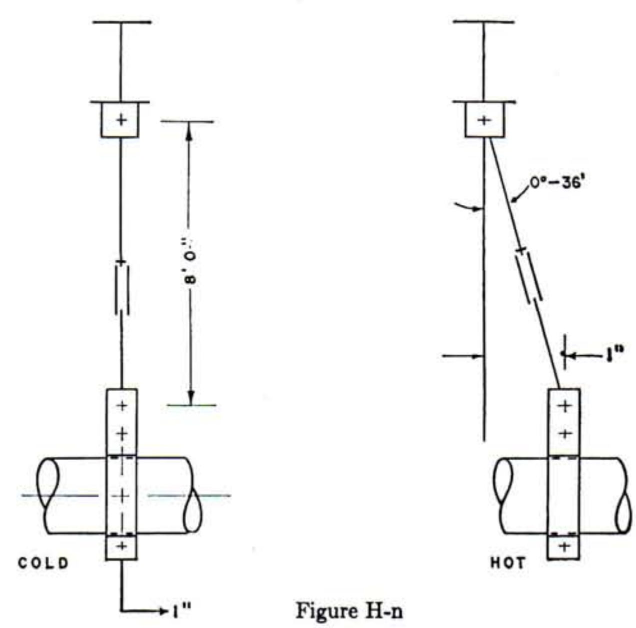


Figure H-n

In other instances the angularity cause by the horizontal piping movements can appreciably effect the position of the piping system, and can cause harmful horizontal forces within the piping system.

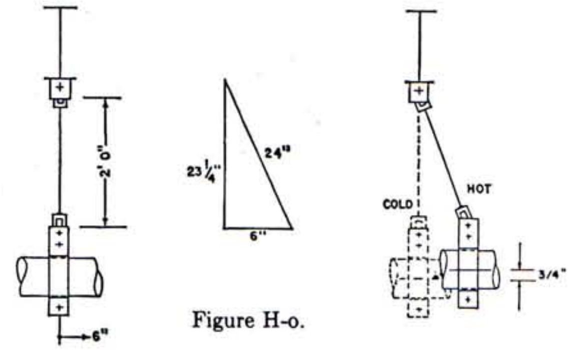


Figure H-o.

In Fig. H-o, note that, because of the large axial piping movement and short hanger rod, the pipe is pulled ¾ inch off elevation when it expands 6 inches horizontally.

The condition described also places a horizontal force component into the piping system. For example, assume a pipe weight of 1000 lb for the above hanger, as in Fig. H-p.

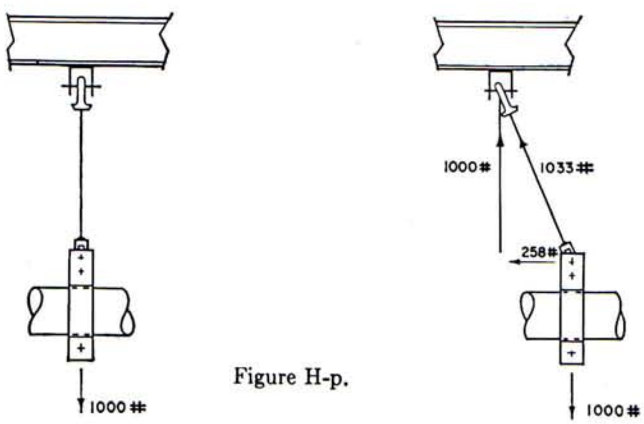


Figure H-p.

The 258 lb horizontal force by itself may not be of great consequence, but where there is a series of hangers located on the same long section of pipe, the effect of the total horizontal force can be serious. (See Fig. H-q.)

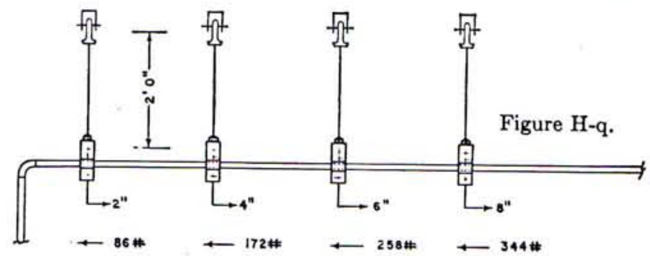


Figure H-q.

Total horizontal force = 86 + 172 + 258 + 344 = 860 lb.

Certainly, for any system subject to horizontal expansion, the rod angularity from the vertical will result in a horizontal force component. The point where this angularity becomes critical cannot be defined for every case, but accepted practice is to limit the swing from the vertical to 4°.

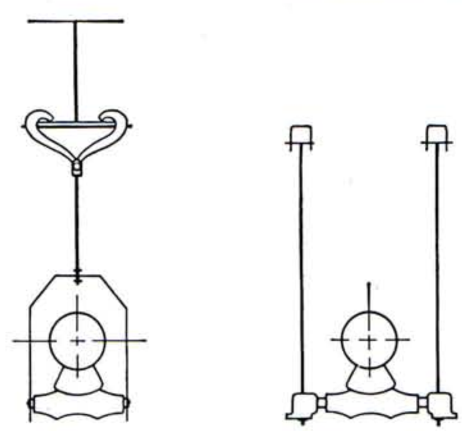
Where this angle is greater than 4°, a pipe roller should be considered.

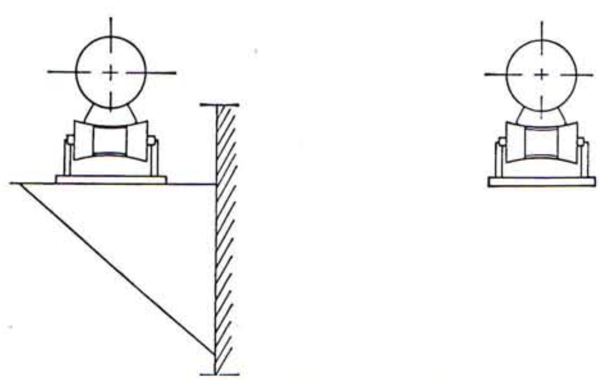
Pipe roller supports are of two basic types: those which attach to overhead structure, and those which are placed beneath the pipe as base supports.

It should be noted that where rollers are required, the pipe operating temperatures usually are sufficiently high that pipe insulation is used to reduce heat loss and for personnel protection. In these cases a pipe covering protection saddle should be used in conjunction with the rollers to keep the insulation from crushing.

Where the piping is not insulated, the pipe will rest directly on the roller. This is common practice for the support of long transmission lines where the gas or fluid transported is not of elevated operating temperatures, but where the pipe run is subject to some change in ambient temperature, as from summer to winter variances.

For example, a pipe line 300 feet long subject to ambient changes from 70°F to 110°F expands only .00306 inch per foot from the low to high temperature.


TYPICAL ROLLER HANGER ASSEMBLIES


TYPICAL BASE ROLLER SUPPORTS

Multiplied by 300 feet, however, the total axial expansion is 300 feet x .00306 inch/foot, or .918 inch.

In instances of this nature, rollers will be used, but the pipe covering protection saddles will not be required.

Hydraulic Shock & Sway Suppressor

While designing a pipe support system, the pipe hanger engineer may find it necessary to include in the system a device to absorb thrust associated with the release of blowoff valves or seismic disturbances. The Grinnell Fig. 200/201 Hydraulic Shock and Sway Suppressor meets this requirement.

A TYPICAL PIPE SUPPORT SPECIFICATION

A. SCOPE

This specification shall apply for the design and fabrication of all hangers, anchors and guides. Where piping design is such that exceptions to this specification are necessary, the particular system will be identified and the exceptions clearly listed through an addendum which will be made a part of the specification.

B. DESIGN

1. All supports and parts shall conform to the latest requirements of the American National Standard Code for Pressure Piping B31.1 and MSS Standard Practice SP-58, except as supplemented or modified by the requirements of this specification.
2. Designs generally accepted as exemplifying good engineering practice, using stock or production parts, shall be utilized wherever possible.
3. Accurate weight balance calculations shall be made to determine the required supporting force at each spring hanger location and the pipe weight load at each equipment connection.
4. Pipe hangers shall be capable of supporting the pipe in all conditions of operation. They shall allow free expansion and contraction of the piping, and prevent excessive stress resulting from transferred weight being induced into the pipe or connected equipment.
5. Wherever possible, pipe attachments for horizontal piping shall be pipe clamps.
6. Horizontal or vertical pipes should be supported preferably at locations of least vertical movement.
7. For critical, high-temperature piping, at hanger locations where the vertical movement of the piping is ¾" or more, or where it is necessary to avoid the transfer of load to adjacent hangers or connected equipment, pipe hangers shall be of an approved constant support design, as Grinnell Fig. 80-V and Fig. 81-H, or equal.

   An exception may be made in the instance where the piping movement occurs at a hanger supporting a portion of a piping riser on which a rigid support is also located. In this case, variable spring hangers may be used for any amount of expansion up to the full recommended working range of the spring, provided the change in supporting effect of the variable spring is added to the design load of the rigid support assembly.

   Where transfer of load to adjacent hangers or equipment is not critical, and where the vertical movement of the piping is less than ¾", variable spring hangers may be used, provided the variation is supporting effect does not exceed 25% of the calculated piping load through its total vertical travel.
8. The total travel for constant support hangers will be equal to actual travel plus 20%. In no case will the difference between actual and total travel be less than 1".
9. Constant supports shall be furnished with travel stops. The travel stops will be factory installed so that the hanger lever is at the "cold" position. The travel stops will be of such design as to permit future reengagement, even in the event the lever is at a position other than "cold", without having to make hanger rod adjustments.
10. Variable springs shall be furnished with travel stops. The travel stops are to be factory installed so that the piston cap is set at the "cold" position. The travel stop which will make the variable spring a rigid hanger during erection shall be of such design as to be easily removable after erection.
11. For low temperature, non-critical systems, where vertical movements up to 2" are anticipated, an approved precompressed variable spring design equal to Grinnell Fig. B-268 may be used. Where the vertical movement is greater than 2", a variable spring hanger equal to Grinnell Fig. 98 may be used. Where movements are of a small magnitude, spring hangers equal to Grinnell Fig. 82 may be used.
12. All rigid hangers shall provide a means of vertical adjustment after erection.

13. Where the piping system is subject to shock loads, such as seismic disturbances or thrusts imposed by the actuation of safety valves, hanger design shall include provision of shock absorbing devices of approved design.

14. Selection of vibration control devices shall not be part of the hanger contractor's work. If vibration is encountered after the piping system is in operation, appropriate vibration control equipment will be installed at the direction of the engineers.

15. Hanger rods shall be subjected to tensile loading only. At hanger locations where lateral or axial movement is anticipated, suitable linkage shall be provided to permit swing.

16. Where horizontal piping movements are such that the hanger rod angularity from the vertical is greater than 4 degrees from the cold to hot position of the pipe, the hanger pipe and structural attachments shall be offset in such a manner that the rod is vertical in the hot position.

17. Hangers shall be designed so that they cannot become disengaged by movements of the supported pipe.

18. For piping 350° and over, hangers shall be spaced in accordance with the latest requirements of the ANSI Code for Pressure Piping B 31.1.

    Spacings of hangers for other piping may be greater than listed by the above Code, provided that:

    a) the sag of the pipe between supports will permit drainage of the system.

    b) no excessive bending or shear stresses result from the pipe weight, or concentrated loads, between supports.

19. Where practical, riser pipe shall be supported independently of the connected horizontal piping.

    Pipe support attachments to the riser piping shall be riser clamps of a design equal to Grinnell Hanger Standard 40.

    The design loads for rigid riser supports shall be as follows:

    Steam Lines – Stock sizes for riser clamps shall be selected using allowable stresses listed in MSS SP-58 and ANSI BBI.1 Section 121 1.2 for the maximum operating load or hydrostatic test load, whichever is greater.

    Water-Filled Lines – Design shall be based on the maximum operating load. Selection of riser clamp stock size shall be based on MSS SP-58 and ANSI B31.1 Section 121.1.2.

20. Supports guides and anchors shall be so designed that excessive heat will not be transmitted to the building steel. The temperature of supporting parts shall be based on a temperature variation factor of 100°F. per inch distance from the outside surface of the pipe.

C. HANGER DESIGN SERVICE

1. Hangers for piping 2½" and larger, and all spring support assemblies, shall be completely engineered.

    a) Engineered hanger assemblies shall be detailed on 8½" x 11" sheets.

       Each sketch will include a location plan showing the location of the hanger in relation to columns or equipment.

       Each sketch will include an exact bill of material for the component parts making up each assembly.

    b) Each engineered hanger assembly will be individually bundled and tagged as far as practical, ready for installation.

2. Hanger material for piping 2" and smaller shall be shipped as loose material, identified by piping system only. Hanger sketches showing typical support arrangements, accompanied by a copy of the piping drawing marked with approximate hanger locations, will be supplied by the hanger contractor.

Nuclear Hangers

The complexities of the code covering the construction of nuclear pipe hangers makes it impossible to cover any more than the barest of details.

The earliest code covering nuclear piping, B 31.7, had little effect on the design and fabrication of hangers nor did the first edition in 1971 of the Boiler and Pressure Vessel Code Section III. However, the 1974 Edition of Section III, Division 1, Subsection NF included Component Supports.

The code provides rules covering materials, design, fabrication and installation, examination, and testing of four classes of quality which are referred to as Classes 1, 2, 3, and MC. It is the responsibility of the owner or his agent to select the class that will provide the quality required for the intended service.

WEIGHTS OF PIPING MATERIALS

The tabulation of weights of standard piping materials has been arranged for convenience of selection of data that formerly consumed considerable time to develop. For special materials, the three formulae listed below for weights of tubes, for weights of contents of tubes, and for weights of piping insulation will be helpful.

Weight of tube $= F \times 10.68 \times T \times (D - T)$ lb/ft

T = wall thickness in inches

D = outside diameter in inches

F = relative weight factor

The weight of tube furnished in this piping data is based on low carbon steel weighing 0.2833 pounds per cubic inch.

Relative Weight Factor F

Aluminum	0.35
Brass	1.12
Cast Iron	0.91
Copper	1.14
Ferritic stainless steel	0.95
Austenitic stainless steel	1.02
Steel	1.00
Wrought iron	0.98

Weight of contents of a tube —

$$G \times .3405 \times (D - 2T)^2 \text{ lb/ft}$$

G = specific gravity of contents

T = tube wall thickness in inches

D = tube outside diameter in inches

The weight per foot of steel pipe is subject to the following tolerances:

SPECIFICATION	TOLERANCE		
ASTM A-53 ASTM A-120	STD WT	+5%,	-5%
	XS WT	+5%,	-5%
	XXS WT	+10%,	-10%
ASTM A-106	SCH 10-120	+6.5%,	-3.5%
	SCH 140-160	+10%,	-3.5%
ASTM A-335	12" and under	+6.5%,	-3.5%
	over 12"	+10%,	-5%
ASTM A-312 ASTM A-376	12" and under	+6.5%,	-3.5%

NOTE:

Weight tolerances, based on ASTM specifications, only apply to standard wall thicknesses and standard pipe sizes.

The weight of welding tees and laterals are for full size fittings. The weights of reducing fittings are approximately the same as for full size fittings.

The weights of welding reducers are for one size reduction, and are approximately correct for other reductions.

Where specific insulation thicknesses and densities differ from those shown, refer to "Weight of Piping Insulation" formula below or to Table on page 50.

Weight of piping insulation –

$$I \times .0218 \times T \times (D + T) \text{ lb/ft}$$

I = insulation density in pounds per cubic foot

T = insulation thickness in inches

D = outside diameter of pipe in inches

1" PIPE 1.313" O.D.

PIPE	Schedule No.	5S	10S	40	80	160	
	Wall Designation			Std.	XS		XXS
	Thickness – In.	0.065	0.109	.133	.179	.250	.358
	Pipe – Lbs/Ft	**0.868**	**1.404**	**1.68**	**2.17**	**2.84**	**3.66**
	Water – Lbs/Ft	**0.478**	**0.409**	**.37**	**.31**	**.23**	**.12**
WELDING FITTINGS	L.R. 90° Elbow	**.2** .3	**.4** .3	**.4** .3	**.4** .3	**.6** .3	**1.0** .3
	S.R. 90° Elbow			**.3** .2			
	L.R. 45° Elbow	**.1** .2	**.3** .2	**.3** .2	**.3** .2	**.4** .2	**.5** .2
	Tee	**.4** .4	**.6** .4	**.8** .4	**.9** .4	**1.1** .4	**1.3** .4
	Lateral	**.7** 1.1	**1.2** 1.1	**1.7** 1.1	**2.5** 1.1		
	Reducer	**.2** .2	**.4** .2	**.3** .2	**.4** .2	**.5** .2	**.5** .2
	Cap	**.1** .3	**.1** .3	**.3** .3	**.3** .3	**.4** .3	**.5** .3

INSULATION	Temperature Range °F	100-199	200-299	300-399	400-499	500-599	600-699	700-799	800-899	900-999	1000-1099	1100-1200
85% Magnesia Calcium Silicate	Nom. Thick., In.	1	1	1½	2	2						
	Lbs/Ft	**.72**	**.72**	**1.23**	**1.94**	**1.94**						
Combination	Nom. Thick., In.						2½	2½	2½	3	3	3
	Lbs/Ft						**3.30**	**3.30**	**3.30**	**4.70**	**4.70**	**4.70**
*Asbestos Fiber – Sodium Silicate	Nom. Thick., In.	1	1	1½	2	2	2½	2½	2½	3	3	3
	Lbs/Ft	**.72**	**.72**	**1.23**	**1.94**	**1.94**	**2.76**	**2.76**	**2.76**	**3.70**	**3.70**	**3.70**

	Pressure Rating psi	Cast Iron		Steel						
		125	250	150	300	400	600	900	1500	2500
FLANGES	Screwed or Slip-On	**2.3** 1.5	**4** 1.5	**2.5** 1.5	**4** 1.5	**5** 1.5	**5** 1.5	**12** 1.5	**12** 1.5	**15** 1.5
	Welding Neck			**3** 1.5	**5** 1.5	**7** 1.5	**7** 1.5	**12** 1.5	**12** 1.5	**16** 1.5
	Lap Joint			**2.5** 1.5	**4** 1.5	**5** 1.5	**5** 1.5	**12** 1.5	**12** 1.5	**15** 1.5
	Blind	**2.5** 1.5	**5** 1.5	**2.5** 1.5	**5** 1.5	**5** 1.5	**5** 1.5	**12** 1.5	**12** 1.5	**15** 1.5
FLANGED FITTINGS	S.R. 90° Elbow						**15** 3.7		**28** 3.8	
	L.R. 90° Elbow									
	45° Elbow						**14** 3.4		**26** 3.6	
	Tee						**20** 5.6		**39** 5.7	

Boldface type is weight in pounds. Lightface type beneath weight is weight factor for insulation.

Insulation thicknesses and weights are based on average conditions and do not constitute a recommendation for specific thicknesses of materials. Insulation weights are based on 85% magnesia and hydrous calcium silicate at 11 lbs/cubic foot. The listed thicknesses and weights of combination covering are the sums of the inner layer of diatomaceous earth at 21 lbs/cubic foot and the outer layer at 11 lbs/cubic foot.

Insulation weights include allowances for wire, cement, canvas, bands and paint, but not special surface finishes.

To find the weight of covering on flanges or fittings, multiply the weight factor by the weight per foot of covering used on straight pipe.

All flanged fitting and flange weights include the proportional weight of bolts or studs to make up all joints.

* 16 lb. cu. ft. density.

1.660" O.D. 1¼" PIPE

PIPE	Schedule No.	5S	10S	40	80	160	
	Wall Designation			Std.	XS		XXS
	Thickness — In.	.065	.109	.140	.191	.250	.382
	Pipe — Lbs/Ft	**1.11**	**1.81**	**2.27**	**3.00**	**3.77**	**5.22**
	Water — Lbs/Ft	**.80**	**.71**	**.65**	**.56**	**.46**	**.27**
WELDING FITTINGS	L.R. 90° Elbow	**.3** .3	**.5** .3	**.6** .3	**.8** .3	**1.0** .3	**1.3** .3
	S.R. 90° Elbow			**.4** .2			
	L.R. 45° Elbow	**.2** .2	**.3** .2	**.3** .2	**.5** .2	**.6** .2	**.7** .2
	Tee	**.7** .5	**1.1** .5	**1.6** .5	**1.6** .5	**1.9** .5	**2.4** .5
	Lateral	**1.1** 1.2	**1.9** 1.2	**2.4** 1.2	**3.8** 1.2		
	Reducer	**.3** .2	**.4** .2	**.5** .2	**.6** .2	**.7** .2	**.8** .2
	Cap	**.1** .3	**.1** .3	**.4** .3	**.4** .3	**.6** .3	**.6** .3

INSULATION	Temperature Range °F	100-199	200-299	300-399	400-499	500-599	600-699	700-799	800-899	900-999	1000-1099	1100-1200
85% Magnesia Calcium Silicate	Nom. Thick., In.	1	1	1½	2	2	2½	2½	2½	3	3	3
	Lbs/Ft	**.65**	**.65**	**1.47**	**1.83**	**1.83**	**2.65**	**2.65**	**2.65**	**3.58**	**3.58**	**3.58**
Combination	Nom. Thick., In.						2½	2½	2½	3	3	3
	Lbs/Ft						**3.17**	**3.17**	**3.17**	**5.76**	**5.76**	**5.76**
*Asbestos Fiber — Sodium Silicate	Nom. Thick., In.	1	1	1	1½	1½	1½	2	2½	2½	3	3
	Lbs/Ft	**.82**	**.82**	**.82**	**1.93**	**1.93**	**1.93**	**2.45**	**3.58**	**3.58**	**4.82**	**4.82**

	Pressure Rating psi	Cast Iron		Steel						
		125	250	150	300	400	600	900	1500	2500
FLANGES	Screwed or Slip-On	**2.5** 1.5	**4.8** 1.5	**3.5** 1.5	**5** 1.5	**7** 1.5	**7** 1.5	**13** 1.5	**13** 1.5	**23** 1.5
	Welding Neck			**3** 1.5	**7** 1.5	**8** 1.5	**8** 1.5	**13** 1.5	**13** 1.5	**25** 1.5
	Lap Joint			**3.5** 1.5	**5** 1.5	**7** 1.5	**7** 1.5	**13** 1.5	**13** 1.5	**22** 1.5
	Blind	**2.8** 1.5	**5.5** 1.5	**3.5** 1.5	**4** 1.5	**7** 1.5	**7** 1.5	**13** 1.5	**13** 1.5	**23** 1.5
FLANGED FITTINGS	S.R. 90° Elbow				**17** 3.7		**18** 3.8		**33** 3.9	
	L.R. 90° Elbow				**18** 3.9					
	45° Elbow				**15** 3.4		**16** 3.5		**31** 3.7	
	Tee				**23** 5.6		**28** 5.7		**49** 5.9	

Boldface type is weight in pounds. Lightface type beneath weight is weight factor for insulation.

Insulation thicknesses and weights are based on average conditions and do not constitute a recommendation for specific thicknesses of materials. Insulation weights are based on 85% magnesia and hydrous calcium silicate at 11 lbs/cubic foot. The listed thicknesses and weights of combination covering are the sums of the inner layer of diatomaceous earth at 21 lbs/cubic foot and the outer layer at 11 lbs/cubic foot.

Insulation weights include allowances for wire, cement, canvas, bands and paint, but not special surface finishes.

To find the weight of covering on flanges or fittings, multiply the weight factor by the weight per foot of covering used on straight pipe.

All flanged fitting and flange weights include the proportional weight of bolts or studs to make up all joints.

* 16 lb. cu. ft. density.

1½" PIPE 1.900" O.D.

PIPE	Schedule No.	5S	10S	40	80	160							
	Wall Designation			Std.	XS		XXS						
	Thickness – In.	.065	.109	.145	.200	.281	.400	.525	.650				
	Pipe – Lbs/Ft	**1.27**	**2.09**	**2.72**	**3.63**	**4.86**	**6.41**	**7.71**	**8.68**				
	Water – Lbs/Ft	**1.07**	**.96**	**.88**	**.77**	**.61**	**.41**	**.25**	**.12**				
WELDING FITTINGS	L.R. 90° Elbow	**.4** .4	**.8** .4	**.9** .4	**1.2** .4	**1.5** .4	**2.0** .4						
	S.R. 90° Elbow			**.6** .3	**.8** .3								
	L.R. 45° Elbow	**.3** .2	**.5** .2	**.5** .2	**.7** .2	**.8** .2	**1** .2						
	Tee	**.9** .6	**1.5** .6	**2** .6	**2.4** .6	**3.0** .6	**3.7** .6						
	Lateral	**1.3** 1.3	**2.1** 1.3	**3.3** 1.3	**5.5** 1.3								
	Reducer	**.3** .2	**.6** .2	**.6** .2	**.8** .2	**1.0** .2	**1.2** .2						
	Cap	**.1** .3	**.2** .3	**.4** .3	**.5** .3	**.7** .3	**.8** .3						

		Temperature Range °F	100-199	200-299	300-399	400-499	500-599	600-699	700-799	800-899	900-999	1000-1099	1100-1200
INSULATION	85% Magnesia Calcium Silicate	Nom. Thick., In.	1	1	1½	2	2	2½	2½	2½	3	3	3
		Lbs/Ft	**.84**	**.84**	**1.35**	**2.52**	**2.52**	**3.47**	**3.47**	**3.47**	**4.52**	**4.52**	**4.52**
	Combination	Nom. Thick., In.						2½	2½	2½	3	3	3
		Lbs/Ft						**4.20**	**4.20**	**4.20**	**5.62**	**5.62**	**5.62**
	*Asbestos Fiber—Sodium Silicate	Nom. Thick., In.	1	1	1	1½	1½	2	2	2½	2½	3	3
		Lbs/Ft	**1.07**	**1.07**	**1.07**	**1.85**	**1.85**	**3.50**	**3.50**	**4.76**	**4.76**	**6.16**	**6.16**

	Pressure Rating psi	Cast Iron		Steel						
		125	250	150	300	400	600	900	1500	2500
FLANGES	Screwed or Slip-On	**3** 1.5	**6** 1.5	**3.5** 1.5	**6** 1.5	**9** 1.5	**9** 1.5	**19** 1.5	**19** 1.5	**31** 1.5
	Welding Neck			**4.5** 1.5	**8** 1.5	**12** 1.5	**12** 1.5	**19** 1.5	**19** 1.5	**34** 1.5
	Lap Joint			**3.5** 1.5	**6** 1.5	**9** 1.5	**9** 1.5	**19** 1.5	**19** 1.5	**30** 1.5
	Blind	**4** 1.5	**6** 1.5	**3.5** 1.5	**8** 1.5	**10** 1.5	**10** 1.5	**19** 1.5	**19** 1.5	**31** 1.5
FLANGED FITTINGS	S.R. 90° Elbow	**9** 3.7		**12** 3.7	**23** 3.8		**26** 3.9		**46** 4	
	L.R. 90° Elbow	**12** 4		**13** 4	**24** 4					
	45° Elbow	**8** 3.4		**11** 3.4	**21** 3.5		**23** 3.5		**39** 3.7	
	Tee	**15** 5.6		**20** 5.6	**30** 5.7		**37** 5.8		**70** 6	

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Insulation weights include allowances for wire, cement, canvas, bands and paint, but not special surface finishes.

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All flanged fitting and flange weights include the proportional weight of bolts or studs to make up all joints.

* 16 lb. cu. ft. density.

2.375" O.D. **2"** PIPE

PIPE

Schedule No.	5S	10S	40	80	160							
Wall Designation			Std.	XS		XXS						
Thickness – In.	.065	.109	.154	.218	.343	.436	.562	.687				
Pipe – Lbs/Ft	**1.60**	**2.64**	**3.65**	**5.02**	**7.44**	**9.03**	**10.88**	**12.39**				
Water – Lbs/Ft	**1.72**	**1.58**	**1.46**	**1.28**	**.97**	**.77**	**.53**	**.34**				

WELDING FITTINGS

	5S	10S	40	80	160	XXS
L.R. 90° Elbow	**.6** .5	**1.1** .5	**1.5** .5	**2.1** .5	**3.0** .5	**4.0** .5
S.R. 90° Elbow			**1** .3	**1.4** .3		
L.R. 45° Elbow	**.4** .2	**.6** .2	**.9** .2	**1.1** .2	**1.6** .2	**2.0** .2
Tee	**1.1** .6	**1.8** .6	**2.9** .6	**3.7** .6	**4.9** .6	**5.7** .6
Lateral	**1.9** 1.4	**3.2** 1.4	**5** 1.4	**7.7** 1.4		
Reducer	**.4** .3	**.9** .3	**.9** .3	**1.2** .3	**1.6** .3	**1.9** .3
Cap	**.2** .4	**.3** .4	**.6** .4	**.7** .4	**1.1** .4	**1.2** .4

INSULATION

	Temperature Range °F	100-199	200-299	300-399	400-499	500-599	600-699	700-799	800-899	900-999	1000-1099	1100-1200
85% Magnesia Calcium Silicate	Nom. Thick., In.	1	1	1½	2	2	2½	2½	3	3	3	3½
	Lbs/Ft	**1.01**	**1.01**	**1.71**	**2.53**	**2.53**	**3.48**	**3.48**	**4.42**	**4.42**	**4.42**	**5.59**
Combination	Nom. Thick., In.						2½	2½	3	3	3	3½
	Lbs/Ft						**4.28**	**4.28**	**5.93**	**5.93**	**5.93**	**7.80**
*Asbestos Fiber—Sodium Silicate	Nom. Thick., In.	1	1	1	1½	1½	2	2	2½	2½	3	3
	Lbs/Ft	**1.26**	**1.26**	**1.26**	**2.20**	**2.20**	**3.32**	**3.32**	**4.57**	**4.57**	**5.99**	**5.99**

FLANGES / FLANGED FITTINGS

Pressure Rating psi	Cast Iron 125	Cast Iron 250	Steel 150	Steel 300	Steel 400	Steel 600	Steel 900	Steel 1500	Steel 2500
Screwed or Slip-On	**5** 1.5	**7** 1.5	**6** 1.5	**9** 1.5	**11** 1.5	**11** 1.5	**32** 1.5	**32** 1.5	**49** 1.5
Welding Neck			**7** 1.5	**11** 1.5	**14** 1.5	**14** 1.5	**32** 1.5	**32** 1.5	**53** 1.5
Lap Joint			**6** 1.5	**9** 1.5	**11** 1.5	**11** 1.5	**32** 1.5	**32** 1.5	**48** 1.5
Blind	**5** 1.5	**8** 1.5	**5** 1.5	**10** 1.5	**12** 1.5	**12** 1.5	**32** 1.5	**32** 1.5	**50** 1.5
S.R. 90° Elbow	**14** 3.8	**20** 3.8	**19** 3.8	**29** 3.8		**35** 4		**83** 4.2	
L.R. 90° Elbow	**16** 4.1	**27** 4.1	**22** 4.1	**31** 4.1					
45° Elbow	**12** 3.4	**18** 3.5	**16** 3.4	**24** 3.5		**33** 3.7		**73** 3.9	
Tee	**21** 5.7	**32** 5.7	**27** 5.7	**41** 5.7		**52** 6		**129** 6.3	

* 16 lb. cu. ft. density.

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Insulation weights include allowances for wire, cement, canvas, bands and paint, but not special surface finishes.

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All flanged fitting and flange weights include the proportional weight of bolts or studs to make up all joints.

2½" PIPE 2.875" O.D.

PIPE

Schedule No.	5S	10S	40	80	160			
Wall Designation			Std.	XS		XXS		
Thickness – In.	.083	.120	.203	.276	.375	.552	.675	.800
Pipe – Lbs/Ft	2.48	3.53	5.79	7.66	10.01	13.70	15.86	17.73
Water – Lbs/Ft	2.50	2.36	2.08	1.84	1.54	1.07	.79	.55

WELDING FITTINGS

	5S	10S	40	80	160	XXS
L.R. 90° Elbow	1.2 .6	1.8 .6	3.0 .6	3.8 .6	5.0 .6	7.0 .6
S.R. 90° Elbow			2.2 .4	2.5 .4		
L.R. 45° Elbow	.7 .3	1.0 .3	1.6 .3	2.1 .3	3.0 .3	3.5 .3
Tee	2.1 .8	3.0 .8	5.2 .8	6.4 .8	7.8 .8	9.8 .8
Lateral	3.5 1.5	4.9 1.5	9.0 1.5	13 1.5		
Reducer	.6 .3	1.2 .3	1.6 .3	2.0 .3	2.7 .3	3.3 .3
Cap	.3 .4	.4 .4	.9 .4	1 .4	1.9 .4	2.0 .4

INSULATION

Temperature Range °F		100-199	200-299	300-399	400-499	500-599	600-699	700-799	800-899	900-999	1000-1099	1100-1200
85% Magnesia Calcium Silicate	Nom. Thick., In.	1	1	1½	2	2	2½	2½	3	3	3½	3½
	Lbs/Ft	1.14	1.14	2.29	3.23	3.23	4.28	4.28	5.46	5.46	6.86	6.86
Combination	Nom. Thick., In.						2½	2½	3	3	3½	3½
	Lbs/Ft						5.20	5.20	7.36	7.36	9.58	9.58
*Asbestos Fiber – Sodium Silicate	Nom. Thick., In.	1	1	1	1½	1½	2	2	2½	2½	3	3
	Lbs/Ft	1.44	1.44	1.44	3.09	3.09	4.34	4.34	5.75	5.75	7.34	7.34

FLANGES / FLANGED FITTINGS

Pressure Rating psi	Cast Iron		Steel						
	125	250	150	300	400	600	900	1500	2500
Screwed or Slip-On	7 1.5	12.5 1.5	8 1.5	14 1.5	17 1.5	17 1.5	46 1.5	46 1.5	69 1.5
Welding Neck			11 1.5	16 1.5	22 1.5	22 1.5	46 1.5	46 1.5	66 1.5
Lap Joint			8 1.5	14 1.5	16 1.5	16 1.5	45 1.5	45 1.5	67 1.5
Blind	7.8 1.5	10 1.5	8 1.5	16 1.5	19 1.5	19 1.5	45 1.5	45 1.5	70 1.5
S.R. 90° Elbow	20 3.8	33 3.9	27 3.8	42 3.9		50 4.1		114 4.4	
L.R. 90° Elbow	24 4.2		30 4.2	47 4.2					
45° Elbow	18 3.5	31 3.6	22 3.5	35 3.6		46 3.8		99 3.9	
Tee	31 5.7	49 5.8	42 5.7	61 5.9		77 6.2		169 6.6	

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* 16 lb. cu. ft. density.

3.500" O.D. **3"** PIPE

PIPE	Schedule No.	5S	10S	40	80	160							
	Wall Designation			Std.	XS		XXS						
	Thickness—In.	.083	.120	.216	.300	.438	.600	.725	.850				
	Pipe—Lbs/Ft	3.03	4.33	7.58	10.25	14.32	18.58	21.49	24.06				
	Water—Lbs/Ft	3.78	3.61	3.20	2.86	2.35	1.80	1.43	1.10				
WELDING FITTINGS	L.R. 90° Elbow	1.7 .8	2.5 .8	4.7 .8	6.0 .8	8.5 .8	11 .8						
	S.R. 90° Elbow			3.3 .5	4.1 .5								
	L.R. 45° Elbow	.9 .3	1.3 .3	2.5 .3	3.3 .3	4.5 .3	5.5 .3						
	Tee	2.7 .8	3.9 .8	7.0 .8	10 .8	12.2 .8	14.8 .8						
	Lateral	4.5 1.8	6.4 1.8	12.5 1.8	18 1.8								
	Reducer	.8 .3	1.5 .3	2.1 .3	2.8 .3	3.7 .3	4.6 .3						
	Cap	.5 .5	.7 .5	1.4 .5	1.8 .5	3.5 .5	3.6 .5						

	Temperature Range °F		100-199	200-299	300-399	400-499	500-599	600-699	700-799	800-899	900-999	1000-1099	1100-1200
INSULATION	85% Magnesia Calcium Silicate	Nom. Thick., In.	1	1	1½	2	2	2½	3	3	3	3½	3½
		Lbs/Ft	1.25	1.25	2.08	3.01	3.01	4.07	5.24	5.24	5.24	6.65	6.65
	Combination	Nom. Thick., In.						2½	3	3	3	3½	3½
		Lbs/Ft						5.07	6.94	6.94	6.94	9.17	9.17
	*Asbestos Fiber—Sodium Silicate	Nom. Thick., In.	1	1	1	1½	1½	2	2	3	3	3½	3½
		Lbs/Ft	1.61	1.61	1.61	2.74	2.74	3.98	3.98	6.99	6.99	8.99	8.99

	Pressure Rating psi	Cast Iron		Steel						
		125	250	150	300	400	600	900	1500	2500
FLANGES	Screwed or Slip-On	8.6 1.5	15.8 1.5	9 1.5	17 1.5	20 1.5	20 1.5	37 1.5	61 1.5	102 1.5
	Welding Neck			12 1.5	19 1.5	27 1.5	27 1.5	38 1.5	61 1.5	113 1.5
	Lap Joint			9 1.5	17 1.5	19 1.5	19 1.5	36 1.5	60 1.5	99 1.5
	Blind	9 1.5	17.5 1.5	10 1.5	20 1.5	24 1.5	24 1.5	38 1.5	61 1.5	105 1.5
FLANGED FITTINGS	S.R. 90° Elbow	25 3.9	44 4	32 3.9	53 4		67 4.1	98 4.3	150 4.6	
	L.R. 90° Elbow	29 4.3		40 4.3	63 4.3					
	45° Elbow	21 3.5	39 3.6	28 3.5	46 3.6		60 3.8	93 3.9	135 4	
	Tee	38 5.9	62 6	52 5.9	81 6		102 6.2	151 6.5	238 6.9	

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* 16 lb. cu. ft. density.

3½" PIPE 4.000" O.D.

PIPE	Schedule No.	5S	10S	40	80	
	Wall Designation			Std.	XS	XXS
	Thickness—In.	.083	.120	.226	.318	.636
	Pipe—Lbs/Ft	3.47	4.97	9.11	12.51	22.85
	Water—Lbs/Ft	5.01	4.81	4.28	3.85	2.53
WELDING FITTINGS	L.R. 90° Elbow	2.4 .9	3.4 .9	6.7 .9	8.7 .9	15 .9
	S.R. 90° Elbow			4.2 .6	5.7 .6	
	L.R. 45° Elbow	1.2 .4	1.7 .4	3.3 .4	4.4 .4	8 .4
	Tee	3.4 .9	4.9 .9	10.3 .9	13.8 .9	20.2 .9
	Lateral	6.2 1.8	8.9 1.8	17.2 1.8	25 1.8	
	Reducer	1.2 .3	2.1 .3	3.0 .3	4.0 .3	6.8 .3
	Cap	.6 .6	.8 .6	2.1 .6	2.8 .6	5.5 .6

Temperature Range °F		100-199	200-299	300-399	400-499	500-599	600-699	700-799	800-899	900-999	1000-1099	1100-1200
INSULATION — 85% Magnesia Calcium Silicate	Nom. Thick., In.	1	1	1½	2	2½	2½	3	3	3½	3½	3½
	Lbs/Ft	1.83	1.83	2.77	3.71	4.88	4.88	6.39	6.39	7.80	7.80	7.80
Combination	Nom. Thick., In.						2½	3	3	3½	3½	3½
	Lbs/Ft						6.49	8.71	8.71	10.8	10.8	10.8
*Asbestos Fiber—Sodium Silicate	Nom. Thick., In.	1	1	1	1½	1½	2	2	3	3	3½	3½
	Lbs/Ft	2.41	2.41	2.41	3.65	3.65	5.07	5.07	8.66	8.66	10.62	10.62

	Pressure Rating psi	Cast Iron 125	Cast Iron 250	Steel 150	Steel 300	Steel 400	Steel 600	Steel 900	Steel 1500	Steel 2500
FLANGES	Screwed or Slip-On	11 1.5	20 1.5	13 1.5	21 1.5	27 1.5	27 1.5			
	Welding Neck			14 1.5	22 1.5	32 1.5	32 1.5			
	Lap Joint			13 1.5	21 1.5	26 1.5	26 1.5			
	Blind	13 1.5	23 1.5	15 1.5	25 1.5	35 1.5	35 1.5			
FLANGED FITTINGS	S.R. 90° Elbow	33 4		49 4			82 4.3			
	L.R. 90° Elbow			54 4.4						
	45° Elbow	29 3.6		39 3.6			75 3.9			
	Tee	51 6	103 6.2	70 6			133 6.4			

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* 16 lb. cu. ft. density.

4.500" O.D. 4" PIPE

PIPE	Schedule No.	5S	10S		40	80	120		160				
	Wall Designation				Std.	XS				XXS			
	Thickness—In.	.083	.120	.188	.237	.337	.438	.500	.531	.674	.800	.925	
	Pipe—Lbs/Ft	3.92	5.61	8.56	10.79	14.98	18.96	21.36	22.51	27.54	31.61	35.32	
	Water—Lbs/Ft	6.40	6.17	5.80	5.51	4.98	4.48	4.16	4.02	3.38	2.86	2.39	
WELDING FITTINGS	L.R. 90° Elbow	3.0 1	4.3 1		8.7 1	12.0 1			18.0 1	20.5 1			
	S.R. 90° Elbow				6.7 .7	8.3 .7							
	L.R. 45° Elbow	1.5 .4	2.2 .4		4.3 .4	5.9 .4			8.5 .4	10 .4			
	Tee	3.9 1	5.7 1		13.5 1	16.4 1			22.8 1	26.6 1			
	Lateral	6.6 2.1	10.0 2.1		20.5 2.1	32 2.1							
	Reducer	1.2 .3	2.4 .3		3.6 .3	4.8 .3			6.6 .3	8.2 .3			
	Cap	.8 .3	1.2 .3		2.5 .6	3.4 .6			6.5 .6	6.6 .6			

	Temperature Range °F	100-199	200-299	300-399	400-499	500-599	600-699	700-799	800-899	900-999	1000-1099	1100-1200
INSULATION: 85% Magnesia Calcium Silicate	Nom. Thick., In.	1	1	1½	2	2½	2½	3	3	3½	3½	4
	Lbs/Ft	1.62	1.62	2.55	3.61	4.66	4.66	6.07	6.07	7.48	7.48	9.10
Combination	Nom. Thick., In.						2½	3	3	3½	3½	3½
	Lbs/Ft						6.07	8.30	8.30	10.6	10.6	10.6
*Asbestos Fiber—Sodium Silicate	Nom. Thick., In.	1	1	1	1½	1½	2	2	3	3	3½	3½
	Lbs/Ft	2.04	2.04	2.04	3.28	3.28	4.70	4.70	8.29	8.29	10.25	10.25

	Pressure Rating psi	Cast Iron		Steel						
		125	250	150	300	400	600	900	1500	2500
FLANGES	Screwed or Slip-On	14 1.5	24 1.5	15 1.5	26 1.5	32 1.5	43 1.5	66 1.5	90 1.5	158 1.5
	Welding Neck			17 1.5	29 1.5	41 1.5	48 1.5	64 1.5	90 1.5	177 1.5
	Lap Joint			15 1.5	26 1.5	31 1.5	42 1.5	64 1.5	92 1.5	153 1.5
	Blind	16 1.5	27 1.5	19 1.5	31 1.5	39 1.5	47 1.5	67 1.5	90 1.5	164 1.5
FLANGED FITTINGS	S.R. 90° Elbow	43 4.1	69 4.2	59 4.1	85 4.2	99 4.3	128 4.4	185 4.5	254 4.8	
	L.R. 90° Elbow	50 4.5		72 4.5	98 4.5					
	45° Elbow	38 3.7	62 3.8	51 3.7	78 3.8	82 3.9	119 4	170 4.1	214 4.2	
	Tee	66 6.1	103 6.3	86 6.1	121 6.3	153 6.4	187 6.6	262 6.8	386 7.2	

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* 16 lb. cu. ft. density.

5" PIPE 5.563" O.D.

PIPE	Schedule No.	5S	10S	40	80	120	160						
	Wall Designation			Std.	XS			XXS					
	Thickness – In.	.109	.134	.258	.375	.500	.625	.750	.875	1.000			
	Pipe – Lbs/Ft	**6.35**	**7.77**	**14.62**	**20.78**	**27.04**	**32.96**	**38.55**	**43.81**	**47.73**			
	Water – Lbs/Ft	**9.73**	**9.53**	**8.66**	**7.89**	**7.09**	**6.33**	**5.62**	**4.95**	**4.23**			
WELDING FITTINGS	L.R. 90° Elbow	**6.0** 1.3	**7.4** 1.3	**16.0** 1.3	**21.4** 1.3		**33** 1.3	**34** 1.3					
	S.R. 90° Elbow	**4.2** .8	**5.2** .8	**10.4** .8	**14.5** .8								
	L.R. 45° Elbow	**3.1** .5	**3.8** .5	**8.3** .5	**10.5** .5		**14** .5	**18** .5					
	Tee	**9.8** 1.2	**12.0** 1.2	**19.8** 1.2	**26.9** 1.2		**38.5** 1.2	**43.4** 1.2					
	Lateral	**15.3** 2.5	**18.4** 2.5	**31** 2.5	**49** 2.5								
	Reducer	**2.5** .4	**4.3** .4	**5.9** .4	**8.3** .4		**12.4** .4	**14.2** .4					
	Cap	**1.3** .7	**1.6** .7	**4.2** .7	**5.7** .7		**11** .7	**11** .7					

	Temperature Range °F	100-199	200-299	300-399	400-499	500-599	600-699	700-799	800-899	900-999	1000-1099	1100-1200
INSULATION: 85% Magnesia Calcium Silicate	Nom. Thick., In.	1	1½	1½	2	2½	2½	3	3½	3½	4	4
	Lbs/Ft	**1.86**	**2.92**	**2.92**	**4.08**	**5.38**	**5.38**	**6.90**	**8.41**	**8.41**	**10.4**	**10.4**
Combination	Nom. Thick., In.						2½	3	3½	3½	4	4
	Lbs/Ft						**7.01**	**9.30**	**11.8**	**11.8**	**14.9**	**14.9**
*Asbestos Fiber – Sodium Silicate	Nom. Thick., In.	1	1	1	1½	1½	2½	2½	3	3	4	4
	Lbs/Ft	**2.34**	**2.34**	**2.34**	**3.76**	**3.76**	**7.35**	**7.35**	**9.31**	**9.31**	**14.37**	**14.37**

	Pressure Rating psi	Cast Iron 125	Cast Iron 250	Steel 150	Steel 300	Steel 400	Steel 600	Steel 900	Steel 1500	Steel 2500
FLANGES	Screwed or Slip-On	**17** 1.5	**28** 1.5	**18** 1.5	**32** 1.5	**37** 1.5	**73** 1.5	**100** 1.5	**162** 1.5	**259** 1.5
	Welding Neck			**22** 1.5	**36** 1.5	**49** 1.5	**78** 1.5	**103** 1.5	**162** 1.5	**293** 1.5
	Lap Joint			**18** 1.5	**32** 1.5	**35** 1.5	**71** 1.5	**98** 1.5	**168** 1.5	**253** 1.5
	Blind	**21** 1.5	**35** 1.5	**23** 1.5	**39** 1.5	**50** 1.5	**78** 1.5	**104** 1.5	**172** 1.5	**272** 1.5
FLANGED FITTINGS	S.R. 90° Elbow	**55** 4.3	**91** 4.3	**80** 4.3	**113** 4.3	**123** 4.5	**205** 4.7	**268** 4.8	**435** 5.2	
	L.R. 90° Elbow	**65** 4.7		**91** 4.7	**128** 4.7					
	45° Elbow	**48** 3.8	**80** 3.8	**66** 3.8	**98** 3.8	**123** 4	**180** 4.2	**239** 4.3	**350** 4.5	
	Tee	**84** 6.4	**139** 6.5	**119** 6.4	**172** 6.4	**179** 6.8	**304** 7	**415** 7.2	**665** 7.8	

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* 16 lb. cu. ft. density.

6.625" O.D. **6"** PIPE

PIPE

Schedule No.	5S	10S		40	80	120	160					
Wall Designation				Std.	XS			XXS				
Thickness—In.	.109	.134	.219	.280	.432	.562	.718	.864	1.000	1.125		
Pipe—Lbs/Ft	**5.37**	**9.29**	**15.02**	**18.97**	**28.57**	**36.39**	**45.3**	**53.2**	**60.01**	**66.08**		
Water—Lbs/Ft	**13.98**	**13.74**	**13.10**	**12.51**	**11.29**	**10.30**	**9.2**	**8.2**	**7.28**	**6.52**		

WELDING FITTINGS

L.R. 90° Elbow	**8.9** 1.5	**11.0** 1.5		**22.8** 1.5	**32.2** 1.5	**43** 1.5	**55** 1.5	**62** 1.5				
S.R. 90° Elbow	**6.1** 1	**7.5** 1		**16.6** 1	**22.9** 1	**30** 1						
L.R. 45° Elbow	**4.5** .6	**5.5** .6		**11.3** .6	**16.4** .6	**21** .6	**26** .6	**30** .6				
Tee	**13.8** 1.4	**17.0** 1.4		**31.3** 1.4	**39.5** 1.4		**59** 1.4	**68** 1.4				
Lateral	**16.7** 2.9	**20.5** 2.9		**42** 2.9	**78** 2.9							
Reducer	**3.3** .5	**5.8** .5		**8.6** .5	**12.6** .5		**18.8** .5	**21.4** .5				
Cap	**1.6** .9	**1.9** .9		**6.4** .9	**9.2** .9	**13.3** .9	**17.5** .9	**17.5** .9				

INSULATION

Temperature Range °F		100-199	200-299	300-399	400-499	500-599	600-699	700-799	800-899	900-999	1000-1099	1100-1200
85% Magnesia Calcium Silicate	Nom. Thick., In.	1	1½	2	2	2½	3	3	3½	3½	4	4
	Lbs/Ft	**2.11**	**3.28**	**4.57**	**4.57**	**6.09**	**7.60**	**7.60**	**9.82**	**98.2**	**11.5**	**11.4**
Combination	Nom. Thick., In.						3	3	3½	3½	4	4
	Lbs/Ft						**10.3**	**10.3**	**13.4**	**13.4**	**16.6**	**16.6**
*Asbestos Fiber—Sodium Silicate	Nom. Thick., In.	1	1	1	1½	1½	2½	2½	3½	3½	4	4
	Lbs/Ft	**2.57**	**2.57**	**2.57**	**4.18**	**4.18**	**8.10**	**8.10**	**13.31**	**13.31**	**15.85**	**15.85**

FLANGES / **FLANGED FITTINGS**

Pressure Rating psi	Cast Iron		Steel						
	125	250	150	300	400	600	900	1500	2500
Screwed or Slip-On	**20** 1.5	**38** 1.5	**22** 1.5	**45** 1.5	**54** 1.5	**95** 1.5	**128** 1.5	**202** 1.5	**396** 1.5
Welding Neck			**27** 1.5	**48** 1.5	**67** 1.5	**96** 1.5	**130** 1.5	**202** 1.5	**451** 1.5
Lap Joint			**22** 1.5	**45** 1.5	**52** 1.5	**93** 1.5	**125** 1.5	**208** 1.5	**387** 1.5
Blind	**26** 1.5	**48** 1.5	**29** 1.5	**56** 1.5	**71** 1.5	**101** 1.5	**133** 1.5	**197** 1.5	**418** 1.5
S.R. 90° Elbow	**71** 4.3	**121** 4.4	**90** 4.3	**147** 4.4	**184** 4.6	**275** 4.8	**375** 5	**566** 5.3	
L.R. 90° Elbow	**88** 4.9		**126** 4.9	**182** 4.9					
45° Elbow	**63** 3.8	**111** 3.9	**82** 3.8	**132** 3.9	**149** 4.1	**240** 4.3	**320** 4.3	**476** 4.6	
Tee	**108** 6.5	**186** 6.6	**149** 6.5	**217** 6.6	**279** 6.9	**400** 7.2	**565** 7.5	**839** 8	

* 16 lb. cu. ft. density.

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All flanged fitting and flange weights include the proportional weight of bolts or studs to make up all joints.

8" PIPE 8.625" O.D.

PIPE

Schedule No.	5S	10S		20	30	40	60	80	100	120	140	160
Wall Designation						Std.		XS				
Thickness – In.	.109	.148	.219	.250	.277	.322	.406	.500	.593	.718	.812	.906
Pipe – Lbs/Ft	**9.91**	**13.40**	**19.64**	**22.36**	**24.70**	**28.55**	**35.64**	**43.4**	**50.9**	**60.6**	**67.8**	**74.7**
Water – Lbs/Ft	**24.07**	**23.59**	**22.90**	**22.48**	**22.18**	**21.69**	**20.79**	**19.8**	**18.8**	**17.6**	**16.7**	**15.8**

WELDING FITTINGS

	5S	10S		20	30	40	60	80	100	120	140	160
L.R. 90° Elbow	**15.4** 2	**21.0** 2				**44.9** 2		**70.3** 2				**120** 2
S.R. 90° Elbow	**6.6** 1.3	**14.3** 1.3				**34.5** 1.3		**50.2** 1.3				
L.R. 45° Elbow	**8.1** .8	**11.0** .8				**22.8** .8		**32.8** .8				**56** .8
Tee	**18.4** 1.8	**25.0** 1.8				**60.2** 1.8		**78** 1.8				**120** 1.8
Lateral	**25.3** 3.8	**41.1** 3.8				**76** 3.8		**140** 3.8				
Reducer	**4.5** .5	**7.8** .5				**13.9** .5		**20.4** .5				**32.1** .5
Cap	**2.1** 1	**2.8** 1				**11.3** 1		**16.3** 1				**32** 1

INSULATION

Temperature Range °F		100-199	200-299	300-399	400-499	500-599	600-699	700-799	800-899	900-999	1000-1099	1100-1200
85% Magnesia Calcium Silicate	Nom. Thick., In.	1½	1½	2	2	2½	3	3½	3½	4	4	4½
	Lbs/Ft	**4.13**	**4.13**	**5.64**	**5.64**	**7.85**	**9.48**	**11.5**	**11.5**	**13.8**	**13.8**	**16.0**
Combination	Nom. Thick., In.						3	3½	3½	4	4	4½
	Lbs/Ft						**12.9**	**16.2**	**16.2**	**20.4**	**20.4**	**23.8**
*Asbestos Fiber – Sodium Silicate	Nom. Thick., In.	1½	1½	1½	1½	1½	2½	2½	3½	3½	4½	4½
	Lbs/Ft	**5.38**	**5.38**	**5.38**	**5.38**	**5.38**	**10.60**	**10.60**	**15.85**	**15.85**	**20.85**	**20.85**

FLANGES / FLANGED FITTINGS

Pressure Rating psi	Cast Iron		Steel						
	125	250	150	300	400	600	900	1500	2500
Screwed or Slip-On	**29** 1.5	**60** 1.5	**33** 1.5	**67** 1.5	**82** 1.5	**135** 1.5	**207** 1.5	**319** 1.5	**601** 1.5
Welding Neck			**42** 1.5	**76** 1.5	**104** 1.5	**137** 1.5	**222** 1.5	**334** 1.5	**692** 1.5
Lap Joint			**33** 1.5	**67** 1.5	**79** 1.5	**132** 1.5	**223** 1.5	**347** 1.5	**587** 1.5
Blind	**43** 1.5	**79** 1.5	**48** 1.5	**90** 1.5	**115** 1.5	**159** 1.5	**232** 1.5	**363** 1.5	**649** 1.5
S.R. 90° Elbow	**113** 4.5	**194** 4.7	**157** 4.5	**238** 4.7	**310** 5	**435** 5.2	**639** 5.4	**995** 5.7	
L.R. 90° Elbow	**148** 5.3		**202** 5.3	**283** 5.3					
45° Elbow	**97** 3.9	**164** 4	**127** 3.9	**203** 4	**215** 4.1	**360** 4.4	**507** 4.5	**870** 4.8	
Tee	**168** 6.8	**289** 7.1	**230** 6.8	**337** 7.1	**445** 7.5	**610** 7.8	**978** 8.1	**1465** 8.6	

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* 16 lb. cu. ft. density.

10.750" O.D. **10"** PIPE

PIPE Schedule No.	5S	10S		20	30	40	60	80	100	120	140	160
Wall Designation						Std.	XS					
Thickness – In.	.134	.165	.219	.250	.307	.365	.500	.593	.718	.843	1.000	1.125
Pipe – Lbs/Ft	**15.15**	**18.70**	**24.63**	**28.04**	**34.24**	**40.5**	**54.7**	**64.3**	**76.9**	**89.2**	**104.1**	**115.7**
Water – Lbs/Ft	**37.4**	**36.9**	**36.2**	**35.77**	**34.98**	**34.1**	**32.3**	**31.1**	**29.5**	**28.0**	**26.1**	**24.6**
WELDING FITTINGS L.R. 90° Elbow	**29.2** 2.5	**36.0** 2.5				**84** 2.5	**112** 2.5					**230** 2.5
S.R. 90° Elbow	**20.3** 1.7	**24.9** 1.7				**62.2** 1.7	**74** 1.7					
L.R. 45° Elbow	**14.6** 1	**18.0** 1				**42.4** 1	**53.8** 1					**109** 1
Tee	**30.0** 2.1	**37.0** 2.1				**104** 2.1	**132** 2.1					**222** 2.1
Lateral	**47.5** 4.4	**70.0** 4.4				**124** 4.4	**200** 4.4					
Reducer	**8.1** .6	**14.0** .6				**23.2** .6	**31.4** .6					**58** .6
Cap	**3.8** 1.3	**4.7** 1.3				**20** 1.3	**26.3** 1.3					**59** 1.3

Temperature Range °F		100-199	200-299	300-399	400-499	500-599	600-699	700-799	800-899	900-999	1000-1099	1100-1200
INSULATION 85% Magnesia Calcium Silicate	Nom. Thick., In.	1½	1½	2	2½	2½	3	3½	3½	4	4	4½
	Lbs/Ft	**5.20**	**5.20**	**7.07**	**8.93**	**8.93**	**11.0**	**13.2**	**13.2**	**15.5**	**15.5**	**18.1**
Combination	Nom. Thick., In.						3	3½	3½	4	4	4½
	Lbs/Ft						**15.4**	**19.3**	**19.3**	**23**	**23**	**27.2**
*Asbestos Fiber—Sodium Silicate	Nom. Thick., In.	1½	1½	1½	1½	1½	2½	2½	3½	3½	4½	4½
	Lbs/Ft	**6.77**	**6.77**	**6.77**	**6.77**	**6.77**	**12.03**	**12.03**	**18.39**	**18.39**	**25.21**	**25.21**

Pressure Rating psi	Cast Iron		Steel						
	125	250	150	300	400	600	900	1500	2500
FLANGES Screwed or Slip-On	**45** 1.5	**93** 1.5	**50** 1.5	**100** 1.5	**117** 1.5	**213** 1.5	**293** 1.5	**528** 1.5	**1148** 1.5
Welding Neck			**59** 1.5	**110** 1.5	**152** 1.5	**225** 1.5	**316** 1.5	**546** 1.5	**1291** 1.5
Lap Joint			**50** 1.5	**110** 1.5	**138** 1.5	**231** 1.5	**325** 1.5	**577** 1.5	**1120** 1.5
Blind	**66** 1.5	**120** 1.5	**77** 1.5	**146** 1.5	**181** 1.5	**267** 1.5	**338** 1.5	**599** 1.5	**1248** 1.5
FLANGED FITTINGS S.R. 90° Elbow	**182** 4.8	**306** 4.9	**240** 4.8	**343** 4.9	**462** 5.2	**747** 5.6	**995** 5.8		
L.R. 90° Elbow	**237** 5.8		**290** 5.8	**438** 5.8					
45° Elbow	**152** 4.1	**256** 4.2	**185** 4.1	**288** 4.2	**332** 4.3	**572** 4.6	**732** 4.7		
Tee	**277** 7.2	**446** 7.4	**353** 7.2	**527** 7.4	**578** 7.8	**1007** 8.4	**1417** 8.7		

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* 16 lb. cu. ft. density.

12" PIPE 12.750" O.D.

PIPE	Schedule No.	5S	10S	20	30		40		60	80	120	140	160
	Wall Designation					Std.		XS					
	Thickness – In.	.156	.180	.250	.330	.375	.406	.500	.562	.687	1.000	1.125	1.312
	Pipe – Lbs/Ft	20.99	24.20	33.38	43.8	49.6	53.5	65.4	73.2	88.5	125.5	139.7	160.3
	Water – Lbs/Ft	52.7	52.2	51.10	49.7	49.0	48.5	47.0	46.0	44.0	39.3	37.5	34.9
WELDING FITTINGS	L.R. 90° Elbow	51.2 3	57.0 3			122 3		156 3					375 3
	S.R. 90° Elbow	33.6 2	38.1 2			82 2		104 2					
	L.R. 45° Elbow	25.5 1.3	29.0 1.3			60.3 1.3		78 1.3					182 1.3
	Tee	46.7 2.5	54.0 2.5			162 2.5		180 2.5					360 2.5
	Lateral	74.7 5.4	86.2 5.4			180 5.4		273 5.4					
	Reducer	14.1 .7	20.9 .7			33.4 .7		43.6 .7					94 .7
	Cap	6.2 1.5	7.1 1.5			29.5 1.5		38.1 1.5					95 1.5

Temperature Range °F			100-199	200-299	300-399	400-499	500-599	600-699	700-799	800-899	900-999	1000-1099	1100-1200
INSULATION	85% Magnesia Calcium Silicate	Nom. Thick., In.	1½	1½	2	2½	3	3	3½	4	4	4½	4½
		Lbs/Ft	6.04	6.04	8.13	10.5	12.7	12.7	15.1	17.9	17.9	20.4	20.4
	Combination	Nom. Thick., In.						3	3½	4	4	4½	4½
		Lbs/Ft						17.7	21.9	26.7	26.7	31.1	31.1
	*Asbestos Fiber – Sodium Silicate	Nom. Thick., In.	1½	1½	1½	1½	1½	2½	2½	4	4	5	5
		Lbs/Ft	7.47	7.47	7.47	7.47	7.47	14.20	14.20	24.64	24.64	32.40	32.40

	Pressure Rating psi	Cast Iron		Steel						
		125	250	150	300	400	600	900	1500	2500
FLANGES	Screwed or Slip-On	58 1.5	123 1.5	71 1.5	140 1.5	164 1.5	261 1.5	388 1.5	820 1.5	1611 1.5
	Welding Neck			87 1.5	163 1.5	212 1.5	272 1.5	434 1.5	843 1.5	1919 1.5
	Lap Joint			71 1.5	164 1.5	187 1.5	286 1.5	433 1.5	902 1.5	1573 1.5
	Blind	95 1.5	165 1.5	117 1.5	209 1.5	261 1.5	341 1.5	475 1.5	928 1.5	1775 1.5
FLANGED FITTINGS	S.R. 90° Elbow	257 5	430 5.2	345 5	509 5.2	669 5.5	815 5.8	1474 6.2		
	L.R. 90° Elbow	357 6.2		485 6.2	624 6.2			1598 6.2		
	45° Elbow	227 4.3	360 4.3	282 4.3	414 4.3	469 4.5	705 4.7	1124 4.8		
	Tee	387 7.5	640 7.8	513 7.5	754 7.8	943 8.3	1361 8.7	1928 9.3		

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To find the weight of covering on flanges or fittings, multiply the weight factor by the weight per foot of covering used on straight pipe.

All flanged fitting and flange weights include the proportional weight of bolts or studs to make up all joints.

* 16 lb. cu. ft. density.

14" O.D. **14"** PIPE

		5S	10S	10	20	30	40		60	80	120	140	160
PIPE	Schedule No.	5S	10S	10	20	30	40		60	80	120	140	160
	Wall Designation					Std.		XS					
	Thickness – In.	.156	.188	.250	.312	.375	.438	.500	.593	.750	1.093	1.250	1.406
	Pipe – Lbs/Ft	**23.0**	**27.7**	**36.71**	**45.7**	**54.6**	**63.4**	**72.1**	**84.9**	**106.1**	**150.7**	**170.2**	**189.1**
	Water – Lbs/Ft	**63.7**	**63.1**	**62.06**	**60.92**	**59.7**	**58.7**	**57.5**	**55.9**	**53.2**	**47.5**	**45.0**	**42.6**
WELDING FITTINGS	L.R. 90° Elbow	**65.6** 3.5	**78.0** 3.5			**157** 3.5		**200** 3.5					
	S.R. 90° Elbow	**43.1** 2.3	**51.7** 2.3			**108** 2.3		**135** 2.3					
	L.R. 45° Elbow	**32.5** 1.5	**39.4** 1.5			**80** 1.5		**98** 1.5					
	Tee	**49.4** 2.8	**59.6** 2.8			**196** 2.8		**220** 2.8					
	Lateral	**94.4** 5.8	**113** 5.8			**218** 5.8		**340** 5.8					
	Reducer	**25.0** 1.1	**31.2** 1.1			**63** 1.1		**83** 1.1					
	Cap	**7.6** 1.7	**9.2** 1.7			**35.3** 1.7		**45.9** 1.7					

INSULATION	Temperature Range °F		100-199	200-299	300-399	400-499	500-599	600-699	700-799	800-899	900-999	1000-1099	1100-1200
	85% Magnesia Calcium Silicate	Nom. Thick., In.	1½	1½	2	2½	3	3	3½	4	4	4½	4½
		Lbs/Ft	**6.16**	**6.16**	**8.38**	**10.7**	**13.1**	**13.1**	**15.8**	**18.5**	**18.5**	**21.3**	**21.3**
	Combination	Nom. Thick., In.						3	3½	4	4	4½	4½
		Lbs/Ft						**18.2**	**22.8**	**27.5**	**27.5**	**32.4**	**32.4**
	*Asbestos Fiber – Sodium Silicate	Nom. Thick., In.	1½	1½	1½	2	2	3	3	4	4	5	5
		Lbs/Ft	**7.90**	**7.90**	**7.90**	**11.18**	**11.18**	**18.00**	**18.00**	**25.42**	**25.42**	**33.53**	**33.53**

	Pressure Rating psi	Cast Iron		Steel						
		125	250	150	300	400	600	900	1500	2500
FLANGES	Screwed or Slip-On	**90** 1.5	**184** 1.5	**95** 1.5	**195** 1.5	**235** 1.5	**318** 1.5	**460** 1.5	**1016** 1.5	
	Welding Neck			**130** 1.5	**217** 1.5	**277** 1.5	**406** 1.5	**642** 1.5	**1241** 1.5	
	Lap Joint			**119** 1.5	**220** 1.5	**254** 1.5	**349** 1.5	**477** 1.5	**1076** 1.5	
	Blind	**125** 1.5	**239** 1.5	**141** 1.5	**267** 1.5	**354** 1.5	**437** 1.5	**574** 1.5		
FLANGED FITTINGS	S.R. 90° Elbow	**360** 5.3	**617** 5.5	**497** 5.3	**632** 5.5	**664** 5.7	**918** 5.9	**1549** 6.4		
	L.R. 90° Elbow	**480** 6.6	**767** 6.6	**622** 6.6	**772** 6.6					
	45° Elbow	**280** 4.3	**497** 4.4	**377** 4.3	**587** 4.4	**638** 4.6	**883** 4.8	**1246** 4.9		
	Tee	**540** 8	**956** 8.4	**683** 8	**968** 8.3	**1131** 8.6	**1652** 8.9	**2318** 9.6		

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Insulation weights include allowances for wire, cement, canvas, bands and paint, but not special surface finishes.

To find the weight of covering on flanges or fittings, multiply the weight factor by the weight per foot of covering used on straight pipe.

All flanged fitting and flange weights include the proportional weight of bolts or studs to make up all joints.

* 16 lb. cu. ft. density.

16" PIPE 16" O.D.

PIPE	Schedule No.	5S	10S	10	20	30	40	60	80	100	120	140	160
	Wall Designation					Std.	XS						
	Thickness—In.	.165	.188	.250	.312	.375	.500	.656	.843	1.031	1.218	1.438	1.593
	Pipe—Lbs/Ft	28.0	32.0	42.1	52.4	62.6	82.8	107.5	136.5	164.8	192.3	223.6	245.1
	Water—Lbs/Ft	83.5	83.0	81.8	80.5	79.1	76.5	73.4	69.7	66.1	62.6	58.6	55.9
WELDING FITTINGS	L.R. 90° Elbow	89.8 4	102.0 4			208 4	270 4						
	S.R. 90° Elbow	59.7 2.5	67.7 2.5			135 2.5	177 2.5						
	L.R. 45° Elbow	44.9 1.7	51.0 1.7			104 1.7	136 1.7						
	Tee	66.8 3.2	75.9 3.2			250 3.2	278 3.2						
	Lateral	127.0 6.7	144.0 6.7			275 6.7	431 6.7						
	Reducer	31.3 1.2	35.7 1.2			77 1.2	102 1.2						
	Cap	10.1 1.8	11.5 1.8			44.3 1.8	57 1.8						

INSULATION	Temperature Range °F	100-199	200-299	300-399	400-499	500-599	600-699	700-799	800-899	900-999	1000-1099	1100-1200
85% Magnesia Calcium Silicate	Nom. Thick., In.	1½	1½	2	2½	3	3	3½	4	4	4½	4½
	Lbs/Ft	6.90	6.90	9.33	12.0	14.6	14.6	17.5	20.5	20.5	23.6	23.6
Combination	Nom. Thick., In.						3	3½	4	4	4½	4½
	Lbs/Ft						20.3	25.2	30.7	30.7	36.0	36.0
*Asbestos Fiber—Sodium Silicate	Nom. Thick., In.	1½	1½	1½	1½	1½	2½	2½	3½	3½	4½	4½
	Lbs/Ft	9.26	9.26	9.26	9.26	9.26	16.35	16.35	24.11	24.11	32.57	32.57

	Pressure Rating psi	Cast Iron		Steel						
		125	250	150	300	400	600	900	1500	2500
FLANGES	Screwed or Slip-On	114 1.5	233 1.5	107 1.5	262 1.5	310 1.5	442 1.5	559 1.5	1297 1.5	
	Welding Neck			141 1.5	288 1.5	351 1.5	577 1.5	785 1.5	1597 1.5	
	Lap Joint			142 1.5	282 1.5	337 1.5	476 1.5	588 1.5	1372 1.5	
	Blind	174 1.5	308 1.5	184 1.5	349 1.5	455 1.5	603 1.5	719 1.5		
FLANGED FITTINGS	S.R. 90° Elbow	484 5.5	826 5.8	656 5.5	958 5.8	1014 6	1402 6.3	1886 6.7		
	L.R. 90° Elbow	684 7	1036 7	781 7	1058 7					
	45° Elbow	374 4.3	696 4.6	481 4.3	708 4.6	839 4.7	1212 5	1586 5		
	Tee	714 8.3	1263 8.7	961 8.3	1404 8.6	1671 9	2128 9.4	3054 10		

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18" O.D. **18"** PIPE

PIPE

	5S	10S	10	20		30		40	60	80	120	160
Schedule No.	5S	10S	10	20		30		40	60	80	120	160
Wall Designation					Std.		XS					
Thickness—In.	.165	.188	.250	.312	.375	.438	.500	.562	.750	.937	1.375	1.781
Pipe—Lbs/Ft	**31.0**	**36.0**	**47.4**	**59.0**	**70.6**	**82.1**	**93.5**	**104.8**	**138.2**	**170.8**	**244.1**	**308.5**
Water—Lbs/Ft	**106.2**	**105.7**	**104.3**	**102.8**	**101.2**	**99.9**	**98.4**	**97**	**92.7**	**88.5**	**79.2**	**71.0**

WELDING FITTINGS

	5S	10S	10	20	Std.	30	XS	40	60	80	120	160
L.R. 90° Elbow	**114.0** 4.5	**129.0** 4.5			**256** 4.5		**332** 4.5					
S.R. 90° Elbow	**75.7** 2.8	**85.7** 2.8			**176** 2.8		**225** 2.8					
L.R. 45° Elbow	**57.2** 1.9	**64.5** 1.9			**132** 1.9		**168** 1.9					
Tee	**83.2** 3.6	**94.7** 3.6			**282** 3.6		**351** 3.6					
Lateral	**157.0** 7.5	**179.0** 7.5			**326** 7.5		**525** 7.5					
Reducer	**42.6** 1.3	**48.5** 1.3			**94** 1.3		**123** 1.3					
Cap	**12.7** 2.1	**14.5** 2.1			**57** 2.1		**75** 2.1					

INSULATION

		100-199	200-299	300-399	400-499	500-599	600-699	700-799	800-899	900-999	1000-1099	1100-1200
Temperature Range °F		100-199	200-299	300-399	400-499	500-599	600-699	700-799	800-899	900-999	1000-1099	1100-1200
85% Magnesia Calcium Silicate	Nom. Thick., In.	1½	1½	2	2½	3	3	3½	4	4	4½	4½
	Lbs/Ft	**7.73**	**7.73**	**10.4**	**13.3**	**16.3**	**16.3**	**19.3**	**22.6**	**22.6**	**25.9**	**25.9**
Combination	Nom. Thick., In.						3	3½	4	4	4½	4½
	Lbs/Ft						**22.7**	**28.0**	**33.8**	**33.8**	**39.5**	**39.5**
*Asbestos Fiber—Sodium Silicate	Nom. Thick., In.	1½	1½	1½	2	2	3	3	4	4	5	5
	Lbs/Ft	**9.93**	**9.93**	**9.93**	**13.72**	**13.72**	**21.84**	**21.84**	**31.22**	**31.22**	**40.77**	**40.77**

FLANGES / FLANGED FITTINGS

Pressure Rating psi	Cast Iron 125	Cast Iron 250	Steel 150	Steel 300	Steel 400	Steel 600	Steel 900	Steel 1500	Steel 2500
Screwed or Slip-On	**125** 1.5		**139** 1.5	**331** 1.5	**380** 1.5	**573** 1.5	**797** 1.5	**1694** 1.5	
Welding Neck			**159** 1.5	**355** 1.5	**430** 1.5	**652** 1.5	**1074** 1.5	**2069** 1.5	
Lap Joint			**165** 1.5	**355** 1.5	**415** 1.5	**566** 1.5	**820** 1.5	**1769** 1.5	
Blind	**209** 1.5	**396** 1.5	**228** 1.5	**440** 1.5	**572** 1.5	**762** 1.5	**1030** 1.5		
S.R. 90° Elbow	**599** 5.8	**1060** 6	**711** 5.8	**1126** 6	**1340** 6.2	**1793** 6.6	**2817** 7		
L.R. 90° Elbow		**1350** 7.4	**941** 7.4	**1426** 7.4					
45° Elbow	**439** 4.4	**870** 4.7	**521** 4.4	**901** 4.7	**1040** 4.8	**1543** 5	**2252** 5.2		
Tee	**879** 8.6	**1625** 9	**1010** 8.6	**1602** 9	**1909** 9.3	**2690** 9.9	**4327** 10.5		

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* 16 lb. cu. ft. density.

20" PIPE 20" O.D.

		5S	10S	10	20	30	40	60	80	100	120	140	160
PIPE	Schedule No.	5S	10S	10	20	30	40	60	80	100	120	140	160
	Wall Designation				Std.	XS							
	Thickness – In.	.188	.218	.250	.375	.500	.593	.812	1.031	1.281	1.500	1.750	1.968
	Pipe – Lbs/Ft	**40.0**	**46.0**	**52.7**	**78.6**	**104.1**	**122.9**	**166.4**	**208.9**	**256.1**	**296.4**	**341.1**	**379.0**
	Water – Lbs/Ft	**131.0**	**130.2**	**129.5**	**126.0**	**122.8**	**120.4**	**115.0**	**109.4**	**103.4**	**98.3**	**92.6**	**87.9**
WELDING FITTINGS	L.R. 90° Elbow	**160.0** 5	**185.0** 5		**322** 5	**438** 5							
	S.R. 90° Elbow	**106.0** 3.4	**122.0** 3.4		**238** 3.4	**278** 3.4							
	L.R. 45° Elbow	**80.3** 2.1	**92.5** 2.1		**160** 2.1	**228** 2.1							
	Tee	**112.0** 4	**130.0** 4		**378** 4	**490** 4							
	Lateral	**228.0** 8.3	**265.0** 8.3		**396** 8.3	**625** 8.3							
	Reducer	**71.6** 1.7	**87.6** 1.7		**142** 1.7	**186** 1.7							
	Cap	**17.7** 2.3	**20.5** 2.3		**71** 2.3	**93** 2.3							

INSULATION	Temperature Range °F		100-199	200-299	300-399	400-499	500-599	600-699	700-799	800-899	900-999	1000-1099	1100-1200
	85% Magnesia Calcium Silicate	Nom. Thick., In.	1½	1½	2	2½	3	3	3½	4	4	4½	4½
		Lbs/Ft	**8.45**	**8.45**	**11.6**	**14.6**	**17.7**	**17.7**	**21.1**	**24.6**	**24.6**	**28.1**	**28.1**
	Combination	Nom. Thick., In.						3	3½	4	4	4½	4½
		Lbs/Ft						**24.7**	**30.7**	**37.0**	**37.0**	**43.1**	**43.1**
	*Asbestos Fiber – Sodium Silicate	Nom. Thick., In.	1½	1½	1½	2	2	3	3	4	4	5	5
		Lbs/Ft	**10.96**	**10.96**	**10.96**	**14.86**	**14.86**	**24.24**	**24.24**	**33.79**	**33.79**	**44.03**	**44.03**

	Pressure Rating psi	Cast Iron		Steel						
		125	250	150	300	400	600	900	1500	2500
FLANGES	Screwed or Slip-On	**153** 1.5		**180** 1.5	**378** 1.5	**468** 1.5	**733** 1.5	**972** 1.5	**2114** 1.5	
	Welding Neck			**195** 1.5	**431** 1.5	**535** 1.5	**811** 1.5	**1344** 1.5	**2614** 1.5	
	Lap Joint			**210** 1.5	**428** 1.5	**510** 1.5	**725** 1.5	**1048** 1.5	**2189** 1.5	
	Blind	**275** 1.5	**487** 1.5	**297** 1,5	**545** 1.5	**711** 1.5	**976** 1.5	**1287** 1.5		
FLANGED FITTINGS	S.R. 90° Elbow	**792** 6	**1315** 6.3	**922** 6	**1375** 6.3	**1680** 6.5	**2314** 6.9	**3610** 7.3		
	L.R. 90° Elbow	**1132** 7.8	**1725** 7.8	**1352** 7.8	**1705** 7.8					
	45° Elbow	**592** 4.6	**1055** 4.8	**652** 4.6	**1105** 4.8	**1330** 4.9	**1917** 5.2	**2848** 5.4		
	Tee	**1178** 9	**2022** 9.5	**1378** 9	**1908** 9.5	**2370** 9.7	**3463** 10.1	**5520** 11		

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* 16 lb. cu. ft. density.

22" O.D. 22" PIPE

PIPE	Schedule No.	5S	10S	10	20	30			60	80	120		
	Wall Designation				Std.	XS							
	Thickness – In.	.188	.218	.250	.375	.500	.625	.750	.875	1.125	1.625	1.875	2.125
	Pipe – Lbs/Ft	**44.0**	**51.0**	**58.0**	**87.0**	**115.0**	**143.0**	**170.0**	**197.0**	**251.0**	**354.0**	**403.0**	**451.0**
	Water – Lbs/Ft	**159.1**	**158.2**	**157.4**	**153.7**	**150.2**	**146.6**	**143.1**	**139.6**	**132.8**	**119.6**	**113.3**	**107.2**
WELDING FITTINGS	L.R. 90° Elbow				**385** 5.5	**508** 5.5							
	S.R. 90° Elbow				**256** 3.6	**338** 3.6							
	L.R. 45° Elbow				**192** 2.4	**253** 2.4							
	Tee				**437** 4.6	**548** 4.6							
	Lateral												
	Reducer				**310** 1.7	**410** 1.7							
	Cap				**86** 2.6	**115** 2.6							

	Temperature Range °F	100-199	200-299	300-399	400-499	500-599	600-699	700-799	800-899	900-999	1000-1099	1100-1200
INSULATION: 85% Magnesia Calcium Silicate	Nom. Thick., In.	1½	1½	2	2½	3	3	3½	4	4	4½	4½
	Lbs/Ft	**9.3**	**9.3**	**12.4**	**15.8**	**19.4**	**19.4**	**23.0**	**26.7**	**26.7**	**30.6**	**30.6**
Combination	Nom. Thick., In.						3	3½	4	4	4½	4½
	Lbs/Ft						**27.0**	**33.4**	**40.1**	**40.1**	**46.9**	**46.9**
*Asbestos Fiber—Sodium Silicate	Nom. Thick., In.	1½	1½	1½	2	2	3	3	4½	4½	5	5
	Lbs/Ft	**12.5**	**12.5**	**12.5**	**17.1**	**17.1**	**26.3**	**26.3**	**41.9**	**41.9**	**47.5**	**47.5**

	Pressure Rating psi	Cast Iron		Steel						
		125	250	150	300	400	600	900	1500	2500
FLANGES	Screwed or Slip-On			**192** 1.5	**507** 1.5					
	Welding Neck			**257** 1.5	**503** 1.5					
	Lap Joint			**278** 1.5	**509** 1.5					
	Blind			**366** 1.5	**668** 1.5					
FLANGED FITTINGS	S.R. 90° Elbow									
	L.R. 90° Elbow									
	45° Elbow									
	Tee									

Boldface type is weight in pounds. Lightface type beneath weight is weight factor for insulation.

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Insulation weights include allowances for wire, cement, canvas, bands and paint, but not special surface finishes.

To find the weight of covering on flanges or fittings, multiply the weight factor by the weight per foot of covering used on straight pipe.

All flanged fitting and flange weights include the proportional weight of bolts or studs to make up all joints.

* 16 lb. cu. ft. density.

24" PIPE 24" O.D.

PIPE	Schedule No.	5S	10	20		30	40	60	80	120	140	160
	Wall Designation			Std.	XS							
	Thickness – In.	.218	.250	.375	.500	.562	.687	.968	1.218	1.812	2.062	2.343
	Pipe – Lbs/Ft	**55.0**	**63.4**	**94.6**	**125.5**	**140.8**	**171.2**	**238.1**	**296.4**	**429.4**	**483.1**	**541.9**
	Water – Lbs/Ft	**188.9**	**188.0**	**183.8**	**180.1**	**178.1**	**174.3**	**165.8**	**158.3**	**141.4**	**134.5**	**127.0**
WELDING FITTINGS	L.R. 90° Elbow	**260.0** 6		**500** 6	**578** 6							
	S.R. 90° Elbow	**178.0** 3.7		**305** 3.7	**404** 3.7							
	L.R. 45° Elbow	**130.0** 2.5		**252** 2.5	**292** 2.5							
	Tee	**174.0** 4.9		**544** 4.9	**607** 4.9							
	Lateral	**361.0** 10		**544** 10	**875** 10							
	Reducer	**107.0** 1.7		**167** 1.7	**220** 1.7							
	Cap	**28.6** 2.8		**102** 2.8	**134** 2.8							

	Temperature Range °F	100-199	200-299	300-399	400-499	500-599	600-699	700-799	800-899	900-999	1000-1099	1100-1200
INSULATION: 85% Magnesia Calcium Silicate	Nom. Thick., In.	1½	1½	2	2½	3	3	3½	4	4	4½	4½
	Lbs/Ft	**10.0**	**10.0**	**13.4**	**17.0**	**21.0**	**21.0**	**24.8**	**28.7**	**28.7**	**32.9**	**32.9**
Combination	Nom. Thick., In.						3	3½	4	4	4½	4½
	Lbs/Ft						**29.2**	**36.0**	**43.1**	**43.1**	**50.6**	**50.6**
*Asbestos Fiber – Sodium Silicate	Nom. Thick., In.	1½	1½	1½	2	2	3	3	4½	4½	5	5
	Lbs/Ft	**13.55**	**13.55**	**13.55**	**18.44**	**18.44**	**28.38**	**28.38**	**45.06**	**45.06**	**50.97**	**50.97**

	Pressure Rating psi	Cast Iron 125	Cast Iron 250	Steel 150	Steel 300	Steel 400	Steel 600	Steel 900	Steel 1500	Steel 2500
FLANGES	Screwed or Slip-On	**236** 1.5		**245** 1.5	**577** 1.5	**676** 1.5	**1056** 1.5	**1823** 1.5	**3378** 1.5	
	Welding Neck			**295** 1.5	**632** 1.5	**777** 1.5	**1157** 1.5	**2450** 1.5	**4153** 1.5	
	Lap Joint			**295** 1.5	**617** 1.5	**752** 1.5	**1046** 1.5	**2002** 1.5	**3478** 1.5	
	Blind	**404** 1.5	**757** 1.5	**446** 1.5	**841** 1.5	**1073** 1.5	**1355** 1.5	**2442** 1.5		
FLANGED FITTINGS	S.R. 90° Elbow	**1231** 6.7	**2014** 6.8	**1671** 6.7	**2174** 6.8	**2474** 7.1	**3506** 7.6	**6155** 8.1		
	L.R. 90° Elbow	**1711** 8.7	**2644** 8.7	**1821** 8.7	**2874** 8.7					
	45° Elbow	**871** 4.8	**1604** 5	**1121** 4.8	**1634** 5	**1974** 5.1	**2831** 5.5	**5124** 6		
	Tee	**1836** 10	**3061** 10.2	**2276** 10	**3161** 10.2	**3811** 10.6	**5184** 11.4	**9387** 12.1		

Boldface type is weight in pounds. Lightface type beneath weight is weight factor for insulation.

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Insulation weights include allowances for wire, cement, canvas, bands and paint, but not special surface finishes.

To find the weight of covering on flanges or fittings, multiply the weight factor by the weight per foot of covering used on straight pipe.

All flanged fitting and flange weights include the proportional weight of bolts or studs to make up all joints.

* 16 lb. cu. ft. density.

26" O.D. **26" PIPE**

PIPE

Schedule No.		10		20								
Wall Designation			Std.	XS								
Thickness—In.	.250	.312	.375	.500	.625	.750	.875	1.000	1.125			
Pipe—Lbs/Ft	**67.0**	**85.7**	**102.6**	**136.2**	**169.0**	**202.0**	**235.0**	**267.0**	**299.0**			
Water—Lbs/Ft	**221.4**	**219.2**	**216.8**	**212.5**	**208.6**	**204.4**	**200.2**	**196.1**	**192.1**			

WELDING FITTINGS

L.R. 90° Elbow			**602** 8.5	**713** 8.5								
S.R. 90° Elbow			**359** 5	**474** 5								
L.R. 45° Elbow			**269** 3.5	**355** 3.5								
Tee			**634** 6.8	**794** 6.8								
Lateral												
Reducer			**200** 2.5	**272** 2.5								
Cap			**110** 4.3	**145** 4.3								

INSULATION

	Temperature Range °F	100-199	200-299	300-399	400-499	500-599	600-699	700-799	800-899	900-999	1000-1099	1100-1200
85% Magnesia Calcium Silicate	Nom. Thick., In.	1½	1½	2	2½	3	3½	4	4½	5	5	6
	Lbs/Ft	**10.4**	**10.4**	**14.1**	**18.0**	**21.9**	**26.0**	**30.2**	**34.6**	**39.1**	**39.1**	**48.4**
Combination	Nom. Thick., In.						3½	4½	5½	6	6½	7
	Lbs/Ft						**37.0**	**51.9**	**67.8**	**76.0**	**84.5**	**93.2**
*Asbestos Fiber—Sodium Silicate	Nom. Thick., In.	2	2	2	2	2	3	3	4½	4½	5	5
	Lbs/Ft	**18.93**	**18.93**	**18.93**	**18.93**	**18.93**	**29.87**	**29.87**	**47.60**	**47.60**	**53.85**	**53.85**

FLANGES / **FLANGED FITTINGS**

Pressure Rating psi	Cast Iron 125	Cast Iron 250	Steel 150	Steel 300	Steel 400	Steel 600	Steel 900	Steel 1500	Steel 2500
Screwed or Slip-On			**292** 1.5	**699** 1.5	**650** 1.5	**950** 1.5	**1525** 1.5		
Welding Neck			**342** 1.5	**799** 1.5	**750** 1.5	**1025** 1.5	**1575** 1.5		
Lap Joint									
Blind			**567** 1.5	**1179** 1.5	**1125** 1.5	**1525** 1.5	**2200** 1.5		
S.R. 90° Elbow									
L.R. 90° Elbow									
45° Elbow									
Tee									

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Insulation weights include allowances for wire, cement, canvas, bands and paint, but not special surface finishes.

To find the weight of covering on flanges or fittings, multiply the weight factor by the weight per foot of covering used on straight pipe.

All flanged fitting and flange weights include the proportional weight of bolts or studs to make up all joints.

* 16 lb. cu. ft. density.

28" PIPE 28" O.D.

PIPE	Schedule No.		10		20	30						
	Wall Designation			Std.	XS							
	Thickness—In.	.250	.312	.375	.500	.625	.750	.875	1.000	1.125		
	Pipe—Lbs/Ft	**74.0**	**92.4**	**110.6**	**146.9**	**182.7**	**218.0**	**253.0**	**288.0**	**323.0**		
	Water—Lbs/Ft	**257.3**	**255.0**	**252.7**	**248.1**	**243.6**	**238.9**	**234.4**	**230.0**	**225.6**		
WELDING FITTINGS	L.R. 90° Elbow			**626** 9	**829** 9							
	S.R. 90° Elbow			**415** 5.4	**551** 5.4							
	L.R. 45° Elbow			**312** 3.6	**413** 3.6							
	Tee			**729** 7	**910** 7							
	Lateral											
	Reducer			**210** 2.7	**290** 2.7							
	Cap			**120** 4.5	**160** 4.5							

INSULATION		Temperature Range °F	100-199	200-299	300-399	400-499	500-599	600-699	700-799	800-899	900-999	1000-1099	1100-1200
	85% Magnesia Calcium Silicate	Nom. Thick., In.	1½	1½	2	2½	3	3½	4	4½	5	5	6
		Lbs/Ft	**11.2**	**11.2**	**15.1**	**19.2**	**23.4**	**27.8**	**32.3**	**36.9**	**41.6**	**41.6**	**51.4**
	Combination	Nom. Thick., In.						3½	4½	5½	6	6½	7
		Lbs/Ft						**39.5**	**55.4**	**72.2**	**80.9**	**89.8**	**99.0**
	*Asbestos Fiber—Sodium Silicate	Nom. Thick., In.	2	2	2	2	2	3	3	4½	4½	5	5
		Lbs/Ft	**20.26**	**20.26**	**20.26**	**20.26**	**20.26**	**31.90**	**31.90**	**52.51**	**52.51**	**59.17**	**59.17**

	Pressure Rating psi	Cast Iron		Steel						
		125	250	150	300	400	600	900	1500	2500
FLANGES	Screwed or Slip-On			**334** 1.5	**853** 1.5	**780** 1.5	**1075** 1.5	**1800** 1.5		
	Welding Neck			**364** 1.5	**943** 1.5	**880** 1.5	**1175** 1.5	**1850** 1.5		
	Lap Joint									
	Blind			**669** 1.5	**1408** 1.5	**1425** 1.5	**1750** 1.5	**2575** 1.5		
FLANGED FITTINGS	S.R. 90° Elbow									
	L.R. 90° Elbow									
	45° Elbow									
	Tee									

* 16 lb. cu. ft. density.

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Insulation weights include allowances for wire, cement, canvas, bands and paint, but not special surface finishes.

To find the weight of covering on flanges or fittings, multiply the weight factor by the weight per foot of covering used on straight pipe.

All flanged fitting and flange weights include the proportional weight of bolts or studs to make up all joints.

30" O.D. **30"** PIPE

PIPE	Schedule No.	5S	10 & 10S		20	30							
	Wall Designation			Std.	XS								
	Thickness—In.	.250	.312	.375	.500	.625	.750	.875	1.000	1.125			
	Pipe—Lbs/Ft	**79.0**	**98.9**	**118.7**	**157.6**	**196.1**	**234.0**	**272.0**	**310.0**	**347.0**			
	Water—Lbs/Ft	**296.3**	**293.5**	**291.0**	**286.0**	**281.1**	**276.6**	**271.8**	**267.0**	**262.2**			
WELDING FITTINGS	L.R. 90° Elbow	**478.0** 10		**775** 10	**953** 10		**596.0** 10						
	S.R. 90° Elbow	**319.0** 5.9		**470** 5.9	**644** 5.9		**388.0** 5.9						
	L.R. 45° Elbow	**239.0** 3.9		**358** 3.9	**475** 3.9		**298.0** 3.9						
	Tee			**855** 7.8	**1065** 7.8								
	Lateral												
	Reducer			**220** 3.9	**315** 3.9								
	Cap			**125** 4.8	**175** 4.8								

Temperature Range °F		100-199	200-299	300-399	400-499	500-599	600-699	700-799	800-899	900-999	1000-1099	1100-1200
INSULATION: 85% Magnesia Calcium Silicate	Nom. Thick., In.	1½	1½	2	2½	3	3½	4	4½	5	5	6
	Lbs/Ft	**11.9**	**11.9**	**16.1**	**20.5**	**25.0**	**29.5**	**34.3**	**39.1**	**44.1**	**44.1**	**54.4**
Combination	Nom. Thick., In.						3½	4½	5½	6	6½	7
	Lbs/Ft						**42.1**	**58.9**	**76.5**	**85.7**	**95.1**	**104.7**
*Asbestos Fiber—Sodium Silicate	Nom. Thick., In.	2½	2½	2½	2½	2½	3	3	4½	4½	5	5
	Lbs/Ft	**27.17**	**27.17**	**27.17**	**27.17**	**27.17**	**33.43**	**33.43**	**55.18**	**55.18**	**62.18**	**62.18**

		Cast Iron		Steel						
	Pressure Rating psi	125	250	150	300	400	600	900	1500	2500
FLANGES	Screwed or Slip-On			**365** 1.5	**975** 1.5	**900** 1.5	**1175** 1.5	**2075** 1.5		
	Welding Neck			**410** 1.5	**1095** 1.5	**1000** 1.5	**1300** 1.5	**2150** 1.5		
	Lap Joint									
	Blind			**770** 1.5	**1665** 1.5	**1675** 1.5	**2000** 1.5	**3025** 1.5		

FLANGED FITTINGS	S.R. 90° Elbow									
	L.R. 90° Elbow									
	45° Elbow									
	Tee									

* 16 lb. cu. ft. density.

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All flanged fitting and flange weights include the proportional weight of bolts or studs to make up all joints.

32" PIPE 32" O.D.

PIPE	Schedule No.		10		20	30	40						
	Wall Designation			Std.	XS								
	Thickness — In.	.250	.312	.375	.500	.625	.688	.750	.875	1.000	1.125		
	Pipe — Lbs/Ft	85.0	105.8	126.7	168.2	209.4	229.9	250.0	291.0	331.0	371.0		
	Water — Lbs/Ft	337.8	335.0	332.3	327.0	321.8	319.2	316.7	311.6	306.4	301.3		
WELDING FITTINGS	L.R. 90° Elbow			**818** 10.5	**1090** 10.5								
	S.R. 90° Elbow			**546** 6.3	**722** 6.3								
	L.R. 45° Elbow			**408** 4.2	**541** 4.2								
	Tee			**991** 8.4	**1230** 8.4								
	Lateral												
	Reducer			**255** 3.1	**335** 3.1								
	Cap			**145** 5.2	**190** 5.2								

	Temperature Range °F	100-199	200-299	300-399	400-499	500-599	600-699	700-799	800-899	900-999	1000-1099	1100-1200
INSULATION: 85% Magnesia Calcium Silicate	Nom. Thick., In.	1½	1½	2	2½	3	3½	4	4½	5	5	6
	Lbs/Ft	12.7	12.7	17.1	21.7	26.5	31.3	36.3	41.4	46.6	46.6	57.5
Combination	Nom. Thick., In.						3½	4½	5½	6	6½	7
	Lbs/Ft						44.7	62.3	80.9	90.5	100.4	110.5
*Asbestos Fiber — Sodium Silicate	Nom. Thick., In.	3	3	3	3	3	3	3	4½	4½	5	5
	Lbs/Ft	41.50	41.50	41.50	41.50	41.50	41.50	41.50	57.27	57.27	64.49	64.49

	Pressure Rating psi	Cast Iron 125	Cast Iron 250	Steel 150	Steel 300	Steel 400	Steel 600	Steel 900	Steel 1500	Steel 2500
FLANGES	Screwed or Slip-On			**476** 1.5	**1093** 1.5	**1025** 1.5	**1375** 1.5	**2500** 1.5		
	Welding Neck			**516** 1.5	**1228** 1.5	**1150** 1.5	**1500** 1.5	**2575** 1.5		
	Lap Joint									
	Blind			**951** 1.5	**1978** 1.5	**1975** 1.5	**2300** 1.5	**3650** 1.5		
FLANGED FITTINGS	S.R. 90° Elbow									
	L.R. 90° Elbow									
	45° Elbow									
	Tee									

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* 16 lb. cu. ft. density.

34" O.D. **34"** PIPE

PIPE	Schedule No.		10		20	30	40						
	Wall Designation			Std.	XS								
	Thickness—In.	.250	.312	.375	.500	.625	.688	.750	.875	1.000	1.125		
	Pipe—Lbs/Ft	**90.0**	**112.4**	**134.7**	**178.9**	**222.8**	**244.6**	**266.0**	**310.0**	**353.0**	**395.0**		
	Water—Lbs/Ft	**382.0**	**379.1**	**376.0**	**370.3**	**365.0**	**362.2**	**359.5**	**354.1**	**348.6**	**343.2**		
WELDING FITTINGS	L.R. 90° Elbow			**926** 11	**1230** 11								
	S.R. 90° Elbow			**617** 5.5	**817** 5.5								
	L.R. 45° Elbow			**463** 4.4	**615** 4.4								
	Tee			**1136** 8.9	**1420** 8.9								
	Lateral												
	Reducer			**270** 3.3	**355** 3.3								
	Cap			**160** 5.6	**210** 5.6								

	Temperature Range °F	100-199	200-299	300-399	400-499	500-599	600-699	700-799	800-899	900-999	1000-1099	1100-1200
INSULATION: 85% Magnesia Calcium Silicate	Nom. Thick., In.	1½	1½	2	2½	3	3½	4	4½	5	5	6
	Lbs/Ft	**13.4**	**13.4**	**18.2**	**23.0**	**28.0**	**33.1**	**38.3**	**43.7**	**49.1**	**49.1**	**60.5**
Combination	Nom. Thick., In.						3½	4½	5½	6	6½	7
	Lbs/Ft						**47.2**	**65.8**	**85.3**	**95.4**	**105.7**	**116.3**
*Asbestos Fiber—Sodium Silicate	Nom. Thick., In.	3	3	3	3	3	3	3	4½	4½	5	5
	Lbs/Ft	**38.74**	**38.74**	**38.74**	**38.74**	**38.74**	**38.74**	**38.74**	**60.50**	**60.50**	**68.04**	**68.04**

		Cast Iron		Steel						
	Pressure Rating psi	125	250	150	300	400	600	900	1500	2500
FLANGES	Screwed or Slip-On			**515** 1.5	**1281** 1.5	**1150** 1.5	**1500** 1.5	**2950** 1.5		
	Welding Neck			**560** 1.5	**1406** 1.5	**1300** 1.5	**1650** 1.5	**3025** 1.5		
	Lap Joint									
	Blind			**1085** 1.5	**2231** .15	**2250** 1.5	**2575** 1.5	**4275** 1.5		
FLANGED FITTINGS	S.R. 90° Elbow									
	L.R. 90° Elbow									
	45° Elbow									
	Tee									

Boldface type is weight in pounds. Lightface type beneath weight is weight factor for insulation.

Insulation thicknesses and weights are based on average conditions and do not constitute a recommendation for specific thicknesses of materials. Insulation weights are based on 85% magnesia and hydrous calcium silicate at 11 lbs/cubic foot. The listed thicknesses and weights of combination covering are the sums of the inner layer of diatomaceous earth at 21 lbs/cubic foot and the outer layer at 11 lbs/cubic foot.

Insulation weights include allowances for wire, cement, canvas, bands and paint, but not special surface finishes.

To find the weight of covering on flanges or fittings, multiply the weight factor by the weight per foot of covering used on straight pipe.

All flanged fitting and flange weights include the proportional weight of bolts or studs to make up all joints.

* 16 lb. cu. ft. density.

36" PIPE 36" O.D.

PIPE	Schedule No.		10		20	30	40						
	Wall Designation			Std.	XS								
	Thickness – In.	.250	.312	.375	.500	.625	.750	.875	1.000	1.125			
	Pipe – Lbs/Ft	**96.0**	**119.1**	**142.7**	**189.6**	**236.1**	**282.4**	**328.0**	**374.0**	**419.0**			
	Water – Lbs/Ft	**429.1**	**425.9**	**422.6**	**416.6**	**411.0**	**405.1**	**399.4**	**393.6**	**387.9**			
WELDING FITTINGS	L.R. 90° Elbow			**1040** 12	**1380** 12								
	S.R. 90° Elbow			**692** 5	**913** 5								
	L.R. 45° Elbow			**518** 4.8	**686** 4.8								
	Tee			**1294** 9.5	**1610** 9.5								
	Lateral												
	Reducer			**340** 3.6	**360** 3.6								
	Cap			**175** 6	**235** 6								

	Temperature Range °F		100-199	200-299	300-399	400-499	500-599	600-699	700-799	800-899	900-999	1000-1099	1100-1200
INSULATION	85% Magnesia Calcium Silicate	Nom. Thick., In.	1½	1½	2	2½	3	3½	4	4½	5	5	6
		Lbs/Ft	**14.2**	**14.2**	**19.2**	**24.2**	**29.5**	**34.8**	**40.3**	**45.9**	**51.7**	**51.7**	**63.5**
	Combination	Nom. Thick., In.						3½	4½	5½	6	6½	7
		Lbs/Ft						**49.8**	**69.3**	**89.7**	**100.2**	**111.0**	**122.0**
	*Asbestos Fiber – Sodium Silicate	Nom. Thick., In.	3	3	3	3	3	3	3	4½	4½	5	5
		Lbs/Ft	**40.84**	**40.84**	**40.84**	**40.84**	**40.84**	**40.84**	**40.84**	**55.83**	**55.83**	**71.48**	**71.48**

	Pressure Rating psi	Cast Iron		Steel						
		125	250	150	300	400	600	900	1500	2500
FLANGES	Screwed or Slip-On			**588** 1.5	**1485** 1.5	**1325** 1.5	**1600** 1.5	**3350** 1.5		
	Welding Neck			**628** 1.5	**1585** 1.5	**1475** 1.5	**1750** 1.5	**3450** 1.5		
	Lap Joint									
	Blind			**1233** 1.5	**2560** 1.5	**2525** 1.5	**2950** 1.5	**4900** 1.5		
FLANGED FITTINGS	S.R. 90° Elbow									
	L.R. 90° Elbow									
	45° Elbow									
	Tee									

Boldface type is weight in pounds. Lightface type beneath weight is weight factor for insulation.

Insulation thicknesses and weights are based on average conditions and do not constitute a recommendation for specific thicknesses of materials. Insulation weights are based on 85% magnesia and hydrous calcium silicate at 11 lbs/cubic foot. The listed thicknesses and weights of combination covering are the sums of the inner layer of diatomaceous earth at 21 lbs/cubic foot and the outer layer at 11 lbs/cubic foot.

Insulation weights include allowances for wire, cement, canvas, bands and paint, but not special surface finishes.

To find the weight of covering on flanges or fittings, multiply the weight factor by the weight per foot of covering used on straight pipe.

All flanged fitting and flange weights include the proportional weight of bolts or studs to make up all joints.

* 16 lb. cu. ft. density.

42" O.D. **42"** PIPE

PIPE	Schedule No.			20	30	40							
	Wall Designation		Std.	XS									
	Thickness – In.	.250	.375	.500	.625	.750	1.000	1.250	1.500				
	Pipe – Lbs/Ft	**112.0**	**166.7**	**221.6**	**276.0**	**330.0**	**438.0**	**544.0**	**649.0**				
	Water – Lbs/Ft	**586.4**	**578.7**	**571.7**	**565.4**	**558.4**	**544.8**	**531.2**	**517.9**				
WELDING FITTINGS	L.R. 90° Elbow		**1420** 15	**1880** 15									
	S.R. 90° Elbow		**1079** 9	**1430** 9									
	L.R. 45° Elbow		**707** 6	**937** 6									
	Tee		**1870**	**2415**									
	Lateral												
	Reducer		**310** 4.5	**410** 4.5									
	Cap		**230** 7.5	**300** 7.5									

	Temperature Range °F	100-199	200-299	300-399	400-499	500-599	600-699	700-799	800-899	900-999	1000-1099	1100-1200
INSULATION: 85% Magnesia Calcium Silicate	Nom. Thick., In.	1½	1½	2	2½	3	3½	4	4½	5	5	6
	Lbs/Ft	**16.5**	**16.5**	**22.2**	**28.0**	**34.0**	**40.1**	**46.4**	**52.7**	**59.2**	**59.2**	**72.6**
Combination	Nom. Thick., In.						3½	4½	5½	6	6½	7
	Lbs/Ft						**57.4**	**79.7**	**102.8**	**114.8**	**126.9**	**139.3**
*Asbestos Fiber – Sodium Silicate	Nom. Thick., In.	3	3	3	3	3	3	3	4½	4½	5	5
	Lbs/Ft	**47.06**	**47.06**	**47.06**	**47.06**	**47.06**	**47.06**	**47.06**	**72.92**	**72.92**	**83.22**	**83.22**

	Pressure Rating psi	Cast Iron 125	Cast Iron 250	Steel 150	Steel 300	Steel 400	Steel 600	Steel 900	Steel 1500	Steel 2500
FLANGES	Screwed or Slip-On			**792** 1.5	**1895** 1.5	**1759** 1.5	**2320** 1.5			
	Welding Neck			**862** 1.5	**2024** 1.5	**1879** 1.5	**2414** 1.5			
	Lap Joint									
	Blind			**1733** 1.5	**3449** 1.5	**3576** 1.5	**4419** 1.5			
FLANGED FITTINGS	S.R. 90° Elbow									
	L.R. 90° Elbow									
	45° Elbow									
	Tee									

* 16 lb. cu. ft. density.

Boldface type is weight in pounds. Lightface type beneath weight is weight factor for insulation.

Insulation thicknesses and weights are based on average conditions and do not constitute a recommendation for specific thicknesses of materials. Insulation weights are based on 85% magnesia and hydrous calcium silicate at 11 lbs/cubic foot. The listed thicknesses and weights of combination covering are the sums of the inner layer of diatomaceous earth at 21 lbs/cubic foot and the outer layer at 11 lbs/cubic foot.

Insulation weights include allowances for wire, cement, canvas, bands and paint, but not special surface finishes.

To find the weight of covering on flanges or fittings, multiply the weight factor by the weight per foot of covering used on straight pipe.

All flanged fitting and flange weights include the proportional weight of bolts or studs to make up all joints.

CHARTS AND TABLES

INSULATION WEIGHT FACTORS

To determine the weight per foot of any piping insulation, use the pipe size and nominal insulation thickness to find the insulation weight factor F in the chart shown below. Then multiply F by the density of the insulation in pounds per cubic foot.

Example. For 4" pipe with 4" nominal thickness insulation, F = .77. If the insulation density is 12 pounds per cubic foot, then the insulation weight is .77 × 12 = 9.24 lb/ft.

Nominal Pipe Size	Nominal Insulation Thickness										
	1"	1½"	2"	2½"	3"	3½"	4"	4½"	5"	5½"	6"
1	.055	.10	.16	.23	.31	.40					
1¼	.048	.12	.15	.22	.30	.39					
1½	.063	.11	.21	.29	.38	.48					
2	.080	.14	.21	.29	.37	.47	.59				
2½	.091	.19	.27	.36	.46	.58	.70	.83			
3	.10	.17	.25	.34	.44	.56	.68	.81			
3½	.14	.23	.31	.41	.54	.66	.78	—	.97		
4	.13	.21	.30	.39	.51	.63	.77	.96	1.10		
5	.15	.24	.34	.45	.58	.71	.88	1.04	1.20		
6	.17	.27	.38	.51	.64	.83	.97	1.13	1.34		
8	—	.34	.47	.66	.80	.97	1.17	1.36	1.56	1.75	
10	—	.43	.59	.75	.93	1.12	1.32	1.54	1.76	1.99	
12	—	.50	.68	.88	1.07	1.28	1.52	1.74	1.99	2.24	2.50
14	—	.51	.70	.90	1.11	1.34	1.57	1.81	2.07	2.34	2.62
16	—	.57	.78	1.01	1.24	1.49	1.74	2.01	2.29	2.58	2.88
18	—	.64	.87	1.12	1.37	1.64	1.92	2.21	2.51	2.82	3.14
20	—	.70	.96	1.23	1.50	1.79	2.09	2.40	2.73	3.06	3.40
24	—	.83	1.13	1.44	1.77	2.10	2.44	2.80	3.16	3.54	3.92

For Pipe sizes and insulation thickness not shown in above chart, use formula on page 23.

LOAD CARRYING CAPACITIES OF THREADED HOT ROLLED STEEL ROD CONFORMING TO ASTM A-36

Nominal Rod Diameter, in.	⅜	½	⅝	¾	⅞	1	1⅛	1¼	1½	1¾	2	2¼
Root Area of Thread, sq. in.	.068	.126	.202	.302	.419	.552	.693	.889	1.293	1.744	2.300	3.023
Max. Safe Load, lbs. at Rod Temp. of 650°F	610	1130	1810	2710	3770	4960	6230	8000	11630	15700	20700	27200

Nominal Rod Diameter, in.	2½	2¾	3	3¼	3½	3¾	4	4¼	4½	4¾	5
Root Area of Thread, sq. in.	3.719	4.619	5.621	6.720	7.918	9.214	10.608	12.100	13.700	15.400	17.200
Max. Safe Load, lbs. at Rod Temp. of 650°F	33500	41580	50580	60480	71280	82890	95400	109000	123000	138000	154000

WEIGHT PER FOOT OF SOLID STEEL ROUNDS

Weights shown are for solid rounds per foot of length. To determine the weight of tubing per foot of length, subtract the weight per foot of the I.D. from the weight per foot of the O.D. All weights are based on steel weighing 0.2833 pounds per cubic inch.

Diam., inches	Weight, pounds	Diam., inches	Weight, pounds	Diam., inches	Weight, pounds	Diam., inches	Weight, pounds	Diam., inches	Weight, pounds	Diam., inches	Weight, pounds	Diam., inches	Weight, pounds	Diam., inches	Weight, pounds
0	...	2 1/2	16.688	6	96.120	9 1/2	240.97	14	523.33	21	1177.5	28	2093.3	35	3270.8
1/32	0.00262	9/16	17.532	1/16	98.136	9/16	244.15	1/8	532.72	1/8	1191.6	1/8	2112.0	1/8	3294.2
1/16	0.01044	5/8	18.398	1/8	100.17	5/8	247.35	1/4	542.17	1/4	1205.7	1/4	2130.9	1/4	3317.7
3/32	0.02346	11/16	19.285	3/16	102.22	11/16	250.58	3/8	551.76	3/8	1219.9	3/8	2149.8	3/8	3341.3
1/8	0.04171	3/4	20.192	1/4	104.30	3/4	253.82	1/2	561.38	1/2	1234.2	1/2	2168.7	1/2	3364.9
5/32	0.06517	13/16	21.120	5/16	106.39	13/16	257.08	5/8	571.10	5/8	1248.6	5/8	2187.8	5/8	3388.7
3/16	0.09386	7/8	22.070	3/8	108.51	7/8	260.37	3/4	580.89	3/4	1263.1	3/4	2207.0	3/4	3412.5
7/32	0.1278	15/16	23.039	7/16	110.65	15/16	263.68	7/8	590.78	7/8	1277.7	7/8	2226.2	7/8	3436.3
1/4	0.1669	3	24.030	1/2	112.81	10	267.00	15	600.74	22	1292.3	29	2245.5	36	3460.5
9/32	0.2112	1/16	25.042	9/16	114.99	1/16	270.35	1/8	610.81	1/8	1307.0	1/8	2264.9	1/8	3484.6
5/16	0.2607	1/8	26.074	5/8	117.19	1/8	273.72	1/4	620.94	1/4	1321.8	1/4	2284.4	1/4	3508.7
11/32	0.3155	3/16	27.118	11/16	119.41	3/16	277.11	3/8	631.17	3/8	1336.7	3/8	2303.9	3/8	3532.9
3/8	0.3755	1/4	28.202	3/4	121.17	1/4	280.52	1/2	641.47	1/2	1351.7	1/2	2323.6	1/2	3557.0
13/32	0.4407	5/16	29.297	13/16	123.92	5/16	283.95	5/8	651.87	5/8	1366.8	5/8	2343.3	5/8	3581.5
7/16	0.5111	3/8	30.414	7/8	126.20	3/8	287.41	3/4	662.34	3/4	1381.9	3/4	2363.2	3/4	3606.0
15/32	0.5867	7/16	31.550	15/16	128.50	7/16	290.88	7/8	672.88	7/8	1397.1	7/8	2383.1	7/8	3630.8
1/2	0.6675	1/2	32.708	7	130.83	1/2	294.37	16	683.52	23	1412.5	30	2403.0	37	3655.2
17/32	0.7536	9/16	33.887	1/16	133.18	9/16	297.89	1/8	694.27	1/8	1427.8	1/8	2423.1	1/8	3680.1
9/16	0.8448	5/8	35.087	1/8	135.55	5/8	301.42	1/4	705.04	1/4	1443.3	1/4	2443.3	1/4	3704.9
19/32	0.9413	11/16	36.308	3/16	137.94	11/16	304.98	3/8	715.96	3/8	1458.9	3/8	2463.5	3/8	3729.7
5/8	1.0430	3/4	37.549	1/4	140.34	3/4	308.56	1/2	726.00	1/2	1474.5	1/2	2483.8	1/2	3754.9
21/32	1.1499	13/16	38.810	5/16	142.77	13/16	312.15	5/8	737.99	5/8	1490.2	5/8	2504.2	5/8	3779.7
11/16	1.2620	7/8	40.091	3/8	145.22	7/8	315.78	3/4	749.10	3/4	1506.1	3/4	2524.7	3/4	3804.8
23/32	1.3794	15/16	41.397	7/16	147.70	15/16	319.41	7/8	760.32	7/8	1522.0	7/8	2545.2	7/8	3830.3
3/4	1.5019	4	42.719	1/2	150.19	11	323.07	17	771.64	24	1537.9	31	2565.9	38	3855.5
25/32	1.6297	1/16	44.066	9/16	152.70	1/16	326.75	1/8	783.03	1/8	1554.0	1/8	2586.7	1/8	3881.0
13/16	1.7627	1/8	45.432	5/8	155.24	1/8	330.46	1/4	794.52	1/4	1570.1	1/4	2607.5	1/4	3906.5
27/32	1.9009	3/16	46.819	11/16	157.79	3/16	334.18	3/8	806.05	3/8	1586.4	3/8	2628.4	3/8	3932.0
7/8	2.0442	1/4	48.227	3/4	160.37	1/4	337.92	1/2	817.71	1/2	1602.7	1/2	2649.3	1/2	3957.8
29/32	2.1929	5/16	49.658	13/16	162.97	5/16	341.69	5/8	829.43	5/8	1619.1	5/8	2670.4	5/8	3983.3
15/16	2.3467	3/8	51.106	7/8	165.58	3/8	345.47	3/4	841.23	3/4	1635.6	3/4	2691.6	3/4	4009.1
31/32	2.5058	7/16	52.578	15/16	168.22	7/16	349.29	7/8	853.13	7/8	1652.1	7/8	2712.8	7/8	4035.0
1	2.6700	1/2	54.067	8	170.88	1/2	353.12	18	865.10	25	1668.8	32	2734.1	39	4061.2
1/16	3.0142	9/16	55.580	1/16	173.56	9/16	356.96	1/8	877.16	1/8	1685.5	1/8	2755.5	1/8	4087.3
1/8	3.3793	5/8	57.113	1/8	176.27	5/8	360.83	1/4	889.30	1/4	1702.3	1/4	2777.0	1/4	4113.5
3/16	3.7651	11/16	58.667	3/16	178.99	11/16	364.72	3/8	901.51	3/8	1719.2	3/8	2798.6	3/8	4139.7
1/4	4.1720	3/4	60.244	1/4	181.73	3/4	368.62	1/2	913.81	1/2	1736.2	1/2	2820.2	1/2	4165.9
5/16	4.5997	13/16	61.839	5/16	184.49	13/16	372.57	5/8	926.22	5/8	1753.2	5/8	2842.0	5/8	4192.4
3/8	5.0481	7/8	63.454	3/8	187.28	7/8	376.51	3/4	938.70	3/4	1770.4	3/4	2863.8	3/4	4218.9
7/16	5.5176	15/16	65.092	7/16	190.09	15/16	380.49	7/8	951.24	7/8	1787.6	7/8	2885.7	7/8	4245.4
1/2	6.0074	5	66.751	1/2	192.91	12	384.49	19	963.89	26	1804.9	33	2907.7	40	4271.9
9/16	6.5187	1/16	68.431	9/16	195.76	1/8	392.55	1/8	976.60	1/8	1822.4	1/8	2929.7	1/8	4298.8
5/8	7.0504	1/8	70.130	5/8	198.63	1/4	400.68	1/4	989.42	1/4	1839.8	1/4	2951.9	1/4	4325.7
11/16	7.6032	3/16	71.851	11/16	201.51	3/8	408.90	3/8	1002.3	3/8	1857.4	3/8	2974.1	3/8	4352.5
3/4	8.1771	1/4	73.595	3/4	204.42	1/2	417.20	1/2	1015.3	1/2	1875.0	1/2	2996.4	1/2	4379.4
13/16	8.7716	5/16	75.356	13/16	207.36	5/8	425.60	5/8	1028.3	5/8	1892.8	5/8	3018.8	5/8	4406.6
7/8	9.3870	3/8	77.140	7/8	210.31	3/4	434.06	3/4	1041.5	3/4	1910.6	3/4	3041.4	3/4	4433.8
15/16	10.023	7/16	78.942	15/16	213.28	7/8	442.59	7/8	1054.7	7/8	1928.5	7/8	3063.9	7/8	4461.0
2	10.680	1/2	80.768	9	216.27	13	451.23	20	1068.0	27	1946.5	34	3086.6	41	4488.5
1/16	11.358	9/16	82.614	1/16	219.29	1/8	459.97	1/8	1081.4	1/8	1964.5	1/8	3109.3	1/8	4515.7
1/8	12.057	5/8	84.480	1/8	222.32	1/4	468.77	1/4	1094.9	1/4	1982.7	1/4	3132.1	1/4	4543.2
3/16	12.777	11/16	86.370	3/16	225.38	3/8	477.64	3/8	1108.4	3/8	2000.1	3/8	3155.0	3/8	4570.8
1/4	13.517	3/4	88.277	1/4	228.46	1/2	486.62	1/2	1122.1	1/2	2019.2	1/2	3178.0	1/2	4598.6
5/16	14.278	13/16	90.208	5/16	231.55	5/8	495.66	5/8	1135.8	5/8	2037.6	5/8	3201.1	5/8	4626.2
3/8	15.061	7/8	92.160	3/8	234.67	3/4	504.81	3/4	1149.6	3/4	2056.1	3/4	3224.2	3/4	4654.1
7/16	15.864	15/16	94.128	7/16	237.81	7/8	514.02	7/8	1163.5	7/8	2074.7	7/8	3247.5	7/8	4681.9

Diam., inches	Weight, pounds	Diam., inches	Weight, pounds	Diam., inches	Weight, pounds	Diam., inches	Weight, pounds	Diam., inches	Weight, pounds	Diam., inches	Weight, pounds	Diam., inches	Weight, pounds	Diam., inches	Weight, pounds
42	4709.8	49½	6541.5	57	8,675.1	64½	11,108	72	13,841	79½	16,875	87	20,210	94½	23,844
⅛	4738.0	⅝	6575.5	⅛	8,713.2	⅝	11,151	⅛	13,890	⅝	16,928	⅛	20,268	⅝	23,907
¼	4766.2	¾	6608.5	¼	8,751.3	¾	11,194	¼	13,938	¾	16,982	¼	20,326	¾	23,971
⅜	4794.5	⅞	6641.8	⅜	8,789.3	⅞	11,238	⅜	13,986	⅞	17,035	⅜	20,384	⅞	24,034
½	4822.7	50	6675.1	½	8,827.7	65	11,281	½	14,034	80	17,088	½	20,442	95	24,097
⅝	4851.2	⅛	6708.4	⅝	8,866.2	⅛	11,324	⅝	14,083	⅛	17,142	⅝	20,501	⅛	24,161
¾	4879.8	¼	6742.1	¾	8,904.9	¼	11,368	¾	14,131	¼	17,195	¾	20,559	¼	24,224
⅞	4908.3	⅜	6775.7	⅞	8,943.3	⅜	11,411	⅞	14,180	⅜	17,249	⅞	20,618	⅜	24,288
43	4936.9	½	6809.4	58	8,982.1	½	11,455	73	14,229	½	17,303	88	20,677	½	24,351
⅛	4965.8	⅝	6843.1	⅛	9,020.8	⅝	11,499	⅛	14,277	⅝	17,356	⅛	20,736	⅝	24,415
¼	4994.4	¾	6876.7	¼	9,059.6	¾	11,543	¼	14,326	¾	17,410	¼	20,794	¾	24,479
⅜	5023.2	⅞	6910.7	⅜	9,098.7	⅞	11,587	⅜	14,375	⅞	17,464	⅜	20,853	⅞	24,543
½	5052.5	51	6944.7	½	9,137.4	66	11,631	½	14,424	81	17,518	½	20,912	96	24,607
⅝	5081.4	⅛	6978.7	⅝	9,176.5	⅛	11,675	⅝	14,473	⅛	17,572	⅝	20,971	⅛	24,671
¾	5110.6	¼	7013.0	¾	9,216.0	¼	11,719	¾	14,522	¼	17,627	¾	21,031	¼	24,735
⅞	5139.9	⅜	7047.4	⅞	9,255.1	⅜	11,763	⅞	14,572	⅜	17,681	⅞	21,090	⅜	24,800
44	5169.1	½	7081.7	59	9,294.5	½	11,807	74	14,621	½	17,735	89	21,149	½	24,864
⅛	5198.7	⅝	7116.0	⅛	9,333.9	⅝	11,852	⅛	14,671	⅝	17,789	⅛	21,209	⅝	24,929
¼	5228.2	¾	7150.4	¼	9,373.4	¾	11,897	¼	14,720	¾	17,844	¼	21,268	¾	24,993
⅜	5257.8	⅞	7185.1	⅜	9,412.8	⅞	11,941	⅜	14,770	⅞	17,899	⅜	21,328	⅞	25,058
½	5287.4	52	7219.7	½	9,452.6	67	11,986	½	14,820	82	17,953	½	21,388	97	25,122
⅝	5317.0	⅛	7254.4	⅝	9,492.4	⅛	12,031	⅝	14,869	⅛	18,008	⅝	21,447	⅛	25,187
¾	5346.9	¼	7289.4	¾	9,532.1	¼	12,075	¾	14,919	¼	18,063	¾	21,507	¼	25,252
⅞	5376.8	⅜	7324.4	⅞	9,572.3	⅜	12,120	⅞	14,969	⅜	18,118	⅞	21,567	⅜	25,317
45	5406.7	½	7359.5	60	9,612.0	½	12,165	75	15,019	½	18,173	90	21,627	½	25,382
⅛	5437.0	⅝	7394.5	⅛	9,652.1	⅝	12,210	⅛	15,069	⅝	18,228	⅛	21,687	⅝	25,447
¼	5467.2	¾	7429.5	¼	9,692.3	¾	12,256	¼	15,119	¾	18,283	¼	21,748	¾	25,512
⅜	5497.2	⅞	7464.8	⅜	9,732.7	⅞	12,301	⅜	15,170	⅞	18,338	⅜	21,808	⅞	25,578
½	5527.7	53	7500.2	½	9,773.2	68	12,346	½	15,220	83	18,394	½	21,868	98	25,643
⅝	5558.0	⅛	7535.6	⅝	9,813.3	⅛	12,392	⅝	15,270	⅛	18,449	⅝	21,929	⅛	25,708
¾	5588.6	¼	7570.9	¾	9,854.1	¼	12,437	¾	15,321	¼	18,505	¾	21,989	¼	25,774
⅞	5619.2	⅜	7606.6	⅞	9,894.5	⅜	12,483	⅞	15,371	⅜	18,560	⅞	22,050	⅜	25,840
46	5649.8	½	7642.3	61	9,935.3	½	12,529	76	15,422	½	18,616	91	22,111	½	25,905
⅛	5680.4	⅝	7678.0	⅛	9,976.1	⅝	12,574	⅛	15,473	⅝	18,672	⅛	22,172	⅝	25,971
¼	5711.3	¾	7714.0	¼	10,017	¾	12,620	¼	15,524	¾	18,728	¼	22,232	¾	26,037
⅜	5742.3	⅞	7749.7	⅜	10,058	⅞	12,666	⅜	15,575	⅞	18,784	⅜	22,293	⅞	26,103
½	5773.2	54	7785.8	½	10,099	69	12,712	½	15,626	84	18,840	½	22,354	99	26,169
⅝	5804.5	⅛	7821.8	⅝	10,140	⅛	12,758	⅝	15,677	⅛	18,896	⅝	22,415	⅛	26,235
¾	5835.4	¼	7858.2	¾	10,181	¼	12,804	¾	15,728	¼	18,952	¾	22,476	¼	26,301
⅞	5866.7	⅜	7894.2	⅞	10,222	⅜	12,850	⅞	15,779	⅜	19,009	⅞	22,538	⅜	26,368
47	5898.0	½	7930.6	62	10,264	½	12,897	77	15,831	½	19,065	92	22,599	½	26,434
⅛	5929.6	⅝	7967.0	⅛	10,305	⅝	12,943	⅛	15,882	⅝	19,121	⅛	22,661	⅝	26,501
¼	5961.2	¾	8003.7	¼	10,347	¾	12,990	¼	15,934	¾	19,178	¼	22,722	¾	26,567
⅜	5992.5	⅞	8040.1	⅜	10,388	⅞	13,036	⅜	15,985	⅞	19,234	⅜	22,784	⅞	26,634
½	6024.4	55	8076.8	½	10,430	70	13,083	½	16,037	85	19,291	½	22,846		
⅝	6056.0	⅛	8113.5	⅝	10,472	⅛	13,130	⅝	16,089	⅛	19,348	⅝	22,907		
¾	6088.0	¼	8150.5	¾	10,514	¼	13,177	¾	16,141	¼	19,405	¾	22,969		
⅞	6119.6	⅜	8187.3	⅞	10,555	⅜	13,224	⅞	16,193	⅜	19,462	⅞	23,031		
48	6151.9	½	8224.3	63	10,597	½	13,271	78	16,245	½	19,519	93	23,093		
⅛	6183.9	⅝	8261.4	⅛	10,639	⅝	13,318	⅛	16,297	⅝	19,576	⅛	23,155		
¼	6216.2	¾	8298.8	¼	10,682	¾	13,365	¼	16,349	¾	19,633	¼	23,218		
⅜	6248.1	⅞	8335.8	⅜	10,724	⅞	13,412	⅜	16,401	⅞	19,690	⅜	23,280		
½	6280.8	56	8373.2	½	10,766	71	13,460	½	16,453	86	19,748	½	23,342		
⅝	6313.1	⅛	8410.6	⅝	10,809	⅛	13,507	⅝	16,506	⅛	19,805	⅝	23,405		
¾	6345.4	¼	8448.0	¾	10,851	¼	13,555	¾	16,558	¼	19,863	¾	23,467		
⅞	6378.0	⅜	8485.7	⅞	10,894	⅜	13,602	⅞	16,611	⅜	19,920	⅞	23,530		
49	6410.6	½	8523.5	64	10,937	½	13,650	79	16,664	½	19,978	94	23,593		
⅛	6443.6	⅝	8561.2	⅛	10,979	⅝	13,698	⅛	16,717	⅝	20,036	⅛	23,655		
¼	6476.2	¾	8598.9	¼	11,022	¾	13,746	¼	16,769	¾	20,094	¼	23,718		
⅜	6509.2	⅞	8637.0	⅜	11,065	⅞	13,794	⅜	16,822	⅞	20,151	⅜	23,781		

AREAS AND CIRCUMFERENCES OF CIRCLES FOR DIAMETERS IN UNITS AND FRACTIONS

Dia.	Area	Circum.	Dia.	Area	Circum.	Dia.	Area	Circum.	Dia.	Area	Circum.	Dia.	Area	Circum.	Dia.	Area	Circum.
0			2	3.1416	6.28319	5	19.635	15.7080	8	50.265	25.1327	14	153.94	43.9823	20	314.16	62.8319
1/32	0.00077	0.098175	1/16	3.3410	6.47953	1/16	20.129	15.9043	1/8	51.849	25.5254	1/8	156.70	44.3750	1/8	318.10	63.2246
1/16	0.00307	0.196350	1/8	3.5466	6.67588	1/8	20.629	16.1007	1/4	53.456	25.9181	1/4	159.48	44.7677	1/4	322.06	63.6173
3/32	0.00690	0.294524	3/16	3.7583	6.87223	3/16	21.135	16.2970	3/8	55.088	26.3108	3/8	162.30	45.1604	3/8	326,05	64.0100
1/8	0.01227	0.392699	1/4	3.9761	7.06858	1/4	21.648	16.4934	1/2	56.745	26.7035	1/2	165.13	45.5531	1/2	330.06	64.4026
5/32	0.01917	0.490874	5/16	4.2000	7.26493	5/16	22.166	16.6897	5/8	58.426	27.0962	5/8	167.99	45.9458	5/8	334.10	64.7953
3/16	0.02761	0.589049	3/8	4.4301	7.46128	3/8	22.691	16.8861	3/4	60.132	27.4889	3/4	170.87	46.3385	3/4	338.16	65.1880
7/32	0.03758	0.687223	7/16	4.6664	7.65763	7/16	23.221	17.0824	7/8	61.862	27.8816	7/8	173.78	46.7312	7/8	342.25	65.5807
1/4	0.04909	0.785398	1/2	4.9087	7.85398	1/2	23.758	17.2788	9	63.617	28.2743	15	176.71	47.1239	21	346.36	65.9734
9/32	0.06213	0.883573	9/16	5.1572	8.05033	9/16	24.301	17.4751	1/8	65.397	28.6670	1/8	179.67	47.5166	1/8	350.50	66.3661
5/16	0.07670	0.981748	5/8	5.4119	8.24668	5/8	24.850	17.6715	1/4	67.201	29.0597	1/4	182.65	47.9093	1/4	354.66	66.7588
11/32	0.09281	1.07992	11/16	5.6727	8.44303	11/16	25.406	17.8678	3/8	69.029	29.4524	3/8	185.66	48.3020	3/8	358.84	67.1515
3/8	0.11045	1.17810	3/4	5.9396	8.63938	3/4	25.967	18.0642	1/2	70.882	29.8451	1/2	188.69	48.6947	1/2	363.05	67.5442
13/32	0.12962	1.27627	13/16	6.2126	8.83573	13/16	26.535	18.2605	5/8	72.760	30.2378	5/8	191.75	49.0874	5/8	367.28	67.9369
7/16	0.15033	1.37445	7/8	6.4918	9.03208	7/8	27.109	18.4569	3/4	74.662	30.6305	3/4	194.83	49.4801	3/4	371.54	68.3296
15/32	0.17257	1.47262	15/16	6.7771	9.22843	15/16	27.688	18.6532	7/8	76.589	31.0232	7/8	197.93	49.8728	7/8	375.83	68.7223
1/2	0.19635	1.57080	3	7.0686	9.42478	6	28.274	18.8496	10	78.540	31.4159	16	201.06	50.2655	22	380.13	69.1150
17/32	0.22166	1.66897	1/16	7.3662	9.62113	1/16	28.867	19.0460	1/8	80.516	31.8086	1/8	204.22	50.6582	1/8	384.46	69.5077
9/16	0.24850	1.76715	1/8	7.6699	9.81748	1/8	29.465	19.2423	1/4	82.516	32.2013	1/4	207.39	51.0509	1/4	388.82	69.9004
19/32	0.27688	1.86532	3/16	7.9769	10.0138	3/16	30.069	19.4387	3/8	84.541	32.5940	3/8	210.60	51.4436	3/8	393.20	70.2931
5/8	0.30680	1.96350	1/4	8.2958	10.2102	1/4	30.680	19.6350	1/2	86.590	32.9867	1/2	213.82	51.8363	1/2	397.61	70.6858
21/32	0.33824	2.06167	5/16	8.6179	10.4065	5/16	31.296	19.8314	5/8	88.664	33.3794	5/8	217.08	52.2290	5/8	402.04	71.0785
11/16	0.37122	2.15984	3/8	8.9462	10.6029	3/8	31.919	20.0277	3/4	90.763	33.7721	3/4	220.35	52.6217	3/4	406.49	71.4712
23/32	0.40574	2.25802	7/16	9.2806	10.7992	7/16	32.548	20.2241	7/8	92.886	34.1648	7/8	223.65	53.0144	7/8	410.97	71.8639
3/4	0.44179	2.35619	1/2	9.6211	10.9956	1/2	33.183	20.4204	11	95.033	34.5575	17	226.98	53.4071	23	415.48	72.2566
25/32	0.47937	2.45437	9/16	9.9678	11.1919	9/16	33.824	20.6168	1/8	97.205	34.9502	1/8	230.33	53.7998	1/8	420.00	72.6493
13/16	0.51849	2.55254	5/8	10.321	11.3883	5/8	34.471	20.8131	1/4	99.402	35.3429	1/4	233.71	54.1925	1/4	424.56	73.0420
27/32	0.55914	2.65072	11/16	10.680	11.5846	11/16	35.125	21.0095	3/8	101.62	35.7356	3/8	237.10	54.5852	3/8	429.13	73.4347
7/8	0.60132	2.74889	3/4	11.045	11.7810	3/4	35.785	21.2058	1/2	103.87	36.1283	1/2	240.53	54.9779	1/2	433.74	73.8274
29/32	0.64504	2.84707	13/16	11.416	11.9773	13/16	36.451	21.4022	5/8	106.14	36.5210	5/8	243.98	55.3706	5/8	438.36	74.2201
15/16	0.69029	2.94524	7/8	11.793	12.1737	7/8	37.122	21.5984	3/4	108.43	36.9137	3/4	247.45	55.7633	3/4	443.01	74.6128
31/32	0.73708	3.04342	15/16	12.177	12.3700	15/16	37.800	21.7949	7/8	110.75	37.3064	7/8	250.95	56.1560	7/8	447.69	75.0055
1	0.78540	3.14159	4	12.566	12.5664	7	38.485	21.9911	12	113.10	37.6991	18	254.47	56.5487	24	452.39	75.3982
1/16	0.88664	3.33794	1/16	12.962	12.7627	1/16	39.175	22.1876	1/8	115.47	38.0918	1/8	258.02	56.9414	1/8	457.11	75.7909
1/8	0.99402	3.53429	1/8	13.364	12.9591	1/8	39.871	22.3838	1/4	117.86	38.4845	1/4	261.59	57.3341	1/4	461.86	76.1836
3/16	1.1075	3.73064	3/16	13.772	13.1554	3/16	40.574	22.5803	3/8	120.28	38.8772	3/8	265.18	57.7268	3/8	466.64	76.5783
1/4	1.2272	3.92699	1/4	14.186	13.3518	1/4	41.282	22.7765	1/2	122.72	39.2699	1/2	268.80	58.1195	1/2	471.44	76.9690
5/16	1.3530	4.12334	5/16	14.607	13.5481	5/16	41.997	22.9730	5/8	125.19	39.6626	5/8	272.45	58.5122	5/8	476.26	77.3617
3/8	1.4849	4.31969	3/8	15.033	13.7445	3/8	42.718	23.1692	3/4	127.68	40.0553	3/4	276.12	58.9049	3/4	481.11	77.7544
7/16	1.6230	4.51604	7/16	15.466	13.9408	7/16	43.446	23.3657	7/8	130.19	40.4480	7/8	279.81	59.2976	7/8	485.98	78.1471
1/2	1.7671	4.71239	1/2	15.904	14.1372	1/2	44.179	23.5619	13	132.73	40.8407	19	283.53	59.6903	25	490.87	78.5398
9/16	1.9175	4.90874	9/16	16.349	14.3335	9/16	44.918	23.7584	1/8	135.30	41.2334	1/8	287.27	60.0830	1/8	495.79	78.9325
5/8	2.0739	5.10509	5/8	16.800	14.5299	5/8	45.664	23.9546	1/4	137.89	41.6261	1/4	291.04	60.4757	1/4	500.74	79.3252
11/16	2.2365	5.30144	11/16	17.257	14.7262	11/16	46.415	24.1511	3/8	140.50	42.0188	3/8	294.83	60.8684	3/8	505.71	79.7179
3/4	2.4053	5.49779	3/4	17.721	14.9226	3/4	47.173	24.3473	1/2	143.14	42.4115	1/2	298.65	61.2611	1/2	510.71	80.1106
13/16	2.5802	5.69414	13/16	18.190	15.1189	13/16	47.937	24.5428	5/8	145.80	42.8042	5/8	302.49	61.6538	5/8	515.72	80.5033
7/8	2.7612	5.89049	7/8	18.665	15.3153	7/8	48.707	24.7400	3/4	148.49	43.1969	3/4	306.35	62.0465	3/4	520.77	80.8960
15/16	2.9483	6.08684	15/16	19.147	15.5116	15/16	49.483	24.9364	7/8	151.20	43.5896	7/8	310.24	62.4392	7/8	525.84	81.2887

AREAS AND CIRCUMFERENCES OF CIRCLES FOR DIAMETERS IN UNITS AND FRACTIONS (Continued)

Dia.	Area	Circum.	Dia.	Area	Circum.	Dia.	Area	Circum.	Dia.	Area	Circum.	Dia.	Area	Circum.	Dia.	Area	Circum.
26	530.93	81.6814	32	804.25	100.531	38	1134.1	119.381	44	1520.5	138.230	50	1963.5	157.080	56	2463.0	175.929
⅛	536.05	82.0741	⅛	810.54	100.924	⅛	1141.6	119.773	⅛	1529.2	138.623	⅛	1973.3	157.472	⅛	2474.0	176.322
¼	541.19	82.4668	¼	816.86	101.316	¼	1149.1	120.166	¼	1537.9	139.015	¼	1983.2	157.865	¼	2485.0	176.715
⅜	546.35	82.8595	⅜	823.21	101.709	⅜	1156.6	120.559	⅜	1546.6	139.408	⅜	1993.1	158.258	⅜	2496.1	177.107
½	551.55	83.2522	½	829.58	102.102	½	1164.2	120.951	½	1555.3	139.801	½	2003.0	158.650	½	2507.2	177.500
⅝	556.76	83.6449	⅝	835.97	102.494	⅝	1171.7	121.344	⅝	1564.0	140.194	⅝	2012.9	159.043	⅝	2518.3	177.893
¾	562.00	84.0376	¾	842.39	102.887	¾	1179.3	121.737	¾	1572.8	140.586	¾	2022.8	159.436	¾	2529.4	178.285
⅞	567.27	84.4303	⅞	848.83	103.280	⅞	1186.9	122.129	⅞	1581.6	140.979	⅞	2032.8	159.829	⅞	2540.6	178.678
27	572.56	84.8230	33	855.30	103.673	39	1194.6	122.522	45	1590.4	141.372	51	2042.8	160.221	57	2551.8	179.071
⅛	577.87	85.2157	⅛	861.79	104.065	⅛	1202.3	122.915	⅛	1599.3	141.764	⅛	2052.8	160.614	⅛	2563.0	179.463
¼	583.21	85.6084	¼	868.31	104.458	¼	1210.0	123.308	¼	1608.2	142.157	¼	2062.9	161.007	¼	2574.2	179.856
⅜	588.57	86.0011	⅜	874.85	104.851	⅜	1217.7	123.700	⅜	1617.0	142.550	⅜	2073.0	161.399	⅜	2585.4	180.249
½	593.96	86.3938	½	881.41	105.243	½	1225.4	124.093	½	1626.0	142.942	½	2083.1	161.792	½	2596.7	180.642
⅝	599.37	86.7865	⅝	888.00	105.636	⅝	1233.2	124.486	⅝	1634.9	143.335	⅝	2093.2	162.185	⅝	2608.0	181.034
¾	604.81	87.1792	¾	894.62	106.029	¾	1241.0	124.878	¾	1643.9	143.728	¾	2103.3	162.577	¾	2619.4	181.427
⅞	610.27	87.5719	⅞	901.26	106.421	⅞	1248.8	125.271	⅞	1652.9	144.121	⅞	2113.5	162.970	⅞	2630.7	181.820
28	615.75	87.9646	34	907.92	106.814	40	1256.6	125.664	46	1661.9	144.513	52	2123.7	163.363	58	2642.1	182.212
⅛	621.26	88.3573	⅛	914.61	107.207	⅛	1264.5	126.056	⅛	1670.9	144.906	⅛	2133.9	163.756	⅛	2653.5	182.605
¼	626.80	88.7500	¼	921.32	107.600	¼	1272.4	126.449	¼	1680.0	145.299	¼	2144.2	164.148	¼	2664.9	182.998
⅜	632.36	89.1427	⅜	928.06	107.992	⅜	1280.3	126.842	⅜	1689.1	145.691	⅜	2154.5	164.541	⅜	2676.4	183.390
½	637.94	89.5354	½	934.82	108.385	½	1288.2	127.235	½	1698.2	146.084	½	2164.8	164.934	½	2687.8	183.783
⅝	643.55	89.9281	⅝	941.61	108.788	⅝	1296.2	127.627	⅝	1707.4	146.477	⅝	2175.1	165.326	⅝	2699.3	184.176
¾	649.18	90.3208	¾	948.42	109.170	¾	1304.2	128.020	¾	1716.5	146.869	¾	2185.4	165.719	¾	2710.9	184.569
⅞	654.85	90.7135	⅞	955.25	109.563	⅞	1312.2	128.413	⅞	1725.7	147.262	⅞	2195.8	166.112	⅞	2722.4	184.961
29	660.52	91.1062	35	962.11	109.956	41	1320.3	128.805	47	1734.9	147.655	53	2206.2	166.504	59	2734.0	185.354
⅛	666.23	91.4989	⅛	969.00	110.348	⅛	1328.3	129.198	⅛	1744.2	148.048	⅛	2216.6	166.897	⅛	2745.6	185.747
¼	671.96	91.8916	¼	975.91	110.741	¼	1336.4	129.591	¼	1753.5	148.440	¼	2227.0	167.290	¼	2757.2	186.139
⅜	677.71	92.2843	⅜	982.84	111.134	⅜	1344.5	129.983	⅜	1762.7	148.833	⅜	2237.5	167.683	⅜	2768.8	186.532
½	683.49	92.6770	½	989.80	111.527	½	1352.7	130.376	½	1772.1	149.226	½	2248.0	168.075	½	2780.5	186.925
⅝	689.30	93.0697	⅝	996.78	111.919	⅝	1360.8	130.769	⅝	1781.4	149.618	⅝	2258.5	168.468	⅝	2792.2	187.317
¾	695.13	93.4624	¾	1003.8	112.312	¾	1369.0	131.161	¾	1790.8	150.011	¾	2269.1	168.861	¾	2803.9	187.710
⅞	700.98	93.8551	⅞	1010.8	112.705	⅞	1377.2	131.554	⅞	1800.1	150.404	⅞	2279.6	169.253	⅞	2815.7	188.103
30	706.86	94.2478	36	1017.9	113.097	42	1385.4	131.947	48	1809.6	150.796	54	2290.2	169.646	60	2827.4	188.496
⅛	712.76	94.6405	⅛	1025.0	113.490	⅛	1393.7	132.340	⅛	1819.0	151.189	⅛	2300.8	170.039	⅛	2839.2	188.888
¼	718.69	95.0332	¼	1032.1	113.883	¼	1402.0	132.732	¼	1828.5	151.582	¼	2311.5	170.431	¼	2851.0	189.281
⅜	724.64	95.4259	⅜	1039.2	114.275	⅜	1410.3	133.125	⅜	1837.9	151.975	⅜	2322.1	170.824	⅜	2862.9	189.674
½	730.62	95.8186	½	1046.3	114.668	½	1418.6	133.518	½	1847.5	152.367	½	2332.8	171.217	½	2874.8	190.066
⅝	736.62	96.2113	⅝	1053.5	115.061	⅝	1427.0	133.910	⅝	1857.0	152.760	⅝	2343.5	171.609	⅝	2886.6	190.459
¾	742.64	96.6040	¾	1060.7	115.454	¾	1435.4	134.303	¾	1866.5	153.153	¾	2354.3	172.002	¾	2898.6	190.852
⅞	748.69	96.9967	⅞	1068.0	115.846	⅞	1443.8	134.696	⅞	1876.1	153.545	⅞	2365.0	172.395	⅞	2910.5	191.244
31	754.77	97.3894	37	1075.2	116.239	43	1452.2	135.088	49	1885.7	153.938	55	2375.8	172.788	61	2922.5	191.637
⅛	760.87	97.7821	⅛	1082.5	116.632	⅛	1460.7	135.481	⅛	1895.4	154.331	⅛	2386.6	173.180	⅛	2934.5	192.030
¼	766.99	98.1748	¼	1089.8	117.024	¼	1469.1	135.874	¼	1905.0	154.723	¼	2397.5	173.573	¼	2946.5	192.423
⅜	773.14	98.5675	⅜	1097.1	117.417	⅜	1477.6	136.267	⅜	1914.7	155.116	⅜	2408.3	173.966	⅜	2958.5	192.815
½	779.31	98.9602	½	1104.5	117.810	½	1486.2	136.659	½	1924.2	155.509	½	2419.2	174.358	½	2970.6	193.208
⅝	785.51	99.3529	⅝	1111.8	118.202	⅝	1494.7	137.052	⅝	1934.2	155.902	⅝	2430.1	174.751	⅝	2982.7	193.601
¾	791.73	99.7456	¾	1119.2	118.595	¾	1503.3	137.445	¾	1943.9	156.294	¾	2441.1	175.144	¾	2994.8	193.993
⅞	797.98	100.138	⅞	1126.7	118.988	⅞	1511.9	137.837	⅞	1953.7	156.687	⅞	2452.0	175.536	⅞	3006.9	194.386

AREAS AND CIRCUMFERENCES OF CIRCLES FOR DIAMETERS IN UNITS AND FRACTIONS (Continued)

Dia.	Area	Circum.	Dia.	Area	Circum.	Dia.	Area	Circum.	Dia.	Area	Circum.	Dia.	Area	Circum.	Dia.	Area	Circum.
62	3019.1	194.779	68	3631.7	213.628	74	4300.8	232.478	80	5026.5	251.327	86	5808.8	270.177	92	6647.6	289.027
1/8	3031.3	195.171	1/8	3645.0	214.021	1/8	4315.4	232.871	1/8	5042.3	251.720	1/8	5825.7	270.570	1/8	6665.7	289.419
1/4	3043.5	195.564	1/4	3658.4	214.414	1/4	4329.9	233.263	1/4	5058.0	252.113	1/4	5842.6	270.962	1/4	6683.8	289.812
3/8	3055.7	195.957	3/8	3671.8	214.806	3/8	4344.5	233.656	3/8	5073.8	252.506	3/8	5859.6	271.355	3/8	6701.9	290.205
1/2	3068.0	196.350	1/2	3685.3	215.199	1/2	4359.2	234.049	1/2	5089.6	252.898	1/2	5876.5	271.748	1/2	6720.1	290.597
5/8	3080.3	196.742	5/8	3698.7	215.592	5/8	4373.8	234.441	5/8	5105.4	253.291	5/8	5893.5	272.140	5/8	6738.2	290.990
3/4	3092.6	197.135	3/4	3712.2	215.984	3/4	4388.5	234.834	3/4	5121.2	253.684	3/4	5910.6	272.533	3/4	6756.4	291.383
7/8	3104.9	197.528	7/8	3725.7	216.337	7/8	4403.1	235.227	7/8	5137.1	254.076	7/8	5927.6	272.926	7/8	6774.7	291.775
63	3117.2	197.920	69	3739.3	216.770	75	4417.9	235.619	81	5153.0	254.469	87	5944.7	273.319	93	6792.9	292.168
1/8	3129.6	198.313	1/8	3752.8	217.163	1/8	4432.6	236.012	1/8	5168.9	254.862	1/8	5961.8	273.711	1/8	6811.2	292.561
1/4	3142.0	198.706	1/4	3766.4	217.555	1/4	4447.4	236.405	1/4	5184.9	255.254	1/4	5978.9	274.104	1/4	6829.5	292.954
3/8	3154.5	199.098	3/8	3780.0	217.948	3/8	4462.2	236.798	3/8	5200.8	255.647	3/8	5996.0	274.497	3/8	6847.8	293.346
1/2	3166.9	199.491	1/2	3793.7	218.341	1/2	4477.0	237.190	1/2	5216.8	256.040	1/2	6013.2	274.889	1/2	6866.1	293.739
5/8	3179.4	199.884	5/8	3807.3	218.733	5/8	4491.8	237.583	5/8	5232.8	256.433	5/8	6030.4	275.282	5/8	6884.5	294.132
3/4	3191.9	200.277	3/4	3821.0	219.120	3/4	4506.7	237.976	3/4	5248.9	256.825	3/4	6047.6	275.675	3/4	6902.9	294.524
7/8	3204.4	200.669	7/8	3834.7	219.519	7/8	4521.5	238.368	7/8	5264.9	257.218	7/8	6064.9	276.067	7/8	6921.3	294.917
64	3217.0	201.062	70	3848.5	219.911	76	4536.5	238.761	82	5281.0	257.611	88	6082.1	276.460	94	6939.8	295.310
1/8	3229.6	201.455	1/8	3862.2	220.304	1/8	4551.4	239.154	1/8	5297.1	258.003	1/8	6099.4	276.853	1/8	6958.2	295.702
1/4	3242.2	201.847	1/4	3876.0	220.697	1/4	4566.4	239.546	1/4	5313.3	258.396	1/4	6116.7	277.246	1/4	6976.7	296.095
3/8	3254.8	202.240	3/8	3889.8	221.090	3/8	4581.3	239.939	3/8	5329.4	258.789	3/8	6134.1	277.638	3/8	6995.3	296.488
1/2	3267.5	202.633	1/2	3903.6	221.482	1/2	4596.3	240.332	1/2	5345.6	259.181	1/2	6151.4	278.031	1/2	7013.8	296.881
5/8	3280.1	203.025	5/8	3917.5	221.875	5/8	4611.4	240.725	5/8	5361.8	259.574	5/8	6168.8	278.424	5/8	7032.4	297.273
3/4	3292.8	203.418	3/4	3931.4	222.268	3/4	4626.4	241.117	3/4	5378.1	259.967	3/4	6186.2	278.816	3/4	7051.0	297.666
7/8	3305.6	203.811	7/8	3945.3	222.660	7/8	4641.5	241.510	7/8	5394.3	260.359	7/8	6203.7	279.209	7/8	7069.6	298.059
65	3318.3	204.204	71	3959.2	223.053	77	4656.6	241.903	83	5410.6	260.752	89	6221.1	279.602	95	7088.2	298.451
1/8	3331.1	204.596	1/8	3973.1	223.446	1/8	4671.8	242.295	1/8	5426.9	261.145	1/8	6238.6	279.994	1/8	7106.9	298.844
1/4	3343.9	204.989	1/4	3987.1	223.838	1/4	4686.9	242.688	1/4	5443.3	261.538	1/4	6256.1	280.387	1/4	7125.6	299.237
3/8	3356.7	205.382	3/8	4001.1	224.231	3/8	4702.1	243.081	3/8	5459.6	261.930	3/8	6273.7	280.780	3/8	7144.3	299.629
1/2	3369.6	205.774	1/2	4015.2	224.625	1/2	4717.3	243.473	1/2	5476.0	262.323	1/2	6291.2	281.173	1/2	7163.0	300.022
5/8	3382.4	206.167	5/8	4029.2	225.017	5/8	4732.5	243.866	5/8	5492.4	262.716	5/8	6308.8	281.565	5/8	7181.8	300.415
3/4	3395.3	206.560	3/4	4043.3	225.409	3/4	4747.8	244.259	3/4	5508.8	263.103	3/4	6326.4	281.958	3/4	7200.6	300.807
7/8	3408.2	206.952	7/8	4057.4	225.802	7/8	4763.1	244.652	7/8	5525.3	263.501	7/8	6344.1	282.351	7/8	7219.4	301.200
66	3421.2	207.345	72	4071.5	226.195	78	4778.4	245.044	84	5541.8	263.894	90	6361.7	282.743	96	7238.2	301.593
1/8	3434.3	207.738	1/8	4085.7	226.587	1/8	4793.7	245.437	1/8	5558.3	264.286	1/8	6379.4	283.136	1/4	7276.0	302.378
1/4	3447.2	208.131	1/4	4099.8	226.980	1/4	4809.0	245.830	1/4	5574.8	264.679	1/4	6397.1	283.529	1/2	7313.8	303.164
3/8	3460.2	208.523	3/8	4114.0	227.373	3/8	4824.4	246.222	3/8	5591.4	265.072	3/8	6414.9	283.921	3/4	7351.8	303.949
1/2	3473.2	208.916	1/2	4128.2	227.765	1/2	4839.8	246.615	1/2	5607.9	265.465	1/2	6432.6	284.314	97	7389.8	304.734
5/8	3486.3	209.309	5/8	4142.5	228.158	5/8	4855.2	247.008	5/8	5624.5	265.857	5/8	6450.4	284.707	1/4	7428.0	305.520
3/4	3499.4	209.701	3/4	4156.8	228.551	3/4	4870.7	247.400	3/4	5641.2	266.250	3/4	6468.2	285.100	1/2	7466.2	306.305
7/8	3512.5	210.094	7/8	4171.1	228.944	7/8	4886.2	247.793	7/8	5657.8	266.643	7/8	6486.0	285.492	3/4	7504.5	307.091
67	3525.7	210.487	73	4185.4	229.336	79	4901.7	248.186	85	5674.5	267.035	91	6503.9	285.885	98	7543.0	307.876
1/8	3538.8	210.879	1/8	4199.7	229.729	1/8	4917.2	248.579	1/8	5691.2	267.428	1/8	6521.8	286.278	1/4	7581.5	308.661
1/4	3552.0	211.272	1/4	4214.1	230.122	1/4	4932.7	248.971	1/4	5707.9	267.821	1/4	6539.7	286.670	1/2	7620.1	309.447
3/8	3565.2	211.665	3/8	4228.5	230.514	3/8	4948.3	249.364	3/8	5724.7	268.213	3/8	6557.6	287.063	3/4	7658.9	310.232
1/2	3578.5	212.058	1/2	4242.9	230.907	1/2	4963.9	249.757	1/2	5741.5	268.606	1/2	6575.5	287.456	99	7697.7	311.018
5/8	3591.7	212.450	5/8	4257.4	231.300	5/8	4979.5	250.149	5/8	5758.3	268.999	5/8	6593.5	287.848	1/4	7736.6	311.803
3/4	3605.0	212.843	3/4	4271.8	231.692	3/4	4995.2	250.542	3/4	5775.1	269.392	3/4	6611.5	288.241	1/2	7775.6	312.588
7/8	3618.3	213.236	7/8	4286.3	232.085	7/8	5010.9	250.935	7/8	5791.9	269.784	7/8	6629.6	288.634	3/4	7814.8	313.374

DECIMAL EQUIVALENTS

64ths	32nds	DECIMALS of a FOOT 0"	1"	2"	3"	4"	5"	6"	7"	8"	9"	10"	11"	64ths	32nds	Decimals of an Inch
	0	0.0000	0.0833	0.1667	0.2500	0.3333	0.4167	0.5000	0.5833	0.6667	0.7500	0.8333	0.9167		0	
1		0.0013	0.0846	0.1680	0.2513	0.3346	0.4180	0.5013	0.5846	0.6680	0.7513	0.8346	0.9180	1		0.015625
	1/32	0.0026	0.0859	0.1693	0.2526	0.3359	0.4193	0.5026	0.5859	0.6693	0.7526	0.8359	0.9193		1/32	0.031250
3		0.0039	0.0872	0.1706	0.2539	0.3372	0.4206	0.5039	0.5872	0.6706	0.7539	0.8372	0.9206	3		0.046875
	1/16	0.0052	0.0885	0.1719	0.2552	0.3385	0.4219	0.5052	0.5885	0.6719	0.7552	0.8385	0.9219		1/16	0.062500
5		0.0065	0.0898	0.1732	0.2565	0.3398	0.4232	0.5065	0.5898	0.6732	0.7565	0.8398	0.9232	5		0.078125
	3/32	0.0078	0.0911	0.1745	0.2578	0.3411	0.4245	0.5078	0.5911	0.6745	0.7578	0.8411	0.9245		3/32	0.093750
7		0.0091	0.0924	0.1758	0.2591	0.3424	0.4258	0.5091	0.5924	0.6758	0.7591	0.8424	0.9258	7		0.109375
	1/8	0.0104	0.0937	0.1771	0.2604	0.3437	0.4271	0.5104	0.5937	0.6771	0.7604	0.8437	0.9271		1/8	0.125000
9		0.0117	0.0951	0.1784	0.2617	0.3451	0.4284	0.5117	0.5951	0.6784	0.7617	0.8451	0.9284	9		0.140625
	5/32	0.0130	0.0964	0.1797	0.2630	0.3464	0.4297	0.5130	0.5964	0.6797	0.7630	0.8464	0.9297		5/32	0.156250
11		0.0143	0.0977	0.1810	0.2643	0.3477	0.4310	0.5143	0.5977	0.6810	0.7643	0.8477	0.9310	11		0.171875
	3/16	0.0156	0.0990	0.1823	0.2656	0.3490	0.4323	0.5156	0.5990	0.6823	0.7656	0.8490	0.9323		3/16	0.187500
13		0.0169	0.1003	0.1836	0.2669	0.3503	0.4336	0.5169	0.6003	0.6836	0.7669	0.8503	0.9336	13		0.203125
	7/32	0.0182	0.1016	0.1849	0.2682	0.3516	0.4349	0.5182	0.6016	0.6849	0.7682	0.8516	0.9349		7/32	0.218750
15		0.0195	0.1029	0.1862	0.2695	0.3529	0.4362	0.5195	0.6029	0.6862	0.7695	0.8529	0.9362	15		0.234375
	1/4	0.0208	0.1042	0.1875	0.2708	0.3542	0.4375	0.5208	0.6042	0.6875	0.7708	0.8542	0.9375		1/4	0.250000
17		0.0221	0.1055	0.1888	0.2721	0.3555	0.4388	0.5221	0.6055	0.6888	0.7721	0.8555	0.9388	17		0.265625
	9/32	0.0234	0.1068	0.1901	0.2734	0.3568	0.4401	0.5234	0.6068	0.6901	0.7734	0.8568	0.9401		9/32	0.281250
19		0.0247	0.1081	0.1914	0.2747	0.3581	0.4414	0.5247	0.6081	0.6914	0.7747	0.8581	0.9414	19		0.296875
	5/16	0.0260	0.1094	0.1927	0.2760	0.3594	0.4427	0.5260	0.6094	0.6927	0.7760	0.8594	0.9427		5/16	0.312500
21		0.0273	0.1107	0.1940	0.2773	0.3607	0.4440	0.5273	0.6107	0.6940	0.7773	0.8607	0.9440	21		0.328125
	11/32	0.0286	0.1120	0.1953	0.2786	0.3620	0.4453	0.5286	0.6120	0.6953	0.7786	0.8620	0.9453		11/32	0.343750
23		0.0299	0.1133	0.1966	0.2799	0.3633	0.4466	0.5299	0.6133	0.6966	0.7799	0.8633	0.9466	23		0.359375
	3/8	0.0312	0.1146	0.1979	0.2812	0.3646	0.4479	0.5312	0.6146	0.6979	0.7812	0.8646	0.9479		3/8	0.375000
25		0.0326	0.1159	0.1992	0.2826	0.3659	0.4492	0.5326	0.6159	0.6992	0.7826	0.8659	0.9492	25		0.390625
	13/32	0.0339	0.1172	0.2005	0.2839	0.3672	0.4505	0.5339	0.6172	0.7005	0.7839	0.8672	0.9505		13/32	0.406250
27		0.0352	0.1185	0.2018	0.2852	0.3685	0.4518	0.5352	0.6185	0.7018	0.7852	0.8685	0.9518	27		0.421875
	7/16	0.0365	0.1198	0.2031	0.2865	0.3698	0.4531	0.5365	0.6198	0.7031	0.7865	0.8698	0.9531		7/16	0.437500
29		0.0378	0.1211	0.2044	0.2878	0.3711	0.4544	0.5378	0.6211	0.7044	0.7878	0.8711	0.9544	29		0.453125
	15/32	0.0391	0.1224	0.2057	0.2891	0.3724	0.4557	0.5391	0.6224	0.7057	0.7891	0.8724	0.9557		15/32	0.468750
31		0.0404	0.1237	0.2070	0.2904	0.3737	0.4570	0.5404	0.6237	0.7070	0.7904	0.8737	0.9570	31		0.484375
	1/2	0.0417	0.1250	0.2083	0.2917	0.3750	0.4583	0.5417	0.6250	0.7083	0.7917	0.8750	0.9583		1/2	0.500000
33		0.0430	0.1263	0.2096	0.2930	0.3763	0.4596	0.5430	0.6263	0.7096	0.7930	0.8763	0.9596	33		0.515625
	17/32	0.0443	0.1276	0.2109	0.2943	0.3776	0.4609	0.5443	0.6276	0.7109	0.7943	0.8776	0.9609		17/32	0.531250
35		0.0456	0.1289	0.2122	0.2956	0.3789	0.4622	0.5456	0.6289	0.7122	0.7956	0.8789	0.9622	35		0.546875
	9/16	0.0469	0.1302	0.2135	0.2969	0.3802	0.4635	0.5469	0.6302	0.7135	0.7969	0.8802	0.9635		9/16	0.562500
37		0.0482	0.1315	0.2148	0.2982	0.3815	0.4648	0.5482	0.6315	0.7148	0.7982	0.8815	0.9648	37		0.578125
	19/32	0.0495	0.1328	0.2161	0.2995	0.3828	0.4661	0.5495	0.6328	0.7161	0.7995	0.8828	0.9661		19/32	0.593750
39		0.0508	0.1341	0.2174	0.3008	0.3841	0.4674	0.5508	0.6341	0.7174	0.8008	0.8841	0.9674	39		0.609375
	5/8	0.0521	0.1354	0.2188	0.3021	0.3854	0.4688	0.5521	0.6354	0.7188	0.8021	0.8854	0.9688		5/8	0.625000
41		0.0534	0.1367	0.2201	0.3034	0.3867	0.4701	0.5534	0.6367	0.7201	0.8034	0.8867	0.9701	41		0.640625
	21/32	0.0547	0.1380	0.2214	0.3047	0.3880	0.4714	0.5547	0.6380	0.7214	0.8047	0.8880	0.9714		21/32	0.656250
43		0.0560	0.1393	0.2227	0.3060	0.3893	0.4727	0.5560	0.6393	0.7227	0.8060	0.8893	0.9727	43		0.671875
	11/16	0.0573	0.1406	0.2240	0.3073	0.3906	0.4740	0.5573	0.6406	0.7240	0.8073	0.8906	0.9740		11/16	0.687500
45		0.0586	0.1419	0.2253	0.3086	0.3919	0.4753	0.5586	0.6419	0.7253	0.8086	0.8919	0.9753	45		0.703125
	23/32	0.0599	0.1432	0.2266	0.3099	0.3932	0.4766	0.5599	0.6432	0.7266	0.8099	0.8932	0.9766		23/32	0.718750
47		0.0612	0.1445	0.2279	0.3112	0.3945	0.4779	0.5612	0.6445	0.7279	0.8112	0.8945	0.9779	47		0.734375
	3/4	0.0625	0.1458	0.2292	0.3125	0.3958	0.4792	0.5625	0.6458	0.7292	0.8125	0.8958	0.9792		3/4	0.750000
49		0.0638	0.1471	0.2305	0.3138	0.3971	0.4805	0.5638	0.6471	0.7305	0.8138	0.8971	0.9805	49		0.765625
	25/32	0.0651	0.1484	0.2318	0.3151	0.3984	0.4818	0.5651	0.6484	0.7318	0.8151	0.8984	0.9818		25/32	0.781250
51		0.0664	0.1497	0.2331	0.3164	0.3997	0.4831	0.5664	0.6497	0.7331	0.8164	0.8997	0.9831	51		0.796875
	13/16	0.0677	0.1510	0.2344	0.3177	0.4010	0.4844	0.5677	0.6510	0.7344	0.8177	0.9010	0.9844		13/16	0.812500
53		0.0690	0.1523	0.2357	0.3190	0.4023	0.4857	0.5690	0.6523	0.7357	0.8190	0.9023	0.9857	53		0.828125
	27/32	0.0703	0.1536	0.2370	0.3203	0.4036	0.4870	0.5703	0.6536	0.7370	0.8203	0.9036	0.9870		27/32	0.843750
55		0.0716	0.1549	0.2383	0.3216	0.4049	0.4883	0.5716	0.6549	0.7383	0.8216	0.9049	0.9883	55		0.859375
	7/8	0.0729	0.1562	0.2396	0.3229	0.4062	0.4896	0.5729	0.6562	0.7396	0.8229	0.9062	0.9896		7/8	0.875000
57		0.0742	0.1576	0.2409	0.3242	0.4076	0.4909	0.5742	0.6576	0.7409	0.8242	0.9076	0.9909	57		0.890625
	29/32	0.0755	0.1589	0.2422	0.3255	0.4089	0.4922	0.5755	0.6589	0.7422	0.8255	0.9089	0.9922		29/32	0.906250
59		0.0768	0.1602	0.2435	0.3268	0.4102	0.4935	0.5768	0.6602	0.7435	0.8268	0.9102	0.9935	59		0.921875
	15/16	0.0781	0.1615	0.2448	0.3281	0.4115	0.4948	0.5781	0.6615	0.7448	0.8281	0.9115	0.9948		15/16	0.937500
61		0.0794	0.1628	0.2461	0.3294	0.4128	0.4961	0.5794	0.6628	0.7461	0.8294	0.9128	0.9961	61		0.953125
	31/32	0.0807	0.1641	0.2474	0.3307	0.4141	0.4974	0.5807	0.6641	0.7474	0.8307	0.9141	0.9974		31/32	0.968750
63		0.0820	0.1654	0.2487	0.3320	0.4154	0.4987	0.5820	0.6654	0.7487	0.8320	0.9154	0.9987	63		0.984375

METRIC CONVERSION TABLE

Inches	Millimeters
0	0.0000
1/128	0.1984
1/64	0.3969
3/128	0.5953
1/32	0.7937
5/128	0.9921
3/64	1.1906
7/128	1.3890

Convert 3.7643 meters to feet, inches and fractions

3.7643 meters
3.6556 = 12 ft
108.70 mm
107.95 = 4 1/4 in.
.75 = 1/32″
3.7643 meters = 12′ 4 9/32″

Convert 15′–6 7/16″ to meters

15′ = 4.5720 meters
6 7/16″ = .163513 meters
15′–6 7/16″ = 4.735513 meters

INCHES AND FRACTIONS—MILLIMETERS

Inches	Millimeters	Inches	Millimeters	Inches	Millimeters	Inches	Millimeters	Inches	Millimeters	Inches	Millimeters
1/16	1.5875	2 1/16	52.3876	4 1/16	103.188	6 1/16	153.988	8 1/16	204.788	10 1/16	255.588
1/8	3.1750	2 1/8	53.9751	4 1/8	104.775	6 1/8	155.575	8 1/8	206.375	10 1/8	257.176
3/16	4.7625	2 3/16	55.5626	4 3/16	106.363	6 3/16	157.163	8 3/16	207.963	10 3/16	258.763
1/4	6.3500	2 1/4	57.1501	4 1/4	107.950	6 1/4	158.750	8 1/4	209.550	10 1/4	260.351
5/16	7.9375	2 5/16	58.7376	4 5/16	109.538	6 5/16	160.338	8 5/16	211.138	10 5/16	261.938
3/8	9.5250	2 3/8	60.3251	4 3/8	111.125	6 3/8	161.925	8 3/8	212.725	10 3/8	263.526
7/16	11.1125	2 7/16	61.9126	4 7/16	112.713	6 7/16	163.513	8 7/16	214.313	10 7/16	265.113
1/2	12.7000	2 1/2	63.5001	4 1/2	114.300	6 1/2	165.100	8 1/2	215.900	10 1/2	266.701
9/16	14.2875	2 9/16	65.0876	4 9/16	115.888	6 9/16	166.688	8 9/16	217.488	10 9/16	268.288
5/8	15.8750	2 5/8	66.6751	4 5/8	117.475	6 5/8	168.275	8 5/8	219.075	10 5/8	269.876
11/15	17.4625	2 11/16	68.2626	4 11/16	119.063	6 11/16	169.863	8 11/16	220.663	10 11/16	271.463
3/4	19.0500	2 3/4	69.8501	4 3/4	120.650	6 3/4	171.450	8 3/4	222.250	10 3/4	273.051
13/16	20.6375	2 13/16	71.4376	4 13/16	122.238	6 13/16	173.038	8 13/16	223.838	10 13/16	274.638
7/8	22.2250	2 7/8	73.0251	4 7/8	123.825	6 7/8	174.625	8 7/8	225.425	10 7/8	276.226
15/16	23.8125	2 15/16	74.6126	4 15/16	125.413	6 15/16	176.213	8 15/16	227.013	10 15/16	277.813
1	25.4001	3	76.2002	5	127.000	7	177.800	9	228.600	11	279.401
1 1/16	26.9876	3 1/16	77.7877	5 1/16	128.588	7 1/16	179.388	9 1/16	230.188	11 1/16	280.988
1 1/8	28.5751	3 1/8	79.3752	5 1/8	130.175	7 1/8	180.975	9 1/8	231.775	11 1/8	282.576
1 3/16	30.1626	3 3/16	80.9627	5 3/16	131.763	7 3/16	182.563	9 3/16	233.363	11 3/16	284.163
1 1/4	31.7501	3 1/4	82.5502	5 1/4	133.350	7 1/4	184.150	9 1/4	234.950	11 1/4	285.751
1 5/16	33.3376	3 5/16	84.1377	5 5/16	134.938	7 5/16	185.738	9 5/16	236.538	11 5/16	287.338
1 3/8	34.9251	3 3/8	85.7252	5 3/8	136.525	7 3/8	187.325	9 3/8	238.125	11 3/8	288.926
1 7/16	36.5126	3 7/16	87.3127	5 7/16	138.113	7 7/16	188.913	9 7/16	239.713	11 7/16	290.513
1 1/2	38.1001	3 1/2	88.9002	5 1/2	139.700	7 1/2	190.500	9 1/2	241.300	11 1/2	292.101
1 9/16	39.6876	3 9/16	90.4877	5 9/16	141.288	7 9/16	192.088	9 9/16	242.888	11 9/16	293.688
1 5/8	41.2751	3 5/8	92.0752	5 5/8	142.875	7 5/8	193.675	9 5/8	244.475	11 5/8	295.276
1 11/16	42.8626	3 11/16	93.6627	5 11/16	144.463	7 11/16	195.263	9 11/16	246.063	11 11/16	296.863
1 3/4	44.4501	3 3/4	95.2502	5 3/4	146.051	7 3/4	196.850	9 3/4	247.650	11 3/4	298.451
1 13/16	46.0376	3 13/16	96.8377	5 13/16	147.638	7 13/16	198.438	9 13/16	249.238	11 13/16	300.038
1 7/8	47.6251	3 7/8	98.4252	5 7/8	149.225	7 7/8	200.025	9 7/8	250.825	11 7/8	301.626
1 15/16	49.2126	3 15/16	100.013	5 15/16	150.813	7 15/16	201.613	9 15/16	252.413	11 15/16	303.213
2	50.8001	4	101.600	6	152.400	8	203.200	10	254.001	12	304.801

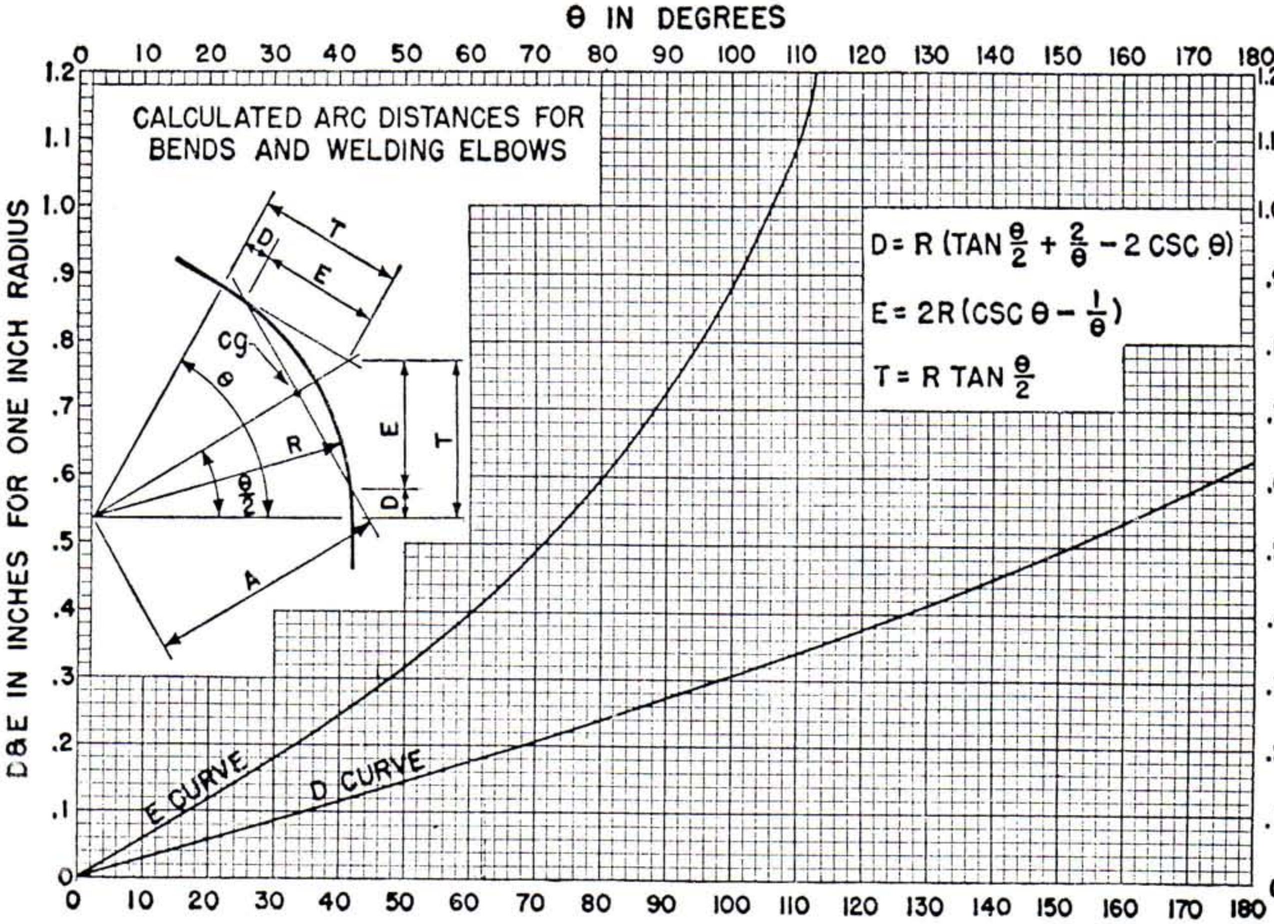
FEET INTO METERS

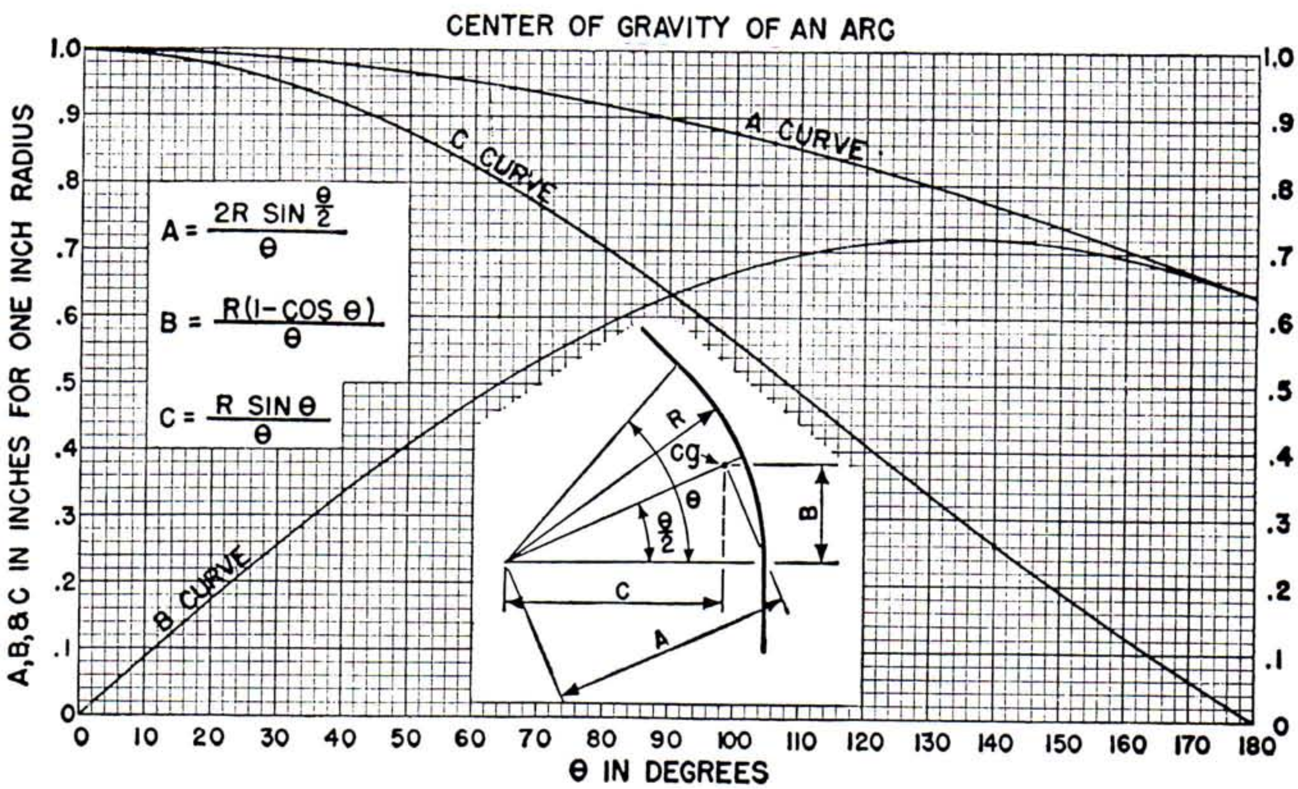
Feet	Meters	Feet	Meters	Feet	Meters	Feet	Meters	Feet	Meters	Feet	Meters	Feet	Meters
1	0.3048	16	4.8768	31	9.4488	46	14.021	61	18.593	76	23.165	91	27.736
2	0.6096	17	5.1816	32	9.7536	47	14.326	62	18.898	77	23.470	92	28.041
3	0.9144	18	5.4864	33	10.058	48	14.630	63	19.202	78	23.774	93	28.346
4	1.2192	19	5.7912	34	10.363	49	14.935	64	19.507	79	24.079	94	28.650
5	1.5240	20	6.0960	35	10.668	50	15.240	65	19.812	80	24.384	95	28.955
6	1.8288	21	6.4008	36	10.973	51	15.545	66	20.117	81	24.689	96	29.260
7	2.1336	22	6.7056	37	11.278	52	15.850	67	20.422	82	24.994	97	29.565
8	2.4384	23	7.0104	38	11.582	53	16.154	68	20.726	83	25.297	98	29.870
9	2.7432	24	7.3152	39	11.887	54	16.459	69	21.031	84	25.602	99	30.174
10	3.0480	25	7.6200	40	12.192	55	16.764	70	21.336	85	25.907	100	30.480
11	3.3528	26	7.9248	41	12.497	56	17.069	71	21.641	86	26.212		
12	3.6556	27	8.2296	42	12.802	57	17.374	72	21.946	87	26.517		
13	3.9624	28	8.5344	43	13.106	58	17.678	73	22.250	88	26.822		
14	4.2672	29	8.8392	44	13.411	59	17.983	74	22.555	89	27.126		
15	4.5720	30	9.1440	45	13.716	60	18.288	75	22.860	90	27.432		

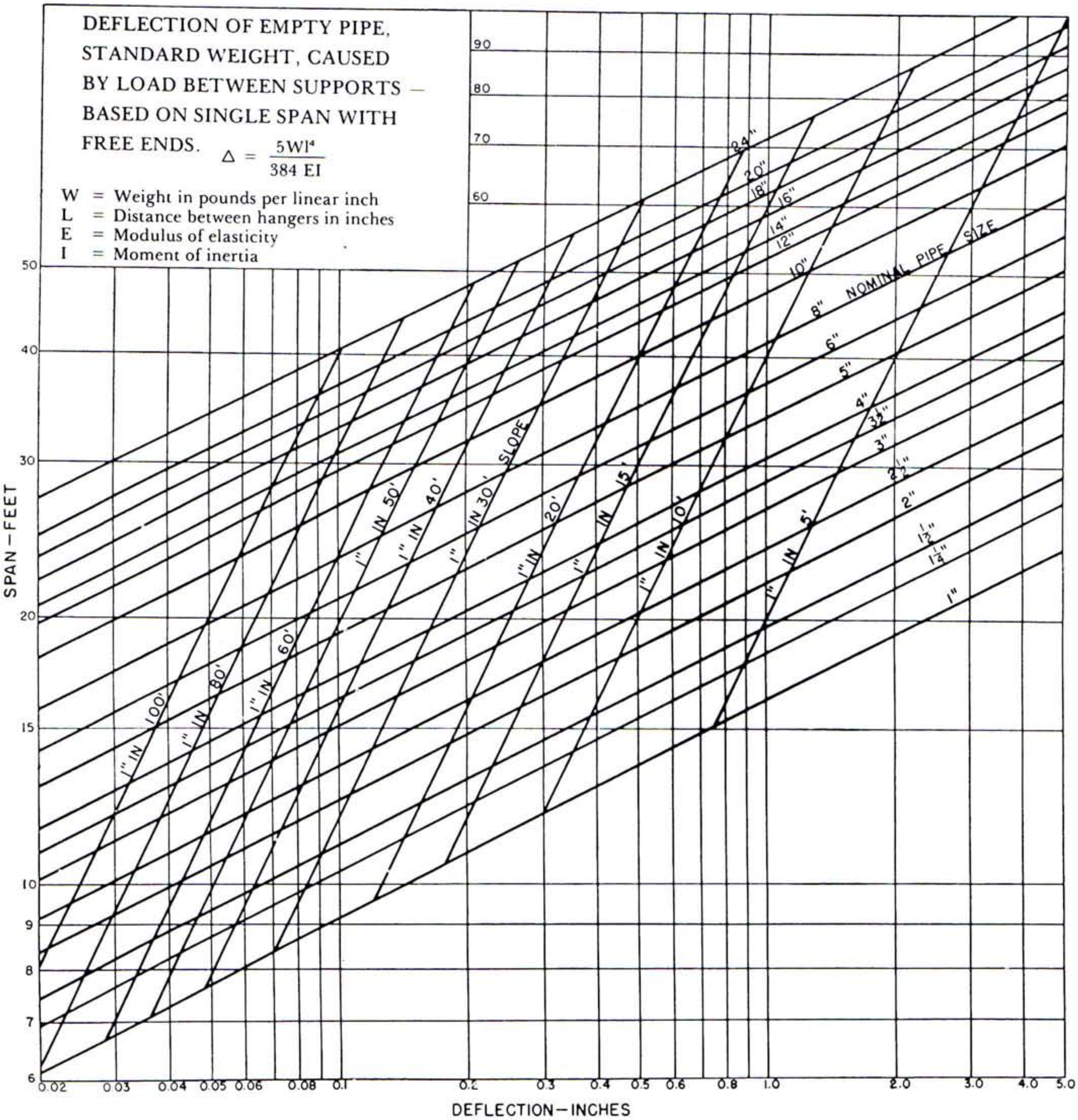
LENGTHS OF ARCS FOR RADIUS 1

Degrees						Minutes		Seconds	
0°	0.000000	60°	1.047198	120	2.094395	0′	0.000000	0″	0.000000
1	0.017453	61	1.064651	121	2.111848	1	0.000291	1	0.000005
2	0.034907	62	1.082104	122	2.129302	2	0.000582	2	0.000010
3	0.052360	63	1.099557	123	2.146755	3	0.000873	3	0.000015
4	0.069813	64	1.117011	124	2.164208	4	0.001164	4	0.000019
5	0.087266	65	1.134464	125	2.181662	5	0.001454	5	0.000024
6	0.104720	66	1.151917	126	2.199115	6	0.001745	6	0.000029
7	0.122173	67	1.169371	127	2.216568	7	0.002036	7	0.000034
8	0.139626	68	1.186824	128	2.234021	8	0.002327	8	0.000039
9	0.157080	69	1.204277	129	2.251475	9	0.002618	9	0.000044
10	0.174533	70	1.221730	130	2.268928	10	0.002909	10	0.000048
11	0.191986	71	1.239184	131	2.286381	11	0.003200	11	0.000053
12	0.209440	72	1.256637	132	2.303835	12	0.003491	12	0.000058
13	0.226893	73	1.274090	133	2.321288	13	0.003782	13	0.000063
14	0.244346	74	1.291544	134	2.338741	14	0.004072	14	0.000068
15	0.261799	75	1.308997	135	2.356194	15	0.004363	15	0.000073
16	0.279253	76	1.326450	136	2.373648	16	0.004654	16	0.000078
17	0.296706	77	1.343904	137	2.391101	17	0.004945	17	0.000082
18	0.314159	78	1.361357	138	2.408554	18	0.005236	18	0.000087
19	0.331613	79	1.378810	139	2.426008	19	0.005527	19	0.000092
20	0.349066	80	1.396263	140	2.443461	20	0.005818	20	0.000097
21	0.366519	81	1.413717	141	2.460914	21	0.006109	21	0.000102
22	0.383972	82	1.431170	142	2.478368	22	0.006400	22	0.000107
23	0.401426	83	1.448623	143	2.495821	23	0.006690	23	0.000112
24	0.418879	84	1.466077	144	2.513274	24	0.006981	24	0.000116
25	0.436332	85	1.483530	145	2.530727	25	0.007272	25	0.000121
26	0.453786	86	1.500983	146	2.548181	26	0.007563	26	0.000126
27	0.471239	87	1.518436	147	2.565634	27	0.007854	27	0.000131
28	0.488692	88	1.535890	148	2.583087	28	0.008145	28	0.000136
29	0.506145	89	1.553343	149	2.600541	29	0.008436	29	0.000141
30	0.523599	90	1.570796	150	2.617994	30	0.008727	30	0.000145
31	0.541052	91	1.588250	151	2.635447	31	0.009018	31	0.000150
32	0.558505	92	1.605703	152	2.652900	32	0.009308	32	0.000155
33	0.575959	93	1.623156	153	2.670354	33	0.009599	33	0.000160
34	0.593412	94	1.640609	154	2.687807	34	0.009890	34	0.000165
35	0.610865	95	1.658063	155	2.705260	35	0.010181	35	0.000170
36	0.628319	96	1.675516	156	2.722714	36	0.010472	36	0.000175
37	0.645772	97	1.692969	157	2.740167	37	0.010763	37	0.000179
38	0.663225	98	1.710423	158	2.757620	38	0.011054	38	0.000184
39	0.680678	99	1.727876	159	2.775074	39	0.011345	39	0.000189
40	0.698132	100	1.745329	160	2.792527	40	0.011636	40	0.000194
41	0.715585	101	1.762783	161	2.809980	41	0.011926	41	0.000199
42	0.733038	102	1.780236	162	2.827433	42	0.012217	42	0.000204
43	0.750492	103	1.797689	163	2.844887	43	0.012508	43	0.000208
44	0.767945	104	1.815142	164	2.862340	44	0.012799	44	0.000213
45	0.785398	105	1.832596	165	2.879793	45	0.013090	45	0.000218
46	0.802851	106	1.850049	166	2.897247	46	0.013381	46	0.000223
47	0.820305	107	1.867502	167	2.914700	47	0.013672	47	0.000228
48	0.837758	108	1.884956	168	2.932153	48	0.013963	48	0.000233
49	0.855211	109	1.902409	169	2.949606	49	0.014254	49	0.000238
50	0.872665	110	1.919862	170	2.967060	50	0.014544	50	0.000242
51	0.890118	111	1.937315	171	2.984513	51	0.014835	51	0.000247
52	0.907571	112	1.954769	172	3.001966	52	0.015126	52	0.000252
53	0.925025	113	1.972222	173	3.019420	53	0.015417	53	0.000257
54	0.942478	114	1.989675	174	3.036873	54	0.015708	54	0.000262
55	0.959931	115	2.007129	175	3.054326	55	0.015999	55	0.000267
56	0.977384	116	2.024582	176	3.071779	56	0.016290	56	0.000271
57	0.994838	117	2.042035	177	3.089233	57	0.016581	57	0.000276
58	1.012291	118	2.059489	178	3.106686	58	0.016872	58	0.000281
59	1.029744	119	2.076942	179	3.124139	59	0.017162	59	0.000286
60	1.047198	120	2.094395	180	3.141593	60	0.017453	60	0.000291

Θ AS TRIG FUNCTION IS IN DEGREES
Θ AS ARITHMETIC VALUE IS IN RADIANS

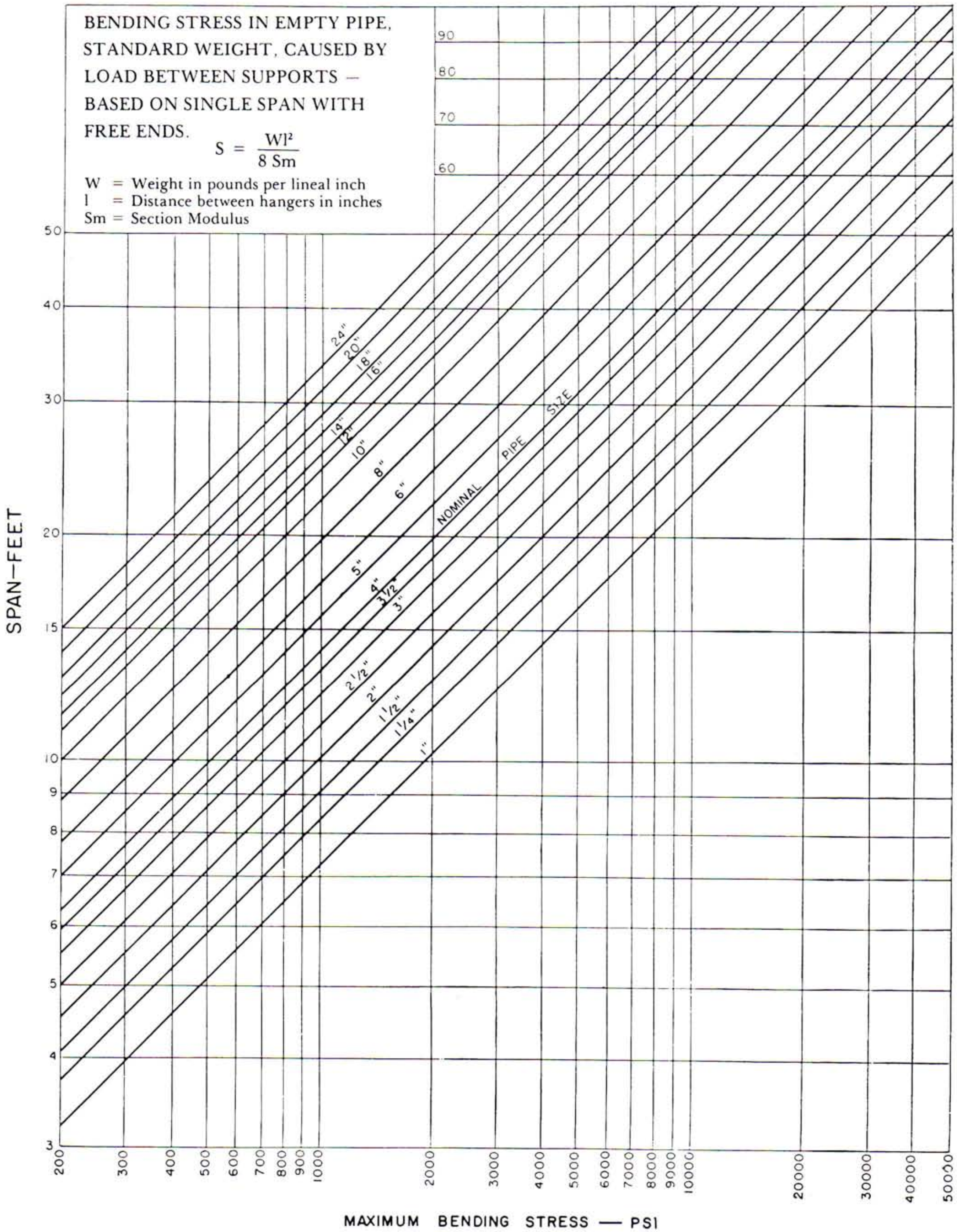




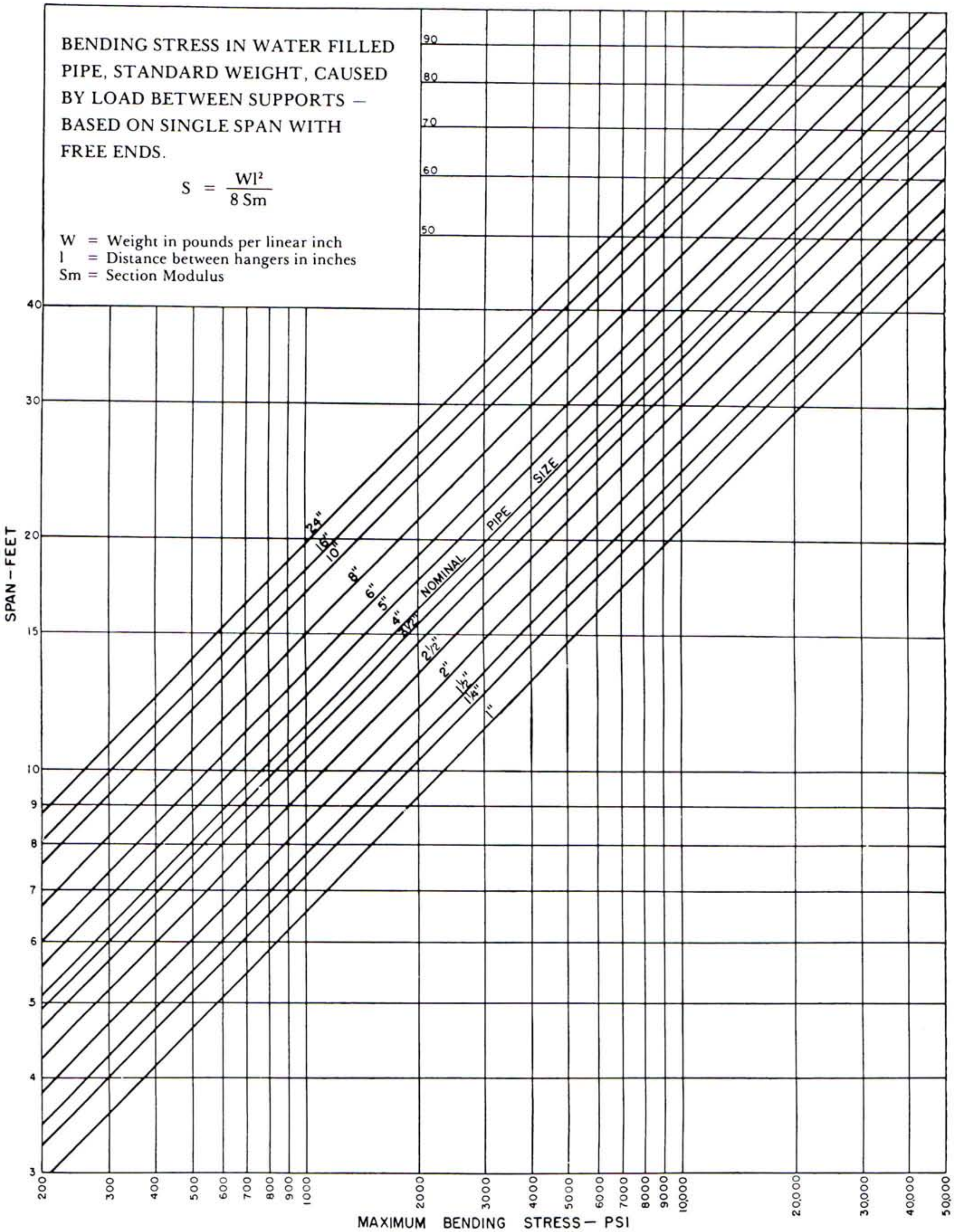


Values are plotted for the pipes empty, since this more nearly approaches the condition that exists for pocketing of condensation. Although the weight of fluid carried by the pipe will cause an increase in the deflection of the pipe between supports, this increased sag disappears during drainage. Therefore, the deflection produced by the weight of empty pipe should be considered in determining slope for drainage.

SEE PAGE 3 FOR EXPLANATION OF CHART USAGE.



SEE PAGE 3 FOR EXPLANATION OF CHART USAGE.



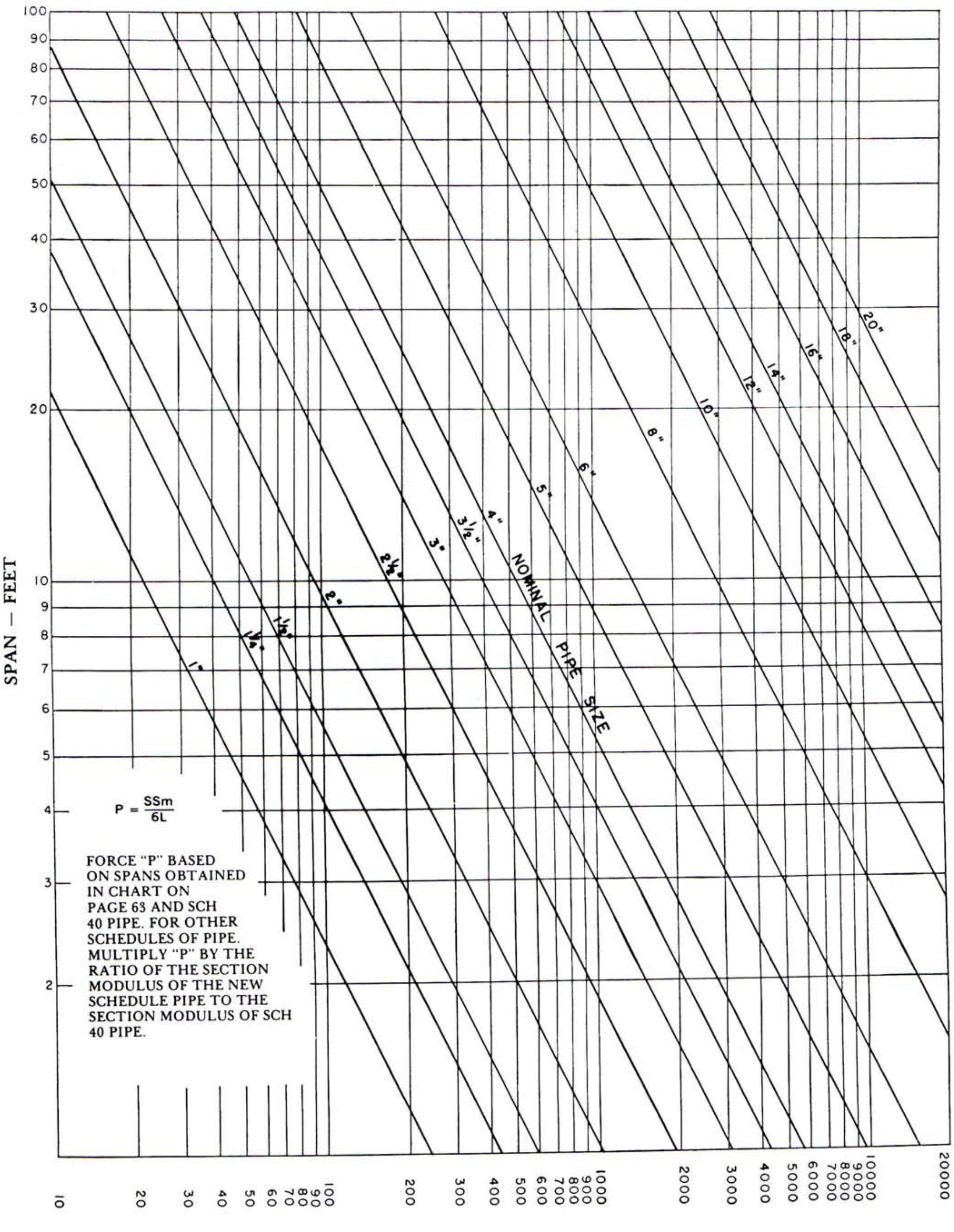
SEE PAGE 3 FOR EXPLANATION OF CHART USAGE.

MINIMUM DISTANCE TO FIRST RIGID HANGER

$$L = \sqrt{\frac{\triangle \times \text{O.D. of Pipe} \times 10^6}{1.6S}}\ ;\ S = 10{,}000 \text{ psi}$$

Deflection	Pipe Size																
	1	1¼	1½	2	2½	3	3½	4	5	6	8	10	12	14	16	18	20
¼	4.5	5.0	5.5	6.0	6.5	7.5	8.0	8.5	9.5	10	11.5	13	14	15	16	17	17.5
½	6.5	7.0	7.5	8.5	9.5	10.5	11	12	13	14.5	16.5	18.5	20	21	22.5	23.5	25
¾	8.0	9.0	9.5	10.5	11.5	13	14	14.5	16	17.5	20	22.5	24.5	25.5	27.5	29	30.5
1	9.0	10	11	12	13.5	15	16	17	18.5	20.5	23	26	28	29.5	31.5	33.5	35.5
1¼	10	11.5	12	13.5	15	16.5	17.5	18.5	21	22.5	26	29	31.5	33	35.5	37.5	39.5
1½	11	12.5	13.5	15	16.5	18	19.5	20.5	23	25	28.5	32	34.5	36	38.5	41	43.5
1¾	12	13.5	14.5	16	17.5	19.5	21	22	24.5	27	30.5	34	37	39	42	44.5	47
2	13	14.5	15.5	17	19	21	22.5	23.5	26.5	29	33	36.5	40	42	44.5	47.5	50
2¼	13.5	15.5	16.5	18.5	20	22	23.5	25	28	30.5	35	39	42.5	44.5	47.5	50.5	53
2½	14.5	16	17	19.5	21	23.5	25	26.5	29.5	32	36.5	41	44.5	47	50	53	56
2¾	15	17	18	20	22	24.5	26	28	31	33.5	38.5	43	47	49	52.5	55.5	58.5
3	15.5	17.5	19	21	23	25.5	27.5	29	32.5	35	40	45	49	51	55	58	61
3½	17	19	20.5	23	25	27.5	29.5	31.5	35	38	43.5	48.5	53	55.5	59	63	66
4	18	20.5	22	24.5	27	29.5	31.5	33.5	37.5	40.5	46.5	52	56.5	59	63	67	70.5
4½	19	21.5	23	26	28.5	31.5	33.5	35.5	39.5	43	49.5	55	60	63	67	71	75
5	20.5	23	24.5	27	30	33	35.5	37.5	41.5	45.5	52	58	63	66	70.5	75	79
5½	21.5	24	25.5	28.5	31.5	34.5	37	39.5	43.5	47.5	54.5	61	66	69.5	74	78.5	83
6	22	25	26.5	30	33	36	38.5	41	45.5	50	57	63.5	69	72.5	77.5	82	86.5

SEE PAGES 16 THROUGH 19 FOR EXPLANATION OF CHART USAGE.



SEE PAGE 16 THROUGH 19 FOR EXPLANATION OF CHART USAGE.

THERMAL EXPANSION OF PIPE MATERIALS — INCHES PER FOOT

Temp. °F	Carbon Steel • Carbon-Moly Steel • Low-Chrome Steel (Thru 3% Cr)										Austenitic Stainless Steels (304, 316, 347)									
	0	10	20	30	40	50	60	70	80	90	0	10	20	30	40	50	60	70	80	90
-200	-.0180	-.0187	-.0192	-.0198	-.0203	-.0209	-.0215	-.0220	-.0225	-.0230	-.0281	-.0295	-.0305	-.0314	-.0324	-.0334	-.0343	-.0353	-.0362	-.0372
-100	-.0121	-.0127	-.0133	-.0140	-.0146	-.0152	-.0158	-.0163	-.0169	-.0174	-.0187	-.0197	-.0207	-.0216	-.0226	-.0236	-.0245	-.0254	-.0263	-.0272
-0	-.0051	-.0058	-.0065	-.0073	-.0080	-.0087	-.0096	-.0103	-.0109	-.0116	-.0078	-.0089	-.0100	-.0112	-.0123	-.0134	-.0145	-.0155	-.0166	-.0176
0	-.0051	-.0044	-.0037	-.0029	-.0022	-.0015	-.0007	.0000	.0008	.0015	-.0078	-.0067	-.0056	-.0044	-.0033	-.0022	-.0011	.0000	.0012	.0023
100	.0023	.0030	.0038	.0046	.0053	.0061	.0068	.0076	.0084	.0091	.0034	.0045	.0056	.0068	.0079	.0090	.0101	.0112	.0124	.0135
200	.0099	.0107	.0116	.0124	.0132	.0141	.0149	.0157	.0165	.0174	.0146	.0158	.0169	.0181	.0192	.0203	.0215	.0227	.0238	.0250
300	.0182	.0191	.0200	.0208	.0217	.0226	.0235	.0244	.0252	.0261	.0261	.0273	.0285	.0297	.0309	.0321	.0332	.0344	.0356	.0368
400	.0270	.0279	.0288	.0298	.0307	.0316	.0325	.0334	.0344	.0353	.0380	.0392	.0404	.0416	.0428	.0440	.0453	.0465	.0477	.0489
500	.0362	.0372	.0382	.0391	.0401	.0411	.0421	.0431	.0440	.0450	.0501	.0513	.0526	.0538	.0550	.0562	.0575	.0587	.0599	.0612
600	.0460	.0470	.0481	.0491	.0501	.0512	.0522	.0532	.0542	.0553	.0624	.0637	.0649	.0662	.0674	.0687	.0700	.0712	.0725	.0737
700	.0563	.0574	.0584	.0595	.0606	.0617	.0627	.0638	.0649	.0659	.0750	.0763	.0776	.0789	.0802	.0815	.0828	.0841	.0854	.0867
800	.0670	.0681	.0692	.0703	.0714	.0726	.0737	.0748	.0759	.0770	.0880	.0893	.0906	.0920	.0933	.0946	.0959	.0972	.0986	.0999
900	.0781	.0792	.0803	.0813	.0824	.0835	.0846	.0857	.0867	.0878	.1012	.1026	.1039	.1053	.1066	.1080	.1094	.1107	.1121	.1134
1000	.0889	.0901	.0912	.0924	.0935	.0946	.0958	.0970	.0981	.0993	.1148	.1162	.1175	.1189	.1202	.1216	.1229	.1243	.1257	.1270
1100	.1004	.1015	.1025	.1036	.1046	.1057	.1068	.1078	.1089	.1099	.1284	.1298	.1311	.1325	.1338	.1352	.1366	.1379	.1393	.1406
1200	.1110	.1121	.1132	.1144	.1155	.1166	.1177	.1188	.1200	.1211	.1420	.1434	.1447	.1461	.1474	.1488	.1502	.1515	.1529	.1542
1300	.1222	.1233	.1244	.1256	.1267	.1278	.1299	.1320	.1342	.1363	.1556	.1570	.1583	.1597	.1610	.1624	.1638	.1651	.1665	.1678
1400	.1334										.1692	.1704	.1717	.1731	.1744	.1757	.1771	.1784	.1796	.1811

THERMAL EXPANSION OF PIPE MATERIALS INCHES PER FOOT

Temp. °F	Intermediate Alloy Steels (5% Thru 9% Cr Mo)	Copper	Brass	Aluminum
−200		−.0275	−.0287	−.0373
−150		−.0231	−.0241	−.0310
−100		−.0183	−.0190	−.0244
−50		−.0132	−.0137	−.0176
0		−.0079	−.0081	−.0104
50		−.0022	−.0023	−.0030
70	0.0000	0.0000	0.0000	0.0000
100	.0022	.0034	.0035	.0046
150	.0058	.0091	.0093	.0123
200	.0094	.0151	.0152	.0200
250	.0132	.0208	.0214	.0283
300	.0171	.0267	.0276	.0366
350	.0210	.0327	.0340	.0452
400	.0250	.0388	.0405	.0539
450	.0292	.0449	.0472	.0628
500	.0335	.0512	.0540	.0717
550	.0379	.0574	.0610	.0810
600	.0424	.0639	.0680	.0903
650	.0469	.0703	.0753	
700	.0514	.0768	.0826	
750	.0562	.0834	.0902	
800	.0610	.0900	.0978	
850	.0658	.0967	.1056	
900	.0707	.1037	.1135	
950	.0756	.1105	.1216	
1000	.0806	.1175	.1298	
1050	.0855			
1100	.0905			
1150	.0952			
1200	.1000			
1250	.1053			
1300	.1106			
1350	.1155			
1400	.1205			

PROPERTIES OF SATURATED STEAM

(Standard Barometer 14.696 psi)

Gauge Pressure, lb/sq in.	Temperature, °F
0	212.00
5	227.14
10	239.39
15	249.75
20	258.76
25	266.78
30	274.02
35	280.62
40	286.71
45	292.37
50	297.66
55	302.62
60	307.32
65	311.77
70	316.00
75	320.03
80	323.90
85	327.59
90	331.15
95	334.57
100	337.88
150	365.85
200	387.78
250	406.01
300	421.71
350	435.59
400	448.12
450	459.59
500	469.99
550	479.93
600	488.79
650	497.29
700	505.15
750	512.75
800	520.92
850	526.97
900	533.63
950	540.26
1000	546.12
1050	551.98
1100	557.84

PROPERTIES OF PIPE

The following formulas are used in the computation of the values shown in the table:

† weight of pipe per foot (pounds) $= 10.6802t(D-t)$
weight of water per foot (pounds) $= 0.3405d^2$
square feet outside surface per foot $= 0.2618D$
square feet inside surface per foot $= 0.2618d$
inside area (square inches) $= 0.785d^2$
area of metal (square inches) $= 0.785(D^2-d^2)$
moment of inertia (inches^4) $= 0.0491(D^4-d^4)$
$= A_m R_g^2$
section modulus (inches^3) $= \dfrac{0.0982(D^4-d^4)}{D}$
radius of gyration (inches) $= 0.25\sqrt{D^2+d^2}$

A_m = area of metal (square inches)
d = inside diameter (inches)
D = outside diameter (inches)
R_g = radius of gyration (inches)
t = pipe wall thickness (inches)

† The ferritic steels may be about 5% less, and the austenitic stainless steels about 2% greater than the values shown in this table which are based on weights for carbon steel.

*** schedule numbers**

Standard weight pipe and schedule 40 are the same in all sizes through 10-inch; from 12-inch through 24-inch, standard weight pipe has a wall thickness of ⅜-inch.

Extra strong weight pipe and schedule 80 are the same in all sizes through 8-inch; from 8-inch through 24-inch, extra strong weight pipe has a wall thickness of ½-inch.

Double extra strong weight pipe has no corresponding schedule number.

a: ANSI B36.10 steel pipe schedule numbers

b: ANSI B36.10 steel pipe nominal wall thickness designation

c: ANSI B36.19 stainless steel pipe schedule numbers

nominal pipe size outside diameter, in.	schedule number* a	b	c	wall thick-ness, in.	inside diam-eter, in.	inside area, sq. in.	metal area, sq. in.	sq ft outside surface, per ft	sq ft inside surface, per ft	weight per ft, lb†	weight of water per ft, lb	moment of inertia, in.^{4}	section modu-lus, in.^{3}	radius gyra-tion, in.
⅛ 0.405	......	......	10S	0.049	0.307	0.0740	0.0548	0.106	0.0804	0.186	0.0321	0.00088	0.00437	0.1271
	40	Std	40S	0.068	0.269	0.0568	0.0720	0.106	0.0705	0.245	0.0246	0.00106	0.00525	0.1215
	80	XS	80S	0.095	0.215	0.0364	0.0925	0.106	0.0563	0.315	0.0157	0.00122	0.00600	0.1146
¼ 0.540	......	......	10S	0.065	0.410	0.1320	0.0970	0.141	0.1073	0.330	0.0572	0.00279	0.01032	0.1694
	40	Std	40S	0.088	0.364	0.1041	0.1250	0.141	0.0955	0.425	0.0451	0.00331	0.01230	0.1628
	80	XS	80S	0.119	0.302	0.0716	0.1574	0.141	0.0794	0.535	0.0310	0.00378	0.01395	0.1547
⅜ 0.675	......	......	5S	0.065	0.710	0.396	0.1582	0.220	0.1859	0.538	0.1716	0.01197	0.0285	0.2750
	......	......	10S	0.065	0.545	0.2333	0.1246	0.177	0.1427	0.423	0.1011	0.00586	0.01737	0.2169
	40	Std	40S	0.091	0.493	0.1910	0.1670	0.177	0.1295	0.568	0.0827	0.00730	0.02160	0.2090
	80	XS	80S	0.126	0.423	0.1405	0.2173	0.177	0.1106	0.739	0.0609	0.00862	0.02554	0.1991
½ 0.840	......	......	5S	0.065	0.710	0.3959	0.1583	0.220	0.1859	0.538	0.171	0.0120	0.0285	0.2750
	......	......	10S	0.083	0.674	0.357	0.1974	0.220	0.1765	0.671	0.1547	0.01431	0.0341	0.2692
	40	Std	40S	0.109	0.622	0.304	0.2503	0.220	0.1628	0.851	0.1316	0.01710	0.0407	0.2613
	80	XS	80S	0.147	0.546	0.2340	0.320	0.220	0.1433	1.088	0.1013	0.02010	0.0478	0.2505
	160	......	......	0.187	0.466	0.1706	0.383	0.220	0.1220	1.304	0.0740	0.02213	0.0527	0.2402
	......	XXS	......	0.294	0.252	0.0499	0.504	0.220	0.0660	1.714	0.0216	0.02425	0.0577	0.2192
¾ 1.050	......	......	5S	0.065	0.920	0.665	0.2011	0.275	0.2409	0.684	0.2882	0.02451	0.0467	0.349
	......	......	10S	0.083	0.884	0.614	0.2521	0.275	0.2314	0.857	0.2661	0.02970	0.0566	0.343
	40	Std	40S	0.113	0.824	0.533	0.333	0.275	0.2157	1.131	0.2301	0.0370	0.0706	0.334
	80	XS	80S	0.154	0.742	0.432	0.435	0.275	0.1943	1.474	0.1875	0.0448	0.0853	0.321
	160	......	......	0.218	0.614	0.2961	0.570	0.275	0.1607	1.937	0.1284	0.0527	0.1004	0.304
	......	XXS	......	0.308	0.434	0.1479	0.718	0.275	0.1137	2.441	0.0641	0.0579	0.1104	0.2840
1 1.315	......	......	5S	0.065	1.185	1.103	0.2553	0.344	0.310	0.868	0.478	0.0500	0.0760	0.443
	......	......	10S	0.109	1.097	0.945	0.413	0.344	0.2872	1.404	0.409	0.0757	0.1151	0.428
	40	Std	40S	0.133	1.049	0.864	0.494	0.344	0.2746	1.679	0.374	0.0874	0.1329	0.421
	80	XS	80S	0.179	0.957	0.719	0.639	0.344	0.2520	2.172	0.311	0.1056	0.1606	0.407
	160	......	......	0.250	0.815	0.522	0.836	0.344	0.2134	2.844	0.2261	0.1252	0.1903	0.387
	......	XXS	......	0.358	0.599	0.2818	1.076	0.344	0.1570	3.659	0.1221	0.1405	0.2137	0.361
1¼ 1.660	......	......	5S	0.065	1.530	1.839	0.326	0.434	0.401	1.107	0.797	0.1038	0.1250	0.564
	......	......	10S	0.109	1.442	1.633	0.531	0.434	0.378	1.805	0.707	0.1605	0.1934	0.550
	40	Std	40S	0.140	1.380	1.496	0.669	0.434	0.361	2.273	0.648	0.1948	0.2346	0.540
	80	XS	80S	0.191	1.278	1.283	0.881	0.434	0.335	2.997	0.555	0.2418	0.2913	0.524
	160	......	......	0.250	1.160	1.057	1.107	0.434	0.304	3.765	0.458	0.2839	0.342	0.506
	......	XXS	......	0.382	0.896	0.631	1.534	0.434	0.2346	5.214	0.2732	0.341	0.411	0.472
1½ 1.900	......	......	5S	0.065	1.770	2.461	0.375	0.497	0.463	1.274	1.067	0.1580	0.1663	0.649
	......	......	10S	0.109	1.682	2.222	0.613	0.497	0.440	2.085	0.962	0.2469	0.2599	0.634

PROPERTIES OF PIPE (Continued)

nominal pipe size outside diameter, in.	schedule number* a	b	c	wall thick-ness, in.	inside diam-eter, in.	inside area, sq. in.	metal area, sq. in.	sq ft outside surface, per ft	sq ft inside surface, per ft	weight per ft, lb†	weight of water per ft, lb	moment of inertia, in.^{4}	section modu-lus, in.^{3}	radius gyra-tion, in.
	40	Std	40S	0.145	1.610	2.036	0.799	0.497	0.421	2.718	0.882	0.310	0.326	0.623
	80	XS	80S	0.200	1.500	1.767	1.068	0.497	0.393	3.631	0.765	0.391	0.412	0.605
1½	160	...	...	0.281	1.338	1.406	1.429	0.497	0.350	4.859	0.608	0.483	0.508	0.581
1.900	...	XXS	...	0.400	1.100	0.950	1.885	0.497	0.288	6.408	0.412	0.568	0.598	0.549
	...	...	...	0.525	0.850	0.567	2.267	0.497	0.223	7.710	0.246	0.6140	0.6470	0.5200
	...	...	...	0.650	0.600	0.283	2.551	0.497	0.157	8.678	0.123	0.6340	0.6670	0.4980
	...	...	5S	0.065	2.245	3.96	0.472	0.622	0.588	1.604	1.716	0.315	0.2652	0.817
	...	...	10S	0.109	2.157	3.65	0.776	0.622	0.565	2.638	1.582	0.499	0.420	0.802
2	40	Std	40S	0.154	2.067	3.36	1.075	0.622	0.541	3.653	1.455	0.666	0.561	0.787
2.375	80	XS	80S	0.218	1.939	2.953	1.477	0.622	0.508	5.022	1.280	0.868	0.731	0.766
	160	...	...	0.343	1.689	2.240	2.190	0.622	0.442	7.444	0.971	1.163	0.979	0.729
	...	XXS	...	0.436	1.503	1.774	2.656	0.622	0.393	9.029	0.769	1.312	1.104	0.703
	...	...	...	0.562	1.251	1.229	3.199	0.622	0.328	10.882	0.533	1.442	1.2140	0.6710
	...	...	...	0.687	1.001	0.787	3.641	0.622	0.262	12.385	0.341	1.5130	1.2740	0.6440
	...	...	5S	0.083	2.709	5.76	0.728	0.753	0.709	2.475	2.499	0.710	0.494	0.988
	...	...	10S	0.120	2.635	5.45	1.039	0.753	0.690	3.531	2.361	0.988	0.687	0.975
	40	Std	40S	0.203	2.469	4.79	1.704	0.753	0.646	5.793	2.076	1.530	1.064	0.947
2½	80	XS	80S	0.276	2.323	4.24	2.254	0.753	0.608	7.661	1.837	1.925	1.339	0.924
2.875	160	...	...	0.375	2.125	3.55	2.945	0.753	0.556	10.01	1.535	2.353	1.637	0.894
	...	XXS	...	0.552	1.771	2.464	4.03	0.753	0.464	13.70	1.067	2.872	1.998	0.844
	...	...	...	0.675	1.525	1.826	4.663	0.753	0.399	15.860	0.792	3.0890	2.1490	0.8140
	...	...	...	0.800	1.275	1.276	5.212	0.753	0.334	17.729	0.554	3.2250	2.2430	0.7860
	...	...	5S	0.083	3.334	8.73	0.891	0.916	0.873	3.03	3.78	1.301	0.744	1.208
	...	...	10S	0.120	3.260	8.35	1.274	0.916	0.853	4.33	3.61	1.822	1.041	1.196
	40	Std	40S	0.216	3.068	7.39	2.228	0.916	0.803	7.58	3.20	3.02	1.724	1.164
3	80	XS	80S	0.300	2.900	6.61	3.02	0.916	0.759	10.25	2.864	3.90	2.226	1.136
3.500	160	...	...	0.437	2.626	5.42	4.21	0.916	0.687	14.32	2.348	5.03	2.876	1.094
	...	XXS	...	0.600	2.300	4.15	5.47	0.916	0.602	18.58	1.801	5.99	3.43	1.047
	...	...	...	0.725	2.050	3.299	6.317	0.916	0.537	21.487	1.431	6.5010	3.7150	1.0140
	...	...	...	0.850	1.800	2.543	7.073	0.916	0.471	24.057	1.103	6.8530	3.9160	0.9840
	...	...	5S	0.083	3.834	11.55	1.021	1.047	1.004	3.47	5.01	1.960	0.980	1.385
3½	...	...	10S	0.120	3.760	11.10	1.463	1.047	0.984	4.97	4.81	2.756	1.378	1.372
4.000	40	Std	40S	0.226	3.548	9.89	2.680	1.047	0.929	9.11	4.28	4.79	2.394	1.337
	80	XS	80S	0.318	3.364	8.89	3.68	1.047	0.881	12.51	3.85	6.28	3.14	1.307
	...	XXS	...	0.636	2.728	5.845	6.721	1.047	0.716	22.850	2.530	9.8480	4.9240	1.2100
	...	...	5S	0.083	4.334	14.75	1.152	1.178	1.135	3.92	6.40	2.811	1.249	1.562
	...	...	10S	0.120	4.260	14.25	1.651	1.178	1.115	5.61	6.17	3.96	1.762	1.549
	...	...	...	0.188	4.124	13.357	2.547	1.178	1.082	8.560	5.800	5.8500	2.6000	1.5250
	40	Std	40S	0.237	4.026	12.73	3.17	1.178	1.054	10.79	5.51	7.23	3.21	1.510
4	80	XS	80S	0.337	3.826	11.50	4.41	1.178	1.002	14.98	4.98	9.61	4.27	1.477
4.500	120	...	...	0.437	3.626	10.33	5.58	1.178	0.949	18.96	4.48	11.65	5.18	1.445
	...	...	...	0.500	3.500	9.621	6.283	1.178	0.916	21.360	4.160	12.7710	5.6760	1.4250
	160	...	...	0.531	3.438	9.28	6.62	1.178	0.900	22.51	4.02	13.27	5.90	1.416
	...	XXS	...	0.674	3.152	7.80	8.10	1.178	0.825	27.54	3.38	15.29	6.79	1.374
	...	...	...	0.800	2.900	6.602	9.294	1.178	0.759	31.613	2.864	16.6610	7.4050	1.3380
	...	...	...	0.925	2.650	5.513	10.384	1.178	0.694	35.318	2.391	17.7130	7.8720	1.3060
	...	...	5S	0.109	5.345	22.44	1.868	1.456	1.399	6.35	9.73	6.95	2.498	1.929
	...	...	10S	0.134	5.295	22.02	2.285	1.456	1.386	7.77	9.53	8.43	3.03	1.920
	40	Std	40S	0.258	5.047	20.01	4.30	1.456	1.321	14.62	8.66	15.17	5.45	1.878
5	80	XS	80S	0.375	4.813	18.19	6.11	1.456	1.260	20.78	7.89	20.68	7.43	1.839
5.563	120	...	...	0.500	4.563	16.35	7.95	1.456	1.195	27.04	7.09	25.74	9.25	1.799
	160	...	...	0.625	4.313	14.61	9.70	1.456	1.129	32.96	6.33	30.0	10.80	1.760
	...	XXS	...	0.750	4.063	12.97	11.34	1.456	1.064	38.55	5.62	33.6	12.10	1.722
	...	...	...	0.875	3.813	11.413	12.880	1.456	0.998	43.810	4.951	36.6450	13.1750	1.6860
	...	...	...	1.000	3.563	9.966	14.328	1.456	0.933	47.734	4.232	39.1110	14.0610	1.6520

PROPERTIES OF PIPE (Continued)

nominal pipe size *outside diameter,* in.	schedule number* a	b	c	wall thickness, in.	inside diameter, in.	inside area, sq. in.	metal area, sq. in.	sq ft outside surface, per ft	sq ft inside surface, per ft	weight per ft, lb†	weight of water per ft, lb	moment of inertia, in.⁴	section modulus, in.³	radius gyration, in.
			5S	0.109	6.407	32.2	2.231	1.734	1.677	5.37	13.98	11.85	3.58	2.304
			10S	0.134	6.357	31.7	2.733	1.734	1.664	9.29	13.74	14.40	4.35	2.295
				0.219	6.187	30.100	4.410	1.734	1.620	15.020	13.100	22.6600	6.8400	2.2700
	40	Std	40S	0.280	6.065	28.89	5.58	1.734	1.588	18.97	12.51	28.14	8.50	2.245
6	80	XS	80S	0.432	5.761	26.07	8.40	1.734	1.508	28.57	11.29	40.5	12.23	2.195
6.625	120			0.562	5.501	23.77	10.70	1.734	1.440	36.39	10.30	49.6	14.98	2.153
	160			0.718	5.189	21.15	13.33	1.734	1.358	45.30	9.16	59.0	17.81	2.104
		XXS		0.864	4.897	18.83	15.64	1.734	1.282	53.16	8.17	66.3	20.03	2.060
				1.000	4.625	16.792	17.662	1.734	1.211	60.076	7.284	72.1190	21.7720	2.0200
				1.125	4.375	15.025	19.429	1.734	1.145	66.084	6.517	76.5970	23.1240	1.9850
			5S	0.109	8.407	55.5	2.916	2.258	2.201	9.91	24.07	26.45	6.13	3.01
			10S	0.148	8.329	54.5	3.94	2.258	2.180	13.40	23.59	35.4	8.21	3.00
				0.219	8.187	52.630	5.800	2.258	2.150	19.640	22.900	51.3200	11.9000	2.9700
8	20			0.250	8.125	51.8	6.58	2.258	2.127	22.36	22.48	57.7	13.39	2.962
8.625	30			0.277	8.071	51.2	7.26	2.258	2.113	24.70	22.18	63.4	14.69	2.953
	40	Std	40S	0.322	7.981	50.0	8.40	2.258	2.089	28.55	21.69	72.5	16.81	2.938
	60			0.406	7.813	47.9	10.48	2.258	2.045	35.64	20.79	88.8	20.58	2.909
	80	XS	80S	0.500	7.625	45.7	12.76	2.258	1.996	43.39	19.80	105.7	24.52	2.878
	100			0.593	7.439	43.5	14.96	2.258	1.948	50.87	18.84	121.4	28.14	2.847
	120			0.718	7.189	40.6	17.84	2.258	1.882	60.63	17.60	140.6	32.6	2.807
8	140			0.812	7.001	38.5	19.93	2.258	1.833	67.76	16.69	153.8	35.7	2.777
8.625	160			0.906	6.813	36.5	21.97	2.258	1.784	74.69	15.80	165.9	38.5	2.748
				1.000	6.625	34.454	23.942	2.258	1.734	81.437	14.945	177.1320	41.0740	2.7190
				1.125	6.375	31.903	26.494	2.258	1.669	90.114	13.838	190.6210	44.2020	2.6810
			5S	0.134	10.482	86.3	4.52	2.815	2.744	15.15	37.4	63.7	11.85	3.75
			10S	0.165	10.420	85.3	5.49	2.815	2.728	18.70	36.9	76.9	14.30	3.74
				0.219	10.312	83.52	7.24	2.815	2.70	24.63	36.2	100.46	18.69	3.72
	20			0.250	10.250	82.5	8.26	2.815	2.683	28.04	35.8	113.7	21.16	3.71
	30			0.307	10.136	80.7	10.07	2.815	2.654	34.24	35.0	137.5	25.57	3.69
	40	Std	40S	0.365	10.020	78.9	11.91	2.815	2.623	40.48	34.1	160.8	29.90	3.67
10	60	XS	80S	0.500	9.750	74.7	16.10	2.815	2.553	54.74	32.3	212.0	39.4	3.63
10.750	80			0.593	9.564	71.8	18.92	2.815	2.504	64.33	31.1	244.9	45.6	3.60
	100			0.718	9.314	68.1	22.63	2.815	2.438	76.93	29.5	286.2	53.2	3.56
	120			0.843	9.064	64.5	26.24	2.815	2.373	89.20	28.0	324	60.3	3.52
				0.875	9.000	63.62	27.14	2.815	2.36	92.28	27.6	333.46	62.04	3.50
	140			1.000	8.750	60.1	30.6	2.815	2.291	104.13	26.1	368	68.4	3.47
	160			1.125	8.500	56.7	34.0	2.815	2.225	115.65	24.6	399	74.3	3.43
				1.250	8.250	53.45	37.31	2.815	2.16	126.82	23.2	428.17	79.66	3.39
				1.500	7.750	47.15	43.57	2.815	2.03	148.19	20.5	478.59	89.04	3.31
			5S	0.156	12.438	121.4	6.17	3.34	3.26	20.99	52.7	122.2	19.20	4.45
			10S	0.180	12.390	120.6	7.11	3.34	3.24	24.20	52.2	140.5	22.03	4.44
	20			0.250	12.250	117.9	9.84	3.34	3.21	33.38	51.1	191.9	30.1	4.42
	30			0.330	12.090	114.8	12.88	3.34	3.17	43.77	49.7	248.5	39.0	4.39
		Std	40S	0.375	12.000	113.1	14.58	3.34	3.14	49.56	49.0	279.3	43.8	4.38
	40			0.406	11.938	111.9	15.74	3.34	3.13	53.53	48.5	300	47.1	4.37
		XS	80S	0.500	11.750	108.4	19.24	3.34	3.08	65.42	47.0	362	56.7	4.33
12	60			0.562	11.626	106.2	21.52	3.34	3.04	73.16	46.0	401	62.8	4.31
12.750	80			0.687	11.376	101.6	26.04	3.34	2.978	88.51	44.0	475	74.5	4.27
				0.750	11.250	99.40	28.27	3.34	2.94	96.2	43.1	510.7	80.1	4.25
	100			0.843	11.064	96.1	31.5	3.34	2.897	107.20	41.6	562	88.1	4.22
				0.875	11.000	95.00	32.64	3.34	2.88	110.9	41.1	578.5	90.7	4.21
	120			1.000	10.750	90.8	36.9	3.34	2.814	125.49	39.3	642	100.7	4.17
	140			1.125	10.500	86.6	41.1	3.34	2.749	139.68	37.5	701	109.9	4.13
				1.250	10.250	82.50	45.16	3.34	2.68	153.6	35.8	755.5	118.5	4.09
	160			1.312	10.126	80.5	47.1	3.34	2.651	160.27	34.9	781	122.6	4.07

PROPERTIES OF PIPE (Continued)

nominal pipe size *outside diameter,* in.	schedule number* a	b	c	wall thickness, in.	inside diameter, in.	inside area, sq. in.	metal area, sq. in.	sq ft outside surface, per ft	sq ft inside surface, per ft.	weight per ft, lb†	weight of water per ft, lb	moment of inertia, in.^{4}	section modulus, in.^{3}	radius gyration, in.
	....	....	5S	0.156	13.688	147.20	6.78	3.67	3.58	23.0	63.7	162.6	23.2	4.90
	....	....	10S	0.188	13.624	145.80	8.16	3.67	3.57	27.7	63.1	194.6	27.8	4.88
	....	....	....	0.210	13.580	144.80	9.10	3.67	3.55	30.9	62.8	216.2	30.9	4.87
	....	....	....	0.219	13.562	144.50	9.48	3.67	3.55	32.2	62.6	225.1	32.2	4.87
	10	....	....	0.250	13.500	143.1	10.80	3.67	3.53	36.71	62.1	255.4	36.5	4.86
	....	....	....	0.281	13.438	141.80	12.11	3.67	3.52	41.2	61.5	285.2	40.7	4.85
	20	....	....	0.312	13.376	140.5	13.42	3.67	3.50	45.68	60.9	314	44.9	4.84
	....	....	....	0.344	13.312	139.20	14.76	3.67	3.48	50.2	60.3	344.3	49.2	4.83
14	30	Std	....	0.375	13.250	137.9	16.05	3.67	3.47	54.57	59.7	373	53.3	4.82
14.000	40	....	....	0.437	13.126	135.3	18.62	3.67	3.44	63.37	58.7	429	61.2	4.80
	....	....	....	0.469	13.062	134.00	19.94	3.67	3.42	67.8	58.0	456.8	65.3	4.79
	....	XS	....	0.500	13.000	132.7	21.21	3.67	3.40	72.09	57.5	484	69.1	4.78
	60	....	....	0.593	12.814	129.0	24.98	3.67	3.35	84.91	55.9	562	80.3	4.74
	....	....	....	0.625	12.750	127.7	26.26	3.67	3.34	89.28	55.3	589	84.1	4.73
	80	....	....	0.750	12.500	122.7	31.2	3.67	3.27	106.13	53.2	687	98.2	4.69
	100	....	....	0.937	12.126	115.5	38.5	3.67	3.17	130.73	50.0	825	117.8	4.63
	120	....	....	1.093	11.814	109.6	44.3	3.67	3.09	150.67	47.5	930	132.8	4.58
	140	....	....	1.250	11.500	103.9	50.1	3.67	3.01	170.22	45.0	1127	146.8	4.53
	160	....	....	1.406	11.188	98.3	55.6	3.67	2.929	189.12	42.6	1017	159.6	4.48
	....	....	5S	0.165	15.670	192.90	8.21	4.19	4.10	28	83.5	257	32.2	5.60
	....	....	10S	0.188	15.624	191.70	9.34	4.19	4.09	32	83.0	292	36.5	5.59
	10	....	....	0.250	15.500	188.7	12.37	4.19	4.06	42.05	81.8	384	48.0	5.57
	20	....	....	0.312	15.376	185.7	15.38	4.19	4.03	52.36	80.5	473	59.2	5.55
	30	Std	....	0.375	15.250	182.6	18.41	4.19	3.99	62.58	79.1	562	70.3	5.53
16	40	XS	....	0.500	15.000	176.7	24.35	4.19	3.93	82.77	76.5	732	91.5	5.48
16.000	60	....	....	0.656	14.688	169.4	31.6	4.19	3.85	107.50	73.4	953	116.6	5.43
	80	....	....	0.843	14.314	160.9	40.1	4.19	3.75	136.46	69.7	1157	144.6	5.37
	100	....	....	1.031	13.938	152.6	48.5	4.19	3.65	164.83	66.1	1365	170.6	5.30
	120	....	....	1.218	13.564	144.5	56.6	4.19	3.55	192.29	62.6	1556	194.5	5.24
	140	....	....	1.437	13.126	135.3	65.7	4.19	3.44	223.64	58.6	1760	220.0	5.17
	160	....	....	1.593	12.814	129.0	72.1	4.19	3.35	245.11	55.9	1894	236.7	5.12
	....	....	5S	0.165	17.670	245.20	9.24	4.71	4.63	31	106.2	368	40.8	6.31
	....	....	10S	0.188	17.624	243.90	10.52	4.71	4.61	36	105.7	417	46.4	6.30
	10	....	....	0.250	17.500	240.5	13.94	4.71	4.58	47.39	104.3	549	61.0	6.28
	20	....	....	0.312	17.376	237.1	17.34	4.71	4.55	59.03	102.8	678	75.5	6.25
	....	Std	....	0.375	17.250	233.7	20.76	4.71	4.52	70.59	101.2	807	89.6	6.23
18	30	....	....	0.437	17.126	230.4	24.11	4.71	4.48	82.06	99.9	931	103.4	6.21
	....	XS	....	0.500	17.00	227.0	27.49	4.71	4.45	93.45	98.4	1053	117.0	6.19
18.000	40	....	....	0.562	16.876	223.7	30.8	4.71	4.42	104.75	97.0	1172	130.2	6.17
	60	....	....	0.750	16.500	213.8	40.6	4.71	4.32	138.17	92.7	1515	168.3	6.10
	80	....	....	0.937	16.126	204.2	50.2	4.71	4.22	170.75	88.5	1834	203.8	6.04
	100	....	....	1.156	15.688	193.3	61.2	4.71	4.11	207.96	83.7	2180	242.2	5.97
	120	....	....	1.375	15.250	182.6	71.8	4.71	3.99	244.14	79.2	2499	277.6	5.90
	140	....	....	1.562	14.876	173.8	80.7	4.71	3.89	274.23	75.3	2750	306	5.84
	160	....	....	1.781	14.438	163.7	90.7	4.71	3.78	308.51	71.0	3020	336	5.77
	....	....	5S	0.188	19.634	302.40	11.70	5.24	5.14	40	131.0	574	57.4	7.00
	....	....	10S	0.218	19.564	300.60	13.55	5.24	5.12	46	130.2	663	66.3	6.99
	10	....	....	0.250	19.500	298.6	15.51	5.24	5.11	52.73	129.5	757	75.7	6.98
	20	Std	....	0.375	19.250	291.0	23.12	5.24	5.04	78.60	126.0	1114	111.4	6.94
20	30	XS	....	0.500	19.000	283.5	30.6	5.24	4.97	104.13	122.8	1457	145.7	6.90
20.000	40	....	....	0.593	18.814	278.0	36.2	5.24	4.93	122.91	120.4	1704	170.4	6.86
	60	....	....	0.812	18.376	265.2	48.9	5.24	4.81	166.40	115.0	2257	225.7	6.79
	....	....	....	0.875	18.250	261.6	52.6	5.24	4.78	178.73	113.4	2409	240.9	6.77
	80	....	....	1.031	17.938	252.7	61.4	5.24	4.70	208.87	109.4	2772	277.2	6.72
	100	....	....	1.281	17.438	238.8	75.3	5.24	4.57	256.10	103.4	3320	332	6.63

PROPERTIES OF PIPE (Continued)

nominal pipe size *outside diameter,* in.	schedule number* a	b	c	wall thickness, in.	inside diameter, in.	inside area, sq in.	metal area, sq in.	sq ft outside surface, per ft	sq ft inside surface, per ft	weight per ft, lb†	weight of water per ft, lb	moment of inertia, in.[4]	section modulus, in.[3]	radius gyration, in.
20 *20.000*	120			1.500	17.000	227.0	87.2	5.24	4.45	296.37	98.3	3760	376	6.56
	140			1.750	16.500	213.8	100.3	5.24	4.32	341.10	92.6	4220	422	6.48
	160			1.968	16.064	202.7	111.5	5.24	4.21	379.01	87.9	4590	459	6.41
22 *22.000*			5S	0.188	21.624	367.3	12.88	5.76	5.66	44	159.1	766	69.7	7.71
			10S	0.218	21.564	365.2	14.92	5.76	5.65	51	158.2	885	80.4	7.70
	10			0.250	21.500	363.1	17.18	5.76	5.63	58	157.4	1010	91.8	7.69
	20	Std		0.375	21.250	354.7	25.48	5.76	5.56	87	153.7	1490	135.4	7.65
	30	XS		0.500	21.000	346.4	33.77	5.76	5.50	115	150.2	1953	177.5	7.61
				0.625	20.750	338.2	41.97	5.76	5.43	143	146.6	2400	218.2	7.56
				0.750	20.500	330.1	50.07	5.76	5.37	170	143.1	2829	257.2	7.52
	60			0.875	20.250	322.1	58.07	5.76	5.30	197	139.6	3245	295.0	7.47
	80			1.125	19.750	306.4	73.78	5.76	5.17	251	132.8	4029	366.3	7.39
	100			1.375	19.250	291.0	89.09	5.76	5.04	303	126.2	4758	432.6	7.31
	120			1.625	18.750	276.1	104.02	5.76	4.91	354	119.6	5432	493.8	7.23
	140			1.875	18.250	261.6	118.55	5.76	4.78	403	113.3	6054	550.3	7.15
	160			2.125	17.750	247.4	132.68	5.76	4.65	451	107.2	6626	602.4	7.07
24 *24.000*	10			0.250	23.500	434	18.65	6.28	6.15	63.41	188.0	1316	109.6	8.40
	20	Std		0.375	23.250	425	27.83	6.28	6.09	94.62	183.8	1943	161.9	8.35
		XS		0.500	23.000	415	36.9	6.28	6.02	125.49	180.1	2550	212.5	8.31
	30			0.562	22.876	411	41.4	6.28	5.99	140.80	178.1	2840	237.0	8.29
				0.625	22.750	406	45.9	6.28	5.96	156.03	176.2	3140	261.4	8.27
	40			0.687	22.626	402	50.3	6.28	5.92	171.17	174.3	3420	285.2	8.25
				0.750	22.500	398	54.8	6.28	5.89	186.24	172.4	3710	309	8.22
			5S	0.218	23.564	436.1	16.29	6.28	6.17	55	188.9	1152	96.0	8.41
				0.875	22.250	388.6	63.54	6.28	5.83	216	168.6	4256	354.7	8.18
	60			0.968	22.064	382	70.0	6.28	5.78	238.11	165.8	4650	388	8.15
	80			1.218	21.564	365	87.2	6.28	5.65	296.36	158.3	5670	473	8.07
	100			1.531	20.938	344	108.1	6.28	5.48	367.40	149.3	6850	571	7.96
	120			1.812	20.376	326	126.3	6.28	5.33	429.39	141.4	7830	652	7.87
	140			2.062	19.876	310	142.1	6.28	5.20	483.13	134.5	8630	719	7.79
	160			2.343	19.314	293	159.4	6.28	5.06	541.94	127.0	9460	788	7.70
26 *26.000*				0.250	25.500	510.7	19.85	6.81	6.68	67	221.4	1646	126.6	9.10
	10			0.312	25.376	505.8	25.18	6.81	6.64	86	219.2	2076	159.7	9.08
		Std		0.375	25.250	500.7	30.19	6.81	6.61	103	217.1	2478	190.6	9.06
	20	XS		0.500	25.000	490.9	40.06	6.81	6.54	136	212.8	3259	250.7	9.02
				0.625	24.750	481.1	49.82	6.81	6.48	169	208.6	4013	308.7	8.98
				0.750	24.500	471.4	59.49	6.81	6.41	202	204.4	4744	364.9	8.93
				0.875	24.250	461.9	69.07	6.81	6.35	235	200.2	5458	419.9	8.89
				1.000	24.000	452.4	78.54	6.81	6.28	267	196.1	6149	473.0	8.85
				1.125	23.750	443.0	87.91	6.81	6.22	299	192.1	6813	524.1	8.80
28 *28.000*				0.250	27.500	594.0	21.80	7.33	7.20	74	257.3	2098	149.8	9.81
	10			0.312	27.376	588.6	27.14	7.33	7.17	92	255.0	2601	185.8	9.79
		Std		0.375	27.250	583.2	32.54	7.33	7.13	111	252.6	3105	221.8	9.77
	20	XS		0.500	27.000	572.6	43.20	7.33	7.07	147	248.0	4085	291.8	9.72
	30			0.625	26.750	562.0	53.75	7.33	7.00	183	243.4	5038	359.8	9.68
				0.750	26.500	551.6	64.21	7.33	6.94	218	238.9	5964	426.0	9.64
				0.875	26.250	541.2	74.56	7.33	6.87	253	234.4	6865	490.3	9.60
				1.000	26.000	530.9	84.82	7.33	6.81	288	230.0	7740	552.8	9.55
				1.125	25.750	520.8	94.98	7.33	6.74	323	225.6	8590	613.6	9.51
30 *30.000*			5S	0.250	29.500	683.4	23.37	7.85	7.72	79	296.3	2585	172.3	10.52
	10		10S	0.312	29.376	677.8	29.19	7.85	7.69	99	293.7	3201	213.4	10.50
		Std		0.375	29.250	672.0	34.90	7.85	7.66	119	291.2	3823	254.8	10.48
	20	XS		0.500	29.000	660.5	46.34	7.85	7.59	158	286.2	5033	335.5	10.43
	30			0.625	28.750	649.2	57.68	7.85	7.53	196	281.3	6213	414.2	10.39

PROPERTIES OF PIPE (Continued)

nominal pipe size *outside diameter,* in.	schedule number* a	b	c	wall thick-ness, in.	inside diam-eter, in.	inside area, sq. in.	metal area, sq. in.	sq ft outside surface, per ft	sq ft inside surface, per ft	weight per ft, lb†	weight of water per ft lb	moment of inertia, in.⁴	section modu-lus, in.³	radius gyra-tion, in.
	40			0.750	28.500	637.9	68.92	7.85	7.46	234	276.6	7371	491.4	10.34
30				0.875	28.250	620.7	80.06	7.85	7.39	272	271.8	8494	566.2	10.30
30.000				1.000	28.000	615.7	91.11	7.85	7.33	310	267.0	9591	639.4	10.26
				1.125	27.750	604.7	102.05	7.85	7.26	347	262.2	10653	710.2	10.22
				0.250	31.500	779.2	24.93	8.38	8.25	85	337.8	3141	196.3	11.22
	10			0.312	31.376	773.2	31.02	8.38	8.21	106	335.2	3891	243.2	11.20
		Std		0.375	31.250	766.9	37.25	8.38	8.18	127	332.5	4656	291.0	11.18
	20	XS		0.500	31.000	754.7	49.48	8.38	8.11	168	327.2	6140	383.8	11.14
32	30			0.625	30.750	742.5	61.59	8.38	8.05	209	321.9	7578	473.6	11.09
32.000	40			0.688	30.624	736.6	67.68	8.38	8.02	230	319.0	8298	518.6	11.07
				0.750	30.500	730.5	73.63	8.38	7.98	250	316.7	8990	561.9	11.05
				0.875	30.250	718.3	85.52	8.38	7.92	291	311.6	10372	648.2	11.01
				1.000	30.000	706.8	97.38	8.38	7.85	331	306.4	11680	730.0	10.95
				1.125	29.750	694.7	109.0	8.38	7.79	371	301.3	13023	814.0	10.92
				0.250	33.500	881.2	26.50	8.90	8.77	90	382.0	3773	221.9	11.93
	10			0.312	33.376	874.9	32.99	8.90	8.74	112	379.3	4680	275.3	11.91
		Std		0.375	33.250	867.8	39.61	8.90	8.70	135	376.2	5597	329.2	11.89
	20	XS		0.500	33.000	855.3	52.62	8.90	8.64	179	370.8	7385	434.4	11.85
34	30			0.625	32.750	841.9	65.53	8.90	8.57	223	365.0	9124	536.7	11.80
34.000	40			0.688	32.624	835.9	72.00	8.90	8.54	245	362.1	9992	587.8	11.78
				0.750	32.500	829.3	78.34	8.90	8.51	266	359.5	10829	637.0	11.76
				0.875	32.250	816.4	91.01	8.90	8.44	310	354.1	12501	735.4	11.72
				1.000	32.000	804.2	103.67	8.90	8.38	353	348.6	14114	830.2	11.67
				1.125	31.750	791.3	116.13	8.90	8.31	395	343.2	15719	924.7	11.63
				0.250	35.500	989.7	28.11	9.42	9.29	96	429.1	4491	249.5	12.64
	10			0.312	35.376	982.9	34.95	9.42	9.26	119	426.1	5565	309.1	12.62
		Std		0.375	35.250	975.8	42.01	9.42	9.23	143	423.1	6664	370.2	12.59
36	20	XS		0.500	35.000	962.1	55.76	9.42	9.16	190	417.1	8785	488.1	12.55
36.000	30			0.625	34.750	948.3	69.50	9.42	9.10	236	411.1	10872	604.0	12.51
	40			0.750	34.500	934.7	83.01	9.42	9.03	282	405.3	12898	716.5	12.46
				0.875	34.250	920.6	96.50	9.42	8.97	328	399.4	14903	827.9	12.42
				1.000	34.000	907.9	109.96	9.42	8.90	374	393.6	16851	936.2	12.38
				1.125	33.750	894.2	123.19	9.42	8.89	419	387.9	18763	1042.4	12.34
				0.250	41.500	1352.6	32.82	10.99	10.86	112	586.4	7126	339.3	14.73
		Std		0.375	41.250	1336.3	49.08	10.99	10.80	167	579.3	10627	506.1	14.71
	20	XS		0.500	41.000	1320.2	65.18	10.99	10.73	222	572.3	14037	668.4	14.67
42	30			0.625	40.750	1304.1	81.28	10.99	10.67	276	565.4	17373	827.3	14.62
42.000	40			0.750	40.500	1288.2	97.23	10.99	10.60	330	558.4	20689	985.2	14.59
				1.000	40.000	1256.6	128.81	10.99	10.47	438	544.8	27080	1289.5	14.50
				1.250	39.500	1225.3	160.03	10.99	10.34	544	531.2	33233	1582.5	14.41
				1.500	39.000	1194.5	190.85	10.99	10.21	649	517.9	39181	1865.7	14.33

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