

EXPANSION AND FLEXIBILITY

The increase in temperature of a pipe from room temperature to an operating steam or water temperature 100 F or more above room temperature results in an increase in length of the pipe for which provision must be made. The amount of linear expansion (or contraction in the case of refrigeration lines) per unit length of material per degree change in temperature is termed the *coefficient of linear expansion* of that material, or commonly, the *coefficient of expansion*. This coefficient varies with the material.

The linear expansion of cast-iron, steel, wrought-iron, and copper pipe, the materials most frequently used in heating and ventilating work, can be determined from Table 4.

The three methods by which the elongation due to thermal expansion may be taken care of are:

1. Expansion joints.
2. Swivel joints.
3. Inherent flexibility of the pipe itself utilized through pipe bends, right-angle turns, or offsets in the line.

Expansion joints of the slip-sleeve, diaphragm, or corrugated types made of copper, rubber, or other gasket material are all used for taking up expansion, but generally only for low pressures or where the inherent flexibility of the pipe cannot readily be used as in underground steam or hot water distribution lines.

Swivel joints are used to some extent in low-pressure steam and hot-water heating systems, and in hot-water supply lines. Since swivel joints

TABLE 4. THERMAL EXPANSION OF PIPE IN INCHES PER 100 FT^a
(For superheated steam and other fluids refer to temperature column)

SATURATED STEAM			ELONGATION IN INCHES PER 100 FT FROM -20 F UP				SATURATED STEAM		ELONGATION IN INCHES PER 100 FT FROM -20 F UP			
Vacuum Inches of Hg.	Pressure Pounds per Square Inch Gage	Temperature Degrees Fahrenheit	Cast-Iron Pipe	Steel Pipe	Wrought-Iron Pipe	Copper Pipe	Pressure Pounds per Square Inch Gage	Temperature Degrees Fahrenheit	Cast-Iron Pipe	Steel Pipe	Wrought-Iron Pipe	Copper Pipe
		-20	0	0	0	0	2.5	220	1.634	1.852	1.936	2.720
		0	0.127	0.145	0.152	0.204	10.3	240	1.780	2.020	2.110	2.960
		20	0.255	0.293	0.306	0.442	20.7	260	1.931	2.183	2.279	3.189
		40	0.390	0.430	0.465	0.655	34.5	280	2.085	2.350	2.465	3.422
29.39		60	0.518	0.593	0.620	0.888	52.3	300	2.233	2.519	2.630	3.665
28.89		80	0.649	0.725	0.780	1.100	74.9	320	2.395	2.690	2.800	3.900
27.99		100	0.787	0.898	0.939	1.338	103.3	340	2.543	2.862	2.988	4.145
26.48		120	0.926	1.055	1.110	1.570	138.3	360	2.700	3.029	3.175	4.380
24.04		140	1.051	1.209	1.265	1.794	180.9	380	2.859	3.211	3.350	4.628
20.27		160	1.200	1.368	1.427	2.008	232.4	400	3.008	3.375	3.521	4.870
14.63		180	1.345	1.528	1.597	2.255	293.7	420	3.182	3.566	3.720	5.118
6.45		200	1.495	1.691	1.778	2.500	366.1	440	3.345	3.740	3.900	5.358

^aFrom *Piping Handbook*, by Walker and Crocker. This table gives the expansion from -20 F to the temperature in question. To obtain the amount of expansion between any two temperatures take the difference between the figures in the table for those temperatures. For example, if a steel pipe is installed at a temperature of 60 F and is to operate at 300 F, the expansion would be 2.519 - 0.593 = 1.926 in.

permit the expansive movement of the pipe by turning of threaded joints, which may ultimately result in a leak, it is preferable to provide sufficient flexibility without resorting to swiveling in the threads.

Probably the most economical method of providing for expansion of piping in a long run is to take advantage of the directional changes which must necessarily occur in the piping and proportion the offsets so that sufficient flexibility is secured. Ninety-degree bends with long, straight tangents in either a horizontal or a vertical plane are an excellent means for securing adequate flexibility with larger sizes of pipe. When flexibility cannot be obtained in this manner, it is necessary to make use of some type of expansion bend. The exact calculation of the size of expansion bends required to take up a given amount of thermal expansion is relatively complicated¹. The following approximate method, however,

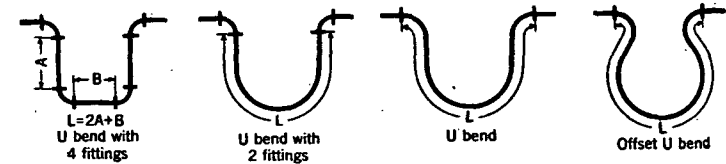


FIG. 1. MEASUREMENT OF L ON VARIOUS PIPE BENDS

has been found to give reasonably good results and is deemed to be sufficiently accurate for most heating work.

Fig. 1 shows several types of expansion bends commonly used for taking up thermal expansion. The amount of pipe, L, required in each of these bends may be computed from Equation 1.

$$L = 6.16 \sqrt{D \Delta} \quad (1)$$

where

L = length of pipe, feet.

D = outside diameter of the pipe used, inches.

Δ = the amount of expansion to be taken up, inches.

This formula, based on the use of mild-steel pipe with wall thicknesses not heavier than extra-strong, assumes a maximum safe value of fiber stress of 16,000 lb per square inch. When square type bends are used, the width of the bend should not exceed about twice the height, since for a given total length of pipe in the bend, the height of the bend becomes progressively less with increase in width until the height approaches zero and no flexibility exists. Actually, wide bends utilize to best advantage the inherent flexibility of the line, but such bends cannot be proportioned on the basis of Equation 1. For such applications, more accurate methods² should be employed. It is further assumed that the corners are made with

¹See (1) *Piping Handbook*, by Walker and Crocker (McGraw-Hill Co.); (2) *A Manual for The Design of Piping for Flexibility by the Use of Graphs*, by E. A. Wert, S. Smith, E. T. Cope, published by The Detroit Edison Company.

²Loc. Cit. Note 1.