

tinued turning in the threaded joint may in time result in a leak, particularly when the pressure is high. The amount of elongation which a swivel joint can take up is controlled by the length of the swing piece employed and by the lateral displacement which is permissible in the long pipe runs.

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

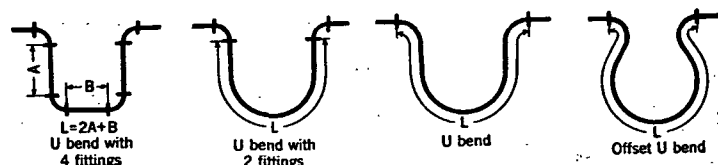


FIG. 1. MEASUREMENT OF L ON VARIOUS PIPE BENDS

is relatively complicated<sup>1</sup>. The following approximate method, however, 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 the following formula:

$$L = 6.16 \sqrt{D \Delta} \quad (2)$$

where

$L$  = length of pipe, feet.

$D$  = outside diameter of the pipe used, inches.

$\Delta$  = 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 two times the height. It is further assumed that the corners are made with screwed or flanged elbows or with arcs of circles having radii five to six times the pipe diameter.

All risers must be anchored and safeguarded so that the difference in

<sup>1</sup>Piping Handbook, by Walker and Crocker, and A Manual for the Design of Piping for Flexibility by the Use of Graphs, by E. A. Wert, S. Smith, and E. T. Cope, published by The Detroit Edison Company.

length when hot from the length when cold shall not disarrange the normal and orderly provisions for drainage of the branches.

It is especially necessary with light-weight radiators so to anchor the piping and so to give it freedom for expansion that no strain therefrom shall be allowed to distort the radiators. When expansion strains from the pipes are permitted to reach these light metal heaters they usually emit sounds of distress which are exceedingly troublesome.

TABLE 6. THERMAL EXPANSION OF PIPE IN INCHES PER 100 FT<sup>a</sup>  
(For superheated steam and other fluids refer to temperature column)

| SATURATED STEAM            |                                                     |                                                | ELONGATION IN INCHES PER<br>100 FT FROM -20 F UP |               |                         |                | SATURATED<br>STEAM                                  |                                                | ELONGATION IN INCHES PER 100<br>FT FROM -20 F UP |               |                         |                |
|----------------------------|-----------------------------------------------------|------------------------------------------------|--------------------------------------------------|---------------|-------------------------|----------------|-----------------------------------------------------|------------------------------------------------|--------------------------------------------------|---------------|-------------------------|----------------|
| Vacuum<br>Inches<br>of Hg. | Pressure<br>Pounds<br>per<br>Square<br>Inch<br>Gage | Temper-<br>ature<br>Degrees<br>Fahren-<br>heit | Cast-<br>Iron<br>Pipe                            | Steel<br>Pipe | Wrought<br>Iron<br>Pipe | Copper<br>Pipe | Pressure<br>Pounds<br>per<br>Square<br>Inch<br>Gage | Tem-<br>perature<br>Degrees<br>Fahren-<br>heit | Cast-<br>Iron<br>Pipe                            | Steel<br>Pipe | Wrought<br>Iron<br>Pipe | Copper<br>Pipe |
|                            |                                                     | -20                                            | 0                                                | 0             | 0                       | 0              | 664.3                                               | 500                                            | 3.847                                            | 4.296         | 4.477                   | 6.110          |
|                            |                                                     | 0                                              | 0.127                                            | 0.145         | 0.152                   | 0.204          | 795.3                                               | 520                                            | 4.020                                            | 4.487         | 4.677                   | 6.352          |
|                            |                                                     | 20                                             | 0.255                                            | 0.293         | 0.306                   | 0.442          | 945.3                                               | 540                                            | 4.190                                            | 4.670         | 4.866                   | 6.614          |
|                            |                                                     | 40                                             | 0.390                                            | 0.430         | 0.465                   | 0.655          | 1115.3                                              | 560                                            | 4.365                                            | 4.860         | 5.057                   | 6.850          |
| 29.39                      |                                                     | 60                                             | 0.518                                            | 0.593         | 0.620                   | 0.888          | 1308.3                                              | 580                                            | 4.541                                            | 5.051         | 5.268                   | 7.123          |
| 28.89                      |                                                     | 80                                             | 0.649                                            | 0.725         | 0.780                   | 1.100          | 1525.3                                              | 600                                            | 4.725                                            | 5.247         | 5.455                   | 7.388          |
| 27.99                      |                                                     | 100                                            | 0.787                                            | 0.898         | 0.939                   | 1.338          | 1768.3                                              | 620                                            | 4.896                                            | 5.437         | 5.660                   | 7.636          |
| 26.48                      |                                                     | 120                                            | 0.926                                            | 1.055         | 1.110                   | 1.570          | 2041.3                                              | 640                                            | 5.082                                            | 5.627         | 5.850                   | 7.893          |
| 24.04                      |                                                     | 140                                            | 1.051                                            | 1.209         | 1.265                   | 1.794          | 2346.3                                              | 660                                            | 5.260                                            | 5.831         | 6.067                   | 8.153          |
| 20.27                      |                                                     | 160                                            | 1.200                                            | 1.368         | 1.427                   | 2.008          | 2705                                                | 680                                            | 5.442                                            | 6.020         | 6.260                   | 8.400          |
| 14.63                      |                                                     | 180                                            | 1.345                                            | 1.528         | 1.597                   | 2.255          | 3080                                                | 700                                            | 5.629                                            | 6.229         | 6.481                   | 8.676          |
| 6.45                       |                                                     | 200                                            | 1.495                                            | 1.691         | 1.778                   | 2.500          |                                                     | 720                                            | 5.808                                            | 6.425         | 6.673                   | 8.912          |
|                            | 2.5                                                 | 220                                            | 1.634                                            | 1.852         | 1.936                   | 2.720          |                                                     | 740                                            | 6.006                                            | 6.635         | 6.899                   | 9.203          |
|                            | 10.3                                                | 240                                            | 1.780                                            | 2.020         | 2.110                   | 2.960          |                                                     | 760                                            | 6.200                                            | 6.833         | 7.100                   | 9.460          |
|                            | 20.7                                                | 260                                            | 1.931                                            | 2.183         | 2.279                   | 3.189          |                                                     | 780                                            | 6.389                                            | 7.046         | 7.314                   | 9.736          |
|                            | 34.5                                                | 280                                            | 2.085                                            | 2.350         | 2.465                   | 3.422          |                                                     | 800                                            | 6.587                                            | 7.250         | 7.508                   | 9.992          |
|                            | 52.3                                                | 300                                            | 2.233                                            | 2.519         | 2.630                   | 3.665          |                                                     | 820                                            | 6.779                                            | 7.464         | 7.757                   | 10.272         |
|                            | 74.9                                                | 320                                            | 2.395                                            | 2.690         | 2.800                   | 3.900          |                                                     | 840                                            | 6.970                                            | 7.662         | 7.952                   | 10.512         |
|                            | 103.3                                               | 340                                            | 2.543                                            | 2.862         | 2.988                   | 4.145          |                                                     | 860                                            | 7.176                                            | 7.888         | 8.195                   | 10.814         |
|                            | 138.3                                               | 360                                            | 2.700                                            | 3.029         | 3.175                   | 4.380          |                                                     | 880                                            | 7.375                                            | 8.098         | 8.400                   | 11.175         |
|                            | 180.9                                               | 380                                            | 2.859                                            | 3.211         | 3.350                   | 4.628          |                                                     | 900                                            | 7.579                                            | 8.313         | 8.639                   | 11.360         |
|                            | 232.4                                               | 400                                            | 3.008                                            | 3.375         | 3.521                   | 4.870          |                                                     | 920                                            | 7.795                                            | 8.545         | 8.867                   | 11.625         |
|                            | 293.7                                               | 420                                            | 3.182                                            | 3.566         | 3.720                   | 5.118          |                                                     | 940                                            | 7.989                                            | 8.755         | 9.089                   | 11.911         |
|                            | 366.1                                               | 440                                            | 3.345                                            | 3.740         | 3.900                   | 5.358          |                                                     | 960                                            | 8.200                                            | 8.975         | 9.300                   | 12.180         |
|                            | 451.3                                               | 460                                            | 3.511                                            | 3.929         | 4.096                   | 5.612          |                                                     | 980                                            | 8.406                                            | 9.196         | 9.547                   | 12.473         |
|                            | 550.3                                               | 480                                            | 3.683                                            | 4.100         | 4.280                   | 5.855          |                                                     | 1000                                           | 8.617                                            | 9.421         | 9.776                   | 12.747         |

<sup>a</sup>From 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.

## PIPE THREADS

All threaded pipe for heating and ventilating installations uses the American Standard taper pipe thread which is made with a taper of 1 in 16 measured on the diameter of the pipe so as to secure a tight joint. Threads of fittings are tapped to the same taper. The number of threads per inch varies with the different pipe sizes. All threaded pipe should be made up with a thread-paste suitable for the service under which the pipe is to be used.