pressure steam (up to 4 lb pressure), this method may be used if buildings are 250 ft or less apart.

3. If the distance between buildings is between 150 ft and 300 ft and the steam line contains high-pressure steam, the lines should be anchored midway between the buildings and allowed to expand into the basements of both buildings. If the steam line contains low-pressure steam this method may be used if buildings are between 250 ft and 600 ft apart. *No manhole is required at the anchor, and a blind pit is all that is necessary.*

TABLE 1. THERMAL EXPANSION OF PIPE IN INCHES PER 100 FEET[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 | 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 |

[a]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.

4. For longer lines, manholes must be located according to judgment and depending upon the expansion value of the type of expansion joint or bend that is used. The minimum number of manholes will be required when an expansion bend or an anchor with double expansion joint is placed in each manhole and the pipes are anchored midway between manholes.

5. A proper hydrostatic test should be applied to the piping before the top of the conduit is applied and before application of insulation. The pressure used in this test should be greater than the pressure used in service, and should be not less than 100 lb per square inch in any case.





The styles and construction of conduits commonly used may be classified as follows. Some of the more common forms are illustrated in Fig. 1.

*Wood Casing.* The pipe is enclosed in a cylindrical casing usually having a wall 4 in. thick and built of segments which are bound together by a wire wrapped spirally around the casing. The casing is lined with bright tin and coated with asphaltum. The pipe is supported on rollers carried in a bracket which fits into the casing. The lengths of casing are tightly fitted together with a male and female joint. This form of conduit is illustrated in Fig. 1 at *A*. The casing rests on a bed of crushed stone with tile drains laid below. The tile drains are of 4-in. field tile or vitrified sewer tile, laid with open joints.

*Filler Type:* The pipes are supported on expansion rollers properly supported from the conduit or independent masonry base. The pipes are protected by a split-tile conduit, and the entire space between the pipes and the tile is filled with an insulating filler. Thus the pipes are nested and the insulation between them and the tile effectively prevents circulation of air. The conduit is placed on a bed of gravel or crushed rock from 4 to 6 in. thick, which is extended upward so as to come about 2 in. above the

TABLE 2. LENGTH OF EXPANSION OFFSETS AND BENDS FOR PROPER EXPANSION OF PIPE

| Total Expansion in Inches[a] | Feet of Pipe and Offset or U-Bend for different Diameters of Pipe | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 2" | 3" | 4" | 5" | 6" | 8" | 10" | 12" | 14" | 16" |
| 1 | 11 | 13 | 15 | 17 | 19 | 21 | 23 | 25 | 27 | 30 |
| 2 | 15 | 18 | 21 | 23 | 26 | 29 | 32 | 35 | 38 | 42 |
| 3 | 18 | 22 | 26 | 29 | 32 | 36 | 40 | 43 | 48 | 52 |
| 4 | 21 | 26 | 30 | 34 | 37 | 42 | 47 | 50 | 56 | 58 |
| 5 | 24 | 30 | 34 | 38 | 41 | 47 | 53 | 57 | 63 | 65 |
| 6 | 27 | 33 | 37 | 41 | 45 | 52 | 58 | 63 | 69 | 71 |
| 7 | 30 | 36 | 40 | 44 | 48 | 56 | 62 | 68 | 74 | .... |
| 8 | 32 | 39 | 43 | 47 | 52 | 60 | 66 | 72 | .... | .... |

[a]This column shows the total expansion the offset will take care of without a cold strain. Although some engineers allow an increase of 40 per cent in the allowable expansion if the pipe is given a suitable initial cold strain when made up, it is regarded as better practice not to allow for it.

The length of pipe in the expansion piece should be the same whether in the form of a single right-angle offset or double offset or U-Bend.

The lengths of arms figured for 12,000 lb. per square inch tension for wrought iron pipe. If steel pipe is used this is good for 16,000 lb. per inch so that the arm will take care of ⅓ more expansion.

parting lines of the tile. A tile underdrain is placed beneath the conduit throughout the entire length and is connected to sewers or to some other point of free discharge. At *B* and *D* in Fig. 1 are shown two forms of tile conduit of the filler type.

*Insulated Tile Type:* The insulating material is molded to the inside of a split-tile conduit. The pipes are supported on expansion rollers usually. The space between the pipes and the insulating conduit lining may also be filled with an insulating filler. The conduit insulation, piping and earth load are supported by the base drain. A few inches of gravel or crushed rock are placed about the conduit and the base drain.

*Sectional Insulation Type* (Tile Conduit): Each pipe is insulated in the usual way with any desired type of sectional pipe insulation over which is placed a standard water-proof jacket with cemented joints. The pipes are enclosed in a split-tile conduit which is placed on a bed of crushed rock or gravel from 4 to 6 in. thick. This gravel bed is extended upward so as to come about 2 in. above the parting lines of the tile. Underdrains are sometimes omitted where this type is used; any water which seeps into the conduit being allowed to flow down the bottom of the conduit to the nearest manhole. Drains are laid from the floor of each manhole to some point of free discharge. The pipes are supported on roller frames and these, according to the type of conduit used, are either supported by the conduit itself or have their lower parts set in concrete, thus supporting the pipes independent of the conduit.