

but in most types of buildings this load will be relatively small compared with the heating load and will seldom occur at the time of the heating peak. Unusual features such as large heaters for swimming pools should not be overlooked.

The pressure at which the steam is to be distributed will depend upon (1) boiler pressure, (2) whether exhaust or live steam, (3) pressure requirements of apparatus to be served. If steam has been passed through electrical generating units, the pressure will be considerably lower than if live steam, direct from the boilers, is used.

The advantages of low pressure distribution (2 to 30 lb per square inch) are (1) smaller heat loss from the pipes, (2) less trouble with traps and valves, (3) simpler problems in pressure reduction at the buildings, and (4) general reduction in maintenance costs. With distribution pressures not exceeding 40 lb per square inch there is little danger even if the full distribution pressure should build up in the radiators through the faulty operation of a reducing valve; but with pressures higher than this a second reducing valve or some form of emergency relief is usually desirable to prevent excessive pressures in the radiators.

The advantages of high pressure distribution are (1) smaller pipe sizes and (2) greater adaptability of the steam to various operations other than building heating.

The different kinds of apparatus which frequently must be served require various minimum pressures. Kitchen equipment requires from 5 to 15 lb per square inch, the higher pressures being necessary for apparatus in which water is boiled, such as stock kettles and coffee urns. An increased amount of heating surface, which is easily obtained in some kinds of apparatus, results in quicker and more satisfactory operation at low pressures. For laundry equipment, particularly the mangle, a pressure of 75 lb per square inch is usually demanded although 30 lb per square inch is sufficient if the mangle is equipped with a large number of rolls and if a slow rate of operation is permissible. Pressing machines and hospital sterilizers require about 50 lb per square inch.

### PIPE SIZES

The lengths of pipe, steam quantities, and initial and terminal pressures having been chosen, the pipe sizes can readily be calculated by means of the Unwin pressure drop formula. This is one of several formulae which may be used. Unwin's formula, which gives pressure drops slightly larger than actual test results, is as follows:

$$P = \frac{0.0001306 W^2 L \left(1 + \frac{3.6}{D}\right)}{d^5} \quad (1)$$

where

- $P$  = pressure drop, pounds per square inch.  
 $W$  = weight of steam flowing, pounds per minute.  
 $L$  = length of pipe, feet.  
 $D$  = inside diameter of pipe, inches.  
 $d$  = average density of steam, pounds per cubic foot.

This formula is similar to the Babcock formula given in Chapter 15.

Information on provision for expansion will be found in Chapter 18. Where steam and return piping are installed in the same conduit, the return piping usually follows the same grade as the steam piping. In general, the condensation is pumped back under pressure. Where the condensation returns by gravity, Table 1 gives the sizes of the return piping. It is evident that at points where the grade is great, smaller pipes can be installed.

### CONDUITS FOR PIPING

Conduits for steam pipes buried underground should be reasonably waterproof, able to withstand earth loads and to take care of the expansion and contraction of the piping without strain or stress on the couplings, or without affecting the insulation or conduit. Expansion of the piping must be carefully controlled by means of anchors and expansion joints or bends so that the pipes can never come in contact with the conduit. Anchors can be anchor fittings or U-shaped steel straps which partially encircle the pipes and are firmly bolted to a short length of structural or cast steel set in concrete. In general, cast steel is preferable to structural steel.

TABLE 1. CAPACITY OF RETURNS FOR UNDERGROUND DISTRIBUTION SYSTEMS IN POUNDS OF CONDENSATE PER HOUR

| Size <sup>a</sup><br>of Pipe<br>In. | Pitch of Pipe per 100 Ft |        |         |         |         |        |
|-------------------------------------|--------------------------|--------|---------|---------|---------|--------|
|                                     | 6"                       | 1'     | 2'      | 3'      | 5'      | 10'    |
| 1                                   | 448                      | 998    | 1890    | 2240    | 3490    | 5490   |
| 1 1/4                               | 1740                     | 2490   | 3990    | 4880    | 6480    | 9480   |
| 1 1/2                               | 2700                     | 4190   | 5740    | 7480    | 9480    | 14500  |
| 2                                   | 4980                     | 7380   | 10700   | 13900   | 16900   | 24900  |
| 3                                   | 13900                    | 22500  | 30900   | 37400   | 50400   | 74800  |
| 4                                   | 30900                    | 44800  | 64800   | 79700   | 105000  | 154000 |
| 5                                   | 54800                    | 79800  | 120000  | 144800  | 195000  | 294000 |
| 6                                   | 90000                    | 138000 | 187000  | 237000  | 312000  | 449000 |
| 8                                   | 190000                   | 277000 | 404000  | 508000  | 660000  | 938000 |
| 10                                  | 344000                   | 498000 | 724000  | 900000  | 1190000 | -----  |
| 12                                  | 555000                   | 798000 | 1148000 | 1499000 | 1990000 | -----  |

<sup>a</sup>Size of pipe should be increased if it carries any steam.

In laying out underground conduits the following points should be borne in mind:

1. The depth of the buried conduit should be kept at a minimum. Excavation costs are a large factor in the total cost.
2. An expansion joint, offset, or bend should be placed between each two anchors.
3. If the distance between buildings is 150 ft or less and the steam line contains high-pressure steam, the line may be anchored in the basement of one building and allowed to expand into the basement of the second building. If the steam line contains low-pressure steam (up to 4-lb pressure), this method may be used if buildings are 250 ft or less apart.
4. 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.
5. For longer lines, manholes must be located according to experience, physical conditions and the expansion value of the type of expansion joint or bend that is used. The