cause high velocities and in the case of counter flowing condensate cause water hammer, (3) that there is a constant initial pressure.

It is recommended that all systems be designed for low initial pressure and a reasonably small pressure drop. Such systems will operate under higher pressures without difficulty. When a system is designed for high pressure with a relatively large pressure drop and then operated at a low pressure, it is apt to be noisy and have poor circulation.

It is recommended that the total pressure drop never exceed one-half of the initial pressure. This applies to cases where the condensate is flowing in the same direction as the steam but in the case of counter flowing condensate the velocities should not exceed those shown in Tables 5, 6 and 7.

Maximum Velocity

The capacity of pipe of a given size in any part of a steam or vapor heating system depends upon the quantity of condensation present, as well as the available pressure drop in the pipe. Where no water is present or where a limited quantity flows by gravity in the same direction as the steam the available pressure drop only need be considered.

Where water and steam flow counter to each other the velocity of the steam must not exceed certain values above which disturbance between the counter-flowing steam and water may produce objectionable sounds, water hammer, or retain water in some parts of the system until pressure goes off. The velocity at which such disturbance takes place depends upon the size of the pipe, its position (whether, vertical or horizontal), its pitch and the quantity of water flowing counter to the steam.

Unusual Conditions

Under this heading are the character and class of the building, the periodicity of use and the degree of normal temperature and the time in which it is to be attained at the beginning of each period.

In public buildings, schools, offices, stores and such buildings (where the occupants are normally at rest) the building should be heated to or near its required temperature at all times. In places of assemblage such as churches, theatres and auditoriums little heat should be used, for as the occupants fill the building it becomes a case of ventilation instead of heating. In factories or other buildings the heat given off by machinery, occupants and illumination and that absorbed by the contents of the building should be taken into account. In buildings that are intermittently heated the extra load due to heating up of a cold system within a stated time must be considered in determining the pipe sizes.

GENERAL DATA ON PIPE SIZE TABLES

The following Tables 1 to 18 have been compiled for use in designing the usual types of steam heating systems, and may be used, by those experienced in the profession, with satisfactory results. The following general principles should be followed:

1. It is recommended that the initial pressure be kept as low as possible, not exceeding 5 lb. gage.

2. It is recommended that the drop in pressure in the mains and riser to the farthest heating unit should not exceed 1 oz. per 100 ft. of straight pipe or its equivalent length, with a lower rate of drop for systems with long runs.[1]

3. In small installations, such as residences, where the longest actual run is seldom over 200 ft. and where the firing periods extend over several hours, resulting in boiler pressure, fluctuating from zero to about 1 lb., the total pressure drop should not exceed 2 oz. for gravity systems. In large buildings, where boilers are under the constant care of a fireman and a uniform pressure is maintained, and where the water line difference will permit, the total drop in pressure may range from 3 to 8 oz. depending upon the equivalent length of the longest run.

4. The total allowable drop in pressure depends upon (*a*) the water line difference, (*b*) the equivalent length of main and riser from the boiler to the farthest heating unit, and (*c*) the regularity of the pressure maintained at the boiler or source of steam supply.

5. The water line difference or distance between the water line of the boiler and the low point of steam main and dry return main should be not less than 24 in., because of the heavy drop in pressure from condensation in heating up a cold system. This difference should be increased 2 in. for every ounce pressure drop in the system. If the total pressure drop were 6 oz., the water line difference should be $6 \times 2 + 24$ or 36 in.

6. There should be a nearly uniform drop in pressure between the source of steam supply and the farthest heating unit on every riser. Care should be taken however, to see that the maximum allowable velocity for smooth operation is not exceeded.

7. In using this method of proportioning a system, care must be exercised to see that no pipe carrying condensate counter to the steam, is loaded to a capacity above the maximum for the particular part of a system in question as shown in Tables 5, 6 and 10 to 18.

DESCRIPTION OF TABLES

Tables 1 to 9 have been compiled for the use of the engineer who wishes to design a system with a pressure drop other than those shown in Tables 11 to 16. These tables may also be used to design transmission mains.

Table 1 gives the numerical value of the four factors of the Babcock formula for various sizes and lengths of pipe and various initial pressures and pressure drops. By multiplying together the four factors for any set of conditions the pound of steam per minute which will flow through the pipe may be found, as illustrated at the bottom of the table.

Table 2 is a basic table giving the theoretical capacities of pipe in square feet of direct cast-iron radiation (Based on ¼ lb. steam per hour per square foot) and the resulting velocity in feet per second for various pressure drops in ounces per 100 ft. length of pipe or equivalent length and with an initial steam pressure of 1 lb. gage. This table was compiled from the values given in Table 1. In using Table 1 or 2 the total pressure drop figured should never equal or exceed the initial pressure. It is recommended that the total pressure drop be less than one-half the initial pressure.

Table 3 is to be used with Table 2 for calculating the capacity of a steam pipe, for other initial pressures and lengths when the capacity is known for 1 lb. pressure and 100 ft. length. See examples for Table 3.

Table 4 gives the length of pipe in feet to be added to the actual length of run to obtain the equivalent length.

Table 5 gives the capacities of up-feed *one*-pipe risers based upon the

[1]This rule applies only when the amount of radiation on any riser does not exceed the values in Tables 5, 6 and 7.