are not as high as desired, higher pressures can be obtained by use of a steam compressor.[2]

It is sometimes desirable to install a separate high-pressure line from the boiler plant for steam supply to laundries or other high-pressure equipment rather than to operate the entire distribution system at higher pressures.

BOILER PLANTS

In the design of a plant for district heating, consideration should be given to the following factors:

1. *Annual load factor*. The ratio of the average hourly plant send-out (defined as rate of flow to the distribution system) to the maximum hourly send-out, which is a direct measure of the extent to which investment in facilities is used. This factor is often employed to determine savings by equipment offering higher efficiency. The load factor for space heating is usually between 10 and 30 percent. For space heating plus additional steam requirements such as water heating, cooking, or laundry, it is between 15 and 40 percent. Load factors for various types of buildings are given in Table 10, Chapter 18.

TABLE 3. LOAD DURATION FOR TYPICAL DISTRICT-HEATING SYSTEM
(Cumulative Hours of Plant Send-out per Year at Various Loads Expressed in Percent of Peak Hourly Load[a])

LOAD % OF PEAK	HOURS PER YEAR	LOAD % OF PEAK	HOURS PER YEAR	LOAD % OF PEAK	HOURS PER YEAR
100	5	70	750	30	4100
95	40	65	1050	20	5150
90	90	60	1400	15	5700
85	150	55	1800	10	6400
80	300	50	2200	6	8760
75	500	40	3100		

[a] Based on curve on page 89, *District Heating Handbook*, Third Edition, 1951.
Note: A plant having a peak send-out of 100,000 lb per hr will send out 80,000 (80 percent of 100,000) lb per hr *or more* for 300 hr per yr.

2. *Duration of load*. The cumulative number of hours for the various plant send-outs, is used to determine the number and sizes of boilers in order to effect most efficient loading of individual units and of the plant as a whole. The cumulative number of hours a typical district heating plant will send out steam at various loads, with loads expressed in percentage of maximum hourly rate, is given in Table 3. It will be noted that the duration of load for the higher send-outs is very low.

3. *Feed-water treatment*. This is desirable in plants to prevent corrosion and scale formation.

4. *Smoke abatement*. This is a modern requirement. The installation of suitable fuel-burning and dust-collecting equipment to limit the emission of smoke and fly ash is usually necessary.

5. *Plant location*. A boiler plant should be situated where fuel deliveries, water supply, and other utility services are convenient and should be as near as possible to the distribution center in order to simplify and shorten the distribution piping.

STEAM DISTRIBUTION PIPING

The methods used in district heating work for the distribution of steam are applicable to any problem involving the supply of steam to a group of buildings. The first step is to establish the route of the pipes which is influenced by local conditions and investment.

Important points in laying out distribution piping are:

1. The depth of the conduit should be kept at a minimum. Excavation costs are a large factor in the total cost. On the other hand, institutional lawns will be damaged if steam conduit is too close to the surface.

2. The use of basement or sub-sidewalk space for the distribution piping where feasible may reduce the cost of installation and maintenance.

3. In some industrial and institutional applications, the distribution piping may be installed, entirely or in part, above ground. This method of construction has the advantage of requiring no excavation and permits easy maintenance but it may introduce freeze-up problems. Thin corrugated aluminum sheets are available for covering the insulation on lines exposed to the weather.

4. Piping routed in loops with suitable valves to provide alternate feeds for major loads, allows service to be maintained despite trouble in any one feeder.

PIPE SIZES

After establishing the route of the pipes, the next step is to determine the pipe sizes. In district heating work it is common practice to design the piping system on the basis of pressure drop. The initial pressure and the minimum permissible terminal pressure are specified, and the pipe sizes are so chosen that the required amount of steam, with suitable allowances for future increases, will be transmitted without exceeding this pressure drop. The steam velocity is therefore almost disregarded and may be very high. Velocities of 35,000 fpm are not considered high. By the use of high velocities the pipe sizes are kept to a minimum with consequent savings in investment. Some lines in a loop system may need to be increased in size in order to handle reverse-direction flow in emergencies.

The steam flowing through any section of the piping can be computed from a study of the hourly steam requirements of the several buildings served. Steam requirements for ventilation-air heating, water heating, laundering, cooking, or processing, should be individually calculated and added to the heating load. Unusual features, such as large heaters for swimming pools, should not be overlooked.

When the lengths of pipe, steam quantities, and initial and terminal pressures have been chosen, the pipe sizes can be calculated by means of Babcock's pressure drop formula given in Table 2 of Chapter 21. The district-heating industry uses *Unwin's* formula for determining pipe sizes because pressure drops can be determined simply and directly from a chart. This formula has been checked by tests, and found correct within ranges of velocity used in district heating. A convenient chart developed from this formula is available from the *National District Heating Association*,[3] and provides a simple yet accurate means for determining pipe sizes.

CONDUITS FOR PIPING

Conduits for underground steam pipes should be reasonably waterproof and able to withstand earth and traffic loads.

Since it is difficult to make a concrete or masonry conduit absolutely watertight, provision should be made for some seepage. The pipe should be protected by a waterproof jacket over the insulation, unless subject to actual submersion, and the seepage should be drained from the inside of the conduit. Underdrainage of the conduit is generally obtained by means of a tile drain laid in gravel underneath the conduit. The tile underdrain should discharge to a sewer or some other drainage point. Manholes are required at intervals for access to valves, traps, and some types of expansion joints.

There are many types of conduits, some of which are prefabricated prod-