Table 1 . . . . Unit Steam Consumption of Process Equipment[a]

Kitchen Appliances (exclusive of water heating)	Consumption,[b] Lb per Hr	Pressure, psig
Stock and vegetable kettles (per 5 gal)	20.0	7–20
Vegetable steamers (per compartment)	40.0	7–20
Steam tables (per sq ft)	1.7	7–20
Bain-Maries (per sq ft)	3.4	7–20
Coffee urns (per gal)	3.4	7–20
Water urns (per gal)	5.0	7–20
Soup warmers (30 x 30 x 28 in.)	100.0	7–20
Egg boilers (3 compartments)	18.0	7–20
Clam, lobster, and potato steamers (per compartment)	40.0	7–20
Oyster pots	18.0	7–20
Plate and cup warmers (per 20 cu ft)	35.0	7–20
Food-warming ovens (per 20 cu ft)	35.0	7–20
Silver burnisher and washers	69.0	7–20
Dishwashers (per tray)	60.0	7–20
Laundry Equipment		
Tumblers		
40 x 94 in.	360	100
30 x 36 in.	225	100
Washers, (per gal water heated)	1	15–100
Flatwork ironers,		
100 to 120 in. chest type (per roll)	60	100
50 to 100 in. cylinder type (per machine)	60–120	100
Standard presses	105	100
Large shirt body presses	190	100
Cuff and neckband presses	15	100
Sleevers	12	100
Steam-electric irons	8	100
Woolen pressing machines		
Large—electric vacuum	25	65
Small—electric vacuum	12	65
Large—steam vacuum	35	65
Small—steam vacuum	20	65
Feather cleaning and sterilizing		
15 pillows per hr	175	100

Hospital Equipment	Consumption,[a] Lb per Hr	Pressure, psig
Sterilizers, for bottles or pasteurization (per bottle)	1	40
Sterilizers, for water, (per gal)	12	40
Sterilizers, for instruments and utensils		
8 x 9 x 18 in., water depth 3½ in.	27	40
9 x 10 x 20 in., water depth 3½ in.	30	40
10 x 12 x 22 in., water depth 4 in.	39	40
12 x 16 x 24 in., water depth 4 in.	60	40
10 x 12 x 36 in., water depth 4 in.	66	40
16 x 15 x 20 in., water depth 10 in.	92	40
20 x 20 x 24 in., water depth 24 in.	144	40
Sterilizers, for instruments @ 240–250 F		
12 x 20 in.	48	40
14 x 22 in.	60	40
16 x 24 in.	72	40
Sterilizers, for surgical supplies		
10 x 20 in.	10	40
12 x 20 in.	22	40
14 x 22 in.	28	40
16 x 24 in.	38	40
16 x 36 in.	54	40
20 x 28 in.	60	40
20 x 36 in.	78	40
20 x 48 in.	98	40
20 x 60 in.	124	40
Sterilizers, (autoclave) (240–250 F)		
15.5 x 24 in.	24	40
17.5 x 26 in.	32	40
21.5 x 30 in.	40	40
24 x 36 in.	42	40
Disinfector, mattress		
30 x 42 x 84 in.	42	35–60
60 x 66 x 108 in.	318	35–60
Blanket warmers		
18 x 24 x 72 in.	4	35–60

[a] From *District Heating Handbook* (National District Heating Association, Third Edition, 1951).
[b] These values represent approximate requirements after warm-up period.

in the district heating industry because of their relatively high first cost as compared with smaller conduits unless they are required to accommodate miscellaneous other services or to provide underground passage between buildings.

4. Overhead piping on poles or structures is generally less expensive than underground lines, especially in some institutional and industrial areas and may be a means of eliminating buried conduit in areas where underground installations would be expensive or undesirable. Thin corrugated aluminum sheets or asphalt-saturated asbestos felt are available for covering the insulation on lines exposed to the weather. Such lines may introduce freeze-up problems, higher heat losses and, in many locations, would be considered unsightly.

5. High-pressure transmission feeders may be employed where the plant is remote from the distribution area, or where it is desirable to augment the capacity of an existing system. Design of such feeders and of distribution systems for various load conditions is covered fully in *District Heating Handbook*, 3rd Edition.[2]

6. 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.[4]

7. It is desirable to estimate as far as possible the probable growth and change in load centers. Since character of the district served is almost certain to change with time the distribution system must be planned so that it can be adapted to accommodate changes. It is helpful to provide a master distribution plan which can be revised from time to time to suit conditions as the system grows.

Steam Distribution Pressure

The pressure at which the steam is to be distributed will depend upon that available at the plant and pressure requirements of apparatus to be served.[4]

The advantages of low-pressure distribution (2 to 50 psig) compared with high pressure are: (1) lower heat loss per square foot of pipe surface; (2) lower losses from leakage, trap discharge, and venting; (3) less trouble with traps and valves; (4) less trouble from flash steam at drainage points; (5) simplified problems in pressure reduction at the buildings; (6) suitability of standard fittings; and (7) general reduction in maintenance costs.

Some heating companies find that the overall losses in relation to steam delivery are higher with high-pressure distribution. With distribution pressures not exceeding 50 psig, there is less danger if the full distribution pressure should build up in the radiators or heaters through the faulty operation of pressure-regulating valves. With pressures

Table 2 . . . . Annual Steam Consumption for Water Heating for Various Types of Buildings, per Cu Ft of Volume[a,b]

Type of Building	Consumption, Lb/(Yr) (Cu Ft)	Consumption Lb/(Yr) (Cu Ft) (100 F deg Temp. Rise of Water)
Hotel	3.20	2.66
Residence club	2.56	2.11
Apartment house	2.41	1.99
Department store	0.95	0.79
Office	0.85	0.71
Theater	0.57	0.48
Parking garage	0.46	0.38

[a] Based on analysis by fourteen district heating companies from metered consumptions. Building volume is approximate gross volume.
[b] From *District Heating Handbook* (National District Heating Association, Third Edition, 1951, p. 247).

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])

Plant Output % of Peak	Hours per Year	Plant Output % of Peak	Hours per Year
100	5	55	1800
95	40	50	2200
90	90	40	3100
85	150	30	4100
80	300	20	5150
75	500	15	5700
70	750	10	6400
65	1050	6	8760
60	1400		

[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 800 hr per yr.

higher than 50 psig, or the safe working pressure of heating or process equipment, a second pressure-reducing valve or some form of emergency relief is required to prevent excessive pressures in the radiators or other equipment.[5]

Pressure reducing valves are more fully described in Chapter 26 (Steam Heating Systems). The installation of reducing valves on district steam installations, however, may present specific problems that are not normally encountered in building steam heating applications. Utility companies in some instances must assume greater responsibilities in their operation and maintenance and are often under regulations that are different for various cities.

The advantages of high-pressure distribution are: (1) smaller pipe sizes; (2) availability of the steam for various other operations requiring higher pressures than the building heating system; and (3) wider flexibility in allowance for maximum pressure drop. Where distribution pressures are not as high as desired, higher pressures can be obtained by use of a steam compressor.[6]

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.

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 for pipes in conduits. Where pipes pass through buildings, however, consideration should be given to the possibility of objectionable noise due to high velocity. By the use of permissible pressure drops with high velocities, after allowance has been made for future increase in load, the pipe sizes may be 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.[4]

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. In this connection, allowance should be made for the diversity of the load, that is, the ratio of the coincident maximum demand of all of the group of buildings served by the main, to the sum of the individual maximum demands of each of the buildings served. This ratio is known as the Coincidence Factor and varies from 0.50 in some institutional groups to 0.90 in areas where loads are principally for heating and heat is turned on at about the same time each morning. Consideration should also be given to the net total load on a line, based on a study of the loads in the various buildings, in order to determine the relative merits of providing one or more separate supply lines to serve all-year loads. Such lines will permit turning off the mains that supply strictly seasonal space-heating loads during the summer months.

When lengths of pipe, steam quantities, and initial and terminal pressures have been chosen, the pipe sizes can be calculated by means of Figs. 22 to 26 of Chapter 26. The district-heating industry, however, 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.[7]

Conduits for Piping

Conduits for underground steam pipes are used to protect the pipe and insulation from external damage and to provide a space in which the pipe is free to expand or contract while held in proper alignment. The conduit should be constructed of non-corrosive materials, or, if of metallic content, should be suitably protected against corrosion. It must be of adequate strength to withstand the earth and traffic forces to which it will be subjected. The conduit should be reasonably waterproof and in many cases provision should be made to drain seepage from its inside. With any form of conduit unless it is actually below water level, provision should be made to completely exclude water or to carry away ground water and prevent it from collecting around the conduit. This is often accomplished by placing a layer of coarse gravel or stone underneath and partly surrounding the conduit with one or two lines of tile having open joints which serve to carry the water to a sewer or other suitable