tated as much as possible, as an air bound system will not heat readily nor properly. In designing the piping arrangement, it is desirable to maintain equivalent resistances in the supply and return piping to and from a radiator. Arranging the piping so the total distance from the boiler to the radiator is the same as the return piping distance from the heating unit back to the boiler, tends to obtain such a result. The

TABLE 1. ORIFICE CAPACITIES FOR LOW PRESSURE STEAM SYSTEMS

This table is based on data from actual tests[a]

Orifice Diameter 64ths of an Inch	6 in. Hg Differential	5 in. Hg Differential	4 in. Hg Differential	2 in. Hg Differential	1 in. Hg Differential
	Capacity Expressed in Square Feet E D R				
7	18–23	16–21	15–19	10–13	
8	23–29	21–27	19–25	13–17	8–11
9	29–36	27–33	25–30	17–21	11–14
10	36–44	33–40	30–37	21–26	14–17
11	44–52	40–48	37–44	26–31	17–20
12	52–62	48–57	44–51	31–37	20–24
13	62–72	57–66	51–59	37–43	24–28
14	72–83	66–76	59–67	43–49	28–32
15	83–94	76–86	67–76	49–56	32–37
16	94–106	86–97	76–86	56–64	37–42
17	106–119	97–109	86–97	64–72	42–47
18	119–133	109–122	97–108	72–80	47–52
19	133–148	122–135	108–120	80–88	52–58
20	148–163	135–149	120–133	88–98	58–64
21	163–179	149–164	133–145	98–107	64–71
	Capacity Expressed in Pounds per Hour				
7	4.5–5.8	4.0–5.3	3.8–4.8	2.5–3.3	
8	5.8–7.3	5.3–6.8	4.8–6.3	3.3–4.3	2.0–2.8
9	7.3–9.0	6.8–8.3	6.3–7.5	4.3–5.3	2.8–3.5
10	9.0–11.0	8.3–10.0	7.5–9.3	5.3–6.5	3.5–4.3
11	11.0–13.0	10.0–12.0	9.3–11.0	6.5–7.8	4.3–5.0
12	13.0–15.5	12.0–14.3	11.0–12.8	7.8–9.3	5.0–6.0
13	15.5–18.0	14.3–16.5	12.8–14.8	9.3–10.8	6.0–7.0
14	18.0–20.8	16.5–19.0	14.8–16.8	10.8–12.3	7.0–8.0
15	20.8–23.5	19.0–21.5	16.8–19.0	12.3–14.0	8.0–9.3
16	23.5–26.5	21.5–24.3	19.0–21.5	14.0–16.0	9.3–10.5
17	26.5–29.8	24.3–27.3	21.5–24.3	16.0–18.0	10.5–11.8
18	29.8–33.3	27.3–30.5	24.3–27.0	18.0–20.0	11.8–13.0
19	33.3–37.0	30.5–33.8	27.0–30.0	20.0–22.0	13.0–14.5
20	37.0–40.8	33.8–37.3	30.0–33.3	22.0–24.5	14.5–16.0
21	40.8–44.8	37.3–41.0	33.3 36.3	24.5–26.8	16.0–17.8

Note.—The radiator orifice plates recommended in this table are made of brass stampings 0.023 in. thick cup-shaped to be inserted in radiator valve unions.

[a] Flow of Steam Through Orifices into Radiators, by S. S. Sanford and C. B. Sprenger (A.S.H.V.E. TRANSACTIONS, Vol. 37, 1931, p. 371).

condensate which occurs in steam piping as well as in radiators must be drained to prevent impeding the ready flow of the steam and air. The effect of back pressure in the returns and excessive re-vaporization, such as occurs where condensate is released from pressures considerably higher than the vacuum or pressure in the return, must be avoided.

It is important that steam piping systems distribute steam not only at full *design* load, but during excess and partial loads. Usually the average winter steam demand is less than half of the demand at the *design* outside

temperature. Moreover, in rapidly warming up a system even in moderate weather, the load on the steam main and returns may exceed the maximum operating load for severe weather, due to the necessity of raising the temperature of the metal in the system to the steam temperature, and the building to the *design* indoor temperature. Investigations of the return of condensate have revealed that as high as 143 percent of the design condensation rate may exist under conditions of actual operation.

The piping design of a heating system is greatly influenced by its operating characteristics. Heating systems do not operate under constant conditions, as conditions change continually, due to variation in load. As the system is being filled with steam, the pressures existing in various locations may be different from those which exist for appreciable periods at other locations, although at equilibrium conditions the pressures are approximately the same. In designing piping it is of especial importance to arrange the system to preclude trouble caused by such pressure differences. The systems which readily release the air, permit uniform

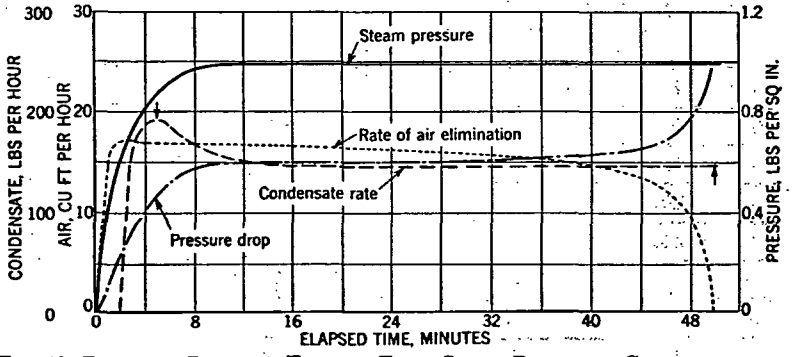


FIG. 18. RELATION BETWEEN ELAPSED TIME, STEAM PRESSURE, CONDENSATE AND AIR ELIMINATION RATES

pressures to be attained in much shorter time intervals than those which are sluggish. Results are given in Fig. 18 from investigations[1] to determine the rate of condensate and air return from a two-pipe gravity heating system. Variations in the steam pressure during the warming-up period, when the rate of air elimination and condensation is high, are clearly indicated in these curves.

It is evident that the condensate flow during the initial warming-up period reaches a peak, which is greater than the constant condensing rate eventually reached when the pressure becomes uniform. Moreover, the peak condensing rate is obtained when the system steam pressure is lower than that existing during a period of constant condensing rate. It will also be noted that the peak rate of air elimination does not coincide with the higher condensing rate.

Steam Flow

The rate of flow of dry steam or steam with a small amount of water flowing in the same direction, is in accordance with the general laws of gas flow, and is a function of the length and diameter of the pipe, the density of the steam, and the pressure drop through the pipe. This relationship