

The rate of steam supply is controlled by a valve in the steam main or by thermostatically controlling the rate of steam production in the boiler. The control valve may be of the automatic *modulating* or *floating* type governed thermostatically from selected control points in the building, or it may be a special pressure reducing valve which will maintain the desired sub-atmospheric pressures by continuous flow into the heating main. All radiator supply valves have incorporated adjustable orifices or are equipped with regulating orifice plates. The sizes of orifices used are larger than for other types of orifice systems because for equal radiator sizes the volume flowing is larger. These orifices are omitted on some systems, depending upon the type of control. Radiator traps and drips are designed to operate at any pressure from 15 lb gage to 26 in. Hg. A vacuum pump capable of operating at high vacuum is preferable to promote accuracy in the distribution of steam throughout the system, particularly in mild weather. This vacuum is partially self-induced by the condensation of the steam in the system under conditions of restricted supply for reduction of the radiator heat emission.

The returns must grade downward constantly and uninterruptedly from the radiator return outlets to the inlet of the receiver of the vacuum pump. One radical difference between this and the ordinary vacuum system is that no lifts should be made in the return line, except at the vacuum pump. The receivers are placed at a lower level than the pump and equipped with float control so that the pump may operate as a return pump under night conditions. The system may be operated in the same manner as the ordinary vacuum system when desired.

Steam for heating domestic hot water should be taken from the boiler header back of the control valve so that pressures sufficiently high for heating the water may be maintained on the heater. The sub-atmospheric method of heating can be used for the heating coils of ventilating and air conditioning systems. The flexible control of heat output secured by this method materially reduces the required size of by-pass around the heaters. Some applications of sub-atmospheric systems are proprietary.

ORIFICE SYSTEMS

Orifice steam heating systems may have piping arrangements identical with vacuum systems. Some of these omit the radiator thermostatic traps but use thermostatic or combination float and thermostatic traps on all drip points. A return condensation pump with receiver vented to atmosphere, a return line vacuum pump, or a return trap, is generally used to return the condensation to the boiler or place of similar disposition, such as a feed-water heater or hot well. The heat emission from the radiators is controlled by varying the pressure differential maintained.

The principle on which these systems operate is based on the fact that the steam flow through an orifice will vary when the ratio of the absolute pressures on the two sides of the orifice exceeds 58 per cent. If the absolute pressure on the outlet side is less than 58 per cent of the absolute pressure on the inlet side, no further increase in flow will be obtained as a result of the increased pressure difference. If an orifice is so designed in size as to exactly fill a radiator with 2 psi gage on one side and $\frac{1}{4}$ psi gage on the other, the absolute pressure relation is:

$$\frac{14.7 + 0.25}{14.7 + 2.0} = 0.90 \text{ or } 90 \text{ per cent.}$$

Should the steam pressure be dropped to $\frac{1}{4}$ lb. on the supply pipe, the pressure on each side of the orifice would be balanced and no steam flow would take place. From this it will be apparent that if an orifice of a given diameter will fill a given radiator with steam when there is a given pressure on the main, reducing this steam main pressure will permit filling various desired portions of the radiator down to the point where the main pressure equals the back pressure in the radiator provided the supply pipe pressures may be controlled sufficiently close. If orifices are designed on a similar basis for a given system and proportioned to the heating capacity of the radiators they serve, all radiators will heat proportionately to the steam pressure. The range of pressure variation is limited by the permissible noise level of the steam flowing under the pressure difference required for maximum heat output. The control of the steam supply is obtained by a valve placed in the steam main, which maintains a deter-

TABLE 8. ORIFICE CAPACITIES FOR LOW PRESSURE STEAM SYSTEMS

This table is based on data from actual tests*

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

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.

*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).