

periphery, thus constituting the rotary jet. These pumps employ a second impeller to pick up the condensate from the separating tank and discharge it to the boiler.

Separation Under a Vacuum.

Pumps operating under this principle are equipped with a receiver maintained under vacuum, located between the pump suction and the return line. These pumps have individual air and water rotors which take their respective suction directly from this receiver, simultaneously delivering the air to the atmosphere and the condensation to the boiler. The air pump is water-sealed, a small volume of water continually passing through the air pump back to the receiver.

Reciprocating Vacuum Pumps

Reciprocating return-line vacuum heating pumps may be either steam-driven or power-driven. The determination of the size of reciprocating vacuum pumps should take into consideration the following factors:

1. The degree of tightness of system.
2. The efficiency of the radiator traps.
3. The temperature of the condensate at the pump.
4. The probable cooling effect of the return piping.
5. The use of lifts in the return.
6. Vacuum to be maintained at the pump.
7. Introduction of large volumes of high temperature water into the return piping near the pump.
8. The use of long runs of piping from the source of steam supply to the farthest radiator.

Steam cylinder sizes of reciprocating vacuum pumps should include the effect of frictional resistance of the piping system, the pump resistance and the possible drop in steam pressure under unusual conditions. When this analysis is not feasible the following formula may be used:

$$A_s = A_w S \left(\frac{V}{2} + P_d \right) \quad (2)$$

where

A_s = area of steam piston, square inches.

A_w = area of water piston, square inches.

P_b = boiler pressure, pounds per square inch.

P_d = discharge pressure, pounds per square inch.

V = vacuum at pump expressed, inches of mercury.

$\frac{V}{2}$ = approximate vacuum, pounds per square inch (2 in. mercury = approximately 1 lb per square inch).

Water cylinder sizes of steam-driven reciprocating vacuum heating pumps may be determined from Table 2. All pumps of this type should be provided with mechanical lubricators. The piston speed in feet per minute of steam-driven pumps should not be more than 20 times the square root of the number of inches in the length of stroke.

The volumetric displacement rate of the water cylinders of steam or

power-driven pumps should be from 8 to 10 times the volumetric rate of flow of the condensate to be handled. The speed of crank shafts of power-driven reciprocating return-line vacuum pumps should not exceed the following:

LENGTH OF STROKE (INCHES)	MAXIMUM CRANK SHAFT SPEED (RPM)
3	80
6	50
8	50
12	40
20	25

Air and Water Capacities

The water and air capacities of vacuum heating pumps are usually referred to in terms of square feet of equivalent heating surface (radiation).

Air to be Handled. The volume of air to be handled depends to a large extent on the vacuum carried and on the type of heating system, that is, whether direct or indirect (central fan). The air requirements are in general proportional to the square feet of equivalent heating surface (240 Btu per square foot) but should be assumed on a decreasing ratio. Approximate values are given in Table 3. The amount of air to be handled for central fan systems or so-called fan blast heaters, although actually less than that for direct heating systems, is usually estimated on the same basis.

Air Capacity of Pumps. In reciprocating pumps the actual volume of air handled may be easily calculated and is equal to the displacement

TABLE 2. CAPACITIES OF VARIOUS SIZES OF DIRECT DOUBLE ACTING STEAM-DRIVEN RECIPROCATING VACUUM PUMPS (FOR STEAM PRESSURE 50 LB. AND ABOVE)

SIZE, INCHES	SQUARE FEET OF DIRECT RADIATION
4 x 3 x 6	1,700
4 x 3½ x 6	2,500
4 x 4 x 6	3,000
4 x 4½ x 6	3,800
4 x 5 x 6	4,700
4 x 5 x 8	6,500
4½ x 6 x 8	10,000
5 x 6 x 10	11,000
5 x 6½ x 10	13,000
5 x 7¼ x 10	17,000
6 x 8 x 12	25,000
8 x 10 x 12	40,000
8 x 12 x 12	55,000
10 x 14 x 12	75,000
10 x 14 x 16	85,000
10 x 14 x 20	100,000
12 x 16 x 20	130,000
14 x 18 x 20	160,000
16 x 20 x 20	200,000
16 x 22 x 20	240,000