times the normal flow. This relation of receiver and pump size to heating system condensing capacity takes account of the peak condensation rate.

A typical installation of a motor driven automatic condensate unit is illustrated in Fig. 10.

VACUUM HEATING PUMPS

On vacuum systems, where the returns are under a vacuum, and sub-atmospheric systems, where the supply piping, radiation and the returns are under a vacuum, it is necessary to use a vacuum pump to discharge the air and non-condensable gases to atmosphere and to dispose of the condensate. Direct-acting steam-driven reciprocating vacuum pumps are sometimes used where high pressure steam is available, or where the exhaust steam from the pump can be utilized. In general, however, these have been replaced by the automatic motor-driven return line heating pump especially developed for this service. Steam turbine drive is also frequently used where steam at suitable pressures is available, the steam being used afterward for building heating. The usual vacuum pump unit consists of a compact assembly of exhausting unit for withdrawing the air-vapor mixture and discharging the air to atmosphere, and a water removal unit which discharges the condensate to the boiler. They are furnished complete with receiver, separating tank and automatic controls mounted as an integrated unit on one base. There are also special steam turbine driven units which are operated by passing the steam to be used in heating the building through the turbine with only a 2 to 3 psi drop across the turbine required for its operation. Under special conditions such as installations where it is necessary to return the condensate to a high pressure boiler, auxiliary water pumps may be supplied. In some instances separate air and water pumps may be used.

For rating purposes[3] vacuum pumps are classified as *low vacuum* and *high vacuum*. Low vacuum pumps are those rated for maintaining 5½ in. Hg vacuum on the system, and high vacuum pumps are those rated to maintain vacuums above 5½ in. Hg.

The required air and condensate removal capacity of vacuum pumps depends upon the size and type of heating system to which they are applied.

The required condensate capacity is closely related to the amount of radiation installed together with the range of the heating requirement. For average design conditions, the theoretical condensing rate of a heating system is approximately 0.5 gpm per 1000 sq ft equivalent direct radiation (EDR) served. Vacuum pump water-delivery rates generally should be the same as for condensation pumps, which range from 2 to 3 times the design condensing rate. This provides sufficient capacity for peak loads and for intermittent automatic operation.

The wide varying operating range and characteristics of individual heating systems have a greater effect on the quantity of air to be removed than on the condensate to be handled. The air handling requirement cannot be found by applying a common factor to the equivalent direct radiation design load although this would be possible in determining the condensate. For low vacuum systems, where the returns are controlled at an average vacuum of 5.5 in Hg vacuum and the temperature averages 160 F, the various manufacturers of vacuum pumps provide pump capacities from 0.3 to 1.0 cfm of air per 1000 sq ft equivalent direct radiation served. For high vacuum systems, the vacuum pump air capacity requirements are generally greater. A capacity of 2.0 cfm of air at 20 in. Hg vacuum per 1000 sq ft equivalent direct radiation served, is a typical

capacity furnished on high vacuum systems. These higher air capacities on sub-atmospheric controlled systems are required basically because of the increase in vacuum which expands the volume of air and vapor that is to be removed to maintain circulation at the higher operating vacuum.

It is particularly important on high vacuum installations to see that the entire system is tight in order to reduce the amount of inward air leakage and, furthermore, to assure that relatively higher temperature steam is prevented from entering the vacuum return lines through leaky traps, high pressure drips, etc. The hotter the returns, the lower will be the possible vacuum for a given air leakage into the system. It is for this reason that the condensate from equipment using steam at high pressure should not be connected directly to a vacuum return line, but should drain to a flash tank or flash leg through a high pressure trap. The receiver should have an equalizing connection to a low pressure steam main and drain through a low pressure trap to the vacuum return main, as indicated later in this chapter in section on Drips.

Vacuum Pump Controls

In the ordinary vacuum system, the vacuum pump is controlled by a vacuum regulator which cuts in when the vacuum drops to the lowest point desired, and cuts out when it has been increased to the highest point, these points being varied to suit the particular system or operating conditions. In addition to this vacuum control, a float control is included which will start the pump whenever sufficient condensate accumulates in the receiver, regardless of the vacuum on the system. A selector switch is usually provided to allow operation at night as a condensate pump only, also to give manual or continuous operation when desired.

There are several variations in the control of the vacuum maintained on the system by the pump. In some sub-atmospheric systems where orifices are used, the vacuum pump control maintains a pressure difference between the supply and the return piping, which is held within relatively close limits. There are other sub-atmospheric systems which utilize special temperature-pressure actuated controls for maintaining the desired conditions in the return lines. Where various zones are connected to the same return main, the return vacuum must be controlled to meet the requirements of the zone operating at the lowest steam supply pressure.

Piston Displacement Vacuum Pumps

Piston displacement return vacuum heating pumps may be either electric or steam driven. Their piston speed in feet per minute should not exceed 20 times the square root of the number of inches in their stroke. They are usually supplied with an air separating tank, open to atmosphere, placed on the discharge side of the pump, and at an elevation sufficiently high to allow gravity flow of the condensate to the boiler. If the boiler pressure is too high for such gravity feed, then an additional steam pump for feeding the boiler is desirable. The extra pump is sometimes avoided by using a closed separating tank with a float controlled vent. In both arrangements, the air taken from the system must be discharged against the full discharge pressure of the vacuum pump. In the case of high or medium pressure boilers, it is better to use the atmospheric separator and the second pump.

In figuring the required displacement for such pumps, a value of from 6 to 10 times the volumetric flow of condensate is used for average vacuums and systems.