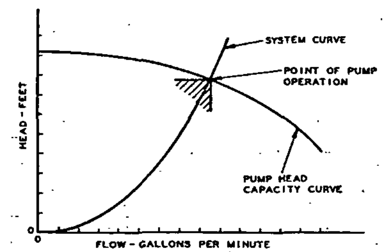

Fig. 6 .... Relation Between Pump Performance Curve and System Characteristic Curve

Fig. 6, indicates the flow and pressure of the pump when coupled to the system.

In the case of the *open* system, the discontinuity of the hydraulic system requires adjustment of the system curve to compensate for the static pressure difference at the break in the hydraulic circuit. Thus a system with more static pressure on the suction flange of the pump than on the discharge flange has static pressure available to increase the system flow. This available static pressure is graphically shown by shifting the system curve down by an amount equal to the static pressure A in Fig. 7.

Conversely, a system that has less static pressure on the suction flange than on the discharge flange has static pressure available to decrease the system flow. This is graphically shown by shifting the system curve up by an amount equal to the static pressure difference between suction and discharge. (See A in Fig. 8.)

Too often, originally accurate estimates of friction losses in circuits are arbitrarily adjusted and cause prediction of pump operation at unrealistically high heads. When the *actual system losses* are less than the adjusted estimate, the *actual system curve* is lower than predicted, and, consequently, the actual pump operating point will shift as shown in Fig. 9, and power requirements will be increased.

This shift in pump operation also increases the *net positive suction head* requirements, and can cause noise and mechanical damage to the pumping equipment.

PUMP LOCATION IN THE HYDRAULIC SYSTEM

In an *open* system, the pump should be placed so that the suction is flooded and flow is not restricted at pump entrance. Condensate pumps are located at the source or reservoir and so connected that the pump inlet is flooded. The pump can then handle condensate as close to the flash point as possible. In this case there is no appreciable pressure drop or friction loss from the reservoir to the impeller eye. In most cases, the pump is attached to, or is part of, the condensate reservoir. Knowledge of the NPSH requirement is desirable, and sometimes essential, for the proper selection of any pump operating with fluids at elevated temperatures.

The selection of the pump location when applied to cooling towers is influenced by the available space, by the necessary protection from the weather, and by the need to prevent freezing. When the pump is placed close to the tower pan or sump, long runs of costly suction piping are eliminated. Where a *prime* condition must be maintained, the suction line from the tower must be horizontal or run at a slope to make it self-venting, and the pump must be placed below the fluid level in the tower. (See Fig. 10.)

Only the discharge line may be looped above the liquid level. If the suction line is looped above the liquid level, it may collect air, restrict full coolant flow and lower system capacity. The suction line must go through, around, or below the obstruction, even if this makes it necessary to relocate or raise the tower. The best position for the pump is at the tower.

Closed systems work best if the pump is located so that it pumps away from the expansion tank and is located close to it. The pump head is then dissipated through the piping.

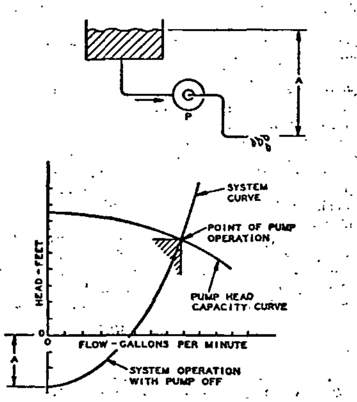

Fig. 7 .... Shift in System Curve Caused by Higher Static Pressure on Suction Side of Pump

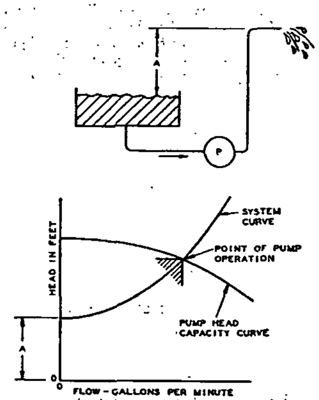

Fig. 8 .... Shift in System Curve Caused by Lower Static Pressure on Suction Side of Pump

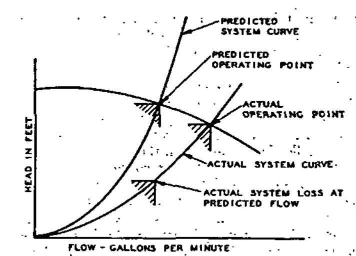

Fig. 9 .... Effect on Pump Performance of Difference Between Predicted and Actual System Curve

(See Chapter 10, 1964 GUIDE AND DATA BOOK on effect of pump location on hot water heating systems.)

In *open* and *closed* systems, the quality of the fluid reaching the pump has a direct bearing on overall performance and life expectancy. Vortexing and air pick-up at the sump in open systems, and circulation of entrained air or gases in closed systems, must be eliminated. Adequate sump depth and size prevent vortexing, and also keep the suction pipe entrance velocity below 3 fps. Furthermore, the low-velocity areas in closed systems should be used to eliminate air. It is especially helpful if the velocity in the separating area does not exceed one-half feet per second. Commercial dip tubes and low-velocity separators are furnished by some manufacturers as packaged equipment.

MOTIVE POWER

Electrically-driven centrifugal pumps are called close-coupled when the impeller is mounted directly on the motor shaft, and long-coupled when the pump shaft is connected to the motor by a flexible coupling, or is belt driven. Due to the small amount of starting torque required on centrifugal pumps driven by squirrel-cage induction motors, *across-the-line starting* is usually employed with proper phase protection and switching. This applies especially to boiler feed-pumps, condensate pumps, circulating pumps, and tower pumps. For *hazardous pump locations*, such as wet pits, pits subject to flooding, or the accumulation of combustible gases, special motors are available. Unless otherwise specified, open, drip-proof motors are supplied by the pump manufacturer, but *splash-proof*, *totally-enclosed*, and *explosion-proof* motors are furnished by all manufacturers on request.

Gasoline- or diesel engine-driven centrifugal pumps are called *close-coupled*, when the impellers and volutes are mounted directly on the engine-shaft and housing; and *long-coupled*, when the pump shaft is connected to the motor by a flexible coupling, or is belt driven. Conversion kits are available for most engines to convert them for use of either natural gas or liquefied petroleum gases (butane or propane) instead of gasoline. Due to speed variations possible with this type of drive, a governor is essential for satisfactory operation, in order to regulate the speed and delivery desired. Steam is usually available to drive centrifugal boiler feed-pumps and booster pumps in power stations by means of turbines. Reciprocating boiler-feed pumps are also usually steam-driven.

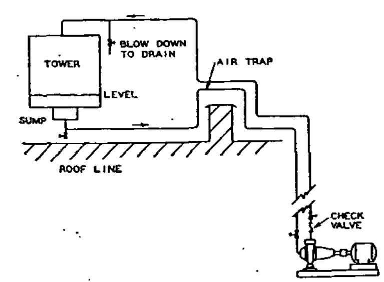

Fig. 10 .... Pump Location Relative to Cooling Tower

PUMP SELECTION AND INSTALLATION

Selection. Where *noise or vibration generation* must be kept at a minimum, it is essential that the pump be suited to the hydraulic characteristics of the system and be accurately selected in order to operate without cavitation. Vibrations and unbalance become more critical with increasing speeds. Therefore, a low-speed pump will operate in most cases more quietly than a pump of the same head and capacity at higher speeds. *Sleeve-bearing* motors are considered quieter in operation than *ball-bearing* motors. *Close-coupled* pumps are generally not used when sound control is important because the motor noise cannot be isolated and consequently, any noise generated will pass directly into the system. In the case of *long-coupled* pumps, where a coupling separates the motor from the pump shaft, the motor can be isolated from the building structure by mounting it on resilient supports. Some motor manufacturers supply resilient mounting for motors, up to 10 hp. Specially designed *quiet motors* are available above that limit.

The selection of the proper pump, speed, and motor combination is more effective in eliminating system noise than the installation of *pipe isolators* which are useful, however, in some cases. Sleeve-bearing motors and pumps generally are restricted to a speed of 1740 rpm.

In systems having highly varying loads, use of pumps with *nonoverloading* motors is recommended. Nonoverloading motors are sized to provide adequate power at any point of the pump curve. If operating conditions can be accurately predicted, a motor can be selected specifically for the power required. In this case the selected motor will often be smaller than the motor originally provided.

Pumps for handling liquids of *medium temperatures* have special seals and bearing lubricants. *High-temperature* pumps for liquids above 325 F have special pump construction and materials. The bearings and seal areas are water-cooled.

Medium-temperature installations sometimes include a high-temperature pump. Packing gland or stuffing box pumps are also used for high-temperature liquids, but must then also be water-cooled. However, in order to keep the high-temperature installation as free of water losses as possible, special mechanical seal pumps are somewhat more popular. (See Chapter 12, 1964 GUIDE AND DATA BOOK.)

Installation. Pump suction and discharge piping connections are not necessarily of the same size as the system leading to or from the pump, but changes in system piping to fit the pump connections should be as close to the pump as possible. Suction and discharge piping must be supported, so that when the flange bolts are tightened, no strain will be transmitted to the pump.

Close-coupled centrifugal pumps, because of the nature of their design, are properly aligned throughout their life with