the conditioned space. For a direct expansion system the evaporator can be held at a temperature not much less than that of the conditioned enclosure except in cases where lower temperatures may be needed in order to establish a desired ratio of dehumidifying to cooling load. When dehumidification requirements dictate the use of unusually low evaprorato temperatures the increased operating cost should properly be charged against the dehumidification rather than the sensible cooling.

Influence of Discharge Pressure

In contrast to the suction pressure, the compressor discharge pressure should be kept as low as operating conditions will allow. This pressure must be high enough to provide a saturation temperature of refrigerant within the condenser which is greater than the exit temperature of the cooling water. The discharge pressure therefore is a direct function of the temperature of the cooling fluid and will automatically rise whenever the temperature of cooling water (or air) rises; it will also rise when the flow rate of the cooling medium is decreased.

Increase in discharge pressure (for fixed suction pressure) raises the enthalpy of the gas leaving the compressor, hence increases the work of compression. Further, the enthalpy of saturated liquid leaving the condenser increased with pressure so the refrigerating effect must decrease. Thus the effect of such a pressure rise is to require more work per pound of refrigerant handled and at the same time to necessitate an increase in the refrigerant flow rate.

Influence of Water Jacket

The preceding discussion has, in every case, assumed isentropic compression. Where exact performance data are not available this assumption is a desirable one since it leads to a conservatively large determination of the power required. In most actual systems the compression process departs from isentropic due to irreversible heat transfers which occur between the vapor in the cylinder and the cylinder wall and also because of intentional heat dissipation from the outside of the cylinder walls to the surroundings, or to a cooling fluid passing through a water jacket around the cylinder.

Exact measurement of the heat carried away in the jacket cooling water requires facilities which frequently are not available on field installations, but a reasonably close approximation to both the heat loss and the work requirement can be obtained from theory, providing the temperature of the gas leaving the compressor is experimentally determined. Knowing the temperature and pressure at both suction and discharge, the actual state points can be readily determined from the tables of refrigerant properties and the entropies and enthalpies thereby evaluated. Then the energy dissipation to cooling water can be calculated approximately from the equation,

$$Q_j = W_r\,(\Delta s)\,T_{avg} \tag{7}$$

where

Q_j = energy dissipated to cooling water, Btu per minute.

W_r = weight of refrigerant, pounds per minute.

Δs = entropy change between suction and discharge.

T_{avg} = average temperature of gas passing through compressor, Fahrenheit degrees, absolute.

The work of compression is then given by the equation:

$$(\text{hp}) = [W_r\,(h_d - h_{vs}) + Q_j] \div 42.42 \tag{8}$$

where

hp = horsepower.

h_d = enthalpy of vapor at compressor discharge.

h_{vs} = enthalpy of saturated vapor entering compressor.

From the form of Equation 8 it would appear that an increase in the energy loss to the jacket would result in a greater power requirement since the Q_j term is additive; actually, however, computation will readily show that the effect of an increase in the Q_j term is to *decrease* the horsepower since the rate of decrease of enthalpy difference will, in every case, exceed the increase in heat loss. Thus compressor cooling is highly desirable as a method of reducing power consumption.

Influence of Superheating and Subcooling

The most common departure from conditions of the simple saturation cycle is that resulting from admission of superheated vapor to the compressor. Thermodynamically, superheat is undesirable since the enthalpy increase required to compress a vapor through a given pressure range increases with superheat. Further, superheated vapor leaving an evaporator is usually an indication that the suction pressure is lower than necessary. Under practical operating conditions, however, superheat is almost universally used as a means of assuring complete vaporization of the refrigerant going to the compressor. With modern compressors operating at high speed and with relatively small clearance space it is particularly necessary to avoid admission through the suction valves of liquid refrigerant.

Another common departure of actual systems from the simple saturation cycle occurs because of subcooling of refrigerant in the condenser. Thermodynamically such subcooling is advantageous since it increases the refrigerating effect without affecting the unit energy requirements of the compressor. Further, it can be shown that for a fixed ratio of condenser cooling water to refrigerant circulating rate the total compressor power requirements will be greater when operating simple saturation than when operating with maximum sub-cooling. What is even more surprising is that condenser pressure may be lower for the sub-cooling cycle than for the saturation cycle; this condition results from the fact that, for the same capacity on a heavily loaded condenser, the refrigerant flow rate is less when there is sub-cooling.

Because of the advantages attendant upon the use of sub-cooling, many methods are in use for obtaining some sub-cooling effect outside of the condenser. One common procedure is to use the cold vapor leaving the evaporator to cool the liquid flowing from condenser to expansion valve. In this case subcooling is realized at the expense of superheating the suction vapor and thermodynamic analysis will show at once that a definite loss will accrue. The only conditions under which such a system can be justified are those for which the vapor would, in any event, pick up a comparable degree of superheat while en route to the compressor; in this event the deliberate superheating, with useful subcooling as a result, is preferable to the useless superheating which would otherwise occur. In small compressors having large surface area in relation to volume, a definite gain is usually accomplished by such interchange, because for such units there would be considerable heating in any event. On very