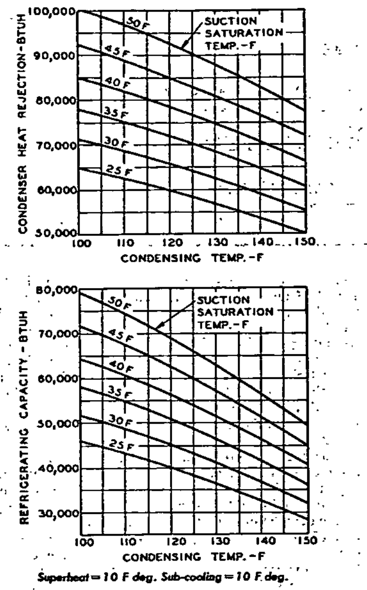


Fig. 2 . . . . Compressor Performance Diagram

The points of intersection of lines on Fig. 5 are re-plotted, omitting the internal variables of refrigerant temperatures, to obtain Fig. 6, thus showing clearly the effect of the two major external variables on the system capacity.

By adding lines of constant evaporator refrigerant temperature, either Fig. 5 or Fig. 6 can be used to determine the ratio of sensible heat capacity to total capacity, from the known characteristics of the evaporator and various evaporator inlet dry-bulb air temperatures.

After the balance point has been determined for any given set of external variables, the values of the internal variables can be determined from the individual diagrams of component performance. From these values, other operating characteristics, such as power input, refrigerant pressures, and refrigerant flow rates, can be determined.

Although the preparation of performance diagrams may be quite extensive in the case of a large or complex system, several simplifying assumptions usually are made to obtain a broad view of the system behavior. The resultant diagram can be used to determine which assumptions should be reconsidered, and to indicate the procedure which should be followed for a more detailed study.

## EFFECTS OF OTHER VARIABLES

### Air Flow

It should be noted that, in the development of the graphical method, illustrated by Figs. 1 to 6, a constant air flow has

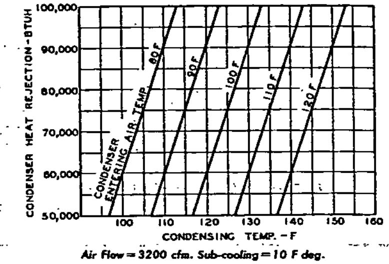


Fig. 3 . . . . Condenser Performance Diagram

been assumed for both the evaporator and condenser. If either or both of the air quantities are varied, the procedure can be repeated, with each variation finally resulting in a new diagram similar to Fig. 6. These diagrams can be compared to determine the effects of air flow variations, as a guide to selection of optimum air flow rates for both evaporator and condenser.

### Heat Transfer Surface

If desirable, performance diagrams such as Figs. 1 to 6 may be plotted for several different amounts of heat transfer surface in the evaporator and condenser. This procedure is often useful in determining the optimum amount of heat transfer surface that should be provided.

### Pressure Drop

The effects of pressure drop in the refrigerant piping have been neglected in order to simplify the discussion of the graphical method of component balancing. However, in actual design practice these effects must be considered. Although the effects of pressure drop on overall system refrigerating capacity may be relatively slight, they may have an important influence on the ability of the system to continue operating under extreme conditions.

The pressure drop from the compressor to the condenser can be estimated for the refrigerant flow at approximately the design conditions. This pressure drop can be expressed as an equivalent temperature drop by use of the refrigerant saturation tables in Chapter 20.

If the equivalent temperature drop were 2 F deg, for example, Fig. 3 would not be superimposed directly on Fig. 2, but would be moved to the right by 2 F deg. Thus, when the saturation temperature corresponding to the condenser inlet pressure is 110 F, the saturation temperature corresponding to the compressor discharge pressure is 112 F.

A similar procedure is used to include the effect of pressure drop in the piping between the evaporator and the compressor. By using the refrigerant flow at the design conditions and knowing the length of connecting line, the pressure drop in the suction line can be estimated. This pressure drop also can be expressed as an equivalent temperature drop.

If this equivalent temperature drop were 1 F deg, for example, Fig. 1 would not be superimposed directly on to Fig. 5, but would be moved to the left by 1 F deg. Thus, when the saturation temperature corresponding to the evaporator outlet is 40 F, the saturation temperature corresponding to the compressor inlet pressure is 39 F.



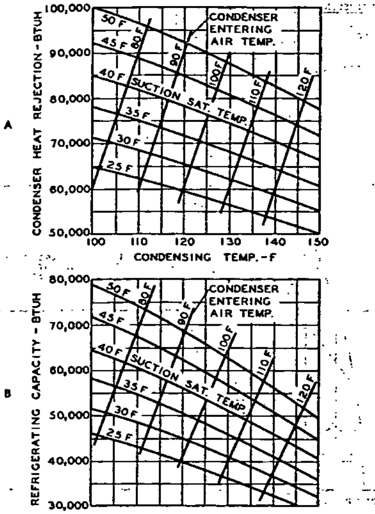


Fig. 4 . . . . Combined Performance Diagram for Compressor and Condenser

### Dry Coil Operation

In developing the graphical method, it was assumed that the evaporator capacity could be expressed as a function of the entering air wet-bulb temperature. This assumption is permissible only if the evaporator is both cooling and dehumidifying the air (wetted-coil operation). If the coil is dry, the variable used in plotting Fig. 1 is entering air dry-bulb temperature.

If there is any doubt as to whether the evaporator will be operating wet or dry under some conditions, it may be desirable to prepare two evaporator performance diagrams, using entering air wet-bulb temperatures for wet operation

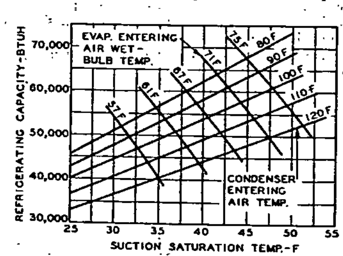


Fig. 5 . . . . Combined Performance Diagram for Evaporator, Compressor, and Condenser

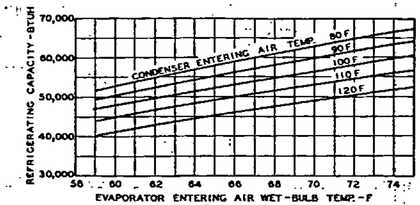


Fig. 6 . . . . Performance Diagram for Overall System

and entering air dry-bulb temperatures for dry operation. Superposing one diagram on the other will permit determination, for any evaporator inlet conditions, as to whether or not there will be dry operation, or the proportion of sensible and latent capacity if there is to be wet operation.

### Refrigerant Flow Control Device

Other assumptions used in developing the graphical method were that the refrigerant flow control device would maintain the stated evaporator superheat and that the condenser subcooling would remain constant. These assumptions are acceptable, at least within a reasonable operating range, for a thermostatic expansion valve.

If a capillary tube restrictor were used as the refrigerant flow control, it would be necessary to make other assumptions, and perhaps to include a diagram of the performance of the restrictor in the superposition procedure.

### Other Considerations

Depending on the objectives of the analysis, the performance diagrams may be prepared, using the refrigerant flow rate instead of the refrigerating capacity.

If the system uses water or brine as an intermediate fluid between the refrigerant and the air or other fluid being cooled, the performance diagrams must include the characteristics of the additional heat exchangers involved.

## TROUBLE DIAGNOSIS

The use of performance diagrams may often be helpful in diagnosing operating difficulties in a system. Comparison of actual performance and actual values of internal variables such as refrigerant temperatures and pressures with the values predicted by the diagrams will often lead to an explanation of the difficulty. It may only be necessary to obtain an indication of the direction in which certain measurable variables should move with changes in operating conditions. For this purpose, free-hand sketches often may be used, without plotting the performance characteristics quantitatively to scale.

## SYSTEM PERFORMANCE

Although this chapter has been limited to a discussion of the balancing of refrigeration system components, the basic balancing process may be applied to other component systems or may be enlarged to include the characteristics of the load on the refrigeration system.

An example of the use of the procedure in other component systems is the combination of fan, motor, and system resistance to air flow, as discussed in Chapter 32.

In air-conditioning system design, superposition of the heat