and often is considered as a safe coincident demand to be added to the other items of load during the cooling cycle.

It is good practice, for periods when the structure is occupied, to base the winter ventilation requirements on the best authoritative recommendations, but to reduce the quantities to the equivalent of the natural infiltration rate at all other periods. Consequently, it is most convenient to have heat loss calculations for each of the two conditions, in order to properly evaluate the effect of the internal heat gain during the occupied period and the reduction in ventilation air for the remainder of the time. This procedure, which was followed in the example illustrated by Fig. 14, not only keeps the size of equipment to a minimum but materially lowers the operating cost.

Since it is important to have a practical balance between the heating and cooling requirements, the various methods for reducing the heat loss

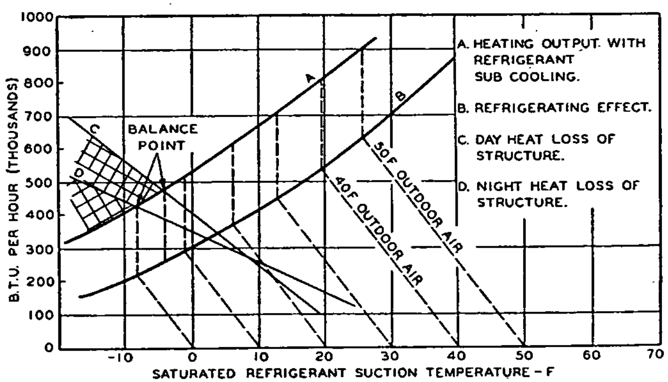


FIG. 14. HEAT LOSS OF STRUCTURE COMPARED WITH CAPACITY OF HEAT PUMP
*(Typical 75 HP Reciprocating, Single Stage, Compressor at Various Outdoor and Refrigerant Temperatures when Operating at 115 F Condensing Temperature.)*

and heat gain of a structure, such as wall and roof insulation, storm windows, etc., are frequently justified and should not be overlooked.

### Equipment Selection

The heat-source heat-sink surface, the heating and cooling surface, the compressor, and all other equipment are sized and selected in accordance with standard refrigeration practice given in other sections of THE GUIDE. The capacity of the equipment must equal the design requirements for both the heating and cooling cycle. As indicated in Figs. 10 and 13, the design of the surfaces and the connecting refrigerant piping should permit gravity drainage of the liquid refrigerant.

On recent air-type heat-source heat-sink custom-built central-plant installations, a suction line accumulator has been used very successfully. The accumulator gives added protection against refrigerant migration and return of liquid to the compressor. Similarly, a separator is used on the high side of the system to permit return of the oil directly to the compressor crankcase.

There are several procedures for obtaining the most practical selection of compressors, heat exchange surfaces, and other component parts for a heat-pump system. One method is to size the equipment to satisfy the cooling requirement, by following the standard accepted refrigeration practice and then checking this choice for the required heating capacity.[9] This can be done, as illustrated by Fig. 14, by plotting the heating requirement of the structure and the heating output of the equipment which has previously been selected for the cooling load. Such a graph will conveniently show how the equipment selection matches the heating requirements. In the example shown by Fig. 14, when using outdoor air as the source, the heating capacity of the equipment will balance the day heat loss of the structure at 6 F outdoor temperature and the night heat loss at 0 F outdoor temperature. There are several possible methods of increasing the heating capacity, if the outdoor design temperature is below the balance point. Supplemental resistance heating is frequently the most practical method, if the drop of outdoor temperature below the balance point occurs for a relatively small percentage of the heating season.



*Multi-staging* of the compressors is another way of overcoming the heating deficiency at the lower outdoor temperatures, when using outdoor air as the heat source.[10] The majority of installations to date have employed single-stage compression, but multi-stage systems have gained popularity and their acceptability undoubtedly will increase. These systems are particularly attractive in the northern climates, where the low outdoor design temperature may make the single stage system impractical. The advantages of multi-staging are the resultant smaller heat-source heat-sink surfaces and the proportionally smaller auxiliaries needed to provide a given heating effect at a given outdoor temperature. Whether these advantages will out-weigh the disadvantage of the cost of staging will depend on the particular requirements of each installation.

*Refrigerant piping* between the various pieces of equipment should be properly sized and installed in accordance with accepted refrigeration practice (see later section on Refrigeration Piping).

As is the case in all mechanical refrigeration systems, particular precaution is necessary in sizing and installing the refrigerant piping, if some form of capacity modulation is installed, or when multiple compressors are used.

### Distribution System for Heating and Cooling Effect

All of the various types of distribution systems, which can be used for year-round air conditioning systems, are equally applicable to heat pumps. This includes (1) hot, cold, or hot and cold water indirect systems, (2) high or low velocity duct systems, (3) individual conditioners mounted along exterior walls, or (4) a combination of any or all of these systems. A number of self-contained packaged or custom-built types of units, instead of one large central-plant system, may be employed to take full advantage of the flexibility of the heat pump and thereby keep the ductwork, piping, electric power and control wiring to an absolute minimum.

Since a heat-pump system contains little reserve heating capacity, a night set-back type of operation is not recommended, particularly during extremely cold weather, because of the morning warm-up requirements.

### Operating Cost

Either the calculated heat loss method or the degree-day method given in Chapter 18 can be used for estimating season heating requirements of heat-pump systems.

If the *balance point* is above the outdoor design temperature, additional