

(1) the steam valve throttles and supplies a reduced amount of steam which, in turn, reduces the degree of solution concentration, (2) the automatic solution valve reduces the quantity of solution reconcentrated which, in turn, reduces the amount of steam condensed, or (3) both effects are obtained simultaneously.

In addition to controlling the amount of refrigeration produced, as outlined above, the temperature of the chilled water must be controlled to meet the requirements of the load. The absorber, through its effect on the evaporator pressure, determines the evaporator temperature, and consequently controls the leaving chilled water temperature. The absorber, in turn, is controlled by the flow rate and concentration of the absorbent solution which it receives, and by the temperature of the cooling water.

For installations where the design load is close to the machine capacity rating, the steam requirements will be 19 to 20 lb of steam per ton-hour. Steam consumption at reduced loads will depend upon the type of capacity control used. Fig. 12 shows the range in consumption for a typical unit.

Auxiliaries

Heat Exchanger. While the entire absorption machine is essentially a group of heat exchangers, one particular component is known as the heat exchanger. This is located, thermodynamically between the absorber and the generator; it preheats dilute solution flowing from the absorber to the generator, while cooling the concentrated solution flowing from the generator to the absorber. It may be of shell-and-tube or double pipe construction.

Purge Unit. Because the lithium bromide cycle operates at a high vacuum, a purge unit is included to maintain that vacuum by removing any noncondensable gas that might accumulate. The purge unit may be a vacuum pump, an eductor or a palladium cell.

Expansion Valve. Mechanical expansion valves are not used in absorption units. The flow of refrigerant liquid to the evaporator is controlled by an orifice or other fixed restriction between the condenser and the evaporator.

Solution and Refrigerant Pumps. In large tonnage units, the dilute solution and the refrigerant are circulated through the unit by small pumps rather than by natural circulation. These pumps may be used to dilute the absorbent solution in the generator when cooling is no longer required, to eliminate any possibility of crystallization of the concentrated solution.

Refrigerant and Solution Piping. In all refrigeration systems, pressure losses in piping must be kept to a minimum, consistent with other design criteria. In an absorption machine, no consideration is needed for lubrication or lubricant recovery. Velocities of solutions and refrigerant

vapors may be selected on the basis of heat transfer vs. pressure drop. Because of their inherently closed-cycle nature, absorption machines are supplied as complete air-conditioners or water chillers (not as components). Complete refrigeration and solution interconnections are furnished as part of the piping of the machine.

Insulation. To prevent sweating, the chilled water headers, the refrigerant pump, and refrigerant piping should be insulated. Insulation may be provided for the absorber-evaporator shell when unusually high ambient conditions are encountered in the equipment room, and adequate ventilation is not available.

Limit Controls

Controls are provided to stop the machine whenever certain conditions are outside pre-selected limits, as follows:

1. **Low temperature cut-out.** This is a low limit thermostat which will stop the unit if the evaporator temperature falls too low. When the refrigerant temperature warms to the cut-in point, the switch resets itself to start the machine again.
2. **Cooling water pressure switch.** This is a pressure sensitive switch which will stop the unit if the cooling water supply fails. The switch resets itself when the cooling water supply is restored.
3. **Chilled water flow switch.** This is a pressure sensitive switch that will stop the unit if the chilled water flow is reduced below design limits. The switch resets itself when the proper chilled water flow is re-established.
4. **Liquid level switches.** These are float-type switches that will stop the unit if the refrigerant level in the evaporator is too low or too high. They are self-resetting.

Protective Devices

1. **High pressure cut-out switch.** This is a pressure sensitive switch that will stop the unit if the high side pressure exceeds a safe limit. It is only required on ammonia-water units.
2. **Generator high-temperature limit switch.** This is a temperature-sensitive switch that will stop the unit if the generator operating temperature exceeds a safe limit. This is generally used only with direct-fired units.
3. **Generator shell bursting disc.** On high temperature water applications, a bursting disc may be furnished in the generator shell.

EQUIPMENT SIZING AND SELECTION

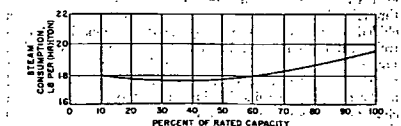
The proper selection of equipment for any air-conditioning application is of utmost importance in obtaining satisfactory results from the system. The critical factors are: (1) the size and nature of the load, and (2) economics (the total owning and operating costs).

The method for calculating the cooling load is shown in Chapter 27. It is important to emphasize that many of the heat gains are variable and that they do not necessarily reach their maximum values simultaneously. Proper evaluation of the timing of these peaks will avoid pyramiding the load. A discussion of the factors affecting the actual instantaneous cooling load will be found in Chapter 27.

A method for preparing a comprehensive economic study appears in Chapter 86 of the 1964 GUIDE AND DATA BOOK.

Table 1 Normal Rating Conditions for Heat-Operated Units

Leaving chilled water temperature	44 F
Chilled water temperature differential	10 F
Entering condenser water temperature	85 F
Steam pressure at control valve inlet	12 psig (dry and saturated)
Scale factor for evaporator, condenser, and absorber	0.0005



* Steam consumption varies from a low of 17.5 at 10% rated capacity to a high of 19.5 lb per ton-hr at 100%.

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Fig. 12 Steam Consumption for a Typical Absorption Unit

Proper preparation of that part of the study pertaining to operating costs requires a working knowledge of the various consumption rates. In the absence of specific manufacturer's information, the following procedure will furnish reasonable estimates of the required machine size and the consumption rates for energy and water.

The nominal capacity rating of an absorption machine is its capacity under a given set of conditions. These conditions are generally accepted to be as given in Table 1.

Therefore, to determine the required size of unit it is necessary to find the nominal capacity rating that will provide the required refrigeration capacity.

Variations in capacity with varying conditions of chilled water temperatures, condenser water entering temperature, and steam pressure are given in Fig. 13.

Capacity factor F_A is plotted as a function of the entering condenser water temperature. Thus $F_A = 1.0$ for an entering condenser water temperature of 85 F. Similarly, F_B is plotted as a function of the leaving chilled water temperature and is 1.0 at 44 F. F_C is plotted as a function of the chilled water temperature differential and is 1.0 at 10 F deg. F_D is plotted as a function of inlet steam pressure and is 1.0 at 12 psig.

The overall capacity factor F_O for the unit is the product of the four capacity factors found from Fig. 13. Therefore, for the conditions given in Table 1, the overall capacity factor

$F_O = 1.0$, and the nominal capacity rating equals the required refrigeration load.

Selection of a unit for conditions other than those given in Table 1 is illustrated by Example 1.

Example 1: A heat-operated air conditioner is to be installed in an office building having a refrigeration load of 200 tons. The chilled water temperature leaving the unit is 42 F, with an 8 F deg differential between entering and leaving temperatures. The water temperature entering the condenser is 87 F. Dry, saturated steam is available at 10 psig at the control valve inlet. Find: (a) the nominal capacity rating of the unit, (b) the steam consumption at full load, (c) the condenser water flow rate, (d) the chilled water flow rate, and (e) the heat rejected to the cooling tower.

Solution: (a) The capacity factors are found from Fig. 13. For 87 F entering condenser water, $F_A = 0.96$. For a 42 F chilled water temperature, $F_B = 0.935$. For an 8 F deg temperature difference, $F_C = 0.99$. For 10 psig steam pressure, $F_D = 0.98$. The overall capacity factor F_O is:

$$F_O = (F_A)(F_B)(F_C)(F_D) = (0.96)(0.935)(0.99)(0.98) = 0.871$$

The nominal capacity rating required is: $200/0.871 = 230$ tons. Any unit with a nominal capacity rating of 230 tons or more could be used for this application.

(b) The steam consumption usually is estimated as 20 lb per ton (hr). Therefore, the steam flow at full load (200 tons) is $200 \times 20 = 4000$ lb per hr.

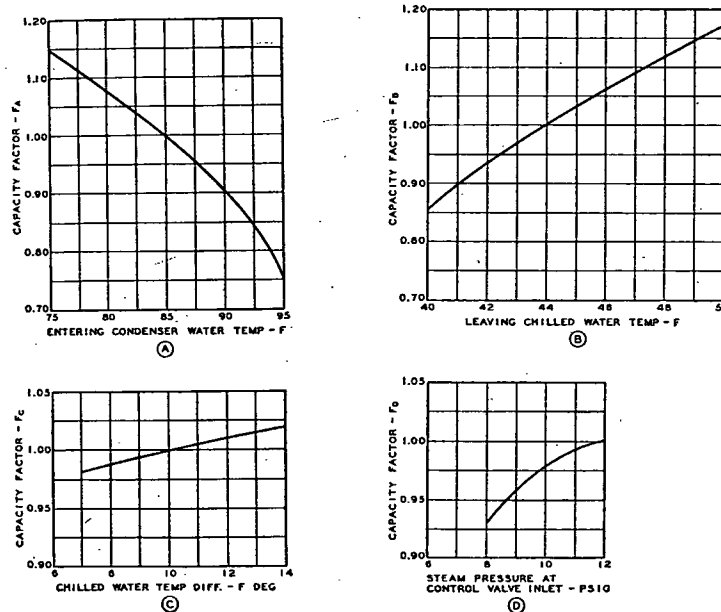


Fig. 13 Capacity Factors for Equipment Selection