

bottle cooled. The temperature differential between bottle and refrigerant is held to a minimum, thereby assuring relatively high suction-pressure operation and consequent improvement in efficiency.

Dependable stock rotation is not assured in this type of cooler since a bottle can be removed from any section of the cooler at will. If the bottles are stacked horizontally, it is possible to arrange the loading so that the fresh warm bottles are located at the bottom, and the cooled bottles are at the top of the cooler. This is desirable because it assures that cold bottles are available for the next customer.

While horizontal stacking of the bottles results in maximum bottle capacity it also impedes the air flow. The cold air is generally blown over the top layer of bottles in the cooler and then proceeds down through the lower layers of bottles to the bottom of the cooler, where a rack is located to provide a space for the return air. In this manner adequate air distribution throughout the entire cooler is obtained. In the larger sizes of coolers it is difficult to cool the bottles in the extreme corners (even in the top layer) to the same temperature as exists in the center of the cooler.

Present construction provides easy access to the refrigeration unit for replacing and servicing. Compact design simplifies replacement of the complete unit.

Vertical Forced-Air Type

These vendors are manufactured in capacities of 40 to 350 bottles. The size of vendor for a particular sales location is influenced mainly by the rate of bottle sales and the time intervals between reloading.

The bottles may be arranged in the vendor in many different ways depending on the type of vending mechanism. The bottles may be stacked compactly in columns, or placed in individual compartments. Still another arrangement consists of inclined shelves on which the bottles roll by gravity to one side where they are removed through a narrow door.

In order to provide a stable bottle temperature, it has been found necessary to provide forced-air circulation.

The evaporator is usually of the finned-tube type, compactly wound or formed, with a fan to circulate air through the evaporator and over the bottles.

An important consideration of the air circulation is to direct it from the evaporator to the bottles which are in position to be vended. This not only helps to keep these bottles colder but enables them to be cooled quickly when the vendor is first loaded with warm bottles. Another consideration is that the

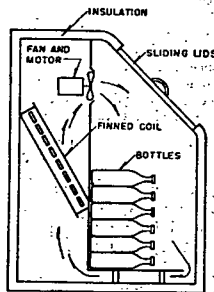


Fig. 2 . . . Horizontal Forced-Air Bottle Cooler

bottles do not need to be refrigerated until a few hours before they are to be vended. This means that the refrigeration capacity does not need to be sufficient to cool a full load of bottles at one time, if the air path can be directed over only part of the load. Generally the bottles move through the refrigerated zone as they progress toward the vending position. Operation of the fan during the off-cycle of the refrigeration system will aid in keeping the bottles at approximately the same temperature. Also, defrosting action is faster with air blowing over the evaporator.

Because it takes several hours to cool a warm bottle with a conventional refrigerating system, it is desirable to provide space in the vendor for precooling some bottles for the next reload. These precooled bottles are then loaded so that they are dispensed ahead of any warm bottles.

Some manufacturers prefer to provide extra space in the vending mechanism and arrange a means of stopping operation before these extra bottles are vended. In this way, the precooled bottles are already in place and the work of transferring the bottles is eliminated when reloading. By this method, rotation of stock is assured and bottles are not left in the precooling space long enough to become stale.

DESIGN CONSIDERATIONS

The purpose of a vendor is to furnish cold bottled beverages to the customers. How well the vendor does this depends largely on how well the vendor is matched to the job. For example, a vendor which would hold a full day's sale and which could be reloaded at closing time each day would need little excess refrigerating capacity over losses through heat leakage. Such a vendor would have many hours during the night in which to cool the bottle load. On the other hand, a vendor which would normally be reloaded several times a day, would require the necessary cooling capacity to cool the bottle load and also compensate for the heat leakage during the day.

Rates of Anticipated Sales

When cooling, up to 50 Btu of heat must be removed per 6 oz bottle, depending on the specific heat of the beverage, weight of glass bottle, and temperature of bottles before they are placed in the vendor. The rate of sales will therefore be an important consideration in the refrigeration capacity of the vendor. If sales are fairly steady, a high degree of zone cooling would be desirable. However, heavy peak demands would require more refrigeration capacity and cooling of a greater percentage of the bottles to assure that the demand could be supplied. Vendors are usually designed for these peaks.

A knowledge of the anticipated sales per hour and per day is needed to determine the machine bottle capacity as well as its refrigeration capacity. The vendor must refrigerate bottles as rapidly as they are sold, except that peak sales may be taken care of by a reserve of cold bottles in the vendor.

Together with the anticipated sales rate, the anticipated reloading schedule will finally determine the bottle capacity of the machine. Reloading once a day is considered normal but reloading twice a day is common. Where a considerable distance must be traveled to reload, it is often practicable to provide a vendor of sufficient size to require reloading only once or twice a week. The extra investment in initial cost may be more than saved in decreased time and travel required to keep a smaller machine in service.

Temperatures

The expected range of ambient conditions is an important factor in design. Many vendors are placed outdoors in direct

sunlight where the cabinet exterior surface may reach 160 F. Some vendors may have sufficient capacity to refrigerate the load in the northern part of the United States but will not be satisfactory in the warmer climates. Aside from adequate cooling capacity, bottle temperature must be controlled within acceptable limits under the expected widely varying ambient temperatures. Controls which hold the bottle temperatures within 2 or 3 F deg at one ambient condition do not always work as well under other ambient conditions. For instance, the constant cut-in control, which has been widely used because of its dependable defrosting action, has the inherent characteristic of allowing the bottle temperature to drop as the ambient rises, because of the increase in compressor running time.

The product must often be cooled from above 100 F (where the product is stored in the sun or delivered from open truck) to 32 F or slightly below. It is desirable to keep bottles as cold as possible without freezing. A product temperature above 40 F is considered unsatisfactory.

One of the most important functions of the control system is to insure adequate defrosting of the evaporator. Several methods used to accomplish this function are: (1) the hot-gas defrost system, (2) a timing device that operates heaters or insures an adequate off period every 24 hr or less, and (3) the use of a gas- or liquid-charged control with a fixed cut-in temperature above freezing. In the latter method the control bulb is placed on the evaporator. In this manner, using a cut-in temperature of approximately 35 F, complete defrosting is insured during each off period of the unit. This necessitates the use of a wide differential control since the cut-off temperature must be in the range of 12 to 25 F, depending upon individual unit design, in order to provide cold bottles under all ambient conditions. Vendors with this control are usually designed for indoor use.

When vendors are used outdoors in locations where temperatures are apt to drop to below 40 F, a control with a cross-ambient feature (liquid charged bellows) must be used, or the entire control must be located inside the cooling compartment. (See Chapter 45.) This is necessary to assure that the actuating bulb is actually functioning to operate the control and give the desired product temperature. If the unit has a capillary tube, it may be desirable to use a thermostatic device to stop the condenser fan when the ambient temperature is low. This will control the condensing temperature and will provide adequate pressures for the proper functioning of the capillary tube at low ambient temperatures.

If it is known that a vendor is to be used in such a way that the entire load of bottles will be used in a few minutes, the best arrangement would be to cool all the bottles as a unit since there would not be time to do much additional cooling before the bottles are used.

One method of assuring adequate cooling with the minimum compressor size is to utilize an area in the refrigeration compartment, which is in relatively poor heat-transfer relationship to the evaporator and to the bottles in the vending mechanism. Bottles placed in this area will gradually cool while the bottles in the vending area are being vended. If the heat transfer characteristics are balanced, these bottles will be cold by the time the bottles in the vending section are used. Warm bottles are then placed in this precooling area. One advantage of this arrangement is that warm bottles can be loaded into the vendor without raising the temperature of the other bottles. The main disadvantage is that extra work is involved in moving the bottles from the precooling area. Also, because of the extra labor involved, the attendant will often load directly into the vending mechanism, leaving the bottles in the precooling area where they will get stale. For

these reasons, the trend has been to incorporate as much of the available space as possible into the vending mechanism itself.

The total capacity of a machine should be slightly more than the expected peak sales between reloadings, plus capacity to last until reloaded bottles are cooled.

The cabinet must be large enough to accommodate the vending mechanism with its bottles and the evaporator and fan. Due to the particular construction of some vending mechanisms, there may be spaces in the vendor which would be wasted if they were not used for precooling bottles.

Bottle Size and Shape

Many different sizes and shapes of bottles are used for beverages, with each brand usually having a distinctive size and shape. Bottle dimensions are critical in some vending mechanisms. Information regarding the bottle length and major diameter, weights of the bottle, liquid, and cap, as well as the specific heat of the filled bottle, and the freezing point of the beverage may be obtained from the bottling plant.

The wide variety of surface irregularities have not caused detectable differences in cooling rates in bottle coolers tested. It is probable that the irregular surfaces promote turbulence with resulting increased heat transfer.

Freezing Point of Beverage

The freezing point of beverages while still under carbonation pressure in the bottle varies considerably. While some beverages with low carbonation and low sugar will form heavy ice crystals near 31 F, others will remain fluid in the capped bottle at temperatures as low as 21 F. Also, sample bottles of the same beverage have been found to vary over a wide range with some bottles showing large amounts of ice crystals at 27 F, while others showed no ice crystals when sustained at 21 F, even after being shaken and jarred.

When the cap (or crown) is removed from a bottled beverage, the freezing point changes radically. Release of the carbon dioxide pressure allows the beverage to assume a consistent freezing point which for many beverages is approximately 29 F. If the liquid is colder than this when the cap is removed, there is a rapidly growing formation of ice crystals as the temperature immediately jumps to the normal freezing point. This may be desirable in some warmer climate areas of the United States, where customers want to have ice crystals or *flake ice* form in their bottle when the cap is removed. To accomplish this, the bottle must be vended at a temperature within a narrow range from 1 to 4 F deg below the freezing point of the beverage at atmospheric pressure. If the temperature of the bottle is lowered further, the ice forming will cause the liquid and ice to push out of the bottle with waste and spillage.

The specific heat of the majority of carbonated beverages is very close to that of water. For determining cooling rates, test bottles may be filled with water to the usual beverage level without undue errors in performance values. To prevent freezing in the bottles it is usual to add enough ethylene glycol antifreeze to the water to lower the freezing point to approximately 20 F.

Air Circulation

Circulating air, used almost universally at present for cooling bottles, may be varied in quantities and velocity for particular applications. While a pound of air will carry only approximately 0.2 Btu for each degree change in temperature as the air moves through the cabinet, the quantity of air will be determined by the velocity needed around the bottles. Vending principles will determine bottle positions in machines