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BENNETT 65

HYDROCOOLING PEACHES

A Practical Guide for Determining Cooling Requirements and Cooling Times

BENNETT '65

Agriculture Information Bulletin No. 293

Agricultural Research Service
U.S. DEPARTMENT OF AGRICULTURE
in cooperation with
College of Agriculture Experiment Stations
University of Georgia

HYDROCOOLING PEACHES

A Practical Guide for Determining Cooling Requirements and Cooling Times

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Hydrocooling is a common practice in peach packinghouses in the principal eastern producing areas. Cooling peaches to the proper temperature before shipment helps to insure that they will reach the consumer in sound, disease-free condition, looking very much like freshly picked fruit. Peaches that are cooled to 40° F. before shipment, and held at that temperature, will not decay and soften during the normal marketing processes.

To get the best returns from your hydrocooler, you should make sure it is cooling the fruit effectively, and at the lowest possible cost. To do this requires some knowledge of the mechanics of the hydrocooling system.

TYPES OF COMMERCIAL HYDROCOOLERS

Until recently, all peach hydrocoolers were of the conventional flood-type design (fig. 1), and peaches were almost always cooled after they were packed in baskets or wirebound boxes used as shipping

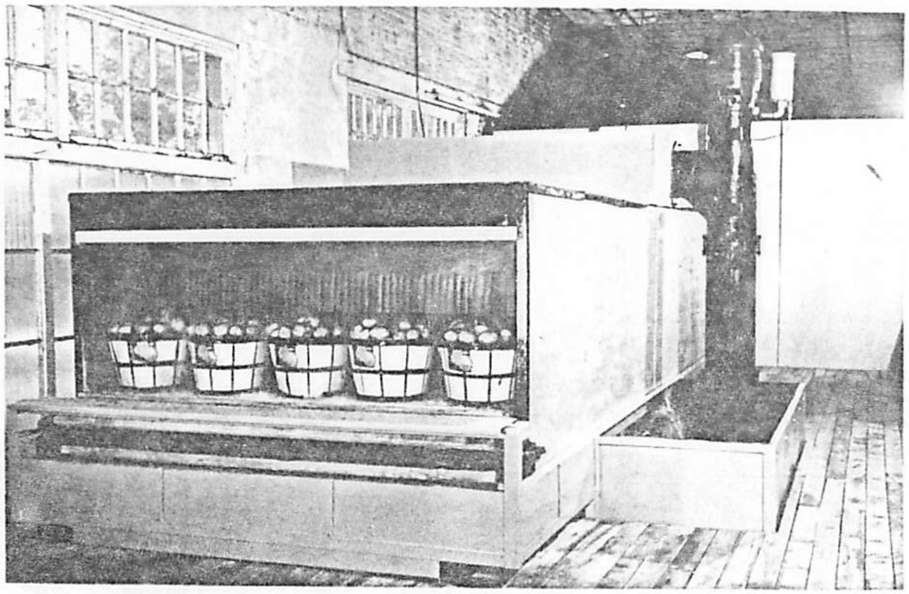

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Figure 1.—Small conventional flood-type hydrocooler. Fruit is packed before it is placed in the cooler.

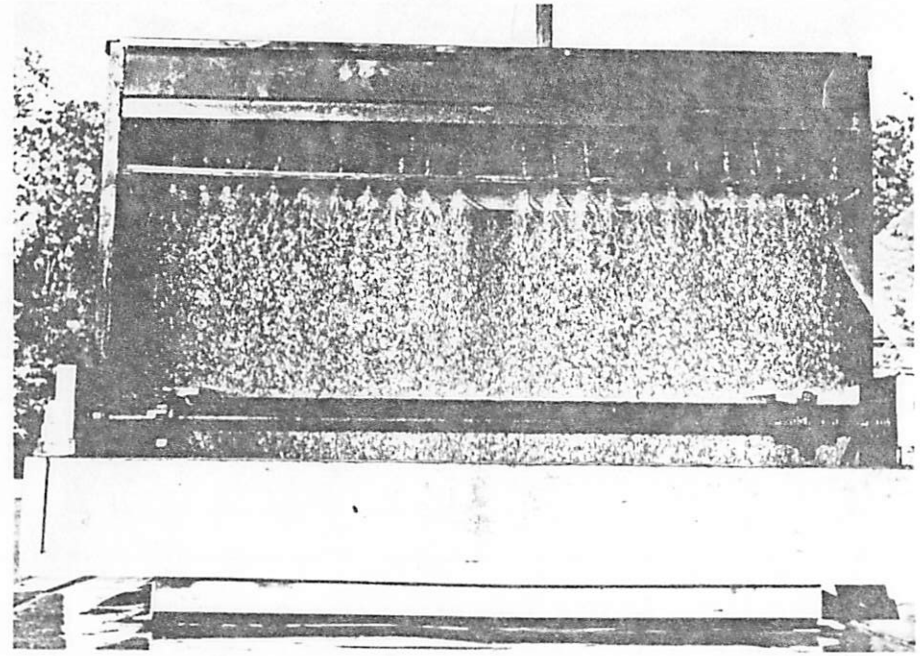

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Figure 2.—End view of conventional flood-type hydrocooler illustrating water distribution.

containers. The flood-type hydrocooler consists of a cooling tunnel through which the containers of peaches are moved on a conveyor. In the tunnel, chilled water flows from overhead flood pans and literally rains on the fruit (fig. 2), completely saturating its surface. In some machines, the water passes through a screen to further disperse it into a fine spray for more uniform distribution over the fruit surface. Conveyor speed can be varied, and cooling tunnels are available in a variety of lengths, permitting considerable operating flexibility.

The hydrocooler is usually designed to deliver water at a rate of approximately 15 gallons per minute per square foot of horizontal cross-sectional area of the tunnel. The water may be chilled by ice or by mechanical refrigeration. Although a water temperature of 32° F. is the most effective, actually in a commercial practice a temperature of 35° F. is usually found. For this reason, the 35° F. temperature is used in the discussion in this report.

Another method—bulk hydrocooling—has come into use recently, largely because some of the new packing procedures and types of shipping containers used for peaches, such as trays overwrapped with film, require that fruit be cooled in bulk.

Some flood-type hydrocoolers may be used for bulk cooling (or can be converted), but bulk cooling is usually done in specially designed bulk hydrocoolers (fig. 3). When flood-type hydrocoolers are used for bulk cooling, a waterflow rate of 5 gallons per minute for each square foot of horizontal tunnel area is sufficient if the fruit is not more than 8 inches deep, and the water is showered in a uniform pattern of fine particles. If the fruit is between 8 and 15 inches deep, 10 gallons per minute is sufficient, if properly distributed.

In bulk hydrocoolers, loose fruit is initially immersed in rapidly circulated chill water. As fruit travels through the cooling tunnel, it is gradually lifted out of the water and exposed to an overhead shower such as that of the conventional flood-type hydrocooler. Waterflow rate is about the same as that for the conventional machine. Figure 4 shows fruit being discharged from a bulk hydrocooler onto a sizer.

A special type of bulk cooler is a large tank or vat containing chill water in which loose fruit remains immersed as it moves slowly from entrance to exit. This type of cooler takes about 8 g.p.m. for each bushel-per-hour of output capacity. Thus a cooler having an output capacity of 150 bushels per hour would pump 1,200 g.p.m. through the tank. This amount of chill water, at the proper temperature, is sufficient to do the necessary cooling. However, to accomplish this cooling in a minimum time requires that the water be rapidly circulated over the fruit surface. Velocity of water in the tank for a given volume pumped, depends upon tank width and depth. A velocity of 20 f.p.m. satisfies the requirement for rapid circulation. Thus a tank 5 feet wide by 1.5 feet deep (7.5 sq. ft.), or other corresponding dimensions, would need to pump 20 f.p.m.×7.5 sq. ft.—150 cubic feet per minute, or 1,200 g.p.m. In this case both the requirement for quantity and rate of flow of water circulated is satisfied.

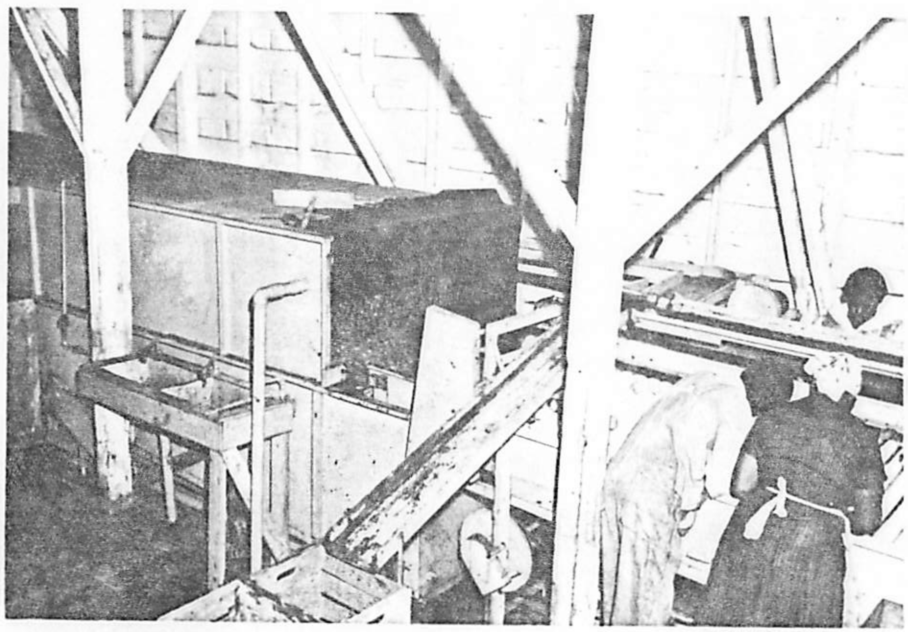

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FIGURE 3.—Bulk hydrocooler located after the grader.

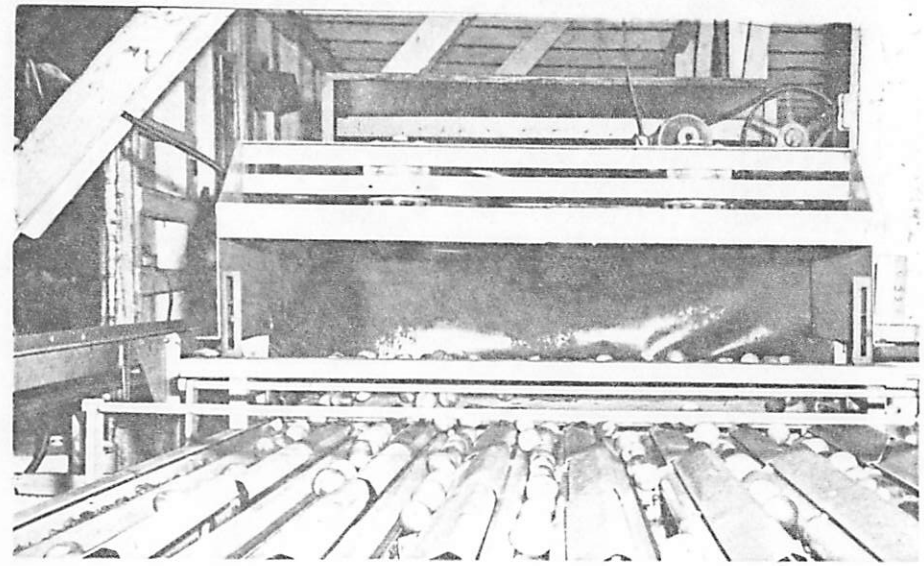

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FIGURE 4.—Chilled peaches emerging from a bulk hydrocooler onto a sizer.

COOLING BY ICE OR MECHANICAL REFRIGERATION

Block ice was used almost exclusively to chill water in the early days of peach hydrocoolers. There should be no difference in the cooling effectiveness of a hydrocooler using ice and one using mechanical refrigeration, other things being equal. As long as block ice is available when it is needed and the cost does not exceed $8 to $10 per ton, ice usually is more economical for the small packer (25 cars or less per year). An exception would be where a mechanical refrigeration system could be used for other purposes during off periods.

Since mechanical refrigeration is usually cheaper than ice in medium-size and large packinghouses, the majority of these packers have shifted to mechanical refrigeration (fig. 5).

A mechanical refrigeration system has three major components—the compressor, the condenser, and the evaporator, sometimes called the cooling coils. The capacity of each component is rated independently in terms of British thermal units (B.t.u.) per hour for specified refrigerant temperatures and pressures. The three components should have the same capacity because the capacity of a system as a whole is governed by the component having the smallest capacity. For example, the output capacity of a 100-ton compressor would be reduced to 80 tons when connected to an evaporator having a normal operating capacity of 80 tons.

Cooling coils are designed to fit specific needs, and their design depends upon the physical circumstances surrounding their use. The most efficient coils for hydrocoolers are contained in as small a space as possible with a maximum exposure

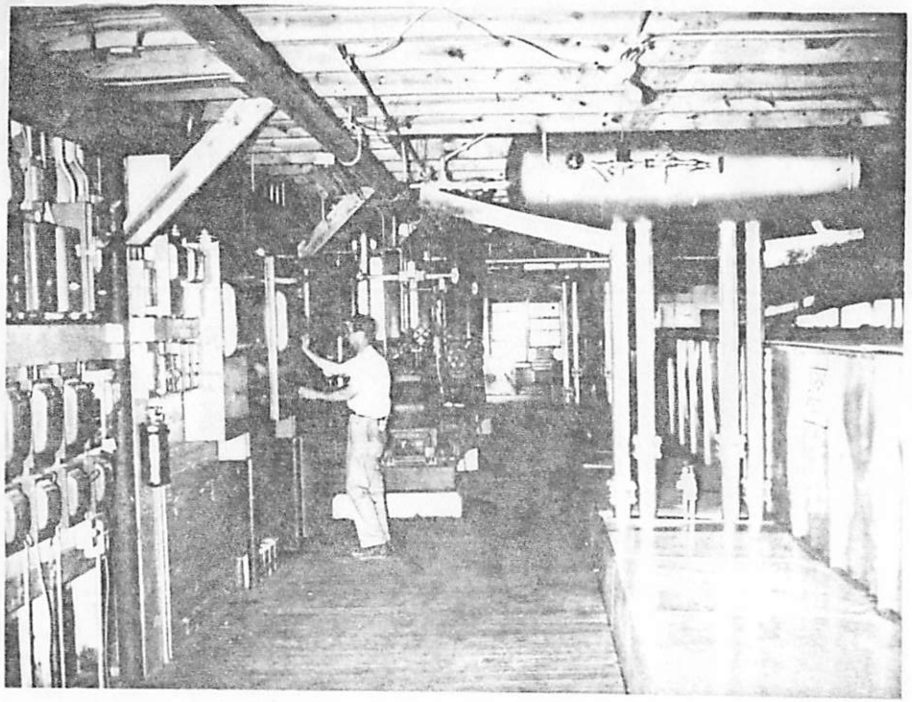

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FIGURE 5.—Two hundred tons of mechanical refrigeration in a large peach packinghouse.

of pipe surface area. They should always be completely immersed in thoroughly agitated water. Figure 6 illustrates efficiently designed coils of the type used in hydrocoolers.

COOLING REQUIREMENTS

Table 1 shows the ice use rate or the refrigeration capacity needed for hydrocooling 100 bushels of peaches an hour for various reductions in fruit temperature. In the Southeast, the average reduction in peach temperature ranges from 35° to 55°, for a final fruit temperature of 40° F., because most peaches arrive at the packinghouse from the field at temperatures of 75° to 95° F. The values listed in table 1 apply only to hydrocooling systems protected from excessive external heat gain as described below.

The amount of ice or refrigeration capacity needed to hydrocool a given amount of peaches depends first on the heat load produced by the fruit. The fruit heat load is computed in British thermal units from the amount of temperature reduction the cooling must accomplish. This load is then increased by about 10 percent to take care of the heat load produced by containers in which the fruit may be packed, pump motors, and any materials, such as the conveyor, that come in contact with the chilled water.

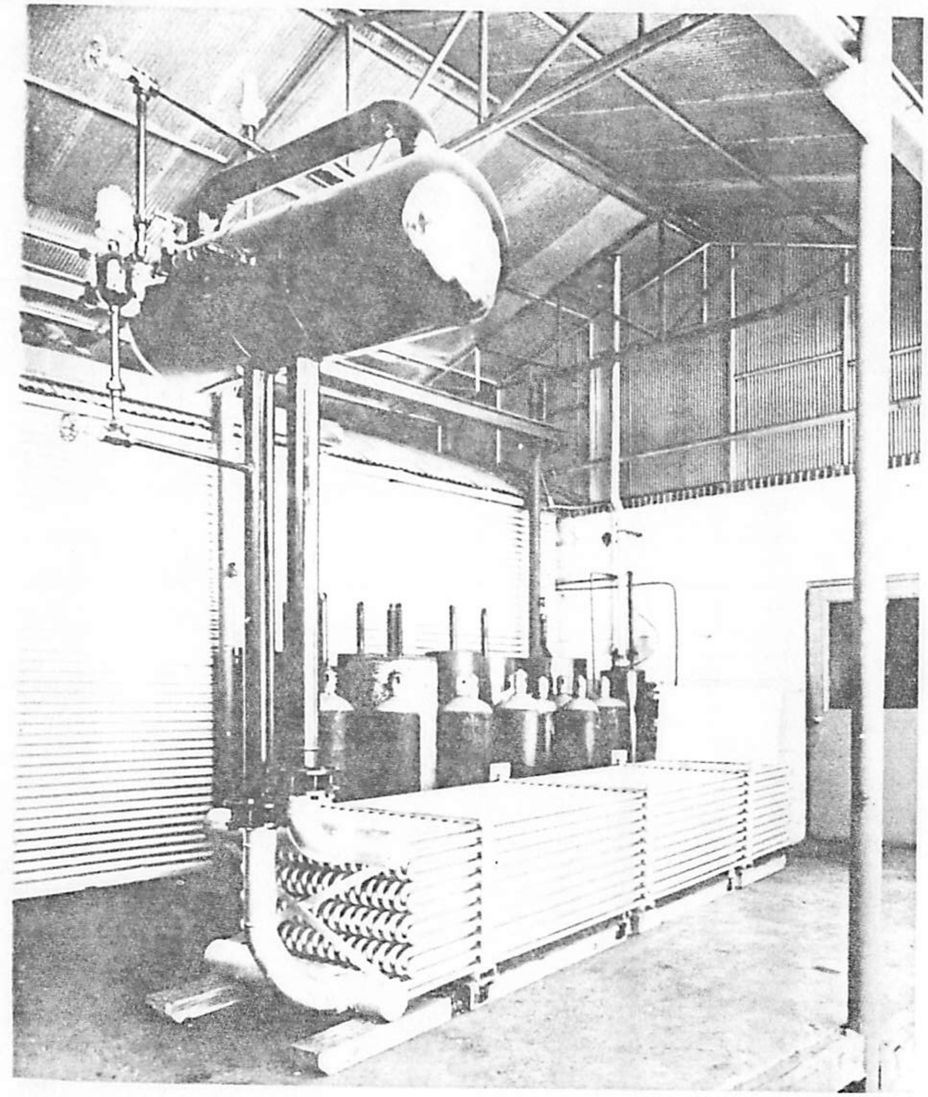

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FIGURE 6.—Cooling coils of superior design. Note overhead surge tank for flooded ammonia system.

Another source of heat load is heat gain from surroundings, which may come from any one or all of the following: (1) The soil or a large mass of concrete beneath or near the hydrocooling system; (2) warm air, especially wind drafts, that may actually blow into the hydrocooler; and (3) radiation from the sun or a hot metal roof or walls.

It is especially important to protect the hydrocooling system as much as possible from heat gain from surroundings. This additional heat load could conceivably amount to as much as, or more than,

TABLE 1.—*Ice use rate or refrigeration capacity needed to hydrocool 100 bushels of peaches per hour, for specified reductions in fruit temperature*

Fruit temperature reduction	Heat load [1]	Ice use rate	Refrigeration required
Degrees F.	*B.t.u./hr.*	*Lb./hr.*	*Tons*
15	82, 800	575	6. 9
20	110, 400	767	9. 2
25	138, 000	958	11. 5
30	165, 600	1, 150	13. 8
35	193, 200	1, 342	16. 1
40	220, 800	1, 533	18. 4
45	248, 400	1, 725	20. 7
50	276, 000	1, 917	23. 0
55	303, 600	2, 108	25. 3
60	331, 200	2, 300	27. 6

[1] See section on cooling requirements, p. 5.

half of the total load on a system. To keep heat gain from surroundings to a minimum, the sidewalls and bottom of the hydrocooler should be insulated with water-resistant thermal insulation. Locating the hydrocooler out of the sun or away from hot walls and air drafts will also help keep down the extra heat load. Because heat gain from surroundings cannot be totally eliminated, about 15 percent of the fruit heat load is added to allow for the additional load. The heat load is therefore computed at approximately 125 percent of the fruit heat load.

HOW LONG SHOULD PEACHES BE IN THE COOLER?

How long it takes to cool peaches to the desired temperature for shipping depends on the size of the fruit, the temperature of the fruit when it enters the cooler, and the temperature of the chilled water.

Large peaches take longer to cool than smaller peaches treated the same. Figure 7 shows that under proper conditions it takes a little more than 30 minutes to cool a 3-inch peach from 90° F. to 40° in 35° water, while the temperature of a 2-inch peach can be reduced by the same amount in 15 minutes.

Rate of cooling is affected by the temperature difference between the fruit and the cooling water. Figure 8 shows the difference in time that it takes to cool 2½-inch-diameter peaches from 90° to 50° F. with water at 45°, 40°, and 35° F.

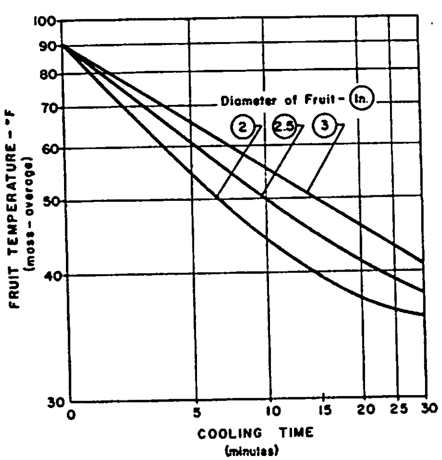


FIGURE 7.—Cooling rate for peaches properly cooled in 35° F. water.

Similarly, the temperature of warm peaches will be reduced faster than

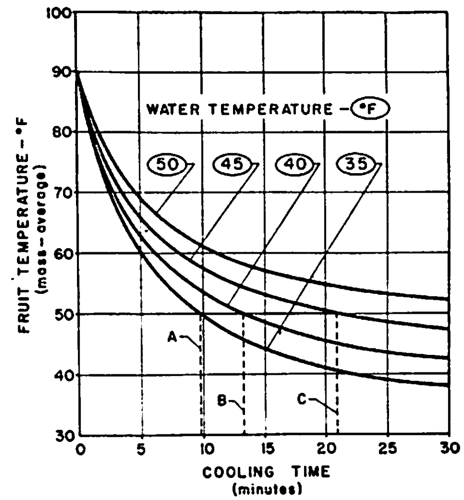


FIGURE 8.—Temperature reduction of 2½-inch-diameter peaches, cooled in water at various temperatures.

that of cooler peaches of the same size in the same water, because heat transfer from the fruit is faster when there is a greater temperature difference between the fruit and the cooling water.

Figure 9 illustrates refrigeration requirements as related to size of fruit and cooling time. To see how the initial fruit temperature affects cooling, look at the chart of figure 10. This chart represents the amount of heat removed from 100 pounds of peaches 2½ inches in diameter cooled in water at 35° F. Notice that 100 pounds of fruit at 80° F. (dotted line A) released 3,400 B.t.u. to the cooling water in 15 minutes while fruit initially at 90° F. gave up 3,850 B.t.u. in the same time. To hydrocool peaches coming in at 90° F. in the same length of time as fruit coming in at 80° F., your refrigeration system must have enough capacity to absorb the extra 4.5 B.t.u. per pound.

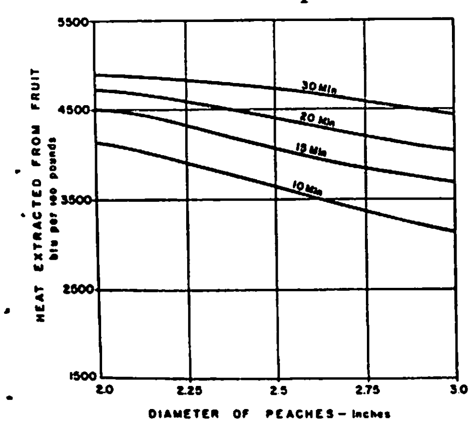


FIGURE 9.—Heat extracted from peaches of specified sizes initially at 90° F., cooled in water at 35° F.

To check on the effectiveness of your hydrocooler, measure the diameter of a number of representative peaches and measure the temperature of the peaches before they go into the cooler and as they come out. The initial fruit temperature is likely to be the same throughout the fruit so it can be measured at any point within the flesh. To get an accurate reading for fruit leaving the hydrocooler, however, the bulb of the thermometer should be inserted to a point about three-fourths the distance from the center to the surface, as shown in figure 11. This point gives the temperature (called mass-average temperature) which represents the amount of heat in the fruit. It is important to measure the temperature at this point, because the temperature of peaches just out of the hydrocooler varies throughout the fruit.

An example of temperature variation within peaches leaving the hydrocooler can be seen in figure 12. Imagine a peach half, sliced along its polar (stem) axis. The lines represent points in the fruit equal distances apart measured radially from the center to the surface. Figure 12(*a*) shows the temperature at these points of a 2½-inch-diameter peach, initially at 90° F., cooled for 5 minutes in well-agitated water at 35° F. The temperature at point A is 76° F., while the mass-

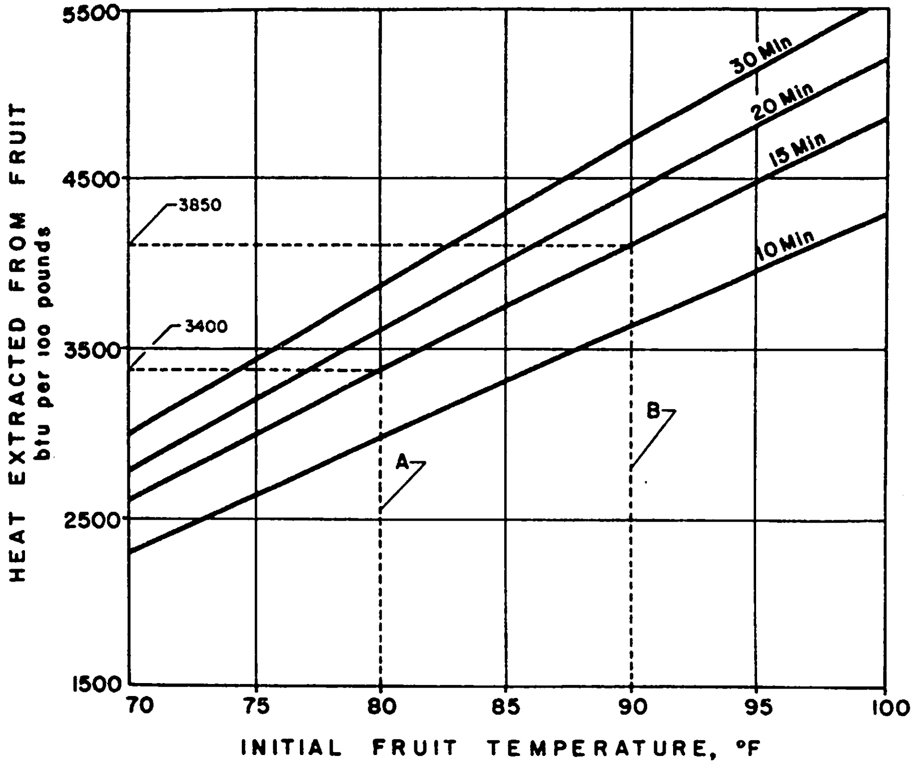


Figure 10.—Cooling rate of a 2½-inch-diameter peach of various starting temperatures in 35° F. water. The temperature of fruit entering the hydrocooler determines the cooling load and hence refrigeration requirements.

average temperature, at point B, is 60° F. The temperature at corresponding points in the same fruit, after 25 minutes of cooling, is seen in figure 12(*b*). Note that at the point where mass-average temperature is taken the difference is about 20° F.

HYDROCOOLER EFFICIENCY

If your hydrocooler is not cooling your peaches to the desired temperature in the time allotted, as determined by the foregoing charts and illustrations, it is not operating as efficiently as it could. The trouble could stem from one or more of the following sources: (1) Not enough refrigeration capacity to handle the load because of poorly designed coils, inadequate compressor or condenser, or insufficient melting of ice; (2) excessive heat gain from surroundings; and (3) failure to provide thorough and uniform coverage of chill water in flood-type coolers or sufficient agitation in bulk coolers. The efficiency of your hydrocooler is also less when you allow peaches to remain in the cooler longer than needed. This is because less heat is removed from the fruit as the fruit draws near the desired final temperature, thus heat gain from surroundings during this extra time imposes a disproportion-

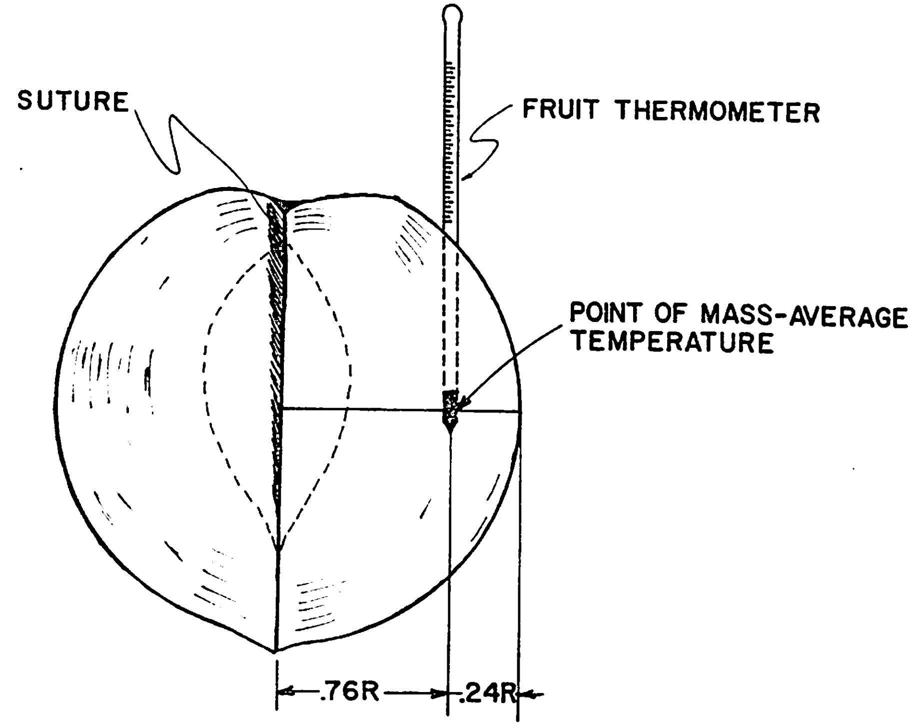
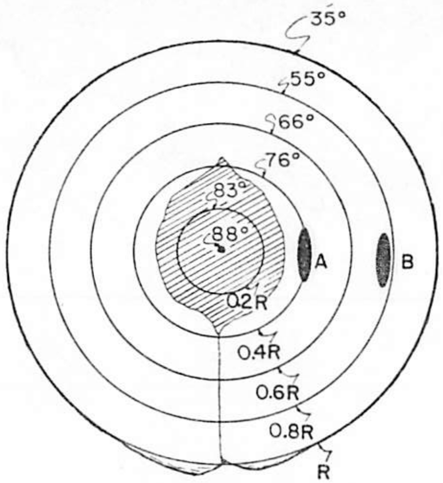


Figure 11.—Measuring the mass-average temperature of a peach with a fruit thermometer.

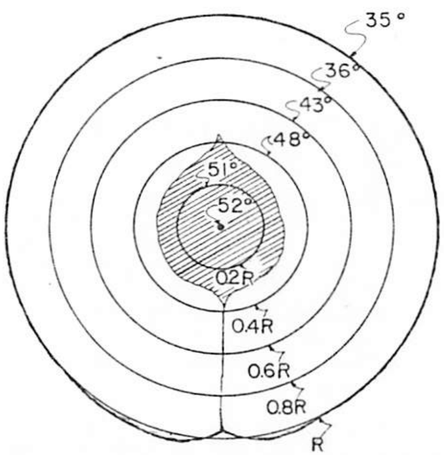
ate share of the load on the cooling system.

To check the efficiency of your hydrocooler, measure or obtain the fruit temperature reduction (initial less final temperature), fruit output, and ice use rate or refrigeration capacity (tons) of your system. Compare your data against the figures given in table 1. An ice use rate or refrigeration capacity significantly higher than the value listed in the table for the corresponding temperature reduction indicates poor design or improper operating practices. In such a case, it is possible to get more work out of your hydrocooler for the same cost or to reduce your operating cost for the same work output. Have your system checked by a competent refrigeration engineer or an extension specialist in agricultural engineering.



(a)

5 MINUTES



(b)

25 MINUTES

FIGURE 12.—Temperature distribution within a 2½-inch-diameter peach initially at 90° F., after being cooled in well-agitated water at 35° F. for (*a*) 5 minutes, and (*b*) 25 minutes.

Washington, D.C. Issued June 1965

U.S. GOVERNMENT PRINTING OFFICE: 1965 O—769-234