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Handling Rained-on and High-Moisture Raisins

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The proper handling of rained-on and high-moisture raisins is critical to minimizing mold infection, fermentation, imbedded sand, and mechanical damage. Following is a discussion of proper field and storage handling methods and alternatives in finish drying that you can use in the event of unfavorable weather conditions.

MOLD AND CONTAMINATION PROBLEMS

Raisin mold is associated with a wide range of primary and secondary fungal organisms normally found in the vineyard. They include species of *Alternaria, Aspergillus, Botrytis, Chaetomium, Cladosporium, Helminthosporium, Hormiscium, Hormodendrum, Penicillium, Rhizopus,* and *Stemphylium*. Yeasts and driedfruit beetle are also important secondary contaminants.

A representative sample of these organisms is present in the vineyard and on the berries at harvest. When wetted with rainfall or dew, berry sugars and amino acids move into the surface water. Fungal spores germinate and grow in this medium on the berry surfaces. If water remains on the berry surfaces, some fungi, such as species of *Alternaria, Botrytis, Aspergillus, Cladosporium,* and *Rhizopus,* will penetrate the skin and colonize the interior of the berry to cause rot. Conditions of free moisture for 24 to 36 hours and temperature of 60° to 75°F (16° to 24°C) are ideal for their development. Smashed or broken berries, immature fruit, and fruit already infected with bunch rot are especially subject to rot infection on the tray following rain. Fungi may also grow on fruit exudates on the paper tray, causing the fruit to stick to the tray. Fungicide treatments applied after a rain have not been effective in reducing mold. This is because infections have already occurred before the application time, and much of the mold originates on the inaccessible bottom fruit on the tray.

Should rain occur, follow these practices to minimize damage and infestation:

- Slip trays to prevent their sticking to the soil. Move them just enough, 1 to 2 inches, to break the seal between the paper and the soil. This interrupts the wicking of moisture from the soil into the tray.

- Turn the trays as soon as possible to expose bottom fruit.

- Do not save fruit stuck to the bottom of trays or mix it with other fruit. Use new trays as needed, or reverse old trays at turning by putting the soil side next to the raisins (but only if soil is not sticking to the underside of the tray) and leaving stuck fruit on the outside.

- Pick moldy or rotten fruit off the tray before rolling. This is the best opportunity to reduce moldy fruit by hand.

- Get rolled fruit out of the field as soon as possible. Do not fill bins with raisins above 18 percent moisture. Use half-filled bins at 18 to 20 percent moisture. Sweat boxes are suitable for raisins up to 20 percent moisture; half-fill them with raisins between 20 and 22 percent moisture. Begin on-farm or commercial drying as dictated by moisture. Immediate drying is needed when raisin moisture exceeds 22 percent.

- Watch for spoilage in boxed raisins. Dump fruit over and spread into more containers at first signs of spoilage.

- Run fruit across a shaker, if possible, to reduce insect infestation and to provide another chance to pick out mold. Do not run fruit with too many uncured berries over a shaker (see chapter 26, Harvesting and Handling).

- Cover tightly with polyethylene during rainy, foggy, or humid weather. Otherwise, raisins will absorb moisture directly from the air. Use paper covering, such as tar-impregnated paper, underneath the plastic to prevent water condensation.

- Deliver the raisins as soon as possible to the packer so that they can be fumigated.

Commercial washing and drying (*wet reconditioning*) may be necessary to further remove mold and embedded sand. The service is offered by many packers and most commercial dehydrators. The need can be determined by a USDA inspection. The fruit is dumped into a water tank (usually heated at 140° to 210°F [60° to 99°C], depending on defect) and is sprayed with the water while being conveyed by an auger up a concave screen, The washing removes embedded sand and disintegrates moldy and damaged berries. The fruit is then spread onto trays for finish drying at 140° to 145°F (60° to 63°C). Other types of wet reconditioning equipment such as incline rubber belts are sometimes used in conjunction with the washing process to remove more moldy berries. The need can be judged by experienced reconditioning operators.

ON-FARM DRYING

Traditionally, drying has been performed by commercial dehydrators and a few growers who have one or more drying tunnels on their farms. However, the limited availability of these facilities and their relatively high maintenance costs have encouraged growers to design less-expensive, more-portable units for occasional use. The systems can be relatively simple in design, as they are usually used for finish drying of raisins of 16 to 22 percent moisture. High-moisture raisins often can be successfully dried in partially filled bins distributed in an open yard, provided the weather stays warm and dry. Drying can be accelerated with plastic film covering and ventilation. Raisins of 23 percent or more moisture are best sent to a commercial dehydrator as soon as possible. Otherwise, they can quickly ferment or mold, especially if the raisins are in near-full bins. Consider cold storage if drying cannot quickly be accomplished. Temperatures of 31° to 34°F (–0.5° to 1.0°C) will greatly slow mold development until drying can be scheduled. On-farm drying systems can be categorized as solar drying with or without plastic covering and artificial drying with a fueled heat source and forced air, portable or stationary.

Natural (Solar) Yard Drying

Open bins. The simplest drying method is to place one- to two-thirds-full bins in an open area. The raisins are raked up on the sides for added exposure and the bins are stacked or covered each night to prevent the deposition of dew on the raisins. Periodically, the raisins are turned over with a fork to expose wetter raisins to the drying conditions. This mixing should be minimized to prevent mechanical damage to soft raisins. Once the raisins are sufficiently dried (below 16 percent moisture), they can be run over a shaker and blended to complete their moisture equalization. Limitations of this method are the requirements of extra bins, yard space, and days of warm, dry weather, and the moving or covering of bins at night or in wet weather.

Clear plastic covering. Clear polyethylene film placed over rows of bins can capture more heat to speed the drying process. Some ventilation is needed to remove moist air and avoid excessive heat accumulation. A common method is to stack partially filled bins in a row and cover them with a peaked roof of plastic along the row length. This can be formed with 2 × 4 boards nailed vertically to the center of every 2nd to 4th bin. The ridge should be about 18 inches (46 cm) above the bins and connected along the top with wire, cord, pipe, or board. Six- to eight-foot (1.8 to 2.4 m) wide clear plastic film is draped along the top and secured down to the sides of the bins with string or nailed lath. Air temperature under the covering can increase 30° to 40°F (17° to 22°C) above ambient temperature on sunny days. Temperatures must be monitored and should not exceed 140°F (60°C). Intermittent openings for ventilation may be necessary to prevent condensation and heat accumulation. A fan can help with ventilation, but most growers depend on natural air movement from breezes and heat convection. Well-covered bins can be left out during rainfall.

The availability of containers is important to success. Raisins of 18 percent moisture can be dried in about 7 days with 75°F (24°C) daily maximum temperatures. They should be mixed periodically during the process (e.g., turned over with a fork every 3 to 4 days). Higher-moisture (around 20 percent) raisins should be dumped over into another container for mixing after 7 days and placed out again to complete their drying.

Portable Artificial Drying Systems

The basic design of a portable artificial drying system consists of a drying tunnel created out of the containers themselves. A stacked row of partially filled bins or sweat boxes (layers separated with boards to allow air flow) is covered with plastic sheeting sealed at the bottom. Most commonly, plywood plenum chambers are placed at each end to direct the heat and air flow. The heat source at the hot (intake) end usually is a space heater or bean-grain dryer heater. Air movement is provided by a fan at the cold (exhaust) end. No uniform design specifications have been developed for these units, as growers have varied their designs according to container type, desired capacity, and available materials. The idea originated from a California Raisin Advisory Board sponsored test in 1963 at the Dick Markarian Ranch in Easton. A pilot design with covered, stacked rows of full sweat boxes was used to dry 17.7 to 20.4 percent moisture raisins down to acceptable moisture levels in 16 to 18 hours. Many grower variations have since arisen.

Each of the two basic plans described here could use either sweat boxes or bins. The simplest system (Plan A) in Figures 28.1, 28.2, and 28.3 was first designed by Jack Goeringer of Biola in the 1960s. It uses simple, wood-framed plenum chambers on each end, space heaters, and a squirrelcage fan from an evaporative cooler. Many growers have since built more solid plenum chambers of plywood sheeting on 2 × 4 lumber framing. A popular design (Plan B) that uses a bean-grain heater and fan is shown in Figures 28.4 and 28.5.

Containers and stacking. There must be an unobstructed, continuous air channel between each layer of containers. Sweat boxes are commonly stacked eight high, two wide, and seven to twelve long (Figure 28.1). Two-inch (5 cm) cleats such as wooden grape stakes or crossarm material is placed between each layer for airflow space. Pallets serve as the base. Bins are usually stacked two high and ten long. The bottom cleats of the bins provide the airflow space. Sometimes growers will switch the hot and cold plenum chambers to opposite ends during the drying cycle. This helps ensure more consistent drying at the two ends of longer stacks.

Plenum chambers. The plenum chambers house the heater and fan on each end and direct and distribute the heated air into and out of the stack. The heater end of Plan A (Figure 28.2) uses empty sweat boxes and 9-foot (2.75 m) boards to drape and secure the plastic sheet. The exhaust end (Figure 28.3) uses a frame of 1 × 6 boards nailed onto a pallet that is covered with tar paper, plywood, or pressboard.

Most growers have built plenum chambers out of

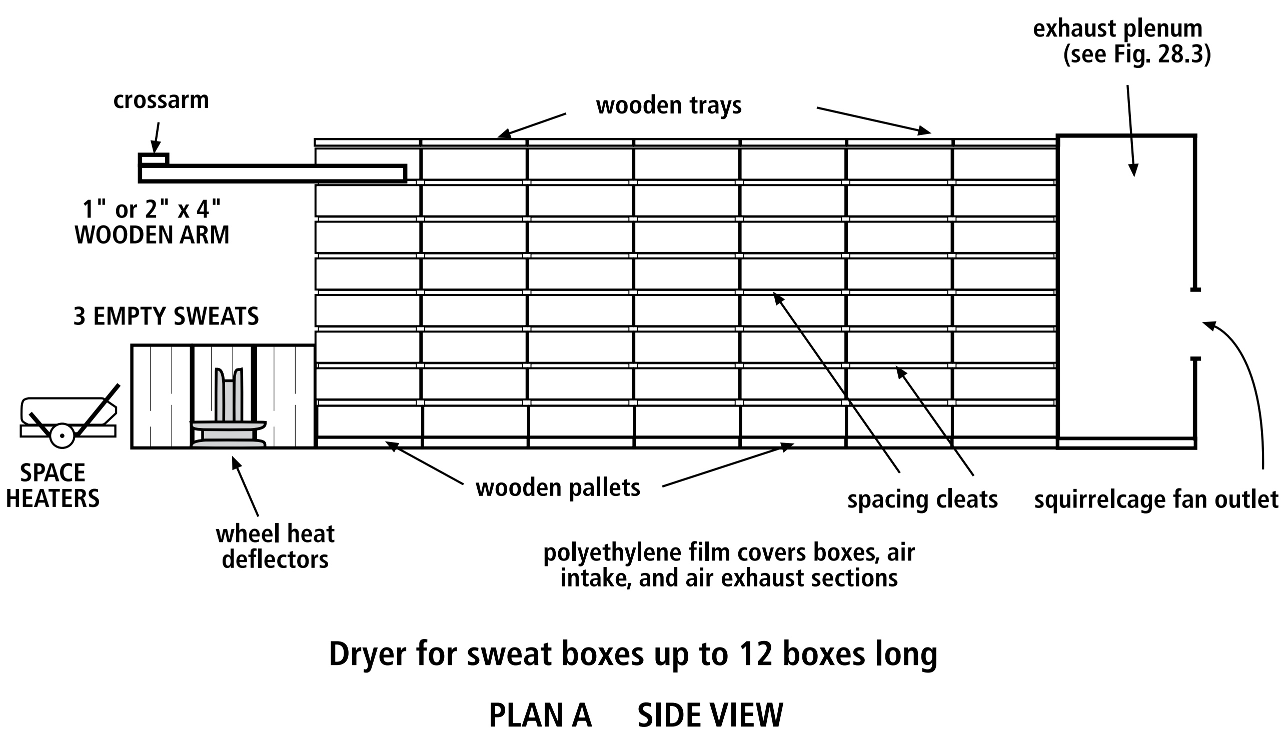
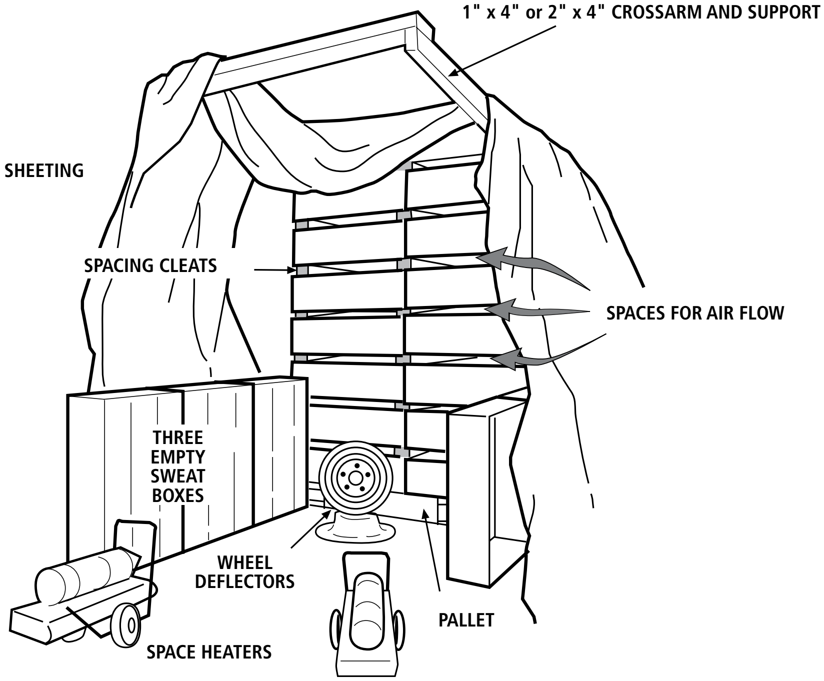
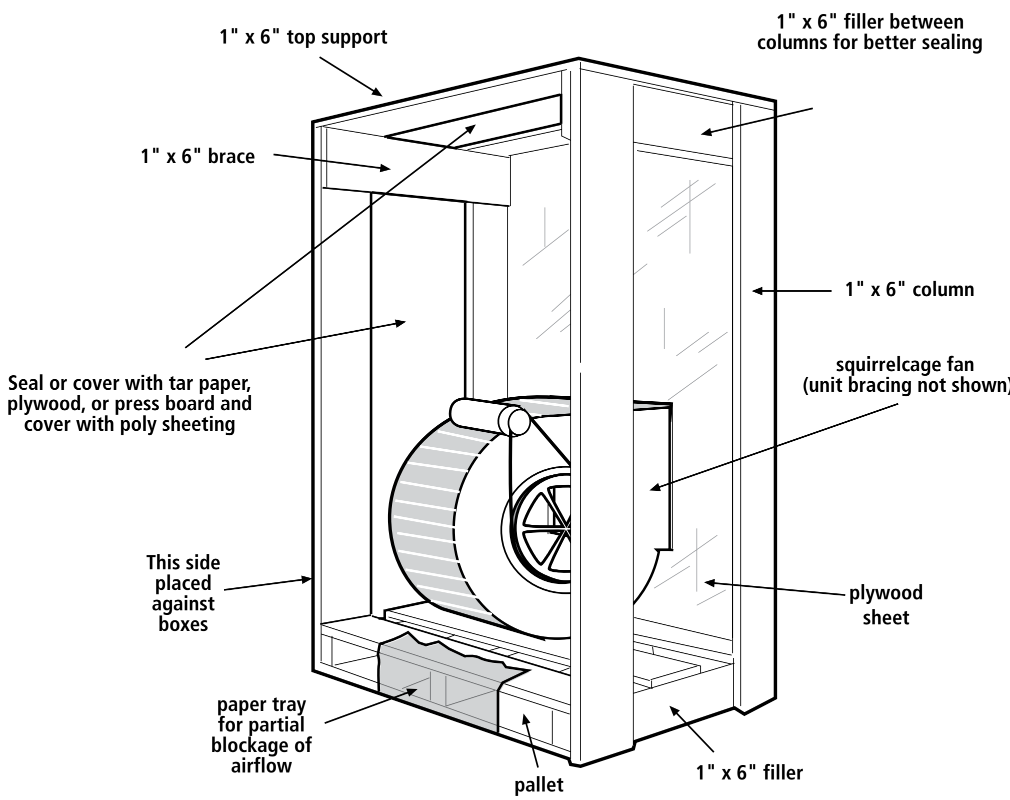


Figure 28.1 Side view of Plan A, showing the stacking of sweat boxes and the attachment of heater space and exhaust plenum over which plastic is secured



PLAN A END VIEW OF HEATER PLENUM WITH SPACE HEATERS

Figure 28.2 End view of Plan A heater space, showing upper board supports and empty sweat boxes used to secure the plastic covering. Placement of space heater and heat deflector is shown.



PLAN A EXHAUST PLENUM END VIEW

Figure 28.3 End view of Plan A exhaust plenum constructed on a pallet. The framing can be covered with tar-impregnated paper or thin plywood. A squirrelcage fan sits inside and blows out through the square port.

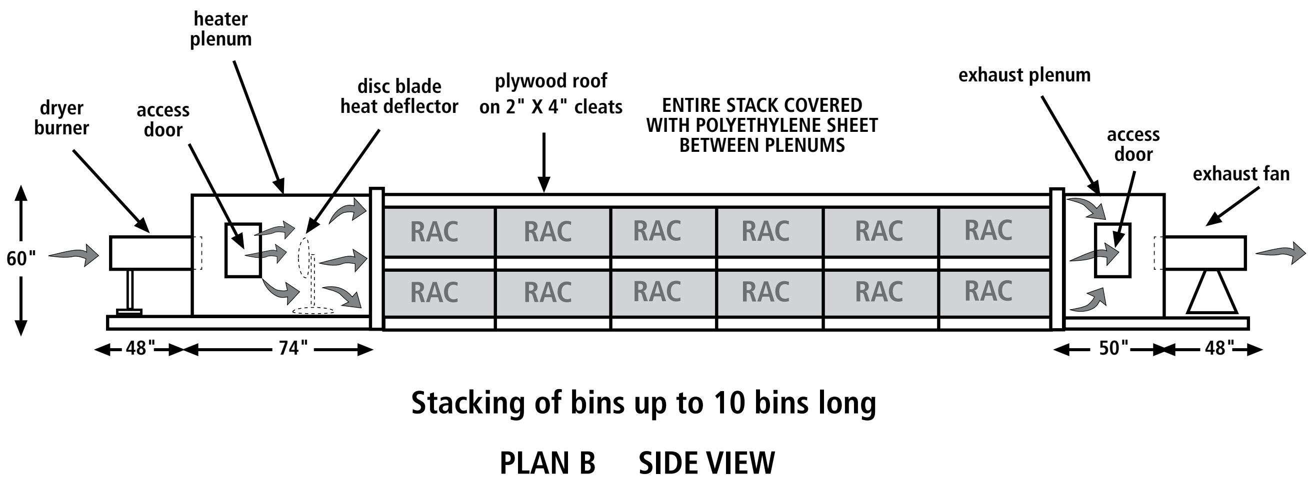


Figure 28.4 Side view of Plan B to show the stacking of bins and dimensions of the hot end and cold end plenum chambers.

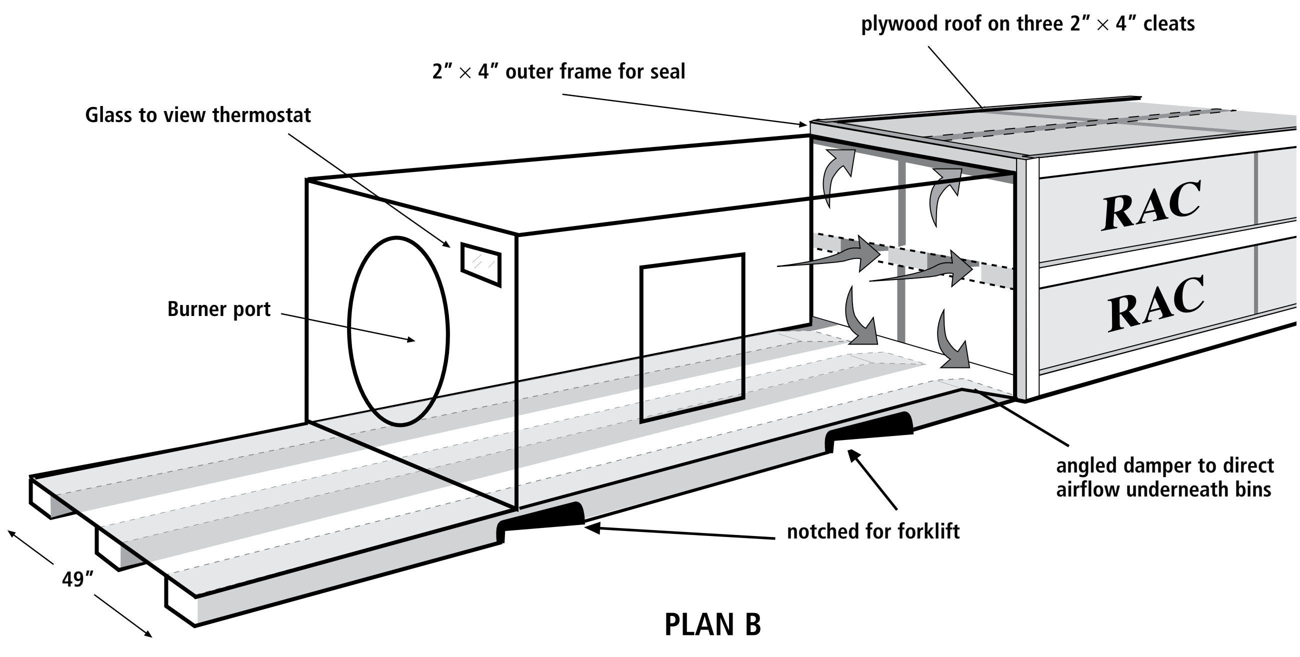


Figure 28.5 End view of the Plan B hot end plenum showing the plywood construction features. The internal 2 × 4 framing is not shown.

plywood sheeting framed onto a pallet or a base built on 4 × 4 lumber skids. The chambers can easily be moved with a forklift and they are relatively airtight. Plan B (Figure 28.4) shows a basic plywood design used with a bean-grain heater and fan. Detail of the hot end (Figure 28.5) shows a unit built on a skid base (framing not shown). It includes a port for the heater, a thermostat viewing window, an access door, forklift notches, and outer framing on the stack end to ensure a good seal with the containers. The optional access door is kept tightly closed during operation. It provides a means of access so you can inspect the front bins, thermometers, and burner outlet. The dimensions of Plan B can be modified for sweat boxes as well as other types of heaters and fans.

Covering. The top of the stack should have an "attic" for airflow. For sweat boxes, this can consist of wooden trays laid on top of grape stakes. For bins, it is best to make a plywood roof in 8-foot sections with 2 × 4 cleats attached along each side and the center. Polyethylene sheeting at least 6 mils (0.15 mm) thick, 20 to 24 feet (6.1 to 7.3 m) wide, and 40 to 50 feet (12.2 to 15.2 m) long, depending on stack dimensions, will cover the stack. Plan A (Figure 28.1) is covered along its entire length with sheeting and should include 1 foot (0.3 m) of extra sheeting at the base of each side of the stack for soil covering. With Plan B (Figure 28.4), only the container part of the tunnel needs covering due to the plenums' solid construction. Soil is not needed to hold the sheeting down. The vacuum created by the high-capacity fan will keep the covering tightly fitted over the outside of the bins. The bin should be placed on a concrete or blacktop surface to keep the fan from pulling sand or soil into the stack.

Heater. Heat sources have ranged from two 75,000 Btuh (British thermal units per hour) space heaters up to a 1,100,000 Btuh bean-grain dryer burner. Higher heat capacity speeds drying, provided the airflow and heat distribution are adequate. Space heaters that use kerosene must burn clean or the fuel will impart off flavors to the raisins. Place space heaters about 6 feet (2 m) in front of the stack and direct them toward a heat deflector.

Heat deflectors. The hot air from the heaters is spread across the front of the stack by heat deflectors. They minimize hot spots that could overdry or caramelize raisins. Disk blades and automobile wheels are commonly used as heat deflectors. The disk blade is welded vertically onto a stand with another disk blade for its base. An automobile wheel can be welded vertically onto another wheel that serves as its base.

Fan. Airflow capacity must be balanced with the heater capacity. A large evaporative cooler squirrelcage fan of approximately 5,000 cubic feet per minute (cfm) (2,360 L/sec) is sufficient for most space heater units. Use a 1-horsepower (HP) motor rather than the ½- or ¾-HP motor supplied with the cooler. Higher-capacity blowers up to 10 to 12 HP and 16,000 cfm (7,550 L/sec) are needed for large heaters up to 1,100,000 Btuh. This capacity follows the concept that a heater input of about 70,000 Btuh is needed to raise the temperature of 1,000 cfm (472 L/sec) of air by 60°F (15.5°C).

Thermostats, thermometers, and temperature. Temperature monitoring and control are critical. A thermostat may be provided with the heater or installed in a representative area of the heater plenum. Several thermometers should also be placed in strategic areas of the stack to monitor the incoming air for hot and cold spots. The temperature at the hot end should be 125° to 130°F (52° to 55°C). *Do not exceed 140°F (60°C).* The temperature at the exhaust end rises very slowly during the first hours of drying.

Raisin moisture monitoring. Drying uniformity varies with design. Top containers and the hot end of the stack tend to dry more quickly due to typically higher temperatures. Variations of 3 percent raisin moisture are not uncommon. Thus, you should take separate raisin samples for moisture comparison from containers at the top and bottom and both ends of the stack. Sample from the center of the containers for an average value. Allow for the raisins to cool and come to equilibrium before you take the samples. Your packer can arrange for sample analysis by the USDA Processed Products Inspection Service.

Swapping the positions of the hot and cold plenum chambers halfway through the drying cycle is a practice that can help drying uniformity throughout the stack. You can also ensure more even drying by placing higher-moisture raisins at the hot end.

The estimation of drying time requires experience. Plan A will take about 24 to 36 hours to take raisins from 18 to 13 percent moisture with sweat boxes two-thirds full. Plan B will take about 24 hours to accomplish similar moisture reduction in full bins. Low relative humidity weather conditions will speed drying, as will freshly filled containers that have not settled. Run the fan for a half-hour with the heater turned off at the end of the drying cycle. This will remove additional warm, moisture-laden air and begin the cooling process.

Handling raisins after drying. Allow for cooling time and moisture equilibrium before further handling. The amount of time will depend on the type of containers and how full they are. Twelve hours may be sufficient with half-filled sweat boxes. Wait up to 7 days for full bins. They can be kept in the stack or moved into a covered shed during this period. The dried raisins should be dumped again across a shaker to complete the mixing and moisture equilibrium process.

Stationary Artificial Drying Systems

A stationary artificial drying facility consists of a solid-constructed building using a low heat source and low air flow. Designs range from garage-like insulated buildings to tunnel-like buildings or converted semi truck trailers. Heaters and fans are placed at opposite ends of the structure. Air enters the heater end and is removed by fans through exhaust vents or ports. Partially filled bins are stacked inside with 2- to 4-inch (5 to 10 cm) spaces between rows. Heaters vary from electric heat pumps to gas-fired stoves or space heaters. Fans can be squirrelcage or propeller-blade type.

Drying temperatures range up to 130°F (55°C). Somewhat lower temperatures are used than for tunnel or portable dryers. This is because the drying cycle is longer and it is difficult to achieve uniform temperatures throughout the building. Drying cycles may last up to 10 days, depending on dryer capacity and raisin moisture content. An advantage is that relatively large lots can be dried together with a minimum of handling and labor. Also, the building can be used for storage when it is not drying raisins. Disadvantages include the costs of a permanent structure and the slower drying time.

Bin Dehydrator Systems

Popular in Australia, *bin dehydrator* systems are worthy of consideration in California. They provide fast turnover of uniformly dried fruit and improved fuel efficiency. The concept is similar to our portable systems that use bins or sweat boxes, but in this case the heated air is forced down through the raisins and recirculated for greater fuel efficiency.

The specially built metal bins are 20 inches (0.5 m) high with a mesh-covered wire bottom about 6 inches (0.15 m) above the ground. The bins are placed in a row and filled with fruit. A simple metal frame erected over the loaded bins supports a plastic cover. The cover is clipped to the flanged top edges of the bins to make it airtight overhead. The plastic extends down to the ground to form a skirt along the sides. The end of the row is connected to a portable propane burner and fan (Figure 28.6). The heated air [122° to 140°F (50° to 60°C)] is forced along the top of the row and downward through the raisins. A portion of the air returns back through the space underneath the bins to the burner-fan unit for heating and recirculation. The bin skirt controls the air movement for recirculation. The skirt can be adjusted to vent a portion of the humid air and to regulate fruit temperature along the bins.

Raisins can be dried in 6- to 12-hour cycles, with the fan run for only for a few hours afterward to cool the fruit. These recirculating units are used widely for finish drying of DOV fruit in Australia. The added cost of constructing the special drying bins and purchasing a forklift bin-dumper can be justified by their regular use each season.

Figure 28.6 A covered "bin dehydrator" with heater unit during operation in Australia. *Photo: L. Peter Christensen.*

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