Fog-Spray Humidification for Produce Storage

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Reason for fog spray.

Fog spray offers an effective and inexpensive method of controlling humidity in a produce storage. This is an alternative to humidity control by large cooling surfaces operated at a temperature close to that of the air. A discussion of the merits of these alternatives is beyond the scope of this paper. If humidity is to be raised in an existing storage, fog spray is much the cheaper solution, however.

A storage operator must consider not only possible methods of controlling humidity, but also the humidity level that is desired. Choice of a desirable humidity level is a subject in itself. The following is a discussion only of the equipment that is needed and of its installation and operation.

Principles, condensation on cooling surfaces

Humidity in storage air depends on a balance of gains and losses of moisture. Moisture is lost by absorption in containers and packing materials, and usually by condensation on cooling surfaces. Moisture is gained by evaporation from the produce, by fog sprays if they are used, and by evaporation from ice or from cooling sprays only if they are within a degree or two of return air temperature. Moisture contained in the room air at any one time is usually not more than may be gained or lost in a few minutes. If gains and losses do not balance the air humidity soon changes until they do.

Introduction of fog spray raises the humidity by changing the balance. Evaporation from produce is reduced, while absorption by containers and condensation on cooling surfaces are increased. The resulting dilution of brine sprays and the accumulation of frost on coils are of practical concern. The changes to be expected from higher humidities, with cooling surfaces 10F colder than the return air, may be calculated as follows:

Return air relative humidity	70	80	90	95
Condensation, gallons per hour per ton of refrigeration	.14	.30	.43	.48

Quantity of spray needed

Estimation of the exact quantity of spray needed is a somewhat complicated psychrometric problem. When spray can be added to the air before it reaches the produce, half a gallon of spray per hour per ton of refrigeration (or per ton of ice melted per day) will offset condensation on the cooling surfaces.

Warm fruit usually gives off more moisture than is absorbed by its containers, even at high humidity. There may be a time, however, after the fruit has cooled, when there is a net moisture absorption by boxes

and fruit, amounting to perhaps a gallon per hour per thousand boxes of grapes. Adding this to condensation on the cooling surfaces, sprays capable of supplying one gallon per hour per ton of refrigeration can maintain 95 per cent relative humidity under any reasonable conditions, and can be throttled down as desired.

Types of nozzles

Nozzles supplied with water and compressed air to produce fog spray seem best adapted to humidification of produce cold storages. The spray should be fine enough to evaporate before it settles to the floor or impinges on any surfaces. Fine spray may be produced with water alone at pressures of several hundred pounds per square inch, but orifices with sufficiently small discharge must be very small, and a high-pressure water pump may cost as much as an air compressor. Available mechanical atomizers are more expensive than air-and-water systems. Steam humidification adds seriously to the refrigeration load.

Two types of air-and-water nozzles are available. The internal-mixing type mixes air and water inside the nozzle and then discharges the mixture through an orifice. This requires that water pressure be not more than 10 to 20 pounds per square inch less than air pressure, or air will stop the spray and blow back into the water lines. Public health regulations prohibit direct connection of such nozzles to a potable water supply because of the possibility that such a blow-back will introduce contamination. Check valves are not a legal safeguard. Water should be pumped to internal mixing nozzles from a tank in which the level is maintained by a float valve. This adds considerably to the complication and cost of the system. Trouble may also be experienced from water pressure being above the air pressure, which produces a coarse spray or even complete stoppage of the air, with a solid stream of water from the nozzle.

In external-mixing nozzles the air and water are discharged through separate orifices and are mixed outside of the nozzle. This eliminates blow-backs and allows the nozzle to operate through a wide range of air and water pressures. These nozzles are designed, however, to syphon water from a tank below the nozzles or to be supplied at water pressures of a pound or two per square inch. Friction in the water piping, or even air bubbles, can effect these low pressures enough to cause uneven discharge from different nozzles. Water lines to such nozzles should be large enough to make friction negligible, and should be carefully leveled or given a slight uniform slope to eliminate bubbles or air lock. Nozzles can be purchased with individual needle valves, which can be used to adjust out any uneven discharge.

Location of nozzles

The ideal position for spray nozzles is in the air supply to the room, at a point where the air has picked up any heat from the ceiling and before it reaches the produce. The spray will not settle, but troublesome drip will result if the spray plume blows against any surfaces, posts, braces, pipes, or even wires, before it evaporates.

Sometimes sprays must be placed near the air returns, or even in the returns, because there is no other place for them. This produces

higher humidity around the cooling surfaces than in the room, which increases condensation on the cooling surfaces, which in turn requires more spray. The effect is not important if the temperature of the air return is within a degree or two of the blast. It can be calculated that with a three-degree difference between blast and return, nozzles in the return instead of in the blast must supply about a half more water, while with an eight degree difference nozzles in the return must supply twice as much water. Condensation on the cooling surfaces is correspondingly increased. Any droplets that impinge on the cooling surfaces add to the condensation or frosting without doing anything to improve the humidity.

There is also another consideration in adding spray to the return air. Air leaving surfaces sprayed with brine cannot be raised to 100 per cent relative humidity by any addition of spray in the return, due to condensation in the brine. The air may then be warmed a degree by friction in a powerful fan and in high-velocity ducts, and perhaps another degree by heat leakage through ceiling and walls in hot weather. Each degree that the air is warmed reduces its relative humidity by about four per cent. The final result may be that it is not possible to obtain satisfactory humidity in the room, no matter how much spray is added to the return air.

Size of nozzles

A fine spray, well distributed, is desirable for quick evaporation, especially if there is limited space in which to install the nozzles. Finer spray is produced by higher pressure air and by more air in proportion to the water discharged. Better distribution is obtained with many small nozzles rather than a few large ones. Unfortunately, higher pressure, more air, and more nozzles all add to the cost of an installation. Three typical nozzles may be characterized as follows, all using 1 cubic foot of air per minute at 40 pounds per square inch.

Best atomization and distribution, highest cost.
1/2 gallon water per hour, spray evaporates about 6 feet from nozzle.

Good atomization and distribution, moderate cost
1 gallon water per hour, spray evaporates about 9 feet from nozzle.

Fair atomization and distribution, lowest cost
1-1/2 gallons water per hour, spray evaporates about 12 feet from nozzle.

Piping and water supply

Nozzles can conveniently be supported by tees turned upward in a three-quarter inch galvanized water line. The line should be leveled or slightly sloped to avoid bubbles and air locks, as noted above. Electrically heated tape or cable can be wrapped around the pipe and the nozzle risers to prevent freezing. Expansion of air as it leaves the nozzles may cool them several degrees and freeze them even when the room is above freezing. Copper tubing of the same size as the air compressor discharge, with flare fitting, is convenient for supplying air.

A strainer should be provided in the water line to prevent plugging of the nozzles with scale or dirt. When starting a new system and at the start of each season it is well to screw off all the nozzle tips and flush and blow out the water and air systems. It is not usually necessary to provide a strainer in the air line.

Controls

Manual adjustment of the water supply requires a fine needle valve, remembering that full flow is only a few gallons an hour. With manual control the operator can take account of conditions everywhere in a room, using a heavy, coarse spray when humidity is low and throttling to a light, fine spray when humidity is high.

Automatic control eliminates the attention of an operator, but it senses conditions only at one point, which may not be representative in a large room containing various lots of fruit. Air usually shut down manually when spraying is discontinued. Descriptions of control equipment may be obtained from firms listed at the end of this paper.

Air supply

Air may be supplied by a compressor sized to operate continuously while supplying the air for one set of nozzles. No tank or pressure regulator is needed, though a relief valve should be installed in the air line for safety.

Alternatively, air for several sets of nozzles may be supplied by one large compressor. A storage tank and a presure regulator are then needed to permit shutting down some of the nozzles. Pressure will run up and down as the compressor cuts in and out. This is allowable with external mixing nozzles but an additional pressure regulating valve is needed to provide close control for internal mixing nozzles. Usually the single large compressor with its accessories will cost more to buy than several small ones, and will cost more to run if some of the nozzles are out of use for any length of time.

Fog-spray nozzles and accessories are known to be available from the following forms. Other names will be added as we learn of them.

Nozzles, strainers and accessories.

Spraying Systems Co., 3201 Randolph St., Bellwood, Illinois
Harang Engineering Co., Tanforan and Montgomery Aves., P. O. Box 396, San Bruno, California
Delavan Manufacturing Co., Grand Ave. & Fourth St., West Des Moines, Iowa

Air Compressors.

Atlas Copco, Inc., 930 Brittan Ave., San Carlos, California
American Brake Shoe Co., 1010 Russ Bldg., San Francisco 4, California
Cal-State Distributors, 735 East 14th St., Oakland, California
Ingersoll-Rand Co., 11 Broadway, New York, N. Y.

Automatic humidity controls.

The Foxboro Co., Foxboro, Massachusetts
El-Tronics Inc., Warren, Pennsylvania
Hygrodynamics Inc., 949 Selim Road, Silver Spring, Maryland
Refrigeration Machinery Corp., 1024 East Anaheim, Wilmington, California
Minneapolis-Honeywell Regulator Co., 1402 E. St., Sacramento 14, Calif.

Pipe-heating cable and accessories

General Electric
Wiring Device Department
Providence 7, Rhode Island