THE CONTROL OF MOISTURE IN FOOD PLANTS

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I. INTRODUCTION

To meet the technology required for food plants in the 1990s, one must control what phase moisture appears in the plant. If moisture appears as a solid (ice), the plant owner will experience lost production and the inability to freeze a continuous, high quality product. If moisture appears in a liquid form (water) in a food plant, problems with quality control, poor shelf life, and governmental inspections are sure to follow. If moisture appears in a vapor form, the plant will invariably produce a high quality product with resultant high profitability.

For the purpose of this presentation, we shall consider the three most common areas in food processing plants:

- The Freezers
- Coolers, Processing and Production Areas
- Special Material Holding Coolers

II. SPRAYED GLYCOL SYSTEM

Since no one has yet invented intelligent air, it still flows the path of least resistance, and since water always freezes at 32°F, the best way to handle freezing applications is with a sprayed system. A sprayed system is one in which the evaporator coil is continuously (or sometimes intermittently) sprayed with a liquid, preventing frost from forming on the coil. Some people have attempted to use a salt solution, usually a salt of sodium chloride, calcium chloride

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or lithium chloride. With sodium chloride, temperatures are limited to around -6°F, but its use is permitted around an edible food product. As for calcium and lithium chloride, there is no tolerance for either one of these materials in an edible food product. The biggest problem with any of the inorganic salt solutions, however, is that they are highly corrosive, increasing maintenance cost and they have a tendency to salt out, thus making them difficult to operate in low temperature situations.

III. FREEZERS

The simplest and most economical way to handle the requirements of a freezer is with a continuous glycol sprayed system. The glycol itself is a stable, organic liquid which is non-corrosive, and, depending upon the operation, has USDA approval for use around open food products. (See Appendix A, A-0).

Spiral freezer applications or continuous belt freezer applications provide ideal settings for a glycol sprayed system. In both cases, they require a constant air temperature leaving the evaporator and a constant airflow (CFM) to ensure the uniform freezing conditions necessary to produce a high quality product. Since both systems involve a constant infeed and outfeed of the product, there is a continuous moisture load in the freezer due to infiltration as well as due to moisture loss from the product. The amount of moisture given up by the product depends upon the product and the rapidity by which it is frozen, while the amount of moisture due to infiltration depends upon the conditions outside the freezer box itself.

Each 1 degree drop the compressor is below 0°F costs the system a minimum of 2 percent in lost compressor capacity:

2 x 0.02 = 0.04, the percent of capacity lost
150 tons x 0.04 = 6 lost tons per hour
6 tons x 2.51 kw/ton x 0.05 kwhr x 22 hrs x 250 days = $4,142
savings by not using hot gas defrost.

D. Miscellaneous Defrosting Costs

Typical installations involving spiral freezers, such as were proposed for the pie line, have shown that approximately every 5 years major repairs must be made on the insulated freezer box and the floor, as well as the spiral freezer mechanism. Similar installations using a spiral freezer have indicated that while using an intermittent defrost method such as hot gas, an average of $20,000 in maintenance bills are involved in keeping the spiral freezer in operation and the insulated box in good condition. This information was noted from a number of people operating under similar situations and was documented in an article from Bakery Equipment. (See Appendix A, A-5). Neither of these costs ($20,000) were noted at plants using glycol defrost methods. This is obviously because no frosting or defrosting occurs. I know of one installation which has run 11 straight years without any shutdown for maintenance on either the spiral freezer or on the insulated enclosure.

E. Plant and Product Safety

It is becoming increasingly prevalent for leaks, either of the pinhole or major leak variety, to occur eventually in refrigeration systems using an intermittent defrost method. These leaks occur in the coils, piping and fittings. This is due to the tremendous shock ınd stress caused when a small amount of liquid is trapped during the hot gas defrost process. A number of articles have been published by the IIAR which describe this phenomenon and explain why it occurs. Needless to say, a glycol sprayed system which requires no defrosting eliminates this potential hazard. The value of obtaining this safety feature is undetermined. (See Appendix A, A-6).

t Sanitation

In the last year or so, there has been a tendency in many food plants for the local FDA or USDA inspectors to take swab tests of evaporator coils in freezer installations. If organisms are found on the coils, they require the operator to periodically clean and sanitize these coils. In any freezer installation this is a major undertaking because the freezer must be shut down, the evaporator coil must be cleaned of all debris and then washed thoroughly with a strong enough hypochlorite solution to ensure the elimination of the organisms. Chlorides of this strength will most assuredly pit aluminum coils and will do a rapid job of removing the zinc from standard hot dipped galvanized coils. Stainless steel coils are not a good solution either. The surface of stainless steel is very irregular and the organisms tend to pile up one on top of the other, making it possible to remove only the top layers when cleaning. (See Appendix A, A-7).

The contamination of these evaporator coils located in the freezer is a normal progression of the migration of microorganisms on aerosols and minute droplets of moisture. Where the organism attaches itself to the droplet of moisture, the moisture then flows from an area of high vapor pressure to an area of low vapor pressure, which is obviously in the freezer. Once in the freezer, the organism has the moisture evaporated from it, becomes airborne and generally ends up on the wetted coil of the evaporator. From this point, the organism stays dormant, recovering from the shock of being hydrated and dehydrated, but it is available for travel in the airstream to the edible food product. This is why the evaporator coils in a freezer get extra attention from government inspectors.

The glycol sprays the evaporator coil continuously and in effect completely sanitizes the coil. Over 98 percent of all airborne organisms are removed by the glycol spray passing through the spray chamber of the glycol cooler. Once in the glycol bath, the organisms can never get out, never reproduce, and for all intents and purposes, are inactivated as far as the plant sanitation procedures are concerned. The extra added benefit from this self-sanitizing and cleaning procedure is undetermined. (See Appendix A, A-8).

G. Airborne Contamination

Listeria monocytogenes cannot be tolerated in a food plant. This is both a USDA and FDA regulation. Recent tests, which are emerging in industry literature, have indicated that the most overlooked problem in controlling Listeria is airborne contamination. Since the glycol sprayed unit removes 98 percent or more of all airborne microorganisms from an airstream passing through the glycol spray cooler, this localized airborne contamination problem is eliminated.

H. Cost Savings

When the above numbers are added up, the glycol system, as compared to hot gas defrost, offers a savings of $517,792, plus whatever value may be assigned to plant and product safety, plant sanitation and airborne contamination. These savings are certainly significant and dramatically show the cost of frost.

The wetter the plant and the wetter the product, the greater the chance for contamination to occur. However, no one in a food processing plant can ignore the possibility that the organism will be found in the product and will cause the unwanted publicity of a recall. The glycol system greatly minimizes this risk, and this value is undetermined.

IV. COOLERS, PROCESSING AND PRODUCTION AREAS

A. Coolers

A dairy holding cooler is an ideal example of what a modern day cooler is all about. The room must be as close to freezing as possible, let us say 35°F, and it must be as dry as possible. There should be no condensation on the walls and ceiling, and minimal condensation on the floor depending upon the frequency of washdown which is currently used. In order to obtain this condition, the dew point held in these areas should be between 20°F and 25°F. When the room is held at this low a dew point, any moisture which condenses on the floor, wall or ceiling will very rapidly vaporize back into the air stream. Since cold-loving organisms such as Listeria monocytogenes and Yersinia (salmonella as well) are definitely persona non grata in these areas, the maintenance of an environment which is cold and dry will certainly help to eliminate their presence. It would be difficult to maintain these areas at the 35°F dry bulb, 25°F dew point condition with intermittent defrost systems because the rapid frosting of the coils makes a relatively constant temperature almost impossible to achieve, and the use of reheat in these areas is definitely not satisfactory because of the rapid growth of organisms should they deposit on the reheat coil.

A comparison of a typical milk cooler with glycol spray and hot gas defrost coils is shown in Table 1:

TABLE 1
MILK COOLER

Glycol Spray

SH 72.3 ton			
LH 19.2 ton		DB	DP
78,000 cfm	in	35°F	24°F
	out	24.9°F	18°F

requires 99 ton, 20°F, flooded NH_3
590 #/hr steam at maximum conditions

HG Defrost

SH 72.3 ton			
LH 19.2 ton		DB	DP
78,000 cfm	in	35°F	24°F
	out	18°F	18°F
	reheat		25°F

requires 140.4 ton, 12°F, NH_3 x 1.25 frost factor = 175.5 ton 600.6 #/hr steam

The sprayed glycol system's ability to control dry bulb and dew point separately has a definite advantage here. With an 18°F refrigerant temperature, you can have air discharging from the spray cooler at 25°F dry bulb and 15°F dew point if you carry a higher concentration of your glycol liquid. The ability to remove microorganisms from an air stream passing through the spray chamber of the glycol unit is a big advantage in this type of area.

It should be kept in mind that even after cleanup, traffic through an area such as this will produce 1,300 percent more organisms, which are released in the air by the disturbance on the floor. These organisms are picked up by aerosols or minute droplets of moisture and quickly find their way to the evaporator coil of the glycol sprayed units. (See Appendix A, A-9).

Some operators of milk rooms have recorded an extra added benefit for keeping their rooms cold and dry. When lift trucks are operating within the area, they do not do as much damage to a dry floor as they do a wet floor. Some operators actually have found that they can use a treated concrete floor, thereby incurring substantial savings over the installation of a dairy brick floor.

B. Processing and Production Areas

Any food processing area is an ideal application for controlling how moisture appears in packaging and production areas. USDA regulations for meat plants now state that the room temperature must be 50°F or below, hot water cleanup must occur every 8 hours, and the room must be free from condensation in any form. Another way of saying this is that the room must be below 50°F, the air must discharge from the evaporators at a temperature above the dew point temperature in the room, and the dew point temperature in the room must be below the surface temperature of the product being processed or packaged.

TABLE 2
Bologna Packing Area

Glycol Spray

		DB	DP
SH = 85 ton			
LH = 7.7 ton		DB	DP
39,000 cfm	in	48°F	16°F
surface temp prod. 18°F	out	25.3°F	9°F

requires 107 ton, 15.7°F NH3 186 #/hr steam at max conditions

With no DP Depression

	DB	DP
in	48°F	16°F
out	10°F	9°F
reheat		25.3°F

requires 152 ton, 0°F, NH3 648 #/hr steam

The above comparison is based on the assumption that no frost will appear on the coils. The compensation for frosting would involve more units handling more air, etc. A wetted coil and reheat would rapidly increase the presence of organisms within the area so it would be very difficult to obtain the desired conditions without a sprayed coil.

Some companies have determined that since they cannot assure themselves that cross contamination will not occur and Listeria will find its way into their final packaging area, they have attempted to make this area at least as free from organisms as possible. The criteria for this type of final packaging area was selected at 40°F DB and 20°F DP. A comparison was made between a refrigeration unit with filters, plus a desiccant wheel, as compared with a glycol sprayed dehumidification system. The results are shown in Table 3. (See Appendix A, A-10)

	Summer	Winter
Glycol spray system	$ 187,000	$ 35,000
Filter coils, desiccant system	$ 369,000	$ 19,400

TABLE 3

C. Why Cold and Dry

The main task of the food producer is to get their product to the consumer before microorganisms can spoil it. Therefore, they should process the product in an environment which is not conducive to microorganism growth. Moisture is necessary for an organism to assimilate its bodily functions, and the colder the environment, the less chance the organism has to reproduce. Before the discovery of such cold-loving organisms as Listeria and Yersinia, a 50°F room temperature was deemed sufficient to retard the growth of pathogenic organisms and certainly slow down the growth of spoilage organisms. Now the World Health Organization (WHO) as well as other responsible agencies, are suggesting that "cold and dry" means as close to freezing as possible, say, 35°F, with dry meaning the dew point in the area should be below the surface temperature of the product being processed. (See Appendix A, A-11).

V. SPECIAL MATERIAL HOLDING COOLERS

Most meat plants are very particular about how they store their raw materials prior to processing. A normal specification for such an area would be dry bulb temperatures between

28°F and 32°F, with a minimum relative humidity of 80 percent. The higher the relative humidity, the better from a shrinkage standpoint of the product. Since a sprayed glycol system can be made to discharge the air at 96 percent relative humidity, one need only select the proper glycol spray cooler at a 3°F or 4°F TD to pick up the sensible heat load, and the air being discharged will be at a continuous 96 percent relative humidity, thus ensuring that you can hold the area at the minimum relative humidity desired. The ability of the glycol system to control the airborne organisms minimizes the chances that the product, while being held at the desired conditions, will not have problems with organism contamination. This is not true of an intermittent defrost unit since the frosting on the coils would not only cause problems with controlling the dry bulb and dew point within the area, but would act as a home for any organisms which find their way into the material holding cooler.

VI. CONCLUSION

When moisture in a vapor phase appears in a food plant, the plant operates smoothly. When moisture appears as a solid, the plant pays a large penalty in lost production, high energy cost, and problems with plant safety and sanitation. When moisture appears as a liquid, problems with shelf life and microorganisms ultimately follow.

The only way to insure plant operation in the vapor phase is to eliminate moisture as a factor by using a glycol spray system which possesses the ability to obtain a dew point depression when necessary. The ability to control dry bulb and dew point separately is a must.

Plant safety must never be overlooked. The necessary steps to hot gas defrost a coil properly should be followed (See Appendix A, A-12) are named. The glycol spray methods are also mentioned. Essentially, you have a choice: you can pray, or you can spray.