Save Maintenance and Component Expenses by Eliminating Moisture in Electrical Cabinets

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Abstract

NEMA 4x rated enclosures do not adequately prevent moisture build up inside electrical cabinets. The presence of moisture in electrical cabinets, motor housings and related equipment at food processing establishments can lead to corrosion, premature component failure, costly down time and extensive repairs. Moisture in the dark internals of an electrical cabinet leads to microbial harborage points that usually go unnoticed. A cabinet dryer system that includes a filter and a membrane can effectively reduce the humidity of the equipment to 10 % or less, minimizing the possibility of moisture. In contrast to other approaches (e.g. the use of light bulbs, heaters or vortex coolers), a cabinet dryer system does not require electricity and is virtually maintenance free. They are robust systems capable of withstanding harsh washdown chemicals while keeping the cabinet moisture free.

The presence of moisture in electrical cabinets, control panels and motor compartments from the washdown process is a critical issue since moisture can lead to a variety of problems that can affect plant efficiency, product quality and food and plant safety. The presence of condensation inside an electrical cabinet or motor compartment can lead to water puddles at the base of the cabinet and condensation on the walls and components. The presence of water leads to corrosion and can compromise electrical connections, leading to significant down time and expensive repairs. These effects can be especially problematic since the ambient temperature changes during the day. While the presence of moisture in electrical cabinets and motor compartments is a problem in essentially all wet process industries, it is especially critical in the food processing industries, since moisture in electrical cabinets can lead to mold and/or bacterial growth and lead to regulatory concerns. Service technicians must be especially careful to shut down power before servicing these wet cabinets due to the chance of electrocution.

A number of approaches for drying electrical cabinets and motor compartments have been tried, including use of dehumidifiers, heaters, heaters with a fan, vortex coolers and air conditioners. While each of these can be useful, none of them lead to an ideal solution. As an example, OSHA requires that these devices should be powered down during the wash down procedure at the very time when drying is most needed. Once the drying device is powered on again, it will then take a period of time (if ever) to re-dry the cabinet. To avoid these issues, many facilities have found that purging the compartment with air that is dried by a cabinet dryer system provides a reliable solution to the problem with considerably lower initial and operating costs. In this paper, we describe an effective method of providing dry compressed air to electrical cabinets and motor compartments in the plant on a 24 hour/day, 7 day/week basis.

Removing Water Vapor from Air via a Filter and a Membrane

Water (and other deleterious materials such as compressor oils and particulate matter) can be readily removed from compressed air with a combination of a coalescing filter, (which removes water droplets, oil and particulate materials) and a membrane module that removes the water vapor. A coalescing filter (Figure 1) is designed to remove the liquids and particulate matter with an efficiency of 99.99% at 0.01 μm. The liquids drain to the bottom of the housing and are emptied via a drain. The compressed air is then passed into a membrane module that consists of a bundle of hollow membrane fibers which are permeable to water vapor (Figure 2). As the compressed air passes through the center of these fibers, water vapor permeates through the walls of the fiber and dry air exits from the other end of the fiber. A small portion of the dry air is redirected along the shell side of the membrane fiber to carry away the moisture which surrounds the fiber and the water vapor is vented to atmosphere. The combination of a coalescing filter and a membrane filter provides air with a dew point of -7°F (-22°C) for saturated inlet air of 100°F (38°C) and 100 psig. The input temperature range is from 40-120°F (4-49°C) and the inlet pressure range is from 60 to 150 psig.

The coalescing filter and membrane are housed in an assembly (Parker Balston, Haverhill MA) to provide ease of operation and maintenance (Figure 3). The auto-drain feature allows for automatic draining of the liquids so that the filter can continue to remove liquids for an unlimited time without loss of efficiency or flow capacity. The only required maintenance is periodic replacement of the filter; typically replacement is done without tools on a periodic basis and is done by simply unscrewing the canisters (captive O-rings are used to minimize the need for spares) and removing the element. The overall assembly does not contain any moving parts and is extremely reliable and quiet in operation. The initial cost of a compressed air dryer system is minimal (under $1000 for a system that provides 3 scfm) and operating costs are correspondingly low.

Using a cabinet drier can frequently solve problems that have been difficult by other methods. As an example, a cabinet drying system was installed on a metal detection system at Dan's Prize, a division of Hormel Foods Corporation. Before the dryer was placed in service, it was necessary to stop production three times a week to remove moisture from the detector. According to Tom Breslin, Manager of Plant Engineering, "once we installed our dryer system, the problem went away. The dryer has been in place for about a year, with no maintenance issues."

Comparing the Membrane/Filter Cabinet Dryer to Other Methods of Drying Electrical Cabinets

Heaters and Fan Heaters

Placing a light bulb in the electrical compartment is perhaps the simplest approach to drying an electrical cabinet. When this approach is employed, the temperature of the cabinet is increased and the relative humidity decreases, but the absolute amount of water vapor in the cabinet remains constant. If the power is shut off or the bulb fails, the temperature returns to the ambient temperature and water vapor may condense and thereby create problem for components inside the cabinet. Similarly, the power to the lamp must be shut off during wash down procedures, leading to the possibility of condensation inside the cabinet. Heat from the lamp can lead to premature component failure; in some facilities, a fan is used to expel the warm air from the cabinet. The fan introduces an additional component to the system that consumes power, may fail and provides a point of water entry since it is open.

Vortex Cooler

A Vortex Cooler is a mechanical device that separates a compressed gas into a hot and a cold stream that can be used to provide cold air which is then passed through the electrical compartment to remove the water vapor. The basis of a Vortex cooler is a swirl chamber into which the pressurized gas is introduced. A conical nozzle is placed at the end of the tube and only the outer shell of the gas, which is cool, escapes at that end. Since cooled air has lower water content than ambient air, the amount of water vapor in the cabinet will be lowered. The initial cost and operating costs of a vortex cooler are quite high. Since a typical vortex cooler that provides 8 scfm of air requires a 2 HP (1490 Watts) compressor output, a considerable expense for power is incurred.

Dehumidifiers and Air Conditioners

Dehumidifiers provide remove water vapor from air and maintain the ambient temperature, while air conditioners provide remove water vapor and cool the air. Both systems require a significant amount of electricity to operate, contain refrigerants which may be environmental hazards. In addition, they contain moving parts which may lead to maintenance issues and can take up valuable space inside a cabinet.

Cabinet Dryer Systems

Cabinet dryer systems which employ a coalescing filter and membrane provide a number of significant benefits over alternative methods of drying cabinets described above. They effectively reduce the water content of the air and can be used on a 24 hour/day, 7 days/week basis, even during wash down periods. No electricity and no refrigerants are required, just a small stream of compressed air.

Using a Cabinet Dryer avoids down time

A major benefit of a cabinet dryer is that it can dramatically reduce downtime due to maintenance emergencies.

When an emergency occurs, it may be necessary to stop the process and maintenance personnel must be re-deployed to remedy the problem. This can cost thousands of dollars per hour and have a deleterious effect on the plant's throughput. Lean staff resource is diverted from routine maintenance activities to deal with premature component failures. Other equipment suffers due to lack of time to perform routine maintenance. In contrast, the use of a Cabinet Dryer eliminates emergencies. Cabinet Dryers have no moving parts and the only maintenance that is required is the periodic replacement of a filter. This can be performed on a scheduled maintenance basis during routine system shutdowns, rather than on an emergency basis. As a typical example, a meat processing plant in the Midwest that was using a heating element to keep a control panel dry found that it was replacing the keypad every three weeks After it replaced the heating element with a Cabinet Dryer, it found that it was possible to operate for six months or more at a time with no failures and could replace the filter on a routine maintenance basis, rather than performing emergency repairs which shut down production.

Dried compressed air reduces operating costs

The operating cost of a filter/membrane based cabinet dryer system is considerably lower than that of alternative systems for maintaining a dry electrical cabinet. As an example, Lee Clarkson, production engineer at Ross Industries in Midland VA, a manufacturer of meat tenderizers, food packaging equipment, and food processing systems, reports that there are essentially no operating costs for the membrane dryer once the system is installed, the cartridge is periodically replaced. Replacement cartridges are quite inexpensive and are typically replaced on an annual basis. The cost of a replacement filter cartridge is $15 (all prices at time of writing). In addition, maintaining a dry cabinet reduces the possibility of corrosion and replacing components. In the case of the meat processing plant discussed above, a saving of ca. $25,000/year was obtained from eliminating the need to replace the control panel and from down time during the replacement time. The overall cost and payback period of cabinet drying methods depends on a broad number of variables that depend on local factors such as the cost per production hour, cost of maintenance labor and cost of electricity.

Conclusions

The use of a membrane Cabinet Dryer to reduce the presence of moisture and condensation provides an effective, reliable and inexpensive approach to the problem of premature component failure due to moisture in electrical cabinets, control panels or motor compartments. Since the system only requires compressed air and does not require electricity and has no moving parts, it can be used on a 24 hour, 7 day a week, 365 days a year basis, even during wash down procedures with a minimum of maintenance requirements. The combination of a coalescing filter and a membrane filter provides air with a dew point of -7°F (-22°C) for saturated inlet air of 100°F (38°C) and 100 psig leading to a relative humidity of 10% or less, ensuring that cabinets will be kept bone dry.

Figure 1 Coalescing Filter – Used to remove oil and water droplets, particulate matter from compressed air. The liquids drip to the bottom of the filter housing and automatically emptied by a drain assembly.

Figure 2 Permeation Membrane – Used to remove water vapor from air. The membrane bundle contains a large number of membranes to provide enhanced

surface area. The water laden air is carried away by a small portion of the dry air (regeneration flow).

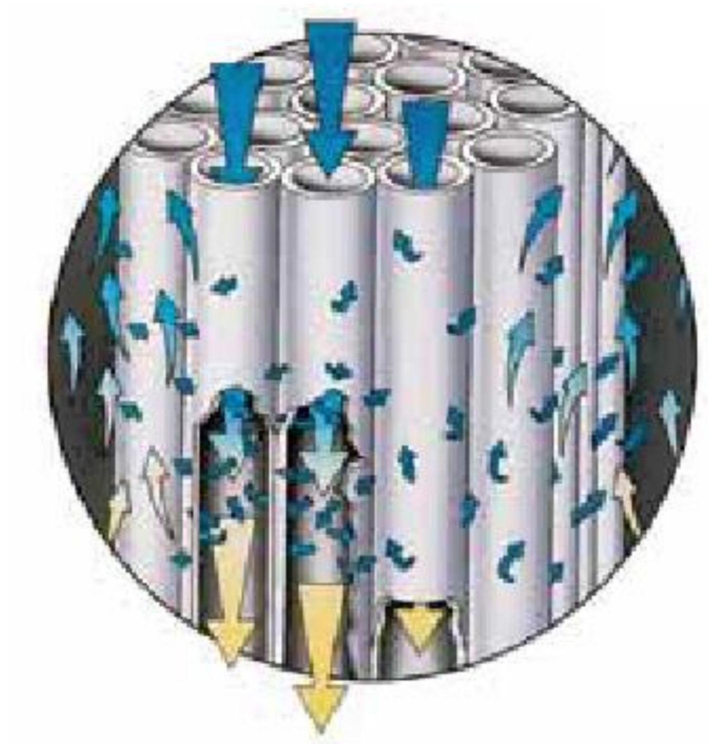

Figure 3 Cabinet Dryer


Compressed
Air In
Dry Purge
Air Out