Methods for Removing Moisture and Oil from Compressed-Air Lines in Paint Facilities

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Moisture in compressed-air lines causes a serious problem for application of paint and powder-coating finishes. The most obvious of the problems is product spoilage as a result of a defective finish caused by spotting or "fish-eyes." Metal that has been sandblasted is susceptible to rusting. Rust and scale can also form in the compressed air piping and clog nozzles or affect the surface of the finished product. If air lines are exposed to extremely cold weather, freezing of the water in those lines can easily occur, blocking the path of the compressed air. Condensation and possible freezing can also occur when compressed-air equipment is exhausted rapidly, especially through small nozzles or orifices.

This article addresses the source of the moisture, as well as other contaminants such as dirt and oil, along with the equipment necessary to remove them from the process air stream. It will deal in general terms with the most common problems and solutions, although each application must be evaluated for its own particular set of problems.

Atmospheric air contains moisture. The amount of actual moisture in the air varies from place to place and season to season. Higher relative humidity (RH) during the summer months is an indication that compressed air systems will be more troublesome during those warm months than in the colder, dryer winter season; however, because of the very process of compressing the atmospheric air, we create a situation where compressed air is virtually always saturated. Another way to state this is that compressed air is going to be at 100% RH, even in the dryer winter months. Let's take a look at why this is so.

Let's assume that atmospheric air being drawn into an air compressor is 50°F and 60% RH. According to moisture tables found in the Fifth Edition of the Compressed Air & Gas Handbook,[1] at 100% RH (saturation), every 1,000 ft^3 of air could hold 0.0702 gal of water. Because the RH is 60%, there is only 0.042 gal of water. Suppose we were to compress the 1,000 ft^3 of air to 100 psig. Using the formula for compression ratio, which is line pressure + atmospheric pressure all divided by atmospheric pressure, we find that we have a ratio of 7.8 to 1, which is to say we reduce the volume of the atmospheric area by nearly eight times; therefore, we would reduce the 1,000 ft^3 to only 128 ft^3, yet all of that moisture is still there. Because the volume is nearly eight times smaller, the RH would increase by eight times, because when compressed to 100 psig, that same 1,000 ft^3 of air can only hold 0.009 gal of moisture. Could the RH actually become $8 \times 60\%$ or 480%? RH, a measure of the vapor content of the air, cannot exceed 100%. The difference between the water content at atmospheric pressure and 60% RH (0.042 gal per 1,000 ft^3) and the moisture capacity at 100 psig (0.009 gal per 1,000 ft^3) is 0.033 gal. This is the amount that will condense, literally be squeezed out of the air as liquid. The result is compressed air at 100% RH and 0.033 gal of liquid water for every 1,000 ft^3 of air ingested by the compressor.

This is a likely scenario in an application where atmospheric air is heated during the compression process to anywhere from 250 to 400°F, cooled by the compressor's intercooler and aftercooler to approximately 90°F, and then allowed to flow through the piping system. When the temperature of the compressed air in the previously mentioned example drops to 110°F, it will reach its saturation point, and liquid will start condensing into the aftercooler as it continues to lower the temperature to 90°F. The more the air cools as it flows through the system, the more condensation will occur. It is imperative that we control this condensation through the proper selection and installation of compressed air dryers. Otherwise, this condensation will occur naturally in the air lines.

There are three types of dryers: deliquescent, refrigerated, and desiccant. The first type, deliquescent, removes the least amount of water vapor and is not usually found in critical applications where air needs to be very dry. This dryer uses saltlike tablets to absorb water vapor from the compressed air. Because the salt is being used up in this process, it must be continually replenished, and the level of protection is minimal. Refrigerated dryers (see Fig. 1) simply cool the compressed air to a temperature of approximately 35°F, condensing the water vapor to a liquid in the process. This liquid is then drained from the dryer through a separator and drain valve. As long as the compressed air is not then exposed to temperatures below the lowest temperature in the dryer, further condensation is not possible.

Desiccant dryers (see Fig. 2) will protect air lines to temperatures between −40 and −100°F, making it the dryer of choice for applications where compressed-air lines are exposed to a cold winter outdoor environment or when extremely dry air is necessary for specialized processing applications.

Let's look at the refrigerated and desiccant type dryers in a little more detail and discuss "dew-point" requirements. Dew point is the temperature at

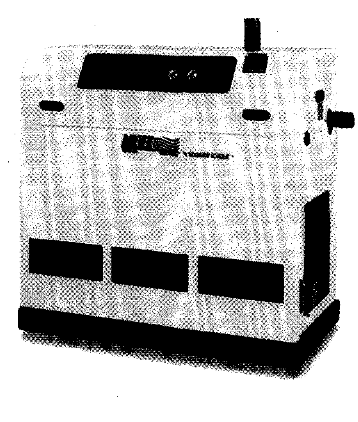

Figure 1. Smart Cycle refrigerated air dryer.

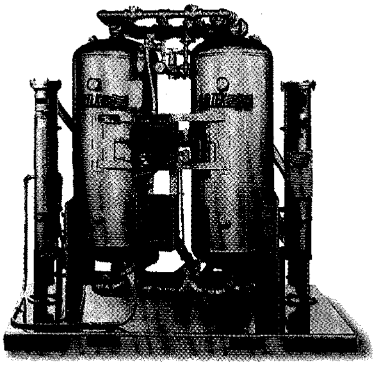

Figure 2. Heatless desiccant dryer.

which water vapor will begin to condense. The temperature at which the RH becomes 100% is another way to define dew point. Because we assume that the RH of the air leaving the compressor and after cooler is 100%, it is already at its dew-point temperature. Any further cooling below that results in water condensing in the compressed-air line.

Refrigerated dryers should be chosen when air lines will not be exposed to temperatures below 35°F. The refrigerated dryer will cool the compressed air then reheat it. The reheating will keep the piping warm enough so that condensation will not occur on the outer surface and drip onto the floor. Approximately 85% of the water vapor that enters this type of dryer will be condensed and drained from the system. Typically, this is adequate for most indoor applications. Refrigerated dryers are also the least expensive and use the lowest amount of energy to operate. Remember its limitation, however. It will protect the system only to 35°F exposure.

Desiccant dryers are typically designed with two towers filled with a desiccant material, usually spherical beads of activated alumina. The compressed air is directed alternately through each of the towers. The desiccant material will attract the water vapor and pull it out of the compressed-air stream. The vapor is held on the outer surface of the desiccant beads through the process of adsorption. At the conclusion of a fixed time cycle, the air stream will be diverted to the other desiccant tower. At that time, the tower that had just adsorbed the moisture will be regenerated through the use of a portion of the dried compressed air from the opposite tower and, in some cases, through a combination of dried compressed air and an external source of heat. One type of dryer makes use of heated atmospheric air to achieve the regeneration. The RH of air dried to a dew point of −40°F is less than 0.8%. At a −100°F dew point, the RH would be only 0.098%.

As mentioned, there are several methods of regenerating these dual-tower units. Some rely solely on dried compressed air, whereas others incorporate the use of electric heaters, blowers, or steam. Each have their own particular advantages and disadvantages and should be evaluated carefully in order to determine which type is best for the individual conditions surrounding any given application.

Finally, a word about the importance of filtration. There are two basic filter types: coalescing and particulate. Coalescing filters (see Fig. 3) remove the oil that may be present in the air stream. It is imperative that whenever using a desiccant-type dryer, a coalescing-type filter be installed at the dryer inlet. Oil coating the desiccant material will quickly render the dryer useless. A particulate filter should be installed after the desiccant dryer to prevent desiccant dust from going downstream. When a refrigerated dryer is used, the coalescence should follow the dryer. A particulate filter is usually unnecessary in this type of application, but if it is used, it should precede the refrigerated dryer.

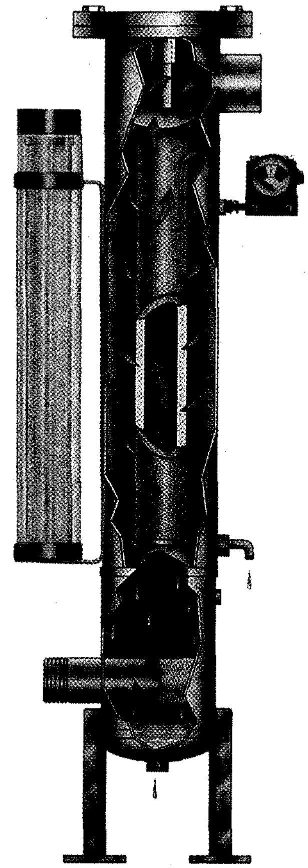

Figure 3. Coalescing filter.

Remember, compressed air is full of water, dirt, and sometimes oil. In order for liquid painting and powder coating systems to function effectively, these contaminants must be eliminated. The cost involved to not do this would be quite prohibitive.

Reference

1. *Compressed Air & Gas Handbook*, 5th ed., Prentice-Hall Inc., A Simon & Schuster Co., Englewood Cliffs, N.J.; 1989

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