Moisture from bulk solids processes can cause significant problems in your dust collection system, including shortened filter life and material buildup that can lead to system component failure or bridging in the dust hopper. These and other complications from moisture can reduce the dust collection system’s performance, drive up the system’s operating costs, and affect product quality. This article explains how moist process air affects a dust collection system’s performance and describes design techniques for successfully managing a high-moisture airstream in your dust collection system.

When warm, moist (humid) air in our atmosphere cools, the moisture condenses to form rain. The same thing can occur inside your dust collection system. Warm, moist process air can cool as it flows through the dust collection system’s ductwork, causing the moisture to condense into liquid water droplets. If your dust is hygroscopic (absorbs water), it will absorb the droplets and form a sludge that can agglomerate on the system’s internal surfaces. This buildup can cause bridging in the dust hopper, preventing reliable discharge; collect on the vanes of the hopper’s rotary airlock valve, causing it to seize; accumulate on pressure sensors, leading to false pressure readings; and collect on duct surfaces, adding excessive weight that can cause the duct to fail. Sludge can also collect on the filter surfaces, increasing the pressure loss across the filters and reducing the efficiency of reverse-pulse-jet or mechanical-shaker cleaning. Moisture can weaken the filter media, causing filter leaks or failures and allowing dust to bypass the filters. Moisture can also prevent collected dust that’s being reclaimed from meeting product quality specifications. These problems can drive up your operating expenses by reducing productivity, shortening filter life, causing maintenance issues, and leading to inconsistent and unreliable system performance.

Even when it doesn’t lead to condensation, moisture in your dust collection system can cause problems. In vapor form, moisture is less dense than dry air. If your system’s components were chosen assuming a dry airstream with no moisture, but your actual airstream contains moisture, the airflow through your system will be higher than planned. This leads to increased energy costs for running the system fan at a higher speed, shortened filter life, undersized and underperforming system equipment, and airflow disruptions that can negatively impact your process.

How moisture and temperature affect a dust collection airstream

Understanding how air moisture and temperature are related and how that relationship affects the airstream in a dust collection system can help you work with your supplier to design a system to handle a moist airstream or troubleshoot problems in an existing system. At any given temperature, air can hold only so much moisture before liquid droplets begin to condense. The temperature at which this occurs is called the dew point (or saturation temperature). Generally, air becomes denser and can hold less moisture in vapor form as its temperature decreases. If the airstream temperature reaches the dew point inside a dust collection system, the water vapor in the airstream will condense within the ductwork or dust collector, leading to the problems already discussed.

Many reference tables, fan performance curves, and industry rules of thumb used in designing dust collection systems are based on “standard air conditions,” which assume a temperature of 70°F, an overall pressure of less than 20 inches water gauge, no moisture content, and sea-
level elevation, and which also ignore the collected dust’s weight and volume. The problem is that very few dust collection systems operate at standard air conditions, especially those collecting dust from moist processes like drying. If the airstream entering your dust collection system will be above 100°F and contain more than 2 percent moisture, you can avoid many performance problems by correcting these standard air assumptions to more accurately reflect your actual operating conditions.

Analyzing moist airstream properties
To ensure that your dust collection system will be able to effectively handle the moisture in your process airstream, you first need to analyze several of the airstream’s physical properties:

- **Dry-bulb temperature**: Better known simply as *air temperature*, this is the airstream temperature as measured by a standard thermometer.
- **Wet-bulb temperature**: This is the lowest temperature at which evaporation will occur in an airstream and can be measured using a wetted thermometer. The process of evaporation takes heat energy from the surrounding air molecules and leaves the air cooler as a result. In moist airstreams, the wet-bulb temperature will be relatively high because the already-moist air can’t absorb very much additional moisture through evaporation. In dry airstreams, the wet-bulb temperature will be relatively low because a lot of evaporation will occur, cooling the air.
- **Moisture content**: Also referred to as *absolute humidity*, this is the mass ratio of water to dry air in the airstream. Do not confuse this with relative humidity, which is the moisture content adjusted for the current temperature.
- **Dew point**: Also referred to as the saturation temperature, this is the temperature at which water vapor in air at constant barometric pressure condenses into liquid water at the same rate at which it evaporates.
- **Enthalpy**: This is the total energy (or heat content per unit mass) of the airstream and helps you determine how much energy you’ll need to add to an airstream to heat it and alter its properties.

You can see the relationships between these and other airstream properties on a *psychrometric chart*, which is used to determine the physical and thermodynamic properties of airstreams and other gas-vapor mixtures. [Editor’s note: Find free downloadable psychrometric charts for several altitudes and in both standard and metric units at www.coolerado.com/products/psychometric-charts/.] Numerous web-based resources, calculators, and even mobile apps can provide the same psychrometric information based on several known airstream properties. With an appropriate psychrometric chart (depending on your application, this may be a high-temperature psychrometric chart) and at least two of the previously listed airstream properties, you can begin a psychrometric analysis of your airstream that will provide critical information for preventing or solving moisture problems:

- For choosing a new dust collection system design, you can use the dry-bulb temperature and moisture content of your process air (which are typically known) as a starting point for making system airflow and other calculations and to determine corresponding values on the psychrometric chart.
- For troubleshooting an existing system, you can measure the dry- and wet-bulb temperatures at multiple system locations to determine whether the airstream is likely to
When dealing with a high-moisture airstream in your dust collection system, your goal is to avoid condensation. To keep the airstream moisture in vapor form, you should maintain a sufficient spread between the dry- and wet-bulb temperatures throughout the system. Base your calculations on worst-case ambient conditions to ensure that the spread is large enough to adequately handle airstream temperature and humidity changes caused by process variations, the changing seasons, and even climate change or the next polar vortex. A good rule of thumb is to keep a 50-degree spread between the dry- and wet-bulb temperatures in your system.

Maintaining this temperature spread can be challenging, but depending on your application, one or more of the following methods can help:

### Bleeding in dry air
A common approach is to bleed in (add) dry air to the high-moisture process airstream as it enters the dust collection system. Consider, for example, a dust collection system collecting dust from a heated drum dryer. The airstream conveying the collected dust is at an elevated temperature and contains a lot of moisture. As the airstream moves through the dust collection system, it begins to cool and could potentially cross its dew point, creating condensation. But if you bleed dry air into the airstream as it enters the system, the combined airstream’s moisture content, wet-bulb temperature, and dew point all decrease, reducing the potential for condensation.

However, if you bleed ambient, nonconditioned air into a high-temperature airstream, while it will increase the air-moisture ratio, it could also reduce the airstream’s overall temperature. Remember, your goal is to maintain the spread between the dry- and wet-bulb temperatures. Cooling the airstream reduces its capacity to hold moisture and may also actually increase the wet-bulb temperature. You can avoid this problem by heating the bleed-in air prior to adding it to the airstream, as shown in Figure 1. Here, the duct from the process is angled against the flow (away from the dust collection system) to enhance air mixing and help disperse the dust throughout the airstream.

### Using process controls
You can also achieve consistent dust collection system operation by using process controls to monitor and maintain target airstream properties. Controls monitoring the dry- and wet-bulb temperatures, for example, can open or close airflow dampers or control variable-frequency fan drives or heating devices to maintain the spread between the two temperatures. Process controls can also reduce the system’s operating costs by minimizing the fan horsepower required to produce the target airflow volume, reducing the energy required to heat the bleed-in air and extending the filter life.

### Locating the dust collector near the process and adding insulation
If adding bleed-in air to your process airstream isn’t possible and process controls can’t adequately maintain the targeted dry- and wet-bulb temperatures, try to locate the dust collector as close as possible to your process to minimize airstream cooling in the ductwork between the process and the collector. You can also insulate the ductwork and dust collector walls to retain as much heat from the process airstream as possible. Both steps will minimize the potential for condensation.

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**For further reading**
Find more information on dust collection systems in articles listed under “Dust collection and dust control” in *Powder and Bulk Engineering*’s article index in the December 2013 issue or the Article Archive on PBE’s website, www.powderbulk.com. (All articles listed in the archive are available for free download to registered users.)

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