CARGOCAIRE

BULK MATERIAL HANDLING

Silo Storage, Pneumatic Conveying Systems, and Truck & Railcar Unloading Systems

WHEN HANDLING DRY BULK PRODUCTS HUMIDITY OFTEN CAUSES PROBLEMS

Hygroscopic ingredients attract and retain moisture. Problems associated with high humidity are product lumping and sticking. When these products are stored in silos or bins or transported in pneumatic conveying systems, moisture causes these ingredients to stick to silo walls and cause blockages in the conveying lines.

Lower productivity, higher production costs and reduced product quality are the results of these problems.

Dehumidification systems are a simple and effective way to combat humidity problems. These systems are widely used to prevent condensation and other moisture related problems, such as sticking or lumping which translates into higher productivity, lower production costs and high quality product.

Munters

SILO STORAGE

Design Concerns

Hygroscopic ingredients and powders (such as sugar and starch) are sensitive to high relative humidity; once moisture is absorbed they become sticky. These ingredients are commonly stored in silos and as they become sticky, build-up occurs on the silo walls and can form into lumps throughout the silo.

Desiccant dehumidifiers are effective in controlling air humidity and temperature inside the silo and are widely used to prevent condensation and moisture problems during storage periods.

Control Level

Condensation forms on any surface (i.e., silo walls and ceiling) that is colder than the dewpoint temperature. This condition occurs mainly at night when the temperature drops. This can occur due to any or all of the following:

- **Humid air entering through vents when the silo is emptied;**
- **Moisture given off by the ingredient;**
- **Unconditioned air entering the silo from truck and railcar unloading systems, pulse jet filters, pressurization fans and/or fluidized discharge bottoms.**

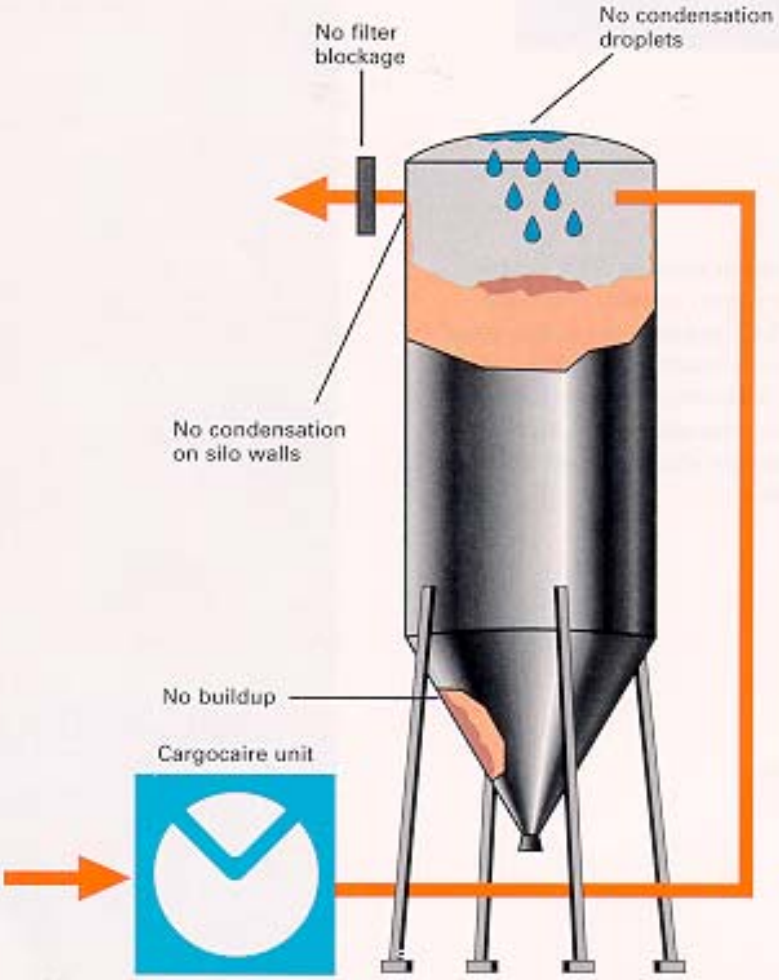
Sanitation issues and material handling problems resulting from silo wall build-up, bacterial growth and ingredient lumping will eventually cause costly downtime.

If an ingredient and the surrounding air are in equilibrium, the moisture content of the material is proportional to the relative humidity of the surrounding air. When a moist ingredient is brought into a dry environment, it will give up moisture until the water vapor pressure at its surface is the same as the vapor pressure in the surrounding air. Conversely, most ingredients absorb moisture from the air when it is moist.

The surface vapor pressure of an ingredient depends primarily on its chemical and physical structure. Each ingredient has different equilibrium characteristics. Surface vapor pressure is also proportional to both ingredient temperature and moisture content, but since most controlled spaces are held at a relatively constant temperature, moisture sorption and desorption has the deceptive appearance of being a function of relative humidity. There is actually a different moisture content-relative humidity equilibrium relationship for each different air and ingredient temperature.

Dehumidifiers are used to keep the air inside the silo at a specified temperature and Relative Humidity (%RH) preventing these problems from occurring.

The condition of dehumidified air required is determined on a case by case basis depending on geographical climate conditions, indoor or outdoor silo locations and ingredient characteristics. Typically, three air changes per hour are required inside the silo to maintain the specified temperature and %RH conditions.



Benefits

- **Ensures a high quality of stored product throughout the year.**
- **Maintains good hygiene.**
- **Prevents ingredient lumping to ensure a smooth flow from the silo.**
- **Prevents ingredient build-up on silo walls reducing costly man-hours for cleaning.**
- **Eliminates condensation inside the silo and resulting bacterial growth and sanitation concerns.**
- **Reduces filter blockages cutting the cost of filter changes.**
- **Reduces the risk of unplanned production stops.**
- **Allows hygroscopic products to be stored in single-wall, non-insulated silos to reduce capital costs.**

PNEUMATIC CONVEYING & AIRVEYING SYSTEMS

Design Concerns

Moisture regain causes many ingredients and powders, that would otherwise convey smoothly, to stick together and build-up in conveying lines. Desiccant dehumidifiers are effective in controlling humidity and temperature and have been widely applied to prevent moisture problems in pneumatic conveying systems.

Control Level

Hygroscopic ingredients and powders are sensitive to high relative humidity, once moisture is absorbed they become sticky. The graph to the right illustrates ingredient moisture content increasing as relative humidity rises.

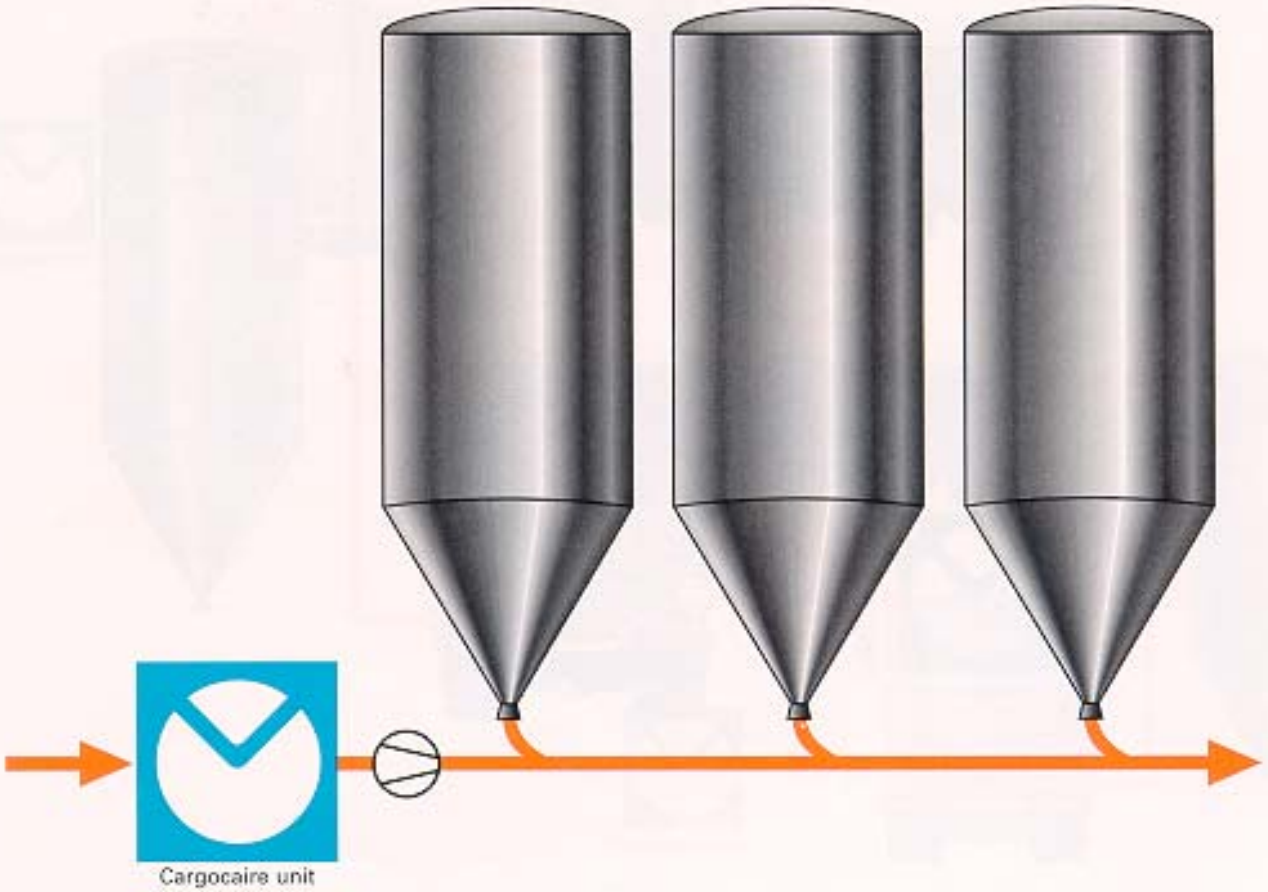
Sticky ingredients or powders build-up inside conveying lines and flow becomes a problem, slowing the process, creating sanitation problems and eventually causing costly downtime.

Dehumidifiers are used to keep the conveying air dry and cool. This allows the pneumatic conveying system to run efficiently by reducing the cost and time required for line cleaning.

The required condition of the dehumidified air is product specific, but is generally in the range of 68-77°F and at 30-40% relative humidity (RH).

Benefits of Dehumidifiers in Pneumatic Conveying

- **Prevents ingredients from sticking together during conveying.**
- **Improves product flow during conveying.**
- **Eliminates build-up of ingredient in conveying line, preventing costly manhours for line cleaning.**
- **Prevents manufacturing downtime.**
- **Reduces moisture regain and solidification of the ingredient on the silo wall by the introduction of dehumidified air through the conveying line into the silo.**
- **Meets GMP and sanitation requirements.**



TRUCK & RAILCAR UNLOADING SYSTEMS

Design Concerns

Many high volume manufacturing facilities receive their hygroscopic ingredients, such as sugar or calcium phosphate, by way of truck or railcar. The pneumatic conveying and airveying systems used to unload the ingredients from these trucks or railcars often experience ingredient sticking and conveying line build-up during high humidity days.

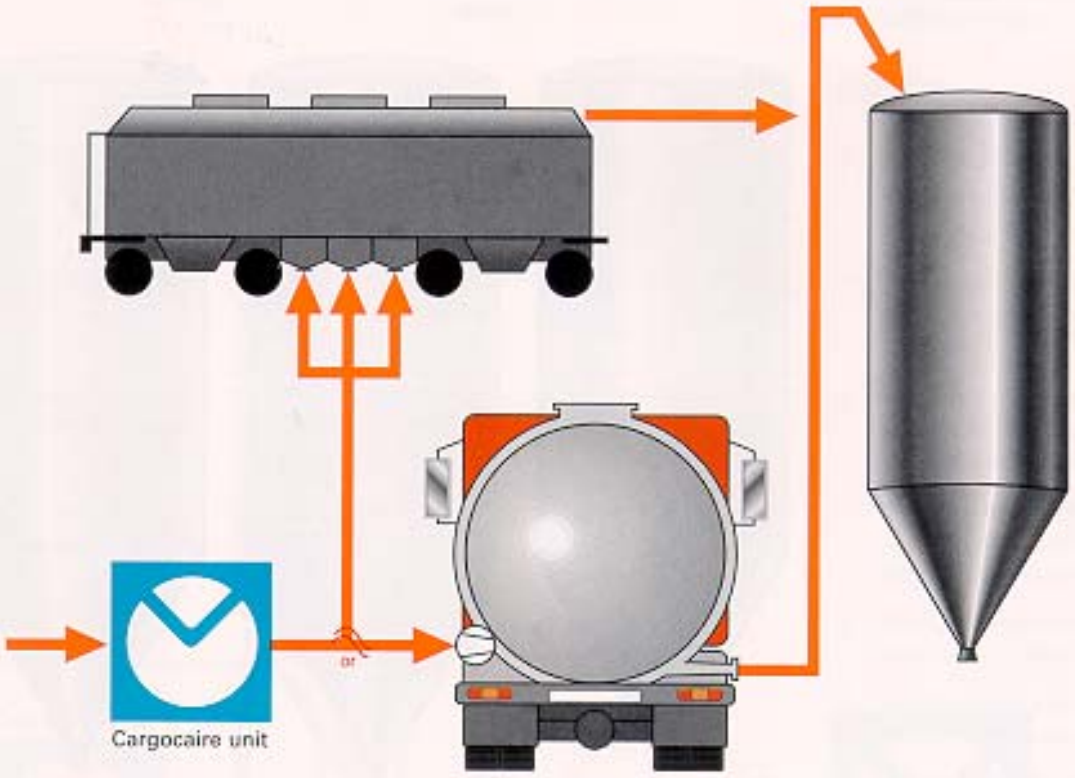
Moisture regain by the ingredient during conveying is the primary cause for sticking and build-up difficulties. The use of desiccant dehumidifiers for supplying dry air to the conveying line is very effective in controlling the relative humidity (RH) and temperature of the conveying airstream and is widely used for unloading systems.

Control Level

Virtually every ingredient/powder has some affinity to absorb moisture from air which is moist, and give up moisture when the surrounding air is dry. In the case of hygroscopic ingredients, their affinity to absorb moisture from the air is particularly acute. This moisture regain causes many hygroscopic ingredients to stick together and build-up in the unloading conveying lines.

Once these ingredients become sticky they build-up inside conveying lines and product flow becomes a problem, slowing the process, creating sanitation problems and eventually causing costly downtime.

Dehumidifiers with pre-cooling are used to keep conveying air dry and cool, allowing the pneumatic conveying system to run efficiently, and reducing the cost and time required for line cleaning. The condition of dehumidified air required is product specific but is generally in the range of 68-77°F and 30-40% RH.



Multiple Functions

Many pneumatic conveying systems designed to unload ingredients from trucks or railcars experience periods of time when they are not in use. During these idle periods, dehumidified air from the conveying system can be used to supply a dry air blanket over the ingredients while they are stored in silos or bins. This alternate function is depicted in the diagram A.

The benefits of blanketing ingredients with dry air are:

- **Prevent ingredient build-up on silo walls and reducing costly man-hours for cleaning;**
- **Ensure smooth flow from the silo by preventing ingredient lumping;**
- **Prevent condensation inside the silo and the resulting bacterial growth and sanitation issues.**

Receiving areas equipped with dedicated conveying systems for both truck unloading and railcar unloading can use the dehumidified air from the truck conveying system to fluidize the railcar bed. Of course, this could only take place during times when a truck is not being unloaded. Diagram B illustrates this dual function.

This type of dual function design is possible when the air volume and pressure rating of the truck conveying system match those required by the railcar's fluidizing bed. Supplying dehumidified air to the fluidizing bed on a railcar will improve the flow of ingredients out of the railcar thereby reducing the time required for unloading.

Benefits of Dehumidifiers in Truck/Railcar Unloading

- **Prevents ingredients from sticking together during conveying.**
- **Improves product flow during conveying.**
- **Eliminates build-up of ingredient in conveying line, preventing costly manhours for line cleaning.**
- **Prevents manufacturing downtime.**
- **Reduces moisture regain and solidification of the ingredient on the silo or hopper walls by the introduction of dehumidified air through the conveying line into the silo or hopper.**
- **Meets GMP and sanitation requirements.**
- **Allows the same dehumidified air used in truck/railcar unloading to be used for delivery dry air into the silo.**

Diagram A

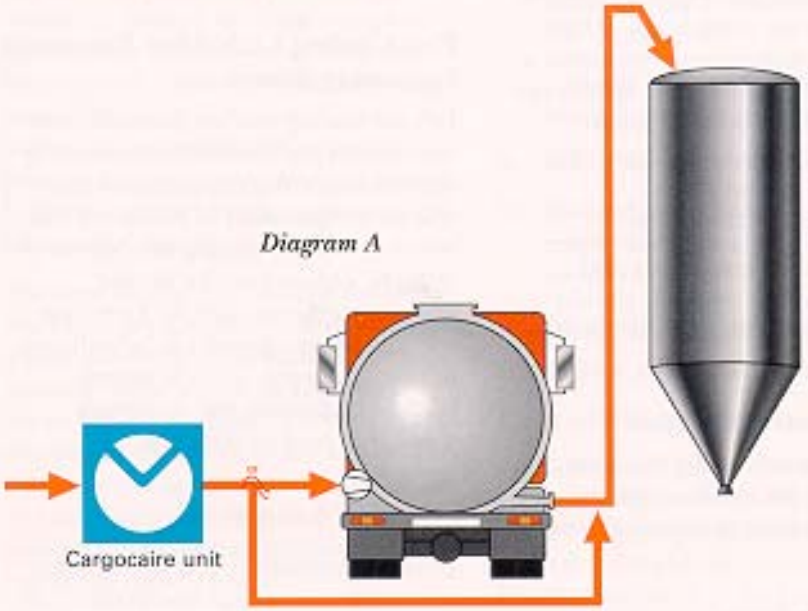
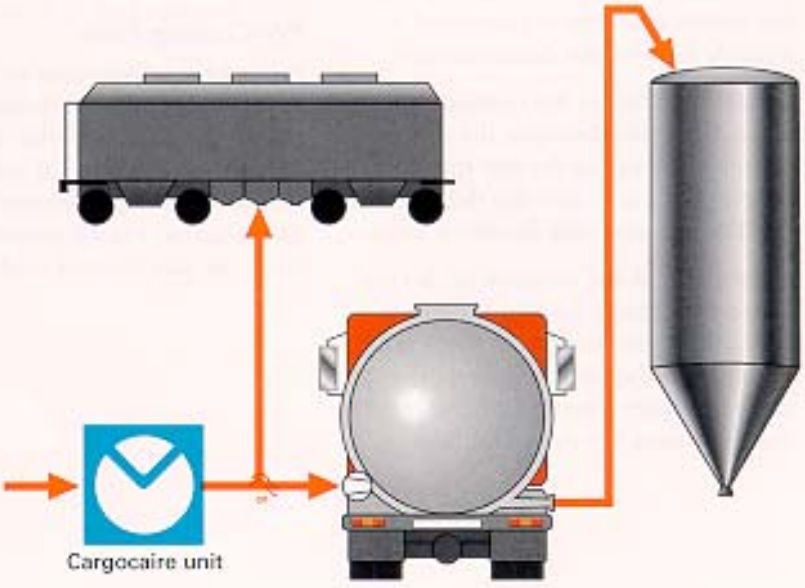


Diagram B



DESIGN REQUIREMENTS

Dehumidification systems for bulk material handling have similar design requirements. The designer should take into consideration the following information.

Loads

When retrofitting or designing bulk material handling systems with dehumidified air, process and reactivation air streams are usually drawn from outdoors. Using outdoor air is preferable due to the high probability of airborne product dust inside these buildings. If room air must be used, sufficient filtration should be added to the inlets of the dehumidifier to ensure that the air entering the dehumidifier is product free.
A secondary concern with using room air is placing the mechanical rooms or other rooms, where these dehumidifiers and pneumatic conveying blowers are located, under a negative pressure due to the large volume of make-up air required.

When using make-up air from the outdoors, there are no room loads, people or door openings influencing the dehumidifier load and it is simple to accurately quantify the temperature and moisture loads. The dehumidification system takes outdoor air and delivers it at the condition determined during design for the storage or conveying system.

The dehumidifier heat load consists of two elements: the sensible heat from the outdoor air and the latent heat in the outdoor air that is converted to sensible heat by the dehumidifier.

Sensible heat from the outdoor air is the difference between the summer design temperature for the specified geographical area and the delivered air condition to the bulk handling system.

Latent heat in the outdoor air is converted to sensible heat by the dehumidifier, in proportion to the amount of moisture the unit removes. The more moisture removed, the warmer the air exiting the dehumidifier.

There is also a winter sensible heating load. This is the difference between the winter design temperature for the specified geographical area and the delivered air condition to the bulk handling system.

The summer and winter design temperatures are published in the American Society of Heating, Refrigeration and Air Conditioning Engineer's (ASHRAE) "Handbook of Fundamentals", Chapter 24.

System Components

Filters

Air filters are located at the reactivation and process intakes of the system. These filters protect the system components against dust, dirt and larger particles, such as feathers and insects from the outside air. There is very little maintenance required in a simple dehumidification system for a bulk material handling system. Keeping air filters clean, however, is necessary for optimum dehumidifier performance.

To allow ease of inspection and replacement, the designer should ensure that nothing obstructs access to the filters.

Airflow Control Dampers

Manual inlet and outlet balancing dampers are set to allow precise adjustment of the required airflows in the unit.

Pre-Cooling Coils

It can be advantageous to pre-cool the air to achieve partial dehumidification before the air enters the unit. Coils should be designed for velocities below 450 feet per minute. It is important to insure proper drainage from the pan located under the coil.

Dehumidifier Reactivation

On units equipped with pre-cooling coils, the maximum reactivation energy requirement will occur when the outside air temperature equals the pre-cool design condition.

As the outdoor temperature drops below that of the design pre-cooling condition, the reactivation energy requirement becomes less due to the decreased moisture of air on the process side of the dehumidifier.

When sizing the reactivation heater, assume that the air entering the heater is the same temperature as the air leaving the pre-cooling coil. Otherwise, the reactivation heater may be undersized when the air temperature entering the heater drops, but the moisture load coming from the cooling coil stays constant.

Post-Cooling Coils After Pneumatic Conveying Blower

Dry air leaving the dehumidification unit enters the pneumatic conveying blower where the temperature rises due to compression of the air in the blower. The air leaving the blower must be reduced to the design temperature (typically 75°F) before the ingredient/powder is introduced to the air stream. This is accomplished by passing the air stream through a post-cooling coil.

Controls & Monitoring

Energy modulation control, whether steam, electric or gas reactivation are selected, is standard with the dehumidifier for reactivation air.
For steam, the reactivation circuit comes with a proportioning electric damper to modulate the reactivation air flow. The controller and sensor are mounted in the reactivation air outlet.
For electric reactivation heat, 100% automatic modulation of heater capacity is standard using a Solid State Proportioning Controller that automatically modulates heater output.
An integral gas modulating valve is furnished with gas reactivation units.

In bulk material handling applications, temperatures or humidity that are slightly higher or lower than specified by the design, for a brief period, do not present serious problems. The normal system alarm indicators allow adequate response time to correct conditions which are outside the design parameters. As an option, a simple humidity sensor can be installed at the process air outlet of the dehumidifier if further monitoring or control of the system is desired.

For precise adjustment of the required airflows in the unit, manual inlet and outlet balancing dampers are set. These dampers are furnished as standard features.

An optional face and bypass plenum, with modulating dampers, is available when more precise relative humidity control is desired or when loads are low enough to send some of the air through the bypass. A proportioning humidity sensor is mounted down stream of the dehumidifier in the process air outlet or conveying system. It sends a signal to a controller which adjusts the damper positions.

The face damper in front of the dehumidifier opens when the humidity rises above the design condition, allowing more air to be dried. As humidity drops below the design condition, the damper in the entry to the bypass duct opens, allowing moist air to bypass the dehumidifier. The face and bypass dampers operate together, one opening as the other closes.

A fixed baffle is located inside the bypass duct. This baffle is essential for even modulation of the airflow through the controlled dampers. If the pressure is not equal through the two circuits, air would take the path of least resistance, rushing through the bypass duct faster and in greater volumes than through the dehumidifier.

Manometers are provided for monitoring the process and reactivation air flow rates. Warning zones on the gauges indicate flows which are too high.

Cost Considerations

Controlling the initial cost of the dehumidification system is largely a question of minimizing the moisture load.

Modulating controls for temperature, humidity and reactivation energy will significantly save in operating costs as the system responds to load changes.

Variables to Specify

To insure complete communication of the project requirements to the manufacturer, be sure to specify:

- **Control levels and appropriate tolerances;**
- **Volume of makeup air required;**
- **Geographical location to determine ASHRAE weather extremes for make-up air;**
- **Type of powder/ingredient being conveyed and/or stored;**
- **Initial moisture content;**
- **Desired energy source for reactivation heat (i.e., electric, steam or gas);**
- **Inlet/outlet orientation choices;**
- **Indoor or outdoor installation;**
- **Available power connection.**

For additional guidance concerning system design and specifications, the design engineer is encouraged to consult a Cargocaire Sales Representative or Sales Engineer.