APPLICATION GUIDE

HUMIDITY CONTROL FOR FREEZER FACILITIES:
STOPPING FROST AND ICE BUILDUP AT SUB-ZERO TEMPERATURES

Ice on a freezer floor didn't form from a leak. It formed from air. Every door opening lets warm, humid air into a space where every surface is a condensation target.

THE MOISTURE PROBLEM

Freezer facilities operating at 0 to -20 degrees Fahrenheit or lower convert atmospheric moisture to ice on every surface it contacts. Unlike cooler environments where condensation remains liquid and can drain away, moisture deposits in freezers form as ice that can accumulate continuously. Evaporator coils build up ice between defrost cycles, reducing airflow and heat transfer until the system initiates a hot gas or electric defrost that temporarily raises the space temperature. Floors accumulate ice that creates slip and trip hazards for forklift operators and personnel. Racking and structural steel build frost layers that add dead weight and interfere with product handling. Product packaging accumulates frost that degrades barcode readability, obscures labeling, and reduces customer-facing product quality.

The moisture source is almost entirely infiltration. Freezer spaces are sealed environments with minimal internal moisture generation. The problem originates at the boundary: dock doors, personnel airlocks, and the interface between the freezer and adjacent cooler or staging spaces. At -10 degrees Fahrenheit, the air inside the freezer holds roughly 2 to 3 grains of moisture per pound. Outdoor summer air at 80 degrees Fahrenheit and 60 percent relative humidity holds 92 grains per pound. That's roughly a 40-to-1 moisture ratio. Every cubic foot of outdoor air that enters the freezer carries moisture that converts to ice almost immediately.

The consequences are operational and financial. Aggressive defrost schedules consume energy and create temperature excursions that stress the product cold chain. Ice accumulation on floors requires manual removal, creating labor costs and safety risk. Product frost damage generates customer complaints and returns. In facilities with automated storage and retrieval systems, ice buildup on racking and guide rails can cause equipment failures and system downtime. The facility spends energy, labor, and maintenance budget managing the consequences of moisture infiltration that could be addressed at the source.

WHY REGULAR AIR CONDITIONING IS NOT ENOUGH

At sub-zero temperatures, cooling-based dehumidification is not a viable option. The space is already well below the freezing point of water, so there's no temperature differential available for a cooling coil to condense moisture from the air. The refrigeration system's own evaporator coils demonstrate this limitation: they're the coldest surface in the space, and they accumulate ice continuously because moisture adsorbs onto their sub-zero surfaces from whatever infiltration air reaches them.

The evaporator coil is, in effect, the facility's only dehumidifier, and it's terribly inefficient at the job. Frost buildup on the coil surface acts as insulation, reducing heat transfer and increasing the pressure differential the compressor must overcome. As the coil ices over, refrigeration capacity degrades, the compressor works harder to maintain setpoint, and energy consumption rises. The defrost cycle that clears the coil briefly adds heat to the space, forcing the compressor to recover the temperature setpoint after each cycle. In a high-infiltration facility with aggressive defrost schedules, the refrigeration system may spend a meaningful fraction of its operating hours compensating for defrost-related temperature excursions rather than maintaining steady-state conditions.

Modern refrigeration systems have made real progress reducing these effects. Predictive defrost controls use a combination of coil temperature sensors, pressure differential monitoring, and runtime algorithms to initiate defrost only when frost accumulation actually warrants it, rather than on fixed time intervals. This eliminates unnecessary defrost events and the temperature excursions they create. Some facilities use redundant evaporator configurations: while one evaporator defrosts, the remaining units maintain space temperature, eliminating the temperature swing that a single-evaporator defrost produces. Variable-speed compressors recover setpoints faster after defrost with less energy overshoot. Improved evaporator coil coatings and wider fin spacing resist frost bridging longer between cycles.

These advances meaningfully reduce the energy penalty and temperature disruption of defrost cycles. But they don't eliminate the underlying cause: moisture entering the space still accumulates as frost on the coils, and defrost cycles are still required to remove it. Better controls and redundant evaporators manage the consequence more efficiently. Reducing the moisture load entering the space addresses the cause.

HOW DESICCANT DEHUMIDIFIERS REMOVE MOISTURE

Desiccant dehumidification addresses freezer moisture at the infiltration boundary rather than allowing it to reach the evaporator coils. A desiccant wheel treating the air at door openings, airlocks, or the ventilation pathway removes moisture through adsorption, delivering air at very low dew points into or adjacent to the freezer space. For a facility operating at -10 degrees Fahrenheit, the supply air must be delivered at a dew point below -10 degrees Fahrenheit so that no frost deposits on any surface in the space. At these dew point targets, the desiccant system operates in its most effective range: low-dew-point performance is the core capability that distinguishes desiccant technology from every other dehumidification approach.

The impact on defrost frequency is direct. With less moisture reaching the evaporator coils, frost accumulation slows and the interval between required defrost cycles extends. Some facilities implementing desiccant dehumidification at the infiltration boundary have reduced defrost frequency by half or more, depending on the ratio of infiltration load to total moisture load. Fewer defrost cycles means less energy consumed in defrost heating, fewer temperature excursions in the freezer, and more stable product storage conditions. The refrigeration system runs closer to its design efficiency because the coils maintain higher heat transfer effectiveness for longer periods between defrosts.

ASHRAE Refrigeration (Chapter 24) identifies desiccant treatment of infiltration air as an effective approach for reducing frost accumulation and defrost energy in freezer and low-temperature storage applications, noting that the economics improve as the operating temperature decreases because the moisture differential between outdoor air and the freezer environment increases.

HOW WE COMBINE COOLING AND DESICCANT IN ONE SYSTEM

The dehumidification system for a freezer facility treats the air in the adjacent spaces, not inside the freezer itself. The desiccant wheel and any pre-cooling are located at the dock, staging area, or airlock, where infiltration air enters before it reaches the freezer boundary. The goal is to deliver air dry enough that moisture doesn't enter the freezer space at all.

Desiccant Air Solutions builds self-contained hybrid units with a built-in DX pre-cooling coil and desiccant wheel designed for dock and staging area installation. The DX coil pre-conditions the incoming air before it reaches the wheel, removing bulk moisture through condensation before the desiccant handles the remaining load. An internal desuperheater recovers condenser heat from the unit's own refrigeration circuit and routes it directly to the reactivation airstream. When additional reactivation capacity is needed beyond recovered heat, the system can also draw from electricity, natural gas, steam, or hot water depending on the application.

Unlike catalog equipment designed for general-purpose dehumidification, Desiccant Air Solutions engineers each system for the specific process conditions and moisture loads of the application. Wheel media selection, pre-cooling capacity, reactivation temperature, and control logic are all configured for the target environment rather than selected from a standard product line.

The system modulates from zero to 100 percent of its moisture removal capacity through bypass damper and variable reactivation control, responding to dew point sensor feedback automatically, scaling output to match real-time door traffic and infiltration conditions without manual intervention. System controls use PID logic with dew point sensor feedback to modulate moisture removal continuously. Standard configurations include BMS integration for remote monitoring, alarm management, and setpoint adjustment. The integrated design produces a dehumidification system with low operating cost because both the pre-cooling and reactivation energy are managed within the same unit. The defrost energy savings, reduced compressor runtime, and improved evaporator efficiency provide an operating cost offset that, in high-infiltration facilities, can represent a substantial return on the system investment within the first years of operation.

WHAT TO THINK ABOUT WHEN SIZING THE SYSTEM

Freezer dehumidification sizing is driven almost entirely by the infiltration load through door openings and airlocks. Internal moisture generation in a well-sealed freezer is negligible; the system must handle the moisture that enters every time a boundary is breached. The critical inputs are door size, door open time per event, number of events per hour, and the outdoor or adjacent-space conditions on the other side of each opening.

A practical starting point: for an 8-foot by 10-foot dock door open an average of 45 seconds per forklift pass, with 20 passes per hour, calculate the infiltration volume using the door area multiplied by the air velocity through the opening (typically 200 feet per minute for an unprotected freezer door) multiplied by total open time per hour. At 80 degrees Fahrenheit and 60 percent relative humidity outdoor conditions, each cubic foot of infiltration air carries 92 grains of moisture per pound minus the 2 to 3 grains in the freezer air, a net load of approximately 89 to 90 grains per pound. Convert to pounds per hour of moisture removal: multiply the infiltration airflow in cubic feet per minute by 60, divide by the specific volume of the outdoor air (approximately 13.8 cubic feet per pound), and multiply by the grains-per-pound differential divided by 7,000.

Freezer Configuration	Operating Temperature	Target Dew Point	Primary Infiltration Source
Warehouse freezer	0 to -10 degrees Fahrenheit	Below -15 degrees Fahrenheit	Dock doors, forklift traffic
Deep freeze storage	-10 to -20 degrees Fahrenheit	Below -25 degrees Fahrenheit	Dock doors, personnel airlocks
Blast freezer / tunnel	-20 to -40 degrees Fahrenheit	Below -45 degrees Fahrenheit	Product entry, door cycling

Freezer Configuration	Operating Temperature	Target Dew Point	Primary Infiltration Source
Ice cream hardening	-20 to -30 degrees Fahrenheit	Below -35 degrees Fahrenheit	Product entry, packaging airlocks
Freezer-to-cooler interface	0 to -10 degrees Fahrenheit (freezer side)	Below freezer temp	Cooler air infiltration through shared doors

High-speed doors, air curtains, and vestibule airlocks reduce the infiltration volume per door event and should be sized alongside the desiccant system. The most effective installations combine fast-acting door hardware that minimizes open time with a desiccant system that treats whatever moisture gets through. Neither approach alone achieves the result both deliver together. For facilities with automated storage and retrieval systems, the airlock design for the ASRS portal becomes a primary sizing input because that single opening may account for a large fraction of the total infiltration budget.

WHY IT MATTERS

Ice in a freezer facility is an operating cost that runs continuously and invisibly until it shows up in the energy bill, the maintenance budget, the slip-and-fall incident report, or the customer complaint about frost-damaged packaging. A desiccant dehumidification system that treats infiltration air at the boundary, powered by condenser heat the refrigeration system is already producing, reduces frost load on evaporator coils, extends defrost intervals, stabilizes product temperatures, and eliminates the floor ice that creates safety hazards. The refrigeration system runs more efficiently, the cold chain stays more stable, and the facility operates with less frost and fewer operational interruptions.

Contact Desiccant Air Solutions at Sales@DesiccantAir.com to discuss sizing, door protection strategy, and defrost cycle reduction for your freezer facility.

REFERENCES

USDA FSIS: Refrigeration and Food Safety (USDA frozen food storage temperature and facility requirements)

ASHRAE Refrigeration Commissioning Guide (commissioning procedures for freezer facility HVAC performance verification)

ASHRAE Refrigeration (Chapters 23-24): Refrigerated-Facility Design and Loads

Desiccant Air Solutions designs and builds custom dehumidification systems combining cooling and desiccant technology for demanding freezer and sub-zero storage applications. Contact us at Sales@DesiccantAir.com.