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Heating and Cooling Coil Freeze Protection Design for 100% Outside Air AHUs

Introduction

Mechanical systems serving many NIH facilities are designed using 100% outside air (OA) Air Handling Units (AHUs) to protect occupants from hazardous materials, including aerosolized chemicals or pathogenic materials generated in biomedical, chemical, animal, and aseptic processing labs. In cold weather, 100% OA systems are particularly at risk for freezing and bursting heating and cooling coils, causing building flooding, which may result in shutdowns that impact large areas of the facility that disrupt ongoing research and require costly repairs. Freeze protection design should therefore be considered a critical requirement on all 100% OA AHUs. This article considers several freeze protection design elements.

Hydronic Coils

Hydronic preheat coils use a mixture of glycol and water. Proper glycol concentration lowers the freezing point of the system's working fluid, which lowers the temperature at which the coils would freeze and rupture. Regular inspection, monitoring, and refilling of system glycol is necessary. Energy heat recovery coils using a glycol/water mixture can provide additional heating capacity to the preheat coil and prevent coil freezing. These coils are installed upstream of the preheat coil and provide free heating from the leaving exhaust air stream.

The weakest portion of the coil is its return ends, so fissures typically occur there. As a result, both preheat and cooling coils may be provided with freeze burst protection via removable pressure relief caps on all ends. Hydronic coils must be drainable at the coil level, which allows water to be removed from the coil in case of emergency.

Circulation pumps ensure that the coil maintains turbulent flow at reduced load. N+1 circulation pumps are required on hydronic preheat coils, installed in the bypass position and operating whenever there is a call for heating. Coil circulation pumps also provide circulation if the preheat system fails which delays the coil from freezing. Single circulation pumps are required on the cooling coils, installed in the bypass position and running whenever the temperature of the air leaving the preheat coil is less than 40F (temperature value adjustable). Cooling coil pumps also lower the probability of coil freezing. All coil circulation pumps shall be powered from an emergency power source.

Control valve selection is critical to ensure that a change in valve position will have a commensurate change in coil output. It is not possible to maintain adequate control if the valves are oversized.

Steam Coils

Steam coils must be used carefully. Distributing steam coils, which have inside and outside tubes, are typically used for 100% OA AHUs. Steam in the inside tubes keeps the condensate in the outside tube from freezing when air passes across the coils at less than 32F (adj.). A vertical integral face and bypass damper (IFB) steam coil is another option. These have a bypass area between coil tubes and bypass (clamshell) dampers on both sides of the coil. The clamshell dampers open to the fins if heating is needed. Typically, when entering air is near or below 32F (adj.), the steam supply modulating control valve is controlled to a minimum valve position or fully open to ensure there is continuous flow, which is less likely to freeze. The face and damper assembly then achieves temperature control. However, IFB steam coils are not always an option because there must be sufficient space downstream of the coil to allow airflow to mix properly and equalize before reaching the cooling coil.

Steam must be effectively distributed through all the circuits in a steam coil, particularly at low loads. Coils must also be properly vented to relieve pressure and keep cold spots from developing. Vacuum breakers must be installed on steam headers, and condensate must be effectively drained from the coils so that it does not freeze or cause cold airflow that could freeze downstream coils. Redundant steam trap assemblies on the preheat coil are required to ensure that condensate is removed when a trap fails or is plugged. The bottom of the steam coil should be adequately elevated to allow for the critical head on the condensate to ensure it drains effectively. Typically, a 14" fill leg is recommended.

Designs shall avoid using a single modulating steam-control valve because it will typically create sub-atmospheric pressure in the coil and tends to hold condensate in the coil. A one-third/two-third valve arrangement helps controllability.

Freeze Stats

Freeze stats, or low limit safety switches, are positioned between the preheat and chilled water coil and monitor the inlet air temperature. They are typically set at 37F (adj). When the freeze stat senses cold, it sends a signal to shut down the unit and start the circulating pump for added protection. This freeze stat then requires a manual reset.

Typically, multiple freeze stats are installed. They must be adequately distributed over the face area of the entire cooling coil, as the control only responds to the area near the lower ends of the capillary tube.

Other Considerations

Automated isolation valves may be required on chilled water supply pipes to the air hander coil to prevent chilled water from flooding the mechanical room if a chilled water coil bursts. The isolation valve closes automatically to prevent flooding when a leak detector sensor, located in or around the AHU, trips. A check valve in the return pipe then allows the excess water to flow out of the coil and prevents water from back-feeding into the ruptured coil.