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TRANE FROSTAT™
COIL FROST PROTECTION SYSTEM IN LARGE VAV ROOFTOP UNITS

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I. BACKGROUND

A. PURPOSE OF BULLETIN

A new coil frost protection system has been designed to better meet the requirements of the marketplace for operating VAV rooftop units at very low airflow and loads. Situations where these low airflow and load conditions can occur include the following:

a. Partially occupied buildings
b. 100% shutoff VAV systems
c. Systems without economizers
d. Poorly designed systems

B. CURRENT FROST PROTECTION SYSTEM

The current frost protection system utilizes hot gas bypass to protect the coil from frosting. This system is not intended to provide capacity modulation. It is intended to keep the coil from frosting during the minimum-on timers of the VAV control of the mechanical cooling. These minimum-on timers are necessary to provide system stability and compressor longevity.

C. OPERATION OF HGBP IN TRANE LARGE VAV ROOFTOPS

Trane's method of hot gas bypass is typical of the industry. This HGBP system modulates hot gas based on suction pressure sensed at the suction line. The hot gas bypass is injected between the TXV and the distributor in the attempt to raise suction pressure and, therefore, coil temperature to a point where condensate will not freeze. A rule of thumb for evaporator coil suction pressures is 52 lb. saturated suction pressure which corresponds to the lowest temperature (27 F) without causing frost. The typical hot gas bypass valve will modulate over a 6 to 8 lb. range. This field adjustable valve must begin to open at 60 lb. to guarantee that it is fully open at 52 lb. (60 lb. - 8 lb. = 52 lb.). Because the opening of the hot gas valve increases the coil temperature, it also increases the temperature of the leaving air.

With an increase in the temperature of the leaving air, the discharge air sensor senses that mechanical cooling may still be required. Under severe conditions and operating parameters, such as low airflow and/or low entering air conditions, additional stages of mechanical cooling may be energized, promoting a frosting condition.

D. ALTERNATIVE COIL FROST PROTECTION SYSTEMS

In addition to hot gas bypass and coil pressure regulators, other methods of coil frost protection are available. These methods involve some type of defrost cycle initiated by a timer, a pressure sensor, or a temperature sensor.

The use of a timer to initiate defrost is not a good choice on a large VAV rooftop unit because of the varying loads. The frost condition may or may not exist when the defrost cycle is initiated by the timer.

The use of pressure differential across the coil is also not the best choice for frost protection on a VAV system. Pressure differentials vary in VAV systems because of modulating air flow.

A more appropriate method to sense a frost condition and initiate a defrost cycle on a large VAV rooftop is to measure one of the following:

a. Suction pressure
b Discharge air temperature
c. Suction line temperature (FROSTAT™ System)

On Trane rooftops, using the suction pressure method of coil frost protection inhibits the unit's ability to sense a loss of refrigerant charge. It may also cause unnecessary compressor shutdowns during the normal suction line transitions caused by mechanical cooling starts.

Leaving active coil air temperature is difficult to sense accurately, particularly at low airflows. A single sensor positioned in one location could possibly result in coil frosting in another location, because the temperature of the refrigerant varies as it progresses through the coil.

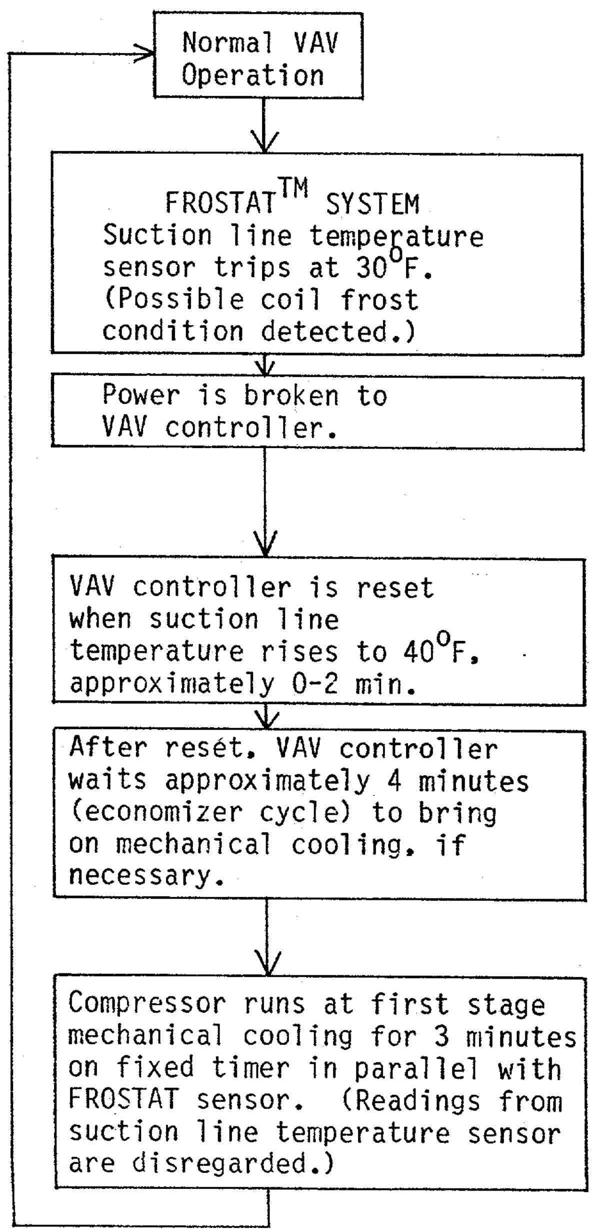
Suction line temperature sensing, the FROSTAT system, which senses suction line temperature at the TXV bulb location, is considered the most reliable of the alternatives and the best coil frost protection system to replace hot gas bypass in Trane large VAV rooftops. It does not pose the inherent problems of the other sensing methods.

II. FROSTAT™ SUCTION LINE TEMPERATURE SENSING

A. OPERATION

This new frost protection system eliminates hot gas bypass and adds a suction line surface temperature switch near the TXV bulb location to shut the cooling off when coil frosting conditions occur. The supply fans are not shut off and will de-ice the coil. Timers prevent the compressor from rapid cycling.

The following flow chart describes the operation of FROSTAT suction line temperature sensing in large VAV rooftop units:



B. OPERATION AND SERVICE ADVANTAGES

The FROSTAT™ system has many operation and service advantages for the customer, while still maintaining occupant comfort level and unit reliability. The following are those advantages:

1. Additional coil frost protection

   The FROSTAT system protects the coil beyond the capabilities of hot gas bypass, down to 5% of the rated airflow of the unit.

2. Reduces energy costs up to 60%

   The FROSTAT system saves energy compared to hot gas bypass because the compressors do not run continuously. They operate only when necessary to cool a space load and to keep the refrigerant system running reliably. This difference in compressor running time can result in a notable compressor energy savings of up to 60% during these low airflow and low load conditions.

   $$\text{Energy Savings} = 1 - \frac{\text{24 min/hr w/switch}}{\text{60 min/hr w/HGBP}}$$

   $$\text{Energy Savings} = (1 - 24/60) \times 100\%$$

   $$\text{Energy Savings} = 60\%$$

   ASHRAE emphasizes this point in ANSI/ASHRAE/IES proposed standard 90.1P "Energy Efficient Design of New Buildings Except Low Rise Residential Buildings" (September 29, 1987) Paragraph 10.4.3.2 which states:

   10.4.3.2 Cooling Equipment Auxiliary Controls. Evaporator coil frosting and excessive compressor cycling at part-load conditions should not be controlled by use of either hot gas bypass or evaporator pressure regulator control.

3. Lowers installation and operating expenses

   The FROSTAT system helps to reduce installation expenses. Time to check, adjust, and maintain the hot gas bypass system is eliminated.

4. Less opportunity for refrigerant leaks

   By eliminating the hot gas bypass line, less possibility exists for leaks in the refrigeration system.

5. Lower minimum operating ambient temperature

   The FROSTAT™ system allows the operating envelope ambient temperatures to be 10 F lower than with a hot gas bypass system.

C. POSSIBLE CUSTOMER CONCERNS

1. Occupant Comfort

Occupant comfort is the major concern of any tenant. Field tests were conducted to determine the effects on space temperature due to cycling compressors. Field tests have shown that the higher discharge air temperature swings due to the normal operation of the FROSTAT control system do not impact the comfort levels in the occupied spaces of the building.

Note: Ventilation air or 100% outside air systems requiring a constant discharge air temperature should not use the FROSTAT design. Hot gas bypass should be utilized in these systems.

2. Unit Reliability

A FROSTAT system under extreme conditions will cycle the compressor a maximum of 8 times per hour, due to its minimum on time of 3 minutes and minimum off time of 5 minutes. This is well within the maximum cycle limits of the compressor.

3. Will it work?

At several existing jobs, the hot gas bypass system for coil frost protection was not working. The FROSTAT suction line temperature system was used to replace hot gas bypass. No problems have been observed in protecting these systems against coil frost at 5% rated unit airflow.