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Preventing Steam Coil Failures

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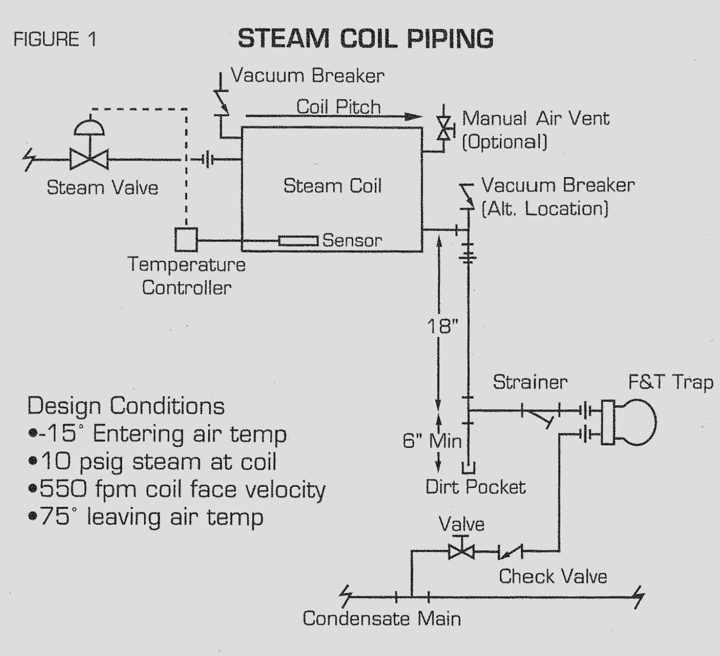
One task that keeps us busy during the winter months is ordering replacement steam heating coils. At the risk of reducing a nice source of business, we would like to discuss why many coils that heat outside air tend to freeze and break. In an ideal world, any modulated steam coil used to heat outside air would have a non-modulated preheat coil or a control system using face and bypass dampers. In reality, there are many coils without either and it is these that are most likely to cause problems.

WHY DO THEY FAIL?

It helps to picture the situation as a race. Steam in the coil turns to water (condensate) as it gives up heat. Once water is formed, the race begins. The water must exit the coil before the freezing air on the finned side can extract enough additional heat from the water to turn it to ice. Unfortunately, installers and designers sometimes fail to recognize the factors which cause water to lose the race! Figure 1 shows a proper installation, one not likely to freeze. After reviewing it, we will review installation and application errors which often result in frozen coils.



The first thing we must realize is that as the temperature of the incoming air rises above the design temperature, the modulating valve must throttle to prevent the leaving air temperature from rising. When it throttles, it lowers the temperature and pressure of the steam entering the coil. Most people are surprised at the amount of throttling that is required. Figure 2 is a performance curve for the coil in the example. As you can see, the coil requires only O psig steam to heat the air to 75ºF at an inlet air temperature of 0ºF! As the inlet air temperature rises above 0ºF, the valve will modulate further, attempting to lower the steam pressure into the vacuum region (below atmospheric pressure). However, the vacuum breaker allows air into the coil, thus preventing a vacuum from forming. As air is admitted, the coil performs using a mixture of air and steam. With the tube side of the coil and the condensate main both at atmospheric pressure, gravity is the only force acting on the condensate to force it from the coil.

THE WATER SHOULD BE ABLE TO DRAIN QUICKLY IF:

1. The condensate return main is at a lower elevation than the coil.
2. The coil is pitched toward the condensate main with a pitch of 1/8" / foot.
3. There is a drip leg ahead of the stream trap of sufficient height (preferably 15-18") so the static head of the water in the leg will overcome the pressure drop of the trap and strainer.
4. The trap has the necessary capacity to discharge the condensate at a pressure differential corresponding to the height of the drip leg (about 1/2 psi).
5. The trap is capable of handling significant

quantities of air (a float and thermostatic trap is recommended).

6. The trap and strainer are properly maintained.

NOW LET'S LOOK AT FACTORS WHICH ARE PRESENT IN MANY INSTALLATIONS:

1. ***NO VACUUM BREAKER IS INSTALLED -*** In this situation, modulation of the steam valve causes a vacuum to form, so that the pressure in the coil is less than the pressure in the condensate main. Condensate will not drain, so the coil will begin to flood. Eventually the capacity of the coil will be reduced so much by the flooding that the steam valve will have to open to admit higher pressure steam to achieve 75ºF discharge air temperature. This will discharge the condensate (and may cause water hammer) unless the condensate has already frozen. Once the condensate is discharged, the coil (now filled with higher pressure steam) will have excess capacity, so the steam valve will again throttle, causing a vacuum, flooding, etc., and the cycle will continue.

2. ***THE CONDENSATE RETURN LINE RISES ABOVE THE COIL OUTLET -*** The system designer may have determined that the condensate will be lifted by steam pressure. This may be true at the full load conditions, however at part load conditions, insufficient pressure may exist to lift the condensate. The result is the flood/discharge cycle described above.

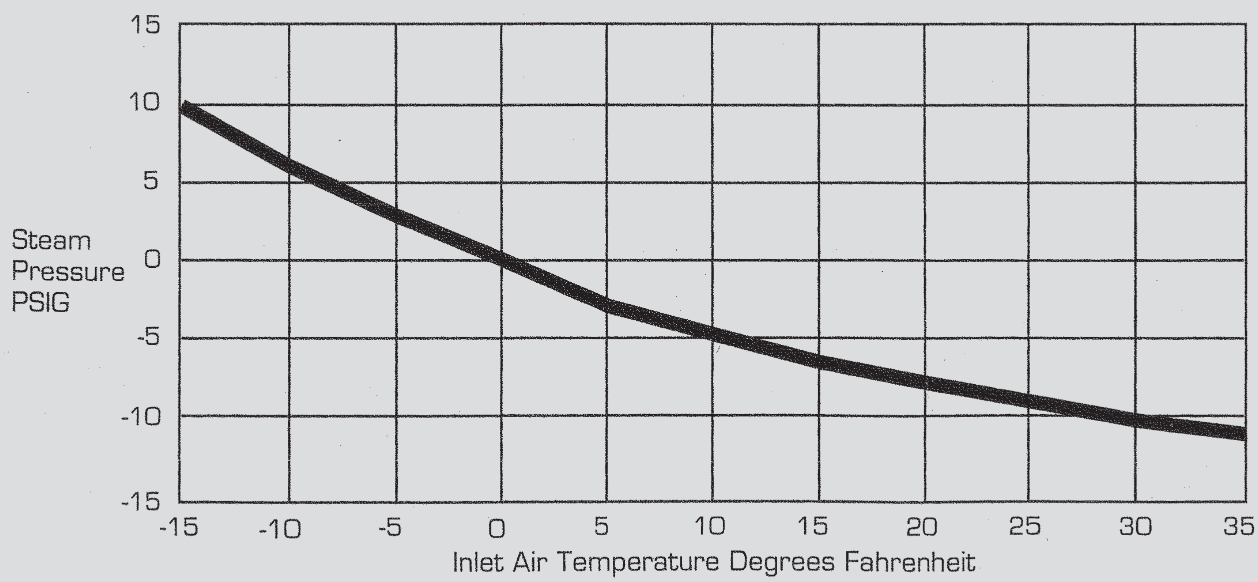
3. ***THE COIL IS NOT PITCHED TOWARD THE RETURN MAIN -*** Because there is only gravity to drain the condensate, this pitch can be a critical factor in getting the condensate out quickly.

4. ***THERE IS EITHER NO DRIP LEG OR A DRIP LEG OF INSUFFICIENT HEIGHT -*** This is a critical mistake, because when the vacuum breaker is open, the only available pressure to force condensate past the strainer and trap is the static head of the condensate in the drip leg. A short drip leg may reduce the trap capacity to the extent that the trap cannot keep up with the condensate loading, so the flood/discharge cycle takes place.

5. ***THE TRAP HAS INSUFFICIENT CAPACITY AT THE PART LOAD PRESSURE DIFFERENTIAL TO DRAIN CONDENSATE -*** It is common practice to oversize the trap by a factor of 2 or 3 times design capacity

FIGURE 2

STEAM PRESSURE REQUIRED TO BRING OUTSIDE AIR TO 75° F



at the design pressure. Usually, this will cover all situations, but like any rule of thumb, there may be instances where this doesn't work out, particularly where higher design pressures result in small traps. The trap capacity should be checked at a differential pressure corresponding to the drip leg static height minus the pressure drop through the strainer to insure proper operation at all conditions.

6. ***IMPROPER TYPE OF TRAP IS USED*** - Traps other than F & T traps may either not discharge sufficient quantities of air or may require more pressure to operate, thus causing slow condensate discharge.

7. ***IMPROPER STRAINER OR TRAP MAINTENANCE*** - This can result in plugged screens and orifices, resulting in slow drainage.

It is important to note that slow condensate discharge can cause a problem other than freezing. When condensate mixes with air admitted by the vacuum breaker the condensate becomes corrosive. If it is allowed to flood a portion of the coil, tube corrosion will take place. Many steam coils fail due to corrosion in the lower regions of the return header or lower tubes.

IN SUMMARY

Installations using coils to heat outside air using modulated steam require special consideration in cold climates. Note that in addition to the above recommendations, there are control options such as freeze protection thermostats which can be used to provide further protection against freezing.