AIR INTAKE FILTER RECYCLES WASTE HEAT TO PREVENT WWTP EQUIPMENT FROM FREEZING

By **Rob Geyer**

Just as winter always arrives, intake filters for blowers and compressors always have the potential to freeze in cold, humid climates. In nearly all of Canada, filter freezing and early morning high differential pressure alarms can be a fact of life for plant operators.

Cold is not necessarily a problem for intake filters, and cold weather alone does not cause filter freezing. The cause of those early morning alarms is that the filter element is suddenly clogged with a high volume of particulate in the form of frozen water vapour. This combination of low temperature and atmospherically available water vapour, in the form of freezing steam, mist, falling snow or sleet, produces sudden high volumes of now solid particulate. When the filter "freezes," it is not failing, but rather functioning, preventing unwanted particulate from entering an equipment inlet.

In addition to freezing vapour, falling snow or sleet, a third filter freezing condition is possible, even if the temperatures are above freezing. At 1°C or 2°C, for example, the very action of air rushing through a filter medium can create an evaporative cooling effect, resulting in frost build up on a filter element. In other words, the machine inlet creates its own frozen water vapour and ice. The higher the inlet air velocity, the more likely the problem becomes.

A wastewater treatment plant provides all the necessary ingredients for intake filter freezing. These include high volume inlet air requirements for aeration blowers and a continuous source of humidity, whether from the adjacent body of water (usually a river), or from the aeration basins themselves. These do not freeze, so create steam all winter.

As the mercury approaches and drops below freezing, condensate rising from the aeration basins crystalizes into ice. The blowers draw this ice into the filters, which increases restriction just the same as if the filter were drawing in dust.

Endustra Filter Manufacturers designed its Tri-Vent® intake filter with the series DK discharge-air knife, to recycle waste heat to discourage filter freezing.

According to Robert Geyer, company president, older filter designs were more prone to freezing. "We first encountered freezing issues with panel (rectangular) filters," he says. The industry standard at one time was cellulose, or needle felt polyester filter elements, and filter face velocities were often 75 to 120 metres/minute. Initial restrictions on these traditional filter designs were in excess of 3" WG (747 Pa) or higher.

Increased velocities resulted in greater suction. When snow or ice was falling, the stronger suction would pull in the dense particulate, and when an evaporative cooling condition existed, frost would build up quickly. Amplifying the problem was the fact that the filters operated at higher restriction levels, making the systems more sensitive to the impact of sudden differential pressure spikes due to a cold snap or snowstorm. Finally, the cellulose media of the era absorbed moisture and the polyester entrained moisture, so the filters could literally freeze.

The Tri-Vent® Series TM09 with freeze discouragement discharge-air knife was designed to use waste heat generated by air compression.

In the early 2000s, Endustra Tri-Vent intake filters addressed the deficiencies of legacy designs by operating at low initial restrictions and slower face velocities, often less than 1/2" WG (125 Pa) and 15 metres/minute. A further advantage of the improved design was proprietary hydrophobic filter media, which created an inherently freeze-resistant filter.

In one plant in Soldonta, Alaska, where average snowfalls exceed 80" and average high temperatures are below freezing

nearly half the year, "freeze resistant" is not enough. During a blower upgrade project, plant operators learned that Endustra offered a freeze discouragement system that did not require additional power and did not negatively impact blower performance. They decided to upgrade intake filters as part of their redesign, and they selected the Tri-Vent ® Series DK in a top-outlet filter design.

The Series DK functions by taking advantage of the physics of air compression. Air compression by 5 KPa blowers commonly used in wastewater treatment plants typically increases air temperatures, between 20°C and 90°C This temperature rise, in most applications, is a useless or often undesirable byproduct of air compression. In many situations, the heat must be removed from compressed air to make it usable for a process. When repurposed to discourage filter freezing, however, the hot discharge air effectively keeps blowers running in harsh weather conditions.

Two schools of thought govern discharge freeze discouragement: volume and pressure. The volume theory holds that 8 – 10% of the total volume of discharge air be redirected to mix with inlet air and bring that inlet air temperature above the freezing point. This method is expensive, not only because a higher volume blower costs more money, but also because the oversizing compromises the energy savings potential inherent in the turndown capacities of modern high-speed machines.

The pressure theory does not require a larger blower. Instead, this method of freeze discouragement works similarly to the way a car's window defroster operates. Waste heat is routed from the blower discharge and conducted in directed jets of air, only when and where required, and the system operates quietly.

In the case of the Series DK, the total percentage of output air requirement is less than 1 – 2% of the total blower volume, and this volume is further reduced by automated controls which monitor environmental conditions and anticipate freezes, regardless of cause, proactively discouraging the natural consequences only when required, and only using as much discharge air as required.

"Air compression by the 5 KPa blowers commonly used in wastewater treatment plants typically increases air temperatures 20 – 90 degrees Celsius.

The operating logic is simple. When the permissible condition of ambient cold temperatures is registered (2°C or less depending on altitude), the controls monitor filter differential pressures. In a properly configured Tri-Vent filter system, it takes a year or more for element differential pressure to increase 1500 – 2000 Pa above the starting point.

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With an average daily increase of less than 5 Pa, if during cold temperature the differential pressure spikes by more than 50 Pa in less than hour, the controls begin to modulate the discharge valve. The valve opens only as much as necessary, until differential pressures begin to decrease, and then gradually closes when differential pressures begin to approach those of the starting point.

So, not only does the discharge knife system use only 1 – 2% of the total blower output, discharge air is used only when necessary.

James Trissel, Soldonta Utility Department Manager, reported that freezing issues, which once happened "all the time" haven't happened once since startup. Instead of early morning alarms, the filters "take care of themselves."

The plant utilizes covered aeration basins, and the nearby river eventually freezes over. This means that for much of the winter, there is no rising steam to freeze. Continual regular snowfall, however, routinely caused filter problems during the long, cold winters.

The DK system uses the same logic to prevent all freezing, but another attribute of the system is that discharge air warms the annular air knife in the filter inlet. As the tubular air knife heats, a portion of the radiant heat transfers from the warm metal to the cold inlet air, and any contact snow melts instantly. This radiant transfer is insufficient to melt all the incoming snow, but it will assist the de-frosting action of the air-knife jets.

Interestingly, the air knife does not need to melt or dissuade all the ice or snow on/in a filter. The discharge air only needs to melt a usable portion of the filter media until weather conditions improve. The filter medium does not absorb or entrain water, and the filter element itself doesn't freeze. Therefore, once the snow stops falling and the air knife melts what remains, the filter element returns to normal operating conditions, and at this point the valve automatically closes. This intermittent control system keeps operation costs low and maximizes filter element life in adverse climates.

The Series DK freeze discouragement system provides an economical solution to a persistent application challenge. It is available on all Tri-Vent filter arrangements, for connections as large as 48". A single control panel can operate up to six blowers with individual filters, or supply discharge air to one filter from multiple blowers in a common header configuration. ■

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