REGULATOR FREEZING

Date: May 2003

This information has been provided through Fisher Regulators

Contact person: Jim Reynolds
jim.reynolds@experitec.com

TECHNICAL BRIEF

Experitec

MAKING PLANTS SMARTER.

Experitec, Inc.

504 Trade Center Boulevard
Chesterfield, MO 63005
636.681.1500

FISHER

Highlights

- **Areas of freezing**
- **How to reducing freezing problems**

REGULATOR FREEZING

Freezing has been a problem since the birth of the gas industry. This problem will likely continue, but there are ways to minimize the effects of the phenomenon.

There are two areas of freezing:

- The first is the formation of ice from water traveling within the gas stream. Ice will form when temperatures drop below 32 degrees F (0 degrees C).
- The second is hydrate formation. Hydrates are a frozen mixture of water and hydrocarbons. This bonding of water around the hydrocarbon molecule forms a compound, which can freeze above 32 degrees F (0 degrees C). Hydrates can be found in pipelines that are saturated with water vapor. It is also common to have hydrate formation in natural gas of high BTU content. Hydrate formation is dependent upon operating conditions and gas composition.

Reducing Freezing Problems:

To minimize problems, we have several options:

- Keep the fluid temperature above the freezing point by applying heat.
- Feed an antifreeze solution into the flow stream.
- Select equipment that is designed to be ice-free in the regions where there are moving parts.
- Design systems that minimize freezing effects.
- Remove water from the flow stream.

Heat the gas:

Obviously, warm water does not freeze. What we have to know is when heat is needed and then apply the heat.

Gas temperature is reduced whenever pressure is reduced. This temperature drop is about 1 degree F for each 15 Psi (1 bar) pressure drop. Calculating the temperature drop and subtracting from the initial temperature can identify potential problems. Usually ground temperature, about 50 degrees F (10 deg C)is the initial temperature. If a pressure reducing station dropped the pressure from 400 to 250 Psig (27 to 17 bar) and the initial temperature of 50 deg F (10 deg C) the final temperature would be 40 deg F (5 deg C).

$$50\text{ F} - (400\text{-}250\text{ psi})\ (1\text{ deg F} / 15\text{ psi}) = 40\text{ F}$$
$$10\text{ C} - (27\text{-}17\text{ bar})\ (1\text{ deg C} / 1\text{ bar}) = 5\text{ C}$$

In this case, a freezing problem is not expected. However, if the final pressure was 25 psi (3 bar) instead of 250 psi (27 bar), the final temperature would be 25 deg F (-2 deg C). We should expect freezing in this example if there is any moisture in the gas stream.

We can heat the entire gas stream with line heaters where the situation warrants. However, this does involve some large equipment and considerable fuel requirements.

Many types of large heaters are on the market today. Some involve boilers that heat a water / glycol solution which is circulated through a heat exchanger in the main gas line. Two important considerations are:

- Fuel efficiencies
- Noise generation

In many cases, it is more practical to build a box around the pressure-reducing regulator and install a small catalytic heater to warm the regulator. When pilot operated regulators are used, we may find that the ice passes through the main regulator without difficulty but plugs the small ports in the pilot. A small heater can be used to heat the supply gas or the pilot itself. A word of caution is appropriate. When a heater remains in use when it is not needed, it can overheat the rubber parts of the regulator. They are usually designed for 180 deg F (82 deg C) maximum. Using an automatic temperature control thermostat can prevent overheating.

Antifreeze Solution:

An antifreeze solution can be introduced into the flow stream where it will combine with the water. The mixture can pass through the pressure reducing station without freezing. The antifreeze is dripped into the pipeline from a pressurized reservoir through a needle valve. This system is quite effective if one remembers to replenish the reservoir. There is a system that allows the pressure regulator between the reservoir and the pipeline with the control line of the small regulator connected downstream of the pressure reducing regulator in the pipeline. The small regulator is set at a lower pressure than the regulator in the pipeline. When the controlled pressure is normal, the small regulator remains closed and conserves the antifreeze. When ice begins to block the regulator in the pipeline, downstream pressure will fall below the set point of the small regulator, which causes it to open, admitting antifreeze into the pipeline as it is needed. When the ice is removed, the downstream pressure returns to normal and the small regulator closes until the ice begins to reform. This system is quite reliable as long as the supply of antifreeze solution is maintained. It is usually used at low volume pressure reducing stations.

Equipment Selection:

We can select equipment that is somewhat tolerant of freezing if we know how ice forms in a pressure-reducing regulator. Since the pressure drop occurs at the orifice, this is the spot where we might expect ice formation. However, this is not necessarily the case. Metal regulator bodies are good heat conductors. As a result, the pressure drop cools the body, not just the port. The moisture in the incoming gas strikes the cooled surface as it enters the body and freezes to the body wall before it reaches the orifice. If the valve plug is located upstream of the orifice, there is a good chance that it will become trapped in the ice and remain in the last position. This ice often contains wormholes, which allows gas to continue to flow. In this case, the regulator will be unable to control downstream pressure when the load changes. If the valve plug is located downstream of the port, it is operating in an area that is frequently ice free. It must be recognized that any regulator can be disabled by ice if there is sufficient moisture in the flow stream.

System Design:

We can arrange station piping to reduce freezing if we know when to expect it. Many have noted that there are few reported instances of freezing when the weather is very cold. (0 deg F (-18 C)).

They have observed that most freezing occurs when the atmospheric temperature is between 35 and 45 degrees F (2 and 7 degrees C). When the atmospheric temperature is quite low, the moisture within the gas stream freezes to the pipe wall before it reaches the pressure-reducing valve, which leaves only dry gas to pass through the valve. We can take advantage of this concept by increasing the amount of piping that is exposed above ground upstream of the pressure-reducing valve. This will assure ample opportunity for the moisture to contact the pipe wall and freeze.

Jim Reynolds has over 33 years of experience in process instrumentation, control valves, regulator technologies. He has been a part of the Experitec team for over 29 years and has developed significant depth of knowledge in the application and use of gas regulators. Jim has received numerous awards and recognition for his technical abilities and his attention to customer service. Jim was the 2000 Experitec President's award winner for technical and service excellence.

When the atmospheric temperature raises enough to melt the ice from the pipe wall, it is found that the operating conditions are not favorable to ice formation in the pressure-reducing valve. There may be sufficient solar heat gain to warm the regulator body or lower flow rates that reduces the refrigeration effect of the pressure drop. Parallel pressure reducing valves make a practical anti-freeze system for low flow stations such as farm taps. The two parallel regulators are set at slightly different pressures (maybe one at 50 psig and the other one at 60 psig). The flow will automatically go through the regulator with the higher set point. When this regulator freezes closed, the pressure will drop and the second regulator will open and carry the load. Since most freezing instances occur when the atmospheric temperature is between 35 degrees and 45 degrees F we expect the ice in the first regulator to begin thawing as soon as the flow stops. When the ice melts from the first regulator it will resume flowing gas. These two regulators will continue to alternate between flowing and freezing until the atmospheric temperature decreases to increases which will get the equipment out of the ice formation temperature range.

Water Removal:

Removing the moisture from the flow stream solves the problem of freezing. However, this can be a difficult task. Where moisture is a significant problem, it may be beneficial to use a method of dehydration. Dehydration is a process that removes the water from the gas stream. Effective dehydration removes enough water to prevent reaching the dew point at the lowest temperature and highest pressure.

Two common methods of dehydration involve glycol absorption and desiccants. The glycol absorption process requires the gas stream to pass through glycol inside a contactor. Water vapor is absorbed by the glycol, which, in turn, is passed through a regenerator that removes the water by distillation. The glycol is reused after being stripped of the water. The glycol system is continuous and fairly low in cost. It is important however, that glycol is not pushed downstream with the dried gas.

The second method, solid absorption or desiccant has the ability to produce much drier gas than glycol absorption. The solid process has the gas stream passing through a tower filled with desiccant. The water vapor clings to the desiccant until it reaches saturation. Regeneration of the desiccant is done by passing hot gas through the tower to dry the absorption medium. After cooling, the system is ready to perform again. This is more of a batch process and will require two or more towers to keep a continuous flow of dry gas. The desiccant system is more expensive to install and operate than the glycol units.

Most pipeline gas does not have water content high enough to require these measures. Sometimes a desiccant dryer is installed in the pilot gas supply lines of a pilot operated regulator is quite effective. This is primarily true where water is present on an occasional basis.

Summary

It is ideal to design a pressure reducing station that will never freeze, but anyone who has spent time working on this problem will acknowledge that no system is foolproof. We can design systems that minimize the freezing potential by being aware of the conditions that favor freezing.