FREEZE PROTECTION FOR NATURAL GAS PIPELINE SYSTEMS AND MEASUREMENT INSTRUMENTATION

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Introduction

The failure to supply natural gas upon demand can cause irreparable damage to a company's corporate image in the 21st Century. Consistent and continuous pipeline operations are key and critical factors in today's natural gas pipeline industry. The competitive nature of the business, together with the strict rules and regulations of natural gas supply, mandate that companies stay on top of all operational parameters that could cause interruption or complete shut-down of the natural gas supply to customers. Identifying what may ultimately cause problems is a first step to controlling and eliminating those problems for the supplier.

The natural phenomenon of freezing is a common occurrence in the operation of a natural gas pipeline system. Whether the gas is "produced gas" from a crude oil well, or "natural gas" from a gas well, the possibility for hydrates and the resultant problems, is real. Freezing is a potential and serious problem starting at the production wellhead through the last point in the customer delivery system. The occurrence of freezing is continuously reduced each step of the way, but care must be taken at each and every step to assure smooth operational conditions and satisfied consumers at the end of the line.

Freezing not only affects the pipeline itself but is also a significant contributor to measurement errors and to instrumentation upsets or failures. All of these potential issues will ultimately affect the overall pipeline operation and may have a major impact on the profitability of your company. The relatively small cost of prevention will produce large dividends from a successful and uninterrupted natural gas supply.

Each situation differs from location to location. For this reason, there are several methods to combat freezing in the total spectrum of the natural gas industry.

The Problem

In searching for potential freezing problems the operator should be aware of the quality of gas, the composition of the gas, piping designs, regulation or restriction points, instrument take-off points and similar pipeline operation features that can and will impact the occurrence of freezing.

Production and gathering systems are typically laden with water vapor thus increasing the likelihood of freezing problems. Transmission lines should be less likely to be affected by freezing since the gas has typically been through a treatment facility and a majority of the liquids have been removed. Typical water allowance is 7 lbs. per million Std. Cu. Ft., (roughly 1 US Gallon) which is considered to be relatively dry gas. Within the normal Local Distribution Company (LDC), the problems associated with freezing SHOULD be almost non-existent. However, price and demand of natural gas can also have an overriding effect on the presence of liquids in the pipeline, as was experienced in 2001 and 2002 in many regions of the United States.

Hydrates can also form into "balls of ice" at temperatures well above freezing. Hydrate crystallization can occur with H2O and hydrocarbons at 60° F and cause damage or completely seal off pipeline flow. This natural phenomenon is unrelated to "freezing" as we know it, but can be addressed in the same manner as standard freezing problems.

There are several points to remember when discussing freezing and they are discussed in the GAS ENGINEERS HANDBOOK, Section 4, Chapter 8, "Gas Hydrates and Gas Dehydration." Two major ones to keep in mind are:

- High BTU Gas is more likely to produce hydrates and freezing problems.
- Joule-Thomson rule of temperature effect as a result of pressure reduction. Temperature will decrease approximately 7 degrees Fahrenheit for every 100 psi pressure reduction.

In a practical case you can have gas flowing in the pipeline at 60 degrees Fahrenheit and 700 psi and have no evidence of freezing. If you pass through a regulator station and cut the pressure to 225 psi, the flowing temperature at the point of regulation will drop 33 degrees Fahrenheit to approximately 27 degrees Fahrenheit. If the gas stream is saturated with water vapor and condensate, you will quickly experience the freezing concerns we are discussing. The gas stream is the same, but conditions have changed and your problems have commenced to affect your operations.

The presence of ice or hydrates can not only shut off the pipeline, but can also alter measurement. If ice forms on the rim of the orifice plate, the flow measurement will be in error as a result of the reduced orifice diameter. If ice forms in the instrumentation supply lines, controllers will cease to function causing a loss of control of the system. Ice can block off sensing ports and other vital instrument readings. Once the ice begins to thaw, problems are still going to be present.

On the initial start-up of a new or cold well, probes, thermal wells, intrusive instruments and orifice plates should have been removed from the pipeline. Large balls of ice traveling down the pipeline can do physical damage to the pipeline itself and to any object protruding into the pipeline such as sample probes, temperature probes, meters, orifice plates and similar intrusive devices**.** After the flowing stream has stabilized and temperature conditions are above the hydrate point, these items can be safely installed.

Simply stated, the presence of ice or hydrates in a natural gas pipeline system provides no foreseeable benefit to the operations of your company.

Solution

In order to correct freezing problems that occur under differing operational conditions, solutions must be designed for the particular needs of the location where the problem exists. Each solution may have specific advantages and disadvantages for the operator. The single most important aspect for any methodology is consistent operation and maintenance with the chosen approach to the freezing problem.

There are several options for the prevention of freezing problems:

1. **Water removal from the gas stream by glycol dehydration**

   One of the most common methods of dehydration for large volumes of gas is glycol absorption. Gas passes through the glycol inside a vessel called a contactor. The object is to remove the water to a point where the water vapor dew point of the gas will not be attained at the highest pressure and lowest temperature of the pipeline system. The glycol absorbs water and is then treated by circulating the glycol to a regenerator and distilling the water out of the glycol. The reconditioned glycol is returned to the contractor and the procedure is repeated. This process can reduce the water dew point to 60-70 degrees Fahrenheit.

   Colder climates frequently dictate a dehydration system in a natural gas system, but even warmer climates may require central dehydration due to pressure, temperature and gas composition. A producer can basically look at three dehydration options.

   1. Partial dehydration at the well head and later additional steps to meet contract specifications.
   2. Chemical injection at the well head with later dehydration at the central delivery point.
   3. Full and complete dehydration at each and every well head.

   This system is a low cost system with continuous operation and minimal pressure loss across the unit, thus making it a money saver in several areas of operation. The drawbacks can be glycol carry-over during surges, contamination by solid particles and inefficiency during fluctuating flow rates.

2. **Water removal by solid absorption**

   A very efficient method of water removal is the dry bed or molecular sieve method. The gas is passed through large towers of solid particles and the molecular sieve absorbs the water very aggressively. Very dry gas over a wide range of flow rates can be attained by this method. Eventually, the sieve becomes saturated and must be regenerated. The stream must be switched to a second tower and hot gas is introduced to the original unit to evaporate the water and dry the sieve.
   Cool gas is then used to cool the desiccant and the tower is ready for re-use. This cycle is repeated until the desiccant has degenerated and is no longer effective. While this method produces very dry gas and has several positive operating characteristics, it is more costly than typical glycol systems and more complex to operate.

3. **Methanol Injection to prevent freezing**

   Methanol (an anti-freeze type solution) injection is a very common practice for freeze protection for smaller systems and specific locations. The methanol is injected into the gas stream by chemical injection pumps or enters the pipeline by methanol drips and effectively lowers the freeze point of the gas. The amounts of methanol required can be calculated by using available tables for specific applications.

A small volume methanol tower can also be fabricated allowing small volumes of gas to pass through the methanol for treatment. Because of the sensitive nature of many pneumatic controllers, this method is occasionally used to prevent freeze-ups in these devices and to prevent liquid migration into small orifices and passages. An additional filter is often used to ensure that the methanol is not carried over into the instrumentation.

4. Heat Application for freeze protection

Heat is a logical solution to freezing problems. It is also a costly approach to the problem for several reasons. Obviously, if the gas is never allowed to reach freezing temperatures, ice cannot form and will not be present. The water will likely not be removed, which remains an issue for operations and contracts, but the freezing is eliminated. The problems with heat are that it is expensive equipment to install, it requires additional fuel (energy and revenue) to produce the heat, and the heat will not remain effective as it travels down the pipeline and away from the heat source.

Heat is also a potential hazard as it can provide an ignition point for the gas. Safety and special emphasis on proper application is a must when using a heat source. The most common application of heat for freeze protection is in a specific and direct situation, as in the case of a regulator valve body. The pressure drop at the regulator is the only problem point and therefore, can be the only specific location where freeze protection is required.
There are multiple ways to apply heat from heating blankets, to catalytic heaters, to fuel line heaters, or in some cases, steam systems where they are properly designed, installed and maintained. Heat systems can be very effective for a localized freezing problem.

5. Practical considerations for freeze protection

During the design phase of the piping system and through to the instrumentation system, certain steps can be taken to reduce the negative effects of freezing problems. Piping configurations that would allow for liquid accumulation should be avoided if at all possible. Drainage should slope towards drain fittings located at low spots. Where possible, use ball valves and large diameter, (1/2” for ½” taps) tubing for instrument feed lines and sensing lines. Avoid restrictions where flow will occur. Tubing runs should slope back toward the pipeline and you should have a leak free instrument system. Liquids, if they are present, will be drawn towards the leak. If you avoid creating traps and liquid drop out areas, your freezing problems will be minimized.

6. Drip pots, coalescers and automatic liquid dumps can reduce freezing problems on instrumentation

Occasional slugs of liquid can damage or even “shut in” many instrument supply systems. Where this slug potential exists or in cases where liquid is a severe problem in the gas supply used for instrumentation, drip pots and coalescers can effectively knockout or reduce the water and condensate in a small volume instrument supply system. If the problem is excessive, an automatic liquid dump designed for instrumentation can be extremely helpful. Whereas the drip pot requires routine manual draining, the automatic liquid dump will act as a drip pot collection vessel with a coalescer and as a result of an internal float assembly and pivot valve, will automatically release the collected liquid to a lower pressure point.

7. Instrument filters designed for freeze protection to control equipment

Many instrument controllers and other sensitive measurement equipment powered by instrument gas supply need the highest level of clean and dry instrument supply that is attainable. In some cases a good linear polyethylene filter can provide adequate protection. But the most common solution for instrument supply gas is the filter dryer.
These units are designed for high pressure applications with removable media cartridges. While various types of media are available from molecular sieve to special H2S removal media, most are equipped with a combination desiccant and charcoal filter cartridge. Coupled with providing extremely dry and fresh gas, the ancillary filtration elements in the cartridge provide for 2-4 micron protection as well. For critical locations, these dryers can be manifolded with offset regulators to provide uninterrupted service. If one side of the

system shuts in due to freezing, the other side takes over the supply while the original inlet side thaws out. The filter dryer can be equipped with "tattle-tale eyes" that indicate saturation of the desiccant and the need for a cartridge replacement. These systems are designed for maximum protection with typical flow rates of around 60-70 cfm. Where a failure in instrument supply would create severe problems, this style dehydration assembly is an ironclad solution for continuous service.

Recently, several manufacturers have combined regulation, filtration, heat and manifold convenience into multi-pressure, single stand alone Instrument Tower Package Systems for the more complex instrument supply needs. They are primarily designed for pneumatic controllers and process control instrumentation systems but can be utilized in many areas that require a clean, dry, regulated and uninterrupted gas or instrument air supply.

Conclusion

Natural gas systems, from mainstream pipeline flow to low pressure instrumentation, are subject to freezing conditions. Through careful planning and evaluation of your specific application, proper selection of available options, and a good routine maintenance program, this industry wide concern can be controlled and minimized. If these issues are ignored, the cost of dealing with the aftermath is almost always more expensive than the preventative action that could have been taken. Avoidance of freezing problems is a good investment and adds to the profitability of your company.

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