Filter out the problem

David Taylor, CECO Environmental, USA, discusses the importance of collaboration between pipeline operators and filtration system designers when faced with unexpected changes in gas quality.

There are over 300 000 miles of gas transmission pipeline in the US today. The vast majority of these pipelines are medium to large-diameter, ranging from 10 - 48 in., and conveying gas typically at pressures of between 500 - 1400 psig in volumes of billions of ft^3/d. As natural gas progressively replaces coal as the preferred fuel for electricity generating plants nationwide, and also becomes a major export commodity in the form of liquefied natural gas (LNG), this national pipeline grid has never been more important.

Like any vital technology, large-diameter, long-distance gas pipelines have their issues. The gas entering these pipelines from processing plants is mostly free of the contaminants that it contained as 'raw' gas from the wellhead. Valuable hydrocarbons have been extracted as NGLs or liquefied petroleum gas, then the gas is dehydrated and cleansed of sulfur compounds like the highly toxic and corrosive hydrogen sulfide that otherwise 'sours' the gas. Nevertheless, while considered essentially clean and dry, the gas transmitted via interstate and intrastate lines is by no means pristine. Given the large quantities and enormous volumes of gas moving through these lines daily, impurities are bound to be part of the stream. Over time, these impurities accumulate in

the line and can degrade performance of or damage critical infrastructure. The most common contaminants are fine solid particles (mainly iron oxides and iron sulfides, collectively known as black powder); paraffin wax; and water, sometimes mixed with unextracted hydrocarbons. Liquids are particularly problematic as they can accumulate in low points of pipelines, resulting in 'terrain slugging'. Colder seasonal temperatures can cause liquids to condense in the pipeline until, driven by gas pressure, they move through the line as 'slugs' of liquid which can damage equipment simply through physical impact.

Solutions for decontamination

Fortunately, there is a wide range of solutions available for extracting these contaminants from large-diameter gas pipelines. Filter-separators move the gas through cylindrical filter elements that capture most of the solids and liquids, and then through a vane mist extractor that catches and drains off the remaining liquid. The vanes are closely spaced, curved or zigzagging plates that are arrayed vertically, on which fine droplets form a film which is then carried out of the gas stream by gravity within sheltered pockets. Filter-separators are most useful for gas streams that contain a combination of liquid and solid particle contamination, and require a high removal efficiency of very small particles (<5 µm).

Figure 1. Slug-catching multi-cyclone separator designed for 2500 psig, including a lower barrel flushing system to purge separated pipeline solids.

Figure 2. Peerless vertical gas coalescer designed with multiple stages of internals to maximise the filter element operating life and assure fine particle filtration below 0.3 µm.

Vanes are also a crucial part of other separator types, especially for gas streams with a high percentage of liquid contaminants. Vertical gas separators can handle high gas volumes and are effective at capturing and draining large liquid slugs. Gas and liquid entering the vessel are diverted by an inlet baffle to diffuse the slugs and remove bulk liquids, which fall to the vessel's bottom sump. The gas and the remaining mist enter a vane separator, where the mist is removed.

Also suitable for decontaminating high-volume gas is another separator type that relies on centrifugal force as well as gravity: the multi-cyclone separator (Figure 1). In these devices, the gas is introduced into a circular array or 'bundle' of cyclones or swirl tubes. These internals force the gas, which is still under high pressure, to spin in a tight spiral pattern. Solids and liquids in the gas are thrown against the inner wall by centrifugal force, carried downward by gravity, and collected in the lower section of the vessel. The scrubbed gas then exits the separator.

Peerless, an 85-year-old company that is now a division of CECO Environmental, has developed and refined versions of all these separator types. Recently, the company was called in to solve a gas quality problem for the operator of a major LNG export facility in the southern US. Since inception, for almost a decade, the facility had been using Peerless ULTRA filter-separators to clean the gas coming from the feed pipeline before measurement and custody turnover. The pipeline entering the plant was large-bore (30 in. diameter) carrying over 1 billion ft^3/d of gas at 700 psi. For years, the line downstream from the separators had been delivering clean, dry gas of consistent quality.

In 2019, however, engineers at the plant began noticing several operational issues. The gas was dirtier, requiring more frequent filter changes in the filter-separators. Operations staff were also seeing higher flow from the drain system, pressure-drop spikes, and intermittent downstream liquid carryover, which indicated incoming slugs. The gas reaching the plant, in short, no longer met the required quality specification. These changes also affected measurement of delivery volume, which is crucial in contractual relations between plant operators and the gas suppliers. The operator turned to Peerless, as supplier of the original filtration equipment, for a solution. Peerless is known for designing separators to meet very specific conditions, and clearly these process conditions had changed.

The source of the problems was quickly established. The pipe into the plant was now fed by several new lines, bringing gas of varying quality over substantial distances from different areas of the US. Specialists in the industry are familiar with the types of issues that can crop up in large-diameter, large-volume gas transport lines over dozens or hundreds of miles. One of the most prevalent is water accumulating in dips and then being driven through the line by the compressors, forming slugs that can overwhelm and even damage the filtration and measurement systems. This was likely the central issue affecting the ULTRA filter-separator and therefore the feed gas quality at the plant. Slugs like these negatively affect compressors and meters in the line when filtration systems

become overloaded, increasing the frequency of maintenance cycles and resultant facility downtime.

Solving the problem

How could these quality variances in the incoming gas feed pipelines be managed? After reviewing the available measurement data with their colleagues at the pipeline operator, the engineering team from Peerless used multi-phase flow analysis software to model the existing facility and several options to resolve the problem. Retrofitting of the ULTRA filter-separators to handle the slugs and suspended particulates was not feasible because of the need for continual gas flow to the LNG plant. The team concluded that what was needed was an additional device upstream of the original ULTRA filter-separators that was robust enough to handle slugs, aerosols, and solids while requiring minimal or zero maintenance.

The solution the team arrived at was to install two Peerless slug-catching multi-cyclone separators on the feeder lines upstream of the ULTRA filter-separators. The multi-cyclones are designed to handle intermittent liquid slugs and to separate liquids and solids (both wet and dry contaminants) effectively. Output from the cyclones will contain less than 0.1 gal. of entrained liquid per million ft^3 of gas. The cyclones also capture solid particles (>85% of 3 µm particles to 100% of all particles more than 8 µm in diameter).

Each vessel's storage capacity is large enough to accept seasonal fluctuations in feed volume, and is also able to accommodate new pipeline connections as the operator acquires new sources of gas. Finally, and crucially, the cyclone separators are 'solid state', requiring no filter replacements and also have no moving parts, meaning that no maintenance is needed other than assuring the drains remain functional. This can considerably lower the overall cost of ownership for the plant operator since the original ULTRA filter-separators will experience less solids loading, which results in a longer operating time between filter element changes. Gas quality measurements downstream of the ULTRAs are now back within specification, and there is a steady flow of clean, dry gas into the liquefaction facility.

Conclusion

In summary, an effective diagnosis and cure of operating challenges requires close collaboration between the pipeline operator and the designer of the filtration system. In this case, Peerless was able to present multiple options for consideration, ranging from a retrofit modification of the internals within the existing filter-separator, to the addition of new equipment to augment the performance of the system by adding slug handling capability to a facility that was originally designed for a steady flow of dispersed pipeline contaminants.

Similar applications may arise whenever new gas supply pipelines are connected, or when natural gas production facilities introduce larger amounts of liquids into the pipeline as water cut changes, especially from hydraulic fracturing or enhanced recovery production sites. As pipeline operators acquire new facilities through consolidation, similar process performance challenges will surely arise. Developing the appropriate solution requires a balanced assessment of multiple factors including system downtime and multi-phase flow analysis to design new systems with the capability to ensure safe, clean, and reliable operations.