PRINCIPLES OF ODORIZATION

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What Is Odorization?

Odorization is the process of adding odorant to natural gas so that its presence can be detected by people. Pipeline quality natural gas public does not possess a particularly strong, distinctive odor of its own, so a powerful odorant is added to make it clearly identifiable by the public in the event of a leak.

Why Do We Odorize?

In 1937 the town of New London, Texas experienced a horrific tragedy. A newly constructed school exploded due to a natural gas leak that had not been detected, and 311 people were killed – the majority of which were children. No one was aware of the leak because of the lack of a distinctive odor. The resulting worldwide media coverage led to a search for a means to clearly identify leaks well before they became dangerous.

How Do we Odorize?

Federal code CRF Title 49 Section 192.625 states “A combustible gas in a distribution line must contain a natural odorant or be odorized so that at a concentration in air of 1/5 (20%) of the lower explosive limit, the gas is readily detectable by a person with a normal sense of smell.”

Natural gas has a lower explosive limit of 5% in air, therefore the concentration of odorant must be high enough to be readily detected at 1% in air (1/5 of 5%).

Additionally, the code states that “Equipment for odorization must introduce the odorant without wide variations in the level of odorant”.

What Is Odorant?

Odorants used in natural gas and LPG are typically thiols, which are organic compounds with sulfur atoms and have a strong distinctive odor.

In the US, mercaptans are predominantly used, with tertiary butyl mercaptan TBM) as the primary constitutent. Tetrahydrothiphene is used to a lesser extent in the US but is more broadly used elsewhere in the world. Finally, ethyl mercaptan is used to odorize LPG.

Odorants used in the gas industry are very powerful – typically detectable at around 1 PPB in the air. They are highly flammable, non-toxic to mammals, but they are toxic to aquatic life.

How Much Odorant Is Used?

In the US, where TBM blends are primarily in use, odorization rates typically fall between 0.5 to 1.0 lbs / MMSCF of natural gas. This is a generalization, and there are users that inject at rates outside this range. THT is typically used at a higher range of 1.0-1.5 lbs /MMSCF.

It is also important to mention that the laws do not specify injection rates – they specify that it must be readily detectable at 1% in air.

Odor Fade And Masking

The reason that injection rates are not specified are the phenomena known as odor fade and odor masking.

Odor masking refers to a condition in which there are other chemicals present in the pipe or in the gas that have the effect of reducing a person's ability to smell the odorant regardless even when the odorant level is the same as was injected by the odorizer.

Odor fade is a term used to refer to odor rates at various locations in a pipeline or distribution network that is meaningfully lower than the rate at which it was injected by the odorizer. It can occur for a variety of reasons, from odorant interacting with steel pipe, to liquids present in the line, flow rates, etc.

Both of these have the end effect of a reduction in the ability to readily detect odorant even though the odorization injection equipment is working correctly.

Thinking about it from a customer's point of view, it just doesn't matter what the levels are, what matters is whether the customer can smell it well before it's dangerous!

Pickling

The odor fade that is due to a chemical interaction between the odorant and steel can be countered by precondition the pipe prior to being placed into service. This process is commonly referred to as "pickling." Essentially by forcing the chemical interactions to take place before delivering gas to customers, the odor loss is negated when placed in actual service. The details of this process are beyond the scope of this paper.

Methods Of Odorization

Over the years a number of different solutions for introducing odorant into natural gas have been developed. There are four primary types of odorizers in use today: wick, passive bypass, pump, and pumpless.

Wick odorizers operate much like an oil lamp in that a wick extends with one end in the natural gas stream and the other in a container of liquid odorant. As the gas flows over the wick, the odorant evaporates into the gas stream and is replenished by the odorant traveling up into the wick. These are often called farm tap odorizers due to their origins. They are typically only well suited for very low flow rates.

Passive bypass odorizers operate by redirecting a portion of the natural gas stream into an odorant tank and back into the pipe. The gas picks up odorant vapors as it passes through the tank. The vaporization rate of odorant varies with pressure and temperature, making it more difficult to control.

Pump and pumpless odorizers are "smart" odorizers. These odorizers use the flow rate of the gas to determine the correct amount of odorant to inject – proportional to flow. They have a means of measuring the amount of odorant actually injected and of alarming if it goes out of range or if there is some other functional issue with the odorizer.

Pump odorizers have a physical pump of varying designs that are either pneumatically or electrically actuated. As the volume per stroke is fixed, the proportion to flow is maintained by adjusting how often the pump strokes.

Pumpless odorizers operate by utlizing differential pressure instead of a pump. A gas source with higher pressure than the pipeline is required to move odorant into the pipe. There are pumpless odorizers for injecting odorant vapors, and for injecting liquid odorant.

Secondary Containment

All odorization systems should have a secondary containment in place to prevent costly environmental cleanup. Due to the concerns of odorant entering waterways, cleanup of spills can be very expensive.

Most odorizer manufacturers offer a skid with secondary containment integrated to the system. Occasionally end users will use an earthen berm or concrete containment, but because these are porous, they will absorb odorant and may have to be removed and/or rebuilt in the event of a spill.

Natural Hazards

Since odorant is stored in the tank under pressure, any rupture to the tank or tubing can cause a large amount of odorant to spill. Even the smallest leak can disturb neighboring areas. While the secondary containment will control the spill, the odor will propagate via wind currents to nearby areas.

For this reason, it is important to be aware of the likelihood of any sort of natural disasters causing problems. Even windblown debris could cause damage that would be disruptive.

Equipment Protection

It is important then to make sure that equipment is protected both from natural and man-made accidents. Consider that a truck on the property could bump into tubing or drive over the top of buried tubing.

When tubing is buried, it is preferable to place it in a secondary, non-conductive conduit. When tubing is routed above ground, it should be fully supported and protected by permanent structures.

Placing the odorizer inside a building adds additional protection against the elements, both for the odorizer and for workers.

Sensitive Areas

Although locating an odorizer in a remote site is ideal, that is not always possible. Be aware of nearby sensitive facilities and prevailing wind direction.

Odorizers will have to be serviced from time to time and that service often involves exposing odorant to the air. Hospitals, schools, churches, are all sensitive facilities that would generate unpleasant public relations if their operations are disrupted due to false gas leak alarms.

When servicing an odorizer, attempt to minimize fugitive smells, keeping in mind that a person becomes “nose-blind” to the smell of odorant fairly rapidly when working with it.

Supporting Technologies

In addition to the odorization system itself, there are numerous supporting technologies to assist in proper odorization and minimizing fugitive odors.

Odor detectors (sniff testers) are designed to make it simple to determine whether the level of odorant in the gas is at a safe level. The machine mixes natural gas with air and an operator literally sniffs it to determine the point at which it becomes “readily detectable.” If that level is less than 1% (1/5 of the LEL), then it meets the requirements.

Odorant measurement devices range from in situ odorant samplers to handheld sensors to stain tubes and can achieve a fairly accurate reading on the concentration of odorant in the gas. Note that this is not a replacement for conducting a sniff test.

Filtration devices are important and perhaps underappreciated components in a system. Liquid filters keep the odorant clean and free of debris so it doesn't cause issues with the odorizer. Gas filters do the same for incoming gas. Passive exhaust filters prevent fugitive smells from being emitted from odorizers that have gas emissions. There are also powered filters for preventing fugitive odors when performing odorizer service. It is important to regularly service these filters for optimum performance.

Spill kits allow for rapid response and odor mitigation in the event of a spill of any size. Several vendors offer pre-assembled kits, and a utility could easily assemble their own. Having one on every odorizer site is highly recommended in order to minimize risk of disruption to nearby infrastructure.

Odorant flares allow an operator to flare off the blanket gas on an odorant tank or a small section of line prior to servicing. By burning the odorant-laden gas, the smell is eliminated in a safe manner.

Lastly, there are odorant masking agents and odorant neutralizers. Masking agents cover up the smell of odorant to make it less obnoxious. Neutralizing agents actually break down the chemical structures to completely kill the odor.

Conclusion

Odorization is a niche in the gas industry that is critical for public safety. There are many different aspects to consider over the life of an odorizer, and education on each of these topics is important to ensure a safe supply of gas.