OVERVIEW OF ODORIZATION SYSTEMS

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Introduction

Odorization of natural gas is one of the most important aspects of delivering gas to customers in a distribution system. It is a requirement that is mandated by the Federal Government ever since the tragic death of students and teachers in a school house in New London, Texas in 1937. Technology, along with innovations to odorization techniques, has advanced rapidly in the last fifteen years, making odorization more reliable.

The purpose of this paper will be to present a number of items that are important to the proper odorization of natural gas in order to meet the requirements outlined in the ***Code of Federal Regulations Title 49 Part 192.625.***

What is Important

These are the items that will be presented in this paper.

- Odorant Tank Calculations
- Odorant Selection
- Odorant Systems
- Example of an Odorant Injection System
- Example of an Odorant Pulse System
- Importance of PLC in Odorization
- Methods of Odorant Detection
- Documentation
- Conclusion

Odorant Tank Calculations

When looking at new or existing odorization systems, one of the first considerations must be given to how large an odorant tank will be needed in order to meet the flowing gas conditions at the site. Most companies try to fill an odorant storage tank once per year. If odorant usage is high, tanks may be refilled two, three or sometimes four times per year. Odorant tanks are generally outdoors, but many tanks, especially used for pulse odorization systems, are located in a building that is partially heated. Site location, accessibility to the odorant tank, building code restrictions are among the few considerations given to selecting a tank size. Tanks must be ASME Code Certified for stationary applications and DOT Code Certified for transportable applications.

Factors used in tank size calculations:

- Gas flow in mmscf/ hour
- Odorant injection rate in pounds/ mmscf
- Hours per day: 24
- Days per year: 365
- Odorant density: density of liquid or average weight at 60 degrees F, always stated in pounds/gallon. Note: Each blend of odorant has a slightly different average weight (lbs) per gallon.

Example of Tank Size Calculation Formula:

1. Gas flow (mcf/hour) X 24 hours X Injection rate required / 1,000,000 = pounds per day usage.
2. Pounds per day / 6.76 (pounds per gallon of odorant density of a certain odorant blend).

Example:

- 2,000,000 cfh X 24 = 48,000,000 cfh X .75 (lb/mmcf) =36,000,000 / 1,000,000 = 36 lb/day / 6.76 = 5.3 gal / day.
- Annual daily usage = 365 days X 5.3 gallons per day = 1,935 gallons per year used.
- Recommended tank size would be around 2,322 gallons (1935 X 1.20 expansion factor).

Odorant Selection

Odorant selection is dependent on several factors at the specific site location. Local knowledge of the gas condition, such as moisture content, CO2 levels, natural mercaptans, H2S and total sulfur will adversely affect the desired odorant levels in a pipeline. Another words, is odorant going into dry clean gas, or is the gas stream saturated with moisture or other known undesirables? Does the gas stream contain propane or propane-air? An entire section could be devoted to this topic, but for the sake of this paper it is sufficient to note that your selection of one of the listed odorant blends should be discussed with the chemical manufacturer. Generally speaking, once a company selects an odorant blend, that blend will be used at numerous delivery points throughout the odorization stations.

Various odorant manufacturers have different product names, symbols or alpha-numeric numbers for the variety of odorants that they blend. Each blend is tested according to numerous test standards. Each blend has specifications and characteristics such as: average weight or density, sulfur content, specific gravity, vapor pressure and others , just to name a few.

Listed below are the various odorant blends manufactured, which when combined with other blends at a specified percentage, offering a wide variety of odorant selection for a specific site location.

- Isopropyl Mercaptan (***IPM***)
- Normal Propyl Mercaptan (***NPM***)
- Tertiary Butyl Mercaptan (***TBM***)
- Secondary Butyl Mercaptan (***SBM***)
- Dimethyl Sulfide (***DMS***)
- Methyl Ethyl Sulfide (***MES***)
- Tetrahydrothiophene (Thiophane) (***THT***)

Combining one or more of the seven listed blends with an exact blend composition (% by weight) gives the company a " best blend " for the known unodorized gas conditions at the site as well as the type of odorant system being used. As an example, when injecting liquid odorant into the pipeline an odorant blend of 80% TBM and 20% MES or 50% TBM and 50% THT is commonly used. When vaporizing odorant into a pipeline any blend ***without THT (Thiophane)*** such as 75% TBM and 25% DMS should be considered. This may be due to the much lower vapor pressure of THT as compared to other odorant blends or compounds that have 5 or 10 times more vapor pressure than THT.

Perhaps the most significant factor in using any odorant blend in any injection system selected is the impact of the temperature on odorant. Temperature changes affects odorant levels in tanks and liquid level gauges. Observations of odorant tanks and sight glasses when temperatures drop indicate odorant levels are lower. When temperatures rise, it appears that odorant levels get higher in the same sight glass when temperatures were colder. This odorant characteristic has very insignificant impact on the actual odorant rate going into the pipeline. It should also be noted that when the temperature of odorant rises, it wants to vaporize at lot quicker. Suffice it to say that choosing the most suitable odorant blend for the type of odorant injection/vaporization system being used is very important.

Types of Systems in Service

There are two generally accepted methods to introduce odorant into a flowing gas stream.

- Chemical Injection
- Chemical Absorption

The chemical injection system is often done by a pump or drip method that takes a certain odorant blend and known volume of liquid odorant and gets the liquid into the pipeline. The pumping system is designed to overcome higher pipeline pressures than the actual pneumatic pressure applied to the pump. Injection systems are typically used in high gas volume applications where there is no pressure drop at the injection site and odorant requirements may vary from one-quarter pound per mmcfh to 8-10 pounds per mmcfh.

All chemical injection systems must be done in a manner that the expected odorant rate, as an example, of ¾ lbs/

mmcfh is proportional to flow rates. This simply means that given the entire different pipeline flowing conditions, the gas must have a consistent smell that ***must be readily detectable at one fifth of the lower explosive limit or 1% gas in the presence of air.*** The lower explosive limit for natural gas in a mixture with air is approximately 5% (1/5 X 5% = 1%)

The second method of odorant injection is done by chemical absorption. The simplest form of this type of system is a wick system. In this type of system, there is an odorant tank with a long wick in it. The system is placed in the flowing gas stream and the wick provides the source of the odorant as the gas stream passes by it. There is a needle valve placed on the flow that goes by the wick to increase or decrease the concentration of the gas going past the wick. These systems are used in low flow applications with generally odorant tanks that are below grade or tanks that range in size from 1 gallon to 60 gallons.

The other chemical absorption system is a pulse bypass system, which will be explained in more detail under the Elements of a Pulse System. Essentially it has either a horizontal or vertical odorant tank that is not completely filled with odorant. This open space or commonly referred to head space in the top of a liquid tank is the area where the unodorized gas enters into the tank and rapidly absorbs the odorant vapors coming from the liquid odorant that has a high propensity to vaporize. These concentrated odorant vapors get pushed out of the liquid tank into the pipeline as a saturated gas odorant, very similar to when you push your finger on top of an aerosol can filled with fragrant air freshener.

System Design Considerations

The attached exhibit lists the necessary information required to design a new odorant injection or odorant bypass system. From the completion of this form, a determination can be made as to the necessary tank size. Each system needs some common elements such as: a meter signal; maximum, minimum and average gas flows; odorant blend; pipeline site conditions (upstream and downstream pressure, gas temperature at the site, available site voltage, PLC options, need for case enclosure heaters and size of NPT pipeline connections).

Once the information is completed on the design specification sheet, a recommendation can be made to available features of an injection or bypass system. Each odorant system is designed to be site specific.

Elements of an Injection System

Once a desired odorant rate has been established and a range of flowing conditions provided, the basic system components of an injection system will consist of the following items.

- ASME Certified Odorant Tank.
- Small tubing connection from tank to liquid filter. Filter catches any scale particles from odorant tank to pump.
- Odorant pump.
- Odorant Positive Displacement (PD) Meter.
- Solenoid valves, regulators, relief valves and check valves.
- Manual Pneumatic timer in case of power failure at site.
- Liquid sight flow assembly with probe just before odorant gets put into the pipeline.
- Small tubing connection from outlet of PD meter to pipeline connection.
- Diffusing probe inside pipeline to prevent dripping of odorant into pipeline.
- Reliable PLC that makes the system work automatically and sends out alarms for any malfunctions.

The injection system components like the pump, PD meter, solenoids, regulators, relief valves, and timer are mounted in a cabinet. An exhibit of this cabinet can be seen below.

Elements of a Pulse System

Similarly, once odorant rate, range of flowing conditions are provided, ***along with a significant pressure drop at the site,*** the basic system components of a bypass system will consist of the following items.

- ASME Certified Odorant Tank with specific pressure ratings and containment pan.
- Electronic or manual odorant tank level device.
- Filter/Dryer canister to remove any moisture of incoming gas into the system.
- Dual solenoid valve section. One for primary working solenoid and one solenoid as a backup in the event the working solenoid fails.
- Appropriate check valves on odorant tank.
- High pressure regulator and relief valve.
- Volume tank bottle.
- Emergency by-pass assembly in the event of a power failure at the site.
- High Flow switch.
- Reliable PLC that makes the system work automatically and send out alarms for any malfunctions.

The mechanical components like, regulators. Reliefs, solenoids, flow switch and emergency bypass assemblies are mounted in a Nema 4 enclosure. The PLC and system wiring are mounted in a separate cabinet. An exhibit of this cabinet can be seen below.

A pulse bypass system is used very often when there is pressure drop at the odorant site. A pressure drop is important because the saturated odorant vapors are coming from the odorant tank must be aerated into the pipeline by a slightly higher pressure than the actual pipeline pressure. An example would be if the pipeline pressure is 150 psig then the aerated pressure would be about 185 psig going into the line.

Pulse bypass systems are most often used in locations where any type of odorant smell cannot be tolerated due to being too close to a hospital, school, nursing home, factory or residential property. Malfunctioning odorant pumps or vent gas is not an option at these sites and causes excessive leak calls to gas companies when no leaks are present due to vapors coming from liquid odorant. In a pulse bypass system there are no liquids to deal with. Only liquids are in the odorant tank. All system components have unodorized gas passing through regulators, solenoids and a flow switch. There is only one outlet check valve from the odorant tank that has odorized gas before it enters the pipeline.

Role of Programmable Logic Controller (PLC)

The controller is an all-in-one operator control station. Properly programmed, it allows the operator to view existing and past conditions at the site location via a touch pad screen. There is an integrated micro SD (up to 2 GB) card for history and alarm logging, which can be exported to a PC in CSV format or for installing program upgrades. There is remote software for the controller to control and view the system status and setup for use with a personal computer. The PLC does history logging of gas flow, odorant usage, injection rate and odorant tank level for up to 600 records of a user definable time period (1 to 65,535 hours per record) with additional logging capabilities to a micro SD card. Alarms are logged from up to 428 alarms with additional logging capabilities to the SD card. Another great feature of the PLC is that the history log and alarms log are viewable from the controller touch pad display or via a personal computer that has software installed. The PLC has all information and programs stored in non-volatile memory. It has a general alarm digital output with additional digital and analog Input/Output information available for specific customization. The power requirements that include the PLC are 120 to 240 VAC. There are two 12 volt batteries that are used for backup to run the PLC and related components for about 2 days without external power. The controller can be set up to receive Modbus RTU slave mode information that is available from the local display but can be set up for Modbus ASCII slave monitoring upon request. There are additional PLC/Drive protocols that are also available. The controller has two configurable RS-232/Rs-485 communication ports as standard equipment. Finally, the PLC can support cellular modem, spread spectrum radio and Ethernet.

The same PLC receives data at a location, tells solenoids, valves and or pumps when, how often and how long to provide odorant into the pipeline. When properly programmed, the same PLC is the brains behind an injection or pulse bypass system.

Methods of Detection

After odorant has been put into the pipeline, the odorant level should be tested to verify that the amount of odorant is near or exactly matched to the intended level. Another word, if ¾ pounds per MMCFH is injected into the pipeline will a technician get this reading at the begging, middle and end of the pipeline where the odorant has been injected?

From a practical sense, a person should be able to readily detect the presence of natural gas at one-fifth the explosive limit with a normal sense of smell. The service person will need to take an actual sample of the gas, smell it and determine if the sample has a smell similar to rotten eggs. Generally, there are company guidelines for the procedure that are written from technical guidelines published by an appropriate State Public Service or Utility Commission. These, often called, Technical Standards will specify who, what when and where odorant concentration checks should be performed. Many companies rely on the use of gas detector tubes to evaluate concentration levels, but a more exact reading comes from lab calibrated instruments.

From a more technical perspective, there are instruments available that many companies use to determine odorant concentration levels. These units must be tested periodically to verify the accuracy of the equipment. The principal behind each unit is to blend air and gas through a sensing chamber. The air is drawn in through each unit and mixed with gas. With higher concentration of natural gas flowing through the sensing units, a reading is taken to determine the amount of odorant in natural gas. These reading are either in pounds per million cubic feet or parts per million.

There are three portable test instruments most commonly used to detect odorant levels and one fixed test unit to detect odorant levels. The first of three portable units is the DTEX unit made by YZ Systems, The Odormeter made by Bacharach and the Heath Odorator made by Heath. The fixed unit is an electro-chemical cell made by OdoeEyes Technologies. Technical information on how each system works can be obtained from each manufacturer. One technical reference that offers guidelines on where and how to take proper test readings can be found in an ASTM D 6273 Publication, called the Standard Test Methods for Natural gas Odor Intensity.

Documentation

Documentation can be done on basic systems that have little or no audit information. A technician makes periodic visits and gets and records odorant levels according to some specific company procedure or policy. Systems that have controllers that perform audit and alarm logging can retrieve a variety of information from the odorizer at the site. Such information will include: accumulated flow data, amount of odorant used, injection rate of odorant, date and time of any malfunctions of equipment at the site, date and time of any alarms logged on the controller.

Whether a basic or smart controller is used at the odorant site, written or computer based documentation of important information on odorant levels is mandatory.

Conclusion

This paper is intended to shed light on items, equipment and procedures that are important to odorizing natural gas, which, when received from producers or transmission companies has no smell to it. Once an odorization system is chosen, company personnel must be trained on how to maintain, troubleshoot and properly record data from equipment at the odorization site and throughout the entire distribution system. The safety of everyone is at stake when natural gas is odorized.

References

Code of Federal Regulations, Title 49 Part 192.625.

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