Tank Blanketing Helps Keep Hydrocarbon Processing Facilities Safe

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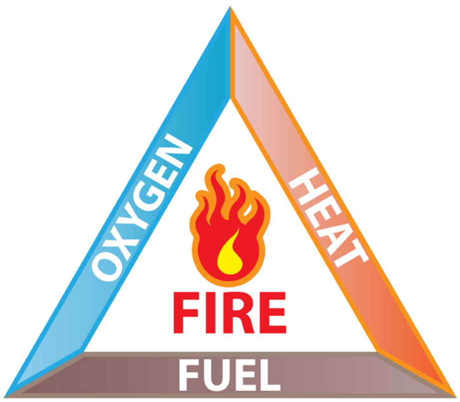
Hydrocarbon processing facilities derive materials that are often flammable and hazardous from petroleum, natural gas, and coal. Hydrocarbons are used for applications such as fuels, electrical power generation, heating, and raw materials. A technique called "chemical tank blanketing," or "padding" applies nitrogen to prevent the materials from catching fire or exploding as well as protect them against contamination, degradation or chemical change. The technique offers several different supply options. A newer approach, which is typically more cost effective for most applications, is that of generating nitrogen on-demand in the plant itself. Before discussing on-demand nitrogen generation, it is first helpful to understand more about chemical blanketing in general.

Blanketing Basics and Benefits

Process control managers often overlook the potential for chemical tank blanketing to improve facility productivity and safety. In tank blanketing, a low-pressure flow of nitrogen gas (typically less than a few psig) with purities of between 95% to 99.9% is introduced above the liquid level of the material or chemical to fill the vapor space at the top of the tank with a dry, inert gas. On closed tanks, this creates a slight positive pressure in the tank. Nitrogen is the most commonly used gas because it is widely available and relatively inexpensive, but other gases such as carbon dioxide or argon are sometimes employed. However, carbon dioxide is more reactive than nitrogen and argon is about ten times more expensive.

Chemical blanketing prevents combustible, flammable or explosive materials from coming into contact with the oxygen in the air, and thereby creates a nonflammable environment. The explanation of this effect is simple. A fire requires three elements (often depicted with the common "fire triangle" illustration): fuel, oxygen and an ignition source such as static electricity or



The "fire triangle" show the three elements needed for a fire to occur.

a spark. All it takes to eliminate the possibility of fire is to remove one of the elements. In considering the fire triangle, note that even when chemical storage tanks are electrically grounded, static changes can always occur. And the very material the tank holds can itself act as a fuel. Therefore, oxygen is typically the only part of the fire triangle that can be controlled.

Maintaining the nitrogen blanket or "pad" also helps prevent the ingression of ambient air (which contains water vapor and oxygen) and therefore eliminates oxidative degradation of the hydrocarbon product, giving them a longer product life.

Considerations for Tank Blanketing Systems

There are several ways a storage tank can be made inert. One way is by reducing the oxygen content in the vapor space to a value less than the minimum concentration that supports combustion, or the limiting oxygen concentration (LOC) value. A tank can also be made inert by reducing the fuel concentration in the headspace to a value less than the minimum concentration that supports combustion, or the lower explosive limit (LEL), or lower flammability limit, value. Finally, a storage tank can be made inert by increasing the fuel concentration in the headspace to a value greater than the maximum concentration that supports combustion, or the upper explosive limit (UEL), or upper flammability limit, value. A material's flammability envelope is bounded by its LEL, UEL and LOC. Material values can be found in material safety data sheets, the National Fire Protection Association's NFPA 69: Standard on Explosion Prevention Systems and chemistry handbooks.

How nitrogen is controlled in tank blanketing applications usually depends on the type of tank used. Typically, tanks with fixed roofs and unsealed tanks are blanketed while tanks with floating roofs are not blanketed. Nitrogen control methods include continuous purge, pressure control and concentration control. Continuous purge provides a constant flow of nitrogen and is probably the easiest method because a control device is not required. However, nitrogen consumption is high. A sealed tank for pressure control blanketing includes a tank blanketing valve that allows the addition of nitrogen when the liquid level drops as well as a vent that vents nitrogen when the liquid level rises. A tank equipped with concentration control blanketing uses a feedback loop from an oxygen analyzer back to the nitrogen generator that tells the generator to cycle on or off. This method economizes the use of nitrogen because it shuts down the nitrogen supply until enough outside air infiltrates to raise the concentration of oxygen above the acceptable limit.

Nitrogen Supply Options

Nitrogen makes up about 78% of the air we breathe and there are several ways to obtain a supply of the gas. Options include receiving nitrogen as a gas in large cylinders; as a liquid in micro-bulk tanks, large tanks or dewars; generated on site by cryogenic plants; or generated on-demand in the facility itself.

Bulk tanks containing liquid nitrogen are typically between 3000 gallon and 11,000 gallon in size. The cost of nitrogen to the end user depends on so-called "vaporization units" that relate to how much of the gas a company purchases annually. As of this writing, gas costs range from $0.30 to $0.70 per 100 cubic feet. Dewars are high-pressure tanks that hold between 3600 cubic feet to 4000 cubic feet of gas. The average cost to the user here is $0.80 to $0.90 per 100 cubic foot.

Cylinders, which hold about 240 cubic feet of gas at an average cost of $1.30 per 100 cubic feet, are the most expensive option. Cylinders can work well for low-flow applications but they can present safety issues because should a cylinder be dropped, the canister can literally turn into a dangerous projectile. Cryogenic plants are rarely used, and then only by the largest of chemical processing facilities.

Because relying on outside supplies can pose problems such as long-term purchase commitments, inflexible delivery schedules, supplier price increases and long procurement processes that result in delays and potential outages, the on-demand method of in-house gas generation can make sense for many applications. At $0.15 or less per 100 cubic feet, it also represents the most cost effective method.

On-Demand Nitrogen Generators

Parker Balston on-demand nitrogen generators, for example, are free standing, housed in a cabinet or skid mounted, depending on the application. Users need only connect a standard compressed air line to the inlet of the generator and connect the outlet to the nitrogen line. Standard features include high efficiency coalescing prefilters with automatic drains and sterile grade afterfilters.

There are two on-demand technologies: membrane gas generators and pressure swing adsorption (PSA) generators. The choice of generator largely depends on the purity of nitrogen needed for the chemical being blanketed. Typically, applications such as fire prevention need nitrogen of 95% to 98% purities and can use membrane generators. Applications such as the blanketing of oxygen sensitive compounds, specialty chemicals and pharmaceuticals need a high purity stream and require the use of PSA generators.

Parker membrane generators separate compressed air into two streams: One stream is 95% to 98% or higher pure nitrogen while the other stream contains the separated oxygen, carbon dioxide, water vapor and other gases.

As an example of how membrane nitrogen generators work, the Parker Balston membrane nitrogen generators use a proprietary hollow fiber membrane technology that separates the compressed air into two streams. One stream is 95% to 98% or higher pure nitrogen while the other stream contains the separated oxygen, carbon dioxide, water vapor and other gases. The generator separates the compressed air into component gasses by passing the air through semipermeable membranes consisting of bundles of hollow fibers. Each fiber has a circular cross section and a uniform bore through its center. Compressed air is introduced into the bore of the membrane fibers at one end of the membrane module. Oxygen, water vapor and other gases permeate the membrane fiber wall and are discharged through a permeate port at low pressure, while the nitrogen is contained within the membrane and flows through the outlet port at operating pressure. The nitrogen gas steam is very dry, with dewpoints of at least -58 degrees F (50 degrees C). Membrane nitrogen generators need no electricity to generate nitrogen so they can be used in Class One explosion-proof environments without any concerns.

On the other hand, PSA systems are for applications needing a high purity stream. A Parker PSA generator uses high efficiency prefiltration to remove all contaminant from the compressed air stream down to 0.01 micron. The filters are followed by dual beds filled with Carbon Molecular Sieve (CMS). In one bed at operating pressure,

A pressure swing adsorption (PSA) generator such as the Twin Tower Gas Generator produces up to 99.99% pure, compressed nitrogen at dewpoints to -58 degrees F (-50 degrees C).

the CMS absorbs oxygen, carbon dioxide and water vapor. The other bed operating at low pressure releases the captured oxygen, carbon dioxide and water. Cycling the pressures in the CMS beds causes all contaminants to be captured and released, while letting the nitrogen pass through. A final sterile grade filter assures removal of any microbial contamination. Users can easily set purities with a flow control valve. The DB-30 nitrogen system, for example, produces a flow of nitrogen as great as 1530 standard ft^3 at 99.9% purity. The unit can achieve higher flow rates if gas of less purity is acceptable and lower flow rates is gas of higher purity is desired. A built in oxygen monitor measures the oxygen concentration of the nitrogen stream. The system requires a minimum feed pressure of 110 psi and can operate at pressures up to 140 psi. The resulting nitrogen has a dewpoint as low as -40 degrees F (-40 degrees C).

Conclusion

Compared to other supply methods, on-demand nitrogen generators provide significant benefits by increasing the safety of handling the gas. Both membrane and PSA units produce nitrogen at precise purities, flow rates and pressures. In addition to providing a significant cost savings, nitrogen generation in-house represents a sustainable approach to the supply of nitrogen. Gas industry sources indicate that an air separation plant uses 1976 kJ of electricity per kilogram of nitrogen at 99.9%%. On-demand nitrogen generation helps reduce the generation of greenhouse gases. Compared to third party supplied bulk nitrogen, generation of 99.9%%nitrogen in house with a PSA system uses 28% less energy. This means up to 28% fewer greenhouse gases are created by the generation of electricity with a typical nitrogen generator. At a purity of 98%%, the energy required for in-house nitrogen consumes 62% less energy. Therefore, in-house generation creates 62% fewer greenhouse gases from electrical power at that purity.

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How to Size a Tank Blanketing System

When determining the required amount of blanketing gas, it is necessary to consider both the blanketing gas replacement for liquid loss during pump-out and the condensation of tank vapors during atmospheric thermal cooling. The maximum flow rate and desired purity determines the size of the nitrogen generator required. Here are the steps to sizing a blanketing generator:

1. Determine the gas flow rate due to pump-out from the following table:

In Breathing Rate Due to Pump-Out (English)

Multiply Maximum Pump-Out Rate In	By	To Obtain
U.S. GPM	8.021	SCFH air required
U.S. GPH	0.134	SCFH air required
Barrels/hr	5.615	SCFH air required
Barrels/day	0.234	SCFH air required
Liters/min	2.118	SCFH air required
m3/hr	35.30	SCFH air required

In Breathing Rate Due to Pump-Out (Metric)

Multiply Maximum Pump-Out Rate In	By	To Obtain
U.S. GPM	0.215	Nm^3/hr air required
U.S. GPM	0.258	Nm^3/hr air required
Barrels/hr	0.151	Nm^3/hr air required
Barrels/day	0.0063	Nm^3/hr air required
Liters/min	0.057	Nm^3/hr air required

2. Determine the gas flow rate due to atmospheric cooling from the following table:

In Breathing Rate Due to Thermal Cooling

Tank Capacity			In Breathing Air Required	
Barrels	Gallons	[m^3]	SCFH	[Nm^3/hr]
60	2,500	[9.5]	60	[1.6]
100	4,200	[15.9]	100	[2.7]
500	21,000	[79.5]	500	[13.4]
1,000	42,000	[159]	1,000	[26.8]
2,000	84,000	[318]	2,000	[53.6]
3,000	126,000	[477]	3,000	[80.4]
4,000	168,000	[636]	4,000	[107.2]
5,000	210,000	[795]	5,000	[134]
10,000	420,000	[1590]	10,000	[268]
15,000	630,000	[2385]	15,000	[402]
20,000	840,000	[3180]	20,000	[536]
25,000	1,050,000	[3975]	24,000	[643]
30,000	1,260,000	[4770]	28,000	[750]
35,000	1,470,000	[5560]	31,000	[830]
40,000	1,680,000	[6360]	34,000	[911]
45,000	1,890,000	[7150]	37,000	[992]
50,000	2,100,000	[7950]	40,000	[1070]
60,000	2,520,000	[9540]	44,000	[1180]
70,000	2,940,000	[11130]	48,000	[1290]
80,000	3,360,000	[12700]	52,000	[1400]
90,000	3,780,000	[14300]	56,000	[1500]
100,000	4,200,000	[15900]	60,000	[1600]
120,000	5,040,000	[19100]	68,000	[1800]
140,000	5,880,000	[22300]	75,000	[2000]
160,000	6,720,000	[25400]	82,000	[2200]
180,000	7,560,000	[28600]	90,000	[2400]

3. Add the requirements of 1 and 2 to select the appropriately sized nitrogen generator.

Source: Tyco