Nitrogen Blanketing of Edible Oils

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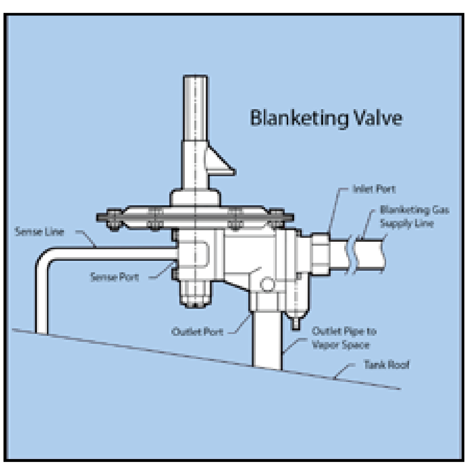
During processing, it may be necessary to store foodstuffs such as edible oils in tanks while awaiting further processing or delivery. Because edible oils are sensitive to spoilage by oxygen in air, any oxygen in the tank must be kept to acceptable levels. In a technique called "tank blanketing," nitrogen is applied to protect the oils against the onset of oxidative rancidity and contamination. The technique is preferred because nitrogen is an inert gas, and, as such, it offers a natural alternative to using chemical additives to prevent rancidity. The process 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 processing facility itself. Before discussing on-demand nitrogen generation, it is first helpful to understand more about tank blanketing in general.



A tank blanketing valve controls the flow rate of nitrogen based on pressure. Source: Protectoseal

Large tanks such as these are used to store edible oils.

Blanketing Basics and Benefits

Process control managers often overlook the potential for chemical tank blanketing to improve facility productivity and product quality. In tank blanketing, a low-pressure flow of nitrogen gas (typically less than a few psig) with purities of between 97% to 99.9% is introduced above the liquid level of the edible oil 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. Maintaining the nitrogen blanket or "pad" helps prevent the ingression of ambient air (which contains water vapor and oxygen) and therefore prevents the onset of oxidative rancidity of the oil. The result is the oil has a longer product life. For example, oxygen and water vapor in air can react with editable oils to eventually form undesirable polymers, acids, aldehydes and ketones. Because nitrogen blanketing removes both oxygen and water vapor from the vessel, it prevents oxidation from ruining the oil.

Considerations for Tank Blanketing Systems

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 and most common 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 source that tells the source 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 or dewars, large outdoor, bulk tanks; generated on site by cryogenic plants; or generated on-demand in the facility itself.

Membrane nitrogen generators use a separation technology made up of polymer fibers that act like a membrane to remove oxygen from a compressed air stream, leaving behind clean, dry nitrogen

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 $1.00 per 100 cubic feet. Dewars are high-pressure tanks that hold between 3600 cubic feet to 4000 cubic feet of gas in a liquid cryogenic state. The average cost to the user here is $0.80 to $1.50 per 100 cubic feet. Cylinders, which hold about 240 cubic feet of gas at an average cost of $10.00-$20.00 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. At $0.15 or less per 100 cubic feet, on-demand nitrogen generators represent the most cost effective method. Relying on outside supplies can pose problems. Long-term purchase commitments, inflexible delivery schedules, supplier price increases and long procurement processes result in delays and potential outages. Therefore, the on-demand method of in-house gas generation can make sense for many applications.

On-Demand Nitrogen Generators

On-demand nitrogen generators are typically free standing, housed in a cabinet or skid mounted, depending on the size of 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 often 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 foodstuffs need a higher purity stream and require the use of PSA generators. 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 99% or higher pure nitrogen while

How to Protect Packaged Foods

In an application closely related to that of tank blanketing, a process called Modified Atmosphere Packaging (MAP), pumps ultra-pure nitrogen and sometimes carbon dioxide as a filler gas into sealed packages of produce and snack food items. Too much oxygen in a package promotes bacterial growth and oxidation, which will compromise product quality and shelf life. Using nitrogen keeps the presence of oxygen at controlled levels, preserving food quality and significantly improving its shelf life. An on-demand nitrogen generator can often be the most effective way to supply the nitrogen.

A similar process is used in wine bottling. Here, a nitrogen blanket reduces the oxygen concentration to less than 0.5%, minimizing contact between oxygen and the wine surface during storage, both pre and post bottling. The process helps preserve the flavor of the wine that can be adversely affected by exposure to oxygen. Nitrogen can also be used to purge air from pipes and hoses prior to bottling and to ensure oxygen is not introduced during transport. Last, sparging with nitrogen is a gentle way to "roll" or mix the storage tanks. Nitrogen removes oxygen introduced during handling, helping to preserve wine integrity. An on-demand nitrogen generator supplies a continuous stream of nitrogen to fill the voids within a package, preserving taste and freshness and extending shelf life.

Snack items such as chips are to be slipped into packages, after which the equipment shoots a stream of carefully controlled amounts of nitrogen into the package to eliminate the possibility of spoilage.

Nitrogen blanketing is being used in the wine bottling process.

the other stream contains the separated oxygen, carbon dioxide, water vapor and other gases. The generator separates the compressedair 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 (see Figure 1). The nitrogen gas steam is very dry, with dewpoints of at least -58°F (50°C). Membrane nitrogen generators need no electricity to generate nitrogen so they can be used in Class One explosion-proof environments without any concerns.

For an example of how a PSA nitrogen generator works, Parker equipment 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, 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 of at least 1530 standard ft^3 at 99.9% purity. The unit can achieve higher flow rates if gas of less purity is acceptable. As flow is reduced purity increases up to 99.999% 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°F (-40°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 fewer greenhouse gases are created by the generation of electricity than 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.

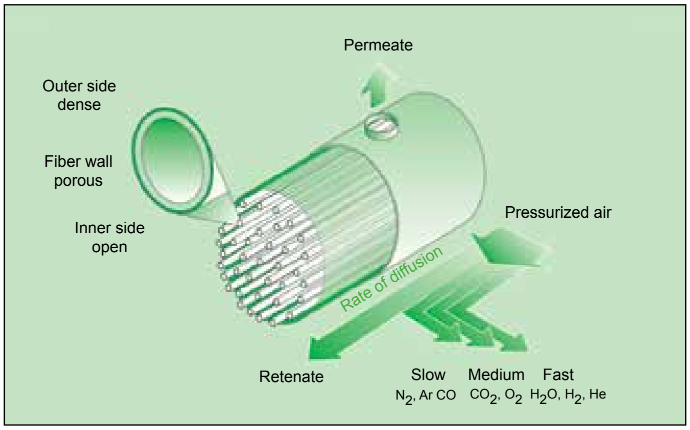


Figure 1 Gas Separation Membrane

Pressure Swing Adsorption (PSA) nitrogen generators use a Carbon Molecular Sieve (CMS) material inside a vessel that contains pressurized air to draw off the nitrogen molecules.

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
m^3/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 Nitrogen 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

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