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PRODUCT QUALITY & PROCESS SAFETY

with Oxygen Analysis and Inert Gas Blanketing

HIGH PERFORMANCE SOLUTIONS FOR OXYGEN ANALYSIS

PRODUCT QUALITY & PROCESS SAFETY

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Inert gas blanketing also known as 'tank blanketing' is a technique that can be used to prevent spoilage in oxygen sensitive products such as food, oils and intermediate products, and to avoid reaching explosive and flammable conditions in a container or process area.

Inert gas blanketing controls oxygen levels through the use of an inert gas. The level of oxygen in the container's head space is measured and when certain conditions are met, - displaces the air surrounding a particular substance being processed by using an inert gas to blanket the vapor space of its container.

Displacing the air eliminates the presence of oxygen (air is made up of 20.9% oxygen) that could be in contact with the vapor phase of the substance being blanketed and also to some extent displaces moisture which could cause spoilage through hydrolytic oxidation. Additionally, by eliminating or decreasing oxygen to a level that cannot support combustion, the risks of flammability are virtually eliminated. Unlike fire suppression or explosion venting systems that operate after the fact, inerting safely protects workers and equipment by preventing combustion before it happens.

So, if you are a process engineer looking for a solution to improve your product quality or a health and safety officer looking to reduce the risk of hazardous, flammable processes, this article is for you.

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Improve Product Quality

When it comes to manufacturing processes within the food and beverage, nutraceutical and pharmaceutical industries, product quality and consistency is essential for customer satisfaction and ultimately your reputation. One process that can greatly affect your product quality is rancidification.

What is Rancidification?

Rancidification is a process caused by oxidation or hydrolysis of fats and oils when exposed to air, water, bacteria or light. The term "rancid" is used to refer to this process and commonly used to denote an unpleasant or undesirable aroma and / or taste in food or beverages. Foods deemed rancid are frequently assumed to be spoiled, or just about to be spoiled and thus rejected by the consumer. Producers of nutraceuticals, such as fish oil capsules for example, go to great lengths to avoid their products from having that rancid smell or taste that may turn consumers away. Even if food has a low level of rancidity and is not really spoiled, consumers will avoid it resulting in lost sales, product returns and a stigma of low quality associated with the brand. The key is then to avoid the conditions that will promote food from becoming rancid.

One technique that is well proven and has been used by a number of manufacturers with great success is inert gas blanketing. Blanketing is used for much more than avoiding rancidity. In fact, inert blanketing has been used anywhere from controlling ripening rates of fruits to preservation during packaging to avoiding edible oils from becoming rancid. Let's look at this latter application in more detail for an example of how this technique can help.

Vegetable or animal derived oils that tend to be liquids at room temperature are unsaturated fats. Without delving too heavily into their chemistry and regardless of whether they are mono-, poly- or trans-fats, unsaturated fats will have double carbon bonds in their molecular make-up. This is important because oils become rancid when certain conditions cause these double bonds to break and thus the oil begins to spoil (see Figure 1).

Double carbon bonds are the weakest links of the molecules and can be broken by oxidation or hydration, in other words, exposure to oxygen or moisture. During normal manufacturing and packaging, foods will be exposed to oxygen and moisture in the air. Providing an inert atmosphere using dry nitrogen, and thus preventing the oxygen and moisture in the air from contacting the oil, will greatly reduce the chances of them becoming rancid. Once the oil becomes rancid the process cannot be reversed and the entire batch has to be disposed of. This is costly not only because of the value of the material lost, but also in labor, testing, quality control, disposal costs and delays in production. Further, avoiding oil from becoming rancid can also help eliminate the potential for substandard products reaching the consumer.
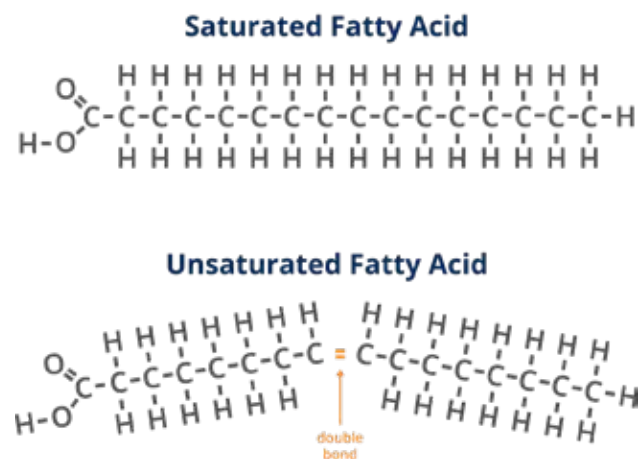

Figure 1: Saturated and Unsaturated fatty acids

Cross Contamination

Another difficulty in handling oils and other foods is not only that they can potentially become rancid, but also that they are typically manufactured in small batches and the containers can be in close proximity of each other. This creates the problem in that potentially strong smelling oils can cross-contaminate milder oils, as for example a fish oil imparting a "fishy" smell to another mild aroma oil. Inert blanketing can be easily adapted to multi-batch operations at relatively low additional cost.

Controlled Oxidation

It should be mentioned also that while inert gas blanketing plays an important role in avoiding rancidity by completely avoiding contact with oxygen and moisture, in some cases, for some food processes, the goal is to control the rate of oxidation and not just eliminate it. Examples would be the beverage industry during fermentation (i.e. wines and beers), cheese manufacturing (ie. Blue cheeses like Roquefort and Gorgonzola) and even in the manufacture of chocolate. However, of the few techniques that can be used to blanket a product, only the Oxygen Measurement and Control technique can effectively control the level of oxygen at any user-set point between 0 and 20.9%. More on the different techniques to control oxygen later.

Combined Product Quality and Process Safety

Blanketing can be used in similar industries for product quality preservation as well as process safety/fire prevention. A good example of this is the growing Cannabidiol oil industry (commonly known as CBD oils) that continues to grow year after year as new uses for these products continue to expand into the health, cosmetic, edible and veterinary areas. There are many types of CBD oil extraction techniques used to separate, or extract, the oil from the raw hemp plant. Once the raw hemp is shredded and pressed, it releases some of its oil, however, much of it still remains in the plant material to be collected.

A solvent is then needed to separate any of the remaining oil still there in order to collect it. Probably one of the most popular solvents used today because of lower price, availability, ability to be recycled and reused, and ease of use is Ethanol which dissolves and mixes well with the oil in the raw material. Once the mixture of CBD oil and Ethanol are removed from the raw processing area, the alcohol needs to be separated or distilled from it. Ethanol is a flammable substance, and when the mixture is heated up the potential for a fire or explosion increases. An effective way to minimize the risk of a fire in this situation is by removing the oxygen present during distillation. This can simply be done by blanketing with an inert gas such as nitrogen removing the oxygen below a level where it no longer poses a risk.

Once the CBD oil is extracted and purified, it needs to be preserved to maintain its quality. Preservation is critically important because of the relative low yields of oil from the raw plant material which makes even small quantities of it very valuable and expensive. Depending on the size of the extraction process, the number of batches and the yield, CBD oil is typically accumulated for a period of time until it is ready to be sold to post-processors who will use it in other industries. Preserving the oil by avoiding oxidation is key to maintaining quality.

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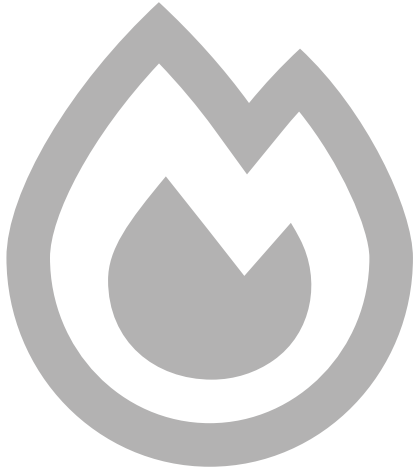
Improve Process Safety with Fire / Explosion Prevention

Chemically, a fire is simply the oxidation of a fuel with an explosion being the oxidation of the fuel at an extremely fast rate. While not all fires will result in explosions, the effects of either can be devastating in terms of injury or death to personnel and destruction of equipment and other property. For the purposes of this article, the reference to fires or explosions is only used when dealing with flammable or combustible materials and does not take into account other causes, as for example, the explosion of a tank or vessel due to hydraulic or pneumatic overpressure.

The Fire Triangle

For a fire to start, three elements must be present. First, some type of fuel must be available. Second, the presence of oxygen to oxidize the fuel. Finally, an ignition source that will kick start the oxidation process in the form of a spark, a heated surface or anything else that can supply the energy to initiate the chemical reaction. These three elements are commonly referred to as the fire triangle (see Figure 2). Since all three elements are needed for a fire, it is only necessary to remove just one of the elements since the other two by themselves will not be able to complete the reaction. Once the fire has started, as long as there is sufficient fuel and oxygen available, the reaction will be self-sufficient and there will be no need for an external heat source (the flames themselves are the heat source). So the idea is to stop a fire before it happens.

A point that must be emphasized is that blanketing works to prevent a hazardous situation from developing, not just to reduce the catastrophic consequences after the operation has had a fire or explosion. There are a number of devices available that help reduce the impacts and spread of a fire
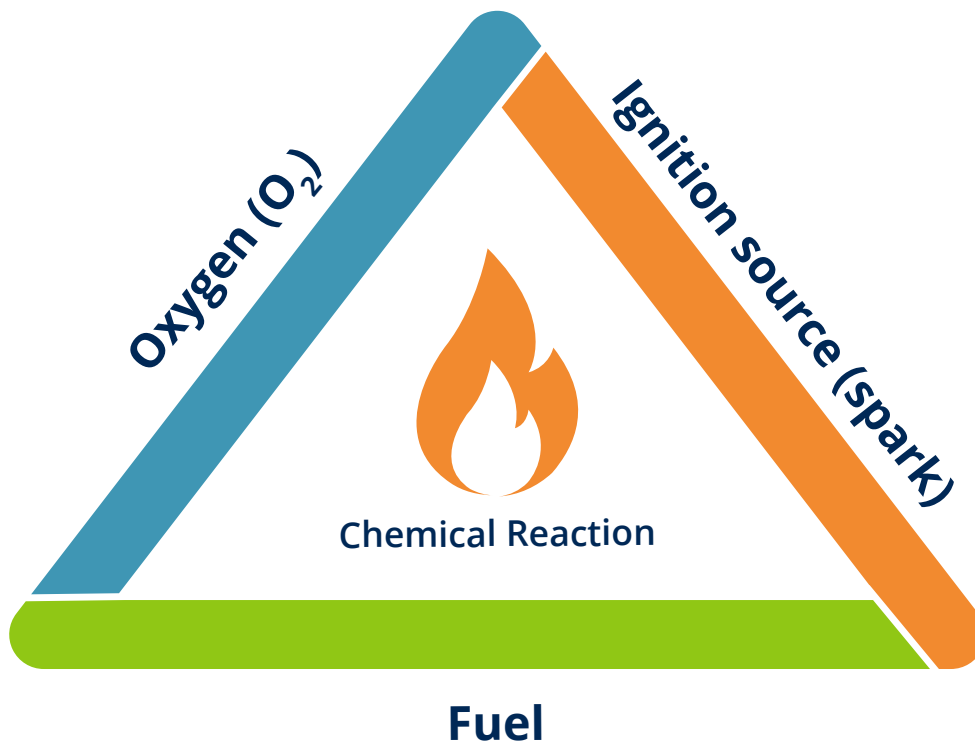
Figure 2: The fire triangle. Depicting the three elements required to start a fire.

or explosion, such as flame arresters, backflow preventers or even sprinklers; however, blanketing works well before that point has been reached adding a layer of safety.

The oxygen and heat portion of the triangle are a constant for manufacturing process; however, the fuel part of the equation would vary depending on the actual process and in some cases, it can be more than one combined. Examples could be industries that deal in the packaging of chemicals such as Acetone, gasoline and Xylene or others that use alcohols like Ethanol for extraction and purification, especially if the alcohol is distilled later using heat.

LFL, UFL and LOC

Even when fuel and oxygen are present, adding an ignition source may not necessarily start a fire. The fuel and oxygen have to be within a certain ratio that is dependent on the type of fuel. The lower flammability limit (LFL) and the upper flammability limit (UFL), sometimes known as the upper and lower explosivity limits (UEL and LEL) indicate the maximum and minimum amounts of fuel that could become flammable in the presence of a normal air atmosphere. LFL and UFL are measured in volume percent of the fuel, typically at 25°C unless otherwise noted. LFL and UFL can be thought of as limit conditions when there is either insufficient fuel for the available oxygen (LFL) or when there is too much fuel for the oxygen present (UFL) for a fire to occur. For example, Butane (C_4H_{10}) has an LFL of 1.8% and a UFL of 8.4%. This means that if there is less than 1.8% of Butane in air, or more than 8.4% of it, it will not burn. Different substances will have different LFL/UFLs, for example, Ammonia's (NH_3) limits are LFL/UFL 15/28%. Most substances have an experimentally determined LFL and UFL and the data is readily publicized. See Table 1 for several examples.

It's important to note that the above LFL and UFL values were determined using normal air oxygen levels (air containing 20.9% oxygen). If an inert gas, such as nitrogen, is introduced then the available oxygen is reduced by means of dilution.

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	Acetone	Ammonia	Butane	Ethane	Ethanol	Gasoline	Hexane	Hydrogen	Methanol	Propane	Toluene	Xylene
LFL	2.6	15.0	1.8	3.0	3.3	1.2	1.2	4.0	6.7	2.1	1.2	1.1
UFL	13.0	28.0	8.4	12.4	19.0	7.1	7.4	75.0	36.0	9.5	7.1	6.6

Table 1: Examples of the upper and lower limits for a few common gases. Concentrations are in percent by vol.

By introducing enough inert gas the oxygen will be forced down to a level where combustion is no longer possible. That point is defined as the limiting oxygen concentration (LOC). It is a measurement of the amount of oxygen below which combustion is not possible regardless of the amount of fuel. If the atmosphere around a potential fuel is kept below the LOC, no flammability is theoretically possible.

What's more, LFL, UFL and LOC are experimentally determined for a binary mixture; therefore, they are not exact and they should not be used to indicate a strict line of demarcation between flammable and non-flammable concentrations in air. In order to avoid risks, safety margins need to be added. The National Fire Protection Association (NFPA) is an international non-profit association that has a number of standard setting committees dedicated to the prevention of fires. In particular NFPA standard 69 sets guidelines for systems designed to prevent fires and explosions in enclosures. NFPA69 sets recommended oxygen levels based on LOC. The standard, which is followed in the US, specifies a requirement to maintain oxygen levels two (2) volume percent below the worst credible LOC for a particular fuel. However, if the LOC is below 5%, it should be no higher than 60% of the LOC. For example, if the LOC of a gas is 12%, then the maximum oxygen content specified by NFPA69 is less than 10%. For a gas with a LOC of 4%, the maximum oxygen level is set at less than 2.4%, or 60% of 4%. The standard also provides different guidelines if oxygen is measured continuously or only periodically. It should also be noted that typical LOC reported values assume nitrogen as the inerting gas. If other gases are used, as for example carbon dioxide (CO_2), or argon (Ar), the LOC values could be different. See Table 2 for some examples.

	Benzene	Butadiene	Cyclopropane	Ethylene	Hexane	Methane	Propane	Hydrogen	Methanol
LOC (N_2/air)	11.2	10.4	11.7	10.0	12.1	12.0	11.5	5.0	10.0
LOC (CO_2/air)	13.9	13.0	13.9	11.7	14.5	14.5	14.5	5.2	12.0
Limits Calculated per NFPA69 (N_2)	9.2	8.4	9.7	8.0	10.1	10.0	9.5	3.0	8.0

Table 2: Examples of some fuels and their LOC in %vol, along with the NFPA69 limit. (adapted from https://www.boconline.co.uk/en/images/Inerting-in-the-chemical-industry_tcm410-166975.pdf, pg. 37)

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Which Inerting Gas is Right for your Process?

Regardless of whether the goal is to preserve quality, increase safety, or both, during manufacturing, the basic process of gas blanketing remains the same, and depends on using a suitable inerting gas to accomplish the task. Typical gases used are nitrogen, carbon dioxide, argon and even steam.

Pure, dry nitrogen is probably the most common gas used for blanketing in inerting systems, but it is certainly not the only one. Other gases also used are carbon dioxide, argon and even steam from water. Carbon dioxide and argon are as effective as nitrogen, but for operations that require large amounts, their cost can be prohibitive, and in the particular case of carbon dioxide, it may present compatibility issues with some of the oxygen sensors.

Water steam is a particularly good gas to use in inerting flammable systems, but has a number of drawbacks that severely limits its usage. Steam is a high pressure, high temperature gas that may not be suitable for a number of containers or products that may need to stay at low pressures and / or room temperature. In addition, steam has a potential to condense and the liquid water could cause rust of internal surfaces, degradation of product or some other undesirable effect. Steam has a niche application in the decommissioning of tanks of flammable substances for example, in which it will not only inert any flammable remnants, but can also clean their internal surfaces.

Nitrogen, due to its extensive availability, relative low cost, inerting properties and the fact it is supplied in a large variety of container sizes, or even generated on-site seems to be the most popular choice.

Blanketing Techniques

There are three main techniques to accomplish blanketing: the pressure method, the timed volume method and the oxygen measurement and control method. Each requires a different set of hardware to accomplish the ultimate goal of reducing oxygen exposure. However, there are significant differences in short and long-term costs and in the reliability and accuracy that can be expected.

Pressure Method (PM)

After a container has been properly purged and its initial oxygen content reduced to the desired set point, by maintaining a positive pressure by means of a pressure regulator on the inerting gas line, any ambient air will be prevented from entering the vessel, thus keeping oxygen levels low (see Figure 3). The concept is that the positive pressure of the inert gas will allow it to leak out preventing the air from leaking in. The pressure regulator in this system will sense the pressure in the container being blanketed and when it falls below a preset level, it will open the valve that admits the inerting gas.
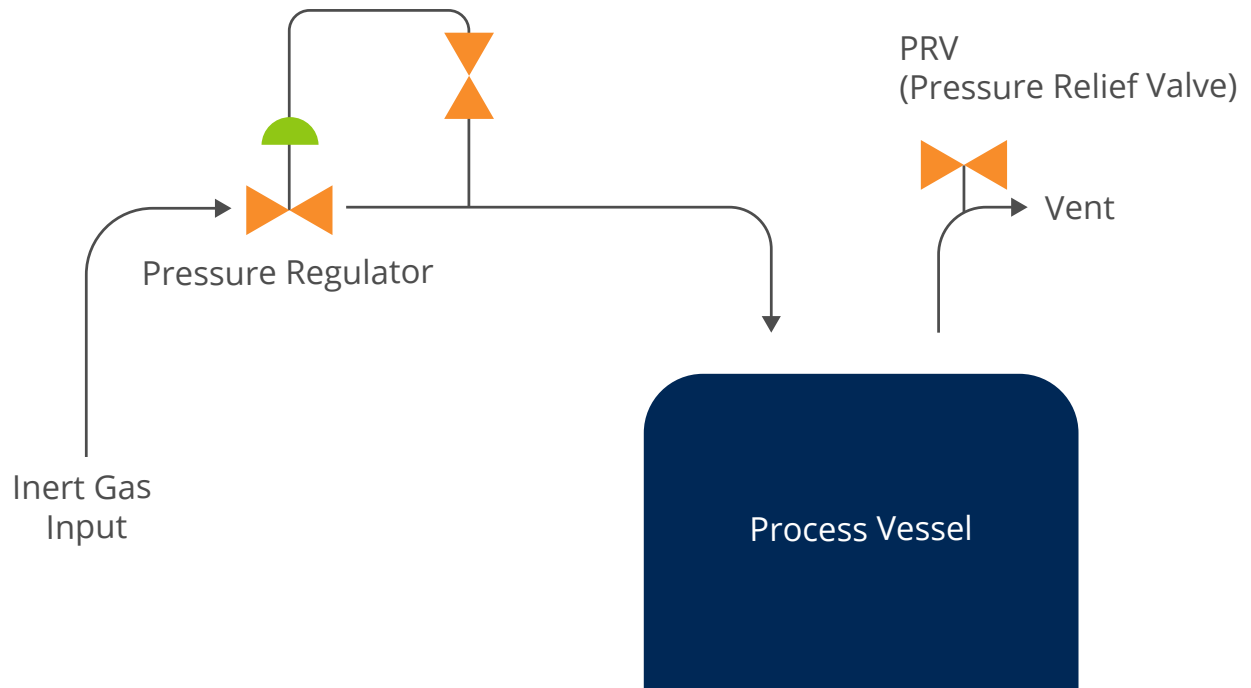
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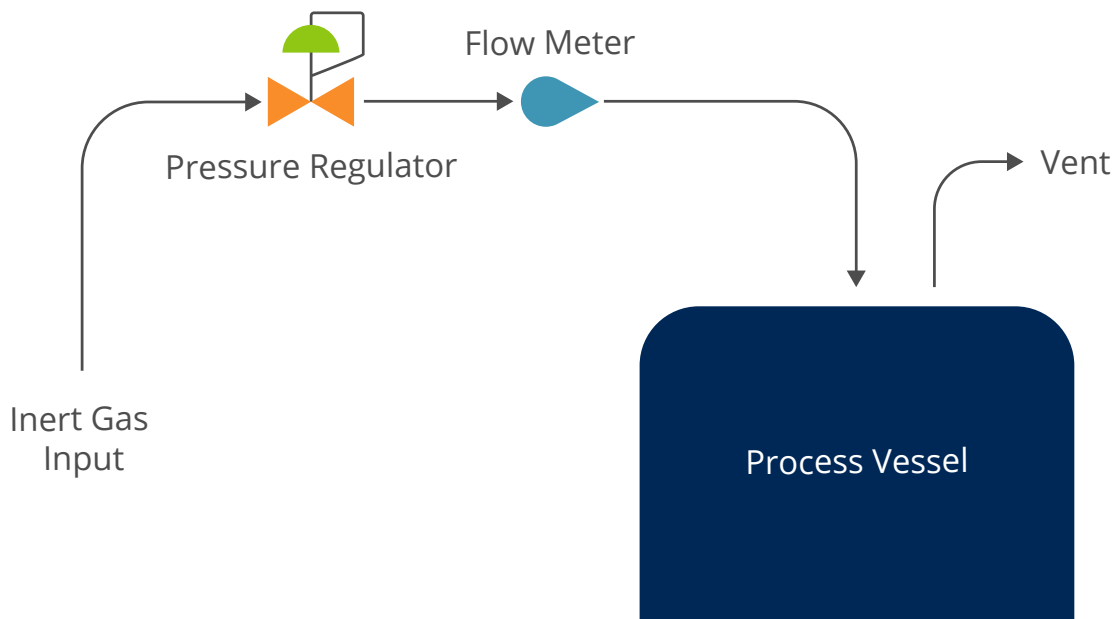
Figure 3: Pressure method (PM) of blanketing

Figure 4: Timed volume method (TVM) of blanketing

Timed Volume Method (TVM)

In this technique, a continuous flow of inerting gas is kept on an initially purged vessel at all times by means of a flow meter (see Figure 4). By keeping a continuous flow, any air that may enter the vessel is purged out and replaced with inerting gas. This technique, similarly to the pressure method technique covered before, cannot control the oxygen level to a given value.

Oxygen Measurement and Control (OMC)

This technique (see Figure 5) uses an oxygen sensor to constantly measure the amount of oxygen in the tank. The sensor output is fed into an electronic analyzer that will read the information and interpret it. The analyzer decides to either open or close a valve that would allow inerting gas into the vessel and would close the valve once oxygen is below the desired level.

The location of the analyzer itself is also important, in particular when dealing with flammable substances. It can be located right next to the process being protected by using the appropriate enclosure required by local fire codes. The analyzer can also be remotely located in the safe zone making sure that appropriate electrical safety barriers are placed in the wiring connecting the sensor, the solenoid valves and the analyzer. In this method, unlike the previous two methods, oxygen is actually measured and controlled to a precise level without making assumptions or estimations.
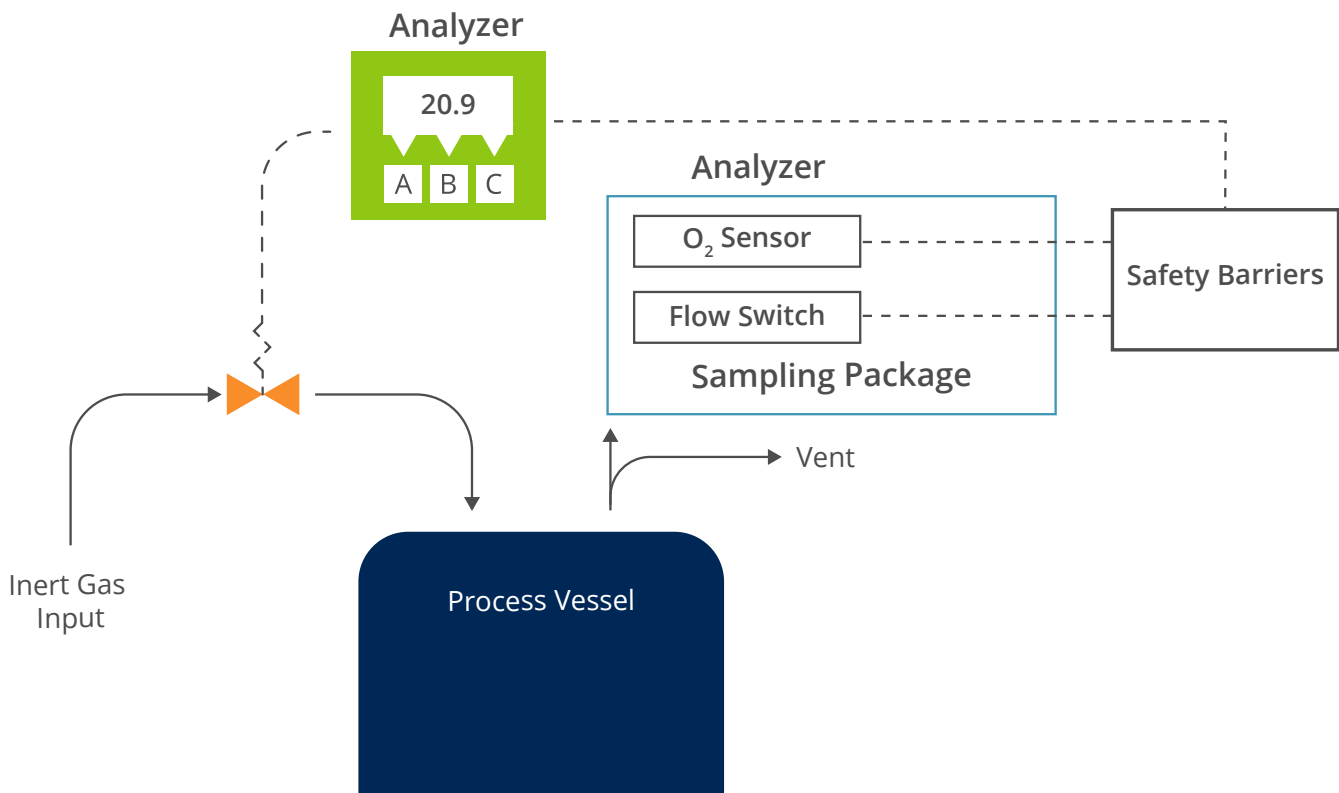

Figure 5: Example of blanketing using oxygen measurement and control (OMC)

Which Technique is Right for You?

The OMC method is by far the most accurate and reliable technique that can be used for inerting and is particularly suited to high risk areas since it relies on actual measurements of the oxygen present and not just a theoretical estimation as in the previous methods. In addition, by only using inerting gas in discreet amounts on demand and not in a continuous flow, nitrogen usage is drastically reduced as compared to the TVM technique. An additional advantage of this method is the lower nitrogen use resulting in lower costs of operation

It is important to notice that these first two techniques rely heavily on being applied on a vessel that has been initially purged. If the PM method is used without first properly purging, the process will be kept at a pressure that includes large concentrations of air, and thus oxygen.

When using the TVM method, it is important to allow a sufficiently long time at the beginning of the process to allow for an adequate number of volume exchanges (the number of recommended volume exchanges for a particular oxygen level has been determined empirically, as shown in the next section, and is also in NFPA69) for all the air to be displaced before normal operations can resume. While the OMC method also requires initial purging, its advantage is that the system will readily notify the user once a safe level has been reached and there is no need for assumptions or calculations. The system will be protected once the oxygen level reaches the set point.

How to Initially Purge a System Correctly

It has been mentioned that for the PM and TVM techniques, it is vital to start with a properly purged tank, and only then they can begin maintaining the low oxygen level required. The purge volume theoretical calculations needed to know when a tank is purged are relatively simple and outlined below. While it is true that using the OMC technique also requires an initial purge, in this case the system itself will let the user know when the proper purging has been accomplished and there is no need for purge calculations. The problem with the PM and TVM techniques is that the systems by themselves do not notify the user when proper purging has been accomplished, thus the need for estimated theoretical values.

The following equation is used for the estimation:

$$V = 2.34 \, x \log\left(\frac{I}{F}\right)$$

Where:
 V = number of volume exchanges needed
 I = Initial oxygen concentration in percent (20.9% for standard air)
 F = Final desired oxygen concentration in the head space

For example, to reduce the oxygen concentration from air to 0.5%

$$V = 2.34 \; x \; log\left(\frac{20.9}{0.5}\right)$$

V = 3.8 volume exchanges needed

$$\frac{Total\;Volume}{of\;inerting\;gas} = V \; x \; (head\;space\;vol.)$$

As Figure 6 shows, when the oxygen level requirements in the head space of the tank becomes lower, the number of initial volume exchanges needed to purge the system become increasealy larger. It should be emphasized here that these are theoretical values, so caution must be exercised.

Using the value calculated for the number of volume exchanges, and having some additional information from the vessel being inerted, as for example, its total volume and how full it is, or better yet, the actual volume of the head space that needs to be inerted, the total volume of inerting gas needed to initially purge it can be calculated as follows:

Continuing with the previous example, if we had a tank of 900 ft³ in total volume which is 75% full, then the head space volume is simply 225 ft³ (25% of 900 ft³), then the volume of inerting gas required is simply:

225 x 3.8 = 855 ft ³

In other words, to take the headspace of a 900 ft³ tank that is 75% full from 20.9% oxygen to 0.5% requires purging it initially with 855 ft³ of nitrogen. After this point, nitrogen only needs to be added to maintain the inerting and to make up for any leaks or internal volume changes of the liquid level in the tank.
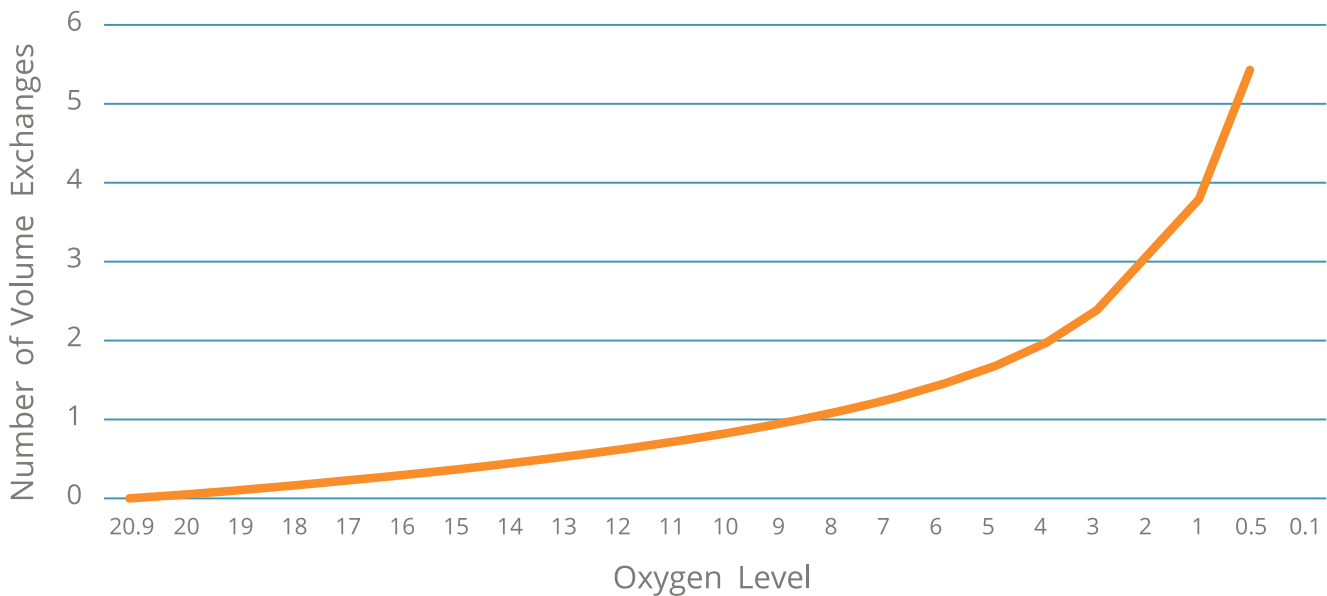

Figure 6: Number of volume exchanges for a set level of oxygen in the tank.

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Typical OMC Components

As we have seen, several techniques can be used to blanket a process with an inert gas. However, only the OMC technique can reliably ensure that the oxygen is at the desired level and provides continuous feedback to the operator. While the basic components of these systems are the same, there are a number of options for each of the components that will affect the overall system's cost, behavior and reliability.

Oxygen Sensors

There are a number of different technologies that can be used to measure oxygen in a gas (as opposed to dissolved oxygen (DO) in a liquid, which is outside the scope of this paper), see Table 3. The most common types are electrochemical (EC), Zirconium oxide, optical and paramagnetic:

Electro-Chemical:
This type of sensor uses a galvanic reaction to produce an electrical signal. Disassociated oxygen in a gas sample reacts with the lead in the anode producing a current that is proportional to the oxygen consumed. The gas sample whose oxygen is being measured, is forced to go through a membrane, in this way the diffusion of oxygen can be controlled and the electrical signal can be made to be linearly proportional to the partial pressure of oxygen in the gas sample.

Sensor manufacturers use different types of electrolyte solutions to achieve similar results. The selection depends on the composition of the gases that are being measured for oxygen. Some sensors, for example, use a weak-acid electrolyte

	Electro-Chemical	Zirconium Oxide	Optical	Paramagnetic
Pros	Low cost, Good accuracy, Fast response times, Simple.	Fast response times, versatile (ppm to 100%), longer operating life (3 to 10 years)	Non-consumable (long life), Non-destructive	Non-consumable, Non-destructive, Does not require recalibration
Cons	Relatively short life (6 to 24 months)	Not suitable for some gases, Subjected to sensor fatigue, Higher cost	High initial cost, Sensitive to contaminants fouling the optical components, Shock sensitive	High initial cost, Not for low ppm use, Not suitable for some gases, Optics can get fouled in dirty environments
Cost	$	$$	$$$	$$$
Life	+	++	+++	+++

Table 3: Oxygen sensor comparisons and application considerations

that can withstand higher levels of CO and CO_2. It is important to consult with the sensor manufacturer before selecting a particular type of electro-chemical solution.

These sensors provide a lot of benefits such as relative low cost, high accuracy and fast response times. On the downside, they are consumable items and need to be replaced regularly. Their service life depends on actual use, oxygen levels, temperature and pressure and exposure to certain chemicals (see Figure 7).

Zirconium Oxide:
High temperature sensor based on the Nernst principle. The zirconium oxide probe is plated on opposing sides with platinum which serve as the sensor electrodes. For a zirconium oxide sensor to operate properly, it must be heated to approximately 650°C. At this temperature, at a molecular level, the zirconium lattice becomes porous, allowing the movement of oxygen ions from a higher concentration of oxygen to a lower one, based on its partial pressure. To create this partial pressure differential, one electrode is usually exposed to air (20.9% oxygen) while the other electrode is exposed to the sample gas. The movement of oxygen ions across the zirconium

oxide produces a voltage between the two electrodes, the magnitude of which is based on the oxygen partial pressure differential created by the reference gas and sample gas.

Zirconium oxide oxygen sensors exhibit excellent response time characteristics. Another virtue is that the same sensor can be used to measure as high as 100% oxygen, as well as low parts per billion concentrations. On the downside, due to the high temperatures of operation, the life of the sensor can be shortened by on/off operation. The coefficients of expansions associated with the materials of construction are such that the constant heating and cooling often causes "sensor fatigue". Another limitation of zirconium oxide oxygen sensors is their unsuitability for trace oxygen measurements when reducing gases (hydrocarbons of any species, hydrogen, and carbon monoxide) are present in the sample gas. At operating temperatures of 650°C, the reducing gases will react with the oxygen, consuming it prior to measurement thus producing a lower than actual oxygen reading. The magnitude of the error is proportional to the concentration of reducing gas. Zirconium oxide oxygen sensors are the "de facto standard" for in-situ combustion control applications.

Figure 7: Typical EC sensors

Optical:

Optical sensors use a sensing membrane that contains a luminescent dye and a light emitting diode (LED). When the membrane is exposed to the sample gas, the oxygen molecules in it will affect how much light the dye emits. The lower the light emitted, the higher the oxygen concentration. An optical filter will measure the amount of light emitted and use that information to provide a measurement of the partial pressure of oxygen in the sample.

Different configurations of membranes and dyes can be used to modify the sensitivity of the sensor depending on the range of detection required. Some of the advantages of this type of sensor are its quick response, and the fact that the sensor is not consumable so it has an extended service life. Another advantage is that it is non-destructive, meaning that no oxygen is used during the measurement. Disadvantages are their very high initial cost and the fact that the optical filters protecting the membrane can get dirty when exposed to the sample gases and affect or even prevent the proper operation of the sensor.

Paramagnetic:

This type of sensor relies on the paramagnetic properties of the oxygen molecule. In a paramagnetic sensor, a sample of gas is exposed to a strong magnetic field which contains two glass spheres filled with nitrogen that are balanced. When oxygen present in the gas is attracted by the magnetic field, the spheres will get pushed out of alignment. The degree of misalignment is measured by using a light source, a mirror and a photo cell. Depending on how strong the push is and thus the balls misalignment, which in turn depends on the partial pressure of oxygen in the gas, the sensor will be able to determine the amount of oxygen in the gas sample.

These sensors are very reliable, relatively shock proof because of the stabilizing effect of the magnetic field on the spheres, and do not require re-calibration. In addition, since they are non-consumable, they have a very long life. However, they cannot be used for applications that require low ppm detection. Another issue is that they can be affected by other gases that are also paramagnetic, such as nitric oxide (NO) and nitrogen dioxide (NO_2) for example. Also, because they rely on the optics of the sensor, dirt could affect their operation.

Figure 8: Sample of oxygen analyzer with a display

Electronic Analyzers

The analyzer is the electronic brain of the system that will interpret the data sent by the sensor and decide what to do with it. When a sensor is exposed to a gas sample, it will react accordingly to its construction, capability and the amount of oxygen in the sample, whereby producing an electrical signal. The signal from the sensor needs to be interpreted and converted into a form of measurement such as parts per million (ppm) or percentage reading based on a "translation" curve specific to the sensor. The reading then will be displayed on a screen (see Figure 8). The analyzer can also send this reading using a 4 to 20 mA signal or via a RS-232 type cable to a PLC so the values can be recorded, read remotely or used in a number of different ways.

The analyzer is also capable of determining if the signal (and therefore the oxygen reading itself) is within a specified range and is programmed to respond with an alarm or other user selected action. For example, if a tank's headspace needs to be kept under 6% oxygen, and the analyzer determines that gas sampled from the headspace is outside that range, it can either turn on a horn or a strobe light to alert nearby users of the situation. It can also simply actuate a solenoid valve connected to a supply of nitrogen and automatically flood the headspace.

The ability of the analyzer to actuate a solenoid valve automatically is one of the advantages of this type of OMC system. If the user is looking to keep the oxygen content in the headspace under 6% as in the example above, then when the oxygen concentration reaches above 6% it can be set to open a valve that will allow nitrogen (or any other inerting gas) into the headspace until the reading return to its low level and then shut it off. In this way, oxygen in the monitored space will remain within the specified range. If for some reason this is not the case, then the analyzer will display a message or set off alarms to alert the user of what is happening.

Analyzers can be programmed to user-defined set values and decide what to do when the set values are reached. Also, they can be programmed on how often to read the sensor output and to interpret the data they receive from it. They can also be used to set a calibration schedule for the sensor and either perform the calibration automatically or alert the user that a calibration is needed.

Analyzers can come in a variety of models that will have a single sensor input or multiple ones. They can have a visual display for the readings and alarms or not. They can have the ability to record and preserve some of the history and data. They can be portable or fixed in place on an instrument panel. They can be designed to work with different sensor technologies and capabilities.

Sample Delivery System

Most sensors need to be in direct physical contact with the sample under test to be able to measure its oxygen content. This is certainly the case with electrochemical (EC) and zirconium oxide sensors. In some instances, this is not a problem since the environment the sensor is exposed to is mild and relatively non-reactive and clean. However, for many applications the sensors are exposed to hot, dusty, wet and / or corrosive environments. This would mean that the samples would first have to be run through a cooler, a filter, a dryer or a scrubber (or all of them) to prepare them prior to actually being delivered to the sensor.
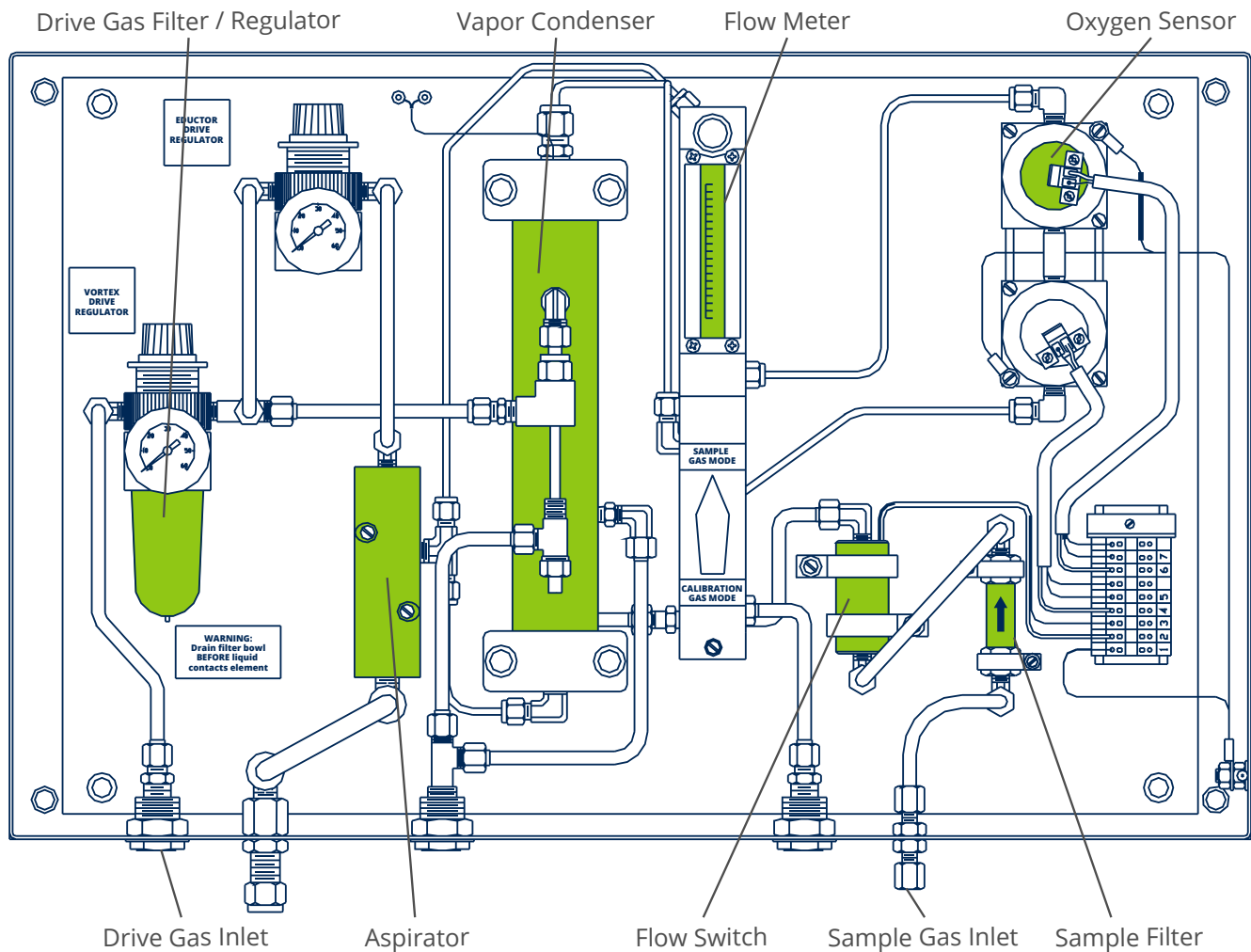
Figure 9: Sample conditioning and delivery system

In addition to the filter shown inside the box in Figure 9, other filters can be used to remove heavier particulate content, trap liquids, remove mist or condensate, scrub corrosive chemicals or even cool the sample. Selection depends on the particular process being blanketed. An additional problem that may be encountered is that many of the systems that are being sampled are run at low pressure (near atmospheric), and in some cases they may not have sufficient pressure differential to drive a sample through the filters and to the sensor. In these cases, a small positive displacement pump or an aspirator may be necessary (see Figure 9).

The aspirator will use an externally supplied gas, such as compressed air or even nitrogen, to create a pressure differential to drive the sample gas past the filters and to the sensors. Note that the drive gas is not mixed with the sample gas.

The sample delivery system is equipped with an extra layer of safety to avoid false negatives. It is possible for a system to show no or a low level of oxygen when in reality there is some present. This could happen for example if there is a blockage in one of the sample delivery tubes, a closed valve, a plugged filter or other. In order to avoid a situation like that, the sample delivery system is equipped with a flow switch. Its function is to alert the user that there is no flow at the sensors. The system could be configured to either sound and alarm, or open the flow of inerting gas to the tank or a combination of other actions designed to protect the system even in the event of a possible failure.

Conclusion

There are a number of options when it comes to gas blanketing as we have discussed previously, but regardless of the particular method used and the set-up, their use will always result in a higher quality, safer process.

Blanketing a process with an inert gas such as nitrogen for example, provides for an effective way to reduce or even eliminate the presence of oxygen from it. This can help eliminate the dangers associated with flammability or an explosion. It some cases, it can eliminate the degradation of food items that may oxidize and become rancid and unusable.

Using a set up with an oxygen sensor, an analyzer and a sample delivery system provides for an automatic mechanism to blanket a process and to verify its condition. Other systems may achieve similar results, but have the draw back of not being able to provide real time verification of oxygen levels and only rely on theoretical calculations. In addition, a blanketing system as the one described here, has the potential to be able to reduce operating costs by only using the minimum amount of nitrogen, or any other inert gas, as needed to achieve the full desired protection.

Gas Analysis Specialists

Neutronics has over 40 years of gas analysis experience so we hope this document has been useful in detailing how inerting control can help you improve your product quality and process safety.

Starting with a reliable solution for preventing flash fires in hazardous solvent-based process conditions, our expertise in inert gas control and sample conditioning systems has grown to include trace measurement and environmental gas detection. Our experience enables us to better understand the demands and needs of our customers and to offer the right products and services for applications in a variety of industries ranging from semiconductor, chemical, and industrial gases to pharmaceutical, biotechnology, and personal care. Here are just a few reasons why you should get in touch with us:

Customizable
We manufacture all the inerting equipment we sell, so we are able to customize it as needed to provide the right answer for you.

Solutions-Driven
We are 100% committed to working with you from the early stages of a project to identify and solve your problems and meet your specific application needs.

Effective Collaboration
We work in an exciting collaborative environment focused on best-in-breed products and services. Building on our engineering bench strength in gas analysis and sensing technologies, we work together to create innovative solutions to help you increase plant productivity, improve process safety, enhance product quality, and ensure longer equipment life.

Customer-Focused Support
We combine years of technical expertise and a strong manufacturing and process industry knowledge base to deliver customer support built on our passion for continuous improvement and excellence in quality and manufacturing.

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