INERTING CONTROL SYSTEMS

TECHNICAL BULLETIN 009364

Engineered solutions for inerting and blanketing
For process safety, quality control, and efficiency

Introduction

Flash fires and explosions are a very real threat to many manufacturers in the chemical and related process industries. In fact, no plant that manufactures or processes flammable liquids, solids, or gases is immune to the risk.

Using nitrogen or other gases to create inert gas atmospheres is a widely used practice that reliably protects against flash fires and explosions. By continuously measuring oxygen levels and adding inert gas only as needed, our inerting control systems keep process units running at safe levels, enhancing workplace safety by protecting plant personnel and plant assets.

Applications for inerting control systems (ICS) can be found in many of the steps of the manufacturing process, ranging from production and product storage to packaging and transportation. In addition to the safety benefits, our systems are used to improve product quality by preventing contact with oxygen and moisture and to lower production costs and increase profitability by efficiently controlling inert gas usage.

Definitions

Inerting involves the addition of a gas to displace atmospheric gases with an inert atmosphere. It is usually done to exclude or partially reduce oxygen or moisture and prevent unwanted reactions which can affect product purity or result in dangerous reactions. Nitrogen is most frequently used, however in certain cases, carbon dioxide or argon may be more suitable.

Blanketing is frequently used to describe the process of maintaining an inert atmosphere during storage and processing. Blanketing with nitrogen is a safe and dependable way to maintain a constant protective layer of gas in the vapor head space above the product. Air in the head space is replaced by high purity dry nitrogen or other suitable gas.

Industries

- Adhesives / sealants / composites
- Chemical processing – fine / specialty chemicals / petrochemicals
- Electronics – packaging / assembly / test
- Food / beverage
- Glass / minerals
- Metals
- Paints / coatings
- Personal care
- Pesticides / agricultural products
- Pharmaceuticals / nutraceuticals / biotechnology
- Printing ink / organic dyes / pigments
- Rubber / plastics
- Semiconductors
- Transportation / material handling

Applications

Centrifuges and separation equipment	Granulators / mills
Distillation and fermentation systems	Hoppers / loaders
Dryers / filters / particle processing	Mixers / blenders
Emission control systems / vent headers	Product handling systems / pneumatic conveying
Filling and packaging systems	Reactors / process vessels
Food processing systems	Storage tanks / silos

PREVENTING EXPLOSION HAZARDS

Risk potential

Many materials handled in the chemical and process industries are capable of forming explosible atmospheres. Ingredients such as gases, solvent vapors, fine droplet mists, and dispersed dusts can all give rise to a hazard in the right circumstances. The simultaneous existence of three components -- a fuel source, oxygen, and a single spark or heat source – can produce disastrous results (see Figure 1).

Fig. 1, fire triangle

For many processes, it is difficult to reliably remove the flammable or combustible material or avoid all potential sources of ignition. When flammable liquids and dry powders are pumped, mixed, filtered, agitated, or otherwise kept in motion, the potential for static electricity is created. While there are many unpredictable sources of ignition in industrial plants, static sparks are the most common source of ignition in chemical and process plant fires.

Flammable liquids, gases, and particulates used in the manufacturing processes become fuel sources in a plant's potential recipe for disaster. At typical process temperatures, many flammable liquids release vapors into the headspace of their vessels or container. Dust clouds can also reach the optimum concentration forming an explosible atmosphere.

Combustion cannot exist without an oxidant, even if fuel and ignition sources are present. The oxidant is normally oxygen but others such as chlorine or nitrogen dioxide may support combustion. Safe operating conditions can be achieved by adding nitrogen or other inert gas to reduce the oxidant concentration below a level that will no longer support combustion.

Minimum oxygen concentration

The concentration of oxygen in air at which the atmosphere can no longer support combustion is known as the minimum oxygen concentration (MOC) for combustion. MOC values vary depending on the material involved and the inert gas used. Values are typically obtained using nitrogen as the inert gas (see Table 1 for examples).

Table 1, MOC values

Flammable material	Minimum oxygen concentration (MOC) % (v/v)
Methane	12
Benzene	11.2
Ethylene	10
Hydrogen	4
Barium stearate	13
Organic pigment	12
Methyl cellulose	10

Oxidant concentration reduction

The 2014 *NFPA 69 Standard on Explosion Protection Systems* covers the minimum requirements for installing systems for the prevention of explosions in enclosures that contain concentrations of flammable gases, vapors, mists, dusts, or hybrid mixtures. Oxidant concentration reduction is recognized by the standard as a method based on preventing combustion. Section 3.3.25 defines the limiting oxidant concentration (LOC) as the concentration of oxidant in a fuel-oxidant-diluent mixture below which a deflagration cannot occur under specified conditions.

Chapter 7, *Deflagration Prevention by Oxidant Concentration Reduction*, states that this technique is permitted where an oxidant and flammable material is confined to an enclosure within which the oxidant concentration can be controlled. Requirements include maintaining the system at a concentration that is low enough to prevent a deflagration. For ICS systems where the oxygen concentration is continuously monitored, paragraph 7.7.2.5 requires one of the following: (1) a safety margin of at least 2 volume percent below the worst credible case LOC shall be maintained; (2) the LOC shall be less than 5 percent, in which case the equipment shall be operated at no more than 60 percent of the LOC. See Tables 2 and 3 below for examples from NFPA 69.

Table 2, LOC values for flammable gases

Gas / vapor	Adjusted LOC* N2—air mixture	Original LOC* N2—air mixture
MEK	9.0	11.0
Acetone	9.5	11.5
Hexane	10.0	12.0
Methanol	8.0	10.0
Butadiene	8.5	10.5
Methyl acetate	9.0	11.0
Hydrogen	3.0	5.0

* Volume % O2 above which deflagration can take place

Table 3, data for combustible dust suspensions

Gas / vapor	Median particle diameter (µm)	LOC* N2—air mixture
Cellulose	22	9
Wheat flour	60	11
Plastic resin	<63	10
Methionine	<10	12
Methyl cellulose	70	10
Aluminum	22	5
Magnesium alloy	21	3

* Volume % O2 above which deflagration can take place

ICS benefits

*For safety…*countless incidents involving flammable processes claim lives, harm personnel, damage equipment, halt production, and cost companies millions of dollars every year. Many companies operate with a false sense of security, relying on grounding and bonding, continuous purging, timed-volume, and pressurization techniques to provide adequate safety margins.

Making the vapor space inert eliminates the possibility of fire or explosion. The Neutronics process inert gas control system (ICS) operates on a real-time measurement basis to keep the oxygen content of the vapor space at a safe level. The analyzer continuously monitors the oxygen level and adds nitrogen or inert gas as needed, holding the oxygen content of the vapor space to a value that is less than the concentration needed to support combustion (MOC or LOC).

*For quality control…*many materials and products, especially in the food, pharmaceutical, nutraceutical, and plastics industries, are affected by exposure to oxygen and moisture. This exposure can degrade the product, causing a reduction its stability and altering color, flavor, and aroma. Using nitrogen to blanket storage or shipping containers provides control of the level of oxygen in the vapor space. It can also create a slight positive pressure, preventing air from entering and causing degradation and spoilage.

In the production of high-value plastic products, various flaws frequently result from similar exposure of the material to moisture and oxygen. Inerting process equipment with nitrogen has been proven to reduce relative humidity and oxygen levels, resulting in a reduction of surface defects in molded plastics products.

*For efficiency…*developing effective strategies to optimize nitrogen usage and to reduce hazardous air pollutants are high priority challenges that need to be considered during safety reviews, plant upgrades, and project planning. Utilizing continuous real-time oxygen monitoring, the ICS adds nitrogen or inert gas only when needed to keep oxygen at a safe level. This can dramatically reduce inert gas usage spending when compared with continuous purge, time-volume, and pressurization techniques.

When chemical processes are continuously purged, large amounts of VOCs are more frequently vented, driving up the cost of scrubbing or incinerating the waste gas as required by the EPA. By adding inert gas only as needed, the ICS reduces VOC emissions…less gas in, fewer VOCs out. Additionally, reducing the oxygen content in the vapor space of a process vessel or storage tank can make it inert, protecting the vessel from structural corrosion damage caused by air and moisture.

System components

Sensors are the eyes and ears of an industrial process control system. The effectiveness of the system depends on the most suitable sensors for reliable operation. For over 35 years, our oxygen sensors have been proven to be the best for harsh and difficult processing applications. Our disposable electrochemical sensors (see Figure 2) continue to deliver reliable performance in even the most demanding applications.

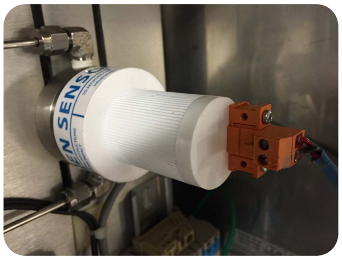

Fig. 2, oxygen sensor

Another key to reliable oxygen monitoring is providing a gas sample that is free of contaminants that can damage the sensor. Here, the Neutronics inert gas control systems separate themselves from the rest. Our unique sample conditioning packages (see Figure 3) and pre-conditioning components attest to our commitment to providing our customers with reliable and long-lasting performance.

Fig. 3, sample conditioning package

Designed for continuous real-time oxygen monitoring, our analyzers (see Figure 4) go beyond basic functionality to give our customers added value with special features that make the ICS both easy to use and simple to integrate into the plant control system. Our analyzers automatically maintain oxygen levels within specified limits by controlling the flow of inert gas into the process or vapor head space (see Figure 5).

Fig. 4, oxygen analyzer/controller

HOW IT WORKS…

The Neutronics ICS is a complete solution designed for sampling, sensing, analyzing, and controlling oxygen. The system measures the oxygen level in real-time and automatically adds inert gas as needed to meet your specific requirements.

1

- The sampler draws a continuous gas sample from the process and conditions it for measurement by the sensor (see Figure 5).
- The sampler is intrinsically safe, suitable for installation in hazardous areas.

2

- The oxygen sensor measures oxygen in the conditioned gas stream.

3

- The oxygen analyzer interprets the sensor signal and compares it to the inert gas control high limit setpoint, the highest oxygen level that you want to maintain in the process (see example shown in Figure 6).

4

- If the oxygen level remains below the high limit setpoint, the system does nothing and continues to monitor the process (normal mode).

5

- If the oxygen level reaches the high limit hazard level, the analyzer activates the inert gas control valve to add inert gas to the process.
- When the oxygen level drops to the low limit setpoint, the control valve is de-activated.
- The low limit setpoint is at least 1% lower than the high limit setpoint.

6

- The oxygen alarm relay is mapped to the oxygen alarm setpoint, which is provided for process safety control.
- If the oxygen level goes past the high limit level, the analyzer activates the alarm relay.
- The high limit setpoint is at least 1% lower than the alarm setpoint.

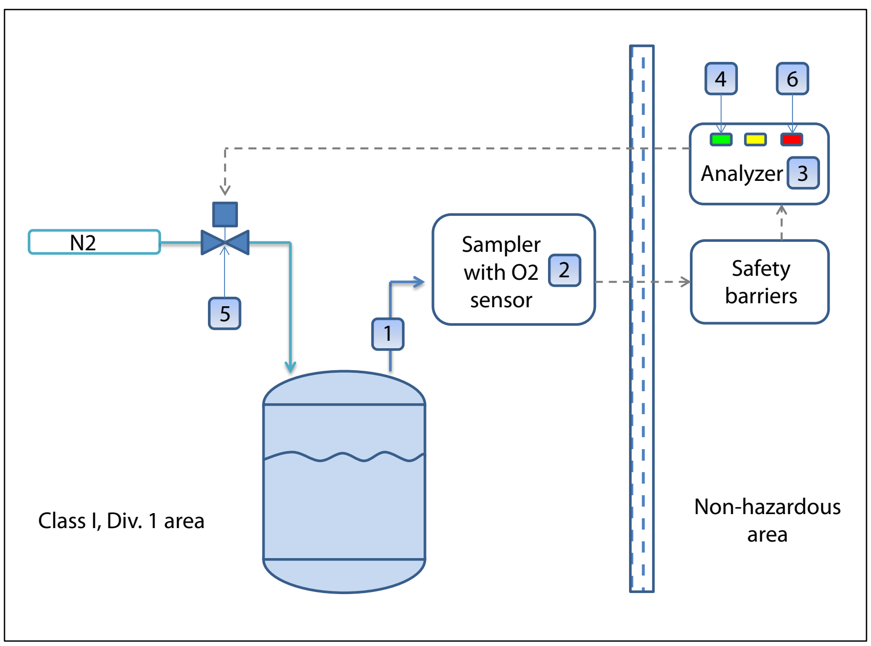

Fig. 5, ICS safe area configuration

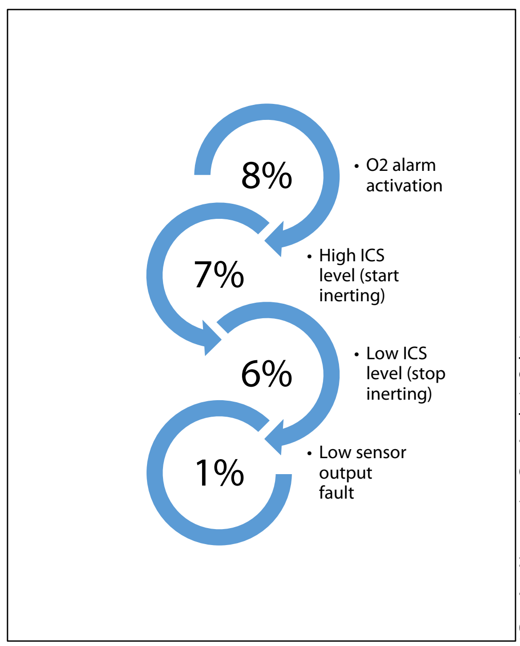

Fig. 6, alarm and control relay settings (alarm setpoint shown with ascending activation)

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