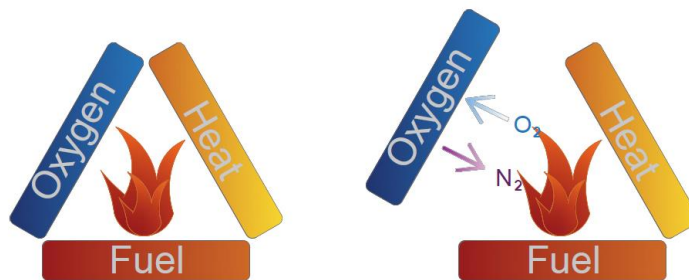


Inerting in the Chemical Industry

➤ What is Inertization?

Inertization in the chemical industry refers to the process of introducing inert gases, such as nitrogen or carbon dioxide, into a system or environment to reduce or eliminate the presence of reactive or hazardous substances. This technique is commonly employed in various industrial processes to prevent explosions, fires, or other hazardous reactions.

Limiting oxygen concentration (LOC) or the maximum permissible oxygen concentration (MPC)



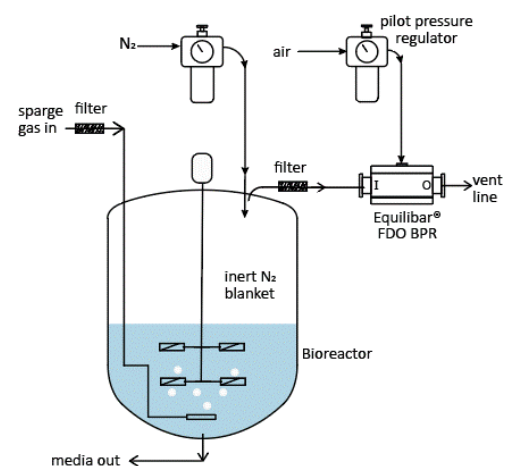
➤ Limiting Oxygen Concentration (LOC)

- Limiting oxygen concentration (LOC) is the minimum concentration of oxygen in a mixture of fuel, air, and an inert gas that will propagate a flame.
- It's also known as the minimum oxygen concentration.
- LOC is expressed in units of volume percent of oxygen and varies with pressure, temperature, and the type of inert gas
- Maintaining oxygen concentrations below the LOC is crucial for the safe operation of chemical processes involving flammable or reactive substances.

- It helps mitigate the risk of fires, explosions, and other hazardous incidents, thereby safeguarding personnel, equipment, and the surrounding environment.

➤ Chemical Reactivity

- Chemical reactivity plays a crucial role in inertization processes within the chemical industry.
- Inertization aims to render substances inert or non-reactive to prevent unwanted chemical reactions, particularly those that could lead to hazards like fires, explosions, or toxic releases.
- Understanding the chemical reactivity of the substances involved is essential for designing effective inertization strategies.
- Chemical reactivity refers to the propensity of substances to undergo chemical reactions and potentially release energy or produce hazardous by-products
- Examples include combustion reactions, polymerization reactions, and metal corrosion processes, all of which involve reactive chemicals that can pose safety hazards if not properly managed.



➤ Importance & Methods of inertization chemical industry

Avoidance of unwanted chemical reactions:

- Prevention of explosive atmospheres in apparatus

Safety

- Safe starting-up and shutting-down of plants
- Prevents the release of toxic or flammable gases

Protect equipment

- Helps to protect chemical industry equipment and facilities from degradation or damage caused by such unwanted reactions

Efficiency

- Increase production efficiency by avoiding product losses or reduced yields caused by possible chemical reactions

Facilitates storage and transport

- Preventing chemicals from degrading or reacting with the container or the environment during the logistics process

➤ Inerting Methods

Inerting methods are techniques used to displace or reduce the concentration of oxygen in a confined space, typically to prevent combustion or oxidation reactions. Here are some common inerting methods:

- Blanketing
- Purging

Blanketing with Inert Gas: This method involves introducing an inert gas, such as nitrogen or carbon dioxide, into the confined space to create a blanket that displaces oxygen. The inert gas forms a protective layer above the substance, preventing contact with oxygen.

Purging: Purging involves completely removing the atmosphere in a confined space and replacing it with an inert gas. This is often done by continuously flushing the space with the inert gas until the desired oxygen concentration is achieved.

➤ Main Difference between Blanketing, Purging and Sparging

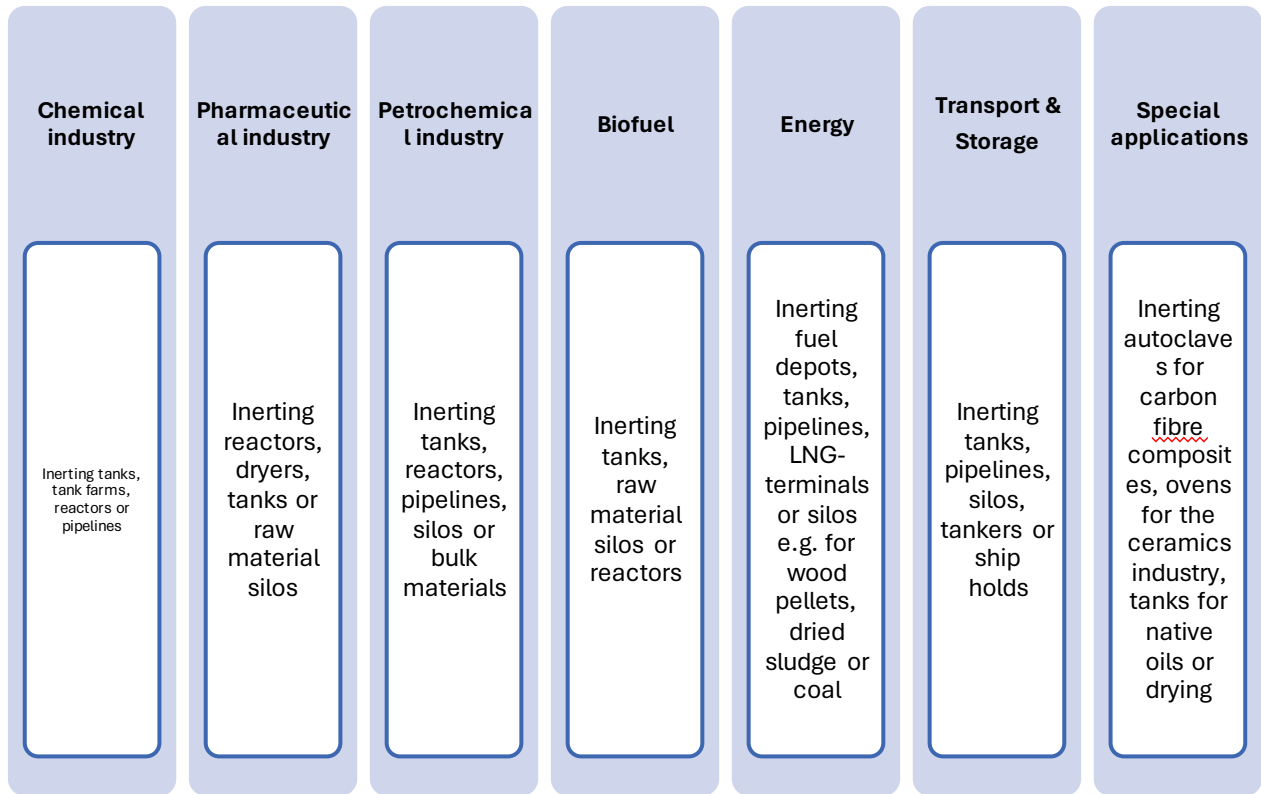
Blanketing

- Requires a constant flow of slightly pressurized inert gas [maintaining an inert layer over materials]

Purging

- It is a time-limited operation that replaces a flammable gas atmosphere with an inert gas. Purging is usually done at start-up or shutdown, and is often used when the vessel being purged only has one opening.

➤ Industry Application Examples



➤ Equipment's Used during inertization

Pressure vessels

Piping systems

Control valves

Gas cylinders

Gas analyzers

Safety devices such as pressure relief valves and

Flame arrestors

➤ Associated Hazards & Safety Considerations

- **Key Hazards in Inertization Process**

Oxygen deficiency:	<ul style="list-style-type: none">• Inadequate oxygen levels in confined spaces can lead to asphyxiation
Gas leaks:	<ul style="list-style-type: none">• Leakage of inert gases or reactive chemicals can pose fire, explosion, or health hazards
Pressure hazards:	<ul style="list-style-type: none">• Overpressurization of vessels or piping systems can result in ruptures or explosions.
Chemical exposure:	<ul style="list-style-type: none">• Contact with reactive chemicals or hazardous materials can cause chemical burns or toxic effects
Equipment malfunctions:	<ul style="list-style-type: none">• Failures of inertisation equipment can compromise process safety and integrity.

- **Common Mistakes**

Inadequate risk assessment	Failure to identify and mitigate potential hazards.
Improper gas selection	Choosing incorrect inert gases or using inappropriate concentrations.
Poor equipment maintenance	Neglecting to inspect, test, or maintain inertization equipment.
Lack of training	Insufficient training and competency among personnel involved in inertization activities.
Ineffective monitoring	Failure to continuously monitor gas concentrations, pressures, and other process parameters.

➤ Monitoring and Control of Risk during Inertization

Control systems:

- Include gas analyzers, flow meters, pressure transmitters, and PLCs that regulate gas flow rates, maintain desired gas concentrations, and trigger alarms or shutdowns in case of deviations from safe operating conditions.

Alarm systems and emergency protocols:

- Alarm systems alert personnel to potential hazards such as gas leaks, overpressure conditions, or equipment failures, and emergency protocols outline procedures for responding to such incidents, including evacuation, containment, and mitigation measures.

➤ Selection of Proper Gas for inertization

Gas	Advantage	Disadvantage
Carbon dioxide	Available in Compressed gas cylinders. The actual percentage of oxygen are allowed higher than required using nitrogen. It has moderate cost (or nil if produced by a process)	Some metals may react Violently (AL, Mg). The Co ₂ stream may generate a considerable accumulation of electrostatic charges.
Nitrogen	Available in the form of Crayogenic gas compressed and in some cases as a waste product of the process	It is less effective in terms of concentration compared to CO ₂ . It reacts at high temperature with Magnesium.
Argon and Helium	They do not contaminate the products and does not react with them	Very expensive
Water Vapor	It can be generated by the processes in the system	It may not be available during start up or shut down. It is incompatible with many combustible dusts. Condensation can disable the neutralizing process.
Exhaust Gas	Usually available in the process. Very modest cost	Need to install heat exchanges, scrubbers, sensors et. Storage is not practical.

➤ Best Practices in the Industry

Comprehensive risk assessment: Identify and assess potential hazards and implement appropriate control measures.

Proper gas selection: Choose inert gases based on process requirements, compatibility, and effectiveness.

Regular equipment inspection and maintenance: Conduct routine inspections, testing, and preventive maintenance of inertisation equipment.

Adequate training and supervision: Provide thorough training and supervision to personnel involved in inertisation activities.

Effective communication: Ensure clear communication and coordination among team members, supervisors, and stakeholders.

➤ Control Measures

Gas detection systems: Install gas detectors to monitor oxygen levels, inert gas concentrations, and potential leaks.

Pressure relief devices: Use pressure relief valves or rupture discs to prevent over-pressurization and release excess pressure safely.

Engineering controls: Implement engineering controls such as ventilation systems, gas scrubbers, and containment measures to mitigate hazards.

Administrative controls: Establish procedures, protocols, and permits for performing inertization activities safely.

Personal protective equipment (PPE): Provide appropriate PPE such as respirators, goggles, gloves, and protective clothing to personnel as needed

➤ Monitoring System for Inertization

Gas analyzers: Use gas analyzers to continuously monitor oxygen, inert gas, and reactive gas concentrations in the process environment.

Pressure sensors: Install pressure sensors to monitor vessel and system pressures and trigger alarms or shutdowns in case of deviations.

Temperature sensors: Employ temperature sensors to monitor process temperatures and detect overheating or abnormal conditions.

Alarm systems: Set up alarm systems to alert personnel to potential hazards such as gas leaks, oxygen deficiency, or overpressure situations.

Regular inspections: Conduct regular visual inspections and walkthroughs to identify any abnormalities or potential safety hazards.

➤ Automation

Automated control systems: Implement automated control systems such as programmable logic controllers (PLCs) or distributed control systems (DCS) to regulate gas flows, pressures, and process parameters.

Remote monitoring: Use remote monitoring technologies to monitor inertization processes in real-time and receive alerts or notifications of any deviations or alarms.

Data logging and analysis: Employ data logging and analysis tools to record process data, analyze trends, and identify opportunities for optimization or improvement.

Automated safety systems: Integrate automated safety systems such as emergency shutdown systems (ESD) or interlocks to automatically activate safety measures in response to abnormal conditions or alarms.

Predictive maintenance: Implement predictive maintenance techniques using sensors and predictive analytics to anticipate equipment failures and schedule maintenance proactively, minimizing downtime and enhancing reliability.