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Potencialno eksplozivna atmosfera - Preprečevanje eksplozij in zaščita - Vodilo o inertizaciji za preprečitev eksplozij

Potentially explosive atmospheres - Explosion prevention and protection - Guidance on inerting for the prevention of explosions

Atmosphères explosibles - Prévention des explosions et protection contre celles ci - Guide de l’inertage pour la prévention des explosions

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13.230	Varstvo pred eksplozijo	Explosion protection

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Potentially explosive atmospheres - Explosion prevention and protection - Guidance on inerting for the prevention of explosions

Atmosphères explosibles - Prévention des explosions et protection contre celles ci - Guide de l'inertage pour la prévention des explosions

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EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
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European foreword

This document (CEN/TR 15281:2022) has been prepared by Technical Committee CEN/TC 305 “Potentially explosive atmospheres – Explosion prevention and protection”, the secretariat of which is held by DIN.

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1 Scope

Inerting is a preventive measure to avoid explosions or fire to happen. By feeding inert gas into a system, which is to be protected against an explosion or a fire, the oxygen content is reduced below a certain limit or completely replaced by an inert gas, depending on the inert gas, on the fuel and the process until no explosion or fire can occur or develop.

Inerting can be used to prevent fire and explosion by reducing the O_2 content.

NOTE Inerting can also be used to prevent and to extinguish smouldering nests and glowing fires which are a primary source of ignition in pulverized fuel storage and handling facilities, substituting air by sufficient inert gas inside the equipment.

The following cases are not covered by the guideline:

- admixture of an inert solid powder to a combustible dust;
- inerting of flammable atmospheres by wire mesh flame traps in open spaces of vessels and tanks;
- firefighting;
- avoiding an explosive atmosphere by exceeding the upper explosion limit of a flammable substance;
- anything related to product quality (oxidation or ingress of humidity) or product losses;
- any explosive atmosphere caused by other oxidizing agents than oxygen.

Other technologies might be used in combination with inerting such as floating screens made of independent collaborative floaters consisting of an array of small floaters non-mechanically linked but overlapping each other in order to form a continuous layer covering the liquid surface.

Product oxidation or evaporation reduction is directly proportional to the surface area covering ratio and quality of the inerting.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 13237:2012, *Potentially explosive atmospheres - Terms and definitions for equipment and protective systems intended for use in potentially explosive atmospheres*

EN ISO 28300:2008, *Petroleum, petrochemical and natural gas industries - Venting of atmospheric and low-pressure storage tanks (ISO 28300:2008)*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN 13237:2012 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at https://www.electropedia.org/
- ISO Online browsing platform: available at https://www.iso.org/obp

3.1
limiting oxygen concentration
LOC
maximum oxygen concentration in a mixture of a flammable substance and air and an inert gas, in which an explosion will not occur, determined under specified test conditions

3.2
maximum allowable oxygen concentration
MAOC
maximum oxygen concentration in a mixture of a combustible substance and air and an inert gas, in which an explosion will not occur, determined under specified test conditions

3.3
trip point
TP
defined value at which the process controller initiates a shut-down trip

3.4
set point
ST
defined value at which the process controller maintains the gas concentration

3.5
lower explosion limit
LEL
concentration of flammable gas or vapour in air, below which the mixture is not explosible

3.6
upper explosion limit
UEL
concentration of flammable gas or vapour in air above which the gas atmosphere is not explosible

3.7
inert gas
non-combustible gas which will not support combustion and does not react at all that avoid explosion to occur mainly by reducing the oxygen-concentration in the protected space

Note 1 to entry: Inert can be argon, nitrogen, carbon dioxide or mixtures of these gases.

3.8
blanketing
replacement of air by an inert gas in an equipment in order to achieve inert conditions

3.9
blanketing regulator
pressure regulators used to introduce inert gas in an equipment to be inerted

3.10
breathing valve
pressure/vacuum valve
device to relieve the pressure or vacuum formed inside the cargo tanks by opening the valves at the designated setting value to protect the tank from over-pressure or vacuum exceeding the design parameters of the tanks

3.11
flame arrester
device fitted to the opening of an enclosure, or to the connecting pipe work of a system of enclosures, and whose intended function is to allow flow but prevent the transmission of flame

3.12
back pressure regulator
device used to control/maintain gas pressure immediately upstream of its installed position

Note 1 to entry: It has the ability to maintain a near constant inlet pressure within design parameters, regardless of pressure or flow fluctuations in other parts of the system.

3.13
smouldering nets
exothermic oxidation, without flaming, that is self-propagating, i.e. independent of the ignition source

Note 1 to entry: It might or might not be accompanied by incandescence.

3.14
Programmable Logic Control
PLC
electronic device designed for control of the logical sequence of events

4 Inerting process and methods

4.1 General

Many processes are routinely inerted to avoid the presence of explosive atmosphere by reducing O_2 content, when potential ignition sources can occur or become active. Inerting should not replace but complement the control of ignition sources to reduce risk to an acceptable level.

Inerting requires design, procedure, maintenance and control to achieve its objective of reducing the risk of explosive atmospheres and hence potential fires and explosions. Inerting may also introduce additional risk to personnel through the creation of asphyxiating atmospheres in case of leakage of inerting gas in the atmosphere, and further more environmental hazards due to entrained gases and dusts in exhausted gas. Such risks should be taken into consideration during engineering and design phase of inerting systems.

Inerting systems are a preventive measure and differ from firefighting systems (e.g. using liquid CO_2, gaseous N_2 or Argon or a dedicated mixture of gases to extinguish a fire) and curative explosion protection systems (like suppression systems, explosion vents, etc.) that are used to minimize and reduce the consequences or severity of a fire or an explosion that already happened.

4.2 Inerting system design and operation

4.2.1 General

To achieve adequate levels of risk reduction from an inerting system, certain design and appropriate maintenance procedures should be followed depending on the selected technology described below.

When designing or increasing the automation of a plant or process, it is important to define safe operating conditions. It is recommended to estimate safety levels.

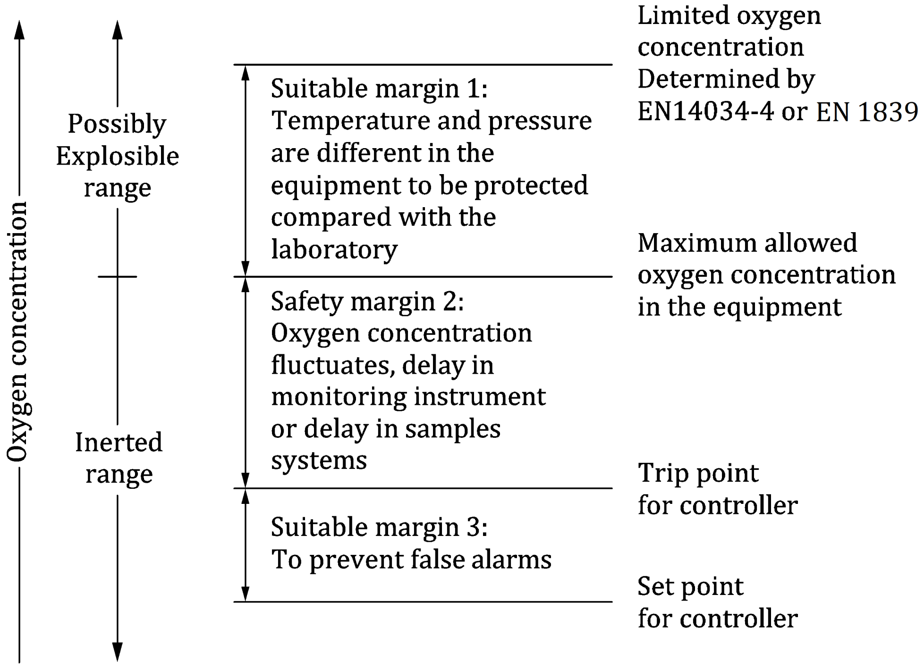


Figure 1 — Oxygen concentrations to be observed when inerting equipment

Effectiveness of inert gas used decreases usually in the following order:

1) CO_2;

2) Steam;

3) Flue gases;

4) N_2;

5) Noble gases.

4.2.2 Design Features

a) The oxygen content of the inert gas supply (LOC is a function of the type of inert gas used and the type of combustible used) and the target oxygen at the end of a purging process should be known (for pressure/vacuum swing).

b) A suitable method for inerting should be chosen, and parameters selected (O_2 analysis).

c) Calculation notes should be provided or the system should be commissioned to show it can reach theoretical design.

4.2.3 Operational Features

a) Inert atmosphere is established as per design and before processing or handling of materials start.

b) System is maintained to keep oxygen levels within design parameters and safety parameters.

c) Cause of system failure should be defined and/or detected and corrective, or protective, actions taken.

d) Personnel are protected, informed and trained on the potential risk of asphyxia, including for operations planned after processing where the inerted system can be made safe for entry.

4.2.4 Information on inert gas to be taken into consideration

a) LOC depends on inert gas used thus variability of gas on an industrial site should be taken into consideration.

b) Oxygen content of the inert gas itself can vary from few ppm to several percent, depending of the source of supply.

c) For some onsite inert gas production methods, the oxygen concentration may vary with the rate of production. This should be taken into consideration in the inerting procedures.

d) Availability of inert gas supply and emergency capacity with appropriate procedures in case of supply failure.

e) Industrial sites that generate their own inert gas should be equipped with an emergency cryogenic storage or compressed cylinder supply as backup.

f) Define the maximum simultaneous demands on the inert gas supply for an industrial site and define priority of supply (process shut down or reduced supply to non-safety related inerting).

4.3 Establishing inert atmosphere

4.3.1 General

There are four basic methods of establishing an inert atmosphere. These methods are described below.

- Pressure swing inerting is a common method for process (reaction) vessels and batch production methods. The choice of such technology depends on the pressure rating of the vessel as well as normal practice on a site and process requirements. Pressure swing is mainly used for small steel tanks with simple geometry that are resistant to pressure. Some vessels with complex shapes and dead ends might be difficult to inert.

- Vacuum swing inerting is another common method for process (reaction) vessels and batch production methods. The choice of such technology depends on the vacuum rating of the vessel as well as practice on a site and process requirements. Vacuum swing is a preferred technology for glass equipment that resist to elevated vacuum conditions and of complex geometry with dead ends that need to be inerted.

- Flow through inerting is used for continuous production process or when products need to be introduced in the process vessels during the production or for non-pressure rated vessels. Such methods imply a circulating flow technique to avoid high consumption of inert gas, asphyxia risks for the personnel and environmental impact.

- Liquid displacement (replacement by inert gas) is commonly used for inerting of storage vessels of various capacities.

4.3.2 Pressure swing inerting

4.3.2.1 Principle

The pressure system is tightly closed and pressurized using an inert gas. The system is then vented to atmosphere, and the process repeated until the required reduction in the oxygen content is achieved. The theoretical oxygen content after a given number of pressure and relieve cycles will be integrated in the control unit functionality. Three inerting trips or cycles are generally used to achieve an acceptable inert condition (to reach LOC).

Where a system is large and contains branches, the gas in the closed ends of the system will be compressed by the inert gas, but it is unlikely to mix well. Thus, when the pressure is released, the gas will simply expand, and the oxygen content in the branches will remain similar to that before it was compressed. Therefore, it will be necessary to take account of this branching when calculating the final oxygen content. Thus, the particular shape of the vessels should be considered as important information for defining pressure swing inerting.

Where the system is very complex, a vacuum purging system may be better and ensure that there is a homogeneous mixture.

With such a method, continuous oxygen monitoring should be used.

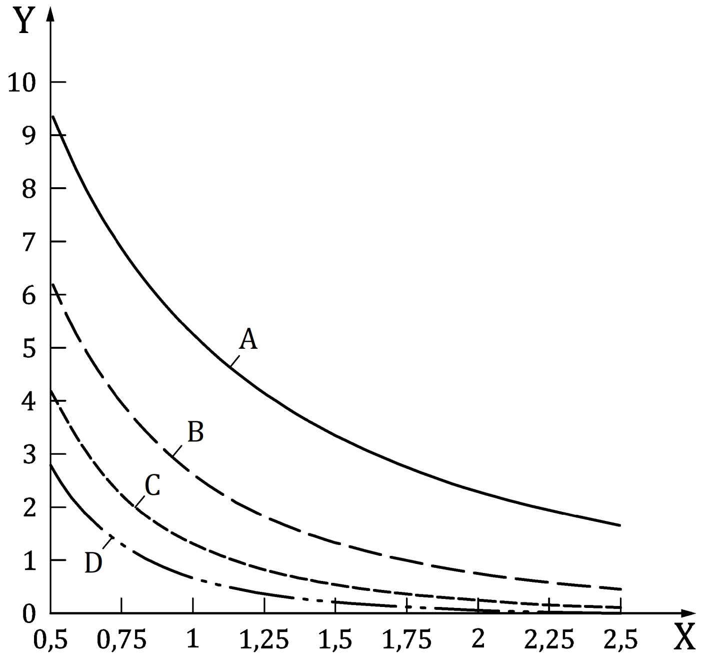
Where a system is operated at over pressure, any leaks will be of inert gas into the workplace. Therefore, adequate precautions should be taken to ensure that personnel cannot be asphyxiated by any escape of inert gas. Where systems are located in the open air, asphyxiation will only present a risk under conditions of massive leakage. In closed workplaces, adequate ventilation has to be provided.

Key features for pressure swing inerting are shown in Table 1.

Table 1 — Key features for pressure swing inerting

Description	Vessel is pressurized with inert gas to target pressure, and then vented back to atmospheric pressure. Pressure swing is repeated the required number of times to reduce oxygen content to the required level (see annex for appropriate levels).
Suitable for	Vessels that can withstand pressure and can be isolated and vented. Small vessels of steel construction with simple geometry
NOT suitable for	Low pressure process vessel which cannot withstand the overpressure cycles Vessels which are difficult to seal Large vessels of complicated geometry Glass equipment
How to design	The appropriate theoretical number of pressure cycles can be found in Figures 2, 3 and 4 and formulae in Annex A Piloted pressure and back pressure regulators and valves for the inerting process. Control of oxygen content. Batch production process
Requirements	Minimum of 2 cycles Verification during commissioning that procedure achieves targeted limit oxygen concentration ‘adequate’ monitoring
Good practice	Pressure test: included when target pressure reached (first swing only)
Benefit	Allows good mixing to effectively reduce the oxygen content
Disadvantage	Leaks — Leaking material is not necessarily inert when mixed with air. — An asphyxiating atmosphere can be formed outside vessel during leak. Large systems with branches may have dead ends which are not inerted.
Defined parameters	Upper pressure, lower pressure (atmospheric usually), number of swings, target oxygen, oxygen in inert gas, flow rate of inert gas

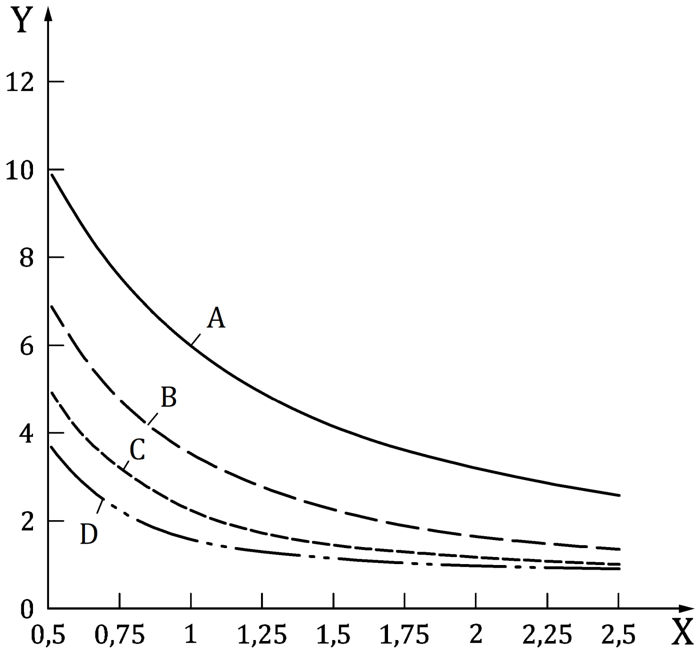
4.3.2.2 Necessary swings for pressure swing inerting



Key

X pressure at peak (barg)
Y final concentration of oxygen in vessel (%)
A 2
B 3
C 4
D 5

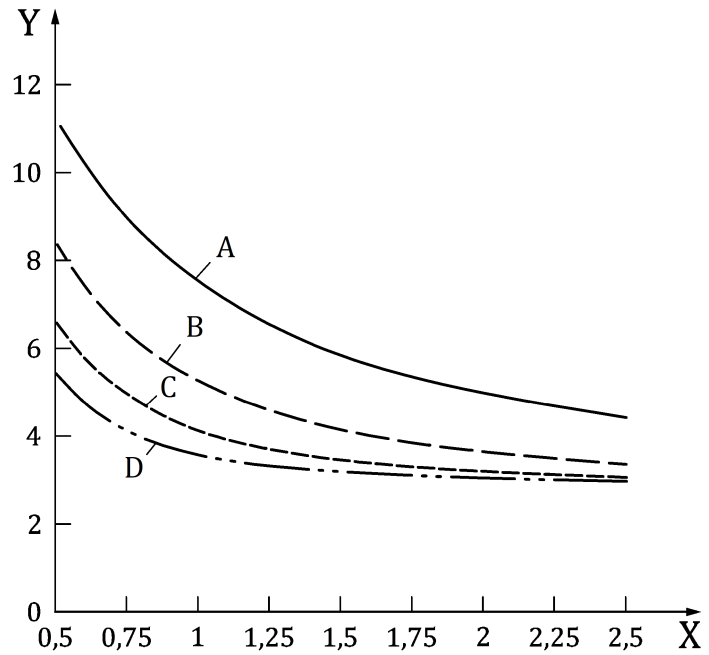
Figure 2 — Final concentration of oxygen achieved in vessel for different numbers of pressure swings (2 to 5) given a concentration of oxygen in the nitrogen supply of 200 ppm



Key

X	pressure at peak (barg)
Y	final concentration of oxygen in vessel (%)
A	2
B	3
C	4
D	5

Figure 3 — Final concentration of oxygen achieved in vessel for different numbers of pressure swings (2 to 5) given a concentration of oxygen in the nitrogen supply of 1 %



Key

X	pressure at peak (barg)
Y	final concentration of oxygen in vessel (%)
A	2
B	3
C	4
D	5

Figure 4 — Final concentration of oxygen achieved in vessel for different numbers of pressure swings (2 to 5) given a concentration of oxygen in the nitrogen supply of 3 %

4.3.3 Vacuum swing inerting

4.3.3.1 Principle

This method can be used where a vessel cannot be subjected to internal pressure, but will withstand full vacuum. Examples in this category are glass vessels.

The procedure is similar to that for pressure swing purging, but, since the vessel is under vacuum, it is possible that air ingress may occur, thus the system integrator needs to take that into consideration. 3 inerting trips or cycles are generally used to achieve an acceptable inert condition (to reach LOC). Where oxygen or air is likely to leak in because the inerted system is held at a sub-atmospheric pressure, then the oxygen concentration should be measured continuously.

For a system operating under vacuum, any leaks will allow air to enter the system and this will gradually destroy any inert atmosphere. The ingress of air can be detected by two methods:

- The inferential method relies on the vacuum source being isolated and the rate of pressure-rise being monitored. Thus, it is possible to estimate the maximum oxygen concentration that would occur with time in the system at a given vacuum.

- The most efficient method to monitor the oxygen level would be to have a continuous measuring system, which would provide adequate warning that the oxygen level in the atmosphere of the system is rising.

Leaks may be complicated to monitor especially for large volumes, positive method of control will be preferred. A combination of both methods (vacuum and pressure swing) can be used taking into consideration the correct safety parameters of each method.

Key features for vacuum swing inerting are shown in Table 2.

Table 2 — Key features for vacuum swing inerting

Description	Vessel is put into target vacuum. Inert gas is introduced to bring back vessel to ambient pressure Vacuum swing is repeated to reduce oxygen content to the required level
Suitable for	Vessels that can withstand vacuum and that can be isolated. Glass equipment
NOT suitable for	Low pressure storages (or non-vacuum rated vessels)
How to design	The appropriate number of vacuum cycles can be found in Figures 5, 6 and 7 and formulae in Annex A
Requirements	At least 2 cycles Leak test – leak rate should not exceed 10 % of either vacuum phase or rate of pressure rise during inert gas addition Verification during commissioning that procedure achieves required limit oxygen concentration Break the vacuum with inert gas
Good practice	— Vacuum phase to lowest achievable vacuum condition — Isolate vacuum system — Monitor pressure rise of the vacuum
Benefit	Less inert gas needed than for pressure swings
Disadvantage	Air is drawn in due to driving force (pressure differential) Under vacuum conditions explosive mixtures can occur even at temperatures well below the flash point so care should be taken
Defined Parameters	Upper pressure (atmospheric; absolute), lower pressure (absolute), number of swings, target oxygen, percentage of oxygen in inert gas

4.3.3.2 Necessary swings for vacuum swing inerting

The number of swings required can be calculated from well-established formulae or can be read from Figure 5, Figure 6 and Figure 7 for 3 different oxygen concentrations.

A maximum 500 mbar (a) vacuum is recommended.

NOTE Using much higher degrees of vacuum is possible but can mean that it is difficult to establish the seal sufficiently to make the pressure test meet the necessary criteria, particularly in solids handling systems where contamination of the seal with particles can be an issue.