



CO₂ / N₂ Emergency Inerting Systems
article for
Journal "Cement and its applications"

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Author: Achim Rott

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System description

of

CO₂ /N₂ – Emergency Inerting systems



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About YARA

Yara International ASA is a global company active in industries ranging from food production to emissions control. We're the world's largest supplier of mineral fertilizers, the world's largest supplier and trader of ammonia and the global leader in a wide range of chemical products. We help boost food production and enable biomass growth to deliver renewable energy. Many of our industrial products safeguard air and water quality and preserve food quality. We can help cleanse the air and eliminate toxic waste by delivering new and innovative solutions for the control and capture of emissions.

Headquartered in Oslo, Norway, number of Yara staff is some 8,000 employees with operations and offices in more than 50 countries. Yara revenues in 2008 was some 10,6 Bil. Euro (90 Mrd. NOK).

Since more than 30 years Yara supplies turn key inerting systems with carbon dioxide or nitrogen as inert gas. Each system is designed and manufactured according to individual customer needs and specifications. More than 400 systems are in operation in all 5 continents. Local directives and conditions are strictly observed, they do play an important role for the engineering and conception of the systems, which are based on 4 basis models. (CO₂ High pressure tank inerting system, CO₂ Low pressure tank inerting system with evaporizer, CO₂ High pressure battery inerting system, N₂ High pressure packs inerting system)

General description inerting process

The hazards caused by so-called hot spots or smoldering fires, sudden spontaneous combustion and explosions lurk everywhere in industry and business, storage, processing and when transporting combustible powders.

In cooperation with the insurers for occupational accidents, legislation has provided all users and shippers involved in this critical area with strict regulations and safety requirements, which must be adhered to.

On International level **ATEX** regulations have to be considered for explosion prevention. In addition the guidelines **CEN/TR 15281**, **VDI 2263-2** and **BGV C15** are used. As an effective preventive measure technological systems based on inert gases are used.

Inert gases have a low level of reactivity and reduce oxygen concentration to below critical levels. Inert gases prevent the occurrence of critical operating conditions and consequently any resulting explosions and fires.

Effectiveness of different inert gases acc. to VDI 2263 part 2 – guideline

- 1. Carbon dioxide / CO₂**
- 2. Steam**
- 3. Flue gases**
- 4. Nitrogen / N₂**
- 5. Noble gases / Argon**



Below the Limiting Oxygen Concentration (LOC) no explosion is possible regardless of the dust concentration. Therefore it is absolutely not necessary to replace all oxygen by inert gas. Inerting is **preventive explosion protection** to avoid explosion capable atmospheres.

All pressurized parts comply with **European Pressure Equipment Directive PED 97/23/EC** as well as **Russian RTN and GOST-R standard**.

Generally, in terms of the European Directive 94/9/EG (Atex 95a) inerting systems are not seen as a protection system and hence is not subject to comply with the requirements for this directive. An installation not in range of a possible dust explosion zone, in accordance with the European Directive 99/92/EG (Zone 20, 21, 22), is thus strongly recommended.

Attention: In the case inerting systems have to be installed within a possible dust explosion zone in accordance with Directive 99/92/EG (Zone 20, 21, 22) it automatically becomes subject to the Directive.

Description inerting process in coal grinding systems

Inerting systems avoid dust explosions and smouldering fires in silos, coal mills and filter equipment by creating an inert atmosphere. In case of a CO-O₂ temperature alarm the inerting process is initiated automatically through the process control system. Therefore constant CO-, O₂ – or temperature measurement and monitoring is absolutely necessary.

In normal operation inerting occurs with the smoke of the rotary kiln plant or from hot gas generator during the operation of a coal mill plant. In case of emergency shutdown or starting and stopping the coal mill plant inert gas is injected.

The goal is to reduce the **Limiting Oxygen Concentration (LOC)** so far, that due to the lack of oxygen explosions can no longer take place. The LOC is the highest concentration of an oxygen/inert gas mixture in which explosion is not possible regardless of the dust concentration.

Maximum Allowed Oxygen Concentration (MAOC) is at security distance of approx. 2-3% below the Limiting Oxygen Concentration. Oxygen limiting concentration depends on kind of coal that is used and needs to be determined separately through expert advice. With lignite (brown coal) for example the LOC amounts to approx. 12% by volume, with hard coal however, it is approx. 14% by volume. Oxygen concentration is to be controlled from the control room with appropriate measuring and/or control devices placed in suitable areas.

Carbon dioxide density amounts to 1.977 kg/m³ (from this it follows that: **2kg liquid CO₂ = 1m³ inert gas**). In accordance with German coal dust regulation BGV C15, a sufficient inertisation is guaranteed, if the geometrical empty volume of the individual components receives a simple rinse, i.e., in a 1:1 ratio. This assures that the Limiting Oxygen Concentration is kept below target and thus a dust explosion is no longer possible. Below the Limiting Oxygen Concentration (LOC) no explosion is possible regardless of the dust concentration. Therefore it is not absolutely necessary to replace all oxygen by inert gas.

Extinguishing smoldering fires is only possible at Oxygen concentration max. 2 – 3%, in this case inerting process has to be repeated up to 3 or 4 times depending on the LOC when inerting is started first.



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The inerting method described here, is so called Blending method as per Flushing method. Here the inert gas is introduced at the highest possible speed, i.e. with a high entry impulse into different parts of the system that have to be inertized. As a result of the strong turbulence that is produced, the gas content undergoes thorough mixing and optimum inerting.

This high speed is reached through special nozzles in connection with the adjusted inert gas pressure at the valve station. The number and size of nozzles is calculated according to geometrical empty volume of the aggregates which have to be protected.

Layout and execution of the mechanical and electrical construction components of the complete inerting system corresponds to YARA Industrial Standard.

General design and size of the stock amount is designed in accordance with the following criteria, which in regards to the safety standard in coal grinding plants was developed in cooperation with the leading cement manufacturers (e.g. Lafarge, Holcim, Cemex, HeidelbergCement) as well as European Engineering and Coal grinding plant manufacturers.

- **Maximally necessary inert gas volume has to be stored 2-3 fold, in addition to a security reserve to be double stocked.**
- **Withdrawal of the maximally required inert gas volume is possible within one hour.**

The necessary inert gas capacity is calculated according to geometrical volumes of all components to be inertized. Calculation basis is total geometrical volume of Coal grinding system (75% of silo net.volume in case of 2 and more silos).

CO₂ High pressure tank inerting system with valve station

(Heidelberg Cement Akcansa - Canakkale Cement plant - Turkey)



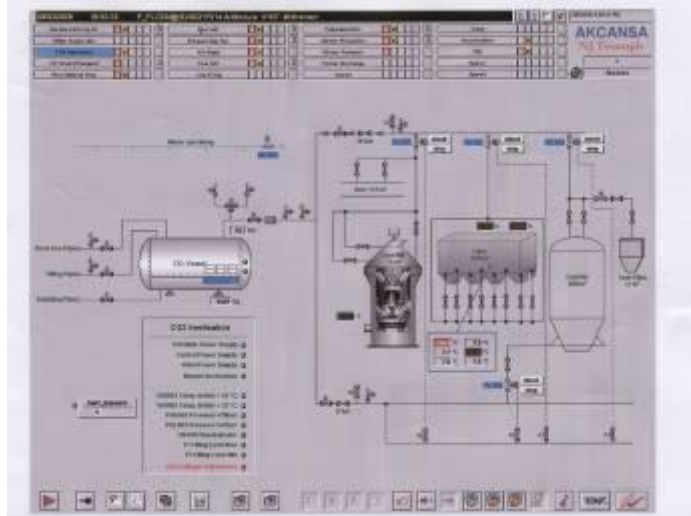


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Carbon dioxide high pressure tanks do have high inert gas capacities and compact tank dimensions, mainly they are used in countries with distinctive seasonal temperature fluctuations with warm summers and cold winters (Europe, Russia, Central Asia, Middle and South America).

The vessel serves the storage of liquefied carbon dioxide that is extracted in gaseous form. The CO₂ storage installation consists of a cylindrical container whose maximum operating pressure is **80 bar**. The installation is operated in the range **from 50 - 70 bar**.

To keep tank operation pressure in winter between 50 - 65 bar up to 3 heaters with max. heating capacity each 19 kW are installed. At hot summer temperatures high pressure tank is cooled either with cooling water (max. temperature +25° C) or erection in airconditioned room (max. temperature +28° C) is recommended.

Several tank sizes from 3 t – 15 t CO₂ storage volume are available. Inert gas capacity of high pressure tank is some 30 – 40 % in 1st hour, depending on tank pressure. When inerting high inert gas volumes, regeneration and pressure build up time is necessary which depends on ambient temperature and installed heater capacity.

CO₂ temperature and the CO₂ pressure are depending on each other based on the following table. A **certain temperature** is allocated to a **certain pressure** and vice versa.

| | |
|-------|-------------|
| -30°C | = 14,27 bar |
| -25°C | = 16,81 bar |
| -20°C | = 19,67 bar |
| -15°C | = 22,89 bar |
| -10°C | = 26,47 bar |
| - 5°C | = 30,45 bar |
| 0°C | = 34,85 bar |
| +5°C | = 39,72 bar |
| +10°C | = 45,06 bar |
| +15°C | = 50,93 bar |
| +20°C | = 57,33 bar |
| +25°C | = 64,32 bar |
| +30°C | = 71,92 bar |



The tank is always filled with deep cold CO₂ from a low pressure tanker with a maximum pressure of between 20 – 25 bar, which corresponds to a liquid CO₂ temperature of between minus 20°C and minus 29°C. Monitoring of CO₂ level and tank pressure by 4...20 mA signal coming from electromechanical weighing device and pressure sensor. The CO₂ storage tank regulation system is essentially a 'black box' system.

Valve station with electrical cabinet

The gas withdrawal valve of the CO₂ vessel is connected to the valve station by a flexible high-grade steel corrugated hose and high-grade steel high pressure pipe. The valve station is a framework rack with integrated pressure reduction and the individual electromechanical operated and controlled valves for the inerting endangered parts all together or individually. flow meter, CO₂ gas detection system for inhouse erection.

Also, the control cabinet is installed and completely connected to the valve station.

During inertization trip CO₂ in gas form is withdrawn from CO₂ tank and then enters into valve station. The flow is monitored at the entry to the valve station using sensors. The CO₂, which is available under pressure in the CO₂ storage system, flows into the pre-selected system areas and displaces the air oxygen. Inerting is triggered by the higher-ranking control system (PLC) in the control room, which permanently monitors CO level, temperatures and oxygen concentration during the grinding process and the storage of the coal dust.

Inerting for the individual consumers is started by opening the correspondent electromechanical ball valves . The pressurized CO₂ is now available at the corresponding ball valves and flows into the respective system parts by means of CO₂ nozzles, once the appropriate ball valves are opened.

The electrical cabinet is controlling and monitoring separately CO₂ tank and valve station, it is designed according to individual customer specification. Electrical control of the tank is self-sustaining and is monitored by control circuits. In particular tank pressure and the filling level is monitored.

Also the valve station is controlled and monitored separately, at the inlet pipe a flow sensor is mounted for indication of leakages at stand by operation. At normal operation valve station and tank are controlled by PLC at control stand, additionally local control is integrated to be able to inert manually in emergency situations like power shutdown. The position of all electromechanical valves is indicated by limit switches.

At present modern state of the art control systems with Profibus signal exchange is installed in the electrical cabinet for communication with central PLC at control stand. Normally inerting systems are fully integrated in higher control centers.



CO₂ Low pressure tank inerting system with evaporizer and valve station
(Lafarge - Bamburi Cement plant - Kenya)



Combines advantages of controlled storage in combination with newest technology. These inerting systems are mainly used in countries with constant temperatures above +5° C and higher like Asia, Near East, Africa, Central and South America or Australia. Inert gas capacity is mainly depending on size of evaporizer and ambient temperature.

Several tank sizes from 4 t – 22 t CO₂ storage volume are available, capacities and number of ambient evaporizer is individually calculated.

CO₂ is stored deep cold in the tank with the help of integrated refrigeration unit. For maximum inert gas discharge tank is equipped with additional pressure build up heating element. Similar to high pressure tank it is equipped with electrical weighing device and pressure sensors for communication via Profibus DP and Optical link modul with state of the art PLC system in cement plant control stand.



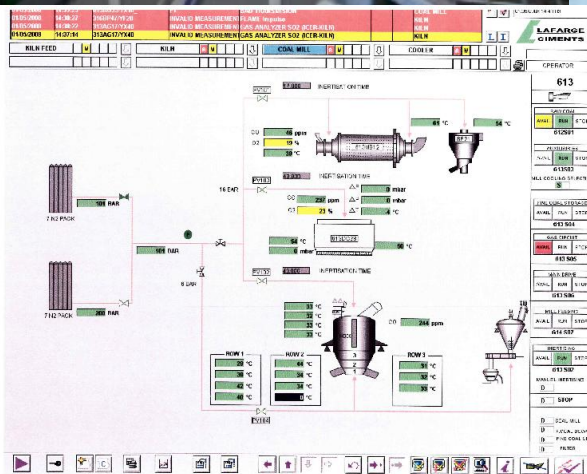
CO₂ high pressure battery inerting system
(Ciments du Sahel - Cement plant - Senegal)



Used for small and middle CO₂-inert gas capacities or in countries with areal disadvantages in infrastructure where carbon dioxide is not available by road tankers. These systems are very compact and do have similar technical equipment of high pressure tanks like electrical weighing device and pressure sensor technology. It is designed for state of the art communication with PLC (programmable logic control). Batteries will be provided with standard CO₂ steel cylinders for inert gas discharge and may be used nearly in all countries of the world. Climate conditions and relevant pressure fluctuations have to be considered, therefore housing and heating might be necessary.



N2 high pressure packs inerting system with valve station
(Lafarge - Rezina Cement plant - Moldova)



Used for small and middle N₂-inert gas capacities or in countries with areal disadvantages in infrastructure where carbon dioxide or nitrogen is not available by road tankers. These systems are very compact and do have similar technical equipment like tank systems with pressure sensor technology. It is designed for state of the art communication with PLC (programmable logic control). N₂ high pressure packs are provided with standard N₂ steel cylinders for inert gas discharge and may be used nearly in all countries of the world. Pressure fluctuations caused by climate conditions don't play a role, therefore erection outside with weather protection roof as a general rule is sufficient.



Current Yara reference projects in Russia and Azerbaijan:



CO₂ – High pressure inerting system 10t tank with valve station for Holcim Garadagh Cement plant, Azerbaijan

One of the world's leading suppliers of cement, Holcim from Switzerland, is building a new, state of the art cement plant in Azerbaijan nearby Baku at the Black Sea. The yearly cement capacity of the new kiln line is 1,7 Mio t, fuel supply of the kiln and precalciner is done with coal powder provided by a coal grinding plant. For preventive explosion protection Yara supplies a CO₂-inerting system, according to newest Holcim safety standards that is approved in collaboration with Azerbaijan authorities. Commissioning of the new cement plant is to be expected in 2011.

HEIDELBERGCEMENT

CO₂ – High pressure inerting system 10t tank with valve station for HeidelbergCement Tula Cement plant, Russia

HeidelbergCement Group is the biggest investor in the building sector of Eastern Europe since 1989. It has a leading market position in Ukraine, Romania, Poland, Czech Republic, Bosnia, Estonia and Hungary. In Russia, HeidelbergCement operates a cement plant in Slanzy, St. Petersburg region and is currently building a new cement plant at Tula, Moscow region, with an annual capacity of 2.0 million tons. Fuel supply is guaranteed by coal grinding plant. For preventive explosion protection Yara supplies a new, state of the art CO₂-inerting system while meeting newest HeidelbergCement safety standard as well as Russian RTN and GOST-U certification. Inert gas is providing a vertical mill with separator, mill filter as well as 2 silos for coal powder storage. Start up of the new cement plant is scheduled 3rd quarter 2010.