Comparison
CO_2 inerting – CO_2 fire extinguishing

Monitoring | Control | Inerting

For preventive explosion protection systems

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1. <u>General</u>

CO_2 is an odorless, colourless, inert gas that suffocates fires primarily by diluting the oxygene concentration that supports combustion processes. It is effective on a wide range of flammable and combustible materials in both surface and deepseated fires. The cooling effect of the CO_2 is rather low in comparison to the extinguishing respectively suffocation effect. CO_2 is the only technical gas which has got physically 3 conditions: solid (dry ice), liquid and vapour (gaseous) according to Plank and Kuprianoff pressure-entalpy (p, h) diagram for CO_2.

Looking at the most solid fuels chemical and physical characteristics (e.g. hard coal, lignite, petcoke, bituminous coal) an sufficient extinguishing effect when using CO_2 will be reached between 2 – 3 % oxygene volume. The extinguishing effect is mainly caused by the oxygene reduction of ambient air below a level which avoids continuation of an exothermical process (fire).

Extinguishing of smoldering fires with CO_2 inert gas is only possible at Oxygen concentration max. 2 – 3%. inerting processes have to be repeated up to 2 or 3 times depending on the LOC (Limiting Oxygene Concentration) when inerting is started first. See attached table.

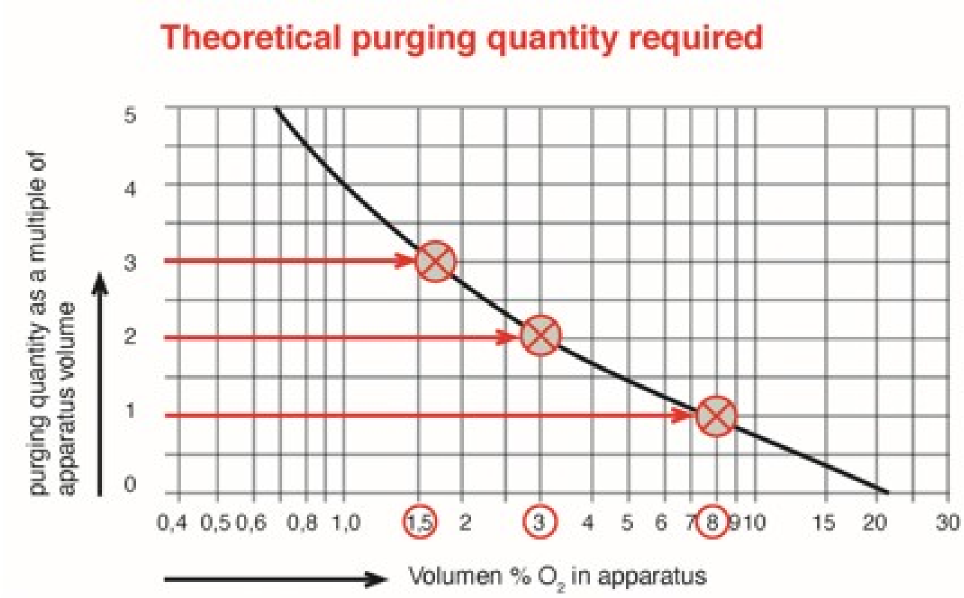

Figure 7: Theoretical purging quantitiv required [12]

Figure 7:
ESCIS Expert Commission for the Safety in the Swiss Chemical Industry
Inerting – Method and Measures for the Avoidance of Ignitable Substances-Air Mixtures in Chemical Production Equipment and Plants

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Inerting systems avoid dust explosions and suffocate smouldering fires in silos, coal mills and filter facilities by creating an inert atmosphere using **gaseous CO_2 or N_2**.
Inerting is a preventive method to avoid explosive atmospheres. Basically inerting systems are no protection systems in relation to European ATEX Guideline 2014/34/EG and therefore in general they don't have to fulfil its standards (exception: erection within ATEX zones)
Nevertheless acc. to ATEX total system directive the complete system shall be designed to be monitored and operated locally, by Central Control Room or in combination with a full-automatic control unit.

Depending on geometrical volumes range of discharge times for inerting of all aggregates is max. 30 – 60 minutes independent on high or low pressure storage. Activation of inerting systems is as soon as critical alarm levels (CO, CH_4, O_2) have exceeded. Inerting systems CO_2 storage capacity is calculated acc. to 3 x geometrical volume of overall coal grinding workshop + silos in order to be able to repeat in general inerting trip up to 2 times.

1. Inerting standards

Design, technical equipment, electrical facilities and cabinet and execution of the complete, CO_2 / N_2-inerting system, gas analyser system and control unit acc. to German and European Industrial Standards.

- Potentially explosive atmospheres - Explosion prevention and protection – Guidance on Inerting for the Prevention of Explosions / DIN/EN 15281:2022
- Dust fires and Dust Explosions: Hazards – Assessment – Protective Measures Inerting / VDI guideline 2263 part 2,
- ATEX directive 2014/34/EU
- VDE regulations
- IEC60079-29.
- European Pressure Equipment Directive PED 2014/68/EU
- European Machine guideline 2006/42/EC
- European Low Voltage Guideline 2014/35/EU

Fire extinguishing or fire fighting systems will extinguish open fires after detection. The Carbon dioxide extinguishing system is a fixed system to extinguish fires by smothering action with **liquid CO_2**. It is a most effective system for protection of electrical hazards, engines or machinery spaces utilizing gasoline or other flammable liquid fuels, paint stores, cargo holds or ordinary combustibles such as paper, wood and textiles along with advantages to protect against fires.

Range of discharge times for fire extinguishing systems is max. between 30 – 120s depending on low or high pressure installation.

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1. **CO2 fire extinguishing or fire fighting standards**

Design and cabinet and execution of the complete CO_2 -fire extinguishing system and control unit acc. to German, European and US-American Industrial Standards.

- ISO 6183:2022 Carbon dioxide extinguishing systems for use on premises – Design and installation
- NFPA 12 – Standard on Carbon Dioxide Extinguishing Systems 2022 Edition
- ASME publications – American society of Mechanical Engineers, e.g. ASME section V III requirements and other
- IEC60079-29.
- European Pressure Equipment Directive PED 2014/68/EU
- European Machine guideline 2006/42/EC
- European Low Voltage Guideline 2014/35/EU

Differences CO_2 tank Inerting systems – CO_2 cylinder fire extinguishing systems

The physical effect of CO_2 fire extinguishing systems is based on thermo-dynamical characteristics of liquid CO_2. Liquid CO_2 is taken out of CO_2 cylinders or insulated CO_2 tanks by a dip tube (= pipe reaching nearly to the bottom of the cylinder or tank). Then liquid CO_2 is flowing through to the coal grinding workshops injection points with the help of pipe network and special CO_2 orifices and nozzles at the pipes end.

Fire extinguishing systems are **designed for fire fighting against open visible flames like a burning motors, engines, machines or ordinary combustibles.** With the help of special nozzles liquid CO_2 is unstressed. CO_2 inert gas as well as CO_2 dry ice snow (-78°C) is generated.

After injection the dry ice snow evaporizes very quickly and is then sublimating direct into CO_2 inert gas.

A smouldering fire at coal grinding workshops or related storage silos is not a bonfire not showing open flames and in most of the cases it is lying under a coal powder column.

CO_2 dry ice snow is cooling down and shocking open fires whereas the CO_2 inert gas is generating a barrier avoiding Oxygen from the ambient air feeding the fire again.

The maximum generation of dry ice snow of CO_2 fire extinguishing systems is when the CO_2 is stored as deep cold CO_2 (-30°C) as it is stored in cryogenic tanks.

e.g. -30°C = 15bar --> dry ice snow rate is some 51% and **CO_2 inert gas rate is some 49%** **(tanks)** (acc. to pressure enthalpy diagram by Plank – Kuprianoff)

but

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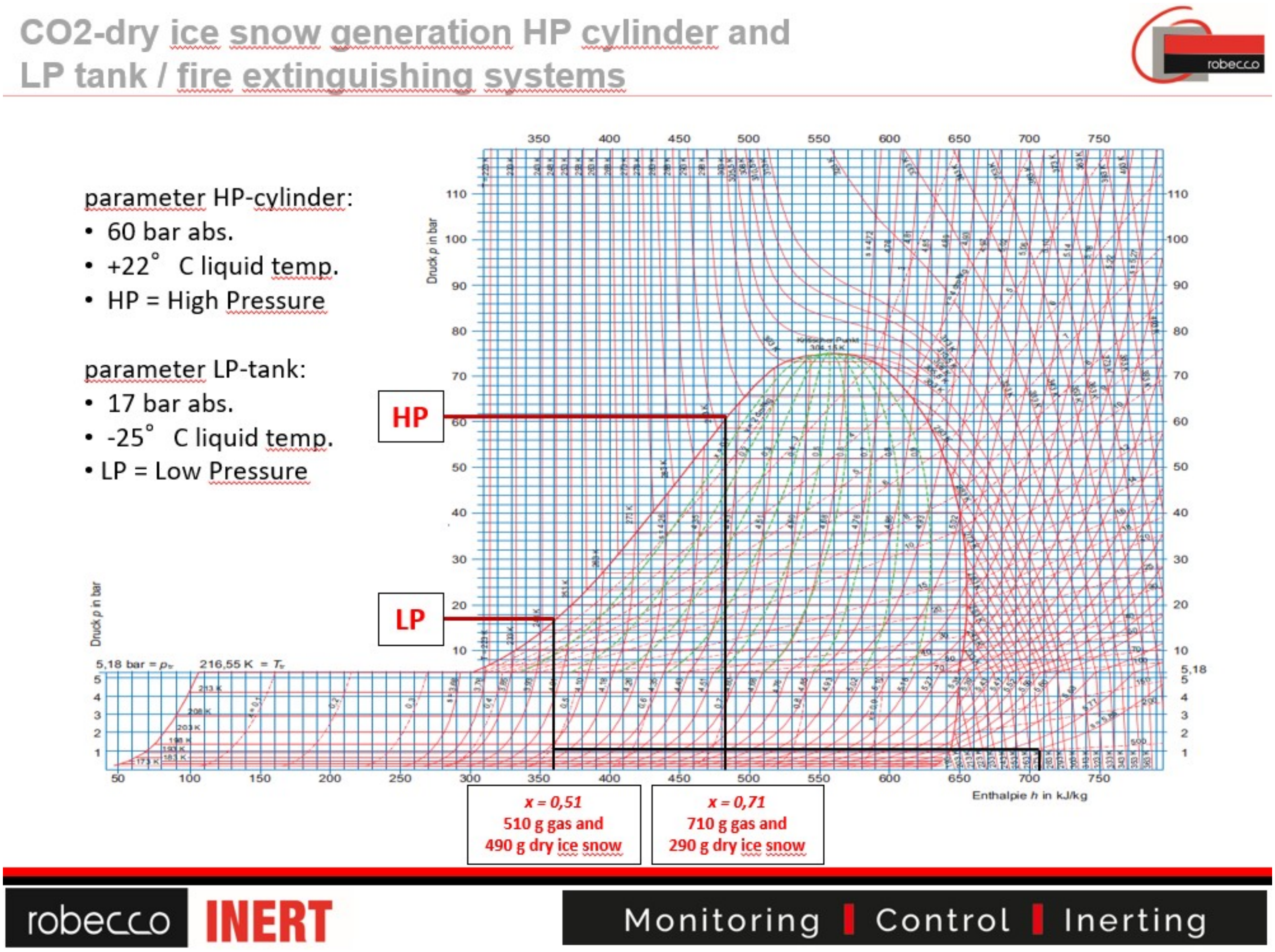
e.g. +20°C = 58bar --> dry ice snow rate is some 30% and CO_2 inert gas rate is some 70% **(cylinders)** (acc. to pressure enthalpy diagram by Plank – Kuprianoff)



Messages and information that can be taken from these physical characteristics.

1. The use of fire extinguishing tanks or cylinders will generate some 29% - 52% dry ice snow depending on pressure. After injection the snow will sublimate within shortest time into CO_2 inert gas. **It is more effective using inert gas (inerting systems) right from the beginning.**

2. A smouldering fire isn’t an open fire with flames. Dry ice snow will have n**o real impact as it is not reaching the smouldering which is normally covered by coal powder column**. Without direct contact to the smouldering fire the dry ice will sublime into inert gas.

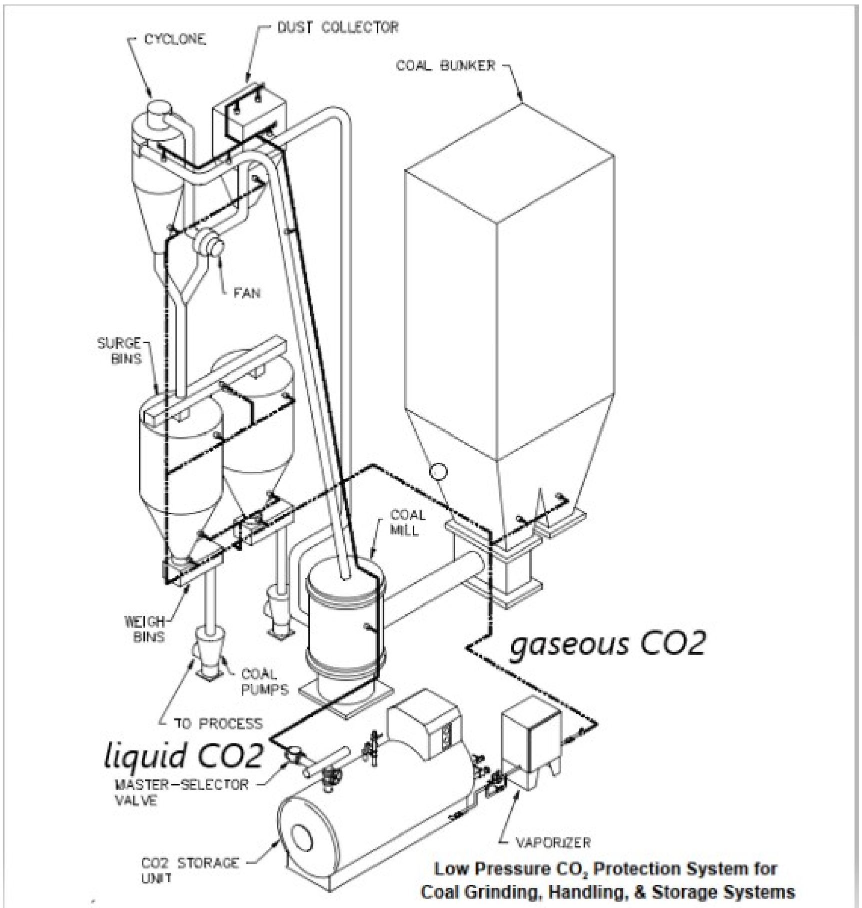
3. What will be the effect of Dry Ice snow (-78° C) if it is sprayed on hot (+150 - +200° C) sensitive metal surfaces in a coal mill ? Will there not be a **temperature shock** generated to the metal

having **consequences on the metallurgical structure ?** Therefore many coal mill manufacturers favourize CO_2 inerting systems instead of fire fighting systems.

4. Liquid CO_2 respectively dry ice cannot be used for injection into silo fluidisation systems or massive problems will be generated. Only gaseous CO_2 can be injected which is penetrating into coal powder and then extinguishing smoldering fires. An operation of coal powder silos without the possibility of inert gas injection into silo cone or silo flat bottom has to be evaluated as a high risk.

   Statement:
   A parallel installation of CO_2 inerting and CO_2 fire extinguishing system isn't recommended by robecco. The installation of a state of the art CO_2 inerting system in combination with reliable gas analysing measurement of safety-related parameters (CO, O_2, CH_4) and an independent central fully-automatic control system acc. to ATEX total system principle and regulation will generate maximum safety.

   Nearly all CO_2 tank operated fire extinguishing system do have CO_2 liquid as well as CO2 gaseous discharge (very low capacity) indicated at following drawing. Why not installing right from the beginning an efficient and highly productive inerting system.



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Statement concerning high static electricity by liquid CO_2 injection:

As manufacturer of CO_2 and N_2 inerting systems acc. to European Inerting guideline DIN EN 15281:2022 directive robecco should like to give some additional informations regarding an article "Dangers of using CO_2 **(liquid)** to quench wood pellet silo fires". The article describes the **phenomen of generation of a considerable amount of high static electricity** which is based on the physical effect when unstressing **LIQUID CO_2.**

The name of this CO_2 application is **CO_2 fire fighting** or **CO_2 fire extinguishing** acc. to European directives like German VdS 2093 or American NFPA12 or similar. CO2 is stored in high pressure cylinders (as mentioned in the article) or in CO2 tanks.

When unstressing liquid CO2 during injection by specially designed nozzles there is a **formation of dry ice particles (so called dry ice snow)**. The quantity of these dry ice particles is depending on the injection pressure / temperature and can be calculated with the help of the pressure – enthalpy diagram for CO2 by Plank and Kuprianoff.

These dry ice particles are responsible for static friction during the injection process and this static friction may ignite pyrolysis gases as described in the article. A proper earthing is a must for this kind of installations.

recommendation: Instead of using LIQUID CO_2 it is urgently recommended to use **gaseous CO_2** which cannot create any static electricity and therefore create no pyrolysis gas explosion.

This application is called **inerting** and it is possible to prevent explosions and extinguishing smoldering fires with inerting systems. robecco is specialist for this application, so called **emergency inerting** for combustible dusts and similar applications (e.g. secondary fuel, biomass, sewage sludge, wood powder storage at silos).

Unfortuneately wording of emergency inerting systems and fire extinguishing / fire fighting / fire suppression systems **are very often mixed up in literature**.

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