Fire Protection Association

RISCAuthority

ACTIVE FIRE PROTECTION GUIDE
CO_2

This document has been produced by the RISCAuthority Active Suppression & Detection working group to provide information and outline guidance on the application of CO_2.

Summary

Refer to AFPG-01 Overarching Active Fire Protection Guide – All Technologies.

Carbon dioxide:

- is a 'compartment' and 'local application' fire protection system
- must be designed to ensure extinguishment
- performance greatly depends on ventilation and sealing of the compartment it is protecting
- has good environmental credentials
- is highly and immediately toxic to humans at extinguishing concentrations
- must never be used in occupied or occupiable applications without strict controls and interlocks in place to prevent human exposure
- as a heavy gas, post-discharge removal procedures are required for low lying areas to avoid risk of harm.

What is CO_2?

CO_2 or carbon dioxide is a naturally occurring gas that is present in the earth's atmosphere at 0.037% by volume, and is classed as an inert gas and clean agent. Between the 1920s and 1960s, CO_2 was the only gaseous fire suppression agent used to any degree.

The amount of agent required for fire suppression depends upon the risk. In general, the following design concentrations are:

Total flood/surface fire – min. concentration 34%. Total flood/deep seated – min. concentration 50%. Local application by area – based on nozzle flow rate. Local application by volume – min. 16kg/m^3/min.

CO_2 is not a truly inert gas, as it is toxic and causes injuries and death by interfering with the functions of the central nervous system. In an accidental discharge of the agent in an occupied location, 5% concentration for 10+ minutes results in shortness of breath, headache, and vomiting. 10% for 2 minutes will cause unconsciousness, 11%+ at 1 minute can lead to death. (Figures quoted for a healthy adult). Death will be very rapid if exposure occurs at the design concentration.

CO_2 is stored as a liquid in cylinders at 58 bar. This is classed as high pressure CO_2, with a range of cylinder sizes (23kg, 34kg, or 45kg). CO_2 can also be bulk stored in large tanks at a low pressure of 20 bar. CO_2 as a liquid is stored under its own vapour pressure, and expands to 0.52m^3 of gas per kilogram of liquid when exposed to air at 10°C.

How it works

CO_2 systems are either total flooding gaseous extinguishing systems, or local applications 'asset' protection systems consisting of a fixed supply of the agent, connected to a piping system with discharge nozzles located in accordance with design manuals to direct the agent into a protected enclosure (floor/room/ceiling void spaces) or onto specific equipment. The systems can be manually operated but are usually operated via a fire detection system.

It discharges as a fog that can impair evacuation. In a fire situation, the discharge of agent will mix with the smoke to all levels of the compartment or machinery it is protecting at low levels, and this needs to be carefully considered in the operating protocols.

Gaseous systems are 'extinguishing systems' only. Suppression without extinguishment is a failed design.

Challenges and considerations

CO_2 can be an effective fire suppression system which extinguishes fire by reducing the oxygen concentration to a point where combustion cannot occur and prevents re-ignition with no risk or damage to equipment when engineered and installed by a competent qualified fire suppression systems installation company.

CO_2 is effective for extinguishing fires within enclosures that are unpopulated. Because of the danger to human life, the gas is normally specified to non-occupied areas for total flooding applications. Where there is possibility that the areas could be populated and where local application systems are in place, additional life safety devices such as pre-alarm warnings (1st stage, then 2nd stage) and hold-off devices and interlocks will need to be provided. Wherever the CO_2 system is installed, training is especially important for personnel who could be working in the vicinity. The No Observable Adverse Effects Level (NOAEL) and Lowest Observable Adverse Effects Level (LOAEL) of the raw agent are 3% and 10% respectively. Please see AFPG-01 for explanation.

Design standards ensure that the extinguishing concentration of gas should remain within the compartment for 20 minutes to reduce the likelihood of reignition. Sealing of the enclosure is essential. This will be determined as part of the design by the conduct of a 'door-fan test' to establish and locate leaks, and the fitment of a specific vent to protect the enclosure from overpressure damage during discharge. Because CO_2 is 50% heavier than air and will remain at low levels, specific extract systems to remove the gas will need to be considered to channel potentially harmful fire gas out of the enclosure via a route that will not endanger people.

Applicable standards

BS 5306-4:2001+A1:2012. *Fire extinguishing installations and equipment on premises. Specification for carbon dioxide systems.*

LPS 1204 – 3.1 *Requirements for firms engaged in the design installation, commissioning, and servicing of gas extinguishing systems.*

LPS 1230 – 1.2 *Requirements for fire testing of fixed gaseous fire extinguishing systems.*

NFPA 12:2022 *Standard on Carbon Dioxide Extinguishing Systems.*

CEA 4007 - *CO_2 Fire extinguishing systems.*

ISO 6183:2009 *Fire protection equipment — Carbon dioxide extinguishing systems for use on premises — Design and installation.*

F.M. Global D-S 4.11N *Carbon Dioxide Extinguishing Systems 2013.*

BS 5839-1:2017 *Fire detection and fire alarm systems for buildings. Code of practice for design, installation, commissioning, and maintenance of systems in non-domestic premises.*

BS7273:2006 *Electrical actuation of gaseous total flooding extinguishing systems.*

Effective for use with:

- engine rooms/generator rooms
- power stations
- flammable liquid storage rooms
- around large industrial machines
- non-occupied environments
- Class A, Class B, and Class C Fires
- electrical equipment (non-conductive).

Has limitations in relation to:

- Class D Fires
- combustible metals (sodium, potassium, magnesium, etc.)
- metal hydrides (sodium hydride, lithium hydride, calcium hydride, etc.)
- chemicals containing their own oxygen supply, such as cellulose nitrate
- occupied environments
- requires the enclosure to be gas tight
- requires life safety devices.

Best practice

CO_2 systems need to be designed carefully to ensure that the discharge of gas provides the correct concentration within the specific time frame, to reduce the oxygen level to diminish the opportunity for the fire to develop and allow it to be suppressed. Once discharged, the gas concentration within the room needs to be 'held' to ensure that the fire cannot be re-ignited. This is done by ensuring that the enclosure is air-tight by a room integrity test. This is undertaken by carrying out a door-fan test to investigate the fissures/unsealed air paths that could allow the enclosure to leak out the gas, while also allowing natural air back into the enclosure. Computer calculations from the fan test confirm the natural air leakage of the enclosure to verify if this can be accommodated to meet the 'hold times' for the gas. Where this is deemed to be insufficient, smoke is added to the fan test to provide visualisation of the leakage paths, which can then be sealed off as required.

Operation of the system should be interlocked with isolation of all sources of heat, energy, fuel, and conveyancing, and also invoke the main building's fire alarm system.

When designed for local application, consideration of the environment, the personnel, the amount of agent, and discharge time need careful consideration. It is also important that once discharged the gas can be readily removed via a sufficient ventilations system, and taking into account the gas density for holding in low lying areas.

Discharge of the gas is by means of a suitable fire detection system, normally a conventional two stage detection system, in which the first detection would raise the alarm, and the second detection would discharge the gas. Fully addressable systems and VESDA/air pipe sampling detection can also be used.

Mistakes at design stage can be costly in terms of performance and lead to fires not being extinguished and injuries or death to personnel. Specialist computer calculation software is essential to ensure that the design of the enclosure/s (floor void, room void, and ceiling void) and local application volume discharge the correct amount of extinguishing agent using the correct selection of nozzles and pipe sizes. Spacing of nozzles is critical to ensure that an even flow of gas is distributed throughout the enclosures, or local to the protected equipment to reduce oxygen levels within the specified discharge time required.

Best use of CO_2

'Asset protection' – CO_2 is designed as a total flood extinguishing system for use in business critical areas and local application to protect specific assets from fire damage.

'Life Safety' – Not installed for life safety, however, as a full system inclusive of fire detection system, it can aid in early detection and evacuation.

'Property protection' – Will only be considered as an extinguishment system. Failure of extinguishment and the fire will rekindle and continue unopposed.

Environmental credentials

CO_2 used in fire protection has never been cited to be phased down or considered to be a contributor to global warming, and therefore it could be ignored.

The quantity used in fire protection is so small compared with other CO_2 emissions that it is highly likely it will never be included. CO_2 is the reference material by which the GWP of all greenhouse gases are measured against, but the F-gas Regulations (EU regulation and eventually the GB regulation) are concentrating all efforts on synthetic gases, particularly HFCs, which are used in a number of applications including fire protection.