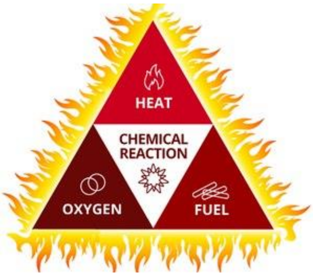
Gaseous Fire Suppression Systems

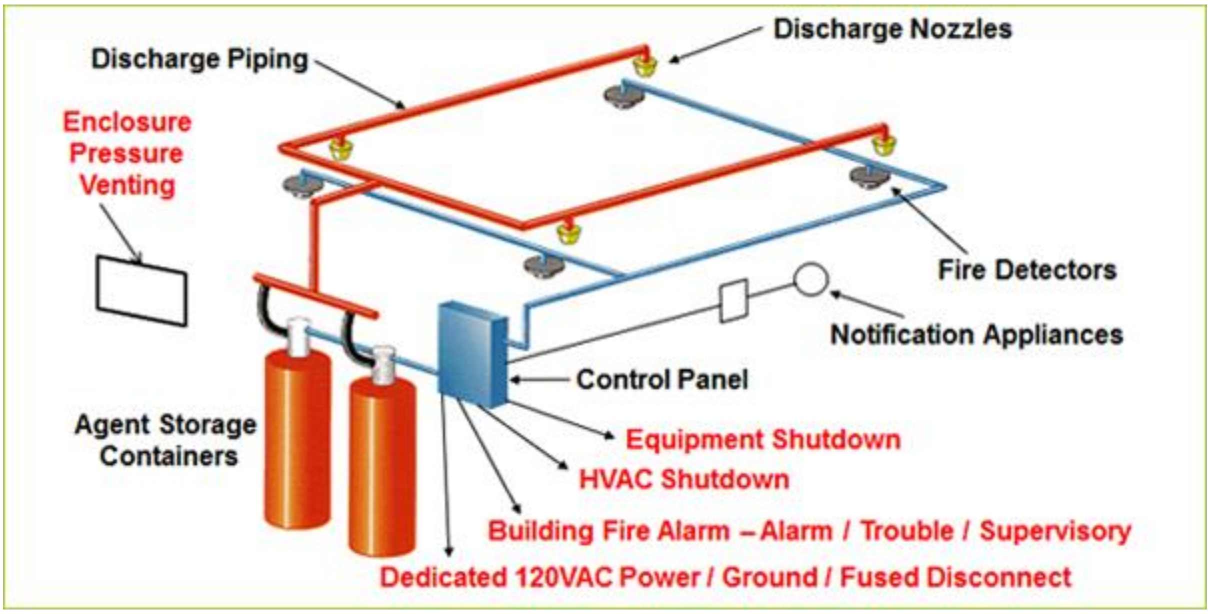
1. Introduction



Suppressions systems generally work by removing / reducing one or more elements of the "fire triangle". However, it needs to be understood that there is a fourth element which makes up the "fire tetrahedron": a sustained chemical reaction. Inert gases work primarily by reducing the available oxygen but halocarbons, as well as cooling and reducing oxygen, break the chain of reaction of the combustion process.

Gas systems are usually installed in relatively small areas where there is perceived to be high value, critical equipment the loss of which could have a serious impact on the business, or where there is a local hazard. Protection may be in the form of ***total flood*** or may comprise ***local application*** on a specific machine or utility. The gas used in such systems is classed as either ***chemical*** or ***inert*** with both being safe for use in occupied environments. Carbon Dioxide is also an effective medium but generally only used in unoccupied spaces where there is limited risk to life safety.

The gas is supplied from a bank of cylinders, via a system of pipework to one or more discharge nozzles. Discharge is brought about on activation of one or more automatic fire detectors or by manual operation. In the case of total flood systems an audible warning is given to alert people and give them time to vacate the room. In the case of CO2 protection there will normally be a lock-off arrangement designed to prevent operation whilst the room is attended. CO2 is potentially lethal at fairly modest concentrations.



Most total flooding gas installations are designed for automatic discharge set to operate on a double knock basis from the activation of conventional smoke heads. The activation of the first smoke head will initiate an alarm and, following a programmed delay, the activation of the second head will cause the system to discharge. Pipework and nozzles should extend into all areas in the protected space including ceiling and floor voids. The system needs to be interfaced to shut down any air-conditioning or ventilation systems prior to discharge. A manual discharge/override will ordinarily be provided.

For total flood systems it is essential that the gas be retained for a pre-defined period. For some gases this is easier than for others. In order to test the integrity of an enclosure full discharge tests used to be undertaken. Now alternative integrity testing procedures have been developed which do not require discharge of the gas. Equally critical is that the integrity of an enclosure is maintained. The integrity is often good until alterations are made, for example services being fed into the enclosure and surrounding gaps not fire-stopped.

2. General Applications

a) High value equipment. In some high tech industries (e.g. microchip fabrication) single pieces of relatively small equipment can be valued at several millions of pounds sterling. In such circumstances even if the premises are sprinklered further protection in the cabinet might be considered.

b) Criticality. Computer systems, telecommunications equipment and centralised control rooms are often critical to a business or to continued production. If these are not easily and quickly replaced or circumvented then protection is merited. Another critical area for production may be plant rooms and in particular electrical switch rooms and sub-stations. Redundancy and methods of circumvention should be considered. Some production equipment might also be considered critical and difficult to replace.

c) Hazard. Local protection may be required where a particular hazard exists. Examples might include flammable liquids stores, printing presses, lacquering lines, oven flues and plant rooms. Such hazards might even merit localised or spot protection even where there is overall protection by sprinklers. Extract flues or ducts may also have the added hazard of being joined into common ducts. A fire in one oven, for example might spread up the ducting and through the common duct rendering all ovens inoperative. Where the extracted fumes are dealt with in a thermal oxidiser at the end of this line then the consequences can be even more serious as such plant cannot be replaced quickly.

d) Complimenting sprinklers. Protection of high value or critical equipment makes little sense unless the remainder of the premises is protected, usually by sprinklers. The exception would be where they form an isolated fire risk as is sometimes the case with external electrical rooms and flammables stores. Additional protection may be required in areas where there is a reluctance to install sprinklers (e.g. electrical rooms and computer rooms) or where a faster acting solution is needed, with the sprinklers as back-up.

NOTE: the driver for installing gas systems in preference to water is often the fear of water damage (water either being legitimately or accidentally discharged). In enclosed electrical cabinets and the like this fear is justified as a fire would need to be fairly well developed before sprinkler heads activate and large amounts of water are discharged.

3. Halocarbons (chemical gases)

Mechanism

Chemical gases function by breaking the chain of reaction of the combustion process, cooling the fire and reducing the available oxygen. They are fluorocarbons that utilise fluorine so have zero ozone depletion potential. Halocarbons are, however, "greenhouse" gases. They are currently accepted in most countries, although banned in parts of Scandinavia.

Halocarbon systems utilise a smaller volume of gas than their competitors and this can save costs on initial installation, although refills are more expensive. Due to the smaller gas volume required they may also be quicker in suppressing a fire. Gas concentrations are typically around 7 or 8%.

However, where halocarbon does not immediately suppress a fire there is break down of the gas, products of which include hydrogen fluoride, a highly corrosive gas when moistened. It is therefore essential that a sufficiently high concentration is achieved on release of the gas and within the shortest possible time.

For manned areas the maximum allowed concentration, below which there is no discernible effect on people, is close to the minimum effective concentration. Therefore, for manned areas the system must be very carefully engineered to be effective and henceforth the area very carefully controlled to prevent changes or deterioration that might diminish the effectiveness of the system.

Advantages: Fast fire extinguishing; minimal thermal shock; zero ozone depletion; relatively small storage space; suitable for occupied areas; over-pressure venting not necessarily required.

Disadvantages: More expensive than inert gases; global warming potential; thermal decomposition product

The most common product on the market is FM 200, but also available are FE 13, FE25, FE227, Novec 1230 and CEA 410

4 Inert Gases

Mechanism

Inert gas systems operate by oxygen depletion, usually reducing the concentration in an enclosure to between 10 and 15%. Systems use naturally occurring gases such as nitrogen, argon and CO2.

The biggest disadvantage with these systems is the number of cylinders required. This can be a problem where space is at a premium and may also result in extra cost, although refills are cheaper.

A big advantage is the lack of any break down products or corrosive effect and the naturalness of the gases involved (which should eliminate the risk of any future restrictions on use). Another advantage is the much wider gap between the minimum effective level and the maximum level at which there is no discernible effect. This combined with the neutral buoyancy of the gas gives much greater effective design latitude. The neutral buoyancy results from the gas having the same density as air. This means that it is much less prone to leakage and integrity of the enclosure is much less critical.

Gas concentrations can be up to 35% which means discharge is associated with a large increase in pressure in an enclosed space. Well designed and maintained pressure venting is therefore essential to avoid structural damage.

Advantages: No thermal decomposition products; lower cost than chemical agents; no ozone depletion/global warming potentials; excellent retention times; safe for occupied areas; no thermal shock.

Disadvantages: greater storage space than halocarbons; over-pressure venting required; longer discharge times.

Common product names includes Argotec (99% argon), Argonite IG55 (50/50 nitrogen and argon), Inergen IG541 (52% nitrogen, 40% argon and 8% CO2) and Inertsafe300 (IG541).

5 Carbon Dioxide

Mechanism

CO_2 systems act via the dilution of Oxygen and cooling action. As stated above CO2 is a "greenhouse gas". However, in this case it is obtained as a by-product from industry or by direct extraction from the air. It is not therefore a significant net contributor to global warming. Its ready availability is unlikely to change. It is cheap and it is clean but it becomes hazardous to human health in concentrations above 6%.

Advantages: low refilling cost; suitable for deep-seated fires; no residue to clean up after discharge; zero ozone depletion potential; electrically non-conductive; excellent grade of risk penetration; local or total flooding; non-corrosive; no thermal decomposition products

Disadvantages: life safety considerations; interlocks required; thermal shock potential; enclosure leakage significant

6. Integrity Testing

Where gas is employed as a total flooding system (in an enclosed room) routine room integrity testing will be required, usually via fan door test. Initial testing is essential to: predict the agent hold time; identify leakage area; and eliminate the need for discharge testing. Routine (NFPA suggest annual though this is quite onerous) retesting is required to assess the implications of modifications and extensions. A "fan door integrity test "calculates the leak-tightness of a room. It predicts how long the extinguishing agent will remain at the correct concentration to effectively suppress the fire. NFPA 2001, Standard on Clean Agent Fire Extinguishing Systems, requires that a minimum concentration of 85% of the adjusted minimum design concentration be held at the highest level of combustibles for a minimum period of 10 minutes.

A large fan is temporarily installed in the doorway of the room to be tested, with the fan blowing into the room (pressurizing the room). The fan speed is adjusted to obtain flow pressure equivalent to the pressure exerted during a fire suppression system discharge. The fan is then reversed on the door to draw air from the room (depressurizing the room). The airflow and pressure readings obtained are entered into a computer program designed to calculate the equivalent leakage area (ELA) for the room. When a room has a suspended (drop) ceiling, then the below ceiling leakage area (BCLA) is calculated as one-half the total ELA and is used in the calculations for retention time.

Given that most gaseous chemical agents used for fire suppression are heavier than air, the agent will begin to leak out of any lower level penetrations left unsealed.

7. Over Pressure Venting

Over Pressure Vents are designed to allow pressure relief within a room during the discharge of a Fire Suppression Agent especially Inert Gas Fire Suppression Systems. This is because the amount of gas being added to the room could be up to 50% more than was there before. This creates an over pressure that must be vented to fresh air to ensure that the walls, windows or doors are not damaged during a discharge. Four types of vent are available: gravity vents; counter-weighted flap vent; electrically operated; and pneumatically operated.

Preferably the vent should either go straight to fresh air or be ducted to fresh air. In the event this is not practical you can vent to an adjacent room as long as the adjacent room is 10x the volume of the room being protected. You cannot extract to an adjacent room only vent to it and only where it is not practical to vent to fresh air.

Inert Gas Over Pressure Vents: part of the minimum requirements and local standards for many years (see BS EN 15004) and critical as the pressures within a room during a discharge of the Inert Gas can be strong enough to damage suspended ceilings (especially if gas is not discharged into the ceiling void), walls, windows and doors. In fact it will go for the weakest point in the room, so it is imperative that Over Pressure Vents are fitted to all rooms containing Inert Fire Suppression Agents

Clean Chemical Agents Dual Pressure Vents: these are different as the pressures exerted during a discharge are both positive and negative . This means that not only does the Pressure Vent have to operate to allow for positive pressure but also for negative pressure. The Pressure Vent has two vents within one enclosure, one allowing positive pressure to fresh air and a second vent that allows negative pressure to pull air from the outside. Although not part of the current standards vents are recommended for Clean Chemical Suppression System installations such as FM200, FE-227 and Novec 1230.

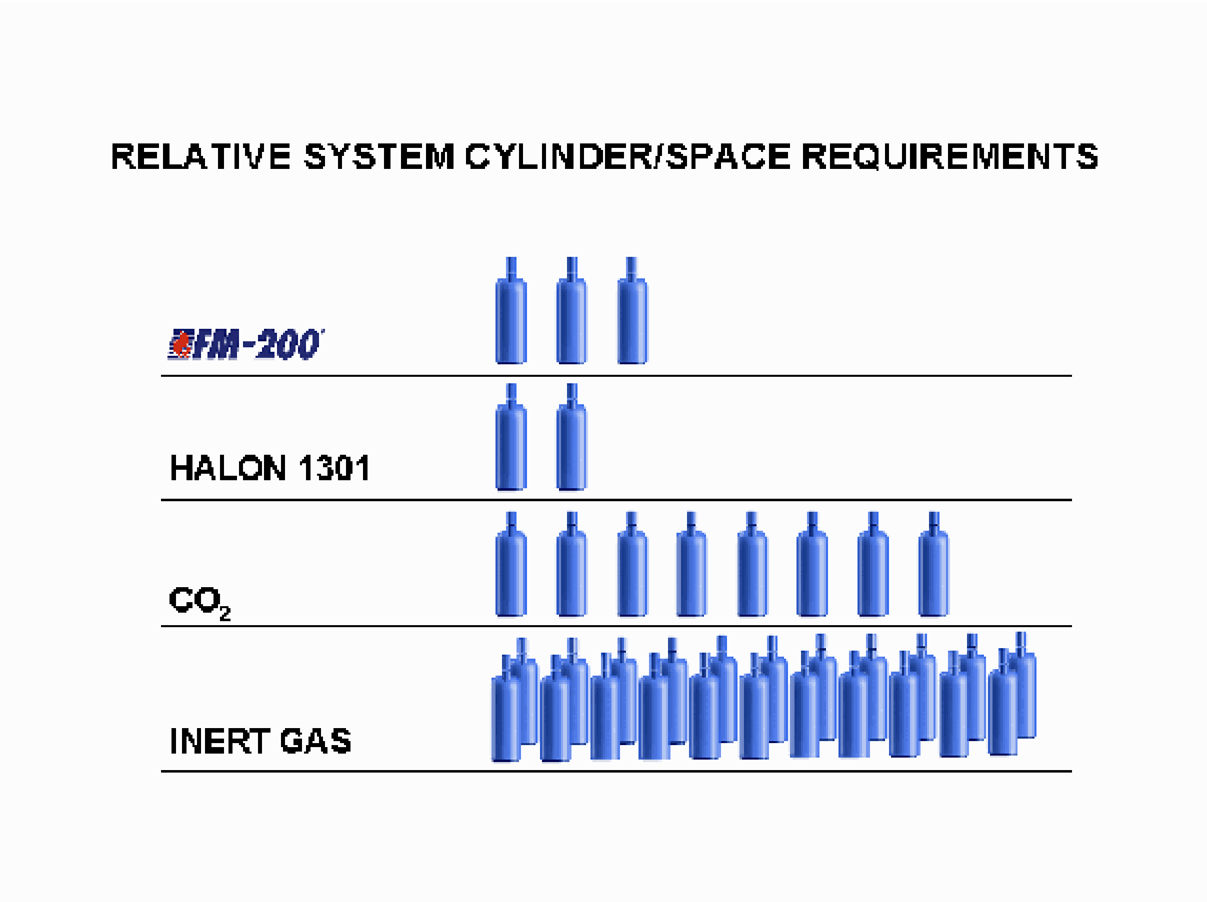
How To Calculate the Size of a Pressure Vent: information required is the room volume, type of Fire Suppression System and maximum allowable room pressure in pascals. The maximum allowable pressure in pascals is usually the hardest thing to get from any building designer or engineer as it is not normally calculated so as a rule of thumb: :-

Room Materials	**Pressure (pascals)**
Block	500
Timber	250
Glass	100

This information is then input into a Pressure Vent Calculator that will calculate what is termed the minimum Free Vent Area. This is the minimum area required to vent and this applies to the vent blades as well as the duct if fitted. Care must be taken in selecting the correct size of vent and multiple vents must be used if the largest vent is not big enough or multiple small vents need to be installed for aesthetics or practicalities.

Combined Pressure Vent and Extraction Vent (Clean Chemical Systems only): As with all Fire Suppression System installations if there is no natural venting to fresh air e.g. a door to fresh air within the room, then forced venting must be provided to ensure that after a fire and or discharge that any contaminants such as smoke or the Fire Suppression Agent itself can be extracted.

With Clean Chemical Agents such as FM200 and Novec 1230 the Extract Vent can be combined with the Pressure Vent so that only one system has to be installed, saving wall space and money. To extract a Clean Chemical Agent a floor box Extraction Vent is installed, as the agent is heavier than air and the Pressure Vent is fitted to the front of the box.



8. Local Applications

Localised systems such as "Firetrace® can provide cost-effective small scale solutions for applications such as electrical/control cabinets; engine bays; laboratory / fume exhaust cabinets; CNC machines and data storage. Such systems usually comprise an extinguishant cylinder linked to polymer tubing which will rupture when subjected to heat causing extinguishant to be released directly onto the seat of a fire. In this "direct" arrangement the tube therefore acts as detector and delivery system. When arranged as an indirect system the tubing will act as detector only with delivery via copper, steel or braided pipework and fixed nozzle. The system will usually be configured with an electrical output to allow connection to a fire alarm system and, ideally, an electrical interface to shut down the cabinet (power and fan) to prevent re-ignition. A variety of extinguishing mediums are available (depending on the application) including FM200, dry chemical powders, CO2, foam and water.

Whilst Firetrace is possibly the most widely recognised local application system there are others available. For example the Redetec system utilises fixed smoke heads or HSSD within a cabinet to detect fire and discharges via fixed nozzles. A choice of suppression mediums are also available.

9. Relevant Standards

In the UK systems should be installed by a LPS1204 certified company in accordance with BS EN 15004-1:2019

Standard	Scope	Applicable to
LPS1204 (Issue 3.1) Requirements for firms engaged in the design installation, commissioning and servicing of gas extinguishing systems	Sets appropriate technical and quality standards to assure interested parties that gas extinguishing systems are properly designed, installed, commissioned and serviced to safeguard life and/or property.	All gases
BS EN 15004-1:2019 Fixed firefighting systems. Gas extinguishing systems. Design, installation and maintenance	One in a series of European standards on gas extinguishing fixed firefighting systems. This part deals with system design, installation and maintenance, while the other parts cover physical properties and system design for individual extinguishants.	All gases
NFPA 2001 – Standard Clean Agent Fire Extinguishing Systems	Requirements for total flooding and local application clean agent fire extinguishing systems. It is intended for use by those who purchase, design, install, test, inspect, approve, operate, and maintain engineered or pre-engineered gaseous agent fire suppression systems so they will function as intended when needed.	All gases
NFPA 12: Carbon dioxide extinguishing systems.	Requirements for carbon dioxide fire-extinguishing systems to help ensure that such equipment will function as intended throughout its life. It is intended for those who purchase, design, install, test, inspect, approve, list, operate, or maintain these systems	CO2
BS 5306-4:2001+A1:2012 Fire extinguishing installations and equipment on premises. Specification for carbon dioxide systems	Specifies requirements for the provision of carbon dioxide fire extinguishing systems in buildings or industrial plant.	CO2
LPS1666 Requirements and Test Procedures for the LPCB approval of direct low pressure (DLP) application fixed fire suppression systems	Standard for systems using heat sensitive pneumatic detection tubing designed for the protection of small unoccupied enclosures such as electrical switchgear cabinets, server racking and similar installations from small local flaming fire sources	Firetrace (& other local applications)

10. Risk Management Checklist

- Does the Installing company have LPS 1204 certification?
- Has the system been installed in accordance with **BS EN 15004-1:2019** ***Fixed firefighting systems. Gas extinguishing systems. Design, installation and maintenance***
- Has the room/compartment been constructed with a recognised degree of fire resistance (minimum 1 hour being recommended)
- Has the cause and effect matrix been verified as part of the commissioning?
- Is suitable over-pressure venting provided (type, size and routing)?
- Is the pressure vent clear of obstructions?
- Is the system configured to discharge gas into all required spaces including ceiling and floor voids?
- Is there an audible warning and time delay prior to discharge of the gas?
- Is there an interface between the gas system and the air handling equipment: the latter being shut down prior to gas discharge?
- Is the installation linked to the building's fire alarm?
- Are there manual hold-off buttons to prevent the release of the gas if personnel are trapped inside the space?
- Is there a maintenance contract in place with a LPS 1204 Certified Company?
- Has the enclosure been pressure tested?
- Has the enclosure been retested after any internal alterations (or after at least three years if no changes have been made)?
- Does the control panel show the system as being in automatic mode? (the system is often manually switched to manual when the space is entered and needs to be switched back)
- Are the pressure gauges on the storage cylinders routinely inspected to ensure the gases have not leaked?

11. Alternatives to Gas Suppression

Sprinklers

Gas suppression is usually installed where sprinklers are deemed to be unsuitable e.g. around sensitive electronic equipment so they are rarely a viable alternative. However, you will sometimes find pre-action sprinkler installations in equipment rooms whereby the pipes are maintained in a dry state and are only filled by the activation of a fire detection system (often configured on a double knock basis). Where such a strategy has been implemented it is also common to find high sensitivity (often aspirating) detection to give very early warning of an incipient fire which initiates a well-practised and robust emergency response. The sprinklers are generally installed as a fall back to protect the building should this emergency response fail.

Water Mist

This is considered a viable alternative to gas suppression and sprinklers in a wide range of applications, including equipment enclosures. Water mist suppresses by its cooling action though, if discharged for sufficient time, will also reduce the oxygen content in an enclosed space. It uses far less water than sprinklers so the risk of excessive water damage is reduced. There are many factors to consider when deciding whether to choose water mist in preference to gas which cannot be covered in this guidance. However, the key factor to consider is whether it has been tested in an application / environment that mirrors the area / application you are looking to protect.

Wet Chemicals / Foam

Generally used in environments with flammable liquid / hot oil risks so limited overlap with gas flooding systems (though gas sometimes used with flammable liquids). Wet chemical suppression is commonly found in kitchens or hand extinguisher applications. Foam is used for protection of larger spaces such as aircraft hangars or over/around large flammable liquid installations.

Inerting Systems

These types of systems reduce the oxygen content of the air to below that which will sustain combustion (circa 14%) hence removing the fire risk completely. Systems such as Oxyreduct do this by introducing nitrogen into the space from an on-site generator. The space is closely monitored for oxygen content and the protected space is safe for occupation. Such a system may be cost prohibitive for small applications due to the initial infrastructure and on-going running costs but can be very effective in large equipment rooms. Also very effective for archives and the like as it removes all risk of consequent damage. As with gas suppression the room integrity (leakage rate) becomes critical but it has been successfully (and cost-effectively) deployed in very large high bay (30m) warehouses so its range of potential applications is wide.

Further information and guidance on this subject is available from:

- The Health and Safety Executive - https://www.hse.gov.uk/
- The Fire Protection Association - https://www.thefpa.co.uk/
- Other trade bodies

For clarification or further information please contact –

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