GASEOUS AUTOMATIC SUPPRESSION SYSTEMS

Gaseous fire suppression is a term to describe the use of inert gases and chemical agents to extinguish a fire; also called Clean Agent Fire Suppression. These Agents are governed by the NFPA Standard for Clean Agent Fire Extinguishing Systems - NFPA 2001, as well as NFPA Standard for Carbon Dioxide Fire Extinguishing Systems - NFPA 12.

The systems typically consist of the agent, agent storage containers, agent release valves, fire detectors, fire detection system (wiring control panel, actuation signaling), agent delivery piping, and agent dispersion nozzles. While NFPA 2001 designated systems are designed for total flooding protection only, there are two methods for applying a Carbon dioxide agent: total flooding and local application.

The main difference in local application from total flooding design is the absence of physical barriers enclosing the fire space. In the context of automatic extinguishing systems, local application does normally not refer to the use of manually operated wheeled or portable fire extinguishers, although the nature of the agent delivery is similar.

These systems shall be designed, installed and maintained by certified professionals. Proper records shall be kept for all works in relation to these systems.
## Applications

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## CO₂ vs Clean Agents

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HIGH PRESSURE CO2 SYSTEMS
Every enterprise has equipment and facilities that are vital to its operation. Business would be seriously affected if these were destroyed by fire.
In many cases valuable assets should not be protected by water or other similar extinguishing agents, as these types of agents often are unable to reach inaccessible parts of the hazard. They can also cause considerable damage - even in excess of that done by the fire itself.

Carbon dioxide is a reliable, versatile and efficient fire fighting agent. It has provided decades of successful operation. It is a dry, inert, non-corrosive gas that will not damage equipment or materials or contaminate liquids or food.
It does not leave any residue to clean-up, and as a result, business down-time is held to a minimum. In addition, carbon dioxide is a non-conductor of electricity, and can even be used without danger in spaces housing high voltage electrical equipment.

Why CO2...
Carbon dioxide is a standard commercial product that is commonly used for carbonated beverages, for fast freezing food, for medical purposes, for purging pipes and tanks, as well as for extinguishing fires. It is readily available in most cities and seaports throughout the world. For more than 80 years carbon dioxide has been used for fire protection purposes. The NFPA standard for fire extinguishing systems was initiated in 1928, was first adopted in 1929.
It has been revised approximately 26 times since, and represents the accumulated knowledge and experience of those who have designed and used CO2 systems for fire extinguishing purposes.

ADVANTAGES OF CO2 FIRE EXTINGUISHING SYSTEMS
- A viable agent for the foreseeable future. No ban on its use.
- Is well established. Has been successfully used for 80 years.
- Is a standard commercial product with many other uses and as a result is readily available in most towns and cities around the world.
- Low agent cost. Beneficial when frequent recharging is a factor, such as with engine test cell protection.
- Installed system cost is lower when compared to clean agents.
- Is stable and inert.
- Does not decompose when subjected to fire.
- Does not cause corrosion or damage materials and equipment.
- Vaporizes completely on discharge. No clean-up of agent required.
- Protected facilities can be back in operation with a minimum of delay.
- Suitable for Class A, B and C fires.
- Four proven and standard methods of application:
  - Total flooding, surface burning.
  - Total flooding, deep seated burning.
  - Local application, area method.
  - Local application, volume method.
  - Accommodates long pipe runs.
  - Readily accommodates systems with selector valves (integrated systems that protect more than one hazard from a common carbon dioxide supply).
  - Carbon dioxide discharges by the force of its own expansion. Does not require super-pressurizing agents, pumps, or other pressurizing mechanisms.
  - May be used simultaneously with other types of extinguishing agents with no effect on extinguishing efficiency.
HIGH PRESSURE CO2 EXTINGUISHING SYSTEMS EXPLAINED

- High pressure storage systems are comprised of CO2 cylinders stored at ambient temperatures. At 70 °F (21 °C), the pressure in this type of storage container is 850 psi (5860 kPa). Low pressure storage systems, on the other hand, are comprised of CO2 cylinders stored at a controlled low temperature of 0 °F (-18 °C). At this temperature the pressure in this type of storage is 300 psi (2068 kPa).

- Advantages of high pressure systems: High pressure cylinders are available in 50, 75 and 100 lb (20, 34 and 45 kg) capacities. Low pressure containers are typically available in one ton increments. This greater flexibility among high pressure systems allows the system designer to allocate storage with greater efficiency, thus saving storage space and money.

- Refrigeration of carbon dioxide is not required. Cylinders can be stored without any special treatment at temperatures between 0 °F and 130 °F (-18 °C and 54 °C) for total flooding systems, and 32 °F to 120 °F (0 °C to 49 °C) for local application. Cylinders can be easily adjusted for higher or lower temperatures by under-filling for higher temperatures, or adding nitrogen for lower temperatures.

- Flexible space requirements – if a single large space is not available, multiple cylinder banks can be divided and stored in a number of smaller locations.

- Flexible for weight requirements – if floor loading is a problem, multiple cylinder banks can be divided and stored in a number of locations to distribute the floor loading.

- Electric power is not required for high pressure carbon dioxide storage.

PRINCIPLES OF OPERATION

A carbon dioxide system consists of a battery of one or more cylinders, manifolled together and connected to a system of distribution pipe work terminating in special carbon dioxide discharge nozzles.

These systems are custom designed for the specific application. The quantity of carbon dioxide required for the protection of any particular hazard is dependent on the cubic capacity or the surface area of the hazard, together with the type of material involved, temperature of the hazard, and with allowance for special conditions. More than one hazard can be protected by the same bank of cylinders, and these systems are referred to as joint systems. Selector or directional valves are utilized to direct the carbon dioxide to the fire area. An interconnected reserve bank of cylinders is generally recommended for this type of protection.

Carbon dioxide systems may be actuated manually or automatically. Automatic systems incorporate fire detectors and controls. The fire detectors are located in the hazard area, and when a fire occurs, send a signal to the control panel which releases the carbon dioxide. Automatic systems are electrically operated and always incorporate a manual override feature.

METHOD OF APPLICATION

There are two methods of applying carbon dioxide to hazards: Total Flooding and Local Application.

Total flooding injects a sufficient volume of carbon dioxide into an enclosure so that an inert atmosphere is created. The enclosure should be reasonably well sealed and doors,
vents and other openings should be arranged to close on the discharge of the system. Enclosures with openings that cannot be closed can be protected if known at the design stage. For deep-seated type hazards (insulation, rags, storage vaults, etc.) The enclosure must be well sealed to retain the carbon dioxide for a long period of time. The location and orientation of discharge nozzles for these applications is not of major concern, minor deviations to project design can generally be accommodated.

Local application is the method used to protect a specific hazard (engine, dip tank, etc.) within an enclosure – without flooding the entire enclosure. Nozzles are arranged to discharge carbon dioxide directly onto the hazard, to build up an inert atmosphere immediately surrounding the hazard. For this application, the layout of piping and nozzles is critical, and deviations to project design must not be made unless approved by the designer.

**PROPERTIES OF CO₂ AS A FIRE EXTINGUISHING AGENT**

Carbon Dioxide (CO₂) is a colorless, odorless, clean, dry, electrically non-conducting, non-corrosive, non-damaging and non-deteriorating inert gas, that is approximately 50 percent heavier than air.

Carbon dioxide is a standard commercial product. It is commonly used for carbonating beverages, for fast freezing food, for medical purposes, and for purging pipes and tanks, as well as for extinguishing fires. Carbon dioxide is available in most cities and seaports throughout the world.

When inhaled, CO₂ produces a tingle in the nostrils, the same as is experienced when drinking carbonated beverages. Carbon Dioxide stimulates breathing (increases the rate of breathing), and is useful in small controlled doses in the resuscitation of drowning and electric shock victims. Carbon Dioxide is stored in liquid form in high pressure steel containers, usually at 850 psig at 70 °F (58 bar at 21 °C). It may also be stored at 300 psig at 0 °F (20 bar at -18 °C), for special large requirements. One of carbon dioxide’s most valuable properties is its amazing high ratio of expansion, approximately 450 to 1.

Carbon dioxide is discharged from the cylinder by the force of its own expansion – without the need for pumps or other pressurizing mechanisms. Carbon dioxide will penetrate every nook and corner of a space where fire might lurk.

On discharge, carbon dioxide creates a cold fog. The temperature of carbon dioxide discharging from a nozzle is approximately 110 °F below zero. This cloud effect, or fogging, is due to the moisture in the air being frozen by the extremely low temperature of the Carbon Dioxide and fine “snow” accompanying the discharge. The fogging will generally dissipate after a few minutes.

**HOW CARBON DIOXIDE EXTINGUISHES FIRE**

Carbon Dioxide extinguishes fire by diluting the oxygen content of the space to a point where it will not support combustion. Reducing the oxygen content from the normal 21 percent in air to 15 percent will extinguish most fires. For some materials the oxygen content must be reduced below 15 percent, and in some cases its concentration needs to go down to as low as six percent of the volume. Surface and flash type fires (oils, paints, etc.) are quickly extinguished, while smouldering or deep-seated fires (baled cotton, clothing, etc.) are extinguished by the prolonged action of a high concentration. In addition to its smothering action, the reduction in temperature due to its rapid expansion will provide some suppression caused by the cooling effect.

**CLEANUP FOLLOWING A CO₂ DISCHARGE**

Carbon Dioxide vaporizes completely on discharge. Whereas the cost of clean-up and
peripheral damage associated with water, foam, and dry chemical agents can exceed the cost of the fire damage itself, cleanup costs associated with carbon dioxide are negligible.

Carbon Dioxide is inert and most materials and equipment are totally unaffected by exposure to it. Carbon dioxide is stable, even at high temperatures, and does not decompose when subjected to fire, therefore it does not cause metals to corrode. The reduction in temperature, caused by the dramatic expansion of the Carbon Dioxide as it discharges from the nozzles, can have a strong chilling effect on objects, including cord shock to delicate electrical equipment.

COMPATIBILITY WITH OTHER EXTINGUISHING AGENTS
Carbon Dioxide may be used simultaneously with other types of fire extinguishing agents for fire fighting purposes. There are no known indications that extinguishing efficiency will be affected.

Use and Limitations
Carbon Dioxide Systems may be utilized for Class, A, Band C fires (North American definition). They are particularly useful for extinguishing fires in specific hazard areas or equipment:
- Where an inert, electrically non-conductive medium is desirable,
- In high value occupancies particularly susceptible to fire, smoke, and water damage,
- Where clean up of another medium would present a problem,
- Where they are as efficient as, but more economical to install than systems using other extinguishing agents.

CARBON DIOXIDE WILL NOT EXTINGUISH FIRES INVOLVING THE FOLLOWING MATERIALS:
- Chemicals containing their own oxygen supply such as cellulose nitrate,
- Reactive metals such as sodium, potassium, magnesium, titanium, zirconium, uranium and plutonium,
- Metal hybrids.

While carbon dioxide will not extinguish these fires, it will not react dangerously with these materials or increase their burning rate. Carbon Dioxide, if used in this type of situation in a total flooding system, will provide protection for adjacent combustibles.

Local application systems with attendant high velocity directed discharge should not be used. Caution is required where carbon dioxide may be discharged into potentially explosive atmospheres. Electrostatic charging of non-grounded conductors may occur during the discharge of liquefied gases. These conductors may discharge to other objects, causing an electric spark of sufficient energy to initiate an explosion.

CO2 Safety Precautions
Safeguards must be taken to ensure the safety of personnel in areas where the atmosphere could be made hazardous by the discharge of carbon dioxide. The following list, which is strongly recommended, is generally taken from NFPA 12: Standard on Carbon Dioxide Extinguishing Systems.

- Provide adequate aisle ways and routes of exit and keep them clear at all times.
- Provide emergency lighting and directional signs as necessary to ensure quick, safe evacuation.
- Provide alarms within such areas that will operate immediately upon detection of the fire, with the discharge of the carbon dioxide and the activation of automatic door closures delayed for sufficient time to allow evacuation of the area before discharge begins.
- Provide only outward swinging self-closing doors at exits from hazard areas, and, where such doors are latched, provide panic hardware.
- Provide continuous alarms at entrances to
such areas until the atmosphere has been restored to normal

- Provide warning and instruction signs at entrances to and inside such areas. These signs should inform persons in, or entering the protected area that a carbon dioxide system is installed, and may contain additional instructions pertinent to the conditions of the hazard.

- Provide for the prompt discovery and rescue of persons rendered unconscious in such areas. This may be accomplished by having such areas searched immediately by trained persons equipped with proper breathing equipment. Self-contained breathing equipment (and personnel trained in its use, and in rescue practices, including artificial respiration), should be readily available.

- Provide instruction and drills for all personnel within or in the vicinity of such areas (including maintenance or construction people who may be brought into the area), to ensure their correct action when carbon dioxide protective equipment operates.

- Provide the means for prompt ventilation of such areas. Forced ventilation will often be necessary. Care should be taken to really dissipate hazardous atmospheres and not merely move them to another location.

- Carbon dioxide is much heavier than air and can collect in pits, cellars and low-lying areas. Care should be taken when entering such areas after carbon dioxide has been discharged.

- Provide means to lock off or disarm the system during periods of system inspection, maintenance, or modification.

- Provide such other steps and safeguards that a careful study of each particular situation indicates are necessary to prevent injury or death.

**STANDARD EQUIPMENT AND OPTIONAL COMPONENTS**

**Cylinder Assemblies**

A basic cylinder assembly consists of a pressure vessel, a valve and siphon tube assembly, and a charge of carbon dioxide. A variety of cylinder sizes are available. They are all designed to hold pressurized carbon dioxide in liquid form at atmospheric temperatures, corresponding to a nominal pressure of 850 psi at 70 °F (58.6 bar at 21 °C). All cylinders are seamless. They are manufactured and tested in accordance with the requirements of Transport (EU) and/or Department of Transport (USA), Specification 3AA-1800 or higher. Large cylinders having capacities of 35, 50, 75 and 100 pounds (15.9, 22.7, 34 and 45 kg) are made of steel. Small cylinders, used for special applications, have capacities of 10 and 15 pounds (4.5 and 6.8 kg) and may be made of aluminum or steel, depending on availability.

Except for special temperature conditions, all cylinders are filled to their specified weight with liquid carbon dioxide. Cylinders are not partially filled. The pressure inside the cylinder will vary as the temperature changes.

In general, the ambient storage temperature for standard cylinders used in local application systems should be between 32 °F and 120 °F (0 °C and 49 °C). For standard cylinders used in total flooding systems, the ambient storage temperature should be between 0 °F and 130 °F (-18 °C and 54 °C). The valves are of the force differential type using a piston seal. The pressure above the piston is maintained at cylinder pressure.
but the area at the top of the piston is greater than the seal area. This results in a higher force above the piston, which acts to keep the valve closed.

To open the valve, the pressure above the piston is vented and cylinder pressure raises the piston to open the valve. A transport plug is attached to the valve by a chain and must be attached to the discharge port when the cylinder is disconnected from the discharge piping.

A pressure relief safety disc, incorporated into the cylinder valve, is designed to release pressure should the cylinder be subjected to exceptionally high temperatures or other abnormal conditions. The disc rupture point is in the range of 2,600 to 3,000 psi (182.7 to 206.8 bar). The safety disc nut is of a type that will relieve pressure without cylinder recoil.

The master valve can be operated manually, by pressure actuator, with a solenoid valve kit, or by direct back pressure from the discharge manifold. The slave valve can be operated only by direct back pressure from the discharge manifold.

Single cylinder systems simply require a single valve with a manual actuator and/or a solenoid valve. This is generally referred to as a master cylinder. For systems with two cylinders interconnected, only one master valve is required. The other cylinder is operated by a slave valve. For systems with three or more cylinders interconnected, some cylinders must act as masters and have solenoid and/or manual actuators arranged for simultaneous operation.

A rigid siphon tube is used in all cylinders to ensure liquid discharge. All cylinders must therefore be installed in the normal upright position.

**DISCHARGE BEND AND DISCHARGE ADAPTERS**

A discharge bend is used to connect the cylinder valve outlet to the system manifold and discharge piping. This flexible hose allows for the temporary misalignment of the cylinders on installation, and for ease of cylinder removal for maintenance. The cylinder end of the hose has a swivel connection for ease of installation.

A discharge bend with a built-in check valve must be used when cylinders are manifolded together. The check valve is locked onto the hose assembly and must not be separated from it. If a cylinder assembly is disconnected from the discharge bend, and if the system operates while the cylinder is disconnected, the check valve will ensure that an appreciable quantity of carbon dioxide will not discharge from the disconnected discharge bend. Flexible discharge bend adapter combinations are available for single cylinder systems where a check valve is not required. When the discharge adapter is used without the flexible bend, a union connection must be installed close to the cylinder for ease of installation and maintenance. It is important that neither the discharge bends nor the discharge adapter be mounted onto the cylinder valve during transportation and storage. The transit plug must remain in place on the cylinder valve until the cylinder is installed and secured in its bracket.

**CYLINDER BRACKETS**

The cylinders can be arranged to be bracketed to a wall or to be free standing when no wall is available. Straps for single cylinder wall mounting installations are available. Brackets for multiple wall mounted installations and frames for multiple cylinder free standing installations are normally supplied by the installer, and assembled on site to suit the space available. For installation of three or more cylinders, a variety of arrangements can be fabricated by the installer. The single row, wall mounting arrangement
is recommended for installations of up to five cylinders.

Double row, free standing arrangements have the advantage (particularly for systems using main and reserve cylinders, and for joint systems), that any cylinder can be removed for recharging without disturbing the others. However, this arrangement requires two aisles and considerably more space.

The double row, wall mounting arrangement is generally used when sufficient space is not available for a free standing arrangement or for a single row wall mounting arrangement.

For marine applications, additional cylinder supports are required. Two straps or sets of retainers must be used.

**Check Valves**
A range of check valves are available.
These are used to isolate the main cylinder manifold from the interconnected reserve cylinder manifold. In the manifolds of joint systems they are also used to prevent the discharge from activated cylinders causing activation of the other cylinders in the bank.

**Bleeder Valves**
Bleeder valves are used in the manifolds of main and reserve banks of cylinders, as well as in the manifolds of systems that have selector valves (joint systems). The bleeder valve vents accidental check valve leakage (that could discharge the other bank or banks of cylinders) from one bank to the other.
The valve is normally open and closes when manifold pressure reaches approximately 20 psi (1.4 bar) to prevent loss of CO2 under normal discharge conditions. The pipe connection is usually ½” NPT.

**DISCHARGE NOZZLES**
Two types of discharge nozzle are available: total flooding type and local application type.
Total flooding nozzles are used where an even distribution of gas is required throughout an enclosure. Local application or directional nozzles are used where a concentration of carbon dioxide is required on a particular surface or piece of equipment.

Nozzles are designed to discharge large volumes of carbon dioxide without freezing. For local application use (when installed in accordance with their approvals), the velocity of discharge from the nozzle is reduced to prevent agitation and splatter of the hazardous material which could spread the fire.
All nozzles have a drilled orifice. The nozzle orifice size will vary depending on the flow...
and the location of the nozzle in the system. It is important that nozzles are installed exactly as specified on the project drawings, otherwise system performance will be jeopardized. Special finishes for nozzles are available and can be provided by special order to suit project requirements.

**Manual Control**

A manual actuator is used to operate the carbon dioxide system manually and locally at the cylinders. The actuator is screwed into a port on the top of the cylinder valve. When two master cylinders are required, the levers of the two actuators are joined together with a connecting link for simultaneous operation.

The actuator has a hole in the side of the main body fitted with a blank plug. This hole allows the actuator to be operated from an external pressure source. It is also used to connect to the discharge from the solenoid valve (when used). The blank plug is removed from the actuator only for these two purposes. Otherwise the plug must remain tightly connected at all times. The hand lever on the manual actuator can be operated from a remote location. This is achieved by connecting a 1/16-inch diameter stainless steel cable to the end of the lever, and running the cable through ½-inch conduit or 3/8-inch pipe to a pull box using corner pulleys at each change in cable direction. Using a mechanical dual junction box, two remote pull boxes can be joined to operate one master cylinder arrangement. Or, one remote pull box can be used to operate two separate manual actuators.

**Automatic Control**

Electric actuation is achieved by using a solenoid valve kit. The solenoid valve is a normally closed device, closed when de-energized and open when energized. The standard solenoid voltage is 24 VDC, but other voltages and special enclosures (including explosion-proof) are usually available by special order. The standard electric connection is by a DIN connector, and a cable assembly is available for ease of connection to field wiring. The solenoid coil is designed and rated for continuous duty service. However, it is recommended that the actuating circuit incorporate a shut-down device (e.g. a pressure switch or time delay relay) to open the circuit when the cylinder is empty.

When the coil is energized for a long period of time, the solenoid enclosure becomes hot. This is a safe operating temperature and will not damage the solenoid. Any excessive heating will be indicated by the smoke of burning coil insulation.

The solenoid valve connects directly to a special adapter on the cylinder valve. The discharge side of the solenoid valve is connected to the pressure port on the manual actuator with supplied 3/16-inch braided hose. When de-energized, the solenoid valve opens allowing pressure from above the main piston of the cylinder valve to operate the actuator and open the valve.

The solenoid should be connected to a Listed control panel that is powered through a separately fused circuit, and that also incorporates battery backup power.

**CONTROL PANELS**

Any control panel specifically listed for extinguishment control (releasing panel) that provides continuous supervision, and that is compatible for the interconnection of all devices, may be used. Listed control panels provide fully supervised detection, signaling and activation control – as well as audible and visual annunciation of the system status. They also provide battery backup power, and control of auxiliary equipment.

**INITIATING DEVICES**

Initiating devices such as heat detectors, smoke detectors, and manual stations should be listed devices compatible with the control panel being utilized. See the respective
manufacturers instruction manuals for installation and operating details. A remote electric manual station should be included in all automatic electric systems. This allows the system to be manually actuated should a fire be visually detected before an automatic detector operates.

PRESSURE OPERATED SWITCH
The pressure operated switch connects to the carbon dioxide discharge piping and operates when the system discharges. The switch may be wired with contacts in the open or closed position. Operation causes the electrical switch contacts to reverse position. Switches can be used to confirm system discharge, to operate alarms, to shutdown motors, pumps, fans and conveyors, to release magnetic door holders, etc., automatically when the system discharges.

The switch may be mounted in any position, but preferred installation is with the pressure connection (CO2 supply line) entering from the bottom. The switch enclosure is rated for standard and weatherproof conditions. When the line load of the equipment to be operated is greater than the switch rating, the switch should be used to break a relay holding-coil circuit.

PRESSURE RELEASE TRIP
The pressure release trip can be used to release dampers, close fire doors, windows, louvres, fuel supply valves, to open dump valves, etc., automatically when the system discharges. The equipment to be operated must be weight or spring loaded, or be pivoted off centre. The release trip is connected to the carbon dioxide discharge piping for operation when the system discharges.

Cable from the equipment to be controlled is looped over the pressure release operating stem. When the trip is operated, the stem retracts and the cable is released.

CHANGE OVER SWITCH
The change-over switch is a rotary type used to direct automatic actuation to a main or reserve cylinder bank when main and reserve cylinders are provided. The switch should be located adjacent to the cylinder bank or in a secure area.

HEADER SAFETY
This pressure relief device is installed in sections of closed piping such as between selector valves and the cylinder manifold. It is a frangible disc assembly designed to rupture if trapped CO2 expands and the line pressure exceeds 2,650 to 3,000 psi (182.7 to 206.8 bar). The body is made of brass and the pipe connection is ½” NPT.

GAS OPERATED SIREN
This unit sounds an alarm by means of carbon dioxide pressure. It is connected to the discharge piping of the system, or to a separate independent carbon dioxide cylinder. Sirens should be located throughout the hazard area in order to ensure an audible alarm will be heard on the activation and discharge of the carbon dioxide system. Due consideration should be given to the normal background noise in the area. If the carbon dioxide system incorporates a delayed action device, the siren must be arranged to operate at the same time that
the delayed action device is initiated.

When connected to the carbon dioxide system piping, the alarm will cease when the gas discharge has been completed. If it is desirable or necessary for the sirens to operate for a longer period of time than will be allowed by the system discharge time, a separate independent carbon dioxide cylinder must be used.

**BRACKET INSTALLATION**
Single bank, wall mounting is recommended for installations of up to five cylinders. Freestanding arrangements allow for multiple banks while maintaining sufficient access to all cylinders for maintenance or replacement purposes.

**STRAP INSTALLATION**
For floor mounted cylinders against a solid wall. Mounting bolts must be anchored to a solid structural member.

**CYLINDER ASSEMBLIES**
Carbon dioxide cylinders may be located inside or outside the protected space, although it is preferable to locate them outside the space. When they are installed within the space they protect, a remote manual control should be installed to ensure the system can be actuated from a safe location outside the fire area. The cylinders should be located to provide convenient access so that they can be readily inspected and easily removed after use for recharging. They should not be installed where they will be exposed to the weather elements or the direct rays of the sun. Cylinders should not be installed where they will be subjected to temperatures of less than 0 °F (-18 °C) or higher than 130 °F (54 °C), unless otherwise specified.

If cylinders are located in a hazardous (explosion-proof) area, the cylinder solenoid control and all other components should be approved for such use, and the installation of all materials needs to be done in an approved manner. Cylinders should be installed in the normal upright position. All cylinders are provided with a siphon tube.

**CLEAN AGENT ENGINEERED SYSTEMS**

**Safe, Powerful**

**Fire Protection For Custom Applications**
Fire protection systems engineered for use with clean agent act fast to knock down fires before they can take hold. With discharge times of 10 seconds or less, lives and valuable property benefit from virtually instant response to the danger posed by fire.

Systems engineered for use with clean agent deliver an effective clean agent that’s safe for use in occupied spaces. The clean agent leaves no messy residue, and will not harm sensitive equipment. It also exceeds all current standards regulating the use of ozone-depleting substances, and is approved by the US Environmental Protection Agency and Environment Europe as an acceptable Halon alternative.

Because clean agent interferes with the chemical properties of fire, it is exceptionally effective in small amounts. This high potency means it can be stored at lower pressure and systems can be designed with lighter pipe work and less agent. Safe, effective, economical, and uncomplicated, clean agent systems are ideal for a wide range of settings from clean rooms and laboratories to applications in mines and marine vessels.

**Where to use Clean Agent Systems**
- Where valuable property needs to be protected
- Where weight and space versus extinguishing potential is a factor
- Where there is difficulty ensuring the safety of personnel
- Where an inert, electrically non-conductive extinguishing agent is required
- Where fast burning, high heat-producing materials are stored or used
- As first line of defense to prevent damage where water sprinkler systems are installed

Some of the hazards suitable for this kind of protection include...
Control rooms, Computer rooms, Data processing centers, Switch gear rooms, Telephone equipment rooms, Cellular transmitter buildings, Dry cleaning plants, Spray booths, Transformer vaults, Radio and TV station facilities, Radar sites, Machinery spaces, Engine compartments, Chemical storage areas, Flammable liquid stores, Museums and archives, Records storage, Bank vaults and depositories, Libraries.

**Typical System Layout**

Clean agent engineered systems are relatively simple to design and lay out. There are four primary objectives that need to be achieved with every system:
- Provide adequate agent and cylinder pressure to flood the area to the specified design concentration in ten seconds or less.
- Provide a means of actuating the fire protection system manually, and/or automatically when fire is detected.
- Provide audible and visible warning prior to system discharge by means of a timer that allows adequate time for evacuation of the immediate area.
- Provide a means of manually aborting the system when the discharge timer is operating.

**What Happens When Fire is Detected**
- Fire detector enters alarm state.
- Releasing panel activates alarm signals, controls equipment and safety devices, and starts the countdown timer.
- When the timer expires clean agent discharges from the container, through the piping system, and out of the discharge nozzles and into the protected area.
- Discharge is complete in 10 seconds or less.

**Applications**
Total flooding clean agent intended for use in both occupied and unoccupied enclosed spaces. As a clean, electrically non-conductive agent it is ideal for use in areas containing sensitive and valuable assets, such as computer hardware and electrical equipment. Clean agents are highly suitable for a wide range of Class A, B and C surface fires.

**Environmental**
Clean agent was developed to extinguish fires in an environmentally responsible manner.
They have a low 100-year Global Warming Potential and a short Atmospheric Life Time. Furthermore, their Ozone Depletion Potential is well within the range of acceptable limits, and its low storage and operating pressures allow the use of relatively light weight cylinders and pipe work.

**Personal Safety**
The United States Environmental Protection Agency has designated clean agents as safe for use in occupied areas at concentrations up to 10 per cent.
Clean agents do not rely on the reduction of oxygen levels to extinguish fire, nor does it increase CO2 levels to artificially stimulate breathing in the protected area.
Standard Equipment and Optional Components
Engineered clean agent Fire Suppression Systems are custom designed for total flooding applications in accordance with the design requirements of NFPA 2001 and other applicable codes and standards.

Systems storage containers are available in a full range of cylinder sizes and individual clean agent fill quantities. They can be arranged for either individual or multiple piped installations to suit each individual hazard requirement. Depending on the system requirements, discharge can be initiated either automatically from a wide variety of detectors, or manually at the cylinder or at a remote location. Electric control panels and auxiliary control components such as pressure switches and pneumatic release trips are utilized to control the operation of fans, power supplies, alarms, dampers, etc. To suit the individual system requirements.

Manifolds
Manifolds may be used to join the discharge pipes of two or more cylinders to enable discharge through a single pipeline to the discharge nozzles. Manifolds are constructed and supplied by the installer. The manifold design for each project will be detailed on the project drawings. It is important that the manifold be constructed exactly as detailed on the project drawings. Any changes will have an effect on the clean agent flow and on the system performance.

Discharge Bends and Check Valves
Discharge bends and check valves are used when cylinders are manifolded together. The discharge bend allows for the misalignment of the cylinders on installation, and for ease of cylinder removal for maintenance. If one cylinder assembly is disconnected from the system, and the other cylinders discharge while that cylinder is disconnected, the check valve will ensure that the clean agent will not discharge from the disconnected discharge bend. It is important that discharge bends are not mounted onto the cylinder valves until the cylinders have been installed and secured in their brackets. These items must not be mounted onto the valves during transportation and storage.

Nozzles
System discharge nozzles are specifically designed to provide an effective distribution of the clean agent throughout the protected space. Nozzles are made of brass. Other materials and special finishes may available as a special order. The nozzle can be located either in the centre of the space to be protected or on side walls. It is equally efficient in either location. Nozzles are not interchangeable. It is important that nozzles be installed exactly as specified on the project drawings, otherwise system performance may be jeopardized. The nozzle orifice diameter is stamped on the bottom of the nozzle body.

Solenoid Valve Actuation
The solenoid valve is installed onto a side port of the cylinder valve. It is configured to vent the piston chamber of the cylinder valve. The solenoid valve is a normally closed device: closed when de-energized and open when energized. The standard solenoid voltage is 24 vdc. Other voltages and special enclosures are available as a special order. The solenoid should be connected through a listed control panel that is powered from the AC supply through a separately fused circuit.

Releasing Panels
Listed control panels provide fully-supervised detection, signalling and extinguishment activation control circuits, audible and visual annunciation of system status, emergency back-up power, and control of auxiliary equipment. Such panels are necessary
for, and compatible with, fire protection equipment.

**Initiating Devices**
Initiating devices such as heat detectors, smoke detectors, and manual stations should be listed devices compatible with the control panel being utilized. See the respective manufacturers instruction manuals for installation and operating details. A remote electric manual station should be included in all automatic electric systems. This allows the system to be manually actuated should a fire be visually detected before an automatic detector operates.

**Nozzles**
Nozzles should be installed as indicated on the project drawings. Except where more than one tier of nozzles is used, or special application conditions apply, the nozzles should not be more than 12 inches from the top (ceiling) of the enclosure. Nozzles can be installed upright or inverted. There must not be any obstruction adjacent to the nozzles, such as structural beams or columns, ducts, cable trays, racks, etc., that could affect the discharge pattern and the mixing of the clean agent and air.

**Clean Agent System Safety**
Safeguards must be taken when using any chemical extinguishing agent and clean agent is no exception. It is important to ensure the safety of personnel in areas where the atmosphere could become hazardous by the discharge or thermal decomposition of the extinguishing agent. The following list, which has been compiled from NFPA and ISO Standards, indicates steps and safeguards that may be necessary.

- Warning and instruction signs at entrances to and inside the protected area informing personnel that a clean agent system is installed.
- These signs may contain additional instructions relevant to the hazard.
- A time delay to enable evacuation of personnel before the commencement of clean agent discharge.
- Alarms within the protected space that will operate immediately upon detection of the fire.
- Continuous alarms at entrances to the protected space until the atmosphere has been restored to normal.
- Only outward swinging self-closing doors at exits from the protected area and, where such doors are latched, provision of panic hardware.
- Adequate aisle ways and exit routes: ensure that they are kept clear at all times.
- Emergency lighting and directional signs as necessary to ensure quick, safe evacuation.
- Prohibition of smoking until the atmosphere has been purged of clean agent (even in very low concentrations, clean agent will decompose when drawn through a lit cigarette and may cause lung damage).
- Prompt discovery and rescue of persons incapacitated in the protected space.
- A means for prompt ventilation of the protected space and all adjacent areas.
- Forced ventilation will often be necessary.
- Instruction and drills of all personnel within or in the vicinity of the protected enclosure.
- Outward opening exit doors operable from inside for all clean agent cylinder storage rooms.
- A means to lock-off or disarm the system during periods of inspection and maintenance of the system or of other equipment within the protected space.
- Any other steps and safeguards that a careful study of each particular situation indicates are necessary.

**FM200 Clean Agent**
**For Total Suppression System**
- Fast and Clean fire protection: Electrically non-conductive, it occupies minimal storage space. Its primary action is through cooling the fire and removing heat energy so that the combustion sustained.
As far as people’s exposure to FM-200 is concerned, safety is not an issue. In fact, FM-200 is even used as a replacement for CFC propellants in pharmaceutical inhalers. It is also a trusted choice in clean agent fire protection, perfect where disruption has to be minimized and survivability of the business is critical. FM-200 is clean, leaving behind no oily particulates, water or corrosive materials. This virtually eliminates any risk of damage to delicate equipment caused by the extinguishant itself.

Finally, the environment is not at risk: FM-200 has a zero effect on the earth’s stratospheric ozone layer and has a minimal impact on the environment in comparison to the impact of a catastrophic fire. FM-200 has an Atmospheric Lifetime of 33 years. It’s a fire protection solution that has already been applied in more than 100,000 situations worldwide in more than 70 countries.

- Every second counts
  Once actuated, FM-200 systems achieve extinguishing levels within 10 seconds, stopping ordinary combustible, electrical and flammable liquid fires before they have a chance to spread. When fire is put out this quickly, it means less damage, lower repair costs and reduced downtime. Your business is soon up and running again.

- Protecting your most valuable asset:
  Extensively tested and studied, FM-200 can be safely used in the presence of people. Its development is supported by the most comprehensive database of toxicological data of any similar product.

- Storage and distribution:
  This clean agent is stored in containers, super-pressurized with dry nitrogen to an operating pressure of 360psi at 70°F (24.8 bar at 20°C).

**NOVEC 1230 Clean Agent For Total Suppression System**

Systems, using Novec™ 1230 Fire Protection Fluid have emerged as the solution of choice for fire extinguishing systems to protect high value assets and processes. It is a clean agent system which is proven to be environmentally friendly.

Today’s need is for a fast-extinguishing, sustainable, clean agent – free of any ozone depletion potential and with the lowest possible emission of “greenhouse gases” – that can be used in occupied spaces.

Novec 1230 fluid meets this demanding profile, precisely. It complies with all statutory requirements, both current and anticipated.

- Complies with ISO 14520
- Meets NFPA 2001 standards
- TPED compliant
- Applications:
  - Gas turbines
  - Oil industry applications
  - Telecommunications
  - Power generation
  - Shipping
  - Museums and archives
Benefits:
- Zero ozone depletion potential
- Global warming potential of one
- Clear, colorless, low-odor agent
- Simple to refill
- Discharges within 10 seconds

- Applications:
  - Telecommunications sites
  - Computer centres
  - Museums and archives
  - Oil and gas industry sites
  - Power generation installations
  - Civil and military marine
  - Rail and mass transit

- Fast acting protection
  Systems using Novec 1230 fluid are designed to work fast, rapidly absorbing heat to the point where combustion ceases. Once actuated, systems deliver the extinguishant within 10 seconds, stopping Class A, B and C fires before they have chance to spread. When fire is extinguished this quickly, the result is less damage, lower refurbishment costs and reduced downtime.

- Playing safe
  Toxicity testing shows Novec 1230 fluid to be safe for use in occupied areas. Studies conducted in independent laboratories demonstrated that the agent is very low in both acute and chronic toxicity, with an extremely high safety margin - the difference between the extinguishing design concentration and the No Observable Adverse Effect Level (NOAEL), making the fluid an extremely safe extinguishing solution for occupied areas. Novec has an Atmospheric Lifetime of 3 to 5 days.

- Low pressure technology:
  Suppression system using Novec needs only 25 bars to achieve homogeneous distribution.

<table>
<thead>
<tr>
<th>Properties</th>
<th>Novec 1230</th>
<th>HFC 125</th>
<th>Halon 1301</th>
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<tbody>
<tr>
<td>Ozone depletion potential (ODP)</td>
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<tr>
<td>Atmospheric lifetime (years)</td>
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<tr>
<td>SNAP</td>
<td>yes</td>
<td>yes</td>
<td>n/a</td>
</tr>
</tbody>
</table>

SNAP* - Significant New Alternatives Policy (US EPA)

**Condensed Aerosol: New Approach for Suppression System**

In the early 1990s upheaval was at hand as a result of the banning of halon in the fire protection industry due to its disastrous environmental effects.

Competition therefore to replace halon became fierce between halo carbons, inert gases and of course condensed aerosols.

Condensed Aerosol Fire Extinguishing Technology was first developed by the Soyuz Space Technology Centre, in Russia more than 30 years ago and consisted of a solid material (solid aerosol forming compound) of mainly potassium salts that on activation transformed into a fire extinguishing aerosol.

Unlike the other alternatives, which offered merely a slight deviation to the old technologies, acceptance of the Aerosol Technology (a relative new comer), its quality, reliability was not immediately forthcoming. Surmounting the market’s initial scepticism held by traditionalists in the industry regarding
the effectiveness and efficiency in a wide range of applications of this new technology, although not difficult, it nonetheless required time and effort at considerable expense.

This was of course achieved by adhering to the industry’s internationally accepted standards related to quality and reliability asserted by undergoing all the necessary relevant assays, tests and trials.

As a result today this technology is seen as one of the most efficient ‘Halon alternative’ available.

**Development of the Condensed Aerosol Fire Extinguishing Technology:**

The original condensed aerosol forming compound developed by Soyuz contained a fundamental flaw in its formula and this was the inclusion of nitro-cellulose (also known as colloxylin, classified as pyrotechnic material) that was used as accelerator of the chemical exothermic reaction leading to the transformation of the solid material to aerosol. However the presence of this type of pyrotechnic material has the following detrimental/debilitating effects that ultimately lead to loss of efficiency:

- Instability with temperature increase
- Decay of its mechanical properties over time
- Reduced operational lifetime

Understanding the limitations of these pyrotechnic materials (nitro-cellulose, nitro-guanidine, or other cellulose derivate) lead manufacturers in Europe and the United States to develop a new solid aerosol forming compound free of such materials. The pronounced advantages that this new compound offered were the extended life time (15 years compared to 5 for those containing pyrotechnical compounds) and stability versus temperature increase.

**Standards and Norms**

When a new technology is introduced in the international market, it develops a complex combination of technical, regulatory and commercial forces which require a detailed understanding of the product and its relationship to competing products approvals and regulatory processes.

As a result the Official Regulatory Bodies are developing the standards covering the new technology. Consultants and specifiers should require that the manufacturer is certified according to ISO 9001 and ISO 14001, the products are certified/listed by accredited Authority such as UL/ULC, BSI or KIWA for land applications and have the Maritime Equipment Directive, MED approval for marine applications and moreover, the products must carry the green label, thus ensuring that they are environment friendly. Additional Certifications and Listings issued by other accredited Authorities will be an added advantage.

**Environmental Considerations**

Some of the newly developed Fire Extinguishing Aerosol Generators do not contain any harmful chemical substance i.e. Sulphur Hexafluoride SF6, Hydro fluorocarbons as HCFC, HFCs (23, 32, 41, 43-10mee, 125, 134, 134a, 152a, 143, 143a, 227ea, 236cb, 236ea, 236fa, 245ca, 365mfc) and Perfluorocarbons PFCs, which are either banned or in the process to be banned or their use is restricted, according to regulation (EC) No 842/2006 of the European parliament and of the Council, due to their negative impact on the environment.

On the contrary, the certifications and reports owned by some aerosol manufacturers are demonstrating that the characteristics of the product / technology are consistent with the most stringent environmental requirements stated by the international regulators bodies.

Specifically:

European Green Policies, “Green Label Mark”. COUNCIL REGULATION (EEC) No 880/92 of 23 March 1992. This Regulation establishes a Community eco-label award scheme which is intended to promote the design, production, marketing and
use of products, which have a reduced environmental impact during their entire life cycle, (eco-label award scheme).

Only Aerosols certified according to this scheme are complying with the European Regulations.
Few Condensed Aerosols have passed all the examinations and been accepted and listed under the SNAP program.

Therefore, no chemical substances responsible for ozone depletion (such as halocarbons) or for global warming or for any kind of environmental impact, are present in the chemical composition.

Therefore the environmental characteristics of certified Aerosol Extinguishing Generators are listed here below:
- ODP - Ozone Depletion Potential = 0
- ALT - Atmospheric Life Time = negligible
- GWP - Global Warming Potential = 0
- Non toxic
- Non corrosive
- No oxygen depletion

On the contrary some solid aerosol forming compounds contain in their chemical formulation Chlorides, thus do not comply with the environmental requirements stated by the international regulators bodies and are not certified and listed.
This is another important issue to consider when selecting an aerosol product.

The final result of all the above mentioned environmental considerations is that the selection of a condensed aerosol system should be directed to the ones, which fulfil all the requirements of European and International directives and which are certified and listed according to these directives.

**Commercial Aspects**
Ever since its introduction in the market, Condensed Aerosol Extinguishing Systems have shown to be the most effective and efficient fire extinguishing agent, both in terms of fire extinguishing capabilities and costs. Aerosol Extinguishing Systems employ a solid compound that is transformed into a fire extinguishing aerosol that extinguishes fire by breaking the uncontrolled chain chemical reactions of combustion **without depleting oxygen**.

Aerosol Extinguishing Systems are presently installed in many countries worldwide including the UK, Italy, Denmark, Norway Germany, Belgium, USA, S. American Countries and more.

It is the preferred choice for **total flooding** fire protection in applications including, but not limited to, computer centers, museums, car and bus engine compartments, pleasure yachts, archive rooms, gold and diamond mines, telecommunications networks, television stations, electrical industrial panels, oil field installations, electrical transformer substations and many more.

The success of Aerosol Extinguishing Systems is partly attributed to the versatility of the systems which allows to protect **internally / locally** the likely sources from where a fire might start e.g. electrical panels, cabinets etc. The important benefit conveyed, from this, is that in the event of a fire occurring in such fire sources, the fire is locally extinguished thus preventing its spreading outside the source. Consequently, no additional fire fighting means are required.
Some of the main advantages that Aerosol Extinguishing Systems offer vis-à-vis gaseous systems are:

1. Tremendous space saving i.e. the space required is only a fraction of the space needed for cylinders etc.

2. Aerosol Extinguishing Systems design calculations are based on uncomplicated parameters resulting in simplified design calculations.

3. Far easier installation - no piping, pressure cylinders, special supports and valves are required thus reducing installation time and costs considerably.

4. Easy maintenance without the need for pressure testing, weighing, pressure/leak detection etc.

5. Cost effectiveness - Aerosol Extinguishing Systems are less expensive compared to most other gaseous systems (Halon replacements) making it more attractive to the end user.
AEROSOL FIRE EXTINGUISHING PRINCIPLE
A cost effective and efficient Total Flooding System.

FIRE

Formation of radicals (O*H*, OH*) during the chemical chain reactions of the fire

AEROSOL PHASE II:

(during extinguishing process) Formation of K* radicals by the disassociation of K₂CO₃

RELATIVE QUANTITY REQUIRED/M²

<table>
<thead>
<tr>
<th>Aerosol</th>
<th>Halocarbons</th>
<th>Inert Gases</th>
<th>CO₂</th>
</tr>
</thead>
</table>

Environment Considerations:
- ODP – Ozone Depletion Potential = 0
- ALT – Atmospheric Life Time = negligible
- GWP – Global Warming Potential = 0
- Non toxic
- Non corrosive
- No oxygen depletion

The latest generation of Aerosol Generators use stable non-pyrotechnic aerosol forming solid compounds and no longer contain pyrotechnic materials such as nitro-guanidine or nitro-cellulose.

AEROSOL PHASE I:

(before extinguishing process)
Inert gases (N₂, H₂O, CO₂)
Carrying solid, micro-sized particles(K₂CO₃)

FIRE IS EXTINGUISHED:

Reactions between radicals lead to the formation of stable compounds (KOH,K₂CO₃)

TYPICAL FIRE EXTINGUISHING AEROSOL GENERATOR DIAGRAM