

## Demystifying the Alternatives to Traditional Plant Fire Suppression

Many of the nation's power generating plants were constructed when there were five fire protection choices for their facilities: alarm and detection, sprinkler, Halon 1301, CO2 or remaining unprotected. Plants have undergone various upgrades to meet increasing levels of performance and to satisfy risk management/ insurance requirements. With the phasing out of Halon 1301 and the emergence of many new fire suppression alternatives, it can be challenging to determine which method is the most appropriate for each unique environment.

### The Demise of Halon 1301

Following its introduction into the fire protection market in the 1960's Halon 1301 experienced three decades as a very popular, effective and diverse method of fire suppression. In applications such as data centers, laboratories, cable spreading rooms, control rooms and areas where getting access to water was a challenge, Halon 1301 was an ideal solution. The effectiveness of the gas was unparalleled at the time and the lack of residue after discharge made it the best available option for a wide array of applications.

However, as mounting evidence emerged that chlorofluorocarbons (CFC's- a component of Halon 1301) were depleting the ozone layer, the downfall of this consummate gas was imminent. In 1989, an international agreement known as the Montreal Protocol was signed into effect, which subsequently called for a cease in production of Halon 1301, effective in 1994. The fire protection industry was then faced with the challenge of refining and developing alternative fire suppression systems that would rival the effectiveness of Halon 1301 without any deleterious effects on the environment.

### Environmental Regulations for Suppression Systems

With increasing emphasis on environmentally safe products, regulations pertaining to the development of chemical-based suppression are continuously evolving. Some of the terms that relate to the environmental regulation of suppression products are listed in the table below:

Acronym	Term	Description
EPA SNAP List	Significant New Alternatives Policy	Evaluates and regulates substitutes for environmentally destructive chemicals that are being phased out by the Clean Air Act (CAA)
ODP	Ozone Depletion Potential	The ratio of the impact on ozone of a chemical compared to the impact of a similar mass of CFC-11 (Freon 11)
GWP	Global Warming Potential	The ratio of the warming caused by a substance to the warming caused by a similar mass of CO2
ATL	Atmospheric Lifetime	The amount of time that a gas remains in the atmosphere before an equilibrium is recovered
NOAEL	No Observable Adverse Effect Level	The highest concentration at which no adverse toxicological or physiological effect has been observed
LOAEL	Lowest Observable Adverse Effect Level	The lowest concentration at which an adverse toxicological or physiological effect has been observed

All of these variables and more play a role in the design of alternative fire suppression systems. In the wake of the Montreal Protocol, the Clean Air Act (ACC) and other environmental measures, the market was flooded with new products, vying to fill the void left by Halon 1301.

### **The Frontrunners Emerge**

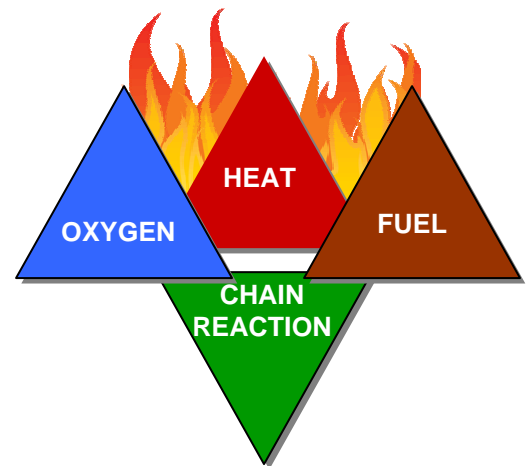
Ultimately the market has settled down and substandard products have been eliminated, leaving a core group of solutions that meet these environmental regulations and individually offer their own benefits for varying applications. Of the suppression products that have materialized over the past few decades, clean agents, hypoxic (oxygen deprivation) systems and water mist have solidified the strongest positions in the marketplace.

Although these methods have the strongest presence in power generating and chemical processing plants, there are other alternatives that are fitting for these applications. Carbon dioxide systems have a long history in these environments but must be applied only in very specific conditions in order to preserve life safety. Aerosols are another suppression alternative that is currently on the rise with a growing presence in industrial applications. As is demonstrated in the *Alternative Suppression Agents Matrix* (Appendix A), there are an abundance of suppression options available to facilities, but careful evaluation is often needed to find the optimal solution for the specific hazard.

### **Clean Agents**

In terms of functionality, clean agents are the alternative that most closely mirror the operation of Halon 1301. By using a mix of cooling effects and inhibiting the chemical interaction of the free radicals of the heat chain reaction and the oxygen/fuel, fires are effectively suppressed.

The category of clean agents generally covers HFC (hydrofluorocarbons) style agents such as FM-200 and ECARO-25 (HFC-125). The early emergence of FM-200 on the market as a replacement, but not a direct drop-in replacement substitute to Halon 1301, has allowed it to gain a massive share of the special hazard systems market, ranging from 75% to 85% of the systems installed.



***Clean agent gases are more costly than inert gases, however simplified storage offsets the cost of the agents, making them an economical suppression option***

Another prevalent clean agent that is not of the HFC family is the Novec 1230 Fire Protection Fluid, manufactured by 3M. Because it has a much higher boiling point than FM-200 & ECARO-25, its advent into the market came with a high degree of visibility because it could be displayed in open containers. The boiling point for FM-200 is 2.48 °F and ECARO-25 is -55.3 °F, whereas Novec 1230 has a boiling point of 120 °F.

The initial price of clean agents compared to inert agents can be a deterrent for facilities when selecting a solution, but the higher cost is offset by economical storage options. Inert agents themselves are comparatively inexpensive but the 360psig stored pressure vessels in which clean agents are housed more than compensates for the cost of the gas, making clean agents the most economical alternative to traditional sprinkler systems.

A caveat with hydrochlorofluorocarbon (HCFC) based agents such as FM-200, HFC-125 and the fluoroketone, NOVEC 1230, is that when exposed to high temperatures, one of the byproducts of thermal decomposition is hydrogen fluoride (HF). This is a caustic acid that can have toxic effects on people and destructive effects on equipment. Factors such as the size of the fire and temperatures involved has a direct bearing on the amount of hydrogen fluoride produced. With the vast majority of installations the level of HF will not reach dangerous toxic loads (DTL).

### **Inert Agents:**

This class of agents utilizes three primary inert gases in varying quantities: nitrogen, argon and carbon dioxide. Utilizing these gases for the purpose of fire suppression involves depriving a fire of oxygen by inserting inert agents, which effectively displaces a significant amount of the room's atmosphere, lowering the level of oxygen to the threshold at which combustion is not supported. Although an effective method of suppression, there are several considerations that must be regarded to determine if inert agents are a viable solution for a particular environment.

Because of the substantial shift in the concentration of atmospheric gases, human exposure must be severely restricted. The general standard for all systems is a maximum exposure time of five minutes per NFPA, although this time interval decreases as concentrations of the agent rise. NFPA sets these limits not only because of the dangers associated with the inert or clean agent themselves, but also because of the undesirable particulates inherent to the fire itself and the risks associated with possible thermal decomposition. Another essential variable that must be assessed is the environment itself.

Proper design of the room in which an inert agent could potentially be deployed is critical to its effectiveness. A typical atmospheric composition is approximately 21% oxygen, 78% nitrogen and a 1% amalgamation of CO<sub>2</sub>, methane, helium and trace amounts of other miscellaneous gases. To successfully control a fire through inert agents, the oxygen level in the room must be reduced to 15% or less. For this to be achieved, anywhere from 35% to 50% of the room volume will be replaced with the inert agent in the span of 60 seconds, making it essential that proper venting exists to exhaust the ambient atmosphere of the room. Failure to provide venting could result in collapsed walls or blown out doors, putting facility occupants at risk. Inert agent hydraulic calculations can provide enclosure minimum strength requirements and required minimum venting to ensure the structural aspects of the room are sufficient.

Beyond the prerequisites of the area that is being protected, plants also need to be cognizant of the requirements associated with storage of the gases. Inert agents, without refrigeration, must be stored as a gas under pressure. To maximize the amount of inert agent available, systems are designed to provide storage in pressures up to 300 bar or 4351 pounds per square inch gauge (PSIG). Most systems are based on 200 Bar (2900 PSIG), making the most expensive component of the system the storage tanks. Due to their limited capacity, many tanks must typically be assembled and manifolded together to protect a space, driving up the cost of the system. A manifold assembly of schedule 80 or 160 piping is required to handle the pressure until an engineered pressure reducer



***Inert Agent systems can be a very effective suppression method, however, the environmental conditions of the area must meet stringent requirements***

orifice is reached. These orifices reduce the pressure and the flow to levels that schedule 40 piping can sustain for the balance of the system piping to the discharge nozzles.

### **Water Mist:**

This group of systems relies chiefly on the most traditional medium for suppressing fires- water. There is a very diverse and wide-ranging product offering of water mist systems available, based on pumped or “twin fluid” systems, giving facilities the flexibility they need for their specific environment. A good fit for mechanical spaces, turbine areas/enclosures and machinery spaces, water mist systems are suitable for environments that present a primarily Class B hazard with limited Class A combustibles.

The foundation of water mist systems is miniscule water droplets that are many times smaller than those created by a typical sprinkler head. With a size range of 10-400 microns, (for reference, a sheet of copy paper is approximately 100 microns thick) these droplets are extremely buoyant and have an overall elevated surface area. When a water droplet impinges on a fire the fire is cooled and the water droplet is converted to steam, expanding at a 1 to 1700 ratio, which also deprives the fire of oxygen.

Some water mist systems also utilize nitrogen to generate a smaller water droplet size through specially engineered nozzles or a distribution system, creating a more robust suppression solution. Nitrogen is used in the piping leading to or at the specially engineered nozzles, displacing the room volume. The amount of nitrogen that is introduced into the room is not as substantial as an inert agent system but it still provides significant aid in the fire suppression effort.

### **Carbon Dioxide:**

Another solution that gained popularity following the halt of Halon 1301 production was carbon dioxide systems, which have maintained a presence in specific applications. A potentially lethal agent, the levels of concentration that are required to control a fire also diminish the level of oxygen to a degree that the atmosphere can no longer support life. Because CO<sub>2</sub> is heavier than air, there is also a risk in any low lying areas immediately adjacent or underneath the hazard where the gas may “pool”. In recent years NFPA has moved to add significant safety features to CO<sub>2</sub> systems when installed in normally occupied enclosures. All other methods of fire suppression must be exhaustively researched (and documented) as viable alternatives prior to allowing CO<sub>2</sub> to be used. Lock out valves, pneumatic time delays, signage and pneumatic audible signals must be included in the system design. In rare cases these safety devices can be eliminated when hazards to personnel and protected equipment present too much of a danger by adding the safety equipment to the system.



***Carbon dioxide systems can be lethal when implemented improperly, which has led to strict NFPA regulations about CO<sub>2</sub> system application***

### **Selecting the Best Option for Your Application**

The advancement of fire suppression systems that fall outside the traditional realm of sprinkler systems is essential to ensuring the protection of power generating plants and chemical processing facilities, especially as the hazards themselves continue to evolve. The disadvantage of a market saturated with new products and features is that the decision making process for facilities has also become more convoluted.

When assessing the various suppression options, the first crucial step is to evaluate the actual hazard to the asset that is being protected. The fire classification must be determined so that the facility can narrow their choices as to which suppression method is the most effective for the application (see Appendix B for the *Hazard Classification Table*).

The next factor that must be considered is the environment in which the agent would be discharged. Adaptations often need to be made to the space such as: sealing walls, modifying doors, HVAC shutdowns, clipping ceiling tiles, dampering supply and exhaust ductwork, sealing conduit and cable penetrations and more. Cylinder storage must also be considered, as some agents demand a close vicinity between the agent and the point of discharge. Halon 1301 was easy to work with hydraulically but many agents are not nearly as flexible regarding distances.

Other influences such as insurance company input and local codes and ordinances can have a substantial impact on the outcome of a facility's suppression scheme as well. The facility must work with the Authority Having Jurisdiction (AHJ) to implement a system that will meet their individual fire protection needs while remaining in compliance with local regulations. Lastly, before finalizing the design, facilities should require proof that the system will operate effectively within their specific environment. It is critical that power generating and chemical processing plants work with a knowledgeable and experienced fire protection solution provider who can ensure that they have selected the appropriate system and used correct design and installation methodologies for the application.

## Alternative Suppression Systems Matrix

### Clean Agent & Aerosol Systems

Agent Trade Name	Halon 1301	FM-200	ECARO-25		NOVEC 1230		Stat-X
<b>Manufacturer</b>	Great Lakes Chemical Corp.	DuPont	DuPont		3M		FireAway
<b>NFPA #</b>	Halon 1301	HFC-227ea	HFC-125		FK-5-1-12		N/A
<b>Type of Agent</b>	N/A	Clean	Clean		Clean		Potassium Radicals
<b>Chemical Make Up</b>	CBrF <sub>3</sub>	CF <sub>3</sub> CHFCF <sub>3</sub>	CHF <sub>2</sub> CF <sub>3</sub>	(C <sub>2</sub> HF <sub>5</sub> )	CF <sub>3</sub> CF <sub>2</sub> C(O)CF(CF <sub>3</sub> ) <sub>2</sub>		Same
<b>Conc. %</b>	5 to 6%	7% FM 7.44% UL	8% NFPA 2001	8.7% ISO	Class A & C (1)= 4.2%	Class B = 4.2%- 8.45%	1-2 Microns
<b>Global Warning Potential (GWP)</b>	7140	3220	2800		1		0
<b>Ozone Depletion Potential (ODP)</b>	10	0	0		0		0
<b>Atmospheric Lifetime (ATL)</b>	65 Years	34.2 Years	32.6 Years		5 Days		0
<b>No Observable Adverse Effect Level (NOAEL)</b>	5%	9%	7.50%		10%		N/A (3)
<b>Lowest Observable Adverse Effect Level (LOAEL)</b>	7.50%	10.50%	10%		>10%		N/A (3)
<b>Discharge Time per NFPA</b>	10 Seconds	10 Seconds	10 Seconds		10 Seconds		7-36 Seconds (4)

### Inert Agent and Hypoxic Systems

Agent Trade Name	CO <sub>2</sub>	Argotec	Argonite	Prolnert	N-100	Inergen	Hypoxic Systems(6)
Manufacturer	N/A	Minimax	Ginge-Kerr	Ginge-Kerr	Koatsu	Ansul	Various
NFPA #	CO <sub>2</sub>	IG-01	IG-55	IG-55	IG-100	IG-541	N/A
Type of Agent	Inert (8)	Inert	Inert	Inert	Inert	Inert	N/A
Chemical Make Up	CO <sub>2</sub>	100% Argon	50% Nitrogen 50% Argon	50% Nitrogen 50% Argon	100% Nitrogen	52% Nitrogen 40% Argon 8% CO <sub>2</sub>	N/A
Conc. %	34% to 75%		37.9% Minimum	Class A & C = 34.2% Class B = 45.5%	40.30%	34.9% Minimum	N/A
Global Warning Potential (GWP)	1	0	0	0	0	0	0
Ozone Depletion Potential (ODP)	0	0	0	0	0	0	0
Atmospheric Lifetime (ATL)	-10	0	0	0	0	0	0
No Observable Adverse Effect Level (NOAEL)	-9	43% (7)	43% (7)	43% (7)	43% (7)	52%	N/A
Lowest Observable Adverse Effect Level (LOAEL)	-9	52% (7)	52% (7)	52% (7)	52% (7)	62%	N/A
Discharge Time per NFPA	30 Seconds to 20 Minutes or more	60 Seconds	60 Seconds	60 Seconds	60 Seconds	60 Seconds	N/A

## Water-Based Systems

Agent Trade Name	Victaulic Vortex	Water Mist	High Pressure System	Low Pressure System	Aquasonic
<b>Manufacturer</b>	Victaulic	Chemetron	Securiplex LLC	Securiplex LLC	Ansul
<b>NFPA #</b>	N/A	N/A	N/A	N/A	N/A
<b>Type of Agent</b>	H <sub>2</sub> O & Nitrogen	H <sub>2</sub> O & Nitrogen	H <sub>2</sub> O	H <sub>2</sub> O & Nitrogen	H <sub>2</sub> O & Nitrogen
<b>Chemical Make Up</b>	Same	Same	Same	Same	Same
<b>Conc. %</b>	<=10 Micron Water Droplets	100-120 Micron Water Droplets	=>10 Micron Water Droplets	200-400 Micron Water Droplets	"Atomized" Water Droplets
<b>Global Warning Potential (GWP)</b>	0	0	0	0	0
<b>Ozone Depletion Potential (ODP)</b>	0	0	0	0	0
<b>Atmospheric Lifetime (ATL)</b>	0	0	0	0	0
<b>No Observable Adverse Effect Level (NOAEL)</b>	N/A	N/A	N/A	N/A	N/A
<b>Lowest Observable Adverse Effect Level (LOAEL)</b>	N/A	N/A	N/A	N/A	N/A
<b>Discharge Time per NFPA</b>	30 Minutes (2)	30 Minutes (2)	30 Minutes (2)	30 Minutes (2)	30 Minutes (2)

Appendix B.

**Hazard Classification Table**

Fire Classification	Hazard Type
A	Paper, wood & general combustibles
B	Flammable liquids
C	Electrical
D	Metals