# Clean Fire Extinguishing Agents (Halon Replacements)

by Deputy Assistant Chief Ronald R. Spadafora

Clean agent extinguishing systems slowly are being introduced into the New York City area. The materials listed in this article are just a few of the most popular agents on the market. The ideal clean agent alternative still has not been manufactured. It is the job of the fire protection engineer to pre-plan the life hazard, if any, fire hazard/load, area to be covered, material/equipment to be protected, container/cylinder storage space available and the compatible clean agent to be used.

It is also wise for Firefighters to inspect and become familiar with this new clean agent technology during drills and building inspection. The information and knowledge will enhance operational strategy at fires and emergencies. Alternative clean agent extinguishing systems are becoming more prevalent. It is important that FDNY members know where these systems are located, what they are protecting, how they operate and the safety precautions to be followed during fire operations and emergencies.

FDNY Firefighters in the 21st century must keep abreast of new fire extinguishing technology being introduced to replace halogenated (halon) hydrocarbons. Halons are hydrocarbons with one or more hydrogen atoms replaced by atoms from the halogen series (Group VIIA elements from the Periodic Table). The substitution of fluorine, chlorine, bromine or iodine confers non-flammability and fire-extinguishing properties to the agent.

Halons are discharged from nozzles or applicators in a gaseous form. Portable and local (agent is discharged directly onto the fire) application extinguishing systems (carbon tetrachloride) were introduced in the early 1900s and have been used extensively since that time. Total flooding (agent stored in tanks, cylinders or containers and discharged through fixed piping and nozzles/applicators into an enclosed space onto the hazard) fire extinguishing systems made their entrance in the 1960s.

Halon fire extinguishing systems are widely used for military, industrial and commercial applications for the protection of life, valuable machinery and equipment. Halons are and have been used to safeguard data centers, turbines, engine compartments, electronic equipment and flammable liquid storage tanks. They are highly effective, leave no residue, are non-electrically conductive and have a low toxicity (halon extinguishing systems generally do not release concentrations of agent high enough to cause life-threatening effects). These agents extinguish Class A-, Class B- and Class C-type fires by inhibiting the chemical chain reaction inside the flame zone.

The U.S. Army Corps of Engineers devised the numerical system for naming halons without the use of chemical names. The first digit of the number denotes the amount of carbon atoms in the compound molecule; the second digit represents the number of fluorine atoms; the third digit stands for the number of chlorine atoms; the fourth digit, the number of bromine atoms; and the fifth digit, the number of iodine atoms. If the fifth digit is zero, it is not expressed. (Table #1)

**Table #1**
**U.S. Army Corps of Engineers Halon Numerical System**

| *Chemical Name* | *Formula* | *Halon Number* |
|---|---|---|
| Carbon tetrachloride | CCl4 | 104 |
| Bromochlorodifluoromethane | CF2BrCl | 1211 |
| Bromotrifluoromethane | CF3Br | 1301 |

Carbon = 1; Fluorine = 2; Chlorine = 3; Bromine = 4; Iodine = 5

The principal halons used for fire extinguishing today are Halon 1211 (primarily portable and local application) and Halon 1301 (total flooding application). Two Halon 1301 total flooding fire extinguishing systems unnecessarily discharged during the historic Banker's Trust Building (280 Park Avenue) fire in the heart of midtown Manhattan in 1993. These systems were protecting computer rooms and were not in the immediate area of the fire. They were activated when smoke entered these spaces, causing smoke detectors to start the systems.

Halons have been shown, however, to play a major role in the depletion of the earth's ozone layer. When released into the atmosphere, they have an atmospheric lifetime of more than 50 years. Halons eventually are broken down by the ultraviolet rays of the sun, causing the release of chlorine. It is this chlorine that is responsible for the breakdown of large quantities of ozone.

The United States banned the production and import of these agents on January 1, 1994, under the Clean Air Act. Existing halon extinguishing systems, however, are legal. Alternative systems must be provided if the halon system is removed or modified. The search for replacement and alternative "clean agents" is ongoing worldwide.

The United States Environmental Protection Agency (U.S. EPA) evaluates various substitute fire extinguishing agents that have low ozone depletion potential (ODP) and short-term atmos-

**INERGEN (inside bank of cylinders shown) is a blend of inert atmospheric gases that boasts zero ozone depletion, zero global warming potential and zero atmospheric lifetime.**

**Varied Applications for Clean Agent Fire Protection**

- Aircraft engine nacelles
- Archives
- Bank vaults
- Cellular sites
- Communications facilities and rooms
- Compressors and pump stations
- Computer rooms
- Data processing, electrical, electronics and telecommunications equipment
- Engine rooms
- Flammable liquid storage
- Gas turbines and diesel generators
- Historical sites
- HVAC control rooms
- Industrial high-ceiling spaces
- Kitchens
- Libraries
- Locomotives
- Machinery
- Mass transit vehicles
- Military vehicles and installations
- Mining equipment
- Museums and art galleries
- Offshore drilling rigs
- Paint spray booths, lockers and mixing rooms
- Petrochemical installations
- Pharmaceutical and medical facilities
- Pleasure craft
- Raised floors
- Record and storage facilities
- Shipboard and marine engine rooms and holds
- Switchgear buildings
- Tape storage
- Textile plants
- Vaults

pheric lifetimes. Through the Significant New Alternatives Policy (SNAP) program, the EPA is transitioning the United States from the halons to human-safe and environment-friendly systems. SNAP-approved substitute fire extinguishing agents for halon, included in this article, are carbon dioxide, inert gas and INERGEN®, water mist, halocarbon agents, fluoroketones and powdered aerosols.

Halon alternatives or clean agents are defined as non-toxic substances that generally are not hazardous to humans in occupied, enclosed spaces. They also do not leave a residue after discharge on the contents of the building they are engineered to protect. Clean agents are very effective at extinguishing fire, fast acting, electrically non-conductive, non-corrosive and economical. They are utilized in both local and total flooding fire extinguishing systems. The following are some of the most commonly used halon alternatives:

• ***Carbon dioxide (CO2)*** is a clean agent that has been in use for many years and is deemed appropriate as a replacement for halon in specified applications. It is a colorless and odorless gas and considered the original clean fire extinguishing agent. From 1920 to 1960, CO2 was generally the only gaseous fire extinguishing agent on the market. It extinguishes fire by displacing oxygen, thereby eliminating one of the four components of the fire tetrahedron (oxygen, heat energy, fuel and chemical chain reaction) vital to sustain combustion. CO2 also has a cooling effect on the fire.

The high concentration of CO2 (minimum application is 34 percent) required to extinguish most fires within enclosed spaces in total flooding applications, however, creates a toxic environment that may be fatal to occupants. The gas is heavier than air and will accumulate along the floor level imitating a cloud, impeding vision and inhibiting occupants attempting to escape the area. It is for these reasons that carbon dioxide is used primarily for the protection of unoccupied buildings or spaces (raised floors in computer rooms) in occupied buildings.

**Unique water mist nozzle with multiple orifices and stainless steel piping.**

In 2000, a woman working at a financial services company at 55 Water Street in lower Manhattan died from suffocation after accidentally locking herself inside a 10,000-square-foot vault holding stock receipts and triggering the activation of a carbon dioxide fire extinguishing system. CO2 is used on Class A- (limited), Class B- and Class C-type fires and has both local and total flooding applications. During local applications, avoid contact with the gas since frostbite can occur.

• ***Inert Gases (argon, nitrogen, helium)*** are known as the noble gases (Group VIIIA elements from the Periodic Table). These gases generally are non-reactive with other chemical substances. Inert gases are colorless, odorless, non-corrosive, leave no residue and are electrically non-conductive.

Extinguishing systems using inert gas are designed to reduce the ambient oxygen concentration inside the protected area from the normal level of 21percent, to between 10 and 14 percent in total flooding applications. Within these oxygen limits, occupants can still survive while flaming combustion cannot be supported. Inert gas systems are used to extinguish Class A, Class B, Class C and some Class D fires.

• ***INERGEN***, manufactured by Ansul® Fire Protection, is the trade name for the clean agent composed of 52 percent nitrogen, 40 percent argon and eight percent carbon dioxide. The nitrogen and argon components are used to offset the weight of the carbon dioxide. INERGEN, therefore, has the same density as a normal atmosphere, which eliminates the need to provide special features within the enclosure to prevent leakage of the extinguishing agent. It has similar characteristics to the inert gases that make up more than 90 percent of this extinguishing agent.

Unlike elemental inert gases, however, it elevates the room concentration of carbon dioxide in total flooding applications. The enhanced carbon dioxide atmosphere helps to stimulate deep breathing in the human body (CO2 effect), enabling potentially trapped occupants to breathe acceptable levels of oxygen.

Unlike carbon dioxide, however, INERGEN does not liquefy under pressure, requiring more space for the storage tanks. Relatively high concentrations of this agent (between 38 and 43 percent) are required in the room or area to be protected. This creates a large amount of pressure that must be relieved in order to prevent damage to the enclosure.

The New York Data Center (32 Avenue of the Americas), at the western end of Chinatown, employs INERGEN as its primary suppression agent. INERGEN is discharged through nozzles and used to extinguish Class A-, Class B-, Class C- and some Class D-type fires.

• ***Water Mist*** systems incorporate specially engineered, fine water spray nozzles that use nitrogen to generate a micronized water mist atmosphere. The nozzles can be designed to deliver their spray under low, medium or high pressures. Water mist systems are more effective at extinguishing fires than standard sprinkler systems. The mist occupies a greater surface area per unit volume of water in comparison to the large water droplets of sprinkler systems. The enhanced surface area of the droplets allows the water mist to rapidly absorb heat energy from the fire. Additionally, as the water mist droplet changes to steam, it displaces available oxygen in the enclosed environment as it expands to approximately 1700 times at the base of the fire.

Water mist systems use substantially less water (one gpm/nozzle) to extinguish fire than do standard sprinkler systems (20 gpm/sprinkler head), resulting in less water build-up and damage. Because the water is de-ionized and so little of it is necessary to extinguish fires, water mist systems surprisingly are designed to

Members are urged to review the following references:
- Answers.com, "Inergen," *http://www.answers.com/topic/inergen*
- Environment Canada, Ontario Region-Environmental Protection Branch, Federal Programs Division, Pollution Prevention Fact Sheet #14: Alternatives to Halon & Other Halocarbon Fire Extinguishing Agents, December 2000, *http://www.p2pays.org/ref/19/18382.pdf*
- Fire Suppression Systems Association (FSSA), "About FSSA," *http://www.fssa.net/displaycommon.cfm?an=1*
- Gootman, Elissa, "Woman Dies of Suffocation After Locking Herself in a Vault," *The New York Times*, July 29, 2000, *http://query.nytimes.com*
- Spectrex Inc., Halon Alternatives--SFE (Powdered Aerosol A), *http://www.spectrex-inc.com/extinguishing/HalonAlternatives.htm*
- Willis Property Risk Control, Willis Technical Advisory Bulletin--Halon Alternatives, February 2005, *www.willis.com/news/Publications/Feb2005_Technical_Advisory_Bulletin_Halon.pdf*

safely protect energized electrical equipment. The Pfizer Buildings in midtown Manhattan employ water mist fire suppression systems to protect their rooftop back-up electrical diesel generators.

A drawback of water mist is that during the extinguishing process in occupied spaces, the air in the enclosure is cooled, creating a foggy atmosphere that can impede evacuation procedures. On the positive side, these systems are natural, non-toxic and highly effective. They are suitable for occupied and unoccupied areas and have both local and total flooding applications. Water mist is used on Class A-, Class B- and Class C-type fires.

• ***Halocarbon Agents*** are synthetic organic substances that contain a carbon-halogen (chlorine, fluorine, bromine or iodine) chemical bond, either individually or in some combination. They are acceptable SNAP replacements for the halons.

***FM-200™***, manufactured by Great Lakes Chemical Corporation, is a common halocarbon agent used widely throughout the world as a replacement for Halon 1301. It is a colorless, liquefied gas that is rapidly fully discharged (within 10 seconds) through nozzles into an area as a clear, non-conductive vapor in total flooding applications. Relatively low concentrations of this agent (between four and nine percent) are required.

FM-200 extinguishes fire via heat removal and inhibits the chemical chain reaction inside the flame zone. It is a clean agent that has acceptable toxicity for use in occupied spaces. The telecommunications hotel at 60 Hudson Street and the NY Telephone Exchange Building (75 Broad Street), both located in lower Manhattan, have FM-200 fire extinguishing systems. Halocarbon agents are effective on Class A, Class B and Class C fires.

DuPont™ Company manufactures several (***FE-25™***, ***FE-13™*** and ***FE-36™***) of the most popular halocarbon fire extinguishing agents.

FE-25 mirrors the fire extinguishing capabilities of Halon 1301 for total flooding system applications. Generally, it is used in concentrations ranging from eight to 12 percent. FE-25 is considered by fire protection engineers as a "drop-in" replacement and retrofit system for Halon 1301 extinguishing systems. FE-13 also is used as a replacement for Halon 1301 and is ideal for cold temperature areas due to its high boiling point and high vapor pressure.

FE-36 is utilized in portable and local application fire extinguishing equipment. It is a replacement for Halon 1211. FE-36 discharges from the extinguisher as a liquid with a discharge range up to 16 feet. It has a very low toxicity level, is non-corrosive, electrically non-conductive and leaves no residue.

• ***Fluoroketones*** are clear, colorless, odorless liquids with low to moderate boiling points that are compressed and pressurized with nitrogen and stored in tanks. Fluoroketones look exactly like water, but don't cause the damage associated with water when extinguishing fire in electronic and other delicate equipment. This agent is readily vaporized upon nozzle discharge. They have an atmospheric lifetime of only five days, as well as zero ozone depletion potential.

**Novec 1230 fire extinguishing system--although a liquid at room temperature inside the cylinders shown, this environmentally friendly halon replacement agent immediately gasifies after being discharged in a total flooding system.**

***Novec™ 1230*** is a fluoroketone fire extinguishing agent manufactured by the 3M™ Company. It has both local and total flooding system applications. This agent has the widest margin of safety when used in total flooding systems in occupied spaces since its use concentration is a very low four to six percent by volume. The control room for lighting the Christmas tree at Rockefeller Center is protected by a Novec 1230 fire extinguishing system. Fluoroketones extinguish Class A, Class B and Class C fires via their cooling effect.

• ***Powdered Aerosols***, which originated in the 1980s in what then was the Soviet Union, first were introduced into the global fire protection market in the early 1990s. They are used primarily in total flooding systems protecting unoccupied, enclosed areas and spaces. Powdered aerosol is manufactured using a varied mixture, which can include dry chemical extinguishing agent, gelled halocarbons, water, inert gas, carbon dioxide and oxygen.

A commonly used powdered aerosol agent (Powdered Aerosol A) consists of up to 40 percent dry chemical extinguishing agent (potassium) and 60 percent gaseous molecules (carbon dioxide, nitrogen, oxygen) contained in modular units (box-like generators with discharge outlets) or applicators of various sizes in a loop configuration around an enclosure. An electrical impulse from a separate detection system or a self-contained detection element provides the catalyst for activation. This energy penetrates into the dry chemical agent/gas mixture, pulverizing the agent and dispersing it very rapidly (0.1 to one second) over long distances into the area being protected. The small particle size (one to two microns) of the agent and enhanced surface area allow it to effectively inhibit the chemical chain reaction inside the fire zone.

Powdered aerosol systems involve simple installation and negligible maintenance, require no pressurized cylinders or piping, are cost-effective and have proved to provoke minimal toxic effects on humans. They generally have zero ozone depletion potential. Powdered aerosol extinguishing systems are beginning to gain acceptance in the U.S. and currently are being used in Iraq to protect U.S. military armored and tactical vehicle crew cabs, engine compartments and under-carriages. They provide highly efficient fire extinguishment of Class A, Class B and Class C fires.

***About the Author...***

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