Halon Replacements:
Powdered Aerosol Extinguishment Systems

by Deputy Assistant Chief Ronald R. Spadafora

In many extinguishing methods, standard dry chemical extinguishing agent is as effective as halon in fire suppression. Dry chemical by itself, however, has drawbacks (messy residue, corrosiveness, extended business interruption) that negate its use as a halon replacement agent. The residue left behind after a release of dry chemical can damage electrical wiring, electronic components and mechanical equipment. Therefore, systems were created that could pulverize dry chemical ingredients into aerosol particulate, greatly reducing its size and increasing its surface area and ability to interfere with the chemical chain reaction occurring inside the flame zone.

The result is a decrease in heat energy being produced by the fire, which eventually allows the burning material to drop below its ignition temperature. This leads to total extinguishment. Powdered aerosol also can be mixed with other extinguishing agents and released from its container under pressure to provide an efficient fire suppression, control and inert system for total flooding, fixed local and portable fire extinguisher applications.

The use of powdered aerosols as replacements for ozone-depleting halon extinguishing agents originated in the Soviet Union in the 1980s. This new technology was introduced to the world in 1990, when members of a Russian contingent lectured on the concept of powdered aerosol extinguishing systems, "Fire Protection Halons and the Environment," at a conference in Geneva, Switzerland. They referred to a solid, fire-extinguishing substance that met many "clean agent" criteria (fast and effective, non-corrosive, leaves no residue, non-electrically conductive, environmentally friendly, low toxicity, etc.).

Powdered aerosols were touted as fire suppressants that could be dispersed into an enclosure to provide a 20-minute or longer fire extinguishing or inert mixture in air. This technology, however, generally is designed for normally unoccupied spaces. Powdered aerosol particulate can raise human blood pH levels and is a respiratory and eye irritant.

For years, Russian businesses had commercialized powdered aerosol extinguishing systems for both total flooding and fixed local applications. Fire protection systems were installed in nuclear power plant control rooms, aircraft nacelles, marine engine compartments, telecommunications centers and electronics cabinets.

A portable powdered aerosol fire extinguisher for commercial use.

A few years later in 1993, more technical information about powdered aerosol was made available at the Halon Alternatives Technical Working Conference in Albuquerque, New Mexico. Today, national testing laboratories and standard associations in the United States are completing their evaluations of powdered aerosol agent and delivery systems, which soon will lead to domestic total flooding, fixed local and portable fire extinguisher approvals. U.S. fire departments, however, currently are using powdered aerosol for portable fire extinguisher applications.

Halon replacement criteria

The ideal halon replacement has not been found. The following standards are used when manufacturing and testing extinguishing agents as possible substitutes for the halons:

Low Environmental Impact

• *Low Ozone Depletion Potential (ODP)*--a relative index pertaining to the potential a substance may have in causing ozone depletion in the earth's stratosphere. These chemicals are broken down by the sun's ultraviolet rays where they release halogen atoms (primarily chlorine and bromine) that then diminish the ozone layer. Chlorofluorocarbons (CFC) are organic chemicals made up of chlorine, fluorine and carbon atoms. They are highly stable and regarded as having a high ODP. CFC-11, a refrigerant, has been given the value of one. The higher a chemical's ODP number, the greater potential damage to the environment. An equal amount of Halon 1301 (used in total flooding applications) with an ODP value of 10, for example, would deplete 10 times more ozone if released into the atmosphere than CFC-11. Halon 1211, used in fixed local and portable fire extinguisher applications has an ODP value of three.

• *Low Global Warming Potential (GWP)*--a relative index dealing with the potential contribution a substance may have when released to the atmosphere in increasing the overall temperature of the earth. Carbon dioxide is the standard measure for GWP and has been given the value of one. Similar to ODP, the higher a chemical's GWP, the greater potential damage to the environment. Halon 1301 has a GWP of 6900, while the GWP for Halon 1211 is 1300. High GWP substances commonly are denoted as "greenhouse gases." These gases interfere with the sun's energy, which after initially being absorbed by the earth's surface, radiate back out into space. Greenhouse gases absorb these infrared rays and then re-emit them back down to earth. This leads to climate change. Greenhouse gases, both natural and synthetic (man-made), include carbon dioxide, methane, nitrous oxide, halon and CFCs.

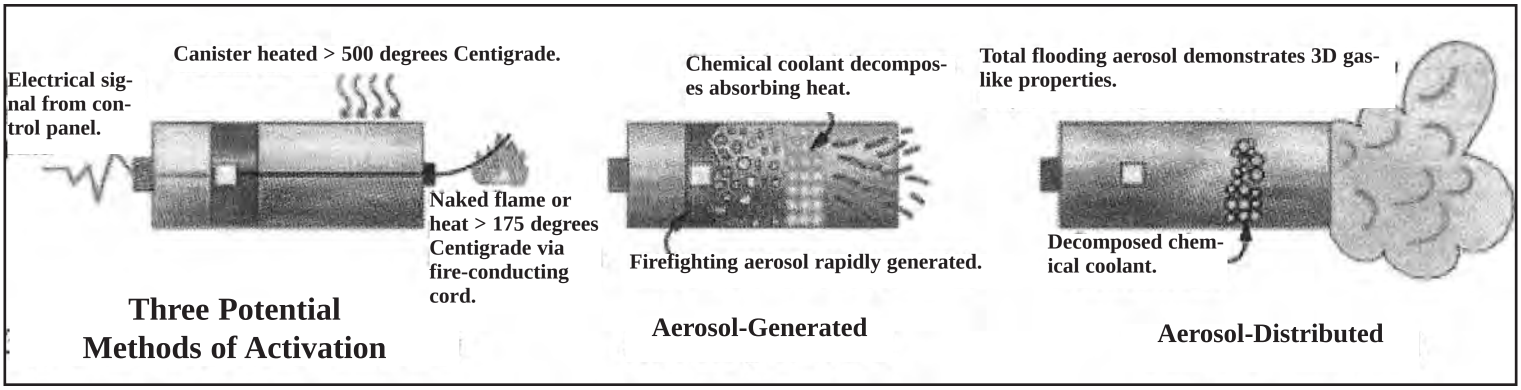
• *Short Atmospheric Lifetime (ALT)*--a measurement of the average time that a substance remains intact once released into the atmosphere. The longer a chemical's ALT, the greater the potential destruction to the environment. Halon 1301 has an ALT of 65 years, while Halon 1211 has an ALT of 11 years.

Low Toxicity

Subject to use conditions, halon replacements should not pose unacceptable human health risks to occupants, workers, the general public or people using the extinguishing agent in portable fire extinguisher applications.

Suppression Effectiveness

This standard is met through successful experimental tests and positive evaluations of the agent's fire suppression (control and extinguishment) efficiency, explosion-repression capabilities, inerting qualities, inhibiting re-ignition characteristics and success



rate on three-dimensional flammable liquid fires.

Cleanliness

It is extremely important that the agent being applied does not have the potential for causing collateral damage to machinery, engines, turbines, electronics equipment, computers, wirings and telecommunications systems. Once the agent is dispersed and the fire extinguished, cleanup should be minimal with no caking or corrosion. Downtime and business interruption should be negligible.

Non-conductive

A primary use of halon is in the protection of electrical, electronics and telecommunications equipment and wiring. Replacement agents must be electrically non-conductive and able to extinguish Class C fires rapidly without short-circuiting and electrical shock.

Economical

Halon replacement systems must be cost-effective for their utilization to advance. The extinguishing agent itself must not be cost-prohibitive. Installation, storage and maintenance costs also must be considered. “Drop-in” agents that are compatible with existing halon extinguishing systems or require the minimal amount of adaptation are preferred.

Types of powdered aerosol extinguishment systems

Propelled Extinguishing Agent Technology (PEAT)--Total flooding PEAT systems incorporate several generators (various shapes and sizes hold between 20 grams to five kilograms of solid extinguishing agent) connected in a loop configuration to a control box/display panel. The generators may hold a small pyrotechnical charge (squib) that is ignited electrically by a signal from a separate detection system or a self-contained detection element incorporated directly into the modular unit. The explosive and igniter are integral components of the generator. The solid, powdered aerosol extinguishing material inside the generator is both pulverized (one- to five-micron-size particles) and pressurized by the reaction. The energy created by the ignition of the pyrotechnical charge penetrates into the mass of the solid agent, thereby increasing its volume, surface area and dispersion range. It also causes the solid to mix readily with chemicals, gases, foams, water vapor and other extinguishing agents that may be inside the container. Kinetic energy allows the extinguishing agent to travel with enhanced velocity in all directions, thereby flooding the protected area. The discharge time is extremely rapid (0.1 to one second). Other types of total flooding generators contain no explosives. An electrical signal from a control panel provides the impulse to pulverize and pressurize the extinguishing agent.

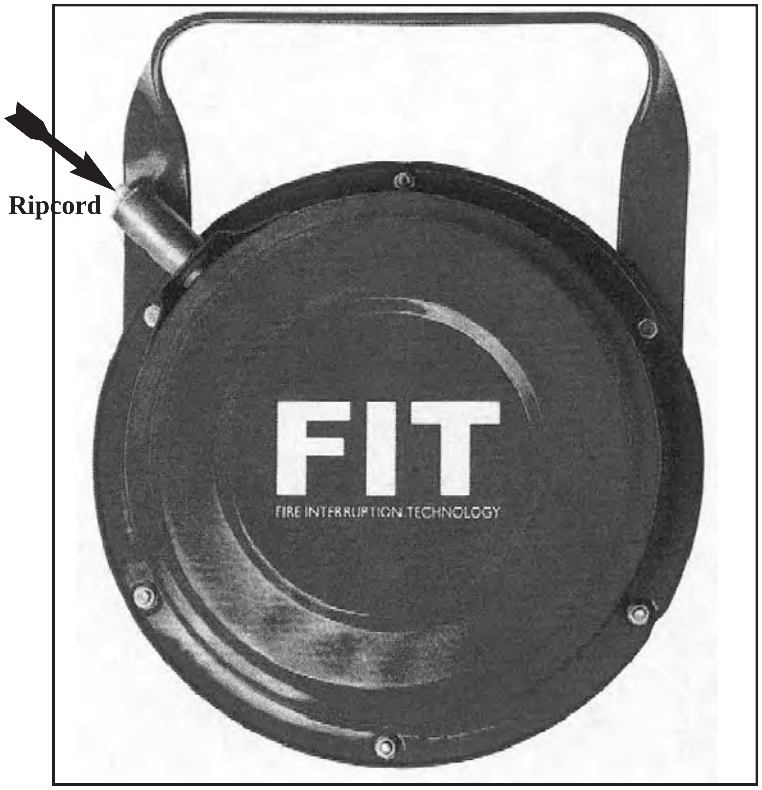
PEAT systems also may use bell-shaped, propelled launchers (PL) instead of generators for both total flooding, as well as fixed local applications. In total flooding applications, a cloud of powdered aerosol is dispersed into the enclosure to extinguish the fire and prevent re-ignition. In fixed local applications, the agent is delivered through the tubular barrel of the launcher directly onto the fire hazard. Propelled launchers are activated in the same ways generators are to protect paint spray booths, pump stations, boiler rooms, transformers, engine rooms and much more. Propelled mini-launchers (PML) are used to meet special fire protection needs within small, confined areas. The protection of military vehicles (crew cabs, engine compartments, chassis and tire areas) is one example. These tiny nozzles hold small amounts of powdered aerosol and dry chemical suppressant. They are regulated by a control box and activated by an optical and/or overheat detection system. When mobilized, the system emits the combination aerosol/dry chemical mixture into the enclosure. Fixed local applications also are available for directional coverage.

PEAT systems are simple to install and require minimal maintenance. They are not dependent upon an agent delivery system (such as high-pressure cylinders, valves, gauges, piping, connectors, nozzles). Powdered aerosol can be used in unheated enclosures and are reliable at temperatures down to -40 degrees Fahrenheit.

Pneumatic Impulse--Another kind of PEAT system uses pneumatic high pressure instead of pyrotechnical charges and squibs to provide impulses to activate containers that are filled with powdered aerosol extinguishing agent. They are used for both total flooding and fixed local systems. In total flooding applications, this system requires air cylinders and piping. A compressed air pump also may be needed for large area protection.

Heat Actuated--This system consists of generators, canisters or drums holding solid, powdered aerosol extinguishing agent. When the container is heated by the fire to approximately 900 degrees Fahrenheit, it converts its contents to a highly fluidized aerosol and is ready to activate. Heat-actuated containers also may have a fire-conducting cord that can be ignited by direct flame contact or room temperature greater than 350 degrees Fahrenheit. The ignition cord can initiate the chemical reaction to provide the energy to pulverize/pressurize the agent. Discharge is not dependent upon a fire detection system, activation system, external electrical power supply or compressed air. Heat-actuated systems are used for total flooding purposes. In an emergency, the containers can be manually carried and/or rolled into position inside the fire area by trained personnel from a safe distance.

Portable Fire Extinguisher--Many fire departments in New York State, New Jersey and Pennsylvania now carry powdered aerosol, handheld fire extinguishers manufactured by ARA Safety Inc., a fire extinguishment technology company based in Vancouver, British Columbia. These portable, nine-pound (four kilogram), discus-shaped generators have been successfully employed by Firefighters to rapidly control and/or extinguish Class A, B and C fires inside structures with a volume up to 2000 cubic feet. They are also ideal for use inside confined spaces (attics, cellars, sub-cellars). This system is activated by pulling a ripcord, which generates a spark of heat and is located on the side of the device. The heat energy acts as a catalyst in starting a thermal reaction inside the device, which pressurizes the agent. It then is thrown into the fire area like a grenade. Within 10 seconds, the generator releases a white cloud of powdered aerosol in all directions, filling the enclosure. The portable fire extinguisher also has heat actuation capability. If the ripcord is not pulled, the device automatically will dispense when deployed into areas with temperatures exceeding 500 degrees Fahrenheit.



The FIT-5 (Fire Interruption Technology) extinguisher from ARA Safety Inc. is being used by many fire departments on the east coast.

Types of Extinguishing Agent

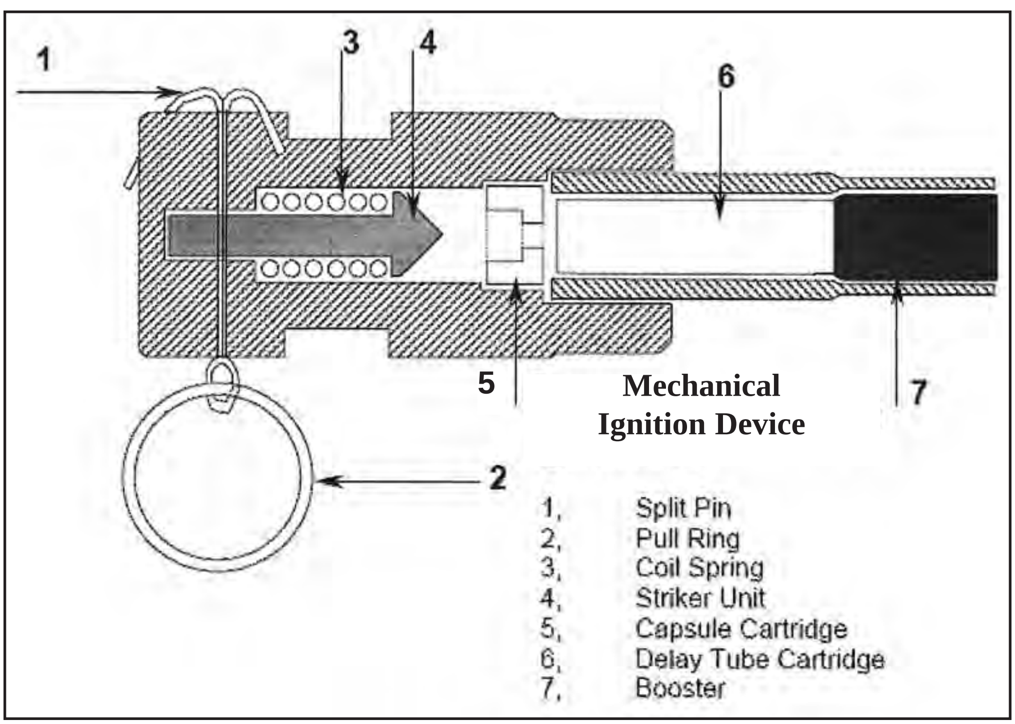
Powdered Aerosol A--Used primarily for total flooding applications in unoccupied areas, this material consists of approximately 60 percent gaseous (carbon dioxide, nitrogen, oxygen) molecules and 40 percent solid (potassium chloride, potassium oxide, potassium carbonate) salt particulate. The agent is contained inside powdered aerosol generator units. It has a long shelf life (more than 10 years).

Like most powdered aerosols, this agent extinguishes fire principally by inhibiting the chemical chain reaction (removal of the free radicals O, H and OH) occurring inside the flame zone between oxygen in the air and the vapors of the burning materials. This process is similar to the extinguishing method of standard dry chemical, but it is enhanced by the extremely small particulate size of the aerosol, which increases the agent's surface area.

Occupants inside structures with normally non-occupied spaces being protected by this agent should be provided with training regarding the associated hazards. In total flooding systems, its dry chemical components can leak out into occupied areas, obscuring the vision of occupants trying to escape the fire, thereby endangering their safe self-removal from the building.

This agent is used to extinguish Class A-, Class B- and Class C-type fire hazards. Powdered aerosol A systems have been installed to protect ship engine compartments, computer rooms, aircraft nacelles, electronics cabinets, telecommunications enclosures, flammable liquid and gas storage facilities, military vehicle engines, sub-floor wiring/cable enclosures and control rooms for nuclear power stations.

Gelled Halocarbon/Dry Chemical Suspension with Sodium Bicarbonate Additive (Formerly Powdered Aerosol B)--Gelled halocarbons are a blend of several hydrofluorocarbons (HFCs) and an additive. The addition of sodium bicarbonate or ammonium polyphosphate, for example, in the mixture enhances the fire suppression characteristics of the agent, as well as minimizes the formation of hydrofluoric acid (HF), which is toxic. HF is created by the decomposition of the HFC gases during a fire. This extinguishing agent is being used in pressurized, direct delivery tubes arranged to protect air cargo areas, boat compartments, automotive engines and most enclosed spaces. The tubes use a heat actuation design. It has both industrial and residential fixed local applications and is employed in portable fire extinguishers. Public and private users of this agent should provide special training regarding the hazards of HFCs and sodium bicarbonate to occupants inside areas being protected. This new technology is both non-corrosive and environmentally friendly. Gelled halocarbon/dry chemical suspension with



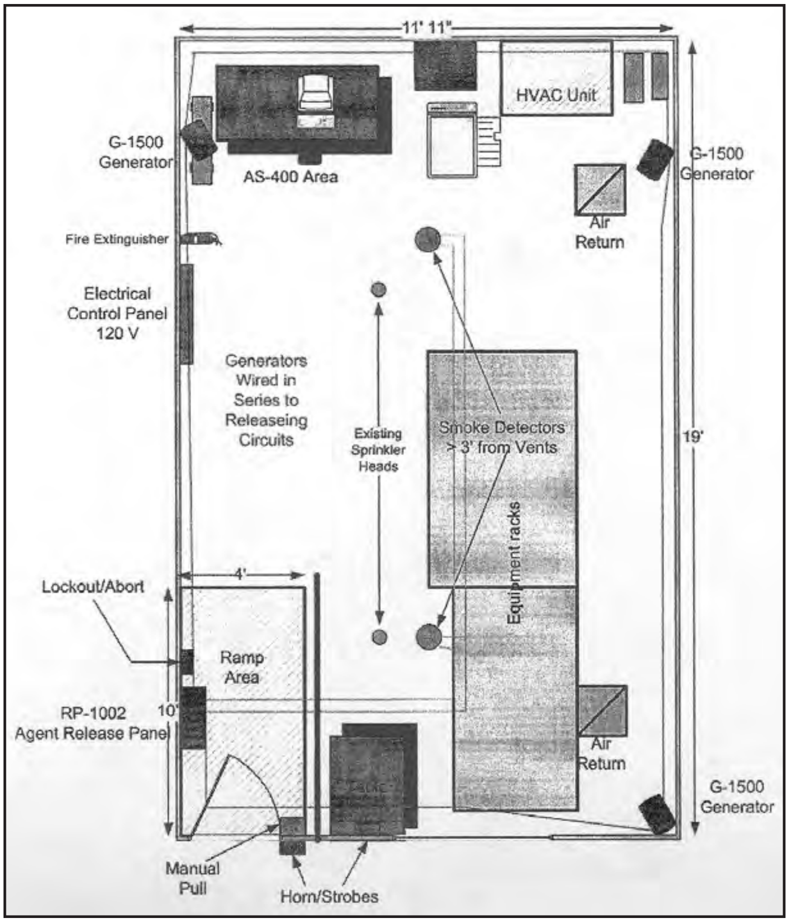
sodium bicarbonate additive is being used to extinguish Class A, Class B and Class C fires.

Powdered Aerosol C--Primarily used for total flooding and fixed local applications. Developed from aerospace technology, the agent consists of a polymer composition, consisting mainly of potassium nitrate with plasticized nitrocellulose and a solid cooling medium. The extinguishing aerosol that is discharged from the generator consists of micron-sized potassium carbonates, as well as nitrogen, carbon dioxide and water vapor. This agent forced into the flame zone from multiple discharge sites interferes with the combustion process and cuts off the flame from the fuel source, reducing the amount of radiated heat feedback. It also provides large surface area heat absorption.

Powdered aerosol C systems can be designed for effective operation in difficult to reach places. Applications using powdered aerosol C include the protection of storage tank farms, pump stations, mining equipment, power substations, drilling equipment, electrical distribution systems, aviation and marine cargo holds, helicopters and petrochemical companies. This agent is being employed on Class A, Class B, Class C and Class K (cooking, commercial kitchen) fires.

Powdered Aerosol D--This agent is a pyrotechnical-generated extinguishing aerosol that is used in total flooding applications. It also is used as an explosion suppressant. It is a solid material (alkaline metal nitrates) housed in a double-walled, hermetically sealed generator. It is an effective, environmentally friendly (ODP=0, GWP=0, ALT=0) fire suppressant that is both non-toxic and non-corrosive. Powdered aerosol D agent is used to extinguish Class A, Class B and Class C fire hazards. To enhance safety, training procedures should be provided to all employees who normally handle containers filled with this material. Applications include warehouses, industrial facilities, flammable liquid storage areas, turbine enclosures, marine engine rooms, aircraft engines and storage vaults.

Powdered Aerosol E--This extinguishing agent, consisting of a mixture of chemicals, is generated by an automated manufacturing process and then supplied to end users in a powdered form. It is a solid material encased inside a container (canister, drum or generator) which, when heated, converts into an aerosol consisting principally of potassium salts. The shelf life of this agent extends to 15 years. This agent is used for total flooding purposes. It is an environmentally friendly (ODP=0, GWP=0, ALT=0), non-toxic and non-corrosive agent. Powdered aerosol E can be applied onto Class A, Class B and Class C fire hazards. Some applications include the protection of petroleum and diesel storage spaces, warehouses, paper mills, rubber factories and electromechanical appliances.



Schematic of powdered aerosol total flooding system denoting generators wired in series to releasing circuits.

Conclusion

Powdered aerosol systems are simplistic and versatile in design. They have a very high effectiveness/weight ratio, making them economical and easy to accommodate, install and maintain. Aerosols consisting solely of solid particulate agent (sodium, potassium) or in conjunction with inert gas, foams, HFCs and water vapor, provide rapid and effective fire suppression and control. Forthcoming approvals for total flooding, fixed local and portable fire extinguisher applications are being finalized in the United States. This then will require the fire service to become even more familiar with this innovative extinguishment technology.

Members are urged to review the following references:

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