

Halon Systems

Halons are hydrocarbons in which one, or more, of the hydrogen atoms has been replaced by atoms of the halogen series, such as bromine, fluorine, chlorine, or iodine. Halon extinguishes fires by breaking the chain reaction of the combustion process. The actual mechanism is not well understood, but the accepted theory is that the halon vapor must decompose (which occurs upon exposure to temperature of 900°F) before it can inhibit the reaction.

The common halons used as fire extinguishing media are Halon 1011 (bromochloromethane), Halon 1211 (bromochlorodifluoromethane), Halon 1202 (dibromodifluoromethane), Halon 1301 (bromotrifluoromethane), and Halon 2402 (dibromotetrafluoroethane). When the hydrogen atoms in a hydrocarbon are replaced by halogen atoms, the chemical and physical properties of the compounds are changed—they are less flammable and exhibit fire extinguishing properties.

HISTORY

Halon in some form has been used since about 1900 for fire suppression, Carbon tetrachloride (Halon 104) was used in the early 1900s as a liquid in hand pump extinguishers. Its advantages were that it could be used around electrical equipment and it left no residue. However, “carbon tet” broke down upon contact with flame and could form mustard gas (used during World War I) and so there were restrictions on the use of these hand pump extinguishers in enclosed, poorly ventilated places.

In the 1920s, methylbromide (Halon 1001) was found to be a better extinguishing agent than Halon 104 and was used by both the Germans and the British as an extinguishing agent in aircraft during World War II. It is a toxic material, however, and so was never popular in portable extinguishers. The Germans developed Halon 1011 as a substitute for Halon 1001 during 1939 and 1940, but it was not widely used as an extinguishing agent until after World War II.

The above three agents are toxic and were removed from service during the 1960s. There may be a few systems left, mostly in older models of both European and American military aircraft, and in some explosion suppression systems; otherwise, these agents have been replaced with other, less toxic, agents. In the 1940s some sixty new agents were tested by universities and the military in the United States and England. From those tests Halon 1301, 1211, 1202, and 2402 were selected for further testing and evaluation. Halon 1202 was shown by these tests to be the most effective extinguishing agent but it is also the most toxic. Halon 1301, on the other hand, is the second most effective agent and the least toxic. As a result, Halon 1301, 1202 and 1211 were used in portable fire extinguishers, and to protect aircraft engines in both military and civilian aircraft in the United States and England.

The idea of using these same agents in fixed pipe extinguishing systems to protect commercial hazards developed during the 1960s. The early applications were total flooding systems using carbon dioxide hardware and technology.

Today, most halon systems are total flooding types, but local application systems are considered possible. The hardware and the technology has come into its own. The more common hazards that can be protected by either Halon 1301 or 1211 are flammable gases, flammable liquids, electrical hazards (transformers, oil switches, and circuit breakers, for instance), engines using flammable fuels, ordinary combustibles (paper, wood, and textiles), and electric computers and data processing equipment (Halon 1301 only).

Halon is not found to be effective on chemicals capable of rapid oxidation in the absence of air, reactive metals (sodium, magnesium., potassium, titanium, zirconium, plutonium, uranium, and the like), metal hydrides, and chemicals capable of autothermal decomposition. Also, many authorities will not recommend halon for protection of ordinary combustibles as the halon agent does not have the penetrating power that water does. Granted, halon will interrupt the chain reaction, but once the halon is dissipated, the fire may rekindle.

THE HALON EXTINGUISHING SYSTEM

The NFPA has standards on Halon 1301 and 1211 only for use in fixed pipe extinguishing systems. There was a standard on Halon 2402 for a short time, but due to the limited use of the compound, the standard was withdrawn.

Halogenated extinguishing agents are simply known as halons today and the system of names used was devised by the U.S. Army Corps of Engineers. This system eliminates the use of the long, confusing chemical names. For instance, Halon 1301 is actually bromotrifluoromethane and Halon 1211 is, actually bromochlorodifluoromethane. The first digit of the number represents the number of *carbon* atoms in the compound; the second represents the *fluorine* atoms; the third represents the chlorine atoms; the fourth represents the bromine atoms; and the fifth represents the iodine atoms. Terminal zeros are not shown.

So bromotrifluoromethane contains one (1) carbon atom, three (3) fluorine atoms, zero (0) chlorine atoms, one (1) bromine atom, and zero (0) iodine atoms. Its full number should be Halon 13010. Bromochlorodifluoromethane has one (1) carbon atom two (2) fluorine atoms, one (1) chlorine atom, one (1) bromine atom, and zero (0) iodine atoms. Its number should be Halon 12110.

Remember that halons are formed by replacing a hydrogen atom in a hydrocarbon with either fluorine, bromine, or chlorine. These three elements influence the properties of halon in the following ways.

Fluorine makes the compound stable, reduces its toxicity, reduces its boiling point, and increases thermal stability. Chlorine improves the fire extinguishing capabilities of the compound, but on the other hand it also reduces its thermal stability and increases its boiling point and toxicity. Bromine changes the compound in the same way as chlorine but more significantly.

The major advantage of halon is that it vaporizes rapidly in a fire situation and leaves no corrosive or abrasive residue. Halon is a nonconductor of electricity. Halon has a high liquid density, which allows relatively small storage cylinders. Although the standards list many applications, one will usually find halon protecting electric and electronic equipment,

computer facilities, aircraft engines, and places where rapid extinguishment is needed and where damage to equipment or cleanup needs to be minimized.

THE OZONE LAYER

The ozone layer protects the Earth from ultraviolet-B radiation by absorbing the radiation. As the layer is reduced, the amount of ultraviolet-B radiation that reaches the Earth increases, disrupting the world's food supply by impacting portions of the food chain, increasing the frequency of skin cancer, increasing the occurrence of cataracts, and suppressing the immune system.

HALON VERSUS THE OZONE LAYER

In 1985, the international community was already moving toward regulations to protect the ozone layer. This worldwide effort became the Coordinating Committee on the Ozone Layer (CCOL) and presented an agreement at the Vienna Convention in 1985. This agreement (signed initially by twenty-seven countries—now forty-three countries and the EEC have signed) formed no specific limits for emissions, but stated the intention of the participants to preserve the ozone layer. Formulating regulations was difficult because the nations could only agree on preserving the ozone layer, but not on how to regulate emissions or even on what products to regulate.

The United States and some Scandinavian countries wanted a freeze on chlorofluorocarbons (CFCs) and halons and then a complete phase out of these materials. Most European nations were not convinced that CFCs and halons were the major problem and wanted a moderate approach. Most developing countries felt that a freeze- and phase-out would hurt them economically, slowing or stopping technological development that they needed badly. There was a lack of hard evidence that man-made chemicals such as CFCs and halons were a major threat to the ozone layer.

In mid-1985, scientists from the British Antarctic Survey published information that showed an annual 40 percent loss in the total ozone layer (since the 1960s) over Antarctica from September through November each year. This came as a surprise, but was confirmed by American and Japanese scientists who studied previously gathered data. Further research (in 1986) culminated in agreement that a chemical cause for the ozone depletion was likely, but did not blame CFCs and halon.

In 1987, further research left no doubt that man-made chemicals, CFCs and halons in particular, were responsible for the ozone depletion over Antarctica. In September 1987, the Montreal Protocol was signed (eventually by thirty-nine countries and the EEC). One of the points in the Protocol was that the *production and use of the fire protection halons is to be allowed to continue at 1986 levels*. This was to go into effect by January 1992, 37 months after the Protocol's date of enforcement of January 1989. The halons included are 1301, 1211, and 2402. CFCs 11, 12, 113, 114, and 115 were considered independently of halon and are to be reduced to 50 percent of the 1986 levels by the Protocol. Less severe restrictions were imposed on halons and the fire protection industry than on other industrial CFCs because there were no viable substitute gases and because fire protection is vital to industry.

The Montreal Protocol also contained trade restrictions for halons and CFCs. These restrictions not only affect the signers of the Protocol but nonsigners as well. Each signing country is to (1) ban the import of bulk chemicals within a year of the effective date of the agreement, (2) ban products containing the identified chemicals within 4 years, (3) in 5 years ban products that are made with the identified chemicals but do not contain them in the finished state.

Preparing for the implementation of the agreements in the Montreal Protocol was done during 1988. But, before the year was over, more evidence indicated that the Protocol did not go far enough. In March 1988, NASA released a report that indicated that the ozone depletion was occurring more rapidly than originally thought; and the report made clear that the causes are not *natural*. Other data shows that ozone depletion in the northern portions of Europe and America, where the greater populations are, was greater than expected. Other studies indicated that bromine and chlorine played a major role in the depletion.

In March 1988, E. I. du Pont de Nemours, the world's major producer of halon and CFC, announced a phase-out of all materials containing harmful CFCs by the year 2000. However, by October 1988, due to more evidence of damage to the ozone layer, du Pont stepped up their timetable to a complete phase-out within 5 years. They also announced the building of a new plant to produce a substitute for Freon 12 (CFC- 12). The plant will produce HCF- 134a which is less harmful to the ozone layer. HCF- 134a also attacks ozone but at a much slower rate than CFC-12. The ozone layer is capable of regeneration but CFC-12 destroys it faster than it can regenerate, whereas HCF-134a destroys it at a slower rate, allowing adequate regeneration. More substitute agents are undoubtedly on the horizon.

In June 1988, there was a conference on halon and the environment held in Switzerland during which a research paper on halon discharge testing was released. It offered guidance and alternatives for nonessential discharge testing of halon, which, at that time, was believed to be an adequate response to the problem. This was not an unreasonable belief. At the NFPA Fall Meeting in Nashville a speaker gave the following statistics on halon discharges during 1985:

- 23 percent used in actual fire suppression,
- 30 percent used in discharge testing,
- 19 percent used in false discharge,
- 18 percent used during servicing of the systems,
- 9 percent used in research and development,
- 0.5 percent used in training.

Assuming the research and development is necessary, 32 percent of the annual halon use is needed; 68 percent of the halon is used in unnecessary discharge testing. One area of unnecessary discharge testing is the retest after a failure-usually on the acceptance test of a newly installed system. The systems fail on acceptance because the rooms or enclosures *do not hold the concentration*, not because the system fails to operate. So if the rooms or enclosures can be evaluated before hand, the number of retests could be reduced significantly.

By September 1988, another report called for a complete phase-out of halons and CFCs in order to stop the accumulation of chlorine and bromine in the atmosphere which would be

allowed under the terms of the Montreal Protocol. Also, to stabilize chlorine levels there would have to be a freeze of methylchloroform production. To stabilize bromine would take a 100 percent phase-out of Halon 1301 and a 90 percent to 100 percent phase-out of Halon 1211 with 100 percent participation by all concerned.

In August and September 1988, the USEPA placed requirements in the Federal Register. These regulations called for a complete phase-out of CFCs and halons.

In 1989, there were further scientific efforts to determine the extent of existing damage to the ozone layer and to find out the potential for further damage. During the Antarctic research it had been learned that the chemical reaction responsible for the damage to the ozone happens only with the formation of polar clouds that occur when the temperature in the stratosphere reaches -100°F. Although high chlorine levels had been found in the Arctic, scientists did not expect to find any problem as the temperatures there are generally warmer than in Antarctica. However, the potential for ozone destruction in the Arctic was about equal to that in Antarctica—the temperatures do get low enough to allow the chemical reaction to occur.

In early 1989, a report was released discussing a method of evaluating enclosure integrity. Halon discharge tests are performed on new halon systems to ensure that the enclosure will maintain the proper concentration for the required time, not to be sure the system will operate. The ability to prove the integrity of the enclosure would eliminate the need to discharge halon at all, except in rare circumstances. This information is now included in the body NFPA 12A, *Standard on Halon 1301 Fire Extinguishing Systems*, and in the appendix of NFPA 12B, *Standard on Halon 1211 Fire Extinguishing Systems*.

Another research effort is the Best/Essential Use Project which is to give alternatives to halon protection, and try to indicate when halon is preferred over alternative methods and vice versa.

During early 1989, two bills were introduced in Congress. S.491, *Stratospheric Ozone and Climate Protection Act of 1989*, freezes production of CFCs and halons (on 7/1/89) to 1986 levels and then reduces them gradually to a total ban on production by July 1997. S.503, *Chlorofluorocarbon and Halon Reduction Act of 1989*, provides a fee system to provide incentives to develop alternative agents and also to provide the money for the research. The fee is \$1.50 per pound multiplied by an ozone-depletion factor. This results in a fee per pound of \$15.00 for Halon 1301 and \$4.50 for Halon 1211.