HALON 1301: USES, RESTRICTIONS, AND REPLACEMENTS

Revision: 4/95
Process or Product: Fire extinguishing with Halon 1301 alternatives by total flooding
Process Code: N/A
Substitute for: Halon 1301
Waste Stream: N/A
Applicable EPA Hazardous Waste Codes: N/A
Applicable EPCRA Targeted Constituents: Halon 1301 (Bromotrifluoromethane)

Introduction:

Halon 1301 is a widely-used fire suppression and explosion protection agent applied primarily in the total flooding manner. It also has one of the highest ozone depletion potentials (ODP) of any compound; thus, its production has been stopped, and its use is being curtailed until existing stocks are exhausted. There are numerous acceptable substitutes approved by EPA's Significant New Alternatives Policy (SNAP) program, although none of them are truly ideal drop-in replacements, and all are only acceptable subject to specific use conditions as cited in 40 CFR 82 Appendix A to Subpart G, "Substitutes Subject to Use Restrictions and Unacceptable Substitutes." Non-halocarbon systems are considered "alternative technologies" and are also subject to EPA SNAP review.

Halon 1301 is, nevertheless, still approved for mission-critical uses:

- Shipboard Room Flooding
- Aircraft Fire Protection

However, existing installations of Halon 1301 that are not considered mission critical must switch to an approved acceptable alternative so that recovery of the existing stock of Halon 1301 can be submitted to the Defense Logistics Agency (DLA) Halon bank. Furthermore, procurement of replacement stocks of Halon 1301 for mission-critical uses must also come from the DLA Halon bank, since its production has already been phased out.

Description:

Halon 1301(CF_3Br) is a brominated fluorocarbon used primarily for fire suppression and explosion prevention. Because it is a severe ozone-depleting substance, there is a serious effort to phase out its use by developing and finding qualified substitutes. As a party to the Montreal Protocol, the United States is committed to reducing the amount of ozone-depleting substances going into the atmosphere. Regulations governing the protection of Stratospheric Ozone were included in the Clean Air Act Amendments of 1990, and Halon 1301 was one of the first compounds to be affected, as production was halted at the end of

1993. A production ban is now in effect.

As a part of the effort to identify suitable replacement products, the US EPA has developed a list of alternatives that were evaluated as an initiative of the SNAP program. Although the list includes many approved "acceptable" alternatives to Halon 1301, it is critical that any alternative under serious consideration have its applicability verified, given the long list of qualifications and use conditions to which each alternative is subject. The wide variation in use conditions is mainly a result of special considerations or property differences, such as cardiotoxicity. Some of these compounds are not as effective in extinguishing a fire, so a higher concentration of the compound may be required. Higher halocarbon gas concentrations also increase the sensitivity of personnel to cardiotoxicity, while at the same time reducing the available oxygen content; as a result, many of the specific use conditions require personnel evacuation in 30 seconds or less, a critical and difficult requirement to meet.

Despite the extensive selection of approved "acceptable" alternatives on the SNAP list, there are some relatively simple and logical guidelines to follow as outlined by the Navy CFC/Halon Clearinghouse:

- Water is the obvious best choice alternative; it is an inexpensive and readily available product, it is environmentally benign (zero ODP and zero global warming potential [GWP]), and it is safe for use in either unoccupied or occupied areas, since it is not toxic. Water sprinkling systems are also relatively simple to operate and to maintain. In addition, they are inherently safe, having no store of high pressure, toxic, or asphyxiating gases or liquids that can be released accidentally. Use of water systems is encouraged wherever feasible.
- Hydrofluorocarbon (HFC) alternatives and some inert gas mixtures can be used where water-based systems are not feasible. Both HFCs and inert gases (argon, carbon dioxide, nitrogen) exhibit zero ODP and have relatively low toxicity. These systems are also considered clean agents, since they do not leave residues on equipment. However, HFCs do have non-zero GWPs, and both HFC and inert gas systems require storage of high pressure gas or liquid that could present a safety problem in the event of an accidental release. Use is acceptable.
- Perfluorocarbon (PFC) alternatives should be used only for applications where no other approved substitute will work. Although PFCs have zero ODP, are reasonably effective extinguishing agents, and also have low toxicity, they can produce toxic decomposition products during a fire. Furthermore, they are very expensive and have the highest GWPs of any of the approved substitutes. Use of PFCs is discouraged.

- Hydrochlorofluorocarbons (HCFCs) are, at best, interim substitutes. HCFCs have non-zero ODPs (albeit an order of magnitude or more below Halon 1301) and non-zero GWPs. In addition, HCFCs are already scheduled for phaseout, and the established time frames could be accelerated at any time. Substitution of any of the HCFCs is not recommended.

The following is a list of acceptable Halon 1301 alternatives in order of preference as recommended by the Navy CFC/Halon Clearinghouse:

1. Pre-action water sprinkling is the preferred first choice, provided the area to be sprinkled can tolerate water while sustaining a minimum amount of collateral damage. Fine water mist systems are pending SNAP approval and should find even greater use in water intolerant areas such as those having electronic systems.
2. Carbon dioxide, HFC-227ea (C_3F_7H), or IG-541.
3. HFC-23 (CF_3H).
4. Perfluorocarbons - only where no other agent is technically feasible.

The complete list of all SNAP-approved acceptable Total Flooding Agent substitutes for Halon 1301 is as follows:

For use in UNOCCUPIED spaces only:

- CF_3I (Halon 13001); No Observed Adverse Effect Level (NOAEL) 0.2%, Lowest Observed Adverse Effect Level (LOAEL) 0.4%.
- HBFC-22B1 (Great Lakes FM-100); an interim substitute at best, since its high ozone depletion potential qualifies it for phased out production by 1 January 1996.
- HCFC-124 (C_2F_4HCl); NOAEL 1.0%, LOAEL 2.5%.
- HFC-125 (C_2F_5H); NOAEL 7.5%, LOAEL 10.0%.
- HFC-134a ($C_2H_2FCF_3$); NOAEL 4.0%, LOAEL 8.0%.
- Inert Gas Blend B (Argonite); also under review for use in occupied areas.
- Powdered Aerosol A (SFE); also under review for use in occupied areas.

For use in OCCUPIED spaces only:

- Carbon dioxide; must meet NFPA 12 and OSHA 1910.162(b)5 requirements.
- HCFC Blend A (North American Fire, NAF S-III); has a non-zero ODP and exhibits high concentrations of decomposition products due to longer than average extinguishing times.
- HFC-227ea (C_3HF_7) (Great Lakes FM-200); NOAEL 9.0%, LOAEL 10.5%; relatively short atmospheric lifetime and low GWP. Conversions do not require major redesign, since FM-200 uses the same type of cylinders as Halon 1301, although some additional storage space will be required, and Halon detection and control

equipment are acceptable for use with FM-200. However, the distribution network will require re-evaluation.

- HFC-23 (CF_3H) (DuPont FE-13); NOAEL 9.0%, LOAEL 10.5%; has a long atmospheric lifetime; thus, a relatively high GWP. Has a higher vapor pressure than Halon 1301; thus, new systems should consider carbon dioxide system hardware. Retrofits with 600 psig (42 bar) Halon 1301 systems should also be suitable.
- Perfluorobutane (C_4F_{10}) (PFC-410 or 3M CEA-410); allowed where no other agent is technically feasible (NOAEL 40%); perfluorocarbons have some of the highest GWPs because of their extremely long atmospheric lifetimes. Installations and product are relatively expensive.
- Perfluoropropane (C_3F_8) (PFC-218 or 3M CEA-308); allowed where no other agent is technically feasible (NOAEL 2X30%); perfluorocarbons have some of the highest GWPs because of their extremely long atmospheric lifetimes. Installations and product are relatively expensive.
- IG-541 (Inergen); a blend of compressed gases: nitrogen, argon, and carbon dioxide; use restricted to a minimum oxygen concentration of 10 percent and a maximum carbon dioxide concentration of 5 percent.
- Water Mist Systems; while water sprinklers do not effectively extinguish electronic fires and also cause extensive water damage, water mist systems can extinguish electronic fires with little damage; however, they are expensive systems to install; they work by the processes of flame cooling, oxygen displacement, and radiant heat attenuation; SNAP approval is pending.
- Water Sprinklers Systems.

Other:

- Sulfur hexafluoride (SF_6); discharge test only agent for total flooding systems; allowed for military use only; has a high global warming potential, though a zero ODP.

When considering a Halon 1301 alternative for any application, each and every candidate must be carefully reviewed for applicability to the SNAP Use Conditions. For example, HFC-227ea (C_3F_7H) cannot be used in normally occupied areas at concentrations greater than 10.5 percent. In areas not normally occupied by people, HFC-227ea concentrations greater than 10.5 percent are allowed, provided that any personnel can escape the area within 30 seconds after discharge of the gas; besides, the area shall be secured so that unprotected personnel are prevented from entering the area during discharge. Oxygen displacement and cardiotoxicity are again the primary concerns. Therefore, careful consideration of the specific SNAP Use Conditions is critical. Furthermore, following selection of the substitute, extreme

care must be taken when converting, retrofitting, or redesigning Halon 1301 systems, especially those for normally occupied areas.

The main questions to ask when considering conversion to a Halon 1301 alternative are the following:

1. Would a water system work for the application? If not, would a non-halocarbon alternative work for the application, such as an inert gas blend of naturally occurring atmospheric gases? If not, which of the halocarbon alternatives would work best?
2. Is the candidate an acceptable EPA SNAP-approved substitute and can its specific use conditions be met?
3. Has the candidate substitute been tested by a nationally recognized testing organization such as Underwriters Laboratories (UL) or Factory Mutual (FM)?
4. Is it necessary that the candidate substitute conform to the National Fire Protection Association Standard for Clean Agent Extinguishing Systems (NFPA Standard 2001)?
5. Does the candidate substitute extinguishing agent have zero ozone depletion potential and low global warming potential? HCFCs and the higher GWP compounds could be further restricted in the future.
6. Is the existing equipment compatible with the candidate substitute? If not, what are the performance compromises, costs, and retrofit requirements?
7. Does the candidate replacement fit the application? Vaporizing liquids like most of the synthetic chemicals require lower volumes of chemical, hence need fewer tanks than do the compressed gases; however, the compressed gases can typically be supplied from a greater distance due to their higher operating pressures. A detailed evaluation of each system must be done to determine the best fit.

Unlike most chemicals, there are no federal reporting requirements for Halon 1301 (nor for the other Halon products, 1211 and 2402) in the event of a release to the atmosphere.

Materials Compatibility:

The HFCs and PFCs are inert chemicals, and thus extremely stable, just like Halon 1301, especially in the absence of excess moisture. As a result, they are compatible with most metals, many plastics, and some elastomers, though they can cause swelling in a number of elastomers. Under normal conditions, these compounds will not degrade during long-term storage. In addition, they are essentially electrically non-conductive and do not leave residues after discharge. However, they do form a greater amount of toxic decomposition products than does Halon 1301. In any case, specific compatibility questions should always

be raised with the manufacturer.

Safety and Health: Dry chemical has a low order toxicity. pefluorocarbons also have a low order toxicity, but care should be taken when handling any of these chemicals. Proper personal protective equipment is recommended.

Consult your local Industrial Health specialist, your local health and safety personnel, and the appropriate MSDS prior to implementing any of these technologies.

Benefits: Halon 1301 production has been stopped and any existing material will most likely be used for its originally intended purpose, since there is no good method of converting it into another compound or destroying it. Therefore, switching from Halon 1301 to an approved alternative will not reduce the amount of ozone-depleting chemical going into the environment. Nonetheless, careful use of the material for mission-critical applications will prolong its useful lifetime, extending the time period over which the material enters the environment, thus lessening the immediate impact on the ozone layer. Finally, because there is no universal drop-in replacement and most of the approved substitutes also have undesirable characteristics like high global warming potentials, careful consideration of the choices is necessary to select the optimal alternative and achieve the maximum benefit.

Economic Analysis: Use of pollution prevention funds for replacement of Halon fire extinguishing systems with non-Halon-based systems is not authorized if the reason for conversion is that the existing system has reached the end of its life expectancy.

Most replacement systems for Halon 1301 are expected to be at least 30 to 50 percent more expensive initially. However, for refills following discharges, the inert gas blends will most likely be ~40 percent less expensive than the synthetic products like the halocarbons, which cost approximately two to three times the price of Halon 1301.

Major Assumptions: N/A

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DLA Halon Bank, (804) 279-4525
Factory Mutual, (617) 255-4773
Fire Suppression Systems Association, (410) 931-8100
Fire Equipment Manufacturers Association, (216) 241-7333
Halon Recycling Corporation, (800) 258-1283, (202) 223-6166
National Fire Protection Association (NFPA), (800) 344-3555
National Association of Fire Equipment Distributors, (312) 644-6610
Navy CFC and Halon Clearinghouse, (703) 769-1883
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Vendors:

DuPont Fluorochemicals
(302) 992-2177, Fax (302) 992-2836
Barley Mill Plaza 13-2150
P.O. Box 80013
Wilmington, DE 19880-0013
Manufacturer of HFC-23 also known by the tradename FE-13, HFC-125 (FE-25), HCFC-124 (FE-241) and HCFC-123 (FE-232)
Mr. Daniel Moore
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Great Lakes Chemical Co.
P.O. Box 2200
West Lafayette, IN, 47906
Manufacturer of HFC-227ea, also known by the tradename FM-200
Fluorine Chemicals Dept.
(317) 497-6206
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3M Center Building, 223-6S-04
St. Paul, MN 55144-1000
(612) 736-6055, Fax (612) 736-7542
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Manufacturer of perfluorocarbons having the designation CEA

The following vendors can provide complete fire suppression systems:

Ansul Fire Protection
1240 Iroquois Drive, Suite 102
Napierville, IL 60563-8537
(708) 305-5700, Fax (708) 305-3360
Also supplies IG-541
Mr. David Pelton

Figgie Fire Suppression Systems
1000 Governors Highway
University Park, IL 60466
(708) 534-1000, Fax (708) 534-1011
Mr. Steve Dimetrovich

Fike Fire Suppression Systems
704 South 10th St.
P.O. Box 610
Blue Springs, MO 64013
(816) 229-3405, Fax (816) 229-4615
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Kidde-Fenwal, Inc.
400 Main St.
Ashland, MA 01721
(508) 881-2000 ext. 2273, Fax (508) 881-8920
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Approving Authority:	Approving authority is controlled locally and is not required by the major claimant.
Note:	This recommendation should be implemented only after engineering approval has been granted by cognizant authority.

Source(s): CFC•Halon News Vol. 4, No. 3, Sep 94 (Navy CFC & Halon Clearinghouse newsletter)
PA Technical Inquiries: 2287, 3188, and 3385.

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Briscoe, M., D. Catchpole, "Fire/Explosion Protection Strategies for Enclosed Oil and Gas Processing Facilities," Proceedings of the 1994 International CFC and Halon Alternatives Conference, pp. 298-307, October 1994.

Sheinson, R. S., et al., "Total Flooding Real Scale Fire Testing with Halon 1301 Replacements," Proceedings of the 1994 International CFC and Halon Alternatives Conference, pp. 324-333, October 1994.

Lubiejewski, P. E., "Replacement of Halon 1301 Portable Fire Extinguishers on Board Naval Aircraft," Proceedings of the 1994 International CFC and Halon Alternatives Conference, pp. 315-323, October 1994.