# UPDATE ON HALON 1301 REPLACEMENT GASES

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## BACKGROUND

Halon 1301 is a Class I Ozone-Depleting Chemical(ODC) which has been banned from new DoD facilities since the early 1990's. Under the Clean Air Act Amendments of 1990, production of Halon 1301 in the USA was ceased in January 1994. On February 1996, a policy memo, signed by the Assistant Secretary of the Army for Installation, Logistics and Environment (ASA(IL&E), established the requirement that Halon 1301 as well as other Class I ODC=s must be removed from all Army facilities by year 2003. Halon 1301 gases has been used as effective fire extinguishing gas in total flooding situation. The uniqueness of this gas was the ability to safely discharge the gas in an occupied space and at the same time be an effective fire extinguishing agent at low concentrations.

Since the banning of Halon 1301 gases, the industry has been trying to develop a clean fire extinguishing agent that could serve as a drop-in replacement agent for Halon 1301. A clean agent is defined by NFPA 2001 (reference 1) as a electrically nonconducting, volatile or gaseous fire extinguishing agent that does not leave a residue upon evaporation. ADrop-in replacement agent@ is in theory a clean agent which can replace Halon 1301 in existing systems, utilizing the existing piping nozzles and tanks. Actual Adrop-in@ replacement gases that met the safety and environmental regulations have not be found. However, the industry has developed several clean agent that are considered replacement gases for Halon 1301, although they are not considered to be Adrop-in@ replacements. These new fire extinguishing agents essentially requires all new equipment, if one were to replace an existing halon system.

## CRITERIA

Fire protection criteria for facilities are listed in MIL-HDBK 1008C (Reference 2), which is tri-service fire protection engineering criteria. In this document, there is no requirement

for any total-flooding gaseous fire protection system, including clean agents. Before being banned, Halon 1301 was listed in MIL-HDBK 1008C (reference 2) as an option to protect mission-essential electronic equipment facilities such as computer rooms, trainers, communication systems, etc. In addition, most users insisted on protecting their electronic equipment installation with Halon 1301. However, now these existing halon systems are required to be removed by year 2003.

The current fire protection criteria for electronic equipment areas requires sprinkler protection and smoke detection connected to the installation fire department. However, even though the present criteria does not required gaseous fire protection system protection, some users request installation of clean fire extinguishing gaseous systems in their facilities. It should be noted even though clean fire extinguishing agents are not required, they are not prohibited. It behooves designer to become familiar with these new clean agents.

Designers must note that a gaseous fire extinguishing system must not be provided to replace required sprinkler protection. However, a gaseous fire extinguishing system could be provided in addition in addition to a sprinkler system. It must be note that total flooding gaseous fire extinguishing systems do not have adequate reliability as stand-alone fire protection systems in most occupancies. They are not effective for deep-seated fires and do not have cooling capability to protect heat-sensitive electronic equipment.

## HALON 1301 REPLACEMENT GASES

In order for a replacement gas to be used in an Army facility, it must be listed by the U.S. Environmental Protection Agency=s Significant New Alternative Policy (SNAP) Program, and have a toxicity clearance approved by the Office of the Army Surgeon General.

The following agents are listed in EPA SNAP for use as Halon 1301 replacement agents. With respect to toxicity clearance from the Army Surgeon General, FM-200, FE-13 and Inergen have been approved. At the time of this report, CEA-410 was not approved, since it has never been submitted. However, the author feels that if CEA-410 is submitted, it would be approved since this agent is actually less toxic than other agents that are approved.

1. FM-200, HFC-227ea (CF3-CHF-CF3), heptafluoropropane,

manufactured red by the Great Lakes Chemical Corporation,

2. FE-13, HFC-23 ($CHF_3$), trifluoromethane, manufactured by DuPont

3. CEA-410, FC-3-1-10 ($C_4F_{10}$), perfluorobutane, manufactured by 3M Corporation.

4. IG-541, Inergen, mixture of nitrogen (52%), Argon (40%) & Carbon dioxide (8%), distributed by Ansul, Inc.

**CLEAN FIRE EXTINGUISHING AGENTS**

FM-200 is the most widely used clean fire extinguishing agent. FM-200 is an effective fire extinguishing agent, is relatively safe and is the most cost effective, as compared to the other available clean agents. FM-200 design concentration for most application is 7 percent by volume. It does have a height limitation of 12 feet for nozzle placement. This means that if the hazard is higher than 12 feet then multiple levels of nozzles are needed to protect the hazard. FM-200 has a molecular weight of 170 versus halon 1301 which has a weight of 149. It is stored as a liquefied compressed gas at relatively low pressures (360 degrees F). It should not be stored or used in facilities that has an ambient temperature less than 32 degrees F. FM-200 is not a drop-in agent to replace Halon 1301 systems. Not only is flow characteristic different, but also FM-200 is not chemically compatible with the elastomeric o-rings typically used in halon systems. One drawback to using this agent, is that it produces a relatively large amount of corrosive products of decomposition (mainly HF) when exposed to a flame or heated surface. The products of decomposition can be highly toxic and corrosive.

FE-13 is DuPont:s choice as a replacement agent for Halon 1301. FE-13 is a very safe agent and is also a very stable gaseous agent. FE-13 has a relatively high vapor pressure and is stored in a liquified state in high pressure cylinders. The design concentration for total flooding is 18%. Its has a higher nozzle height limitation of 25 feet as compared to FM-200 which is 12 feet. FE-13 has a molecular weight of 70. It has better tolerance to cold temperature, down to -40 degrees F. FE-13 is more costly as compared to FM-200 because of the greater amount of agent needed to effectively extinguish a fire and the cost of high pressure equipment.

CEA-410 is an effective fire extinguishing agent, even more effective than FM-200. Its design concentration is 6% as compared to FM-200 which is 7%. It is also one of the safest agent available with an

NOAEL of 40%, as compared to FM-200's NOAEL of 9%. It too is utilized as a low pressure system. CEA-410 does have a height limitation of 10 feet for nozzle placement. It has a molecular weight of 238 versus halon 1301 which has a weight of 149. There is a major problem with this agent that limits its application. Even though CEA-410 has a zero ozone depletion potential (ODP), it has a high global warming potential (GWP) and a long atmospheric lifetime (approximately 2500 years). EPA has accepted CEA-410 subject to ANarrowed Use Limits@ in accordance with the final SNAP Ruling dated March 18, 1994. AUsers must observe the limitations on CEA-410 acceptability by undertaking the following measures: (i) conduct an evaluation of foreseeable conditions of end use; (ii) determine that human exposure to the other alternative agents may approach or result in cardiosensitization or other unacceptable toxicity effects under normal operating conditions; and (iii) determine that the physical or chemical properties or other technical constraints of the other agents preclude their use.@ EPA requires that this evaluation be documented for future reference, however reporting to the EPA is not required. Possible justification for using CEA-410 are (1) high concentrations of agent that may be needed due to the hazards encountered, (2) volume of room may significantly fluctuate, and (3) occupants may be unhealthy and or have impaired egress.

Inergen, IG 541, is mixture of nitrogen (52%), argon (40%) and carbon dioxide (8%), and is distributed by Ansul, Inc. IG 541 is an inert gas clean agent which essentially reduces the oxygen concentration to extinguish fire and prohibit fire development. It operates in a similar manner as carbon dioxide, except that it does not create an untenable condition at concentrations necessary to extinguish fires. Inergen systems are high pressure systems which require heavy duty piping and high pressure storage cylinders. In the opinion of the author, Inergen is the least safest clean agent and the most costly one for a total room flooding application, of all the agents listed in this report. The high cost is driven by the relatively large amount of agent, the heavy duty equipment, and large number of cylinders needed for a total room flooding. Another safety concern of inergen is over-pressurization of the space which can cause ceiling and walls to dislodge. A designer must consider over pressurization especially in a tight enclosure. In the author=s opinion, inergen=s primary application would be for a small unoccupied space such as underfloor cable space.

See Table for a summary of clean agents characteristics.

| AGENT | DESIGN CONCENTRATION | CONCENTRATION HEPTANE | APPROX. COST ($/LB) | NOAEL | COMMENTS |
|---|---|---|---|---|---|
| HALON 1301 | 5.0% | 3.1% | $8.00 | 5% | Existing must removed by 2003 |
| FM-200 (Great Lakes) | 7.0% | 6.6% | $32 | 9% | Limits: 32°F, 12 feet nozzle height |
| CEA-410 (3M) | 6.0% | 5.2% | $32 | 40% | Limits: 32°F, 10 feet nozzle height<br><br>Sidewall heads and hardware same as Halon.<br><br>EPA Aacceptable subject to narrowed use limits@ |
| FE-13 (DuPont) | 18.0% | 12% | $24 | 50% | Limits: -40°F, 25 feet nozzle height<br><br>High pressure |
| Inergen (Ansul) | 40.0% | 29.1 | $24 | 43% | Limits: 10 feet nozzle height<br><br>High pressure |

Table: HALON 1301 REPLACEMENT AGENTS

**SAFETY CONSIDERATIONS**

The designer must be aware of the safety considerations when designing a total room flooding fire extinguishing system. NFPA 2001 (reference 1) requires a pre-discharge alarm and a time delay that will allow sufficient time for the occupants to evacuate prior to discharge. Even though the system is designed to not produce concentrations above the No Observed Adverse Effect Level (NOAEL), there are inherent hazards with gaseous total flooding fire extinguishing systems

including the clean agents, in an occupied space. Some of the hazards are a loud noise during discharge that can be startling, turbulence caused by high velocity discharges which can be sufficient enough to dislodge loose items, such as ceiling tiles, and cold temperature which if in direct contact with vaporizing liquids can cause frostbite burns to skin.

The discharge of clean agent to extinguish a fire might can create a hazard to personnel from the products of composition that result when the clean halocarbon agents are exposed to fire and to hot surfaces. NFPA 2001 states that Aunnecessary exposure to the natural agents or to the decomposition products should be avoided.@

Most spaces where these systems are provided are in occupied spaces that are accessible to handicap persons who may not be able to evacuate quickly or who are not in the best health.

The following are steps and safeguards are necessary to prevent injury to personnel in occupied areas where total flooding systems are installed:

1. Provisions of adequate aisle ways and routes of exit and procedures to keep them clear at all times.

2. Provision of emergency lighting and directional signs to ensure quick, safe evacuation.

3. Provision of pre-discharge alarms and adequate time delay to allow occupants to evacuate before agent discharge.

4. Provision of outward-swinging, self closing doors at exits. Provision of panic hardware on exit doors.

5. Provisions of warning and instruction signs at entrances to and inside such areas.

6. Provisions of instruction and drills for all personnel.

7. Provision of means for prompt ventilation of such areas in the event of system activation.

**ADDITIONAL DESIGN CONSIDERATIONS**

The spaces receiving the total flooding protection must be a tight enclosure. All penetrations and openings must be permanently sealed or equipped with automatic closers.

Forced-air ventilating systems must be shut down or closed automatically. Completely self contained recirculating systems are not required to shut down. The volume of the system and associated ductwork shall be considered as part of the total hazard volume when determining agent quantities.

A potential problem is over-pressurization of the enclosure. Research has indicated pressure relief venting may be required for the new agents. In halon systems, the quantity of agent to extinguish a fire was significantly less than for alternative agents and so the positive pressures produced were smaller. Over-pressurization was not usually a consideration in the design of Halon systems. However, with clean agents, the pressure differentials are greater and must be considered by the designer. The enclosure must be designed to relief these pressures but still maintain concentrations. Pressurization is also affected by fire size and the agent discharge rate. Pressurization can be as high as 1000 Pa in a fire situation.

**REFERENCES**

1. National Fire Protection Association (NFPA) 2001, Standard on Clean Agent Fire Extinguishing Systems, 1996 Edition, 1 Batterymarch park, Quincy, MA 02269-9109.

2. Military Handbook (MIL-HDBK)1008C, Fire Protection For Facilities Engineering, Design and Construction, 10 June 1997, Defense Printing Service, Standardization Document Order Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.