INTRODUCTION

Section 612 of the US Clean Air Act of 1990 (Reference 1) requires the EPA to enact regulations making it unlawful to replace any Class I or Class II substance with any substitute that may impact human health or the environment and to publish lists of both prohibited and acceptable substitutes. The risk assessments required for each substitute will be conducted under the Significant New Applications Policy (SNAP) Program. In order for the EPA to make informed decisions about the possible substitutes, the New Mexico Engineering Research Institute was tasked under contract to ICF Incorporated to identify the current halon use areas and to suggest viable, near-term substitutes for the specific Halon 1211, 1301, and 2402 applications. Here, the term "substitutes" includes both replacement agents (halon-like chemicals) as well as alternatives (non-halon-like agents such as water, foam, and CO₂). This paper describes the effort undertaken to determine all the halon uses to date and to identify proposed substitutes.

HALON APPLICATIONS

A written and telephone survey was performed to identify the known Halon 1211, 1301, and 2402 uses to date. The survey resulted in the list of uses presented in Table 1. Halon 1301 and 1211 were indicated to be in wide use in a variety of applications in fixed systems and portable use, respectively. Halon 2402 was identified as having limited use as a fire extinguishing agent in the United States, except for possible replacement in existing systems (Reference 2). It has been used extensively in other countries, particularly in Italy, in Eastern European countries, and in the Soviet Republics. The properties of Halon 2402 make it most suitable for a streaming discharge from portable systems or in localized applications. At one time, Caterpillar, Inc., had a Halon 2402 fire extinguishing system in their tractors; trucks; and large-wheel loaders for engine compartments, transmission areas, and related non-occupied area use (Reference 3). However, they no longer make this unit. It has been reported that Boeing Aircraft has used Halon 2402 in some of their
<table>
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<tr>
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<td>2. Commercial</td>
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<td>3. Aircraft Cargo Bays</td>
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<td>5. Aircraft Engine Nacelle</td>
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<td>6. Spacecraft Fire Protection</td>
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<td><strong>MARINE APPLICATIONS</strong></td>
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<td>2. Machinery Spaces</td>
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<td>3. Control Rooms</td>
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<td>4. Automobile Ferry Boats</td>
</tr>
<tr>
<td><strong>CIVILIAN GROUND TRANSPORTATION</strong></td>
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<td>2. Vehicle Fixed Systems</td>
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<td>3. Vehicle Handhelds</td>
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<td>3. Production Control Rooms</td>
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<tr>
<td>4. Nuclear Power Plant Control Rooms</td>
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<tr>
<td>5. Medical Facilities</td>
</tr>
<tr>
<td><strong>OIL PRODUCTION, REFINING, TRANSFER, AND STORAGE</strong></td>
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<td>1. North Slope Facilities</td>
</tr>
<tr>
<td>2. Pipeline Pumping Stations</td>
</tr>
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<td>3. Off-Shore Oil Production</td>
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<td>4. Other Fixed Facilities</td>
</tr>
<tr>
<td><strong>PROTECTION OF NON-ELECTRONIC FACILITIES</strong></td>
</tr>
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<td>1. Flammable Liquid Storage</td>
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<tr>
<td>2. Explosion Suppression</td>
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<td>3. Libraries, Museums, Art Galleries</td>
</tr>
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<td>4. Records Storage</td>
</tr>
<tr>
<td>5. Bank Vaults and Depositories</td>
</tr>
<tr>
<td>6. Warehouses</td>
</tr>
<tr>
<td>7. Cooking and Food Processing</td>
</tr>
<tr>
<td><strong>TOTAL-FLOOD PROTECTION OF SPECIAL FACILITIES</strong></td>
</tr>
<tr>
<td>1. Antarctic Research Facilities</td>
</tr>
<tr>
<td>2. Toll Booths</td>
</tr>
<tr>
<td>3. Research Laboratories</td>
</tr>
<tr>
<td>4. Anechoic Chambers</td>
</tr>
<tr>
<td><strong>APPLICATIONS UNIQUE TO THE MILITARY</strong></td>
</tr>
<tr>
<td>1. Tactical Vehicles</td>
</tr>
<tr>
<td>2. Aircraft Fuel Cell Inerting</td>
</tr>
<tr>
<td>3. Missile Vector Control</td>
</tr>
<tr>
<td>4. High Security Fixed Facilities</td>
</tr>
<tr>
<td><strong>TRAINING-AND-TESTING</strong></td>
</tr>
</tbody>
</table>

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older 700 series aircraft, possibly the 707, 727, and 747; however, personnel now at Boeing have no knowledge of that use (Reference 4). In the past, Frito-Lay, Inc., used a Halon 2402 system in their plant at Rosenberg, Texas. However, this system is no longer in use. They are now primarily using carbon dioxide for their frying vats (Reference 5). Fenwal Safety Systems have used Halon 2402 in some explosion suppression systems in the past.

Some of those systems are still in existence; however, it has proven difficult or impossible to get replacement agent (Reference 6). Halon 2402 has been used for thrust vector control in missiles; however, alternatives are under investigation (Reference 7).

NEAR-TERM REPLACEMENTS

Near-term replacements are defined as halon-like agents (halocarbons) with significant toxicological information in existence with, at the very least, data available on acute toxicity, with fire or explosion suppression testing that indicates the material could be used as a replacement for one or more halon in some applications, and the compound is or is expected to be commercially available. Here, the availability is not necessarily limited to availability as a fire extinguishant. In several cases, the chemical is or is expected to be a CFC replacement in refrigeration and other CFC applications.

Four elements are needed for an agent to qualify as a halon replacement: an acceptable environmental impact (primarily, a low ODP), a low toxicity, cleanliness/volatility, and effectiveness. It is relatively easy to meet any three of these requirements, but a replacement that meets all four requirements well has yet been identified. A number of candidate "near-term" replacement agents have been examined (Table 2), but all have trade-offs. None of the currently available halon replacement agents (or alternative agents) can be used as drop-in substitutes in existing systems and equipment. Here, we use the term "drop-in" to mean no change in equipment design or amount of agent storage required.
TABLE 2. NEAR-TERM REPLACEMENT CANDIDATES

<table>
<thead>
<tr>
<th>Candidate</th>
<th>Chemical Formula</th>
<th>Commercialization as Halon Replacement</th>
</tr>
</thead>
<tbody>
<tr>
<td>HBFC-22B1</td>
<td>CHF₂Br</td>
<td>Great Lakes (FM 100)</td>
</tr>
<tr>
<td>HCFC-22</td>
<td>CHClF₂</td>
<td>Du Pont (FE 232)</td>
</tr>
<tr>
<td>HCFC-123</td>
<td>CF₃CHCl₂</td>
<td>Du Pont (FE 241)</td>
</tr>
<tr>
<td>HCFC-124</td>
<td>CF₃HClF</td>
<td></td>
</tr>
<tr>
<td>HFC-23</td>
<td>CHF₃</td>
<td>Du Pont (FE 13)</td>
</tr>
<tr>
<td>HFC-32</td>
<td>CH₂F₂</td>
<td></td>
</tr>
<tr>
<td>HFC-125</td>
<td>CF₃CH₂F₂</td>
<td>Du Pont (FE 25)</td>
</tr>
<tr>
<td>HFC-134a</td>
<td>CF₃CH₂F</td>
<td></td>
</tr>
<tr>
<td>HFC-227ea</td>
<td>CF₃CHFCF₃</td>
<td>Great Lakes (FM 200)</td>
</tr>
</tbody>
</table>

| FC-3-1-10  | C₄F₁₀            | 3M (PFC 410)                           |
| FC-5-1-14  | C₆F₁₄            | 3M (PFC 614)                           |

| NAF S-III  | Blend (Primarily HCFC) | N. A. Fire Guardian                   |
| NAF P      | Blend (Primarily CFCs) | N. A. Fire Guardian                   |
| Halotron I | Blend (Primarily HCFC) | American Pacific Corp.                |

In an attempt to compare the different replacements, information on several selection parameters was compiled in Table 3 on the list of near-term replacements.

ALTERNATIVE AGENTS

In many applications in which halons have been traditionally used, other types of fire extinguishing agents could be substituted for halogenated extinguishants. Table 4 lists some of the alternative (non-halocarbon) agents available to date. In some cases, the use of these alternative agent would also require alternative engineering or logistical approaches. Generally, water, dry chemicals, foam, and combination alternatives are suitable for some Halon 1211 applications, with CO₂ extinguishers also suitable in certain instances. Water sprinklers, CO₂ flooding, and inert gases are most suitable as Halon 1301 alternatives.
<table>
<thead>
<tr>
<th>Parameter</th>
<th>22B1</th>
<th>22</th>
<th>123</th>
<th>124</th>
<th>23</th>
<th>32</th>
<th>125</th>
<th>134a</th>
<th>227ea</th>
<th>3-1-10</th>
<th>5-1-14</th>
<th>NAF S-III</th>
<th>NAF P</th>
<th>Halotron I</th>
</tr>
</thead>
<tbody>
<tr>
<td>ODP, relative to CFC-11a</td>
<td>-1.4</td>
<td>0.055</td>
<td>0.02</td>
<td>0.022</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.044b</td>
<td>0.71</td>
<td>0.02</td>
</tr>
<tr>
<td>GWP, relative to CFC-11b</td>
<td>0.36</td>
<td>0.018</td>
<td>0.096</td>
<td>13d</td>
<td>0.58</td>
<td>0.27</td>
<td>0.7f</td>
<td>18.2e</td>
<td>6-12m</td>
<td>0.31b</td>
<td>0.11-0.23m</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lifetime, yearsc</td>
<td>7f</td>
<td>15.3</td>
<td>1.6</td>
<td>6.6</td>
<td>400d</td>
<td>28.1</td>
<td>15.5</td>
<td>&gt;500f</td>
<td>&gt;500f</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ext Concentration, %b</td>
<td>4.4i</td>
<td>11.6</td>
<td>6.3</td>
<td>8.2</td>
<td>12.4</td>
<td>9i</td>
<td>94</td>
<td>10.5</td>
<td>5.9e</td>
<td>5.5i</td>
<td>4.4k</td>
<td>8.3hj</td>
<td>-6.5m</td>
<td></td>
</tr>
<tr>
<td>WEq8</td>
<td>1.1</td>
<td>2.4</td>
<td>1.8</td>
<td>2.6</td>
<td>2.0</td>
<td>1.1</td>
<td>2.6</td>
<td>2.5</td>
<td>2.4</td>
<td>3.07</td>
<td>2.8</td>
<td>1.9</td>
<td>2.3</td>
<td>2.30</td>
</tr>
<tr>
<td>SVEqo</td>
<td>1.3</td>
<td>3.0</td>
<td>2.3</td>
<td>2.9</td>
<td>4.6</td>
<td>1.7</td>
<td>3.2</td>
<td>3.1</td>
<td>2.5</td>
<td>3.03</td>
<td>3.1</td>
<td>2.3</td>
<td>2.3</td>
<td>2.3</td>
</tr>
<tr>
<td>Inert Conc, %p</td>
<td>8.0</td>
<td>18.8</td>
<td>12</td>
<td>19.8</td>
<td>17.5</td>
<td>14.7</td>
<td>13.5</td>
<td>12</td>
<td>9.5</td>
<td>7.2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WEqq</td>
<td>1.6</td>
<td>2.5</td>
<td>2.6</td>
<td>2.2</td>
<td>1.4</td>
<td>2.8</td>
<td>2.2</td>
<td>3.2</td>
<td>3.5</td>
<td>3.8</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SVEqr</td>
<td>1.6</td>
<td>3.2</td>
<td>2.8</td>
<td>4.8</td>
<td>2.2</td>
<td>3.4</td>
<td>2.7</td>
<td>3.4</td>
<td>3.5</td>
<td>3.4</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Toxicity, LC50, %s</td>
<td>10.8l</td>
<td>27-30</td>
<td>3.2u</td>
<td>23-36</td>
<td>66.3</td>
<td>&gt;76</td>
<td>70</td>
<td>50</td>
<td>&gt;80</td>
<td>&gt;30p</td>
<td>30p</td>
<td>-3.2m</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Primary Applicationw</td>
<td>S</td>
<td>T</td>
<td>S</td>
<td>T</td>
<td>T</td>
<td>T</td>
<td>T</td>
<td>T</td>
<td>T</td>
<td>S</td>
<td>T</td>
<td>S</td>
<td>S</td>
<td></td>
</tr>
</tbody>
</table>

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a Calculated from atmospheric data provided by Dr. A. R. Ravishankara, Aeronomy Laboratory, National Oceanic and Atmospheric Administration, Boulder Colorado.
c Average values from Reference 8 unless otherwise noted.
d Reference 9.
e Reference 10.
f Reference 11.
g Reference 12.
h Reference 13 unless otherwise noted.
i Reference 14 gives an extinguishment concentration of 3.9 percent for same fuel.
j Reference 15.
k Reference 16.
l Specified as the "Minimum Design Concentration" in Reference 17. A higher estimated concentration is expected from data supplied to EPA SNAP program by North American Fire Guardian.
m Estimated.

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8 Calculated weight of candidate required for flame extinguishment relative to that required for a given halon. WEq = (ECr/ECr) X (MWr/MWr); ECr = extincting conc., MWr = Mole Weight, Cr = Candidate, R = reference halon. Relative to Halon 1211 for HBFC-22B1, HCFC-123, FC-5-1-14, and Halotron I; relative to Halon 1301 for other agents.

9 Calculated storage volume of candidate required for flame extinguishment relative to that required for a given halon. SVEq = WEq X (LDp/LDC); LD = Liquid Density. Relative to Halon 1211 for HBFC-22B1, HCFC-123, FC-5-1-14, and Halotron I; relative to Halon 1301 for other agents.

10 Reference 18. The explosion inertion concentration of Halon is 4.3 percent.

11 Calculated weight of candidate required for explosion inertion relative to that required for Halon 1301. WEq = (ICr/ICr) X (MWr/MWr).

12 Calculated storage volume of candidate required for explosion inertion relative to that required for Halon 1301. SVEq = WEq X (LDp/LDC).

13 Unless otherwise noted, 4-hour rat values from Reference 15.

14 Reference 19.

15 Reference 20.

16 Reference 21.

w S = streaming. T = Total Flood.
**TABLE 4. ALTERNATIVE AGENTS**

<table>
<thead>
<tr>
<th>WATER FOAM</th>
<th>COMBINATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Low-Expansion <strong>Foam</strong></td>
<td>1. Loaded Stream</td>
</tr>
<tr>
<td>2. High- and Medium-Expansion Foam</td>
<td>2. other</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>DRY CHEMICAL</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Monoammonium Phosphate</td>
<td>1. Carbon Dioxide</td>
</tr>
<tr>
<td>2. Sodium Bicarbonate</td>
<td>2. Nitrogen</td>
</tr>
<tr>
<td>3. Potassium Bicarbonate</td>
<td>3. Argon</td>
</tr>
<tr>
<td>4. Proprietary</td>
<td>4. Helium</td>
</tr>
<tr>
<td>5. Inert Gases</td>
<td></td>
</tr>
</tbody>
</table>

**HALON USE SECTORS AND SUBSTITUTES**

Table 5 contains a list of specific halon applications divided into ten major groups. This table omits fire hazards for which halons have received little use (e.g., aircraft hanger fixed systems). Since for most applications, little performance difference exists between the physically acting replacement candidates (HCFCs, HFCs, and FCs), in many cases, only "streaming halocarbon," "flooding halocarbon," or just "halocarbon" has been noted. A streaming halocarbon is one that has suitable physical properties to allow satisfactory streaming in the application noted. Similarly, a flooding halocarbon is one that is more gaseous and will satisfactorily fill a space. Since the degree of *streaming* or total-flood capability needed depends on the application, no attempt has been made at this time to determine which candidates could be used. However, Table 3 indicates which replacements have properties making them more suitable for streaming or for total *flood*. In general, the substitutes are listed in order of decreasing preference based on the assessment as it now stands. *It must be recognized that substitutes are proposed rather than recommended.* In many cases, little or no testing has been performed to show the applicability of the suggested substitutes. Combinations of substitutes shown in Table 5 may provide optimal protection for specific applications.
# TABLE 5. HALON USE SECTORS AND SUGGESTED SUBSTITUTES

<table>
<thead>
<tr>
<th>Application</th>
<th>Substitutes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A. PORTABLE EXTINGUISHERS FOR FIXED FACILITIES</strong></td>
<td></td>
</tr>
<tr>
<td>1. Residential</td>
<td>Dry Chemical, Carbon Dioxide, Water, Foam, Combination</td>
</tr>
<tr>
<td>2. Commercial</td>
<td></td>
</tr>
<tr>
<td>a. Offices:</td>
<td>Carbon Dioxide, Dry Chemical, Water</td>
</tr>
<tr>
<td>b. Manufacturing:</td>
<td>Dry Chemical, Carbon Dioxide, Water, Streaming Halocarbon</td>
</tr>
<tr>
<td>c. Retail Sales:</td>
<td>Dry Chemical, Carbon Dioxide, Water</td>
</tr>
<tr>
<td>3. Military and Government</td>
<td></td>
</tr>
<tr>
<td>a. Offices:</td>
<td>Carbon Dioxide, Dry Chemical, Water</td>
</tr>
<tr>
<td>b. Special Facilities:</td>
<td>Dry Chemical, Carbon Dioxide, Water, Foam, Streaming Halocarbon</td>
</tr>
<tr>
<td><strong>B. AEROSPACE APPLICATIONS</strong></td>
<td></td>
</tr>
<tr>
<td>1. Handheld Extinguishers for On-Board Aircraft</td>
<td></td>
</tr>
<tr>
<td>a. Passenger Areas</td>
<td>Loaded Stream, Streaming Halocarbon</td>
</tr>
<tr>
<td>a. Cockpit</td>
<td>Streaming Halocarbon, Carbon Dioxide</td>
</tr>
<tr>
<td>2. Ground-Based Aircraft Fire Protection</td>
<td></td>
</tr>
<tr>
<td>a. Flightline</td>
<td>Streaming Halocarbon, Perfluorohexane, 123 or Halotron I, Carbon Dioxide</td>
</tr>
<tr>
<td>b. Crash/Rescue</td>
<td>Dry Chemical, Foam</td>
</tr>
<tr>
<td>3. Aircraft Cargo Bays</td>
<td>Carbon Dioxide, Inert Gas, Flooding Halocarbon</td>
</tr>
<tr>
<td>4. Dry Bay Explosion Suppression</td>
<td>Halocarbon, Dry Chemical</td>
</tr>
<tr>
<td>5. Aircraft Engine Nacelle</td>
<td>Halocarbon, Dry Chemical</td>
</tr>
<tr>
<td>Application</td>
<td>Substitutes</td>
</tr>
<tr>
<td>-------------</td>
<td>-------------</td>
</tr>
</tbody>
</table>
| 6. Spacecraft Fire Protection | Fixed Systems: Carbon Dioxide, Inert Gas, FC or HFC  
Portable: FC or HFC |
| 7. Aircraft Manufacture | Portable Plug-In Halocarbon  
Halocarbon |

### C. MARINE APPLICATIONS

<table>
<thead>
<tr>
<th>Application</th>
<th>Substitutes</th>
</tr>
</thead>
</table>
| 1. Crew Quarters | Fixed System: Water  
Portable: Dry Chemical, Carbon Dioxide, Water |
| 2. Machinery Spaces | Fixed System: Carbon Dioxide, Foam, Water, Halocarbon  
Portable: Dry Chemical, Carbon Dioxide, Foam, Halocarbon |
| 3. Control Rooms | Fixed System: Flooding Halocarbon |
| 4. Automobile Ferry Boats | Fixed System: Flooding Halocarbon |

### D. CIVILIAN GROUND TRANSPORTATION

<table>
<thead>
<tr>
<th>Application</th>
<th>Substitutes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Rail Transportation</td>
<td>Dry Chemical Carbon Dioxide</td>
</tr>
<tr>
<td>2. Vehicle Fixed Systems</td>
<td>Dry Chemical Carbon Dioxide</td>
</tr>
<tr>
<td>3. Vehicle Handhelds</td>
<td>Dry Chemical Carbon Dioxide</td>
</tr>
</tbody>
</table>

### E. TOTAL-FLOOD ELECTRONICS PROTECTION

<table>
<thead>
<tr>
<th>Application</th>
<th>Substitutes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Nuclear Power Plant Control Rooms</td>
<td>Flooding Halocarbon Inert Gases</td>
</tr>
<tr>
<td>2. Telecommunications</td>
<td>Water Sprinklers Inert Gases</td>
</tr>
</tbody>
</table>
| 3. Production Control Rooms | Essential: Flooding Halocarbon Inert Gases  
Nonessential: Water Sprinklers Flooding Halocarbon Inert Gases |
<table>
<thead>
<tr>
<th>Application</th>
<th>Substitutes</th>
</tr>
</thead>
<tbody>
<tr>
<td>4. Data Processing</td>
<td></td>
</tr>
<tr>
<td>a. Occupied Areas</td>
<td>Water Sprinklers</td>
</tr>
<tr>
<td></td>
<td>Underfloor CO₂</td>
</tr>
<tr>
<td></td>
<td>Inert Gases</td>
</tr>
<tr>
<td></td>
<td>CO₂ with Prior Evacuation</td>
</tr>
<tr>
<td></td>
<td>Flooding Halocarbon</td>
</tr>
<tr>
<td>b. Unoccupied Areas</td>
<td>Carbon Dioxide Flood</td>
</tr>
<tr>
<td></td>
<td>Water Sprinklers</td>
</tr>
<tr>
<td></td>
<td>Underfloor CO₂</td>
</tr>
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<td>Inert Gases</td>
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<td>5. Medical Facilities</td>
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<td>Inert Gases</td>
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<td>Water Sprinklers</td>
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<td></td>
<td>Flooding Halocarbon</td>
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<tr>
<td>F: OIL PRODUCTION, REFINING, TRANSFER, AND STORAGE</td>
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<tr>
<td>1. North Slope Facilities</td>
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<tr>
<td>a. Fixed Total-Flood Inert Gases</td>
<td>Flooding Halocarbon</td>
</tr>
<tr>
<td>b. Portable Non-Electronic</td>
<td>Dry Chemical</td>
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<tr>
<td></td>
<td>Foam Carbon Dioxide</td>
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<tr>
<td>c. Portables Control Rooms,</td>
<td>Carbon Dioxide</td>
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<tr>
<td>Electronic Areas</td>
<td>Halocarbon</td>
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<tr>
<td>2. Pipeline Pumping Stations</td>
<td>Fixed Carbon Dioxide</td>
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<td>Inert Gases</td>
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<td>Flooding Halocarbon</td>
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<td>3. Off-Shore Oil Production</td>
<td>Fixed: Flooding Halocarbon</td>
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<td>Inert Gases</td>
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<td>4. Other Fixed Facilities</td>
<td>Storage Tanks: Foam</td>
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<td>G. PROTECTION OF NON-ELECTRONIC FACILITIES</td>
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<tr>
<td>1. Flammable Liquid Storage</td>
<td>Fixed, Unoccupied: Foam System Carbon Dioxide</td>
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<tr>
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<td>Inert Gas Flooding Halocarbon</td>
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<td>Fixed, Occupied: Foam System Inert Gases</td>
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<td></td>
<td>Flooding Halocarbon</td>
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<tr>
<td>2. Explosion Suppression (fiberboard manufacturing, corn starch drying, incineration, grain elevators)</td>
<td>Normally Unoccupied Dry Chemical Halocarbon Inert Gases</td>
</tr>
<tr>
<td>3. Libraries, Museums, Art Galleries</td>
<td>Inert Gases Flooding Halocarbon Water Sprinklers</td>
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<tr>
<td>Application</td>
<td>Substitutes</td>
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<td>4. Records Storage</td>
<td>Unoccupied: <strong>Carbon Dioxide</strong>&lt;br&gt;Inert Gas&lt;br&gt;Flooding Halocarbon&lt;br&gt;Water Sprinklers</td>
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<tr>
<td></td>
<td>Occupied: Inert Gases&lt;br&gt;Flooding Halocarbon&lt;br&gt;Water Sprinklers</td>
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<tr>
<td>5. Bank Vaults and Depositories</td>
<td>Unoccupied: <strong>Carbon Dioxide</strong>&lt;br&gt;Inert Gas&lt;br&gt;Flooding Halocarbon&lt;br&gt;Water Sprinklers</td>
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<tr>
<td></td>
<td>Occupied: Inert Gases&lt;br&gt;Flooding Halocarbon&lt;br&gt;Water Sprinklers</td>
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<td>6. Warehouses</td>
<td>Unoccupied: Water Sprinklers&lt;br&gt;<strong>Carbon Dioxide</strong>&lt;br&gt;Inert Gas&lt;br&gt;Flooding Halocarbon</td>
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<tr>
<td></td>
<td>Occupied: Water Sprinklers&lt;br&gt;Inert Gases&lt;br&gt;Flooding Halocarbon</td>
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<td>7. Cooking and Food Processing</td>
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<td>H. TOTAL-FLOOD PROTECTION OF SPECIAL FACILITIES</td>
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<tr>
<td>1. Toll Booths</td>
<td>Flooding Halocarbon</td>
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<tr>
<td>2. Antarctic Research Facilities</td>
<td>Occupied: Inert Gases&lt;br&gt;Flooding Halocarbon</td>
</tr>
<tr>
<td>3. Research Laboratories</td>
<td>Water Sprinklers&lt;br&gt;Flooding Halocarbon</td>
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<td>4. Anechoic Chambers</td>
<td>Inert Gases&lt;br&gt;Flooding Halocarbon</td>
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<td>I. APPLICATIONS UNIQUE TO THE MILITARY</td>
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<tr>
<td>1. Fixed Systems for Tactical Vehicles</td>
<td>crew Compartment&lt;br&gt;Flooding Halocarbon</td>
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<td></td>
<td>Engine Compartment&lt;br&gt;<strong>Dry Chemical Carbon Dioxide</strong>&lt;br&gt;Halocarbon</td>
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<tr>
<td>2. Aircraft Fuel Cell Inerting</td>
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<td>3. Missile Vector Control</td>
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<td>4. High Security Fixed Facilities</td>
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<td>J. TRAINING AND TESTING</td>
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<td>a Work is needed to verify applicability;</td>
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</tbody>
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REFERENCES


