A Guide to Completing a Risk Screen: Collection and Use of Risk Screen Data

Fire Suppression Sector

Under the Significant New Alternatives Policy (SNAP) Program, EPA evaluates the human health and environmental risks of proposed replacements for class I ozone-depleting substances (ODS) and analyzes the acceptability of the replacements. This risk screening process is based on information provided by the submitter in the SNAP application. After receipt of the requested information, EPA follows certain steps for analyzing the information. The remainder of this document supplements EPA's Background Document on the fire suppression and explosion protection sector (hereinafter referred to as the Background Document)[1] by outlining the two-tiered process for completing a risk screen; Part A lists the information needed from the submitter, and Part B summarizes the methodology EPA uses to determine acceptability of the proposed replacement.

A. Information Required from the Submitter

For approval of a halon replacement agent proposed for use in fire suppression end uses, a SNAP application must be submitted, and a risk screen must be prepared. To complete the risk screen, EPA requires information on the physical properties, the conditions of use, and the toxicological effects of the proposed product. A more detailed description of the information needed is provided below.

A.1. Physical Chemical Properties

- Molecular weight, chemical formula, and CAS number, if available, of each constituent in the formulation.
- Vapor pressure, physical state, melting point, and boiling point of ingredients.
- Composition of the agent, including impurities, expressed as weight percent. For agents where the dispersed agent is different from the original formulation, such as pyrotechnically generated aerosols, include both composition of the original formulation and of the dispersed agent.
- Chemical formula and concentration of byproducts created during manufacturing or use of fire suppressant.
- Flammability information, including flashpoint, upper flammability limit (UFL), lower flammability limit (LFL), and auto ignition temperature[2].
- Ozone depleting potentials (ODPs) (for ground level emissions, and for emissions at the appropriate altitude for aircraft applications) and atmospheric lifetimes (ALTs) of all components of the proposed agent.
- Global warming potentials (GWPs) of all components of the proposed blend. Specifically, for those components with long ALTs, 100-year GWPs should be provided. For those components with short ALTs[3], indirect 100-year GWPs should be reported by analyzing the GWPs of breakdown products (i.e., molecules resulting from reaction of the parent compound in the atmosphere).

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[1] U.S. EPA, 1994. *Risk Screen on the Use of Substitutes for Class I Ozone-Depleting Substances: Fire Suppression and Explosion Protection (Halon Substitutes)*. Stratospheric Protection Division. March 1994.

[2] Any substitute that is flammable will be deemed unacceptable as a fire-suppression agent. However, individual constituents of a substitute blend may be flammable if they exist in such small quantities that the fire suppressant blend is non-flammable.

[3] For evaluating ODPs, a short atmospheric lifetime is considered less than half a year, although special analysis may be needed for a compound with an ALT up to a year. For GWPs, it is important to assess whether the products could have as long or longer lifetimes than the parent molecule, which is unlikely to occur for gases having an atmospheric lifetime greater than about a year.

A.2 Conditions of Manufacture, Installation, Maintenance, and Use

A.2.1 Manufacture

- Description of the activities during which workers may be exposed to chemicals.
- Approximate dimensions of a room in which the fire suppressant will be manufactured.
- Methods used to prevent inhalation of and oral exposure to the components of the proposed fire suppressant during manufacture (e.g., controls installed or personal protective equipment used).
- The rate of airflow in the area in which the proposed fire extinguisher will be manufactured.

A.2.2 Installation, Maintenance, and Use

- Description of the installation and maintenance activities during which workers may be exposed to flooding agent chemicals.
- Description of inspection and servicing activities for streaming agents.
- The ODS being replaced (e.g., Halon 1211 or Halon 1301)
- The type of extinguisher (e.g., streaming agent or flooding agent[4]).
- The type of space in which the extinguisher will be used (i.e., occupied or unoccupied).
- For gaseous fire extinguishants the design concentration[5] expressed volumetrically on a percent basis. For example 5% v/v.
- For aerosol extinguishants, the extinguishing application density[6] and the design application density[7] expressed in g/m^3.
- The charge size of the proposed blend; and the purpose and size of the space in which the extinguishing device will be used. Also include the approximate dimensions of the space in which the fire extinguisher will be used.
- The release rate of the fire extinguisher expressed in g/sec.
- The dispersion of the fire extinguisher material (e.g., is the charge distributed evenly throughout the room?) Provide information describing dispersal system (e.g., is the fire suppression agent a liquid which is vaporized upon release through the high pressure nozzle? What are the locations of the nozzles?). The behavior of particles/aerosols upon release (e.g., agglomeration and settling).
- The rate of airflow in the area in which the fire extinguisher will be used (if this information is available) or a recommendation of airflow rate that would provide proper ventilation in areas where the fire extinguisher would be used.

A.3 Toxicological Effects

The toxicological information needed for a SNAP evaluation depends upon the type of fire extinguisher and the type of area in which the extinguisher will be used because these factors affect how people might be exposed to an agent. The schematic on the following page outlines the toxicological information needed for each kind of fire suppression risk screen.

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[4] In some instances, the type of fire extinguisher is not covered by the definitions of a streaming agent or a flooding agent. Some extinguishers may be defined as self-contained automatic fire extinguishing systems (SCAFE), or locally applied extinguishing systems (LAES), and they must be designated as such in the SNAP application.

[5] The design concentration is defined as the extinguishing concentration times a safety factor of 1.2 or 1.3, depending on the class of the hazard and the type of extinguishing system (NFPA 2001).

[6] The extinguishing application density is the minimum mass of a specific aeorsol-forming compound per m^3 of enclosure volume required to extinguish fire involving particular fuel under defined experimental conditions excluding any safety factor. (July 21, 2003-Draft NFPA 2010 Standard)

[7] The design application density is the extinguishing application density including a safety factor, required for system design purposes. (July 21, 2003-Draft NFPA 2010 Standard)

1: All Fire Suppression Submissions need:

Regardless of end-use, all risk screens need the following[8]:

- Material Safety Data Sheets for compounds contained in the proposed fire extinguishing formulation or blend
- Average and high worker exposure concentrations during the manufacture of the suppressant
- Inhalation toxicity studies if a) workers are exposed to the chemicals during manufacture or b) long-term exposure levels have not been determined by OSHA, NIOSH, ACGIH, or AIHA
- Genotoxicity studies (e.g., Ames assays, forward mutation assays, cytogenetic assays) to determine the potential for the agent to induce DNA damage

2a: In-kind Halon Alternatives:

Halocarbons
Inert Gas
Carbon dioxide

Submissions Need the Following Additional Pieces of Information:

2b: Not-in-kind Halon Alternatives:

Powdered Aerosols
Foam
Water Mist

Submissions Need the Following Additional Pieces of Information:

3a: Inert Gas

Streaming or Flooding Agent

•Information in box 1 is still required, but no additional information required for evaluating this end-use

3b: Halocarbon Gaseous

Streaming Agent

•Cardiac Sensitization Study

•Acute, sub-acute, and subchronic toxicity inhalation studies with rats

Flooding Agent

For occupied spaces:
•Cardiac Sensitization Study
•Acute and sub-acute toxicity inhalation studies with rats
For unoccupied spaces:
Information in box 1 is still required, but no additional information required for evaluating this end-use

3c: Carbon Dioxide

Streaming or Flooding Agent

•Information in box 1 is still required, but no additional information required for evaluating this end-use

3d: Foam

Streaming Agent

•Acute toxicity inhalation study with rats

•Ocular irritation studies (Draize test)

3e: Powdered Aerosols

Flooding Agent

For occupied spaces:
•Static Acute toxicity inhalation study with rats at design application density.
•Ocular irritation studies (Draize test)
•Additional information discussed below
For unoccupied spaces:
Information in box 1 is still required, but no additional information required for evaluating this end-use

3f: Water Mist

Streaming or Flooding Agent

No Information Needed.

[8] Only water mist does not need the toxicity information presented in box 1.

A.4 Additional Considerations for Powdered Aerosols Used in Occupied Spaces:

The use of powdered aerosol flooding agents in occupied spaces requires special consideration of the following issues: the physical properties and toxicity of the agent, and visibility in the protected space. These considerations, along with the required additional information, are discussed below.

A.4.1 Use

- The likelihood that the fire extinguisher will accidentally discharge (reported as the number of accidental discharges in 1 million).
- The number of extinguishing devices (i.e., generators) installed in a room and the location of these devices within the space.

A.4.2 Aerosol Particle Properties

- The length of time it takes for the particles to become distributed throughout the space and the particle size distribution over time.
- The settling rate of the particles, and the mass median aerodynamic diameter (MMAD) of the effluent released from the nozzle.
- Composition of effluent, amounts of other gases generated by weight percent.

A.4.3 Toxicity

- Draize Test results, according to EPA's OPPTS protocol 870-2400.
- An inhalation test, preferably a 15-minute static inhalation assay, with the compound at the design application density. If these data are not available, a 4-hour short-term constant exposure inhalation test at the highest achievable concentration may be performed instead.

A.4.4 Visibility

It should be noted that even if the above concerns are properly addressed and EPA approves the proposed powdered aerosol fire extinguisher for use in occupied spaces, visibility may be a further safety concern. For example, if the particle size and design concentration are such that an individual would not be able to see well enough to exit the occupied space, other authorities having jurisdiction over the design, installation, use, and maintenance of fire extinguishing systems in specific sectors (e.g., NFPA, OSHA, IMO) may disapprove of the use of the agent in occupied spaces. Alternatively, an approval by these authorities may hinge upon certain safety measures in place such as proper lighting and training of the occupants in a particular area protected by the powdered aerosol-containing fire protection device.

Table 1 provides model estimates of visibility (cm) in an occupied space following the discharge of a powdered aerosol extinguishant. The table shows that the visibility is a strong function of the powdered aerosol's concentration and MMAD. As the MMAD of the aerosol deviates from 0.5 µm and the concentration of the powdered aerosol remains constant, the visibility in the space improves. The model is based on daylight conditions, and may not precisely correspond to visibility in actual protected areas such as shipboard machinery spaces without natural light; however, the model can still be used as an approximate gauge for these circumstances. Note, that if lighting is substantially below daylight conditions, then the values in Table 1 overestimate the visibility. For a full description of the visibility model and a discussion of mitigating activities that can improve visibility, see Attachment – the Draft NFPA 2010 Standard.

Table 1. Visibility as a Function of Particle MMAD and Concentration

Particle size MMAD in µm	10	285600	2856	286	143	95	71	57	41	32	26	22
	9	248400	2484	248	124	83	62	50	36	28	23	19
	8	207600	2076	208	104	69	52	42	30	23	19	16
	7	177600	1776	178	89	59	44	36	25	20	16	14
	6	156000	1560	156	78	52	39	31	22	17	14	12
	5	139200	1392	139	70	46	35	28	20	16	13	11
	4	123600	1236	124	62	41	31	25	18	14	11	10
	3	114000	1140	114	57	38	29	23	16	13	10	9
	2	81600	816	82	41	27	20	16	12	9	7	6
	1	25200	252	25	13	8	6	5	4	3	2	2
	0.8	15600	156	16	8	5	4	3	2	2	1	1
	0.5	**12000**	**120**	**12**	**6**	**4**	**3**	**2**	**2**	**1**	**1**	**1**
	0.1	163200	1632	163	82	54	41	33	23	18	15	13
	0	10	1,000	10,000	20,000	30,000	40,000	50,000	70,000	90,000	110,000	130,000
	Concentration in mg/m^3											

Note: Non-shaded cells represent visibility in cm.

B. Incorporation of the Submitted Information into the Risk Screen

Once all the appropriate information on the fire suppressant's physical properties, conditions of use, and toxicological effects has been identified through the submission and any additional supporting information, EPA uses the collected data to develop a risk screen, which evaluates the formulation's effects on human health and the environment. The environmental effects of ODS alternatives are assessed through consideration of ALT, ODP, GWP, surface water contamination, volatile organic compounds (VOCs), and solid waste disposal. The evaluation of human health effects is made by considering occupational exposure, exposure at end-use, and general population exposure.

B.1. Environmental Risk Screening

The effects of a proposed formulation on the environment are evaluated by comparing the chemical's ALT, ODP, and GWP to those of the ODS chemical it is replacing. Any proposed formulations with 100-year GWPs greater than 1,000 and/or ODPs greater than zero are cause for concern. Any compound that contains chlorine, iodine, or bromine must be assessed for its ODP. For compounds that have not yet been assigned an ODP, the analog method must be used. The analog method predicts how the compound will break down in the atmosphere and estimates the ODP of each piece by comparison to a similarly structured molecule with a known ODP.

The use of each fire suppressant is also analyzed to determine if any of the chemical constituents are likely to be released into surface water or disposed as solid waste. For in-kind halon alternatives, water discharges and disposal are not a concern, since they vaporize upon discharge. Additionally, fire suppressant halocarbons are generally recycled at decommissioning rather than released to the atmosphere (U.S. EPA 1994a).

For not-in-kind halon alternatives, with the exception of water mist, risk screens must provide guidance on how to safely dispose of the solid constituents released by the fire extinguisher. Safety requirements may include use of a wet vacuum for clean-up of a powdered aerosol or foam. Additionally, if the solid constituents are very toxic, EPA may require that the solids be handled as hazardous waste, but in many cases the chemicals may be disposed in accordance with Federal, State, or local requirements.

Finally, VOC emissions from the use of these substitutes are also assessed. It was determined in the Background document that VOC emissions from substitutes for Halon 1301 in the total flooding sector are likely to be insignificant compared to VOC emissions from all other sources (i.e., both anthropogenic and biogenic). However, any compounds with VOC concerns are identified in the risk screen and their regulatory status is also noted.

B.2. Human Health Risk Screening

To evaluate the human health risks associated with the use of proposed fire suppressants, risk screens assess the compound's toxicity in up to three exposure scenarios: (1) occupational exposure at manufacture, (2) short-term exposure at end use, and (3) general population exposure. The resulting exposure levels for each scenario are then compared to those deemed acceptable. For many compounds, the acceptable exposure limits have already been established by the Occupational Safety and Health Administration (OSHA), the National Institute for Occupational Safety and Health (NIOSH), the American Conference of Industrial Hygienists (ACGIH), and the American Industrial Hygiene Association (AIHA); however, for those compounds without predetermined exposure limits, acceptable levels must be set by EPA, based on available toxicity information. The remainder of this section elaborates on the three exposure scenarios assessed by EPA and explains how the information provided by submitters is used in the process.

It should be noted that new fire suppression agents that combine previously accepted agents are not automatically SNAP approved. These new combinations must be evaluated on a case-by-case basis. In some cases a full risk screen is not conducted, but instead a summary evaluation is prepared that reviews previous relevant risk screens for agents that have already been approved and takes into account any exposure issues related to varying concentrations of incorporated agents. In other instances, a full risk screen is still necessary.

B.2.1 Occupational Exposure at Manufacture

All types of fire suppressant risk screens assess the occupational exposure resulting from manufacture of the fire suppressant. If workers are exposed to the chemicals during manufacturing, the risk screen must compare this exposure to a long-term exposure limit based on the inhalation toxicity studies provided by the submitter or the exposure limits published in material safety data sheets. It is not always required that occupational exposure be calculated, if the risk screen suggests that the long-term exposure limit will not be exceeded and peak exposures will not exceed ceiling concentration limits. For inert gas extinguishers, average and high-end worker exposure concentrations must be below those that could reduce the oxygen concentration below 12% (ICF 1997). Additionally, risk screens recommend exposure controls, as appropriate, such as using protective clothing and proper ventilation, as well as training in the areas of proper chemical handling and plant hygiene.

B.2.2 Short-Term Exposure at End Use, Installation, and Maintenance

The methods for determining short-term exposures vary depending on the following variables: 1) the type of fire suppressant agent 2) whether the fire suppressant application is proposed for use in total flooding or streaming uses 3) whether the fire suppressant application is proposed for use in occupied or unoccupied spaces 4) whether the exposure occurs during end use, installation, or maintenance. The following short-term exposures have been considered for in-kind halon alternatives:

1) Gaseous halocarbons used as flooding agents in occupied spaces with end use exposure
2) Gaseous halocarbons used as flooding agents in occupied spaces with installation and maintenance exposure
3) Gaseous halocarbons used as flooding agents in unoccupied spaces with end use exposure
4) Gaseous halocarbons used as flooding agents in unoccupied spaces with installation and maintenance exposure
5) Gaseous halocarbons used as streaming agents in occupied spaces with end use exposure
6) Gaseous halocarbons used as streaming agents in occupied spaces with installation and maintenance exposure
7) Inert gases or carbon dioxide used as flooding agents in occupied spaces with end use exposure
8) Inert gases or carbon dioxide used as flooding agents in occupied spaces with installation and maintenance exposure
9) Inert gases or carbon dioxide used as flooding agents in unoccupied spaces with end use exposure
10) Inert gases or carbon dioxide used as flooding agents in unoccupied spaces with installation and maintenance exposure
11) Inert gases or carbon dioxide used as streaming agents in occupied spaces with end use exposure
12) Inert gases or carbon dioxide used as streaming agents in occupied spaces with installation and maintenance exposure

The following short-term exposures have been considered for not-in-kind halon alternatives:

1) Powdered aerosols used as flooding agents in occupied spaces with end use exposure
2) Powdered aerosols used as flooding agents in occupied spaces with installation and maintenance exposure
3) Powdered aerosols used as flooding agents in unoccupied spaces with end use exposure
4) Powdered aerosols used as flooding agents in unoccupied spaces with installation and maintenance exposure
5) Powdered aerosols used as streaming agents in occupied spaces with end use exposure and/or installation maintenance exposure
6) Foams used as streaming agents in occupied spaces with end use exposure
7) Foams used as streaming agents in occupied spaces with installation and maintenance exposure
8) Water mists used as flooding agents in occupied or unoccupied spaces with end use and/or installation maintenance exposure

Each possible combination of variables is presented below using check boxes, followed by a description of the methods used to evaluate the short-term exposure for those variables. For example, as indicated by the check boxes, In-kind Halon Alternative Method 1 is a description of the process used to evaluate a gaseous halocarbon, flooding agent, used in an occupied space, for short-term exposure at the end use.

In-kind Halon Alternative – Method 1

1.	☒ Gaseous Halocarbon	☐ Inert Gas Agents or Carbon Dioxide
2.	☒ Flooding Agents	☐ Streaming Agents
3.	☒ Occupied Spaces	☐ Unoccupied
4.	☒ End Use	☐ Installation and Maintenance

For occupied spaces, the design concentration is used to calculate exposure levels to which an individual would be exposed in the event of an accidental release of the full charge of the fire suppression system. This exposure level is then compared to the no observable adverse effect level (NOAEL) for cardiac sensitization, which may be estimated using the cardiotoxic sensitization study provided by the submitter. For any other blend constituents that are not gaseous halocarbons, their design concentrations are compared to calculated short-term exposure limit (STEL) values, which may be estimated using the inhalation toxicity studies provided by the submitter. It is also necessary for halocarbons proposed for use in occupied spaces to be assessed for asphyxiation risks. To assess whether asphyxiation could result from use of the gaseous halocarbon, the design concentration and size of the room are used to calculate the amount of extinguisher released into the space. This released amount is compared to the amount of gas needed to reduce the oxygen within the space to 12 percent (because oxygen levels of 12 percent or less will lead to asphyxiation).

In-kind Halon Alternative – Method 2

1. ☒ Gaseous Halocarbon	☐ Inert Gas Agents or Carbon Dioxide
2. ☒ Flooding Agents	☐ Streaming Agents
3. ☒ Occupied Spaces	☐ Unoccupied
4. ☐ End Use	☒ Installation and Maintenance

For occupied spaces, the same methods for assessing short-term exposure at end use are used to assess exposure during installation and maintenance. See the section above.

In-kind Halon Alternative – Method 3

1. ☒ Gaseous Halocarbon	☐ Inert Gas Agents or Carbon Dioxide
2. ☒ Flooding Agents	☐ Streaming Agents
3. ☐ Occupied Spaces	☒ Unoccupied
4. ☒ End Use	☐ Installation and Maintenance

For unoccupied spaces, end-use exposure is not assessed. If solid or liquid constituents are present in the blend with a gaseous halocarbon, it may be necessary to determine settling rates for the various constituents and calculate reentry times for those constituents posing inhalation risks. Risk screens also designate safety procedures that must be followed during clean-up (e.g.,use of protective goggles, self-contained breathing apparatus, and full protective clothing).

In-kind Halon Alternative – Method 4

1. ☒ Gaseous Halocarbon	☐ Inert Gas Agents or Carbon Dioxide
2. ☒ Flooding Agents	☐ Streaming Agents
3. ☐ Occupied Spaces	☒ Unoccupied
4. ☐ End Use	☒ Installation and Maintenance

For unoccupied spaces, exposure at installation and maintenance is assessed using the same methods that are used for end use, installation, and maintenance in an occupied space. If the estimated exposure exceeds the exposure limits, and is therefore found unsafe for use in an occupied space, then the fire suppression agent may still be found acceptable for use in an unoccupied space if the installation and maintenance workers wear gloves, goggles, and SCBA.

In-kind Halon Alternative – Method 5

1. ☒ Gaseous Halocarbon	☐ Inert Gas Agents or Carbon Dioxide
2. ☐ Flooding Agents	☒ Streaming Agents
3. ☒ Occupied Spaces	☐ Unoccupied
4. ☒ End Use	☐ Installation and Maintenance

The risk screening procedure for gaseous halocarbons proposed for use as streaming agents entails calculating an instantaneous exposure level, defined as the concentration of the substitute one minute after release, assuming that the entire charge is released into the space within the first minute and that the vapors of the gaseous halocarbon are distributed instantaneously and evenly throughout the room by air currents (U.S. EPA 1994a). The resulting concentration is compared to the cardiotoxic NOAEL of the proposed substitute to assess acute toxicity. For any blend constituents that are not gaseous halocarbons, the calculated instantaneous exposure value is compared to the STEL value, which may be estimated using the inhalation toxicity studies provided by the submitter. For halocarbons used in occupied spaces, it is also necessary to assess the risk of asphyxiation. To do so, the design concentration and size of the room are used to calculate the amount of extinguisher that would be released into the space. This released amount is compared to the amount of gas needed to reduce the oxygen within the space to 12 percent (because oxygen levels of 12 percent or less may lead to asphyxiation).

In-kind Halon Alternative – Method 6

1. ☒ Gaseous Halocarbon ☐ Inert Gas Agents or Carbon Dioxide
2. ☐ Flooding Agents ☒ Streaming Agents
3. ☒ Occupied Spaces ☐ Unoccupied
4. ☐ End Use ☒ Installation and Maintenance

Exposures are not likely to result from installation and maintenance of hand-held portable fire extinguishers. However, exposures are more likely to result from inspection and servicing of these systems. Therefore, risk screens may recommend exposure controls, as appropriate, such as proper ventilation during the recharging of hand-held portable systems and training of inspectors and service technicians in proper chemical handling.

In-kind Halon Alternative – Method 7

1. ☐ Gaseous Halocarbon ☒ Inert Gas Agents or Carbon Dioxide
2. ☒ Flooding Agents ☐ Streaming Agents
3. ☒ Occupied Spaces ☐ Unoccupied
4. ☒ End Use ☐ Installation and Maintenance

For occupied spaces, the design concentration is used to calculate exposure levels to which an individual would be exposed in the event of an accidental release of the full charge of the fire suppression system. This design concentration is used to determine whether occupants could be asphyxiated due to lowered oxygen levels. Based on the physiological effects of inert gas agents in humans, a minimum oxygen concentration of 12% at sea level is required. In addition, per OSHA requirements, protective gear (SCBA) must be available in the event that personnel must remain in or reenter the area.

In-kind Halon Alternative – Method 8

1. ☐ Gaseous Halocarbon ☒ Inert Gas Agents or Carbon Dioxide
2. ☒ Flooding Agents ☐ Streaming Agents
3. ☒ Occupied Spaces ☐ Unoccupied
4. ☐ End Use ☒ Installation and Maintenance

For occupied spaces, the same methods for assessing short-term exposure at end use are used to assess exposure during installation and maintenance. See the section above.

In-kind Halon Alternative – Method 9

1. ☐ Gaseous Halocarbon ☒ Inert Gas Agents or Carbon Dioxide
2. ☒ Flooding Agents ☐ Streaming Agents
3. ☐ Occupied Spaces ☒ Unoccupied
4. ☒ End Use ☐ Installation and Maintenance

For unoccupied spaces, protective gear (SCBA) must be available in the event that personnel must enter the area after an accidental release. Furthermore, for constituents that may be asphyxiates, the minimum time that workers must wait after an accidental release before entering the space must be calculated.

In-kind Halon Alternative – Method 10

1. ☐ Gaseous Halocarbon ☒ Inert Gas Agents or Carbon Dioxide
2. ☒ Flooding Agents ☐ Streaming Agents
3. ☐ Occupied Spaces ☒ Unoccupied
4. ☐ End Use ☒ Installation and Maintenance

For unoccupied spaces, exposure at installation and maintenance is assessed using the same methods that are used for end use, installation, and maintenance in an occupied space. If the estimated exposure exceeds the exposure limits, and is therefore found unsafe for use in an occupied space, then the fire suppression agent may still be found acceptable for use in an unoccupied space if the installation and maintenance workers wear gloves, goggles, and SCBA.

In-kind Halon Alternative – Method 11

1. ☐ Gaseous Halocarbon ☒ Inert Gas Agents or Carbon Dioxide
2. ☐ Flooding Agents ☒ Streaming Agents
3. ☒ Occupied Spaces ☐ Unoccupied
4. ☒ End Use ☐ Installation and Maintenance

The risk screening procedure for inert gases and carbon dioxide proposed for use as streaming agents entails calculating an instantaneous exposure level, defined as the concentration of the substitute one minute after release, assuming that the entire charge is released into the space within the first minute and that the vapors of the inert gas or carbon dioxide are distributed instantaneously and evenly throughout the room by air currents (U.S. EPA 1994a). The instantaneous concentration is used to determine whether occupants could be asphyxiated due to lowered oxygen levels. Based on the physiological effects of inert gas agents in humans, a minimum oxygen concentration of 12% at sea level is required.

In-kind Halon Alternative – Method 12

1.	☐ Gaseous Halocarbon	☒ Inert Gas Agents or Carbon Dioxide
2.	☐ Flooding Agents	☒ Streaming Agents
3.	☒ Occupied Spaces	☐ Unoccupied
4.	☐ End Use	☒ Installation and Maintenance

Exposures are not likely to result from installation and maintenance of hand-held portable fire extinguishers. However, exposures are more likely to result from inspection and servicing of these systems. Therefore, risk screens may recommend exposure controls, as appropriate, such as proper ventilation during the recharging of hand-held portable systems and training of inspectors and service technicians in proper chemical handling.

Not–in-kind Halon Alternative – Method 1

1.	☒ Powdered Aerosols	☐ Foam	☐ Water Mist
2.	☒ Flooding Agents	☐ Streaming Agents	
3.	☒ Occupied Spaces	☐ Unoccupied	
4.	☒ End Use	☐ Installation and Maintenance	

For occupied spaces, the EPA uses the design application density to calculate the amount of fire suppressant that an individual would inhale within a period of five minutes--the maximum time permitted in order to exit the space. An exposure concentration is then calculated based on the mass median aerodynamic diameter and models such as Regional Deposited Dose Ratio (RDDR; U.S. EPA 1994b) or Multiple-Path Particle Dosimetry (MPPD; CIIT 2002), which estimate the amount of aerosol that is expected to enter the lungs of a human. This information allows the EPA to compare the exposure concentration to that used in the acute inhalation toxicity tests submitted as part of the application for SNAP approval. Ultimately, this exposure concentration is compared to a STEL, which may be estimated using these inhalation toxicity studies. For powdered aerosols, ocular irritation, and visibility must also be considered (see Powdered Aerosol Flow Chart in Attachment 1).

Not–in-kind Halon Alternative – Method 2

1.	☒ Powdered Aerosols	☐ Foam	☐ Water Mist
2.	☒ Flooding Agents	☐ Streaming Agents	
3.	☒ Occupied Spaces	☐ Unoccupied	
4.	☐ End Use	☒ Installation and Maintenance	

For occupied spaces, the same methods for assessing short-term exposure at end use are used to assess exposure during installation and maintenance. See the section above.

Not–in-kind Halon Alternative – Method 3

1. ☒ Powdered Aerosols	☐ Foam	☐ Water Mist
2. ☒ Flooding Agents	☐ Streaming Agents	
3. ☐ Occupied Spaces	☒ Unoccupied	
4. ☒ End Use	☐ Installation and Maintenance	

For unoccupied spaces, it may instead be necessary to determine the settling rates for the various constituents and to calculate reentry times for constituents that pose inhalation risks. Risk screens also designate the safety procedures that must be followed during clean-up (e.g., use of protective goggles, self-contained breathing apparatus, and full protective clothing).

Not–in-kind Halon Alternative – Method 4

1. ☒ Powdered Aerosols	☐ Foam	☐ Water Mist
2. ☒ Flooding Agents	☐ Streaming Agents	
3. ☐ Occupied Spaces	☒ Unoccupied	
4. ☐ End Use	☒ Installation and Maintenance	

For unoccupied spaces, exposure at installation and maintenance is assessed using the same methods that are used for end use, installation, and maintenance in an occupied space. If the estimated exposure exceeds the exposure limits, and is therefore found unsafe for use in an occupied space, then the fire suppression agent may still be found acceptable for use in an unoccupied space if the installation and maintenance workers wear gloves, goggles, and SCBA.

Not–in-kind Halon Alternative – Method 5

1. ☒ Powdered Aerosols	☐ Foam	☐ Water Mist
2. ☐ Flooding Agents	☒ Streaming Agents	
3. ☒ Occupied Spaces	☐ Unoccupied	
4. ☒ End Use	☒ Installation and Maintenance	

Only flooding agent powdered aerosols are evaluated through this risk screen process. Dry powder fire suppressants (carbon dioxide; sodium bicarbonate combinations) are already approved for use as streaming agents. It is highly unlikely that pyrotechnically generated aerosols would be developed for streaming applications given the high temperatures generated upon discharge.

Not–in-kind Halon Alternative – Method 6

1. ☐ Powdered Aerosols	☒ Foam	☐ Water Mist
2. ☐ Flooding Agents	☒ Streaming Agents	
3. ☒ Occupied Spaces	☐ Unoccupied	
4. ☒ End Use	☐ Installation and Maintenance	

Traditionally, foams have only been used as streaming agents and not as flooding agents.
The risk screening procedure for foams proposed for use as streaming agents entails calculating an instantaneous exposure level using dispersal information provided by the submitter. EPA uses the instantaneous release to calculate the amount of fire suppressant that an individual would be exposed to within a period of five minutes--the maximum time permitted in order to exit the space. This exposure concentration may then be compared to a STEL, which may be estimated using the inhalation toxicity studies provided by the submitter. Ocular irritation must also be considered.

Risk screens also designate the safety procedures that must be followed during clean-up (e.g. use of protective goggles, self-contained breathing apparatus, and full protective clothing).

Not–in-kind Halon Alternative – Method 7

1. ☐ Powdered Aerosols ☒ Foam ☐ Water Mist
2. ☐ Flooding Agents ☒ Streaming Agents
3. ☒ Occupied Spaces ☐ Unoccupied
4. ☐ End Use ☒ Installation and Maintenance

Exposures are not likely to result from installation and maintenance of hand-held portable fire extinguishers. However, exposures are more likely to result from inspection and servicing of these systems. Therefore, risk screens may recommend exposure controls, as appropriate, such as proper ventilation during the recharging of hand-held portable systems and training of inspectors and service technicians in proper chemical handling.

Not–in-kind Halon Alternative – Method 8

1. ☐ Powdered Aerosols ☐ Foam ☒ Water Mist
2. ☒ Flooding Agents ☒ Streaming Agents
3. ☒ Occupied Spaces ☒ Unoccupied
4. ☒ End Use ☒ Installation and Maintenance

No information is required to assess end-use exposure because water mist is non-toxic. This is the case whether water mist is used in occupied or unoccupied spaces, or whether it is used as a streaming or flooding agent. Water mist systems containing additives have not been submitted for SNAP approval; however, if such an application is received, these systems will be evaluated on a case-by-case basis and additional information may be required.

B.2.3 General Population Exposures

The risk assessment must determine whether any constituent of the fire suppressant poses an exposure risk to the general population through ambient air, surface water, or solid waste exposures. The exposure risk may be either from release during manufacture or from release at the end use. If the general population is exposed to the proposed fire suppressant through the ambient air, an exposure concentration must be determined and compared to a Reference Concentration (RfC) for that chemical constituent. If a constituent has previously been approved for another end-use for which the general population exposure is expected to be higher, then it can be assumed that exposure to that constituent will not cause any significant health threats to the general population in the proposed end use. For a more detailed discussion of fire suppressant release into surface water or disposal as solid waste, see “Environmental Risk Screening” under section B of this report.

Exposure Limits Used in a Risk Screen

There are a number of exposure limits that can be used for comparison to exposure concentrations, as provided in the table below (FAA 2002). EPA would use exposure limits created by OSHA, NIOSH, ACGIH, and AIHA, respectively, if available, before those established by the EPA or commercial organizations.

Table 2. Exposure Limits Established by Various Organizations

Importance/ Relevance	Exposure Limit		Establishing Organization	Definition
		Long-Term Exposures[a]		
1	PEL	Permissible Exposure Limit	OSHA	Enforceable 8-hour TWA for airborne substances
2	REL	Recommended Exposure Limit	NIOSH	Recommended 8-hour TWA
3	TLV	Threshold Limit Value	ACGIH	Recommended 8-hour TWA
4	WEEL	Workplace Environmental Exposure Limit Guide	AIHA	Recommended 8-hour TWA
5	WGL[b]	Workplace Guidance Level	EPA	8-hour per day TWA value
6	AEL	Acceptable Exposure Limit	Commercial	Produced by any commercial organization , usually an 8-hour TWA
		Short-Term Exposures[b]		
1	STEL	Short-term Exposure Limit	OSHA	Enforceable 15-minute TWA exposure that should not be exceeded any time during a work day
2	CL	Ceiling Level	OSHA	Enforceable exposure level that cannot be exceeded for any time period
3	IDLH	Immediately Dangerous to Life and Health	NIOSH	Maximum concentration that will allow one to escape within 30 minutes without irreversible health affects
4	EGL	Emergency Guidance Level	EPA	Concentration that will allow one to escape within 15 or 30 minutes without irreversible health effects
		General Population Exposures		
	RfC	Reference Concentration	Any	Human population exposure, resulting from continuous inhalation or daily oral dose of a chemical that is unlikely to result in adverse systemic effects.[c]
		Cardiotoxic Exposures		
	NOAEL LOAEL	No-observed-adverse-effects level Lowest-observed-adverse-effect level	Any	Both NOAEL and LOAEL determined by the onset of arrhythmias resulting from the inhalation of a chemical in the presence of epinephrine.

Source: Adapted from FAA, 2002. Options to the Use of Halon for Aircraft Fire Suppression Systems – 2002 Update.
a. For Fire Suppressants the long-term exposure values are used for assessment of occupational exposure.
b. For Fire Suppressants, STEL values are typically used for assessment of end use exposure.
c. Definition summarized from http://www.epa.gov/ttnatwhlthef/hapglossaryrev.html

Acronym List

ACGIH	American Conference of Government Industrial Hygienists
AIHA	American Industrial Hygiene Association
ALT	atmospheric lifetime
CAS	Chemical Abstracts Service
EPA	U.S. Environmental Protection Agency
FAA	Federal Aviation Administration
GWP	global warming potentials
IMO	International Maritime Organization
LAES	location application extinguishing systems
LFL	lower flammability limit
LOAEL	lowest observed adverse effect level
MPPD	Multiple-Path Particle Dosimetry
MMAD	mass median aerodynamic diameter
NFPA	National Fire Protection Association
NIOSH	National Institute for Occupational Safety and Health
NOAEL	no observable adverse effect level
ODP	ozone depleting potential
ODS	ozone depleting substances
OPPTS	Office of Pesticides, Prevention, and Toxic Substances
OSHA	Occupational Safety and Health Administration
RDDR	Regional Deposited Dose Ratio
RfC	Reference Concentration
SCAFE	self-contained automatic fire extinguishing systems
SCBA	self-contained breathing apparatus
SNAP	Significant New Alternatives Policy
STEL	short-term exposure limit
UFL	upper flammability limit
VOCs	volatile organic compounds

Glossary

Atmospheric lifetime[c]	The time it takes for a compound to be reduced to 1/e or 36.8% of its original concentration in the atmosphere. Most gases only have one atmospheric lifetime because they follow pure exponential decay. However, for other compounds such as CO_2 as time increases, the amount of time it takes to reduce the compound to 36.8% of its concentration increases. In these cases a compound's second atmospheric lifetime is several hundreds of years.
Total flooding system[e,h]	A system designed to automatically discharge an agent and achieve a specified minimum agent concentration throughout a confined space.
Global warming potential[a]	The ratio of the atmospheric warming caused by a substance to the warming caused by a similar mass of carbon dioxide.
Location application extinguishing system	These systems release extinguishing agent from a fixed nozzle directly onto burning material. Unlike flooding systems, these systems are not designed to distribute agent evenly throughout an entire volume of a protected space and unlike streaming systems, they are not designed to allow for a human being to manipulate the discharge direction or quantity.
Lower flammability limit[g]	Minimum concentration of a substance at which ignition will occur.
Lowest observed adverse effect level[e]	The lowest concentration at which an adverse physiological or toxicological effect has been observed.
Mass median aerodynamic diameter[d]	The particle size distribution of any aerosol statistically, based on the weight and size of the particles. Fifty percent of the particles by weight will be smaller than the median diameter and fifty percent of the particles will be larger.
Multiple-Path Particle Dosimetry[d]	A dosimetry model which allows for the extrapolation between inhalation concentrations in animal models to that of a human to predict responses at particular exposure concentrations.
No observed adverse effect level[e]	The highest concentration at which no adverse physiological or toxicological effect has been observed.
Ozone depleting potential[b]	ODP is a ratio of the impact of a chemical on ozone compared to the impact of a similar mass of CFC-11. Thus, the ODP of CFC-11 is defined to be 1.0.
Ozone depleting substances[b]	ODS include CFCs, HCFCs, halons, methyl bromide, carbon tetrachloride, and methyl chloroform. ODS are generally very stable in the troposphere and only degrade under intense ultraviolet light in the stratosphere. When they break down, they release chlorine or bromine atoms, which then deplete ozone.
Regional Deposited Dose Ratio[d]	A dosimetry model which allows for the extrapolation between inhalation concentrations in animal models to that of a human to predict responses at particular exposure

	concentrations.
Reference concentration[f]	An estimate (with uncertainty spanning perhaps an order of magnitude) of a daily exposure to the human populations (including sensitive subgroups) that is likely to be without appreciable risk of deleterious effects during a lifetime. The inhalation reference concentration is for continuous inhalation exposures and is appropriately expressed in units of mg/m^3.
Self-contained automatic fire extinguishing systems	These systems function similarly to total flooding agents, but they are designed for smaller spaces were complex flooding agents may not be necessary. SCAFE systems generally appear as ball-shaped cylinders suspended from the ceiling of a protected space, and they protect small-enclosed spaces by automatically releasing a set quantity of an extinguishing agent evenly throughout a protected volume.
Streaming Agent	These systems are portable fire extinguishers from which the discharge direction and quantity of release may be manipulated by human beings at the time of the fire.
Upper flammability limit[g]	Maximum concentration at which ignition will occur.
Volatile organic compounds[a]	Any organic compound that participates in atmospheric photochemical reactions except those designated by EPA as having negligible photochemical reactivity.

[a] U.S. EPA 2004. Terms of the Environment. http://www.epa.gov/OCEPAterms/
[b] U.S. EPA 2003. Ozone Depletion Glossary. http://www.epa.gov/ozone/defns.html
[c] Wuebbles 2003. Personnel Communication by e-mail. October 22, 2003 and December 12, 2003.
[d] The Draft NFPA 2010 Standard (http://www.nfpa.org/PDF/2010_Draft0903.pdf?src=nfpa). See Attachment 2.
[e] NFPA, 2000. *NFPA 2001 Standards for Clean Agent Fire Extinguishing Systems*, 2000 Edition. The Technical Committee on Halon Alternative Protection Options. February 2000.
[f] U.S. EPA, 1994b. Regional Deposited Dose Ratio Program in the "Methods for Derivation of Inhalation Reference Concentrations and Application of Inhalation Dosimetry" EPA/600/8-90/066F, October 1994.
[g] U.S. EPA 2002. Detailed Questions About HC-12a®, OZ-12®, DURACOOL 12a®, EC-12a, and other Flammable Hydrocarbon Refrigerants. http://www.epa.gov/ozone/snap/refrigerants/hc12alng.html
[h] U.S. EPA, 1994a. *Risk Screen on the Use of Substitutes for Class I Ozone-Depleting Substances: Fire Suppression and Explosion Protection (Halon Substitutes)*. Stratospheric Protection Division. March 1994.

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1. CIIT/RIVM, 2002. Chemical Industry Institute of Toxicology/ National Institute for Public Health and the Environment. Multiple Path Particle Dosimetry Model. V1.0, October 2002.

2. FAA, 2002. *Options to the Use of Halon for Aircraft Fire Suppression Systems – 2002 Update.* DOT/FAA/AR-99/63. Office of Aviation Research, Washington, D.C. February 2002.

3. ICF 1997. Physiological Effects of Alternative Fire Protection Agents - Hypoxic Atmospheres Conference. Stephanie Skaggs prepared the proceedings of the conference held May 22, 1997 in New London, CT.

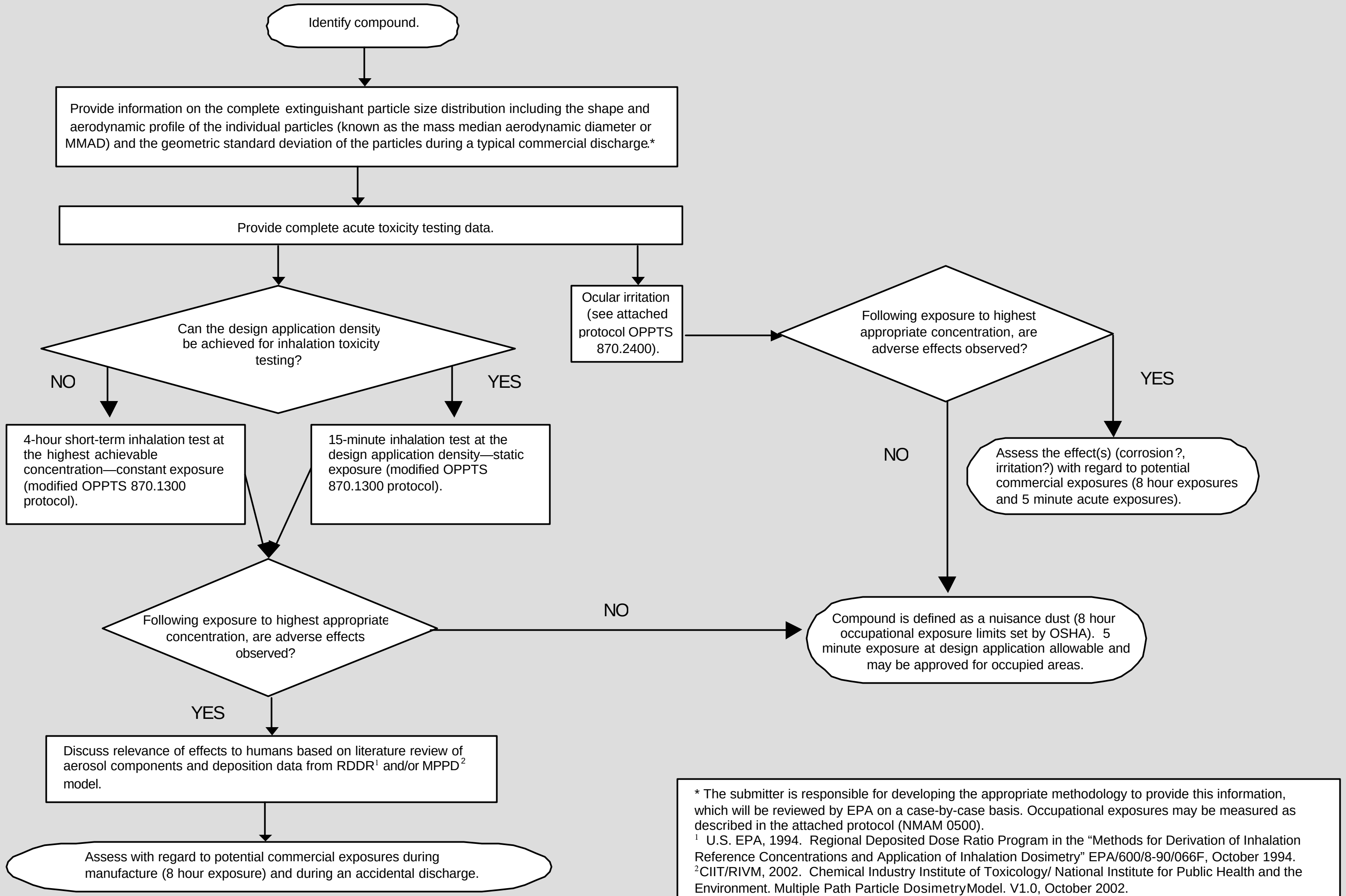
4. NFPA, 2000. *NFPA 2001 Standards for Clean Agent Fire Extinguishing Systems,* 2000 Edition. The Technical Committee on Halon Alternative Protection Options. February 2000. p 14.

5. NFPA, 2003. *NFPA 2010-Standard for Fixed Aerosol Fire Extinguishing Systems.* DRAFT July, 21, 2003.

6. U.S. EPA, 1994a. *Risk Screen on the Use of Substitutes for Class I Ozone-Depleting Substances: Fire Suppression and Explosion Protection (Halon Substitutes)*. Stratospheric Protection Division. March 1994.

7. U.S. EPA, 1994b. Regional Deposited Dose Ratio Program in the “Methods for Derivation of Inhalation Reference Concentrations and Application of Inhalation Dosimetry” EPA/600/8-90/066F, October 1994.

Attachment 1: Flowchart for Assessment of Powdered Aerosols



* The submitter is responsible for developing the appropriate methodology to provide this information, which will be reviewed by EPA on a case-by-case basis. Occupational exposures may be measured as described in the attached protocol (NMAM 0500).

[1] U.S. EPA, 1994. Regional Deposited Dose Ratio Program in the "Methods for Derivation of Inhalation Reference Concentrations and Application of Inhalation Dosimetry" EPA/600/8-90/066F, October 1994.

[2] CIIT/RIVM, 2002. Chemical Industry Institute of Toxicology/ National Institute for Public Health and the Environment. Multiple Path Particle DosimetryModel. V1.0, October 2002.