Significant New Alternatives Policy Program
Refrigeration and Air-conditioning Sector

Risk Screen on Substitutes in Commercial Ice Machines (New Equipment)

Substitute: HFC-32 (Difluoromethane)

This risk screen is restricted to commercial ice machines covered under UL 60335-2-89 (Edition 2): Household and Similar Electrical Appliances: Particular Requirements for Commercial Refrigerated Appliances and Ice-Makers with an Incorporated or Remote Refrigerant Unit or Motor-Compressor

This risk screen does not contain Clean Air Act (CAA) Confidential Business Information (CBI) and, therefore, may be disclosed to the public.

1. INTRODUCTION

Ozone-depleting substances (ODS) are being phased out of production in response to a series of diplomatic and legislative efforts that have taken place over the past three decades, including the Montreal Protocol and the Clean Air Act Amendments of 1990 (CAAA). The U.S. Environmental Protection Agency (EPA), as authorized by Section 612 of the CAAA, administers the Significant New Alternatives Policy (SNAP) Program, which identifies acceptable and unacceptable substitutes for ODS in specific end-uses based on assessment of their health and environmental impacts.

EPA's decision on the acceptability of a substitute is based on the findings of a screening assessment of potential human health and environmental risks posed by the substitute in specific applications. EPA has already screened a large number of substitutes in many end-uses and applications within all of the major ODS-using sectors including: refrigeration and air conditioning; solvent cleaning; foam blowing; aerosols; fire suppression; adhesives, coatings, and inks; and sterilization. The results of these risk screens are presented in a series of Background Documents that are available in EPA's docket.

The purpose of this risk screen is to supplement EPA's Background Document on the refrigeration and air-conditioning sector (EPA 1994) (hereinafter referred to as the Background Document). This risk screen evaluates the potential use of HFC-32 as a substitute in new equipment in the commercial ice machines end-use. Table 1 presents the composition of the proposed substitute.

Table 1. Composition of HFC-32 and Potential Impurities

Constituent	Chemical Formula	CAS Number	Concentration (Weight Percent)
Difluoromethane (HFC-32)	CH_2F_2	75-10-5	≥99.5%
Potential Impurities (Maximum Concentration)[a,b]			
HCFC-22	$CHClF_2$	75-45-6	<0.5%
Methylene chloride	CH_2Cl_2	75-09-2	
HCFC-31	CH_2FCl	593-70-4	
Hydrogen fluoride	HF	7664-39-3	
Hydrochloric acid	HCl	7647-01-0	

[a] Typical (actual) impurity concentrations may be considerably lower than the maximum value listed above. To meet AHRI Standard 700 purity of 99.5% by weight, the total of all volatile organic impurities is capped at 0.5% by weight (AHRI 2019).
[b] Schoenenberger et al. (2015).

Section 2 summarizes the results of the risk screen for the proposed substitute listed in Table 1. The remainder of the risk screen is organized into the following sections:

- Section 3: Atmospheric Assessment
- Section 4: Volatile Organic Compound Assessment
- Section 5: Discussion of End-Use Scenarios
- Section 6: Potential Health Effects
- Section 7: Flammability Assessment
- Section 8: Asphyxiation Assessment
- Section 9: End-Use Exposure Assessment
- Section 10: Occupational Exposure Assessment
- Section 11: General Population Exposure Assessment
- Section 12: References

2. SUMMARY OF RESULTS

HFC-32 is recommended for SNAP approval for new commercial ice machines in accordance with Underwriters Laboratories (UL) Standard UL 60335-2-89 (Edition 2): Household and Similar Electrical Appliances: Particular Requirements for Commercial Refrigerated Appliances and Ice-Makers with an Incorporated or Remote Refrigerant Unit or Motor-Compressor. Unless otherwise noted, this document refers to the 2022 edition of American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) Standard 15[1] and the second edition of UL 60335-2-89.[2] EPA's risk screen indicates that the use of the proposed substitute will be less harmful to the atmosphere than the continued use of ODS and certain hydrofluorocarbon (HFC) refrigerants, as it is less harmful to the ozone layer and has lower climate impact; other refrigerants that have higher climate impact than the proposed substitute are listed as acceptable.

HFC-32 is excluded from the definition of volatile organic compounds (VOC) under CAA regulations (40 CFR 51.100(s)), so impacts on local air quality from the release of HFC-32 are not a concern. In addition, HFC-32 is classified as an A2L refrigerant; however, the proposed substitute is not expected to present a flammability concern provided use conditions are followed.

It is expected that the manufacturer's safety data sheet (SDS) for HFC-32 and good manufacturing practices will be adhered to during handling or use of HFC-32, and that appropriate safety and personal protective equipment (PPE) (e.g., protective gloves, tightly sealed goggles, protective work clothing, and suitable respiratory protection in case of leakage or insufficient ventilation) consistent with Occupational Safety and Health Administration (OSHA) guidelines will be used during charging, servicing, and disposal of commercial ice machines using HFC-32. Because commercial ice machines will be installed in locations with adequate space and/or ventilation in accordance with EPA recommendations and requirements, industry standards, and the installation and maintenance manuals for equipment using HFC-32, significant flammability risk and human health risk to end-users, personnel, or the general population is unlikely.

[1] Safety Standard for Refrigeration Systems ASHRAE Standard 15 establishes safeguards for life, limb, health, and property and prescribes safety requirements (ASHRAE 2022a).

[2] UL 60335-2-89 Standard for Commercial Refrigerating Appliances and Ice-Makers with an Incorporated or Remote Refrigerant. Unit or Compressor establishes safety requirements for the construction, electrical system, electrical components, refrigeration system, and performance of commercial refrigerators and freezers and commercial ice machines (UL 2021).

Additional safeguards, including the specified refrigerant concentration limit (RCL) for HFC-32, are also provided by adherence to industry standards including: ASHRAE Standards 15, 34,[3] and 62.1;[4] Air Conditioning, Heating, and Refrigeration Institute (AHRI) Standard 700;[5] and UL Standard 60335-2-89.

3. ATMOSPHERIC ASSESSMENT

This section presents an assessment of the potential risks to the atmosphere posed by the use of HFC-32 in commercial ice machines. The ozone depletion potential (ODP), global warming potential (GWP), and the atmospheric lifetime (ALT) of the proposed substitute are presented in Table 2.

The proposed substitute is substantially less harmful to the ozone layer and has lower climate impact when compared to refrigerants such as HCFC-22.[6] HFC-32 has a lower climate impact than those predicted for other substitutes examined in the Background Document, as well as certain common HFC refrigerants in commercial ice machines, including R-404A and R-410A. Thus, EPA believes that the use of HFC-32 would result in substantially less harm to the climate and ozone layer than the continued use of ODS and certain HFC refrigerants. EPA also notes that other refrigerants are acceptable in the same end-use that have lower climate impact compared to the proposed substitute, including R-513A and R-450A.

Table 2. Atmospheric Impacts of HFC-32 Compared to Other Refrigerants used in Commercial Ice Machines

Refrigerant	Ozone Depleting Potential (ODP)[a]	Global Warming Potential (GWP)[b]	Atmospheric Lifetime in Years (ALT)[b]
HFC-32	0	675	4.9
Other Refrigerants			
R-404A[c]	0	3,922	NA[c]
R-410A[d]	0	2,088	NA[d]
R-513A[e]	0	630	NA[e]
R-450A[f]	0	601	NA[f]

NA = Not applicable.
[a] World Meteorological Organization (WMO) 2022 Scientific Assessment Report (2022).
[b] Intergovernmental Panel on Climate Change (IPCC) 4th Assessment Report (Forster et al. 2007), unless otherwise noted.
[c] Atmospheric lifetimes are not given for blends, because the components separate in the atmosphere. R-404A is a blend consisting of HFC-143a (52% by weight), HFC-125 (44%), and HFC-134a (4%). The ALT for HFC-143a is 52 years, the ALT for HFC-125 is 29 years, and the ALT for HFC-134a is 14 years (Forster et al. 2007).
[d] R-410A is a blend consisting of HFC-32 (50%) and HFC-125 (50%). The ALT for HFC-32 is 4.9 years and the ALT for HFC-125 is 29 years (Forster et al. 2007).
[e] R-513A is a blend consisting of HFC-134a (44%) and HFO-1234yf (56%). The ALT for HFC-134a is 14 years and the ALT for HFO-1234yf is 12 days (Forster et al. 2007, WMO 2022).
[f] R-450A is a blend consisting of HFC-134a (42%) and HFO-1234ze(E) (58%). The ALT for HFC-134a is 14 years and the ALT for HFO-1234ze(E) is 19 days (Forster et al. 2007, WMO 2022).

[3] Designation and Safety Classification of Refrigerants ASHRAE Standard 34 establishes a uniform system for assigning reference numbers, safety classifications, and refrigerant concentration limits to refrigerants. Safety classifications based on toxicity and flammability data are included (ASHRAE 2022b).
[4] Ventilation for Acceptable Indoor Air Quality ASHRAE Standard 62.1 establishes minimum ventilation rates and other measures intended to provide indoor air quality that is acceptable to human occupants and that minimizes adverse health effects (ASHRAE 2022c).
[5] AHRI Standard 700: Standard for Specifications for Refrigerants establishes purity specifications, to verify composition, and to specify the associated methods of testing for acceptability of refrigerants regardless of source (new, reclaimed, and/or repackaged) for use in new and existing refrigeration and air conditioning products within the scope of AHRI (AHRI 2019).
[6] HCFC-22 has an ODP of 0.037, GWP of 1,810, and ALT of 12 years (WMO 2022, Forster et al. 2007).

4. VOLATILE ORGANIC COMPOUND ASSESSMENT

HFC-32 is excluded from the definition of VOC under CAA regulations (40 CFR 51.100(s)). Therefore, VOC impacts from the release of HFC-32 are not a concern.

5. DISCUSSION OF END-USE SCENARIOS

HFC-32 has been proposed for use in self-contained and remote commercial ice machines. Self-contained ice machines are units with the ice maker and condensing unit contained within a single package and are combined with an integrated bin (ACEEE 2012). These units can be batch-type (harvest rates of ≤ 1,000 pounds of ice per 24 hours or > 1,000 pounds of ice per 24 hours) or continuous-type (harvest rates of ≤ 1,200 pounds of ice per 24 hours or > 1,200 pounds of ice per 24 hours) (88 FR 73098, October 24, 2023). Remote ice machines are units with the condenser mounted in a remote location, typically on the roof and have ice-making capabilities that can range from a few hundred to a few thousand pounds of ice per day (ACEEE 2012).

Commercial ice machines typically have charge sizes ranging from 0.5 kilograms to 2.6 kilograms (UNEP 2019, EPA 2022) and can have a maximum charge size of 10 kilograms (Manitowoc 2021). However, commercial ice machines can have a wide range of refrigerant charge sizes and configurations depending on ice-making capacity and ice shape (e.g., cubes, pellets, flakes). (UNEP 2019).

UL 60335-2-89 limits the releasable charge of HFC-32 in commercial ice machines by limiting the charge size and/or requiring mitigation measures depending on the equipment type and/or installation location. The charge limits for self-contained ice machines located in a public corridor or lobby[7] and self-contained ice machines not located in a public corridor or lobby are 0.920 kilograms and 3.98 kilograms, respectively, and the releasable amount for the evaporator in a field-erected ice machine is limited to 3.98 kilograms.[8] Furthermore, UL 60335-2-89 limits the releasable amount of HFC-32 for the condensing unit in field-erected systems installed indoors but not in a machinery room to 79.6 kilograms. UL 60335-2-89 does not limit the charge size or releasable charge amount of HFC-32 for condensing units in field-erected systems installed outdoors or in a machinery room, provided that the releasable amount of any individual unit is limited to 3.98 kilograms.

As noted above, charge sizes for these equipment types can range from 0.5 kilograms to 10 kilograms, but equipment containing HFC-32 must be designed in compliance with UL 60335-2-89 to ensure the maximum charge or releasable amount is 0.920 kilograms, 3.98 kilograms, or 79.6 kilograms depending on the equipment type and/or installation location.[9] Therefore, this risk screen models the maximum charge size and releasable amounts as stipulated by UL 60335-2-89 for each equipment type and/or installation location.

Commercial ice machines can be installed in a wide range of locations with varying room volumes and equipment configurations (e.g., multiple evaporators connected to a single condenser). To represent reasonable worst-case scenarios for self-contained commercial ice machines, it is assumed that a self-contained commercial ice machine with a charge size of 0.920 kilograms is installed in an enclosed alcove of a public commercial building and a self-contained commercial ice machine with a charge size of

[7] This scenario could include a commercial ice machine installed in an alcove off a hallway in a hotel or other commercial building, as is modeled in this risk screen. End-users should be sure to install equipment according to building codes and in such a way that egress from the building is not impeded.

[8] Each charge size limit and maximum releasable charge is calculated in accordance with UL 60335-2-89 for each location as follows: self-contained systems located in a public corridor or lobby – 3 times the LFL (0.306 kg/m^3 for HFC-32 [ASHRAE 2022b]); self-contained systems not located in a public corridor or lobby – 13 times the LFL; evaporator in a field-erected ice machine – 13 times the LFL; and condensing unit in a field-erected system installed indoors but not in a machinery room – 260 times the LFL.

[9] Systems that contain larger charge sizes must be designed in accordance with UL 60335-2-89 (e.g., be equipped with internal leak detection and ventilation systems) such that releases cannot exceed the maximum releasable charge.

3.98 kilograms is installed in a restaurant kitchen. The alcove is assumed to have an effective volume of 15 m^3 (530 ft^3) (i.e., excluding the space filled by the ice machine, furniture, boxes, etc.) based on estimates of a space with a height of 2.44 meters (8 feet) and a floor area of 6.25 m^3 (67 ft^2), and the restaurant kitchen is assumed to have a height of 2.44 meters (8 feet) and a typical effective volume of 120 m^3 (4,240 ft^3) (i.e., excluding the space filled by the ice machine, shelving, other kitchen equipment, etc.) (Manitowoc 2015).

To represent a reasonable worst-case scenario for a remote ice machine, it is assumed that the maximum releasable charge of 79.6 kilograms is emitted into a seafood processing facility[10] with a height of 5.5 meters (18 feet) and an effective volume of 5,700 m^3 (201,300 ft^3) (i.e., excluding the space filled by the condenser, shelving, other equipment, etc.), consistent with a typical factory size. This risk screen does not model releases from remote ice machines into a machinery room because it is assumed that the machinery room will be equipped with mitigation systems that limit the concentration of leaked refrigerant in the room, as required by UL 60335-2-89 and ASHRAE Standard 15.

Under these worst-case scenarios, the full charge of each unit is assumed to be emitted into the enclosed alcove, restaurant kitchen, or seafood processing facility with 0.5, 20, or 15 air changes per hour (ACH), respectively,[11,12,13] over the course of one minute, which represents a catastrophic release of refrigerant due to a puncture or other major damage to the refrigeration system and is most appropriate for flammable refrigerants.

A vertical concentration gradient is also assumed since HFC-32 is denser than air (the specific gravity of HFC-32 is greater than 1 (air = 1)) and will settle in higher concentrations closer to the ground. To simulate the vertical concentration gradient, it is assumed that 95 percent of the leaked refrigerant mixes evenly into the bottom 0.4 meters (1.3 feet) of the room, and the rest of the refrigerant mixes evenly in the remaining volume (Kataoka 2000).

Table 3 details the end-use modeling assumptions used throughout the risk screen (i.e., in Sections 7, 8, and 9).

Table 3. Commercial Ice Machine End-Use Scenario Model Assumptions

Parameter	Assumptions		
Refrigeration Unit	Self-contained Ice Machine		Remote Ice Machine
Modeled Release (kg)	0.920	3.98	79.6[a]
Room Type	Alcove (Public)	Restaurant Kitchen	Seafood Processing Facility
Room Size (m^3)	15 (530 ft^3)[b]	120 (4,240 ft^3)[c]	5,700 (201,300 ft^3)[d]
Length of Release (minutes)	1	1	1
Ventilation Rate (ACH)	0.5[e]	20[f]	15[g]
Vertical Concentration Gradient (m)	0.4 (1.3 ft.)	0.4 (1.3 ft.)	0.4 (1.3 ft.)

[a] Systems that contain larger charge sizes and are not installed in a machinery room or outdoors must be designed in accordance with UL 60335-2-89 such that releases cannot exceed the maximum releasable charge.
[b] The average size of the enclosed alcove is assumed based on estimates of a space with a height of 2.44 meters (8 feet) and a floor area of 6.25 m^2 (67 ft^2).
[c] Manitowoc (2015).

[10] A seafood processing facility is assumed to appropriately represent the use of commercial ice machines in any large industrial facility and recognizes that a commercial ice machine with a large production capacity can be installed in a wide variety of industrial locations.
[11] The air exchange rate for an enclosed alcove is derived from the requirements in ANSI/ASHRAE Standard 62.1-2022, Table 6.1 (ASHRAE 2022c). Ventilation requirements (presented as cubic feet per minute per square foot of ventilated space in the standard) were converted to air exchanges per hour using the assumed room size for the scenario.
[12] The ACH for a restaurant kitchen is derived from the suggested sufficient ventilation in commercial kitchens of 20 to 40 air changes per hour (McMullan 2014).
[13] The air exchange rates for a seafood processing facility are derived from the suggested sufficient air changes per hour in enclosed processing and food handling areas of between 5 and 25 air changes per hour (Lelieveld, H.L.M. 2014).

[d] The average size of the seafood processing facility is assumed to be consistent with the typical factory size used in occupational exposure modeling.
[e] ASHRAE (2022c).
[f] McMullan (2014).
[g] Lelieveld (2014).

EPA recognizes that commercial ice machines may be placed in a variety of locations with different room sizes and ventilation rates. There may also be instances in which the consumer chooses to place an ice machine and other pieces of equipment (e.g., a vending machine) within an enclosed space (thus further limiting the effective volume of the space), or a single ice machine in a very small, enclosed space. When units are installed in smaller, enclosed spaces, there is a higher risk for asphyxiation, flammability, or exposure concerns. To address this variability in room volumes and charge sizes for installed self-contained and remote commercial ice machines, this risk screen incorporates threshold analyses in addition to the worst-case scenario modeling.

For HFC-32, flammability is the more concerning risk screen attribute, as compared to acute toxicity and asphyxiation. The flammable concentration limit (FCL) for HFC-32 is lower than both the acute toxicity exposure level (ATEL) and the concentration necessary to reduce oxygen in air to the hypoxia no observed adverse effect level (NOAEL).[14] Therefore, a threshold analysis is performed in the flammability assessment for this risk screen to determine the room size and charge size limit or maximum releasable charge requirements at which a flammability concern would exist for the use of HFC-32.

6. POTENTIAL HEALTH EFFECTS

To assess potential health risks from exposure to the proposed substitute in commercial ice machines, EPA identified the relevant toxicity threshold values and compared them to modeled exposure concentrations for different scenarios. According to ASHRAE Standard 34, HFC-32 is listed under safety group A2L with an ATEL of 200,000 ppm and an RCL of 36,000 ppm (ASHRAE 2022b). ASHRAE 34 ATELs and RCLs[15] are intended to reduce the risks of acute toxicity, asphyxiation, and flammability hazards in normally occupied, enclosed spaces during refrigerant use and protect end-users from the potential dangers of a catastrophic leak from a refrigeration unit (ASHRAE 2022b). Therefore, this risk screen references the ATEL and RCL, in addition to the lower flammability limit (LFL) and hypoxia NOAEL and occupational exposure limits, as additional, conservative limits to ensure that significant flammability, toxicity, and asphyxiation risks do not occur.

Using the exposure scenarios described in Section 5, risks from potential one-time consumer exposures at end-use are compared to the ATEL in Section 9. For the occupational exposure analysis, described in Section 10, potential risks from chronic and acute worker exposure are evaluated by comparing exposure concentrations with available occupational exposure limits. Potential risks of chronic worker exposure were evaluated using workplace guidance levels (WGL), such as Occupational Exposure Limits (OEL).

Risks from potential acute occupational exposures at end-use were evaluated by comparing exposure concentrations to emergency guidance levels (EGL). In the absence of an established short-term exposure limit (STEL), acute exposure guideline level (AEGL), or emergency response planning guideline (ERPG) for HFC-32, potential short-term, occupational exposures can be compared to an EPA-derived STEL and the RCL. The STEL is a conservatively-derived exposure limit that is intended to protect workers in an occupational setting in which they are exposed to these chemicals on a daily basis. The STEL does not represent a limit for a single exposure in a lifetime.

[14] Twelve percent oxygen in air (i.e., 120,000 ppm) is the NOAEL for hypoxia (ICF 1997).
[15] ASHRAE Standard 15 implements ASHRAE 34, requiring that “the concentration of refrigerant in an enclosed space following a complete discharge of a high-probability system shall not exceed the RCL” (ASHRAE 2022a).

Table 4 lists the relevant exposure limits for HFC-32 and is followed by Table 5, which provides an explanation of each exposure limit. EPA's approach for identifying or developing these values is discussed in Chapter 3 of the Background Document.

Table 4. Exposure Limits of HFC-32

Proposed Substitute	WGL (Long-term Exposure) ppm[a]	EGL (Short-term Exposure) ppm	RCL ppm[a]	ATEL ppm[a]
HFC-32	1,000 (8-hour OEL)	3,000 (15-min STEL)[b]	36,000	200,000

An explanation of each exposure limit and exposure-limit related terminology is described in Table 5.

[a] ASHRAE (2022b).

[b] Neither the ACGIH nor AIHA recommends ceiling or short term exposure limits for HFC-32. A STEL for HFC-32 of 3,000 ppm was developed by EPA based on the 1,000 ppm OEL value. The STEL was estimated as three times the OEL, which is an established method of estimating a STEL by ACGIH. [STEL] = [OEL] x 3 = 1,000 ppm x 3 ≈ 3,000 ppm.

Table 5. Explanation of Exposure Limit-Related Terminology[a]

Organization	Definition	
OSHA	Occupational Safety and Health Administration	
NIOSH	National Institute for Occupational Safety and Health	
ACGIH	American Conference of Governmental Industrial Hygienists	
AIHA	American Industrial Hygiene Association	
Exposure Limit	**Definition**	**Explanation**
Short-Term Exposure		
STEL	Short-Term Exposure Limit	A 15-minute time-weighted average (TWA) exposure that should not be exceeded during a workday, even if the 8-hour TWA is within the threshold limit value-time weighted average (TLV–TWA), set by ACGIH.
ATEL	Acute Toxicity Exposure Limit	The ATEL is the refrigerant concentration limit intended to reduce the risks of acute toxicity hazards in normally occupied, enclosed spaces according to ASHRAE Standard 34. The ATEL includes consideration of mortality, cardiac sensitization, anesthetic or central nervous system effects and other escape impairing effects and permanent injury. The ATEL is similar to the Immediately Dangerous to Life or Health (IDLH) concentrations set by NIOSH.
RCL	Refrigerant Concentration Limit	The RCL for a refrigerant is intended to reduce the risks of acute toxicity, asphyxiation, and flammability hazards in normally occupied, enclosed spaces. The RCL for each refrigerant is the lowest of the ATEL, Oxygen Deprivation Limit (ODL), and Flammable Concentration Limit (FCL). Determination assumes full vaporization with no removal by ventilation, dissolution, reaction, or decomposition and complete mixing of refrigerant in the space to which it is released.
IDLH	Immediately Dangerous to Life and Health	If exposed to this concentration, room occupants are expected to be able to escape the room within 30 minutes without experiencing escape-impairing or irreversible health effects.
Long-Term Exposure		
OEL	Occupational Exposure Limit	The TWA concentration for a normal eight-hour workday and a 40-hour workweek to which nearly all workers can be repeatedly exposed without adverse effect, based on the OSHA PEL, ACGIH TLV-TWA, OARS-WEEL, or consistent value.

[a] All information in this table taken from EPA (1994) except where otherwise noted.

According to the SDS, exposure to HFC-32 may be hazardous if inhalation, skin contact, or eye contact with the proposed substitute occurs at sufficiently high levels. HFC-32 can cause symptoms of asphyxiation when present in concentrations high enough to significantly lower oxygen concentrations below 19.5 percent by volume (e.g., headaches, ringing in ears, dizziness, drowsiness, nausea, vomiting, depression of all senses, and unconsciousness). Under some circumstances of over-exposure (i.e., oxygen levels fall below 6 percent by volume), death may occur.

HFC-32 can also cause cardiac arrhythmia if inhaled in sufficiently great quantities. If HFC-32 is inhaled, person(s) should be immediately removed from the contaminated space and exposed to fresh air. In accordance with the SDS, EPA further recommends that if breathing is difficult or irregular, person(s) should be given oxygen, provided a qualified operator is present, and medical attention be sought.

Exposures of HFC-32 to the skin may cause frostbite. In the case of dermal exposure, the SDS for HFC-32 recommends that person(s) immediately wash the affected area with water, and that person(s) remove all contaminated clothing; if frostbite occurs, bathe (not rub) the affected area with lukewarm, not hot, water. If water is not available cover the affected area with a clean, soft cloth) and seek medical attention immediately. Exposures of HFC-32 to the eyes could cause eye irritation. In the case of ocular exposure, the SDS for HFC-32 recommends that person(s) immediately flush the eyes, including under the eyelids, with copious amounts of water.

EPA's review of the human health impacts of this proposed substitute is contained in the public docket for this decision. These risks and procedures after exposure are similar for other common refrigerants. The potential health effects of HFC-32 can be minimized by following the exposure guidelines, ventilation, and PPE recommendations outlined in the SDS for HFC-32 and this risk screen.

7. FLAMMABILITY ASSESSMENT

ASHRAE Standard 34 classifies HFC-32 as a Class A2L refrigerant (ASHRAE 2022b). HFC-32 is flammable when its concentration in air is in the range of 14.4 percent to 29.9 percent by volume (144,000 ppm to 299,000 ppm) (ASHRAE 2022b, Daikin 2019). In the presence of an ignition source (e.g., flame on a cigarette lighter or gas stove), a fire could occur if the concentration of HFC-32 were to exceed the LFL of 144,000 ppm, posing a significant safety concern for workers and personnel if it is not handled carefully. Only refrigerant technicians trained to work with flammable refrigerants should handle commercial ice machines containing HFC-32 during manufacturing, installation, servicing, transportation, and disposal. The remainder of this section addresses flammability risks and summarizes the recommended measures to ensure safe handling and use of the refrigerant during manufacture, servicing, and end-use.

7.1 Flammability Risk at Substitute and Equipment Manufacture

The manufacture of HFC-32 and the charging of HFC-32 commercial ice machines is expected to occur in a closed system, and self-contained units are typically factory-sealed. Remote commercial ice machines are expected to be field-charged. As a result, releases of HFC-32 during manufacturing operations in the presence of an ignition source are not anticipated.

During manufacture of HFC-32, EPA recommends that engineering controls should include normal and local ventilation (e.g., chemical hoods) for standard manufacturing procedures so workers can avoid physical contact with the refrigerant and to limit emissions. In general, use of appropriate PPE consistent with OSHA guidelines is recommended, such as splash goggles, mechanically-resistance gloves when handling cylinders, chemically-resistant gloves (e.g., butyl rubber, chlorinated polyethylene, or neoprene) when handling the gas mixture, and protective clothing.

All HFC-32 storage and transport equipment should be installed with safety devices that minimize the likelihood of catastrophic releases. It is expected that refrigerants be properly stored, that caution will be used within manufacturing facilities to minimize explosion risk, and that workers adhere to the requirements set by ASHRAE Standard 62.1 and OSHA under 29 CFR 1910. OSHA requirements include proper ventilation and storage practices within manufacturing facilities to prevent fire and explosion. Good manufacturing practices should be adhered to during the manufacture of equipment containing HFC-32.

7.2 Flammability Risk at Servicing and End-Use

The risk of flammability during servicing and end-use for the reasonable worst-case scenarios was investigated for HFC-32. Both servicing and end-use of HFC-32 commercial ice machines are expected to take place in the same space (i.e., the installation and use location). In order to determine the potential flammability risks during servicing or end-use in case of a catastrophic release of refrigerant, concentrations of HFC-32 immediately following the modeled release of refrigerant were compared with the LFL for HFC-32 (i.e., 144,000 ppm). The results of the flammability assessment are presented in Table 6.

Table 6. Flammability Assessment for HFC-32[a]

Equipment Type	Reasonable Worst-Case Scenario	Modeled Release (kg)[b]	Effective Room Size (m^3)	Room Type	Maximum Instantaneous Concentration (ppm)[c,d]
Self-Contained Ice Machine	1	0.920	15 (530 ft^3)	Alcove (Public)	**163,950**
	2	3.98	120 (4,240 ft^3)	Restaurant Kitchen	**88,660**
Remote Ice Machine	3	79.6	5,700 (201,300 ft^3)	Seafood Processing Facility	**84,140**

[a] **Bold font** indicates modeling results. Cells highlighted in green are the scenarios with acceptable flammability levels (i.e., do not exceed the LFL) given various modeling assumptions. Cells highlighted in red are the scenarios with unacceptable flammability levels (i.e., reach or exceed the LFL) given various modeling assumptions.
[b] See Section 5 for more information.
[c] LFL of HFC-32 is 144,000 ppm.
[d] Values provided in this column refer to the concentration in the lower 0.4 meters of the room, which presents the most conservative risk as 95% of the leaked refrigerant is present in this space.

As presented in Table 6, the maximum instantaneous concentration in the lower compartment of the room does not exceed the LFL for HFC-32 (i.e., 144,000 ppm) at the modeled release for a self-contained commercial ice machine installed in a restaurant kitchen or a remote ice machine in a seafood processing facility. The LFL for HFC-32 could be reached in the worst-case scenario for self-contained commercial ice machines installed in a public alcove at the modeled charge size.

The risk of fire is minimal if commercial ice machines are installed in a room with volumes in accordance with standards and regulations and if they meet the requirements of UL 60335-2-89. As spaces using commercial ice machines can be smaller than those modeled in this assessment and because persons or equipment in the room may reduce the effective volume of the space, commercial ice machines containing HFC-32 should not be installed in enclosed areas with effective volumes less than indicated by relevant safety standards (e.g., ASHRAE Standards 15 and 34 and UL 60335-2-89) unless additional steps are taken to protect against a flammability risk (e.g., higher ventilation rates).

Because self-contained and remote ice machines may be used in a variety of room sizes, threshold analyses on the charge released and room size were also performed. The threshold analyses were based off the conditions at which the HFC-32 concentration would reach the LFL (i.e., 144,000 ppm).

Table 7. Flammability Threshold Assessment[a]

Unit Type	Threshold Analysis Scenario	Modeled Release (kg)[b]	Effective Room Size (m^3)	Room Type	Maximum Instantaneous Concentration (ppm)[c]
Self-Contained Ice Machine	1a: Charge Size	**0.81**	15 (530 ft^3)	Alcove (Public)	144,000
	1b: Room Size	0.920	**17.1 (600 ft^3)**		
	2a: Charge Size	**6.46**	120 (4,240 ft^3)	Restaurant Kitchen	
	2b: Room Size	3.98	**73.9 (2,610 ft^3)**		

Remote Ice Machine	3a: Releasable Charge	**136.2**	5,700 (201,300 ft³)	Seafood Processing Facility	
	3b: Room Size	3.98	**3,330 (117,620 ft³)**		

[a] Modeling results are signified with **bold font**. Cells highlighted in green indicate that the maximum releasable charge and/or unit charge size at which a flammability result could occur is more conservative than what is modeled in the flammability assessment. Red indicates that the maximum releasable charge and/or unit charge size at which a flammability result could occur is less conservative than what is modeled in the flammability assessment.
[b] See Section 5 for more information.
[c] LFL of HFC-32 is 144,000 ppm.

The threshold conditions at which a flammability concern would exist (i.e., when the maximum instantaneous concentration following the modeled release equals the LFL for HFC-32) were determined and are shown in Table 7. In order for flammability to not be a concern based on the results shown in Table 7, the space in which a 0.920-kilogram self-contained system is installed would have to be greater than 17.1 m^3 (600 ft^3). For self-contained commercial ice machines installed in a restaurant kitchen or remote ice machines installed in a seafood processing facility, the charge size and releasable charge would have to be larger than the maximum modeled charge released in order for flammability to be a concern. The minimum room sizes in which installed equipment could cause a flammability concern vary based on charge release assumptions. However, UL 60335-2-89 requirements should be followed to ensure the maximum releasable amount is limited to the appropriate amount based on the equipment type and installation location.

According to the results of this flammability assessment, commercial ice machines containing HFC-32 should only be installed in a room with volumes in accordance with standards and regulations (e.g., ASHRAE Standards 15 and 34 and UL 60335-2-89) and with an effective volume greater than required to maintain maximum concentrations below the LFL. Refrigeration systems containing an A2L refrigerant with a charge size of more than 4 times the LFL expressed as kg/m^3 (i.e., 1.22 kilograms for HFC-32) in an independent circuit shall not be installed within 6 meters (20 feet) of an open flame, as stipulated by ASHRAE Standard 15-2022 7.5.3 (ASHRAE 2022a). End-users, therefore, should be sure to install commercial ice machines with an appropriate capacity and charge size for the intended space and refrigeration requirements that are consistent with manufacturer recommendations and the specifications of relevant safety standards (e.g., ASHRAE Standards 15 and 34 and UL 60335-2-89).

In addition, it is important that only properly trained and EPA Section 608-certified refrigerant technicians handle HFC-32. Proper ventilation should be maintained at all times during the manufacture, use, and servicing of equipment containing HFC-32. During charging and servicing operations, technicians should ensure that proper ventilation is in place through the use of fans (or other mechanical ventilation devices) and portable refrigerant detectors should be used to alert technicians to the presence of leaked refrigerant in the area.

8. ASPHYXIATION ASSESSMENT

The risk of asphyxiation for the reasonable worst-case scenarios described in Section 5 was investigated for HFC-32. In this section, risk of asphyxiation is assessed by modeling the oxygen concentration under the equipment types, maximum charge sizes for self-contained units and maximum releasable charges for field-erected systems, and room sizes specified in the reasonable worst-case scenarios.

This analysis does not consider ventilation or conditions that are likely to occur that would increase oxygen levels to which individuals would be exposed, such as open doors or windows, fans operating, conditioned airflow (either heated or cooled), or openings at the bottom of doors that allow air to flow in and out. As specified in Section 5, this analysis assumes a vertical concentration gradient. If the proposed substitute passes the screening analysis with these restrictive assumptions in place, it can be reasonably assumed that no risks of asphyxiation will be present under real-world conditions. The results of the asphyxiation assessment are summarized in Table 8.

Table 8. Asphyxiation Assessment for HFC-32[a,b]

Equipment Type	Reasonable Worst-case Scenario	Modeled Release (kg)[c]	Effective Room Size (m^3)	Room Type	Percent Oxygen Concentration[d]
Self-Contained Ice Machine	1	0.920	15 (530 ft^3)	Alcove (Public)	**17%**
	2	3.98	120 (4,240 ft^3)	Restaurant Kitchen	**19%**
Remote Ice Machine	3	79.6	5,700 (201,300 ft^3)	Seafood Processing Facility	**19%**

[a] Modeling results are signified with **bold font**. Cells highlighted in green indicate modeled values that result in an acceptable oxygen concentration (i.e., above 19.5% oxygen, which is defined by OSHA as an oxygen-deficient environment (OSHA 2007)), yellow indicates modeled values that result in oxygen concentrations that are considered oxygen-deficient but are above 12%, the NOAEL for hypoxia (ICF 1997), and red indicates modeled values are equivalent or less than 12% oxygen.
[b] The typical concentration of oxygen in air is considered to be 21% (Mackenzie & Mackenzie 1995).
[c] See Section 5 for more information.
[d] A vertical concentration gradient of 0.4 meters (1.3 feet) is assumed for the alcove, restaurant kitchen, and seafood processing facility.

Based on the results of the asphyxiation assessment, HFC-32 in self-contained and remote commercial ice machines presents a risk of asphyxiation, as all modeled scenarios yield oxygen concentrations that are considered oxygen deficient. However, these estimated exposures were derived using fairly conservative assumptions and do not take into account any ventilation, which would increase oxygen levels to which individuals would be exposed. Conditions resulting in oxygen levels under 12 percent would only occur with charge sizes and releasable amounts that are significantly larger than the maximum charge sizes and releasable charge amounts required under UL 60335-2-89 or room sizes that are unlikely for the proposed applications.

EPA does not believe that the use of HFC-32 in commercial ice machines poses a significant risk of asphyxiation or impaired coordination to personnel, provided systems are installed in appropriate spaces according to guidelines from the manufacturer and the SDS for HFC-32.

9. END-USE EXPOSURE ASSESSMENT

This section presents estimates of potential end-user exposures to HFC-32 in the event of a catastrophic release from commercial ice machines under the reasonable worst-case scenarios outlined in Section 5.

For the end-use exposure assessment, 15-minute TWA exposures for the proposed substitute were calculated using the box model described in the Background Document, which was adapted to estimate concentrations on a minute-by-minute basis. Estimates for acute/short-term end-use exposures resulting from catastrophic leakage of refrigerant from self-contained and remote commercial ice machines were examined. As discussed in Section 5, the full charge or releasable charge of the equipment, depending on the equipment type, is assumed to be emitted over the course of one minute.

The analysis was undertaken to determine the 15-minute exposures for HFC-32, which were then compared to the standard toxicity limits presented in Table 4 to assess the risk to end-users. The estimated TWA values are fairly conservative as the analysis does not consider opened windows, fans operating, conditioned airflow (either heated or cooled) and other variables that would reduce the levels to which individuals would be exposed. Modeling results are presented in Table 9.

Table 9. End-Use Exposure Assessment for HFC-32[a]

Equipment Type	Reasonable Worst-case Scenario	Modeled Release (kg)[b]	Room Size (m^3)	Room Type	Ventilation Rate (ACH)	15-minute TWA (ppm)[c]
Self-Contained Ice Machine	1	0.920	15 (530 ft^3)	Alcove (Public)	0.5	**154,720**
	2	3.98	120 (4,240 ft^3)	Restaurant Kitchen	20	**17,690**
Remote Ice Machine	3	79.6	5,700 (201,300 ft^3)	Seafood Processing Facility	15	**22,140**

[a] Modeling results are signified with **bold font**. Cells highlighted in green represent modeled values that result in acceptable exposure levels under the modeling assumptions, and cells highlighted in red represent modeled values that could result in toxicity concerns (i.e., exceed the ATEL) under the modeling assumptions.
[b] See Section 5 for more information.
[c] ATEL for HFC-32 is 200,000 ppm.

According to the results in Table 9, the estimated 15-minute TWA exposures for HFC-32 in self-contained commercial ice machines installed in an alcove and restaurant kitchen and in remote ice machine installed in a seafood processing facility would not exceed the ATEL (i.e., 200,000 ppm) in a one-minute release scenario. Furthermore, these estimated exposures were derived using fairly conservative assumptions that do not necessarily reflect the actual room attributes where commercial ice machine equipment containing HFC-32 will be installed.

To prevent exposure and potential serious side effects during larger releases, EPA recommends that the RCL for HFC-32 (i.e., 36,000 ppm) is not exceeded in any location where an HFC-32 system is installed, unless proper leak protection devices are in place to prevent exposures of HFC-32 beyond the recommended limits. However, because the RCL for HFC-32 is driven by the flammability of HFC-32, if concentrations exceed the RCL, but do not exceed the ATEL, acute toxicity is not expected to be a concern. It is also unlikely that systems would be installed in smaller room sizes than modeled without additional ventilation, such as open doors or conditioned airflow, which is not considered in the analysis described above. Proper leak detection devices, engineering control requirements, and adherence to the SDS will further prevent exposures of HFC-32 during larger releases beyond the recommended exposure limits described in Table 4.

10. OCCUPATIONAL EXPOSURE ASSESSMENT

This section assesses potential exposures to workers during manufacture of HFC-32, and charging, servicing, and disposal of HFC-32 self-contained and remote commercial ice machines. To ensure that use of the proposed substitute commercial ice machines does not pose an unacceptable risk to personnel during charging, servicing, and disposal, occupational exposure modeling was performed using a box-model approach. For a detailed description of the methodology used for this screening assessment, the reader is referred to the occupational exposure and hazard analysis described in Chapter 5 of the Background Document.

For the purposes of this risk screen, occupational exposure is modeled for self-contained and remote commercial ice machines with charge sizes of 0.920 kilograms, 3.98 kilograms, and 79.6 kilograms for consistency with the charge size or maximum releasable charge amounts, according to UL 60335-2-89, modeled in Sections 7, 8, and 9 (as described in Section 5).

Estimates of refrigerant release per event for various release scenarios were obtained from the Vintaging Model (EPA 2022).[16] For charging, servicing, and disposal activities, the release rate per event was

[16] ICF maintains the Vintaging Model for EPA to simulate the aggregate impacts of the ODS phaseout on the use and emissions of various ODS and their substitutes over a period of several years across 78 different end-uses. The model tracks the use and emissions of various compounds for the annual vintages of new equipment that enter service in each end-use. The vintage of each type of equipment determines such factors as leak rate, charge size, number of units in operation, and the initial ODS substance that the equipment contained.

multiplied by the number of events estimated to occur over a workday. The modeled exposure concentrations were compared to the STEL at charging and servicing in Table 10 and the long-term exposure limit at disposal in Table 11.

10.1 Occupational Exposure at Manufacture of Proposed Substitute

During manufacture of HFC-32, the SDS for the proposed substitute should be referenced and proper engineering controls and PPE should be used. To prevent significant exposures and control emissions if leaks occur, engineering controls for standard manufacturing procedures in accordance with industrial hygiene guidelines should be used, including normal and local ventilation (e.g., chemical hoods) and vapor-in-air detection systems. In general, the use of PPE consistent with OSHA guidelines is recommended—such as respiratory protection (including a self-contained breathing apparatus (SCBA) in case of insufficient ventilation), tightly sealed goggles, and protective gloves—so workers can avoid physical contact with the refrigerant.

In addition, as for other halogenated refrigerants, there is a risk of generation of toxic degradation products such as hydrogen fluoride, carbonyl halides, and carbon monoxide if HFC-32 is exposed to high temperatures or fire. Other reaction products such as carbon dioxide might also be present. Containers of HFC-32 should be stored in cool, dry conditions in well-sealed receptacles in a well-ventilated area and should not be allowed to contact open flames, heat, or other sources of ignition. EPA believes that when proper handling and disposal guidelines are followed, in accordance with both good industrial hygiene and manufacturing practices, and the SDS for HFC-32, there is no significant risk to workers during the manufacture of HFC-32.

10.2 Occupational Exposure at Equipment Manufacture, Charging, and Servicing

Self-contained and remote commercial ice machines are typically charged by the Original Equipment Manufacturer (OEM) or field-charged and serviced at the end-use location. Points of release for charging and servicing commercial ice machines would be from connection/disconnection of temporary lines for charging and recovery equipment.

Charging occurs within an enclosed area equipped with automatic ventilation, refrigerant detectors, and alarm systems. Servicing typically occurs on site at the end-use. Worker exposures to HFC-32 during charging and servicing of commercial ice machines are expected to be minimal. In addition, control technologies are typically employed such as electronic leak detectors, frequent monitoring of refrigerant with level gauges, system temperatures, pressures, visual leak checking, and technology upgrades to reduce emissions. Room ventilation, leak monitors, and alarms also help minimize exposure.

Charging and servicing activities for commercial ice machines are not expected to result in significant worker exposure when certified technicians follow the procedures outlined in the HFC-32 SDS and maintenance manual, undergo proper training, and wear appropriate PPE (e.g., gloves and safety glasses).

During charging and servicing of commercial ice machines, the release per event was assumed to be one and three percent of the equipment charge, respectively. Furthermore, the number of events per workday was assumed to equal the maximum number of units anticipated to be serviced in one day (i.e., eight units divided by eight hours per workday). The analysis models the maximum charge sizes for self-contained commercial ice machines and the maximum releasable amount for remote commercial ice machines.

To evaluate the risk of exposure at charging and servicing, the maximum 15-minute TWA exposure for HFC-32 was compared to the STEL and the RCL (See Table 10).

Table 10. Occupational Risk Assessment at Manufacture, Charging and Servicing for HFC-32[a]

Modeled Charge Size (kg)[b]	Charging		Servicing		15-min STEL (ppm)[b]	RCL (ppm)[c]
	Release Rate	15-minute TWA (ppm)	Release Rate	15-minute TWA (ppm)		
0.920	1%	**40**	3%	**480**	3,000	36,000
3.98		**170**		**2,090**		
79.6		**410**		**5,250**		

[a] Modeling results are signified with bold font. Cells highlighted in green represent modeled values that result in acceptable exposure levels under the modeling assumptions, cells highlighted in yellow represent modeled values that exceed the STEL but not the RCL, and cells highlighted in red represent modeled values that could result in toxicity concerns under the modeling assumptions.
[b] For the purposes of the occupational risk assessment, modeled releases during charging and servicing are relative to the maximum releasable charge of the unit.
[c] See Table 4 for more information.

Based on the assumptions described above, the modeling indicates that short-term (15-minute) worker exposure concentrations of HFC-32 are not likely to exceed its STEL (i.e., 3,000 ppm) for self-contained and remote commercial ice machines during charging and servicing under most modeled charge sizes. The 15-minute STEL could be exceeded during servicing of remote commercial ice machines with a charge size of 79.6 kilograms, though the RCL is not exceeded. The recommendations for proper engineering controls and PPE in the SDS for HFC-32 should be followed. The estimated exposures were derived using conservative assumptions, and do not take into account the use of additional engineering controls or PPE.

Additionally, all of these exposure estimates are significantly lower than the RCL for HFC-32 (i.e., 36,000 ppm), which is a limit intended to reduce the risks of asphyxiation, flammability, and acute toxicity hazards in normally occupied, enclosed spaces according to ASHRAE Standard 34 (ASHRAE 2022b). However, because the RCL for HFC-32 is driven by the flammability of HFC-32, if concentrations exceed the RCL but do not exceed the ATEL (i.e., 200,000 ppm), acute toxicity is not expected to be a concern. The modeling assumptions also do not reflect the use of any local exhaust ventilation or other engineering controls, which are likely to be used during charging and servicing operations, thereby further reducing exposure to HFC-32.

Furthermore, these types of systems are typically charged and serviced by properly trained personnel and EPA Section 608-certified refrigerant technicians, as required by EPA regulations, using proper industrial hygiene techniques. When charging or servicing commercial ice machines, these techniques should be strictly followed. Adherence to the proposed substitute's SDS and use of proper engineering controls and PPE make it unlikely that exposure exceeding the ATEL of HFC-32 would occur. Adequate ventilation should always be established during any use, handling, or storage of HFC-32.

Systems with charge sizes larger than those modeled in the occupational exposure assessment that meet the requirements of UL 60335-2-89 are also not expected to result in an occupational exposure concern during charging and servicing provided there is adherence to the proposed substitute's SDS and proper industrial hygiene techniques are followed.

If charging and servicing is taking place in an enclosed space without any mechanical ventilation, facilities should be cleared of non-essential personnel and technicians should wear a SCBA and other appropriate protective equipment. Engineering controls should include vapor-in air detection systems and local exhaust ventilation during use of HFC-32 to prevent dispersion throughout the workplace. In addition, an eye wash and safety shower should be near the manufacturing facility and locations where HFC-32 is stored and ready for use. In general, use of PPE is recommended, such as splash goggles, mechanically resistant gloves when handling cylinders and chemically resistant gloves when handling the gas mixture (e.g., butyl rubber, chlorinated polyethylene, or neoprene).

10.3 Occupational Exposure at Disposal

Disposal of HFC-32 commercial ice machines is expected to occur with limited frequency and with limited duration of exposure to the installed refrigerant. Typically, potential exposures to the refrigerant during recovery and disposal are expected to occur during activities related to decommissioning refrigeration systems (e.g., attaching of hoses associated with draining or otherwise discharging of refrigerant from the refrigeration units into cylinders) and would be similar to those during servicing, because similar refrigerant charging and/or recovery equipment would be used (see Section 10.2 and Table 10 for information and modeling results related to exposure during servicing activities).

To model a worst-case scenario during disposal for self-contained and remote commercial ice machines, the release per event was conservatively assumed to be 100 percent of the equipment charge (representing a catastrophic release). It was assumed that 10 units are disposed during an 8-hour workday; however, it was assumed that of the 10 units, only the last unit per workday would experience the catastrophic release (i.e., 100 percent of the equipment charge). The remaining 9 units were assumed to release only an incidental amount of refrigerant (i.e., one percent per unit) from the connecting and disconnecting of lines, as it is likely that if a worker was exposed to the entire charge of a system during disposal activities, they would immediately stop working, clear the area until all refrigerant has been removed from the space (e.g., through ventilation), and adhere to the exposure procedures recommended in the SDS for the proposed substitute.

Table 11 displays the maximum estimated 8-hour TWA occupational exposure levels for HFC-32 during disposal of commercial ice machines at the charge size limits and maximum releasable charge amounts.

Table 11. Occupational Risk Assessment at Disposal for HFC-32[a]

Equipment Type	Modeled Charge Size (kg)[b]	8-Hour TWA Occupational Exposure (ppm)	8-Hour Long Term Exposure Limits (ppm)[c]
Self-Contained Ice Machine	0.920	**300**	1,000
	3.98	**1,300**	
Remote Ice Machine	79.6	**25,940**	

[a] Modeling results are signified with **bold font**. Cells highlighted in green represent modeled values that result in acceptable exposure levels under the modeling assumptions (i.e., do not exceed the OEL), and cells highlighted in red represent modeled values that could result in toxicity concerns under the modeling assumptions (i.e., exceed the OEL).

[b] For the purposes of the occupational risk assessment, modeled releases during disposal are relative to the maximum releasable charge of the unit.

[c] 8-hour OEL. See Table 4 for more information.

The results in Table 11 indicate that occupational exposure during disposal of self-contained commercial ice machines is not likely to exceed the 8-hour long term exposure limit of 1,000 ppm for the modeled charge size of 0.920 kilograms. The 8-hour long term exposure limit could be exceeded for the modeled charge sizes of 3.98 kilograms and 79.6 kilograms in self-contained and remote commercial ice machines, respectively. The recommendations for proper engineering controls and PPE in the SDS for HFC-32 should be followed.

Furthermore, these types of systems are typically disposed of by properly trained personnel and EPA Section 608-certified refrigerant technicians, as required by EPA regulations, using proper industrial hygiene techniques. When disposing of commercial ice machines, these techniques should be strictly followed. Adherence to the proposed substitute's SDS and use of proper engineering controls and PPE make it unlikely that exposure to HFC-32 would occur.

Systems with charge sizes larger than those modeled in the occupational exposure assessment that meet the requirements of UL 60335-2-89 are also not expected to result in an occupational exposure concern during disposal provided there is adherence to the proposed substitute's SDS and proper industrial hygiene techniques are followed.

Adequate ventilation should always be established during any use, handling, or storage of HFC-32. If disposal is taking place in an enclosed space without any mechanical ventilation, facilities should be cleared of non-essential personnel and technicians should wear a SCBA and other appropriate protective equipment. Engineering controls should include vapor-in air detection systems and local exhaust ventilation during use of HFC-32 to prevent dispersion throughout the workplace. In addition, an eye wash and safety shower should be near the manufacturing facility and locations where HFC-32 is stored and ready for use. In general, use of PPE is recommended, such as splash goggles, mechanically resistant gloves when handling cylinders and chemically resistant gloves when handling the gas mixture (e.g., butyl rubber, chlorinated polyethylene, or neoprene).

Toxicity risks would be further minimized by the installation of signage which warns room occupants to remain standing (as higher concentrations are likely to accumulate near the floor) and to not enter recessed parts of the facility (e.g., maintenance crawl spaces and below-grade service areas) and exit the facility immediately should they hear the refrigerant detector alarm.

11. GENERAL POPULATION EXPOSURE ASSESSMENT

This section presents an assessment of potential risks to the general population posed by the use of HFC-32 in self-contained and remote commercial ice machines. The general population is defined in this risk screen as non-personnel who are subject to exposure of the proposed substitute near industrial facilities, including manufacturing or equipment production factories, equipment operating sites, or recycling centers, rather than non-personnel at end-use.

HFC-32 is not expected to cause a significant risk to human health in the general population when manufactured for use and used as a refrigerant in self-contained and remote commercial ice machines. The proposed substitute will be manufactured in a closed process and is proposed for use in closed systems; thus, significant releases are not anticipated. At room temperature, HFC-32 is a gas and, therefore, releases to ground or surface water are not anticipated, as HFC-32 is anticipated to dissipate into the atmosphere upon release to outside air (i.e., because natural ventilation rates would be higher and there is no enclosed space to maintain a high concentration of HFC-32). Should air releases during manufacturing operations occur, engineering controls should be used (e.g., carbon absorption scrubbers) to collect HFC-32 and prevent its release to the atmosphere. EPA believes that by using proper engineering controls and by following disposal and containment recommendations outlined in the proposed substitute's SDS and this risk screen, exposure to HFC-32 is not expected to pose a significant toxicity risk to the general population.

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