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. 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 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.

Additional safeguards, including the specified refrigerant concentration limit (RCL) for HFC-32, are also provided by adherence to industry standards including: American Society of Heating, Refrigerating and

Air-Conditioning Engineers (ASHRAE) Standards 15,[1] 34,[2] and 62.1;[3] Air Conditioning, Heating, and Refrigeration Institute (AHRI) Standard 700;[4] and Underwriters Laboratories (UL) Standard 60335-2-89.[5]

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) 2018 Scientific Assessment Report (2018).
[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 11 days (Forster et al. 2007, Papadimitriou et al. 2007).
[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 16.4 days (Forster et al. 2007, Hodnebrog, O. et al. 2013).

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[1] Safety Standard for Refrigeration Systems ASHRAE Standard 15 establishes safeguards for life, limb, health, and property and prescribes safety requirements (ASHRAE 2022a).
[2] 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).
[3] 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).
[4] 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).
[5] 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).
[6] HCFC-22 has an ODP of 0.055, GWP of 1,810, and ALT of 12 years (WMO 2018, 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 have ice-making capabilities less than 250 pounds of ice per 24 hours. 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).

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 corridor or lobby[7] and self-contained ice machines with doors/drawers are 0.92 kilograms and 2.45 kilograms, respectively, and the releasable amount for field-erected ice machines is limited to 3.98 kilograms.[8] Furthermore, UL 60335-2-89 limits the charge size of HFC-32 in field-erected systems to 15.9 kilograms for systems equipped with mitigation or 79.6 kilograms for systems installed in a machinery room or outdoors; however, the releasable amount of HFC-32 from field-erected ice machines is still 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 releasable amount is 0.92 kilograms, 2.45 kilograms, or 3.98 kilograms depending on the equipment type and/or installation location.[9] Therefore, this risk screen models the maximum 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. 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 0.92 kilograms is installed in an enclosed alcove of a commercial building and a self-contained commercial ice machine with a charge size of 2.45 kilograms is installed in a restaurant kitchen. The alcove is assumed to have a height of 2.44 meters (8 feet) and an effective volume of 15 m^3 (530 ft^3) (i.e., excluding the space filled by the ice machine, furniture, boxes, etc.), 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.).

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[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 corridor or lobby – 3 times the LFL (0.306 kg/m^3 for HFC-32); self-contained systems with doors/drawers– 8 times the LFL; and field-erected systems with open cases – 13 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.

Under these worst-case scenarios, the full charge of each unit is assumed to be emitted into the enclosed alcove or restaurant kitchen with 0.5 and 20 air changes per hour (ACH), respectively,[10,11] 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).

To represent a reasonable worst-case scenario for a remote ice machine, it is assumed that the maximum releasable charge of 3.98 kilograms is emitted into a machinery room (e.g., within a seafood processing facility)[12] with a height of 2.44 meters (8 feet) and an effective volume of 142 m^3 (5,000 ft^3) (i.e., excluding the space filled by the condenser, shelving, other equipment, etc.) (CDC 2014). ASHRAE Standard 15 establishes design and engineering control requirements for HFC-32 refrigeration system machinery rooms. According to this standard, the machinery room housing refrigeration equipment is required to have doors that prevent any refrigerant from escaping to an occupied space during a leak and that facilitate easy egress in an emergency. Walls, floors, and ceilings in machinery rooms should be of tight construction and made of non-combustible materials (ASHRAE 2022a).

The machinery room must also be equipped with leak detection systems that activate an alarm and ventilation system at a concentration less than the threshold limit value-time weighted average (TLV-TWA) of the refrigerant (i.e., 1,000 parts per million (ppm) for HFC-32) to ensure high enough levels of air exchange upon leak detection to ventilate the space and remove the refrigerant in accordance with ASHRAE 15-2022 8.9.8. Specifically, the mechanical ventilation must be capable of exhausting air from the machinery room in not less than the quantity calculated using the following equation:

$$Q = 100\sqrt{G}$$

where Q equals airflow in cubic feet per minute and G equals the total refrigerant charge of the system in pounds. The airflow can then be converted to the ventilation rate using the following equation:

$$Ventilation\ Rate\ (ACH) = \frac{60Q}{V}$$

where V equals the volume of the room in cubic feet and Q equals the airflow in cubic feet per minute. Based on a maximum releasable charge of 3.98 kilograms, ventilation systems must provide a minimum mechanical ventilation rate of 3.5 ACH. The purpose of the ventilation system is to remove the leaked refrigerant from the machinery room upon leak detection. According to ASHRAE 15, the machinery room must be vented to the outdoors and the exhaust inlets must be located in an area where refrigerant from a leak is likely to concentrate, typically near the floor (ASHRAE 2022a).

The machinery room should also be restricted to authorized personnel in accordance with ASHRAE Standard 15. EPA recommends that signs are present on the doors of the machinery room indicating there is restricted access and that HFC-32 refrigerant is in use and can cause suffocation, injury, or death. An

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[10] 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.
[11] 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).
[12] 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.