Significant New Alternatives Policy Program
Refrigeration and Air-conditioning Sector

Risk Screen on Substitutes in Water Coolers (Retrofit Equipment)

Substitute: R-480A (RS-20)

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 R-480A (also known as RS-20) as a substitute in retrofit equipment in the water coolers end-use. Table 1 presents the composition of the proposed substitute.

Table 1. Composition of R-480A and Potential Impurities

Constituent	Chemical Formula	CAS Number	Concentration (Weight Percent)
trans 1,3,3,3-tetrafluoropropene (HFO-1234ze(E))	$CF_3CH{=}CHF$	29118-24-9	≤86%
1,1,1,2,3,3,3-heptafluoropropane (HFC-227ea)	CF_3CHFCF_3	431-89-0	≤9%
Carbon dioxide (CO2)	CO_2	124-38-9	≤5%
Potential Impurities (Maximum Concentration)			
Unidentified	NA	NA	≤0.5%

NA = Not available.
[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).

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 Modeled
- 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

R-480A is recommended for SNAP approval for retrofit water coolers. 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 lower climate impact than the proposed substitute are listed as acceptable.

The components of R-480A (i.e., HFO-1234ze(E), HFC-227ea, and CO_2) are 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 R-480A are not a concern. In addition, because R-480A is considered to be nonflammable, the proposed substitute is not expected to present a flammability concern.

It is expected that the manufacturer's safety data sheet (SDS) for R-480A and good manufacturing practices will be adhered to during handling or use of R-480A, 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 manufacture, installation and servicing, and disposal of water coolers using R-480A. Because water coolers 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 R-480A, 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 R-480A, are also provided by adherence to industry standards including: ASHRAE Standards 15,[1] 34,[2] and 62.1;[3] Air Conditioning, Heating, and Refrigeration Institute (AHRI) Standard 700;[4] and UL Standard 399.[5]

3. ATMOSPHERIC ASSESSMENT

This section presents an assessment of the potential risks to the atmosphere posed by the use of R-480A in water coolers. The ozone depletion potential (ODP) and global warming potential (GWP) of the proposed substitute and the atmospheric lifetime (ALT) of each component are presented in Table 2.

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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 399 Drinking Water Coolers establishes safety requirements for self-contained drinking-water coolers employing hermetic refrigerant motor-compressors or thermoelectric water chilling systems and designed for connection to alternating-current circuits rated not greater than 600 volts in accordance with the National Electrical Code, NFPA 70 (UL 2017).

The proposed substitute is substantially less harmful to the ozone layer and has lower climate impact, and a shorter ALT when compared to refrigerants such as HCFC-22.[6] R-480A has a lower climate impact than those predicted for other substitutes examined in the Background Document, as well as certain common HFC refrigerants in water coolers, including HFC-134a. Thus, EPA believes that the use of R-480A 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 or higher climate impact compared to the proposed substitute, including R-513A, R-450A, and R-290.

Table 2. Atmospheric Impacts of R-480A Compared to Other Refrigerants used in Water Coolers

Refrigerant	Ozone Depleting Potential (ODP)[a]	Global Warming Potential (GWP)[b]	Atmospheric Lifetime in Years (ALT)[b]
R-480A	0	291[c]	NA[d]
Individual Components			
HFO-1234ze(E)	0	1[a]	19 days[a]
HFC-227ea	0	3,220	34.2
CO_2	0	1	5-200[e]
Other Refrigerants			
HFC-134a	0	1,430	14
R-513A[f]	0	630	NA[f]
R-450A[g]	0	601	NA[g]
Propane (R-290)	0	3[a]	15 days[a]

NA = Not applicable.
[a] World Meteorological Organization (WMO) 2022 Scientific Assessment Report (2022).
[b] GWPs are determined using the 100-year GWP values from Annex F to the Montreal Protocol, which are based on the 100-year GWP values provided in the Intergovernmental Panel on Climate Change (IPCC) 4th Assessment Report (Forster et al. 2007), unless otherwise noted. These same 100-year GWPs also are numerically equal to the exchange values listed in the American Innovation and Manufacturing Act of 2020.
[c] Calculated based on maximum concentrations from Table 1.
[d] Atmospheric lifetimes are not given for blends, because the components separate in the atmosphere. The ALTs for the individual components are listed in the table.
[e] The carbon dioxide response function used in the IPCC 4th Assessment Report is based on the revised version of the Bern Carbon Cycle Model using a background carbon dioxide concentration value of 378 ppm. The decay of a pulse of carbon dioxide with time t is given by

$$a_0 + \sum_{i=1}^{3} a_i \cdot e^{-t/\tau_i}$$

where a_0 = 0.217. [f] 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).
[f] 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).
[g] 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).

4. VOLATILE ORGANIC COMPOUND ASSESSMENT

The components of R-480A (i.e., HFO-1234ze(E), HFC-227ea, and CO_2) are excluded from the definition of VOC under CAA regulations (40 CFR 51.100(s)). Therefore, VOC impacts from the release of R-480A are not a concern.

[6] HCFC-22 has an ODP of 0.055, GWP of 1,810, and ALT of 12 years (EPA 2014, Forster et al. 2007).

5. DISCUSSION OF END-USE SCENARIOS MODELED

R-480A has been proposed for use in water coolers, including water fountains affixed to the wall or ground and stand-alone water coolers. Water coolers have a typical charge size of 0.2 kilograms and a maximum charge size of 1 kilogram (EPA 2022,[7] UNEP 2022).

Water coolers can be installed in a wide range of locations with varying room volumes (e.g., residential homes, commercial office buildings, outdoors). To represent reasonable worst-case scenarios for water coolers, it is assumed that a water cooler with a charge size of 0.2 kilograms is installed in an enclosed alcove of a public commercial building and a water cooler with a charge size of 1 kilogram 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 water cooler, furniture, boxes, etc.) based on estimates of a space with a height of 2.44 meters (8 ft) and a floor area of 6.25 m^2 (67 ft^2), and the restaurant kitchen is assumed to have a height of 2.44 meters (8 ft) and a typical effective volume of 120 m^3 (4,240 ft^3) (i.e., excluding the space filled by the water cooler, shelving, other kitchen equipment, etc.) (Manitowoc 2015).

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 or 20 air changes per hour (ACH), respectively,[8,9] over the course of two time durations: 1) one minute, which represents a catastrophic release of refrigerant due to a puncture or other major damage to the refrigeration system, and 2) fifteen minutes, which represents the accidental release of refrigerant due to a non-catastrophic leak in the system (e.g., valve failure). The one-minute time duration is most appropriate for determining the fire risks of flammable refrigerants because the potential maximum instantaneous concentration can be estimated and compared to the lower flammability limit. Because R-480A is nonflammable, the one-minute time duration presents a less relevant scenario. While both scenarios are evaluated in this risk screen for consistency purposes, the scenario that analyzes a release of refrigerant over a 15-minute time duration more accurately represents a reasonable worst-case scenario for R-480A in water coolers.

A vertical concentration gradient is also assumed since R-480A is denser than air (the specific gravity of R-480A is greater than 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	Water Cooler	
Charge Size (kg)	0.2	1
Room Type	Alcove (Public)	Restaurant Kitchen
Room Size (m^3)	15 (530 ft^3)[a]	120 (4,240 ft^3)[b]

[7] 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.

[8] 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.

[9] 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).

Length of Release (minutes)	1; 15	1; 15
Ventilation Rate (ACH)	0.5[c]	20[d]
Vertical Concentration Gradient (m)	0.4 (1.3 ft.)	0.4 (1.3 ft.)

[a] 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).
[b] Manitowoc (2015).
[c] ASHRAE (2022c).
[d] McMullan (2014).

EPA recognizes that water coolers 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 a water cooler and other pieces of equipment (e.g., ice machine, vending machine) within an enclosed space (thus further limiting the effective volume of the space), or a single water cooler in a very small, enclosed space. When units are installed in smaller, enclosed spaces, there is a higher risk for flammability, asphyxiation, or exposure concerns. To address this variability in room volumes and charge sizes for water coolers, this risk screen incorporates threshold analyses in addition to the worst-case scenario modeling for scenarios which the results of the screening-level assessment warrant further risk evaluation.

R-480A is nonflammable and the acute toxicity exposure limit (ATEL) (see Section 6) is lower than the concentration necessary to reduce oxygen in air to the hypoxia no observed adverse exposure level (NOAEL).[10] Therefore, a threshold analysis is performed in the end-use exposure assessment for this risk screen to determine the room size and charge size limit requirements at which a flammability concern would exist for the use of R-480A in water coolers.

6. POTENTIAL HEALTH EFFECTS

To assess potential health risks from exposure to the proposed substitute in water coolers, EPA identified the relevant toxicity threshold values and compared them to modeled exposure concentrations for different scenarios. According to ASHRAE 34, R-480A is listed under safety group A1 with an ATEL and RCL of 59,000 parts per million (ppm) (ASHRAE 2022d). ASHRAE Standard 34 ATELs and RCLs[11] are intended to reduce the risk 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 hypoxia NOAEL and occupational exposure limits, as additional, conservative limits to ensure that significant 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 were 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 (OELs).

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 (EPRG) for R-480A, 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.

[10] Twelve percent oxygen in air (i.e., 120,000 ppm) is the NOAEL for hypoxia (ICF 1997).
[11] 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 R-480A 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 R-480A and Components

Proposed Substitute	WGL (Long-term Exposure) ppm[a]	EGL (Short-term Exposure) ppm	RCL ppm[a]	ATEL ppm[a]
R-480A	900 (8-hour OEL)[c]	2,700 (15-min STEL)[b]	59,000[c]	59,000[c]
Individual Components				
HFO-1234ze(E)	800 (8-hour OEL)	2,400 (15-min STEL)[d]	16,000	59,000
HFC-227ea	1,000 (8-hour OEL)	3,500 (15-min STEL)[e]	84,000	84,000
CO_2	5,000 (8-hour OEL)	30,000 (15-minute ACGIH STEL) 40,000 (30-minute NIOSH IDLH)	30,000	30,000

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

[a] ASHRAE (2022b), unless otherwise specified.

[b] Neither the ACGIH nor AIHA recommends ceiling or short-term exposure limits for the blend R-480A. A STEL for R-480A of 2,700 ppm was developed by EPA based on the 900 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 = 900 ppm x 3 ≈ 2,700 ppm.

[c] ASHRAE (2022d).

[d] Neither the ACGIH nor AIHA recommends ceiling or short-term exposure limits for HFO-1234ze(E). A STEL for HFO-1234ze(E) of 2,400 ppm was developed by EPA based on the 800 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 = 800 ppm x 3 ≈ 2,400 ppm

[e] Neither the ACGIH nor AIHA recommends ceiling or short-term exposure limits for HFC-227ea. A STEL for HFC-227ea 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	
OARS	Occupational Alliance for Risk Science	
Exposure Limit	**Definition**	**Explanation**
Short-Term Exposure		
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 Acute-Toxicity Exposure Limit (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.
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.
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.
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, AIHA-WEEL, 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 R-480A may be hazardous if inhalation, skin contact, or eye contact with the proposed substitute occurs at sufficiently high levels. R-480A 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.

If R-480A 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 R-480A to the skin may cause frostbite. In the case of dermal exposure, the SDS for R-480A recommends that person(s) immediately wash the affected area with plenty of water, and that persons(s) remove all contaminated clothing; if frostbite occurs, bathe (not rub) the affected area with a clean, soft cloth, and seek medical attention immediately. Exposures of R-480A to the eyes could cause eye irritation. In case of ocular exposure, the SDS for R-480A recommends that person(s) immediately flush the eyes, including under the eyelids, with copious amounts of water for 15 minutes.

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 R-480A can be minimized by following the exposure guidelines, ventilation, and PPE recommendations outlined in the SDS for R-480A and this risk screen.

7. FLAMMABILITY ASSESSMENT

ASHRAE Standard 34 classifies R-480A as a Class A1 refrigerant and is considered to be nonflammable (ASHRAE 2022b). Based on this classification, charging, servicing, and use of R-480A are not expected to present a flammability risk in water coolers.

8. ASPHYXIATION ASSESSMENT

The risk of asphyxiation for the reasonable worst-case scenarios described in Section 5 was investigated for R-480A in water coolers. In this section, risk of asphyxiation is assessed by modeling the oxygen concentration under the maximum charge sizes 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 6 below.

Table 6. Asphyxiation Assessment for R-480A[a,b]

Reasonable Worst-case Scenario	Charge Size (kg)[c]	Effective Room Size (m^3)	Room Type	Percent Oxygen Concentration[d]
1	0.2	15 (530 ft^3)	Alcove (Public)	**19.5%**
2	1	120 (4,240 ft^3)	Restaurant Kitchen	**20%**

[a] Modeling results are signified with **bold font**. Cells highlighted in green indicate modeled values 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, R-480A in water coolers does not present a significant risk of asphyxiation. Additionally, 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 that are significantly larger than charge sizes expected for this end-use or room sizes that are unlikely for the proposed applications.

EPA does not believe that the use of R-480A in water coolers 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 R-480A.

9. END-USE EXPOSURE ASSESSMENT

This section presents estimates of potential end-user exposures to R-480A in the event of a catastrophic release from water coolers 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 water coolers were examined. As discussed in Section 5, the full charge is assumed to be emitted over the course of one minute.

The analysis was undertaken to determine the 15-minute exposures for R-480A, which were then compared to the standard toxicity limits presented in **Error! Reference source not found.** 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 7.

Table 7. End-Use Exposure Assessment for R-480A[a]

Equipment Type	Reasonable Worst-case Scenario	Charge Size (kg)[b]	Room Size (m^3)	Room Type	Ventilation Rate (ACH)	15-minute TWA (ppm)[c]	
						1-min Release	15-min Release
Water cooler	1	0.2	15 (530 ft^3)	Alcove (Public)	0.5	**14,900**	**8,100**
	2	1	120 (4,240 ft^3)	Restaurant Kitchen	20	**2,000**	**1,700**

[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 R-480A is 59,000 ppm.

According to the results in Table 7, the estimated 15-minute TWA exposure for R-480A in self-contained water coolers installed in a public alcove and restaurant kitchen would not exceed the ATEL (i.e., 59,000 ppm) in a one-minute release scenario or a fifteen-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 R-480A will be installed.

Because self-contained ice machines may be used in a variety of room sizes, threshold analyses on the charge size limit and room size were also performed. The threshold analyses were based off the conditions at which the R-480A concentration would reach the ATEL (i.e., 59,000 ppm).

Table 8. Flammability Threshold Assessment[a]

Unit Type	Threshold Analysis Scenario	Charge Size (kg)[b]	Effective Room Size (m^3)	Room Type	Maximum Instantaneous Concentration (ppm)[c]
Water cooler	1a: Charge Size	**1.6**	15 (530 ft^3)	Alcove (Public)	59,000
	1b: Room Size	0.2	**1.9 (62 ft^3)**		
	2a: Charge Size	**60**	120 (4,240 ft^3)	Restaurant Kitchen	
	2b: Room Size	1	**2.0 (66 ft^3)**		

[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 toxicity result could occur is more conservative than what is modeled in the end-use exposure assessment. Red indicates that the maximum releasable charge and/or unit charge size at which a toxicity result could occur is less conservative than what is modeled in the end-use exposure assessment.
[b] See Section 5 for more information.
[c] ATEL of R-480A is 59,000 ppm.

The threshold conditions at which an end-use exposure concern would exist (i.e., when the maximum instantaneous concentration following a complete release equals the ATEL for R-480A) were determined and are shown in Table 8. In order for toxicity to not be a concern based on the results shown in Table 8, the space in which a 0.2-kilogram water cooler is installed would have to be greater than 1.9 m^3 (62 ft^3). For water coolers installed in a restaurant kitchen, the charge size and releasable charge would have to be larger than the maximum modeled charge released in order for toxicity to be a concern. The minimum room sizes in which installed equipment could cause a toxicity concern vary based on charge release assumptions.

To prevent exposure and potential serious side effects during larger releases, EPA recommends that the RCL for R-480A (i.e., 59,000 ppm) is not exceeded in any location where a R-480A system is installed, unless proper leak protection devices are in place to prevent exposures of R-480A beyond the recommended limits. 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 protection devices, engineering control requirements, and adherence to the SDS will further prevent exposures of R-480A 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 R-480A and charging, servicing, and disposal of R-480A water coolers. To ensure that use of the proposed substitute in water coolers 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.

Estimates of refrigerant release per event for various release scenarios were obtained from the Vintaging Model (EPA 2022). For charging, servicing, and disposal activities, the release rate per event was 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 long-term exposure limits at disposal in Table 11.

10.1 Occupational Exposure at Manufacture of Proposed Substitute

During manufacture of R-480A, the SDS 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 addition, 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 R-480A is exposed to high temperatures or fire. Other reaction products such as carbon dioxide might also be present. Containers of R-480A 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 R-480A, there is no significant risk to workers during the manufacture of R-480A.

10.2 Occupational Exposure at Equipment Manufacture, Charging, and Servicing

Water coolers are typically charged by the Original Equipment Manufacturer (OEM) and serviced at the end-use location. As stated by the submitter, for OEM system manufacture (i.e., charging at OEM location), points of release from these leak-tight systems 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. The submitter indicates that typical and maximum worker exposures to R-480A during charging and servicing of water coolers are less than 900 ppm per 8-hour workday (Refrigerant Solutions 2023). 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 water coolers are not expected to result in significant worker exposure when certified technicians follow the procedures outlined in the R-480A SDS and equipment maintenance manual, undergo proper training, and wear appropriate PPE (e.g., gloves and safety glasses).

During charging and servicing of water coolers, 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).

To evaluate the risk of exposure at charging and servicing, the maximum 15-minute TWA exposure for R-480A was compared to the STEL and the RCL (see Table 9).

Table 9. Occupational Risk Assessment at Manufacture, Charging, and Servicing for R-480A[a]

Modeled Charge Size (kg)[b]	Charging		Servicing		15-min STEL (ppm)[c]	RCL (ppm)[c]
	Release Rate	15-minute TWA (ppm)	Release Rate	15-minute TWA (ppm)		
0.2	1%	**3.8**	3%	**57**	2,700	21,000
1		**19**		**280**		

[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 **Error! Reference source not found.** for more information.

Based on the assumptions described above, the modeling indicates that short-term (15-minute) worker exposure concentrations of R-480A are not likely to exceed its STEL (i.e., 2,700 ppm) for water coolers during charging and servicing under the modeled charge sizes. The recommendations for proper engineering controls and PPE in the SDS for R-480A 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 R-480A (i.e., 59,000 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). 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 R-480A.

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 water coolers, 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 R-480A would occur. Adequate ventilation should always be established during any use, handling, or storage of R-480A.

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 R-480A to prevent dispersion throughout the workplace. In addition, an eye wash and safety shower should be near the manufacturing facility and locations where R-480A 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 R-480A water coolers is expected to occur with limited frequency (up to approximately ten disposal events per day) at disposal facilities 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 9. for information and modeling results related to exposure during servicing activities). The submitter indicates that worker exposures to R-480A during recovery and disposal are less than 900 ppm, per 8-hour workday (Refrigerant Solutions 2023).

To model a worst-case scenario during disposal for water coolers, 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 10. displays the maximum estimated 8-hour TWA occupational exposure levels for R-480A during disposal of water coolers at the modeled charge sizes.

Table 10. Occupational Risk Assessment at Disposal for R-480A[a]

Equipment Type	Charge Size (kg)[b]	8-Hour TWA Occupational Exposure (ppm)	8-Hour Long Term Exposure Limits (ppm)[c]
Water coolers	0.2	**29**	900
	1	**150**	

[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 **Error! Reference source not found.** for more information.

The results in Table 10. indicate that occupational exposure during disposal of water coolers is not likely to exceed the 8-hour long term exposure limit (i.e., 900 ppm) for the modeled charge sizes of 0.2 and 1 kilograms. The recommendations for proper engineering controls and PPE in the SDS for R-480A 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 water coolers, 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 R-480A would occur.

Adequate ventilation should always be established during any use, handling, or storage of R-480A. 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 R-480A to prevent dispersion throughout the workplace.

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 R-480A in water coolers. 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 personnel at end-use.

R-480A 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 water coolers. 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, R-480A is a gas and, therefore, releases to ground or surface water are not anticipated, as R-480A 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 R-480A). Should air releases during manufacturing operations occur, engineering controls should be used (e.g., carbon absorption scrubbers) to collect R-480A 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 R-480A is not expected to pose a significant toxicity risk to the general population.

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