# Significant New Alternatives Policy Program
# Refrigeration and Air-conditioning Sector

## Risk Screen on Substitutes in Industrial Process Refrigeration

### Substitute: R-448A (Solstice® N-40)

**This risk screen does not contain Clean Air Act (CAA) Confidential Business Information (CBI) and, therefore, may be disclosed to the public. Brackets [ ] represent redacted CBI content.**

## 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 two 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-448A as a substitute in the industrial process refrigeration end-use. Table 1 presents the composition of the proposed substitute.

**Table 1. Composition of R-448A and Potential Impurities**

| Constituent | Chemical Formula | CAS Number | Concentration (Weight Percent)[a] |
|---|---|---|---|
| Difluoromethane (HFC-32) | $CH_2F_2$ | 75-10-5 | ≤26% |
| Pentafluoroethane (HFC-125) | $C_2HF_5$ | 354-33-6 | ≤26% |
| 1,1,1,2-Tetrafluoroethane (HFC-134a) | $CF_3CH_2F$ | 811-97-2 | ≤21% |
| 2,3,3,3-Tetrafluoro-prop-1-ene (HFO-1234yf) | $C_3H_2F_4$ | 754-12-1 | ≤20% |
| *trans*-1,3,3,3,-Tetrafluoro-1-propene (HFO-1234ze(E)) | $CHFCHCF_3$ | 29118-24-9 | ≤7% |
| **Potential Impurities (Maximum Concentration)** | | | |
| [ ] | | | |

Note: Typical (actual) impurity concentrations may be considerably lower than the maximum values 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. The total of all impurities listed above is controlled so that it does not exceed 0.5% by weight in R-448A (Honeywell 2014a).

Section 2 summarizes the results of the risk screen for the proposed substitute blend 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: Potential Health Effects
- Section 6: Flammability Assessment
- Section 7: Asphyxiation Assessment
- Section 8: Occupational Exposure Assessment
- Section 9: General Population Exposure Assessment
- Section 10: References

## 2. SUMMARY OF RESULTS

R-448A is recommended for SNAP approval for industrial process refrigeration. 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 other commonly used refrigerants, as it is less harmful to the ozone layer and has lower climate impact. The components of R-448A 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-448A are not a concern. In addition, because R-448A 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-448A and good manufacturing practices will be adhered to during handling or use of R-448A, 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, servicing, and disposal of industrial process refrigeration systems using R-448A. Because industrial process refrigeration systems are to be installed in locations with adequate space and/or ventilation in accordance with EPA recommendations and the equipment maintenance manuals for R-448A in each end-use, significant toxicity risk to personnel is also unlikely. Exposure at the end-use is captured in the occupational exposure assessment, as consumer use of industrial process refrigeration equipment is not anticipated.

In addition, potential health risks from exposure to the proposed substitute is considered to be a larger concern for workers than asphyxiation,[1] due to the large spaces in which these systems are installed and serviced. Additional safeguards, including a specified refrigerant concentration limit (RCL) for R-448A are also provided by adherence to industry standards including American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) Standards 15,[2] 34,[3] and 62.1.[4]

## 3. ATMOSPHERIC ASSESSMENT

[1] The oxygen deprivation limit (ODL) for R-448A is 140,000 ppm per Standard 34 (ASHRAE 2016b). Exposure estimates remain significantly below this level (see Table 5).
[2] Safety Standard for Refrigeration Systems ASHRAE Standard 15 establishes safeguards for life, limb, health, and property and prescribes safety requirements.
[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.
[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.

This section presents an assessment of the potential risks to the atmosphere posed by the use of R-448A in industrial process refrigeration. The ozone depletion potential (ODP) and global warming potential (GWP) of the proposed substitute blend and the atmospheric lifetime (ALT) of each component 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 CFC-12 and HCFC-22. R-448A has comparable or lower climate impact than those predicted for other substitutes examined in the Background Document as well as commonly utilized refrigerants in industrial process refrigeration, including HFC-134a, R-404A, and R-507A. Thus, EPA believes that the use of R-448A would result in substantially less harm to the climate and ozone layer than the continued use of ODS and other commonly used refrigerants in industrial process refrigeration systems.

**Table 2. Atmospheric Impacts of R-448A Compared to Other Refrigerants Used in Industrial Process Refrigeration**

| Refrigerant | Ozone Depleting Potential (ODP)[a] | Global Warming Potential (GWP)[b] | Atmospheric Lifetime in Years (ALT)[b] |
|---|---|---|---|
| R-448A | 0 | 1,387 | NA[c] |
| **Individual Components** | | | |
| HFC-32 | 0 | 675 | 4.9 |
| HFC-125 | 0 | 3,500 | 29 |
| HFC-134a | 0 | 1,430 | 14 |
| HFO-1234yf | 0 | 4[d] | 11 days[d] |
| HFO-1234ze(E) | 0 | 1[e] | 16.4 days[e] |
| **Other Refrigerants** | | | |
| CFC-12 | 0.82 | 10,900 | 100 |
| HCFC-22 | 0.13 | 1,810 | 12[a] |
| R-507A[f] | 0 | 3,985 | NA[g] |
| R-404A[h] | 0 | 3,922 | NA[i] |
| HFC-134a | 0 | 1,430 | 14 |

NA = Not applicable.
[a] World Meteorological Organization (WMO) 2010 Scientific Assessment Report (2011).
[b] Intergovernmental Panel on Climate Change (IPCC) 4th Assessment Report (Forster et al. 2007).
[c] Atmospheric lifetimes are not given for blends, because the components separate in the atmosphere. The ALT for the individual components are also listed in this table.
[d] Papadimitriou et al. (2007).
[e] Hodnebrog, O. et al. (2013).
[f] R-507A is a blend consisting of HFC-125 (50%) and HFC-143a (50%).
[g] Atmospheric lifetimes are not given for blends, because the components separate in the atmosphere. The ALT for HFC-125 is 29 years and ALT for HFC-143a is 52 years (Forster et al. 2007).
[h] R-404A is a blend consisting of HFC-143a (52%), HFC-125 (44%) and HFC-134a (4%).
[i] Atmospheric lifetimes are not given for blends, because the components separate in the atmosphere. 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).

## 4. VOLATILE ORGANIC COMPOUND ASSESSMENT

The components of R-448A (i.e., HFC-32, HFC-125, HFC-134a, HFO-1234yf, and HFO-1234ze(E)) are excluded from the definition of VOC under CAA regulations (40 CFR 51.100(s)). Therefore, VOC impacts from the release of R-448A are not a concern.

## 5. POTENTIAL HEALTH EFFECTS

To assess potential health risks from exposure to the proposed substitute in industrial process refrigeration, EPA identified the relevant toxicity threshold values and compared them to modeled exposure concentrations for different scenarios. According to ASHRAE Standard 34, R-448A is listed under safety group A1 with an acute toxicity exposure limit (ATEL) and RCL of 110,000 parts per million (ppm) (ASHRAE 2016b). ASHRAE 34 ATELs and RCLs[5] 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 2016b). The ATEL for R-448A is intended to reduce the risk of anesthetic effects and cardiac sensitization, which are the most hazardous potential health effects from significant exposure to R-448A. As such, 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.

For the occupational exposure analysis, described in Section 8, 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 Workplace Environmental Exposure Levels (WEEL).

Risks from potential acute occupational exposures to workers 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 R-448A, potential short-term, occupational exposures can be compared to an AEGL or 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.

Table 3 lists the relevant exposure limits for R-448A and its components and is followed by Table 4, 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 3. Exposure Limits of R-448A and Components**

| R-448A Component | WGL (Long-term Exposure) ppm | EGL (Short-term Exposure) ppm | RCL ppm |
|---|---|---|---|
| R-448A | 890 (8-hour AEL) | 2,670 (15-min STEL)[a] | 110,000 |
| **Individual Components** | | | |
| HFC-32 | 1,000 (8-hour WEEL) | 3,000 (15-min STEL)[b] | 36,000 |
| HFC-125 | 1,000 (8-hour WEEL) | 3,000 (15-min STEL)[c] | 75,000 |
| HFC-134a | 1,000 (8-hour WEEL) | 8,000 (10-min AEGL-1)<br>8,000 (30-min AEGL-1) | 50,000 |
| HFO-1234yf | 500 (8-hour WEEL) | 1,500 (15-min STEL)[d] | 16,000 |
| HFO-1234ze(E) | 800 (8-hour WEEL) | 2,400 (15-min STEL)[e] | 16,000 |

An explanation of each exposure limit and exposure-limit related terminology is described in Table 4.
[a] Neither ACGIH nor AIHA recommends ceiling or short term exposure limits for the blend R-448A. A STEL for R-448A of 2,670 ppm was developed by EPA based on the 890 ppm AEL value. The STEL was estimated as three times the AEL, which is an established method of estimating a STEL by ACGIH. [STEL] = [AEL] x 3 = 890 ppm x 3 ≈ 2,670 ppm.
[b] Neither 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 WEEL value. The STEL was estimated as three times the AEL, which is an established method of estimating a STEL by ACGIH. [STEL] = [AEL] x 3 = 1,000 ppm x 3 ≈ 3,000 ppm.
[c] Neither ACGIH nor AIHA recommends ceiling or short term exposure limits for HFC-125. A STEL for HFC-125 of 3,000 ppm was developed by EPA based on the 1,000 ppm WEEL value. The STEL was estimated as three times the AEL, which is an established method of estimating a STEL by ACGIH. [STEL] = [AEL] x 3 = 1,000 ppm x 3 ≈ 3,000 ppm.

[5] 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 2016a).

[d] Neither ACGIH nor AIHA recommends ceiling or short term exposure limits for HFO-1234yf. A STEL for HFO-1234yf of 1,500 ppm was developed by EPA based on the 500 ppm WEEL value. The STEL was estimated as three times the AEL, which is an established method of estimating a STEL by ACGIH. [STEL] = [AEL] x 3 = 500 ppm x 3 ≈ 1,500 ppm.
[e] Neither 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 WEEL value. The STEL was estimated as three times the AEL, which is an established method of estimating a STEL by ACGIH. [STEL] = [AEL] x 3 = 800 ppm x 3 ≈ 2,400 ppm.

**Table 4. 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** | | |
| 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. |
| AEGL[b,c] | Acute Exposure Guideline Level 1 | AEGL-1 is the airborne concentration of a substance above which it is predicted that the general population, including susceptible individuals, could experience notable discomfort, irritation, or certain asymptomatic nonsensory effects. However, the effects are not disabling and are transient and reversible upon cessation of exposure. |
| **Long-Term Exposure** | | |
| WEEL | Workplace Environmental Exposure Level | Developed by OARS for to protect healthy workers against acute and chronic health effects, this limit is based on repeated daily exposures over a working lifetime and averaged over an 8-hour workday. |
| TLV-TWA | Threshold Limit Value –Time-Weighted Average | The TWA concentration for a conventional 8-hour workday and a 40-hour workweek, to which it is believed that nearly all workers may be repeatedly exposed, day after day, for a working lifetime without adverse effect according to ACGIH. |

[a] All information in this table taken from EPA (1994) except where otherwise noted.
[b] EPA (2012).
[c] Applicable to emergency exposure periods ranging from 10 minutes to 8 hours.

According to the SDS, exposure to R-448A may be hazardous if inhalation, skin contact, or eye contact with the proposed substitute occurs at sufficiently high levels. The most likely pathway of exposure is through inhalation. R-448A 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-448A 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. Rescuers should not attempt to retrieve victims of exposure to R-448A without adequate PPE. At a minimum, a self-contained breathing apparatus (SCBA) should be worn. Exposures of R-448A directly to the skin may cause frostbite. In the case of dermal exposure, the SDS for R-448A recommends that person(s) immediately wash the affected area with water and 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 R-448A to the eyes could cause eye irritation. In case of ocular exposure, the SDS for R-448A 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-448A can be minimized by following the exposure guidelines, ventilation, and PPE recommendations outlined in the SDS for R-448A and this risk screen.

## 6. FLAMMABILITY ASSESSMENT

R-448A is classified as an A1 refrigerant by ASHRAE Standard 34, and is considered to be nonflammable (Honeywell 2014a, ASHRAE 2016b). Based on this classification, manufacture, servicing, and use of R-448A is not expected to present a flammability risk in industrial process refrigeration.

## 7. ASPHYXIATION ASSESSMENT

R-448A is not expected to cause a significant risk of asphyxiation when used in industrial process refrigeration. These systems are typically installed in large spaces (e.g., outdoors, on roofs, large manufacturing facilities) where it would be unlikely for a release of R-448A to reduce the normal concentration of oxygen in air (21 percent) in the space to 12 percent,[6] even in the case of a catastrophic leak. EPA believes that by installing R-448A industrial process refrigeration systems in appropriate spaces according to guidelines from the manufacturer, and the SDS for R-448A, potential releases of R-448A are not expected to pose a significant risk of asphyxiation or impaired coordination to personnel, and are consistent with the potential risks and for other commonly used refrigerants.

## 8. OCCUPATIONAL EXPOSURE ASSESSMENT

This section assesses potential exposure to workers during manufacture of R-448A, and charging, servicing, and disposal of R-448A in industrial process refrigeration systems. To ensure that use of the proposed substitute in industrial process refrigeration does not pose an unacceptable risk to workers during charging, servicing, and disposal, occupational exposure modeling at installation 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.[7] For charging, servicing, and disposal activities, the release rate per event was multiplied by the

[6] Twelve percent oxygen in air is the No Observed Adverse Effect Level (NOAEL) for hypoxia (ICF 1997).
[7] ICF maintains the Vintaging Model for EPA in order 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 65 different end-uses. The model tracks the

number of events estimated to occur over a workday. The modeled exposure concentrations were compared to STEL at charging in Table 8.

## 8.1 Occupational Exposure at Manufacture of Proposed Substitute

The components of R-448A (i.e., HFC-32, HFC-125, HFC-134a, HFO-1234yf, and HFO-1234ze(E)) are blended in the United States. During manufacture of the components and blending of R-448A, the SDS for HFC-32, HFC-125, HFC-134a, HFO-1234yf, and HFO-1234ze(E) should be referenced and proper engineering controls and PPE used.

Release points during manufacture would be connection/disconnection of temporary lines from filling equipment. Refrigerant contained in temporary lines during blending would be recovered, and breaking of fittings should result in *de minimus* releases. To prevent significant exposure if such leaks occur, engineering controls should be used, including normal and local ventilation (e.g., chemical hoods) and vapor-in-air detection systems for standard manufacturing procedures so workers can avoid physical contact with the refrigerant and to achieve emission control. In general, use of PPE consistent with OSHA guidelines is recommended, such as respiratory protection (including SCBA in case of insufficient ventilation), tightly sealed goggles, and protective gloves (OSHA 1994).

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-448A is exposed to high temperatures or fire. Other reaction products such as carbon dioxide might also be present. Containers should be stored in cool, dry conditions in well-sealed receptacles and should not be allowed to contact open flames, glowing metal surfaces, or electrical heating elements. 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-448A, there is no significant risk to workers during the manufacture of R-448A.

## 8.2 Occupational Exposure at Equipment Charging, Servicing, and Disposal

All charging, servicing, and disposal activities for R-448A industrial refrigeration systems are anticipated to occur onsite. Although modeling is only performed for charging, it is assumed that exposure during servicing and disposal would not exceed exposure during charging because similar refrigerant charging and/or recovery equipment would be used. Furthermore, because it is likely that less refrigerant remains in the unit at disposal, it is assumed that charging of refrigeration units in industrial process refrigeration systems would require transfer of a greater amount of refrigerant, and thus result in greater worker exposure. Thus, occupational exposure was conservatively modeled based on charging.

According to the submitter, charge sizes in industrial process refrigeration systems can vary greatly by application, load, and refrigerant feed, ranging from a typical charge size of 500 kilograms to a maximum charge size of 12,000 kilograms (Honeywell 2014a). Charging of industrial process refrigeration systems is expected to occur with limited frequency (up to approximately one event per day) and with limited duration of exposure to the refrigerant charge. Release points during charging would be connection/disconnection of temporary lines from charging equipment. Refrigerant contained in temporary lines during charging would be recovered, and breaking of fittings should result in *de minimus* releases (Honeywell 2014a). Such activities and related exposure is anticipated to occur within 15-30 minutes (per event/day). To evaluate the risk of exposure at charging, the maximum modeled exposure concentration

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.

for each component of R-448A was compared to the 15-minute STEL values developed by EPA for each component based on the individual WEEL values.

The release per event was assumed to be 1 percent of the equipment charge during charging[8] and was multiplied by the number of installations estimated to occur over a workday (i.e., one installation was assumed for industrial process refrigeration systems). The analysis models the typical and maximum anticipated charge sizes for industrial process refrigeration, as provided by the submitter. To evaluate the risk of exposure during charging, the maximum 15-minute TWA exposure for R-448A was estimated for the installation scenario and compared to the STEL and RCL (see Table 5).

**Table 5. Occupational Risk Assessment at Charging[a]**

| Charge Size (kg) | 15-minute TWA Occupational Exposure (ppm) | 15-min Short Term Exposure Limits (ppm)[b] | RCL (ppm) |
|---|---|---|---|
| 500 | **1,400** | 2,670 | 110,000 |
| 12,000 | **33,530** | | |

**Bold font** indicates modeling results.
[a] Cells highlighted in green are the scenarios that are deemed to be acceptable given various modeling assumption options.
[b] See Table 3 for more information.

Based on the assumptions described above, the short-term (15-minute) worker exposure concentrations are not likely to exceed the STEL for R-448A for the typical charge size for industrial process refrigeration systems. The modeling indicates that worker exposure could exceed the STEL for R-448A for the installation scenario for the maximum charge size for industrial process refrigeration; however, the modeling assumptions do not reflect the use of any local exhaust ventilation or other engineering controls, which are likely to be used during installation, servicing, and disposal operations, thereby preventing significant exposure to R-448A. In addition, all of the estimated exposures are significantly lower than the RCL or ATEL for R-448A which are limits intended to reduce the risks of acute toxicity hazards in normally occupied, enclosed spaces according to ASHRAE Standard 34. Commonly used refrigerants in IPR would also yield similar results based on these conservative assumptions, therefore risks associated with the proposed substitute are not expected to be greater.

Additional precautions are appropriate for industrial process refrigeration applications. Industrial process refrigeration systems are complex systems used in various types of manufacturing industries and are installed in large manufacturing facilities. Such facilities are already equipped with proper engineering controls and industrial hygiene practices for safety purposes and therefore are expected to have the capabilities to mitigate exposures to any large releases of refrigerant from the refrigeration system. Facility personnel are also equipped with proper PPE and trained to work in such environments that contain numerous workplace hazards, and are expected to be only at marginally incremental risk for exposures to refrigerant releases in these settings.

Furthermore, these types of systems are typically charged, serviced, and disposed by trained and EPA Section 608-certified refrigerant technicians using proper industrial hygiene techniques. When charging, servicing, or disposing of such large refrigeration systems, 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-448A would occur. Adequate ventilation should always be established during any use, handling, or storage of R-448A. Engineering controls should include vapor-in air detection systems and local exhaust ventilation during use of R-448A to prevent dispersion throughout the workplace. In addition, an eye wash and safety shower should be near the manufacturing facility and locations where R-448A is stored and ready for use. In general, use of PPE is recommended, such as

[8] IPCC (2006) estimates that first-fill losses during installation of industrial refrigeration systems in food processing can range from 0.5% to 3%; DECC (2011) estimates that first-fill losses for industrial process refrigeration is approximately 1%; and, SKM Enviros (2011) suggests that this loss rate should be less than 4%. A proposed update to EPA's Vintaging Model recommends a first-fill emissions rate of 1% from industrial process refrigeration manufactured after 1990.

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.

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 the components of R-448A (i.e., HFC-32, HFC-125, HFC-134a, HFO-1234yf, or HFO-1234ze(E)) are exposed to high temperatures or fire. Other reaction products such as carbon dioxide might also be present. Containers should be stored in cool, dry conditions (maximum storage temperature should be 40°C) in well-sealed receptacles and should not be allowed to contact open flames, glowing metal surfaces, or electrical heating elements. EPA believes that when proper handling and disposal guidelines are followed in accordance with both good industrial hygiene practices, and the SDS for R-448A and its components, there is no significant risk to workers during the use of R-448A.

## 9. GENERAL POPULATION EXPOSURE ASSESSMENT

This section presents an assessment of potential risks to the general population posed by the use of R-448A in industrial process refrigeration systems. 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-448A 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 industrial process refrigeration systems. 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-448A is a gas and, therefore, releases to ground or surface water are not anticipated, as R-448A 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-448A). Should air releases during manufacturing operations occur, engineering controls should be used (e.g., carbon absorption scrubbers) to collect R-448A and prevent its release into 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-448A is not expected to pose a significant toxicity risk to the general population.

## 10. REFERENCES

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