# Safety data sheet
# according to Regulation (EC) No 1907/2006, Annex II

## SECTION 1: Identification of the substance/mixture and of the company/undertaking

### 1.1 Product identifier

**refrigerant R 1234yf**
**8887100019/8887100016**
2,3,3,3-Tetrafluoropropene
Registration number (ECHA): 01-0000019665-61-XXXX
Index: ---
EINECS, ELINCS, NLP: 468-710-7
CAS: 754-12-1

### 1.2 Relevant identified uses of the substance or mixture and uses advised against
**Relevant identified uses of the substance or mixture:**
Refrigerant
**Uses advised against:**
No information available at present.

### 1.3 Details of the supplier of the safety data sheet
Dometic WAECO International GmbH, Hollefeldstr. 63, 48282 Emsdetten, Germany
Phone:+49 (0) 2572 879 0, Fax:+49 (0) 2572 879 300
GB

Dometic UK Ltd Dometic House, The Brewery, DT11 9LS Blandford St Mary, Dorset, United Kingdom
Phone:+44 (0) 0844 626 0133, Fax:+44 (0) 0844 626 0143
www.waeco.de

Qualified person's e-mail address: info@chemical-check.de, k.schnurbusch@chemical-check.de Please DO NOT use for requesting Safety Data Sheets.

### 1.4 Emergency telephone number
**Emergency information services / official advisory body:**
IRL

National Poisons Information Centre, Beaumont Hospital, Dublin 9, Ireland, Tel.:
+353 (0)1 809 2166 (Public Poisons Info Line, 8am-10pm, 7 days a week)
+353 (0)1 809 2566 (Info for Healthcare Professionals ONLY, 24 h, 7 days a week)
**Telephone number of the company in case of emergencies:**
+49 (0) 700 / 24 112 112 (CCWA)

## SECTION 2: Hazards identification

### 2.1 Classification of the substance or mixture
**Classification according to Regulation (EC) 1272/2008 (CLP)**

| Hazard class | Hazard category | Hazard statement |
|---|---|---|
| Flam. Gas | 1 | H220-Extremely flammable gas. |
| Press. Gas | (Liq.) | H280-Contains gas under pressure, may explode if heated. |

### 2.2 Label elements
**Labeling according to Regulation (EC) 1272/2008 (CLP)**

2,3,3,3-Tetrafluoropropene
CAS: 754-12-1, Index:--- EC: 468-710-7

Danger

H220-Extremely flammable gas. H280-Contains gas under pressure, may explode if heated.

P210-Keep away from heat, hot surfaces, sparks, open flames and other ignition sources. No smoking. P281-Use personal protective equipment as required.
P377-Leaking gas fire: Do not extinguish, unless leak can be stopped safely. P381-In case of leakage, eliminate all ignition sources.
P410+P403-Protect from sunlight. Store in a well-ventilated place.

### 2.3 Other hazards
No vPvB substance
No PBT substance
Liquid projections or spray may cause frostbite.
Danger of bursting (explosion) when heated

## SECTION 3: Composition/information on ingredients

### 3.1 Substance

| **2,3,3,3-Tetrafluoropropene** | |
|---|---|
| **Registration number (REACH)** | 01-0000019665-61-XXXX |
| **Index** | --- |
| **EINECS, ELINCS, NLP** | 468-710-7 |
| **CAS** | 754-12-1 |
| **content %** | |
| **Classification according to Regulation (EC) 1272/2008 (CLP)** | Flam. Gas 1, H220<br>Press. Gas (Liq.), H280 |

### 3.2 Mixture
n.a.

For the text of the H-phrases and classification codes (GHS/CLP), see Section 16.
The substances named in this section are given with their actual, appropriate classification!
For substances that are listed in appendix VI, table 3.1 of the regulation (EC) no. 1272/2008 (CLP regulation) this means that all notes that may be given here for the named classification have been taken into account.

## SECTION 4: First aid measures

### 4.1 Description of first aid measures
First-aiders should ensure they are protected!
Never pour anything into the mouth of an unconscious person!

### Inhalation

Remove person from danger area.
Supply person with fresh air. Call doctor immediately.
If the person is unconscious, place in a stable side position and consult a doctor.
Respiratory arrest - Artificial respiration apparatus necessary.

### Skin contact
Wash thoroughly using copious water - remove contaminated clothing immediately. If skin irritation occurs (redness etc.), consult doctor.
Cover frostbite aseptically.

### Eye contact
Remove contact lenses.
Wash thoroughly for several minutes using copious water - call doctor immediately, have Data Sheet available.

### Ingestion
Typically no exposure pathway.

### 4.2 Most important symptoms and effects, both acute and delayed
If applicable delayed symptoms and effects can be found in section 11 and the absorption route in section 4.1.
In certain cases, the symptoms of poisoning may only appear after an extended period / after several hours.
drowsiness
Headaches
intoxication
At high concentrations:
Suffocating effect.
Victim does not notice suffocation.

### 4.3 Indication of any immediate medical attention and special treatment needed
Symptomatic treatment.
No administration of adrenaline-ephedrine preparations.

## SECTION 5: Firefighting measures

### 5.1 Extinguishing media
### Suitable extinguishing media
Water jet spray / alcohol resistant foam / CO2 / dry extinguisher

### Unsuitable extinguishing media
High volume water jet

### 5.2 Special hazards arising from the substance or mixture
In case of fire the following can develop:
Hydrofluoric acid
Oxides of carbon
Toxic gases
Danger of bursting (explosion) when heated

### 5.3 Advice for firefighters
In case of fire and/or explosion do not breathe fumes.
Protective respirator with independent air supply.
Full protection
Cool container at risk with water.
Dispose of contaminated extinction water according to official regulations.

## SECTION 6: Accidental release measures

### 6.1 Personal precautions, protective equipment and emergency procedures
Keep non-essential personnel away.
Remove possible causes of ignition - do not smoke.
Ensure sufficient supply of air.
Avoid inhalation, and contact with eyes or skin.

### 6.2 Environmental precautions
Prevent surface and ground-water infiltration, as well as ground penetration.
Prevent penetration into drains, cellars, working pits or other places in which accumulation could be hazardous.

If accidental entry into drainage system occurs, inform responsible authorities.

### 6.3 Methods and material for containment and cleaning up

If spray or gas escapes, ensure ample fresh air is available.
Allow to evaporate.

### 6.4 Reference to other sections

For personal protective equipment see Section 8 and for disposal instructions see Section 13.

## SECTION 7: Handling and storage

In addition to information given in this section, relevant information can also be found in section 8 and 6.1.

### 7.1 Precautions for safe handling

### 7.1.1 General recommendations

Ensure good ventilation.
Room ventilation also at ground level.
Avoid inhalation of the vapours.
Avoid contact with eyes or skin.
Keep away from sources of ignition - Do not smoke.
Take precautions against electrostatic charges.
Use explosion-proof equipment.
Do not use on hot surfaces.
Eating, drinking, smoking, as well as food-storage, is prohibited in work-room.
Observe directions on label and instructions for use.
Use working methods according to operating instructions.

### 7.1.2 Notes on general hygiene measures at the workplace

General hygiene measures for the handling of chemicals are applicable.
Wash hands before breaks and at end of work.
Keep away from food, drink and animal feedingstuffs.
Remove contaminated clothing and protective equipment before entering areas in which food is consumed.

### 7.2 Conditions for safe storage, including any incompatibilities

Keep out of access to unauthorised individuals.
Store product closed and only in original packing.
Not to be stored in gangways or stair wells.
Do not store with flammable or self-igniting materials.
Keep protected from direct sunlight and temperatures over 50°C.
Store cool.
Store in a well ventilated place.
Observe special regulations for gases.

### 7.3 Specific end use(s)

No information available at present.

## SECTION 8: Exposure controls/personal protection

### 8.1 Control parameters

---

### 8.2 Exposure controls

### 8.2.1 Appropriate engineering controls

Ensure good ventilation. This can be achieved by local suction or general air extraction.
If this is insufficient to maintain the concentration under the WEL or AGW values, suitable breathing protection should be worn.
Applies only if maximum permissible exposure values are listed here.

### 8.2.2 Individual protection measures, such as personal protective equipment

General hygiene measures for the handling of chemicals are applicable.
Wash hands before breaks and at end of work.
Keep away from food, drink and animal feedingstuffs.

Remove contaminated clothing and protective equipment before entering areas in which food is consumed.

Eye/face protection:
Tight fitting protective goggles with side protection (EN 166).

Skin protection - Hand protection:
Leather gloves
If applicable
Insulating gloves EN 511 (cold)
The breakthrough times determined in accordance with EN 374 Part 3 were not obtained under practical conditions.
The recommended maximum wearing time is 50% of breakthrough time.

Skin protection - Other:
Protective working garments (e.g. safety shoes EN ISO 20345, long-sleeved protective working garments).

Respiratory protection:
If air supply is not sufficient, wear protective breathing apparatus.
Protective respirator with independent air supply.
Observe wearing time limitations for respiratory protection equipment.

Thermal hazards:
If applicable, these are included in the individual protective measures (eye/face protection, skin protection, respiratory protection).

Additional information on hand protection - No tests have been performed.
In the case of mixtures, the selection has been made according to the knowledge available and the information about the contents.
Selection of materials derived from glove manufacturer's indications.
Final selection of glove material must be made taking the breakthrough times, permeation rates and degradation into account.
Selection of a suitable glove depends not only on the material but also on other quality characteristics and varies from manufacturer to manufacturer.
In the case of mixtures, the resistance of glove materials cannot be predicted and must therefore be tested before use.
The exact breakthrough time of the glove material can be requested from the protective glove manufacturer and must be observed.

### 8.2.3 Environmental exposure controls
No information available at present.

## SECTION 9: Physical and chemical properties

### 9.1 Information on basic physical and chemical properties

| | |
|---|---|
| Physical state: | Liquefied gas |
| Colour: | Colourless |
| Odour: | Slightly |
| Odour threshold: | Not determined |
| pH-value: | n.a. |
| Melting point/freezing point: | Not determined |
| Initial boiling point and boiling range: | -29,4 °C |
| Flash point: | n.a. |
| Evaporation rate: | Not determined |
| Flammability (solid, gas): | Extremely flammable |
| Lower explosive limit: | 6,2 Vol-% |
| Upper explosive limit: | 12,3 Vol-% |
| Vapour pressure: | 6067 hPa (21°C) |
| Vapour pressure: | 14203 hPa (54°C) |
| Vapour density (air = 1): | 4 |
| Density: | 1,1 g/cm3 (25°C) |
| Bulk density: | Not determined |
| Solubility(ies): | Not determined |
| Water solubility: | 198,2 mg/l (24°C, Regulation (EC) 440/2008 A.6. (WATER SOLUBILITY)) |
| Partition coefficient (n-octanol/water): | 2,15 (Regulation (EC) 440/2008 A.8. (PARTITION COEFFICIENT)) |

| | |
|---|---|
| Auto-ignition temperature: | 405 °C |
| Decomposition temperature: | Not determined |
| Viscosity: | Not determined |
| Explosive properties: | Product is not explosive. When using: development of explosive vapour/air mixture possible. |
| Oxidising properties: | Not determined |

### 9.2 Other information

| | |
|---|---|
| Miscibility: | Not determined |
| Fat solubility / solvent: | Not determined |
| Conductivity: | Not determined |
| Surface tension: | Not determined |
| Solvents content: | Not determined |
| Molar mass: | 114 g/mol |

## SECTION 10: Stability and reactivity

### 10.1 Reactivity
The product has not been tested.

### 10.2 Chemical stability
Stable with proper storage and handling.

### 10.3 Possibility of hazardous reactions
No dangerous reactions are known.

### 10.4 Conditions to avoid
See also section 7.
Heating, open flame, ignition sources

### 10.5 Incompatible materials
See also section 7.
Alkali metals
Magnesium
Zinc
Light metals

### 10.6 Hazardous decomposition products
See also section 5.2
No decomposition when used as directed.

## SECTION 11: Toxicological information

### 11.1 Information on toxicological effects
Possibly more information on health effects, see Section 2.1 (classification).

| 2,3,3,3-Tetrafluoropropene | | | | | | |
|---|---|---|---|---|---|---|
| **Toxicity / effect** | **Endpoint** | **Value** | **Unit** | **Organism** | **Test method** | **Notes** |
| Acute toxicity, by oral route: | | | | | | n.d.a. |
| Acute toxicity, by dermal route: | | | | | | n.d.a. |
| Acute toxicity, by inhalation: | | | | | | n.d.a. |
| Skin corrosion/irritation: | | | | | | n.d.a. |
| Serious eye damage/irritation: | | | | | | n.d.a. |
| Respiratory or skin sensitisation: | | | | | | n.d.a. |
| Germ cell mutagenicity: | | | | | | n.d.a. |
| Carcinogenicity: | | | | | | n.d.a. |
| Reproductive toxicity: | | | | | | n.d.a. |
| Specific target organ toxicity - single exposure (STOT-SE): | | | | | | n.d.a. |

| | | | | | | |
|---|---|---|---|---|---|---|
| Specific target organ toxicity - repeated exposure (STOT-RE): | | | | | | n.d.a. |
| Aspiration hazard: | | | | | | n.d.a. |
| Symptoms: | | | | | | n.d.a. |

## SECTION 12: Ecological information

Possibly more information on environmental effects, see Section 2.1 (classification).

**2,3,3,3-Tetrafluoropropene**

| Toxicity / effect | Endpoint | Time | Value | Unit | Organism | Test method | Notes |
|---|---|---|---|---|---|---|---|
| 12.1. Toxicity to fish: | | | | | | | n.d.a. |
| 12.1. Toxicity to daphnia: | | | | | | | n.d.a. |
| 12.1. Toxicity to algae: | | | | | | | n.d.a. |
| 12.2. Persistence and degradability: | | | | | | | n.d.a. |
| 12.3. Bioaccumulative potential: | | | | | | | n.d.a. |
| 12.4. Mobility in soil: | | | | | | | n.d.a. |
| 12.5. Results of PBT and vPvB assessment | | | | | | | n.d.a. |
| 12.6. Other adverse effects: | | | | | | | n.d.a. |

## SECTION 13: Disposal considerations

### 13.1 Waste treatment methods

### For the substance / mixture / residual amounts

EC disposal code no.:
The waste codes are recommendations based on the scheduled use of this product.
Owing to the user's specific conditions for use and disposal, other waste codes may be allocated under certain circumstances. (2014/955/EU)
14 06 01 chlorofluorocarbons, HCFC, HFC
Recommendation:
Sewage disposal shall be discouraged.
Pay attention to local and national official regulations.
E.g. suitable incineration plant.

### For contaminated packing material

Pay attention to local and national official regulations.
Recommendation:
Return to manufacturer with residual pressure.
15 01 04 metallic packaging

## SECTION 14: Transport information

### General statements

14.1. UN number: 3161

### Transport by road/by rail (ADR/RID)

14.2. UN proper shipping name:
UN 3161 LIQUEFIED GAS, FLAMMABLE, N.O.S. (R-1234YF)
14.3. Transport hazard class(es): 2.1
14.4. Packing group: -
Classification code: 2F
LQ: 0
14.5. Environmental hazards: Not applicable

Tunnel restriction code: B/D

## Transport by sea (IMDG-code)

14.2. UN proper shipping name:
LIQUEFIED GAS, FLAMMABLE, N.O.S. (R-1234YF)

14.3. Transport hazard class(es): 2.1
14.4. Packing group: -
EmS: F-D, S-U
Marine Pollutant: n.a
14.5. Environmental hazards: Not applicable

## Transport by air (IATA)

14.2. UN proper shipping name:
Liquefied gas, flammable, n.o.s. (R-1234YF)

14.3. Transport hazard class(es): 2.1
14.4. Packing group: -
14.5. Environmental hazards: Not applicable

## 14.6. Special precautions for user

Persons employed in transporting dangerous goods must be trained.
All persons involved in transporting must observe safety regulations.
Precautions must be taken to prevent damage.

## 14.7. Transport in bulk according to Annex II of MARPOL and the IBC Code

Freighted as packaged goods rather than in bulk, therefore not applicable.
Minimum amount regulations have not been taken into account.
Danger code and packing code on request.
Comply with special provisions.

# SECTION 15: Regulatory information

## 15.1 Safety, health and environmental regulations/legislation specific for the substance or mixture

Observe restrictions:
Comply with trade association/occupational health regulations.

Directive 2012/18/EU ("Seveso III"), Annex I, Part 1 - The following categories apply to this product (others may also need to be considered according to storage, handling etc.):

| Hazard categories | Notes to Annex I | Qualifying quantity (tonnes) of dangerous substances as referred to in Article 3(10) for the application of - Lower-tier requirements | Qualifying quantity (tonnes) of dangerous substances as referred to in Article 3(10) for the application of - Upper-tier requirements |
|---|---|---|---|
| P2 | | 10 | 50 |

The Notes to Annex 1 of Directive 2012/18/EU, in particular those named in the tables here and notes 1-6, must be taken into account when assigning categories and qualifying quantities.

Directive 2010/75/EU (VOC): 100 %

## 15.2 Chemical safety assessment

A chemical safety assessment was carried out.

# SECTION 16: Other information

Revised sections: 2,16
Employee training in handling dangerous goods is required.
These details refer to the product as it is delivered.
Employee instruction/training in handling hazardous materials is required.
The following phrases represent the posted Hazard Class and Risk Category Code (GHS/CLP) of the product and the constituents (specified in Section 2 and 3).
H280 Contains gas under pressure, may explode if heated.

H220 Extremely flammable gas.

Flam. Gas — Flammable gases (including chemically unstable gases)
Press. Gas (Liq.) — Gases under pressure-Liquefied gas

## Any abbreviations and acronyms used in this document:

AC Article Categories
acc., acc. to according, according to
ACGIH American Conference of Governmental Industrial Hygienists
ADR Accord européen relatif au transport international des marchandises Dangereuses par Route (= European Agreement concerning the International Carriage of Dangerous Goods by Road)
AOEL Acceptable Operator Exposure Level
AOX Adsorbable organic halogen compounds
approx. approximately
Art., Art. no. Article number
ATE Acute Toxicity Estimate according to Regulation (EC) 1272/2008 (CLP)
BAM Bundesanstalt für Materialforschung und -prüfung (Federal Institute for Materials Research and Testing, Germany)
BAuA Bundesanstalt für Arbeitsschutz und Arbeitsmedizin (= Federal Institute for Occupational Health and Safety, Germany)
BCF Bioconcentration factor
BGV Berufsgenossenschaftliche Vorschrift (= Accident Prevention Regulation)
BHT Butylhydroxytoluol (= 2,6-Di-t-butyl-4-methyl-phenol)
BMGV Biological monitoring guidance value (EH40, UK)
BOD Biochemical oxygen demand
BSEF Bromine Science and Environmental Forum
bw body weight
CAS Chemical Abstracts Service
CEC Coordinating European Council for the Development of Performance Tests for Fuels, Lubricants and Other Fluids
CESIO Comité Européen des Agents de Surface et de leurs Intermédiaires Organiques
CIPAC Collaborative International Pesticides Analytical Council
CLP Classification, Labelling and Packaging (REGULATION (EC) No 1272/2008 on classification, labelling and packaging of substances and mixtures)
CMR carcinogenic, mutagenic, reproductive toxic
COD Chemical oxygen demand
CTFA Cosmetic, Toiletry, and Fragrance Association
DMEL Derived Minimum Effect Level
DNEL Derived No Effect Level
DOC Dissolved organic carbon
DT50 Dwell Time - 50% reduction of start concentration
DVS Deutscher Verband für Schweißen und verwandte Verfahren e.V. (= German Association for Welding and Allied Processes)
dw dry weight
e.g. for example (abbreviation of Latin 'exempli gratia'), for instance
EC European Community
ECHA European Chemicals Agency
EEA European Economic Area
EEC European Economic Community
EINECS European Inventory of Existing Commercial Chemical Substances
ELINCS European List of Notified Chemical Substances
EN European Norms
EPA United States Environmental Protection Agency (United States of America)
ERC Environmental Release Categories
ES Exposure scenario
etc. et cetera
EU European Union
EWC European Waste Catalogue
Fax. Fax number
gen. general
GHS Globally Harmonized System of Classification and Labelling of Chemicals
GWP Global warming potential

HET-CAM Hen's Egg Test - Chorionallantoic Membrane
HGWP Halocarbon Global Warming Potential
IARC International Agency for Research on Cancer
IATA International Air Transport Association
IBC Intermediate Bulk Container
IBC (Code) International Bulk Chemical (Code)
IC Inhibitory concentration
IMDG-code International Maritime Code for Dangerous Goods
incl. including, inclusive
IUCLID International Uniform ChemicaL Information Database
LC lethal concentration
LC50 lethal concentration 50 percent kill
LCLo lowest published lethal concentration
LD Lethal Dose of a chemical
LD50 Lethal Dose, 50% kill
LDLo Lethal Dose Low
LOAEL Lowest Observed Adverse Effect Level
LOEC Lowest Observed Effect Concentration
LOEL Lowest Observed Effect Level
LQ Limited Quantities
MARPOL International Convention for the Prevention of Marine Pollution from Ships
n.a. not applicable
n.av. not available
n.c. not checked
n.d.a. no data available
NIOSH National Institute of Occupational Safety and Health (United States of America)
NOAEC No Observed Adverse Effective Concentration
NOAEL No Observed Adverse Effect Level
NOEC No Observed Effect Concentration
NOEL No Observed Effect Level
ODP Ozone Depletion Potential
OECD Organisation for Economic Co-operation and Development
org. organic
PAH polycyclic aromatic hydrocarbon
PBT persistent, bioaccumulative and toxic
PC Chemical product category
PE Polyethylene
PNEC Predicted No Effect Concentration
POCP Photochemical ozone creation potential
ppm parts per million
PROC Process category
PTFE Polytetrafluorethylene
REACH Registration, Evaluation, Authorisation and Restriction of Chemicals (REGULATION (EC) No 1907/2006 concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals)
REACH-IT List-No. 9xx-xxx-x No. is automatically assigned, e.g. to pre-registrations without a CAS No. or other numerical identifier. List Numbers do not have any legal significance, rather they are purely technical identifiers for processing a submission via REACH-IT.
RID Règlement concernant le transport International ferroviaire de marchandises Dangereuses (= Regulation concerning the International Carriage of Dangerous Goods by Rail)
SADT Self-Accelerating Decomposition Temperature
SAR Structure Activity Relationship
SU Sector of use
SVHC Substances of Very High Concern
Tel. Telephone
ThOD Theoretical oxygen demand
TOC Total organic carbon
TRGS Technische Regeln für Gefahrstoffe (=Technical Regulations for Hazardous Substances)
UN RTDG United Nations Recommendations on the Transport of Dangerous Goods
VbF Verordnung über brennbare Flüssigkeiten (= Regulation for flammable liquids (Austria))
VOC Volatile organic compounds
vPvB very persistent and very bioaccumulative

WEL-TWA, WEL-STEL WEL-TWA = Workplace Exposure Limit - Long-term exposure limit (8-hour TWA (= time weighted average) reference period), WEL-STEL = Workplace Exposure Limit - Short-term exposure limit (15-minute reference period) (EH40, UK).
WHO World Health Organization
wwt wet weight

The statements made here should describe the product with regard to the necessary safety precautions - they are not meant to guarantee definite characteristics - but they are based on our present up-to-date knowledge.
No responsibility.
These statements were made by:
**Chemical Check GmbH, Chemical Check Platz 1-7, D-32839 Steinheim, Tel.: +49 5233 94 17 0, Fax: +49 5233 94 17 90**

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**Annex of Safety data sheet**

| **Identified use:**<br>**ES and title** | **Sector of Use (SU)** | **Product Category (PC)**<br><br>**Article Category (AC)** | **Process category (PROC)** | **Environmental Release Category (ERC)** |
|---|---|---|---|---|
| ES 1 : Industrial Use, Heat Transfer Fluids – Refrigerants, Coolants | SU 3, 10, 17 | PC 16<br>AC 1, 2 | PROC 8b, 9 | ERC 7 |
| ES 2 : Professional Use, Heat Transfer Fluids – Refrigerants, Coolants | SU 22 | PC 16<br>AC 1, 2 | PROC 8a | ERC 9b |
| ES 3 : Formulation of preparations | SU 3, 10, 17 | PC 16<br>AC 1, 2 | PROC 3 | ERC 2 |
| ES 4 : Use, service life, and waste stage environmental exposure | SU 3, 10, 17, 21, 22 | Only environmental releases evaluated | Only environmental releases evaluated | ERC 2, 7, 9a, and 9b |

## Overview of Uses and Exposure Scenarios

HFO-1234yf is used as a heat transfer fluid in mobile air conditioning (MAC) equipment and in stationary air conditioning and refrigeration equipment. It is imported into the European Union (EU) and used by workers at Original Equipment Manufacturers (OEMs) to charge MAC and stationary equipment. Workers also use HFO-1234yf when servicing charged equipment during its service life or when dismantling charged equipment at the end of its service life. In addition, workers use the substance during blending and repackaging activities. Worker exposure may potentially occur during the activities associated with these uses, but exclusively when disconnecting and/or connecting the tight seal shut-off valve coupler hoses during transfer operations. Therefore, the exposure potential is limited in time and minimalized in amount due to the coupler system employed. Environmental exposure is also a possibility when conducting these transfer operations. Minimal releases to the ambient air may potentially occur during activities such as blending and repackaging of the substance, charging and servicing of equipment, dismantling of equipment, and if leakages occur from the charged equipment during its service life. Releases to other environmental compartments beside the ambient air are not possible because HFO-1234yf is a liquefied gas.
Potential consumer exposure is limited to those extremely rare occasions when all of the following conditions are met: the MAC is leaking, HFO-1234yf vents directly into the passenger compartment of the automobile, the passenger compartment remains totally closed, and passengers are present in the car.

| **1.1 Exposure Scenario ES1** |
|---|
| Industrial Use, Heat Transfer Fluids – Refrigerants, Coolants |
| Industrial uses : Uses of substances as such or in preparations at industrial sites (SU3) ; Formulation [mixing] or preparations and/or re-packaging (excluding alloys) (SU10) : General manufacturing, e.g., machinery, equipment, vehicles, other transport equipment (SU17) excluding buses |
| Contributing environmental scenario CS1: Industrial use of substances in closed systems (ERC7). Quantified in ES4 |
| Contributing worker scenario CS2: Transfer of substance or preparation into small containers (dedicated filling line, including weighing) (PROC9)<br>Contributing worker scenario CS3: Transfer of substance or preparation (charging/discharging) from/to vessels/large containers at dedicated facilities (PROC8b) |
| Exposure Scenario 1 (ES 1) describes the activities and processes covered when workers charge various types of packaging, A/C and refrigeration equipment in an industrial setting. It includes:<br>• Refrigerant packaging workers,<br>• Automobile original equipment manufacturer (OEM) assembly workers, and<br>• Stationary equipment OEM assembly workers. |
| 1.2.1 Contributing scenario CS1 controlling environmental exposure for ERC 7 |
| Industrial use of substances in closed systems |
| Assessed and quantified in ES4 |
| Product characteristics |
| Low global warming potential (GWP) liquefied gas with a concentration of 100%; Not biodegradable |
| Amounts used |
| 9000 tonnes per annum (tpa) – EU |
| Frequency and duration of use |
| Continuous use/8-hour shift, 200 operating days/year; Intermittent release |
| Environmental factors not influenced by risk management |
| None |
| Other given operational conditions affecting environmental exposure |
| Under normal conditions of use, exposure would primarily occur when workers disconnect the couplings. Conservatively assumed that approximately 1% (5 grams/mobile A/C) released to air (Henne et al., 2012; Reimann & Shallcross et al., 2011) (release fraction of 0.01). |
| Technical conditions and measures at process level (source) to prevent release |
| Process designed to minimize releases to wastewater; Process designed to minimize releases to soil; Ensure that the valves of the cylinders are tightly closed and not leaking; Handle substance within a closed system; Transfer via enclosed lines; Clear transfer lines prior to de-coupling. |
| Technical onsite conditions and measures to reduce or limit discharges, air emissions and releases to soil |
| None |
| Organizational measures to prevent/limit release from site |

| |
|---|
| Use of ATEX 137 and ATEX 95 Directives to mitigate flammability properties of HFO-1234yf and/or Chemical Substances at Work (Directive 98/24/EC); Regular inspection and maintenance of equipment and machines. |
| Conditions and measures related to municipal sewage treatment plant |
| No STP |
| Conditions and measures related to external treatment of waste for disposal |
| Not applicable |
| Conditions and measures related to external recovery of waste |
| Not applicable |
| 1.2.2 Contributing scenario CS2 controlling worker exposure for PROC 9 |
| Transfer of substance or preparation into small containers (dedicated filling line, including weighing) |
| Product characteristic |
| Liquefied gas; Covers percentage substance in the product up to 100 % (unless stated differently); Assumes activities are at room temperature. |
| Amounts used |
| 120 kg/8-hour shift – worker; ~50 000 kg/y for plant site producing 100 000 vehicles per year |
| Frequency and duration of use/exposure |
| Duration of use/exposure: Intermittent; 20 min/8-hour shift (Under normal operation exposure occurs only at ending of filling process (disconnection), estimated at 0.083 min (5 sec) per disconnecting process x1 processes/fill x 30 fills/hr x 8 hr/shift)<br>Frequency: 200 days/year |
| Human factors not influenced by risk management |
| Light work, respiration volume = 10 $m^3$/8-hour shift |
| Other given operational conditions affecting workers exposure |
| Indoor use; Under normal conditions of use, exposure would primarily occur when workers disconnect the couplings. |
| Technical conditions and measures at process level (source) to prevent release |
| Ensure that the valves of the cylinders are tightly closed and not leaking; Handle substance within a closed system; Transfer via enclosed lines; Clear transfer lines prior to de-coupling. |
| Technical conditions and measures to control dispersion from source towards the worker |
| Mechanical ventilation giving at least [ACH]: 3; Room volume: >50 $m^3$.; Local exhaust ventilation (Effectiveness: < 10 ppm) |
| Organizational measures to prevent/limit releases, dispersion and exposure |
| Use of ATEX 137 and ATEX 95 Directives to mitigate flammability properties of HFO-1234yf and/or Chemical Substances at Work (Directive 98/24/EC); Use of ISO 13043 (April 15, 2011) (Road vehicles – Refrigerant systems used in mobile air conditioning systems (MAC) – Safety requirements) and SAE J639 (Safety Standards for Motor Vehicle Refrigerant Vapor Compression Systems), SAE J2843 (R-1234yf [HFO-1234yf] Recovery/Recycling/Recharging Equipment for Flammable Refrigerants for Mobile Air-Conditioning Systems) and SAE J2845 (Technician Certification for Service and Containment of Refrigerants Used in Mobile A/C Systems); Regular inspection and maintenance of equipment and machines.; Ensure operatives are trained to minimise |

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| exposures. |
| Conditions and measures related to personal protection, hygiene and health evaluation |
| Use eye protection to EN 166 or ANSI Z87.1, designed to protect against liquid splashes. Wear suitable gloves tested to EN374 or complying with U.S. OSHA guidelines. |
| 1.2.3 Contributing scenario CS3 controlling worker exposure for PROC 8b. |
| Transfer of substance or preparation (charging/discharging) from/to vessels/large containers at dedicated facilities |
| Product characteristic |
| Liquefied gas; Covers percentage substance in the product up to 100 % (unless stated differently); Assumes activities are at room temperature. |
| Amounts used |
| Not applicable |
| Frequency and duration of use/exposure |
| Duration of use/exposure: Intermittent; Conservatively assumed less than 15 minutes/day<br>Frequency: 200 days/year |
| Human factors not influenced by risk management |
| Light work, respiration volume = 10 $m^3$/8-hour shift |
| Other given operational conditions affecting workers exposure |
| Outdoor use; Under normal conditions of use, exposure would primarily occur when workers connect and disconnect the couplings. |
| Technical conditions and measures at process level (source) to prevent release |
| Ensure that the valves of the cylinders are tightly closed and not leaking; Handle substance within a closed system; Transfer via enclosed lines; Clear transfer lines prior to de-coupling. |
| Technical conditions and measures to control dispersion from source towards the worker |
| None |
| Organizational measures to prevent/limit releases, dispersion and exposure |
| Use of ATEX 137 and ATEX 95 Directives to mitigate flammability properties of HFO-1234yf and/or Chemical Substances at Work (Directive 98/24/EC); Use of ISO 13043 (April 15, 2011) (Road vehicles – Refrigerant systems used in mobile air conditioning systems (MAC) – Safety requirements) and SAE J639 (Safety Standards for Motor Vehicle Refrigerant Vapor Compression Systems), SAE J2843 (R-1234yf [HFO-1234yf] Recovery/Recycling/Recharging Equipment for Flammable Refrigerants for Mobile Air-Conditioning Systems) and SAE J2845 (Technician Certification for Service and Containment of Refrigerants Used in Mobile A/C Systems); Regular inspection and maintenance of equipment and machines.; Ensure operatives are trained to minimise exposures. |
| Conditions and measures related to personal protection, hygiene and health evaluation |
| Use eye protection to EN 166 or ANSI Z87.1, designed to protect against liquid splashes. Wear suitable gloves tested to EN374 or complying with U.S. OSHA guidelines. |
| 1.3. Exposure estimation and reference to its source |
| ASSESSMENT METHOD: CS1: ECETOC TRA v.3. ; CS2 and CS3: Available measured data for HFC-134a were used to evaluate the worker exposure to HFO-1234yf. For comparison purposes only, ECETOC TRA v.3 was also used to estimate inhalation exposure for workers. |

Information for CS1: Local releases to the environment

| Release | Release factor estimation method | Explanation / Justification |
|---|---|---|
| **Water** | Process and substance knowledge | **Initial release factor:** ERC7 assumes 5%<br>**Final release factor:** 0%<br>**Local release rate:** 0 kg/day<br>**Explanation / Justification:** Substance is a liquefied gas. |
| **Air** | Henne et al., 2012; Reimann & Shallcross et al., 2011 | **Initial release factor:** ERC7 assumes 5%<br>**Final release factor:** ~1%<br>**Local release rate:** ~350 kg/day across entire 27 EU countries plus Croatia, Norway, Switzerland, and Turkey (EU-27+) after 90% of fleet is converted and at a steady state.<br>**Explanation / Justification:** 5 grams/charging event, which is approximately 1% of the total charge volume (500+ or – grams); Henne et al, 2012; Reimann & Shallcross et al., 2011. |
| **Soil** | Process and substance knowledge | **Initial release factor:** ERC7 assumes 5%<br>**Final release factor:** 0%<br>**Local release rate:** 0 kg/day<br>**Explanation / Justification:** Substance is a liquefied gas. |

The exposure concentrations and RCRs for both HFO-1234yf and its potential degradation product TFA are reported in ES4.

Information for CS2: Exposure concentrations and risks for worker

| Route of exposure and type of effects | Exposure concentration | Source for exposure concentration | Exposure concentration and DNEL (or DMEL) units | DNEL (or DMEL) | Risk characterisation |
|---|---|---|---|---|---|
| Inhalation, systemic, long-term | 37 | Bureau Veritas North America, 2008; data generated on HFC-134a | mg/m$^3$ | 950 | 0.039 |
| | 190 | TRA v.3 tool used to estimate exposure concentration for comparison purposes only | | | 0.2 |
| Inhalation, systemic, acute | Not needed | Not needed | | | Not needed |
| Inhalation, local, long-term | Not needed | Not needed | | | Not needed |
| Inhalation, local, acute | Not needed | Not needed | | | Not needed |

| | | | | | |
|---|---|---|---|---|---|
| Dermal, systemic, long-term | Not needed | Not needed | | | Not needed |
| Dermal, systemic, acute | Not needed | Not needed | | | Not needed |
| Dermal, local, long-term | Not needed | Not needed | | | Not needed |
| Dermal, local, acute | Not needed | Not needed | | | Not needed |
| Combined routes, systemic, long-term | | | | | 0.039 |
| Combined routes, systemic, acute | | | | | Not needed |

The RCR for inhalation exposure was <1. This indicates that adverse impact to workers is not expected.

Information for CS3: Exposure concentrations and risks for worker

| Route of exposure and type of effects | Exposure concentration | Source for exposure concentration | Exposure concentration and DNEL (or DMEL) units | DNEL (or DMEL) | Risk characterisation |
|---|---|---|---|---|---|
| Inhalation, systemic, long-term | 37 | Bureau Veritas North America, 2008; data generated on HFC-134a | $mg/m^3$ | 950 | 0.039 |
| | 50 | TRA v.3 tool used to estimate exposure concentration for comparison purposes only | | | 0.05 |
| Inhalation, systemic, acute | Not needed | Not needed | | | Not needed |
| Inhalation, local, long-term | Not needed | Not needed | | | Not needed |
| Inhalation, local, acute | Not needed | Not needed | | | Not needed |
| Dermal, systemic, long-term | Not needed | Not needed | | | Not needed |
| Dermal, systemic, acute | Not needed | Not needed | | | Not needed |
| Dermal, local, long-term | Not needed | Not needed | | | Not needed |
| Dermal, local, acute | Not needed | Not needed | | | Not needed |

| | | | | | |
|---|---|---|---|---|---|
| Combined routes, systemic, long-term | | | | | 0.039 |
| Combined routes, systemic, acute | | | | | Not needed |

The RCR for inhalation exposure was <1. This indicates that adverse impact to workers is not expected.

**2.1. Exposure Scenario ES2**

Professional Use, Heat Transfer Fluids – Refrigerants, Coolants

Professional uses: Public domain (administration, education, entertainment, services, craftsmen) (SU22)

Contributing environmental scenario CS1: Wide dispersive outdoor use of substances in closed systems (ERC9b). Quantified in ES4.

Contributing worker scenario CS2: Transfer of substance or preparation (charging/discharging) from/to vessels/large containers at non-dedicated facilities (PROC8a)

Exposure Scenario 2 (ES 2) describes the activities and processes covered when professional workers service mobile or stationary A/C or refrigeration equipment. Although each of these workers may use different charge quantities of HFO-1234yf at different frequencies and in different professional settings, they all use equipment during the servicing procedure that is similar to the equipment used during industrial refrigerant charging or packaging. Therefore, professional workers have a similar potential for exposure as do industrial workers, except professional users process fewer units during the work shift and they are more likely to perform the work outdoors. If working indoors, however, their work space would likely be smaller than for industrial users. Therefore, a separate exposure scenario was deemed warranted. In general, the potential release to the environment is also the same between the various servicing workers (mobile and stationary) and industrial workers, de minimus release to only air as described in detail in ES1.

2.2.1 Contributing scenario CS1 controlling environmental exposure for ERC9b

Wide dispersive outdoor use of substances in closed systems

Assessed and quantified in ES4

Product characteristics

Low global warming potential (GWP) liquefied gas with a concentration of 100%; Not biodegradable

Amounts used

4000 tonnes per annum (tpa) – EU

Frequency and duration of use

Continuous use/release, 365 operating days/year; Intermittent release

Environmental factors not influenced by risk management

None

Other given operational conditions affecting environmental exposure

Under normal conditions of use, exposure would primarily occur when workers connect and disconnect the couplings. Conservatively assumed that approximately 6.4% of charge would be released if servicing completed by a skilled worker and that approximately 64% of charge would be

| |
|---|
| released if servicing completed by an unskilled worker (Henne et al, 2012) despite the fact that servicing is only allowed at professional service centers and completed by skilled workers. |
| Technical conditions and measures at process level (source) to prevent release |
| Process designed to minimize releases to wastewater; Process designed to minimize releases to soil; Ensure that the valves of the cylinders are tightly closed and not leaking; Handle substance within a closed system; Transfer via enclosed lines; Clear transfer lines prior to de-coupling. |
| Technical onsite conditions and measures to reduce or limit discharges, air emissions and releases to soil |
| None |
| Organizational measures to prevent/limit release from site |
| None |
| Conditions and measures related to municipal sewage treatment plant |
| No STP |
| Conditions and measures related to external treatment of waste for disposal |
| Not applicable |
| Conditions and measures related to external recovery of waste |
| Not applicable |
| 2.2.2 Contributing scenario CS2 controlling worker exposure for PROC 8a |
| Transfer of substance or preparation (charging/discharging) from/to vessels/large containers at non-dedicated facilities |
| Product characteristic |
| Liquefied gas; Covers percentage substance in the product up to 100 % (unless stated differently); Assumes activities are at room temperature. |
| Amounts used |
| Mobile A/C: 0.5 kg/service event; Stationary Equipment: 0.05 – 300 kg/service event |
| Frequency and duration of use/exposure |
| Duration of use/exposure: Intermittent;<br>Mobile A/C: ~1 minute/ 8-hour shift (0.083 minutes (5 seconds) per connecting process x 2 connecting processes per vacuuming/re-charging procedure x 1 servicing event per hour x 8 hours per shift)<br>Stationary Equipment: ~< 1 minute/8-hour shift (0.083 minutes (5 seconds) per connecting process x2 connecting processes per vacuuming/ re-charging procedure x up to 4 servicing events per 8-hour shift)<br>Frequency: 200 days/year |
| Human factors not influenced by risk management |
| Light work, respiration volume = 10 $m^3$/8-hour shift |
| Other given operational conditions affecting workers exposure |
| Indoor use; Under normal conditions of use, exposure would primarily occur when workers connect and disconnect the couplings. |
| Technical conditions and measures at process level (source) to prevent release |
| Ensure that the valves of the cylinders are tightly closed and not leaking; Handle substance within a |

closed system; Transfer via enclosed lines; Clear transfer lines prior to de-coupling.

Technical conditions and measures to control dispersion from source towards the worker

None

Organizational measures to prevent/limit releases, dispersion and exposure

Use of ATEX 137 and ATEX 95 Directives to mitigate flammability properties of HFO-1234yf and/or Chemical Substances at Work (Directive 98/24/EC); Use of ISO 13043 (April 15, 2011) (Road vehicles – Refrigerant systems used in mobile air conditioning systems (MAC) – Safety requirements) and SAE J639 (Safety Standards for Motor Vehicle Refrigerant Vapor Compression Systems), SAE J2843 (R-1234yf [HFO-1234yf] Recovery/Recycling/Recharging Equipment for Flammable Refrigerants for Mobile Air-Conditioning Systems)and SAE J2845 (Technician Certification for Service and Containment of Refrigerants Used in Mobile A/C Systems); EN 378 (Refrigerating systems and heat pumps – Safety and environmental requirements); Regular inspection and maintenance of equipment and machines.; Ensure operatives are trained to minimise exposures.

Conditions and measures related to personal protection, hygiene and health evaluation

Use eye protection to EN 166 or ANSI Z87.1, designed to protect against liquid splashes. Wear suitable gloves tested to EN374 or complying with U.S. OSHA guidelines.

2.3. Exposure estimation and reference to its source

**ASSESSMENT METHOD**: **CS1:** TRA v.3. **CS2:** Available measured data on HFC-134a were used to evaluate the professional worker exposure to HFO-1234yf. For comparison purposes only, TRA v.3 was also used to estimate inhalation exposure for workers.

Information for CS1: Local releases to the environment

| Release | Release factor estimation method | Explanation / Justification |
|---|---|---|
| **Water** | Activity and substance knowledge | **Initial release factor:** ERC9b assumes 5%<br>**Final release factor:** 0%<br>**Local release rate:** 0 kg/day<br>**Explanation / Justification:** Substance is a liquefied gas. |
| **Air** | Henne et al., 2012 | **Initial release factor:** ERC9b assumes 5%<br>**Final release factor:** ~6.4% of initial charge if servicing by skilled workers; ~64% of initial charge if servicing by unskilled workers<br>**Local release rate:** 4 580 kg/day across entire EU-27+.<br>**Explanation / Justification:** Release estimates made by Henne et al., 2012 under the assumption that 90% of entire EU-27+ fleet is converted and at a steady state. |
| **Soil** | Activity and substance knowledge | **Initial release factor:** ERC9b assumes 5%<br>**Final release factor:** 0%<br>**Local release rate:** 0 kg/day<br>**Explanation / Justification:** Substance is a liquefied gas. |

The exposure concentrations and RCRs for both HFO-1234yf and its potential degradation product TFA are reported in ES4.

Information for CS2: Exposure concentrations and risks for worker

| Route of exposure and type of effects | Exposure concentration | Source for exposure concentration | Exposure concentration and DNEL (or DMEL) units | DNEL (or DMEL) | Risk characterisation |
|---|---|---|---|---|---|
| Inhalation, systemic, long-term | 85.6 | Gjolstad et al., 2003; refrigeration repair workers' data generated on HFC-134a | mg/m$^3$ | 950 | 0.09 |
| | 5.1 | Bureau Veritas North America, 2007; mobile A/C workers; data generated on HFC-134a | | | 0.005 |
| | 240 | TRA v.3 tool used to estimate exposure concentration for comparison purposes only | | | 0.25 |
| Inhalation, systemic, acute | Not needed | Not needed | | | Not needed |
| Inhalation, local, long-term | Not needed | Not needed | | | Not needed |
| Inhalation, local, acute | Not needed | Not needed | | | Not needed |
| Dermal, systemic, long-term | Not needed | Not needed | | | Not needed |
| Dermal, systemic, acute | Not needed | Not needed | | | Not needed |
| Dermal, local, long-term | Not needed | Not needed | | | Not needed |
| Dermal, local, acute | Not needed | Not needed | | | Not needed |
| Combined routes, systemic, long-term | | | | | 0.09 |
| Combined routes, systemic, acute | | | | | Not needed |

The RCR for inhalation exposure was <1. This indicates that adverse impact to workers is not expected.

| 3.1. Exposure Scenario ES3 |
|---|
| Formulation of preparations |
| Industrial uses : Uses of substances as such or in preparations at industrial sites (SU3) ; Formulation [mixing] or preparations and/or re-packaging (excluding alloys) (SU10) : General manufacturing, e.g. machinery, equipment, vehicles, other transport equipment (SU17) excluding buses |
| Contributing environmental scenario CS1: Formulation of preparations (ERC2) (Covered by ES4) |
| Contributing worker scenario CS2: Use in closed batch process (synthesis or formulation) (PROC3) |
| Exposure Scenario 3 (ES 3) describes the activities and processes covered when workers blend various types of refrigeration substances and load the products into ISO containers or tanks. The blended products may contain up to nearly 100% of HFO-1234yf. Activities are expected to occur outdoors, but with the same equipment used during the charging and/or packaging procedures described in ES 1. In this process, however, yield rates are set at 99.75%. Therefore, potential releases to ambient air are expected to be < 0.25% and releases to wastewater and soil are expected to be at 0%.<br>The equipment used for refrigerant blending and loading employs shut-off valve couplers that do not permit release of refrigerant unless a tight seal is made between the blending/filling equipment and the unit. In addition, blending/filling hoses are designed to be connected with the system prior to opening the valve(s) of the containers holding the substances. After blending operations are finished or the containers are filled, the valve(s) are closed prior to decoupling the hoses. |
| 3.2.1 Contributing scenario CS1 controlling environmental exposure for ERC2 |
| Formulation of preparations |
| Assessed and quantified in ES4 |
| Product characteristics |
| Low global warming potential (GWP) liquefied gas; Covers percentage substance in the product up to 100 % (unless stated differently); Not biodegradable |
| Amounts used |
| 5000 tonnes per annum (tpa) – EU; Daily amount: 25 000 kg/day – EU |
| Frequency and duration of use |
| Continuous use/8-hour shift, 200 operating days/year; Intermittent release |
| Environmental factors not influenced by risk management |
| None |
| Other given operational conditions affecting environmental exposure |
| Under normal conditions of use, exposure would primarily occur when workers connect and disconnect the couplings. Assumed 0.25% released to air (12.5 tpa), 0% released to wastewater and 0% released to soil. |
| Technical conditions and measures at process level (source) to prevent release |
| Process designed to minimize releases to wastewater; Process designed to minimize releases to soil; Ensure that the valves of the cylinders are tightly closed and not leaking; Handle substance within a closed system; Transfer via enclosed lines; Clear transfer lines prior to de-coupling. |
| Technical onsite conditions and measures to reduce or limit discharges, air emissions and releases to soil |
| None |

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| Organizational measures to prevent/limit release from site |
| Use of ATEX 137 and ATEX 95 Directives to mitigate flammability properties of HFO-1234yf and/or Chemical Substances at Work (Directive 98/24/EC); Regular inspection and maintenance of equipment and machines. |
| Conditions and measures related to municipal sewage treatment plant |
| No STP |
| Conditions and measures related to external treatment of waste for disposal |
| Not applicable |
| Conditions and measures related to external recovery of waste |
| Not applicable |
| 3.2.2 Contributing scenario CS2 controlling worker exposure for PROC 3 |
| Use in closed batch process (synthesis or formulation) |
| Product characteristic |
| Liquefied gas; Covers percentage substance in the product up to 100 % (unless stated differently); Assumes activities are at ambient temperature (unless stated differently). |
| Amounts used |
| Up to 2 500 kg/shift – worker, based on conservative yearly volume estimate and two shifts/day with five workers/shift |
| Frequency and duration of use/exposure |
| Intermittent; 8-hour shift; 200 days/year; Conservatively assumed less than 15 minutes exposure duration/worker, which is based on 70 to 100 connections per day with two shifts/day, five workers/shift, and 30 seconds potential exposure/connection. |
| Human factors not influenced by risk management |
| Light work, respiration volume = 10 $m^3$/8-hour shift |
| Other given operational conditions affecting workers exposure |
| Outdoor use; Under normal conditions of use, exposure would primarily occur when workers connect and disconnect the couplings. |
| Technical conditions and measures at process level (source) to prevent release |
| Ensure that the valves of the cylinders are tightly closed and not leaking; Handle substance within a closed system; Transfer via enclosed lines; Clear transfer lines prior to de-coupling. |
| Technical conditions and measures to control dispersion from source towards the worker |
| None |
| Organizational measures to prevent/limit releases, dispersion and exposure |
| Use of ATEX 137 and ATEX 95 Directives to mitigate flammability properties of HFO-1234yf and/or Chemical Substances at Work (Directive 98/24/EC); EN 378 (Refrigerating systems and heat pumps – Safety and environmental requirements); Regular inspection and maintenance of equipment and machines.; Ensure operatives are trained to minimise exposures. |
| Conditions and measures related to personal protection, hygiene and health evaluation |
| Use eye protection to EN 166 or ANSI Z87.1, designed to protect against liquid splashes. Wear suitable gloves tested to EN374 or complying with U.S. OSHA guidelines. |
| 3.3. Exposure estimation and reference to its source |

ASSESSMENT METHOD: CS1 and CS2: ECETOC TRA v.3

Information for CS1: Local releases to the environment

| Release | Release factor estimation method | Explanation / Justification |
|---|---|---|
| **Water** | Process and substance knowledge | Initial release factor: ERC2 assumes 2%<br>Final release factor: 0%<br>Local release rate: 0 kg/day<br>Explanation / Justification: Substance is a liquefied gas. |
| **Air** | Process and substance knowledge | Initial release factor: ERC2 assumes 2.5%<br>Final release factor: ~0.25%<br>Local release rate: 62.5 kg/day across EU-27+.<br>Explanation / Justification: Based on process knowledge. |
| **Soil** | Process and substance knowledge | Initial release factor: ERC2 assumes 0.01%<br>Final release factor: 0%<br>Local release rate: 0 kg/day<br>Explanation / Justification: Substance is a liquefied gas. |

The exposure concentrations and RCRs for both HFO-1234yf and its potential degradation product TFA are covered and reported in ES4.

Information for CS2: Exposure concentrations and risks for worker

| Route of exposure and type of effects | Exposure concentration | Source for exposure concentration | Exposure concentration and DNEL (or DMEL) units | DNEL (or DMEL) | Risk characterisation |
|---|---|---|---|---|---|
| Inhalation, systemic, long-term | 17 | TRA v.3 tool used to estimate exposure concentration | mg/m$^3$ | 950 | 0.018 |
| Inhalation, systemic, acute | Not needed | Not needed | | | Not needed |
| Inhalation, local, long-term | Not needed | Not needed | | | Not needed |
| Inhalation, local, acute | Not needed | Not needed | | | Not needed |
| Dermal, systemic, long-term | Not needed | Not needed | | | Not needed |
| Dermal, systemic, acute | Not needed | Not needed | | | Not needed |
| Dermal, local, long-term | Not needed | Not needed | | | Not needed |
| Dermal, local, acute | Not needed | Not needed | | | Not needed |
| Combined routes, systemic, long-term | | | | | 0.018 |

| | | | | | |
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| Combined routes, systemic, acute | | | | | Not needed |

The RCR for inhalation exposure was <1. This indicates that adverse impact to workers is not expected.

**4.1 Exposure Scenario ES4**

Use, Service Life, and Waste Stage Environmental Exposure

Industrial uses : Uses of substances as such or in preparations at industrial sites (SU3) ; Formulation [mixing] or preparations and/or re-packaging (excluding alloys) (SU10) : General manufacturing, e.g.. machinery, equipment, vehicles, other transport equipment (SU17) excluding buses; Consumer uses : Private households (=general public = consumers) (SU21) ; and Professional uses : Public domain (administration, education, entertainment, services, craftsmen) (SU22).

Contributing environmental scenario CS1: HFO-1234yf: Wide dispersive outdoor use in closed systems (ERC9b); TFA: Wide dispersive outdoor use of long-life articles, high or intended release (ERC 10b).

Contributing worker scenarios: CS2: HFO-1234yf: Use and Service life (PROC 8a, 9) related to physico-chemical properties

According to Henne et al., 2012, an estimated 19.2 Gg/yr (19 200 tonnes per annum (tpa)) of HFO-1234yf may be emitted to the air from MACs once the conversion to HFO-1234yf in the automobile fleet is complete and at a steady-state (estimated to occur in the year 2020). This value represents the high emission scenario (95% confidence band) for the EU-27+. The 19 200 tonnes estimated to be released per year was based on a predicted car fleet of about 335 million, approximately 90% of which have the substance in the MAC, and on all the lifecycle activities for the HFO-1234yf, except for chemical manufacturing, which does not presently occur in the EU-27+.

4.2.1 Contributing scenario CS1 controlling environmental exposure for ERC9b, 10b

Wide dispersive use in closed systems (ERC9b); TFA: Wide dispersive outdoor use of long-life articles, high or intended release (ERC10b)

See ES1, 2, 3 above, respectively for conditions of use covered by ES4.

**Predicted yearly emissions based on Henne et al 2012 and ES3 estimated releases**

| Activity | Potential amount released (g/MAC) | Percentage of original fill amount potentially released (%) | Fraction of automobiles with release | Henne et al emission factor (g/yr/MAC) | How Henne et al emission factor and/or fraction of automobiles with release determined | Predicted emissions for activity (tpa) |
|---|---|---|---|---|---|---|
| MAC filling at Original Equipment Manufacturers | 5 | 0.9 | 0.9 | 0.42 | 5 g/MAC divided by 12 years (average MAC lifetime) | 127 |
| MAC refilling by skilled personnel | 35 | 6.4 | 0.81 | 2.92 | 35 g/MAC divided by 12 years | 792 |
| MAC refilling by unskilled personnel | 350 | 64 | 0.09 | 29.2 | 350 g/MAC divided by 12 years | 880 |
| Regular automobile usage | 35.8 | 6.5 | 0.9 | 35.8 | In-use car data for 2002/2003 with no loss rate improvement | 10 794 |
| Irregular usage (sudden leaks from accidents, stone impacts, and component defects) | 550 | 100 | 0.017 | 550 | All or original fill released; 1.9% cars/year times 90% of cars with HFO-1234yf in MAC | 3 132 |
| MAC dismantling by skilled personnel | 100 | 18 | 0.25 | 8.33 | 100 g/MAC divided by 12 years | 698 |
| MAC dismantling by unskilled personnel | 400 | 73 | 0.25 | 33.3 | 400 g/MAC divided by 12 years | 2 789 |
| | | | | | **Total estimated emissions for ES1 and ES2** | **~19 212** |
| Formulation of preparations (ES3) | Not applicable | Not applicable | Not applicable | Not applicable | 0.25% of 5 000 tpa | 12.5 |
| | | | | | **Total estimated emissions for ES1, ES2, and ES3** | **~19 225** |

| 4.2.2 Contributing scenario CS2 controlling worker exposure for Use and Service life (PROC 8a, 9) related to physico-chemical properties |
|---|
| Transfer of substance at non-dedicated facilities |
| Product characteristic |
| Extremely flammable liquefied gas; Covers percentage substance in the product up to 100 % (unless stated differently); Assumes activities are at ambient temperature (unless stated differently). |
| Amounts used |
| Mobile A/C: 0.5 kg/service event; Stationary Equipment: 0.05 – 300 kg/service event |
| Frequency and duration of use/exposure |
| Duration of use/exposure: Intermittent;<br>Mobile A/C: ~1 minute/ 8-hour shift (0.083 minutes (5 seconds) per connecting process x 2 connecting processes per vacuuming/re-charging procedure x 1 servicing event per hour x 8 hours per shift)<br>Stationary Equipment: ~< 1 minute/8-hour shift (0.083 minutes (5 seconds) per connecting process x2 connecting processes per vacuuming/ re-charging procedure x up to 4 servicing events per 8-hour shift)<br>Frequency: 200 days/year |
| Human factors not influenced by risk management |
| None |
| Other given operational conditions affecting workers exposure |
| Indoor use; Under normal conditions of use, exposure would primarily occur when workers connect and disconnect the couplings. |
| Technical conditions and measures at process level (source) to prevent release |
| Ensure that the valves of the cylinders are tightly closed and not leaking; Handle substance within a closed system; Transfer via enclosed lines; Clear transfer lines prior to de-coupling. |
| Technical conditions and measures to control dispersion from source towards the worker |
| None |
| Organizational measures to prevent/limit releases, dispersion and exposure |
| Use of ATEX 137 and ATEX 95 Directives to mitigate flammability properties of HFO-1234yf and/or Chemical Substances at Work (Directive 98/24/EC); Use of ISO 13043 (April 15, 2011) (Road vehicles – Refrigerant systems used in mobile air conditioning systems (MAC) – Safety requirements) and SAE J639 (Safety Standards for Motor Vehicle Refrigerant Vapor Compression Systems), SAE J2843 (R-1234yf [HFO-1234yf] Recovery/Recycling/Recharging Equipment for Flammable Refrigerants for Mobile Air-Conditioning Systems)and SAE J2845 (Technician Certification for Service and Containment of Refrigerants Used in Mobile A/C Systems); EN 378 (Refrigerating systems and heat pumps – Safety and environmental requirements); Regular inspection and maintenance of equipment and machines.; Ensure operatives are trained to minimise exposures. |
| |
| 4.3. Exposure estimation and reference to its source |
| ASSESSMENT METHOD: CS1: ECETOC TRA v.3 |

Information for CS1:
Predicted exposure concentrations and risk characterisation ratios for HFO-1234yf:

| Protection target | Exposure concentration | Exposure concentration and PNEC units | PNEC | Risk characterisation |
|---|---|---|---|---|
| Sewage treatment plant (STP) | Not released to STP | mg/L | Not applicable | Not applicable |
| Freshwater | 1.11E-10 | mg/L | 0.1 | 1E-09 |
| Sediment (freshwater) | 1.67E-09 | mg/kg dry weight (dwt) | 1.77 | 9E-10 |
| Agricultural soil | 1.97E-09 | mg/kg dwt | 1.54 | 1E-09 |
| Marine water | 3.19E-11 | mg/L | 0.01 | 3E-09 |
| Sediment (marine water) | 4.81E-10 | mg/kg dwt | 0.178 | 3E-09 |
| Man via the environment (local) | 3.28E-06 | mg/kg body weight/day | 271 (DNEL)† | 1.21E-08 |

† The DNEL was derived by taking the worker inhalation, long-term, systemic DNEL of 950 mg/m$^3$ and converting it to a dose by multiplying by a presumed daily inhalation rate of 20 m$^3$/day and dividing by an adult body weight of 70 kg.

The RCRs for HFO-1234yf for all protection targets were all much less than 1. This indicates that adverse impact to the environment and environmental receptors is not expected from potential releases of HFO-1234yf during original filling, refilling, regular usage, irregular usage, and dismantling.

Predicted exposure concentrations and risk characterisation ratios for TFA if instantaneous conversion after HFO-1234yf vented to air:

| Protection target | Exposure concentration | Exposure concentration and PNEC units | PNEC (ECHA, 2014) | Risk characterisation |
|---|---|---|---|---|
| Sewage treatment plant (STP) | Not released to STP | mg/L | Not applicable | Not applicable |
| Freshwater | 1.06E-05 | mg/L | 1 | 1E-05 |
| Sediment (freshwater) | 5.86E-05 | mg/kg dry weight (dwt) | 4.22 | 1E-05 |
| Agricultural soil | 9.23E-06 | mg/kg dwt | 0.0083 | 1E-03 |
| Marine water | 9.14E-05 | mg/L | 0.1 | 9E-05 |
| Sediment (marine water) | 5.03E-05 | mg/kg dwt | 0.422 | 1E-04 |
| Man via the environment (local) | 1.12E-04 | mg/kg body weight/day | 0.25 (DNEL) | 4E-04 |

The RCRs for TFA for all protection targets were all much less than 1. This indicates that adverse impact to the environment and environmental receptors is not expected from the potential conversion of HFO-1234yf to TFA during original filling, refilling, regular usage, irregular usage, and dismantling.

Assessment method for CS2: SAE International Cooperative Research Program 1234

Information for CS2:
**Predicted exposure concentrations and physicochemical risk characterisation evaluation**

HFO-1234yf is classified as an extremely flammable gas. This classification is based solely on the existence of a lower and upper flammability limit in air at 20°C. The flammability limits in air are 6.2%(V) and 12.3%(V) (method: ASTM E681-04). HFO-1234yf has a boiling point of -29,4 °C
and an autoignition temperature of 405°C. The auto-ignition temperature is very high and is of no concern during normal handling and use.

As HFO-1234yf is not classified as dangerous on the basis of (eco) toxicological properties, only the risk due to its flammable properties is required to be characterized. Exposure to HFO-1234yf within the confines of an automobile as a consequence of leaks due to random collisions is the worst-case situation as higher concentrations are more easily attained because HFO-1234 may escape in a shorter period of time than during a corrosion-type leak. Again, following a collision situation, a Micro automobile with effective volume of 1.25 $m^3$ was used to determine if the refrigerant's lower flammability level would be attained. In the most severe situation, 70% of the refrigerant is potentially leaked into the passenger cabin after a side impact collision. According to SAE J2772, breakage of other components would more likely lead to a significant release of refrigerant to the ambient air rather than to the passenger cabin. Results from this evaluation suggest that the refrigerant reaches a maximum concentration of 127 000 $mg/m^3$ (27 200 ppm), well below the lower flammability level of 62 000 ppm.

Exposure to HFO-1234yf due to worst-case corrosion-type leaks (slower gradual leaks) has been shown to reach a maximum concentration of below 2% in the luxury vehicle (maximum was 1.8% as tested); typical commuter vehicles have higher body air leakage and thereby lower maximum refrigerant concentrations (maximum was 1.2% as tested) than luxury vehicles due to the reduced road noise requirement for the higher end vehicles.