

Safety Data Sheet (SDS/MSDS)

Trifluoromethane (R23 / HFC-23)

CAS No.: 75-46-7 UN No.: 1984 Date: August 29, 2026 Version: V1.0

1 Chemical Product and Company Identification

1.1 Product Identifier

Chemical Name	Trifluoromethane
Synonyms	R23, HFC-23, HFC23, Fluoroform, Freon 23, FE-13
CAS Number	75-46-7
UN Number	1984 (High-pressure liquefied gas)
Hazardous Goods Number	22026 (Class 2.2 Non-flammable, non-toxic gas)
Molecular Formula	CHF ₃
Molecular Weight	70.01 g/mol
Main Uses	Ultra-low temperature refrigerant (cascade refrigeration system low-temperature stage), fire extinguishing agent (total flooding system), semiconductor etching process gas, organic synthesis intermediate

1.2 Manufacturer/Supplier Information

Supplier Name	Hangzhou Wula Chemical Co., Ltd.
Address	No. 7 Longtan Road, Yuhang District, Hangzhou, Zhejiang, China
Postal Code	311100
Telephone	+86-571-87024025
Fax	+86-571-87024025
Email	safety@wulachem.cn

1.3 Emergency Telephone

National Chemical Emergency Hotline (China): +86-532-83889090 (24 hours)

Zhejiang Chemical Emergency: +86-571-88071797

2 Hazards Identification

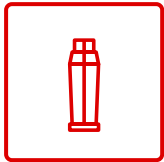
2.1 GHS Hazard Classification

Hazard Classification:

- Gases under pressure (Physical Hazard) — High-pressure liquefied gas
- Specific target organ toxicity - single exposure (Health Hazard, narcotic effects) — Category 3 (at high concentrations)

Note: Frostbite caused by liquid contact with skin/eyes is a physical low-temperature injury; there is no dedicated "frostbite" category in GHS. This substance is ASHRAE Class A1 (non-flammable, low toxicity). The primary physical hazard is pressurized gas.

2.2 GHS Label Elements



GHS04 Gas under pressure

Signal Word: WARNING

Hazard Statements:

- H280** Contains gas under pressure; may explode if heated.
- H336** May cause drowsiness or dizziness (at high concentrations).

Precautionary Statements:

- P102** Keep out of reach of children. Read label before use.
- P271** Use only outdoors or in a well-ventilated area.
- P280** Wear protective gloves/protective clothing/eye protection/face protection.
- P304+P340** IF INHALED: Remove person to fresh air and keep comfortable for breathing.
- P308+P313** IF exposed or concerned: Get medical advice/attention.
- P403** Store in a well-ventilated place.
- P410+P403** Protect from sunlight. Store in a well-ventilated place.
- P405** Store locked up.

2.3 Other Hazards

- Vapor is heavier than air and can spread along the ground, accumulating in low-lying areas and causing oxygen-deficient environments.
- This product is non-flammable, but decomposes at high temperatures (>400°C) to produce toxic and corrosive gases (hydrogen fluoride, etc.).
- Cylinders may rupture when heated due to increased internal pressure.
- At high concentrations, can cause simple asphyxiation and cardiac sensitization (arrhythmia).

Critical Temperature Note: R23 has a critical temperature of 25.9°C (78.6°F), which is close to room temperature. When ambient temperature exceeds 25.9°C, the substance in the cylinder transitions to a supercritical fluid state, and vapor pressure rises sharply to the critical pressure (approximately 4.84 MPa / 701.6 psia), placing extreme demands on cylinder pressure resistance. Temperature must be strictly controlled during summer transport and storage to prevent overheating and overpressurization.

3 Composition/Information on Ingredients

3.1 Substance/Mixture

This product is a pure substance.

3.2 Ingredient Information

Component Name	CAS Number	Concentration (mass fraction)
Trifluoromethane	75-46-7	≥99.9% (Premium grade ≥99.95%)

3.3 Impurity Information

Impurity	Premium Grade	First Grade
Acidity (as HCl)	≤0.1 ppm	≤1 ppm
Moisture	≤5 ppm	≤10 ppm
Evaporation residue	≤100 ppm	≤100 ppm
Non-condensable gases (25°C, volume)	≤1.5%	≤1.5%
Chlorides	Pass	Pass

4.1 Description of Necessary First Aid Measures

General Advice: Immediately remove the patient from the contaminated area. Keep warm and quiet. Show this safety data sheet to the attending physician.

Inhalation:

- Quickly move the patient to fresh air. Keep airway open.
- If breathing is difficult, administer oxygen.
- If breathing has stopped, perform artificial respiration (use a bag-valve-mask or pocket mask; avoid mouth-to-mouth).
- If heartbeat has stopped, begin CPR immediately.
- Keep patient warm and at rest. Observe closely.
- Seek medical attention immediately.

Skin Contact (Frostbite):

- Immediately flush frostbitten area with plenty of warm water (37-40°C / 98.6-104°F) to promote rewarming.
- Do NOT use hot water (>40°C) or direct heat (e.g., electric heaters).
- Avoid rubbing frostbitten areas to prevent worsening tissue damage.
- Carefully remove frozen clothing. If clothing is adhered to skin, do not force removal; cut around the adhered area.
- Cover the wound with a sterile dressing.
- Seek medical attention immediately.

Eye Contact:

- Immediately hold eyelids open and flush with plenty of running water or saline solution for at least 15 minutes.
- Ensure thorough flushing of all parts of the eyeball by lifting upper and lower eyelids.
- Remove contact lenses before flushing if feasible.
- Seek medical attention immediately, preferably from an ophthalmologist.

Ingestion:

Not applicable. This product is a gas at room temperature and cannot be ingested.

4.2 Most Important Symptoms and Health Effects

- Acute inhalation: Dizziness, drowsiness, headache, nausea, loss of coordination, loss of consciousness, arrhythmia.
- High-concentration inhalation: Can cause simple asphyxiation (displacement of oxygen in air) and cardiac sensitization (arrhythmia).

- Skin contact with liquid: Frostbite (skin turns white, hardens, pain, blisters).
- Eye contact with liquid: Severe frostbite, corneal damage, visual impairment.

4.3 Indication of Immediate Medical Attention and Special Treatment

Physician's Note:

- Treat symptomatically. Maintain airway patency. Administer oxygen if necessary.
- Monitor cardiac function; high-concentration exposure may cause arrhythmia.
- Avoid catecholamine drugs such as epinephrine (may increase myocardial sensitivity to fluorocarbons, inducing ventricular fibrillation).
- Treat frostbite with conventional methods: warm water (37-40°C) rewarming. Never use dry heat or friction.
- If thermal decomposition products (HF) exposure is suspected, treat as hydrogen fluoride poisoning. Monitor serum calcium and administer calcium gluconate if necessary.

5

Firefighting Measures

5.1 Extinguishing Media

Suitable Extinguishing Media: This product is non-flammable. Use extinguishing agents appropriate for the surrounding fire. Carbon dioxide, dry chemical powder, water spray, or foam may be used.

Unsuitable Extinguishing Media: No specific restrictions.

5.2 Special Hazards

- This product is non-flammable. No flash point. No explosive limits.
- Decomposes at high temperatures (>400°C), producing toxic and corrosive gases: hydrogen fluoride, carbon monoxide, carbonyl fluoride, etc.
- Cylinders may rupture when heated due to increased internal pressure. This risk is especially critical when ambient temperature approaches or exceeds the critical temperature (25.9°C).
- May react with alkali metals, alkaline earth metals, and aluminum powder under specific conditions.

5.3 Hazardous Combustion Products

Hydrogen fluoride (HF), carbon monoxide (CO), carbonyl fluoride (COF₂), other fluorinated compounds

5.4 Firefighting Precautions and Protective Equipment

- Firefighters must wear positive-pressure self-contained breathing apparatus (SCBA) and full protective firefighting gear.
- Move containers away from fire area if it can be done safely.
- Spray water to cool fire-exposed containers until firefighting is complete.
- If containers in the fire change color or emit sounds from pressure relief devices, evacuate immediately.

- Isolate the accident scene. Unauthorized persons are prohibited from entering.
- Avoid directing water jets directly onto leaking liquefied gas, as this accelerates evaporation and dispersion.

6 Accidental Release Measures

6.1 Personal Precautions, Protective Equipment, and Emergency Procedures

- Quickly evacuate personnel from the leak area to upwind locations. Isolate the area and strictly restrict access.
- Emergency responders should wear positive-pressure SCBA, general work clothing, low-temperature protective gloves, and safety goggles.
- Enter the site from upwind direction.
- Shut off the leak source if possible.
- Do not touch or walk through the spilled material.
- Designate emergency contact personnel and be ready for external support.

6.2 Environmental Precautions

- Prevent gas from entering sewers, basements, or enclosed spaces.
- Provide adequate ventilation to accelerate dispersion.
- **Pay special attention to controlling greenhouse gas emissions during large leaks.** R23 has a GWP of 14,700. Recovery should be prioritized to prevent release into the atmosphere.
- Avoid release into the atmosphere, water bodies, and soil.

6.3 Methods and Materials for Containment and Cleaning Up

- **Small leaks:** Enhance ventilation to accelerate gas dispersion. Monitor oxygen levels to prevent asphyxiation.
- **Large leaks:**
 - Close the leak source valve (if safe to operate).
 - Use dedicated gas recovery equipment to recover the gas (preferred method for recycling).
 - If recovery is not possible, use water spray to dilute and dissolve, but prevent water contamination.
 - If the cylinder valve cannot be closed, immerse the cylinder in an alkaline solution for absorption treatment.
- **Cylinder leak disposal:** Move the cylinder to a well-ventilated, safe area and release slowly. If the valve cannot be closed, contact the supplier for professional handling.

6.4 Reference

See Section 8 (Exposure Controls/Personal Protection) and Section 13 (Disposal Considerations).

Special Warning: R23 vapor density is approximately 2.4 times that of air. It will accumulate in low-lying areas and enclosed spaces, creating an oxygen-deficient environment. Before entering enclosed spaces or low areas, oxygen content must be tested ($\geq 19.5\%$) with standby monitoring by another person.

7 Handling and Storage

7.1 Handling Precautions

- Operate in a closed system. Provide adequate natural or local exhaust ventilation.
- Personnel must receive specialized training, strictly follow operating procedures, and hold relevant certifications.
- Prevent gas leakage into the workplace air.
- Avoid contact with reactive metals and strong oxidizers.
- Handle cylinders gently. Prevent damage to cylinders and accessories. Do not drop, slide, roll, or impact.
- Equip the workplace with emergency leak handling equipment.
- No smoking, eating, or drinking in the workplace.
- Wear thermal insulation gloves and safety goggles when handling liquid to prevent frostbite.
- Use explosion-proof ventilation systems and equipment.
- Regularly inspect cylinders, valves, and piping for leaks.
- Avoid high-temperature environments in the workplace. Pay special attention that ambient temperature should not exceed 25°C (near critical temperature).

7.2 Safe Storage Conditions, Including Incompatibilities

- Store in a cool, dry, well-ventilated warehouse designated for non-flammable gases.
- Storage temperature should not exceed 25°C (near the critical temperature of 25.9°C ; exceeding this will cause supercritical state and pressure surge). Keep away from fire, heat sources, and direct sunlight.
- Store separately from oxidizers and reactive metals. Do not mix storage.
- The storage area should be equipped with emergency leak handling equipment.
- Cylinders should be stored upright with valve caps and shock-absorbing rings properly attached. Secure cylinders to prevent tipping.
- Use explosion-proof lighting and ventilation facilities.
- Do not use mechanical equipment and tools that may produce sparks.
- Maximum filling factor: 0.76 kg/L.
- Post clear safety warning signs in the storage area.
- Implement dual-person receipt/dispatch and dual-person custody procedures.

Storage Temperature Note: R23 has a critical temperature of only 25.9°C. In summer high-temperature environments, the medium in the cylinder can easily reach or exceed the critical temperature, entering a supercritical state. At this point, regardless of applied pressure, the gas cannot be liquefied, and vapor pressure will equal or approach the critical pressure (4.84 MPa / 701.6 psia), posing a severe threat to cylinder safety. Storage environment temperature must not exceed 25°C, and temperature monitoring with over-temperature alarm devices must be provided.

7.3 Specific End Uses

For industrial use only. Personnel must be professionally trained. Main applications: ultra-low temperature refrigerant for cascade refrigeration system low-temperature stage (evaporation temperature -80°C to -100°C), fire extinguishing agent for total flooding systems, semiconductor manufacturing etching gas. Prohibited for food contact, medical inhalation, or other unapproved uses.

8 Exposure Controls/Personal Protection

8.1 Occupational Exposure Limits

China OEL	No statutory limit established. Recommended reference: ACGIH TLV: 1000 ppm (TWA, 8-hour)
ACGIH TLV-TWA (USA)	1000 ppm (approx. 2890 mg/m ³), Time-weighted average
OSHA PEL-TWA (USA)	1000 ppm (8-hour TWA)
German MAK	1000 ppm (approx. 2900 mg/m ³)
Biological Exposure Limit	Not established

Note: Per GBZ 2.1-2019 "Occupational Exposure Limits for Hazardous Factors in the Workplace - Part 1: Chemical Hazardous Factors," this substance is not currently listed in China's occupational exposure limit table. International standards are recommended for reference during operations.

8.2 Exposure Monitoring Methods

Gas chromatography with flame ionization detection (GC-FID) or mass spectrometry (GC-MS); non-dispersive infrared spectroscopy (NDIR)

8.3 Engineering Controls

- Enclose production processes. Provide general or local exhaust ventilation.
- Provide safety showers and eyewash stations.
- Install gas detection alarms (oxygen monitoring and fluoride monitoring) in areas where large leaks may occur.
- Use explosion-proof electrical equipment.

8.4 Personal Protective Equipment

Respiratory Protection:

- Normal conditions (air concentration below limits): No special protection required.
- At higher concentrations: Half-face respirator with organic vapor/acid gas cartridges recommended.
- High-concentration environments or emergency rescue/evacuation: Positive-pressure self-contained breathing apparatus (SCBA) required.

Eye Protection:

- Normal operations: No special protection required.
- When handling liquid or potential liquid contact: Chemical safety goggles or face shield must be worn to prevent frostbite.

Skin Protection:

- Hand protection: General work gloves for normal operations; low-temperature thermal insulation gloves (e.g., dry ice gloves, leather cold-weather gloves) for liquid contact.
- Body protection: General work clothing for normal operations; cold-weather suit for liquid contact.
- Other: No smoking in the workplace. Avoid high-concentration inhalation. When entering tanks, confined spaces, or other high-concentration areas, standby monitoring by another person is required.

8.5 Hygiene Measures

- Remove contaminated clothing promptly after work. Wash skin thoroughly.
- Maintain good personal hygiene habits.
- Workplaces should be equipped with eyewash stations and emergency showers.

9 Physical and Chemical Properties

9.1 Basic Physical and Chemical Properties

Appearance	Colorless gas with a slight ethereal odor; gaseous at room temperature and atmospheric pressure; colorless transparent liquid under pressure
Odor Threshold	No data available (slight ethereal odor)
pH	Not applicable (gas)
Melting Point	-155.0°C (-247.0°F)
Boiling Point (101.3 kPa)	-82.1°C (-115.8°F)
Flash Point	None (non-flammable gas)
Evaporation Rate	No data available

Flammability (gas)	Non-flammable
Upper/Lower Explosive Limits	Not applicable (non-flammable gas)
Vapor Pressure (25°C)	Approx. 4.84 MPa (4840 kPa) — near critical pressure; temperature slightly above 25°C reaches supercritical state
Vapor Density (air = 1)	Approx. 2.4 (heavier than air)
Liquid Density (at boiling point)	Approx. 1.445 g/cm ³
Solubility	Slightly soluble in water (approx. 0.1 g/L at 25°C); soluble in ethanol, ether, and other organic solvents
Partition Coefficient (log P, octanol/water)	Approx. 0.64
Auto-ignition Temperature	Not applicable (non-flammable)
Decomposition Temperature	>400°C (thermal decomposition begins)

9.2 Thermodynamic Properties

Critical Temperature	25.9°C (78.6°F) — close to room temperature; requires special attention
Critical Pressure	4.836 MPa (4836 kPa / 701.6 psia)
Critical Density	0.528 g/cm ³
Critical Volume	133 cm ³ /mol
Heat of Vaporization (at boiling point)	Approx. 231 kJ/kg
Liquid Specific Heat (at boiling point)	Approx. 1.88 kJ/(kg·°C)
Gas Specific Heat (25°C, constant pressure)	0.726 kJ/(kg·°C)

9.3 Other Safety Data

ASHRAE Safety Class	A1 (non-toxic, non-flammable)
Ozone Depletion Potential (ODP)	0 (does not deplete ozone layer; see Section 12.6)

Global Warming Potential (GWP, 100-year)	14,700 (extremely high greenhouse effect; see Section 12.6)
Atmospheric Lifetime	Approx. 270 years

Critical Temperature Note: R23 has a critical temperature of 25.9°C, one of the lowest among common refrigerants. This means:

- Below 25°C, R23 can exist as a liquid under pressure (high-pressure liquefied gas);
- Above 25.9°C, R23 enters a supercritical state and cannot be liquefied by pressure alone. Vapor pressure equals or approaches the critical pressure;
- In practical applications, R23 is primarily used in the low-temperature stage of cascade refrigeration systems (evaporation temperature -80°C to -100°C) and is not used alone for conventional refrigeration;
- Temperature must be strictly controlled during transport and storage to prevent supercritical state and overpressurization.

10 Stability and Reactivity

10.1 Reactivity

Chemically stable under normal temperature and pressure. Not prone to chemical reactions.

10.2 Chemical Stability

Stable under normal temperature and pressure.

10.3 Possibility of Hazardous Reactions

- Thermal decomposition at high temperatures (>400°C), producing toxic hydrogen fluoride, carbon monoxide, and carbonyl fluoride.
- May react with alkali metals, alkaline earth metals, and aluminum powder at high temperatures or under specific conditions.
- May undergo oxidation-reduction reactions with strong oxidizers.

10.4 Conditions to Avoid

High temperature, open flame, direct heat sources, cylinder overpressurization. Special attention: avoid ambient temperatures exceeding the critical temperature of 25.9°C.

10.5 Incompatible Materials

Reactive metals (sodium, potassium, calcium, aluminum powder, magnesium powder, etc.), strong oxidizers

10.6 Hazardous Decomposition Products

Hydrogen fluoride (HF), carbon monoxide (CO), carbonyl fluoride (COF₂), other fluorinated compounds

10.7 Polymerization Hazard

Polymerization will not occur.

11 Toxicological Information

11.1 Acute Toxicity

Rat Inhalation LC ₅₀ (4-hour)	>500,000 ppm (above 50% volume, highest tested concentration)
Mouse Inhalation LC ₅₀ (2-hour)	>700,000 ppm
Rabbit Dermal LD ₅₀	No data (gaseous substance)

11.2 Skin Irritation/Corrosion

Liquid contact can cause frostbite (physical injury) but is not a chemically corrosive substance. GHS classification: No skin corrosion/irritation classification (physical frostbite only).

11.3 Eye Irritation/Corrosion

Liquid contact can cause severe frostbite and corneal damage. GHS classification: No specific eye irritation classification (physical frostbite effect).

11.4 Respiratory or Skin Sensitization

No sensitization reported. Existing animal studies and epidemiological data show no sensitizing effects.

11.5 Germ Cell Mutagenicity

In vitro and in vivo tests (Ames test, chromosomal aberration test, mouse micronucleus test, etc.) showed no mutagenic effects.

11.6 Carcinogenicity

No sufficient evidence of carcinogenicity.

- IARC (International Agency for Research on Cancer): Not listed
- ACGIH (American Conference of Governmental Industrial Hygienists): Group A4 (Not classifiable as a human carcinogen)
- EPA (U.S. Environmental Protection Agency): Not listed

11.7 Reproductive Toxicity

Animal studies showed no significant reproductive toxicity or developmental toxicity at high concentrations (>50,000 ppm). No human reproductive toxicity data available.

11.8 Specific Target Organ Toxicity - Single Exposure

- Narcotic effects (Category 3): High-concentration inhalation can cause central nervous system depression, manifested as dizziness, drowsiness, headache, and impaired consciousness.
- Cardiac effects: High-concentration exposure may cause arrhythmia, especially under stress or exercise (cardiac sensitization to catecholamines).
- Simple asphyxiation: At high concentrations, can displace oxygen in air, causing hypoxic asphyxiation.

11.9 Specific Target Organ Toxicity - Repeated Exposure

Repeated low-concentration exposure showed no significant target organ toxicity. Long-term animal inhalation studies (high concentration) did not reveal definitive organ damage.

11.10 Aspiration Hazard

As a gas, aspiration pneumonitis is generally not a concern. However, high-concentration inhalation can cause central nervous system depression, cardiac sensitization, and simple asphyxiation.

12 Ecological Information

12.1 Ecotoxicity

Fish Acute Toxicity (LC ₅₀ , 96h)	> 100 mg/L (low toxicity to fish)
Daphnia Acute Toxicity (EC ₅₀ , 48h)	> 100 mg/L
Algal Growth Inhibition (EC ₅₀ , 72h)	> 100 mg/L
Bacterial Toxicity	No data available

12.2 Persistence and Degradability

- Atmospheric degradation: Primarily degraded by reaction with hydroxyl radicals. Atmospheric lifetime: approximately 270 years (extremely persistent).
- Biodegradability: Not readily biodegradable (resistant to microbial decomposition).
- Hydrolysis: Not readily hydrolyzed at room temperature.
- Photolysis: Can undergo photochemical degradation in the atmosphere, but at a very slow rate.

12.3 Bioaccumulation Potential

log P = 0.64. Low bioaccumulation potential (below the bioconcentration threshold of log P = 4.5).

12.4 Mobility in Soil

As a gas, it readily volatilizes. Low water solubility results in high mobility. After entering soil, it readily volatilizes into the atmosphere.

12.5 PBT and vPvB Assessment

Does not meet PBT (Persistent, Bioaccumulative, and Toxic)/vPvB (very Persistent, very Bioaccumulative) criteria. However, its extremely long atmospheric lifetime (270 years) exhibits high persistence characteristics.

12.6 Other Adverse Environmental Effects

Extremely High Global Warming Potential (GWP) Warning:

- **Ozone Depletion Potential (ODP):** 0 (does not deplete the ozone layer; HFC non-ODS substance)
- **Global Warming Potential (GWP, 100-year time horizon):** 14,700 (relative to CO₂ = 1) — one of the highest GWP values among common refrigerants
- **Atmospheric Lifetime:** Approximately 270 years (extremely resistant to natural degradation)
- R23 GWP is approximately 11 times that of R134A (GWP = 1,300) and 14,700 times that of CO₂
- Large-scale release would have a severe impact on global warming. Emissions must be strictly controlled, with recovery and recycling prioritized.

13 Disposal Considerations

13.1 Waste Treatment Methods

Product/Residues:

- **Direct release into the atmosphere is strictly prohibited** (GWP = 14,700, extremely high greenhouse effect).
- Recovery and regeneration for recycling is the preferred treatment method.
- If recycling is not possible, send to a qualified hazardous waste treatment facility.
- High-temperature incineration may be used; fluoride emissions from incineration exhaust must be removed via alkaline scrubbers.
- Advanced technologies such as plasma decomposition or catalytic decomposition may be used.
- Do not discharge into sewers, water bodies, or soil.

Contaminated Packaging:

- Empty cylinders should be returned to the supplier or qualified processing facility. Do not discard or cut without authorization.
- Empty cylinders retaining residual pressure must be managed as hazardous waste.

13.2 Disposal Precautions

- Consult national and local regulations before disposal, such as the "Law of the People's Republic of China on the Prevention and Control of Environmental Pollution by Solid Waste" and "Pollution Control Standard for Hazardous Waste Storage."

- Operators should wear appropriate personal protective equipment (see Section 8).
- Ensure adequate ventilation to prevent asphyxiation.
- Disposal must be carried out by qualified entities.
- Disposal records should be maintained.
- **As a substance with extremely high GWP, R23 disposal must strictly comply with the Kigali Amendment and relevant HFC control regulations' emission reduction requirements.**

14 Transport Information

14.1 UN Number

1984 (Trifluoromethane, high-pressure liquefied gas)

14.2 UN Proper Shipping Name

TRIFLUOROMETHANE / REFRIGERANT GAS R 23

14.3 Transport Hazard Class

Class 2.2 — Non-flammable, non-toxic gas

14.4 Packing Group

Not applicable (Class 2 gases have no packing group classification)

14.5 Packing Mark

- Primary hazard label: Non-flammable, non-toxic gas label (green, Class 2.2)
- Subsidiary hazard label: None

14.6 Packing Method

- Seamless steel cylinders compliant with GB 5099 "Seamless Steel Gas Cylinders" or equivalent standards.
- Common specifications: 13.6kg, 50kg, 100kg, 400kg, 800kg cylinders.
- Maximum filling factor: 0.76 kg/L.
- Cylinder valve outlet thread direction: Right-hand thread (for non-flammable, non-toxic gases).

14.7 Special Requirements by Transport Mode

Road Transport (GB/T 12268):

- Transport vehicles must have hazardous goods transport qualification.
- Cylinders must have valve caps and shock-absorbing rings properly attached.
- Cylinders are generally laid flat with valve outlets facing the same direction; no crossing. Height must not exceed vehicle guardrails.
- In summer, transport during morning or evening hours. Prevent sun exposure. **Special attention: ambient temperature must not exceed 25°C** to avoid approaching critical temperature and overpressurization.

- Follow designated routes. Do not stop in residential or densely populated areas.
- Transport vehicles should be equipped with temperature monitoring devices.

Rail Transport (Railway Dangerous Goods Transport Regulations):

- No free rolling (shunting by gravity prohibited).
- Transport in boxcars. Cylinders stored upright or laid flat and secured.

Sea Transport (IMDG Code):

- UN 1984, Class 2.2
- Marine pollutant: No
- Stowage category: A (may be stowed on deck or under deck)
- Keep away from heat sources. Maintain good ventilation.

Air Transport (ICAO/IATA DGR):

- UN 1984, Class 2.2
- Non-flammable, non-toxic gas
- Transportable on both passenger and cargo aircraft (subject to packaging quantity limits)

14.8 Transport Precautions

- Do not transport with oxidizers, reactive metals, or food chemicals.
- Transport vehicles should be equipped with appropriate fire extinguishing equipment and leak emergency handling equipment.
- Transport personnel must be specially trained and certified.
- Protect from sun exposure, rain, and high temperatures during transport. **Strictly control transport temperature not to exceed 25°C.**
- When stopping en route, keep away from fire, heat sources, and high-temperature areas.
- Vehicle exhaust pipes must be equipped with flame arresters.
- Load and unload gently to prevent damage to cylinders and accessories.

15 Regulatory Information

15.1 Chinese Regulations

- **Regulations on the Safe Management of Hazardous Chemicals** (State Council Order No. 591): Safety management of hazardous chemical production, storage, use, distribution, and transport
- **Catalogue of Hazardous Chemicals** (2015 Edition): Listed substance
- **Chemical Classification and Labeling Standards** (GB 30000 series): GHS classification and labeling standards
- **Safety Data Sheet for Chemical Products - Content and Order** (GB/T 16483-2008): SDS compilation standard

- **Regulations on the Safe Use of Chemicals in the Workplace** ([1996] Labor Ministry Document No. 423)
- **Occupational Exposure Limits for Hazardous Factors in the Workplace - Part 1: Chemical Hazardous Factors** (GBZ 2.1-2019)
- **Gas Cylinder Safety Technical Regulations** (TSG 23-2021)
- **Regulations on Road Transport of Dangerous Goods**
- **Production Safety Law of the People's Republic of China**
- **Law of the People's Republic of China on the Prevention and Control of Atmospheric Pollution:** Including greenhouse gas management
- **Law of the People's Republic of China on the Prevention and Control of Environmental Pollution by Solid Waste**
- **Regulations on the Management of Ozone-Depleting Substances:** Not a controlled substance (ODP=0), but must comply with HFC control regulations
- **Kigali Amendment to the Montreal Protocol on Substances that Deplete the Ozone Layer:** China has ratified. R23, as an HFC substance with extremely high GWP, is included in the control and phase-down schedule.

15.2 International Regulations

- **UN GHS (Globally Harmonized System of Classification and Labeling of Chemicals):** 8th Revised Edition
- **Montreal Protocol on Substances that Deplete the Ozone Layer:** Not a controlled ozone-depleting substance (ODP=0)
- **Kigali Amendment to the Montreal Protocol (2016):** R23, as an HFC substance with extremely high GWP (14,700), is included in the global HFC phase-down control. All parties must gradually reduce HFC production and consumption according to agreed schedules.
- **Kyoto Protocol / Paris Agreement:** Listed in the greenhouse gas inventory (HFC category). R23 receives special attention due to its extremely high GWP.
- **EU F-Gas Regulation (EU 517/2014):** R23 is listed as a controlled fluorinated greenhouse gas. Substances with GWP ≥ 150 are subject to strict control and quota restrictions. R23 (GWP=14,700) is classified as an extremely high-GWP substance facing phase-out.
- **EU REACH Regulation (EC 1907/2006):** Listed registered substance
- **EU CLP Regulation (EC 1272/2008):** Classification, labeling, and packaging regulation
- **U.S. EPA SNAP Program:** Approved for certain refrigeration and fire suppression applications, but restrictions are tightening.
- **U.S. AIM Act (American Innovation and Manufacturing Act):** Requires phased reduction of HFC production and use. R23 faces priority phase-down due to extremely high GWP.
- **U.S. OSHA HCS 2012:** Hazard Communication Standard
- **U.S. DOT 49 CFR:** Hazardous materials transport regulations

- **ADR/RID:** European Agreement concerning the International Carriage of Dangerous Goods by Road/Rail
- **IMDG Code:** International Maritime Dangerous Goods Code
- **IATA DGR:** International Air Transport Association Dangerous Goods Regulations

16

Other Information

16.1 References

- NIOSH Pocket Guide to Chemical Hazards
- International Chemical Safety Card (ICSC) No. 0577
- NOAA CAMEO Chemicals Database
- PubChem Compound Database (CID 6376)
- ASHRAE Handbook - Refrigeration Systems and Applications
- UNEP Ozone Secretariat - Kigali Amendment to the Montreal Protocol
- IPCC Fifth Assessment Report (AR5) - GWP data
- GB/T 16483-2008 "Safety Data Sheet for Chemical Products - Content and Order"
- GB 30000 series "Chemical Classification and Labeling Standards"
- UN "Globally Harmonized System of Classification and Labeling of Chemicals" (GHS) 8th Revised Edition

16.2 Abbreviations

Abbreviation	Full Name
SDS/MSDS	Safety Data Sheet / Material Safety Data Sheet
GHS	Globally Harmonized System of Classification and Labeling of Chemicals
CAS	Chemical Abstracts Service (Number)
UN	United Nations (Hazardous Goods Number)
ODP	Ozone Depletion Potential
GWP	Global Warming Potential
HFC	Hydrofluorocarbon
LC ₅₀	Lethal Concentration, 50%
LD ₅₀	Lethal Dose, 50%
TLV-TWA	Threshold Limit Value - Time-Weighted Average

PEL	Permissible Exposure Limit
SCBA	Self-Contained Breathing Apparatus
PBT	Persistent, Bioaccumulative, and Toxic
AIM Act	American Innovation and Manufacturing Act

16.3 Disclaimer

This Safety Data Sheet (SDS) is compiled in accordance with GB/T 16483-2008 and the UN GHS standard. It is intended to provide guidance on the safe use, handling, and disposal of the product. The information serves only as a safety operation guide and does not constitute a warranty of product specifications or performance. Users should assess its applicability based on specific use scenarios and local regulatory requirements, and take necessary safety precautions. The compiler assumes no legal liability for any direct or indirect losses arising from the use of the information in this document. The data in this document may be updated with new research findings and regulatory changes. It is recommended to regularly check for the latest version.