

THE LINDE GROUP

Linde

Gases & Applications



Foreword

This book – Gases and Applications – has been produced to give a brief insight into the broad range of applications our gases have. It also provides information on the different grades, or specifications, of the gases which are necessary to support these many applications. In addition, information is provided on typical gas mixtures and the applications they are used for.

New applications for gases and gas mixtures are continuously emerging as technologies develop and industries change. One important trend, however, is the need for higher specifications for the gases as applications become more exacting and sensitive to contaminants. This book concentrates on the higher specifications of gases that are now available. Your local Linde representative would be delighted to discuss these with you and provide you with more information.

Enjoy the read and we are happy to receive any feedback on our HiQ® website. (<http://hiq.linde-gas.com>)

The Linde Group
Merchant and Packaged Gases

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Introduction to the 2017 edition

The 2015 edition was revised to provide an insight into the range of gas purities that are offered by The Linde Group, particularly the specialty gases and chemical gases with their HiQ® branding.

The purity specifications for each gas were enhanced to provide typical purity and impurity data whilst new tables were added to indicate typical packages and equipment which could be expected to be available for these gases.

In the 2017 edition, we have expanded the book to include a section on typical gas mixtures offered by The Linde Group with information on the applications they are used for and recommendations on ancilliary equipment for each gas mixture.

Each gas and gas mixture is classified according to the Globally Harmonized System of Classification of Chemicals (GHS) currently being implemented by countries around the world, with the European GHS being taken as reference.

Disclaimer

Linde reserves the right to make alterations to specifications, quantities, etc., for production or other reasons, subsequent to publication.

The information contained herein has been prepared by qualified experts at Linde. While we believe that the information is accurate within the limits of the analytical methods employed, and complete to the extent of the specific analyses performed, we make no warranty or representation as to the suitability of the use of the information for any particular purposes.

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5) Transport hazard symbols

→ Hazard symbols for transportation of dangerous goods are based on the United Nations Recommendation. In this book the standards for the road transportation of gases applicable in Europe and the United States of America are shown as examples.

ADR symbols (EU standard)

Primary labels:



Non-combustible



Flammable



Toxic

Combination labels:



Non-combustible/Oxidising



Toxic/Oxidising



Toxic/Corrosive



Toxic/Flammable



Flammable/Self igniting



Toxic/Self igniting



Toxic/Oxidising/Corrosive



Toxic/Flammable/Corrosive

DOT symbols (US standard)

Primary labels:



Non-combustible



Flammable



Toxic

Combination labels:



Non-combustible/Oxidising



Toxic/Oxidising



Toxic/Corrosive



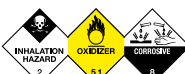
Toxic/Flammable



Flammable/Self igniting



Toxic/Self igniting



Toxic/Oxidising/Corrosive



Toxic/Flammable/Corrosive

→ Note that national and local laws and regulations regarding transport and packaging of hazardous materials must be followed at all times. The hazard symbols shown in this book may vary in certain regions and countries.

6) Globally Harmonized System (GHS)

→ According to the new Globally Harmonized System for Classification and Labelling of Chemicals (GHS) issued by the United Nations, the following pictograms are used to identify the hazards of substances and mixtures on the product information documents, i.e. package labels and safety data sheets:

Physical hazards



Explosive



Flammable



Oxidising



Gas under pressure



Corrosive

Health hazards



Toxic



Corrosive



Irritant/Sensitiser



Respiratory (and other)

Environmental hazards



Furthermore, a signal word (DANGER/WARNING) needs to be assigned; Hazard (H-) statements are replacing Risk (R-) phrases, and Precautionary (P-) statements are replacing Safety (S-) phrases. Appendix 02 shows a correspondence table between R-phrases and old EC symbols vs. the new S-statements and the new GHS symbols.

Transport of dangerous goods diamonds are not affected by the GHS. In the case of a single package, GHS pictograms may not be used if they duplicate transport of dangerous goods pictograms.

The European GHS entered into force on 20 January 2009 (Regulation No 1272/2008 on classification, labelling and packaging – called GHS-CLP in this book); all products shall be classified and labelled in accordance with GHS-CLP criteria:

- by 1 December 2010 for all pure substances,
- by 1 June 2015 for all mixtures.

In cases where GHS-CLP does not provide an official classification, the classification proposed by industry, i.e. by EIGA (European Industrial Gas Association) or the REACH Regulation is taken into consideration in this book.

7) Physical data

→ Physical data reproduced by permission of the Design Institute for Physical Properties (DIPPR), under the auspices of the American Institute of Chemical Engineers.

→ When nothing else is stated, the pressure is absolute.

8) International agreements

→ The Montreal Protocol (1987) on Substances that Deplete the Ozone Layer. This international agreement, signed by almost 200 countries, will lead to the eventual total phase-out of chlorofluorocarbons (CFC), halons, hydrobromofluorocarbons (HBFC), methyl chloroform, carbon tetrachloride, hydrochlorofluorocarbons (HCFC) and methyl bromide.

Total bans or production caps and import quotas now apply to all categories of ozone-depleting products (ODP) in all signatory developed countries.

In developing countries, high-ODP products are currently subject to control. Regulation of lower-ODP products is scheduled to apply by 2015.

Some territories (e.g. EU) have already imposed application-specific usage bans ahead of the Montreal Protocol schedule.

Certain exemptions apply for essential uses (e.g. laboratory, medical and military) and non-emissive applications (e.g. as feedstock in production processes).

- **The Kyoto Protocol (1997)** is an international Framework Convention on Climate Change with the objective of reducing greenhouse gases in an effort to prevent anthropogenic climate change.

The scope of the protocol covers a “basket of six” identified greenhouse gases: carbon dioxide, methane, nitrous oxide, sulfur hexafluoride, hydrofluorocarbons (HFC) and perfluorocarbons (PFC).

Some territories (e.g. EU) have already imposed tighter emissions limits and application-specific usage bans ahead of the Kyoto Protocol schedule. Other countries (e.g. USA) are considering limiting the production and import of some of the products covered by the Protocol.

Carbon dioxide is the baseline unit to which all other greenhouse gases are related. Therefore carbon dioxide has a Global Warming Potential (GWP) of 1.

- **The Rotterdam Convention (1998)** is a multilateral treaty to promote shared responsibility and cooperative efforts among parties in the international trade of certain hazardous chemicals. Its objectives are to protect human health and the environment from potential harm and to contribute to the environmentally sound use of these chemicals by facilitating information exchange about their characteristics, by providing for a national decision-making process on their import and export and by disseminating these decisions to the relevant parties.

Some territories have issued specific regulations to implement the requirements of the Convention, for example the PIC (Prior Informed Consent) Regulation in the EU.

9) Source and applications

- The application icons on the top right of the page summarise the applications the gas is used for. The source and applications paragraphs provide some examples of how the gases can be manufactured and used. See the “Application areas and product sources” paragraph for more details.
- In some geographies, certain applications may need to comply with specific regulatory requirements such as registration or authorisation. This is for example the case for gases used in medical applications or as pesticides and biocides.

Gas mixtures section

The typical gas mixtures section has a similar layout and information to the pure gas section except that there is one page per mixture rather than two pages and there are no physical properties tables. The typical packages and ancillary equipment tables in the pure gas section are replaced by a recommended ancilliary equipment table.

Appendix 01 – Material compatibility table

For most gas types, there are recommendations on suitable materials when selecting equipment. The information has been compiled from what Linde believes to be reliable sources (International Standards: Compatibility of cylinder and valve materials with gas content; Part 1: ISO 11114-1, Part 2: ISO 11114-2). The data must be used with caution. Raw data such as this cannot cover all conditions in relation to concentration, temperature, humidity, impurities and aeration. This table should be used as a guideline to choose possible materials, after which more extensive investigation and testing should be carried out under the specific conditions of use. The data mainly refers to high-pressure applications at ambient temperature and the safety aspect of material compatibility rather than the quality aspect. For more specific information and for information not contained in this book please contact your Linde representative.

Application areas and product sources

In this book we have divided the market into thirteen application areas. These areas are represented by icons placed beside the application text if the area is using the gas in question. The division is based on ISIC codes, and is therefore aligned with published statistics.

The applications mentioned in this book are examples of how the gases can be used. Gases find their ways into new application fields as the market grows and techniques become more refined. Therefore new applications evolve and old applications disappear. In this respect the book is a snapshot at the time of compilation.

Product sources given in this book are not exhaustive, but rather examples of common possible ways of producing the substances.

Note that purity levels and impurities shown on the left-hand pages are examples from our broad specialty gases range. Some applications might need a higher purity than mentioned and in other cases a lower purity may be sufficient for a certain application or process.

Linde can deliver most pure gases and a large variety of gas mixtures at all required purity levels. Please contact your local Linde representative or visit HiQ.Linde-Gas.com for our full range of HiQ® specialty gases.



AUTO



CHEM



CONSTR



ENERGY



FOOD



MANUF



MEDICAL



METAL



OEM



PETRO



PHARMA



R&D



SEMI

Cross reference register

AUTO, automotive and transport-related industries



AUTO

Acetylene	Ethene	Sulfur hexafluoride
Air, synthetic	Fluorine	Xenon
Ammonia	Helium	1% Oxygen, Balance Nitrogen
Argon	Methane	20 ppm Carbon Monoxide, Balance Air
n-Butane	Nitric oxide	450 ppb Nitric Oxide, Balance Nitrogen
iso-Butane	Nitrogen dioxide	450 ppb Nitrogen Dioxide, Balance Air
Carbon dioxide	Nitrous oxide	450 ppb Sulfur Dioxide, Balance Air
Carbon monoxide	Oxygen	5 ppm Ammonia, Balance Nitrogen
Carbonyl sulfide	Propane	3.4% Carbon Dioxide, 15.6% Nitrogen, Balance Helium
Epoxyethane	Propylene	
Ethane	Sulfur dioxide	

CHEM, chemical industries except petrochemical and pharmaceutical



CHEM

Acetylene	Dimethylamine	n-Pentane
Aminomethane	2,2-Dimethylpropane	iso-Pentane
Ammonia	Epoxyethane	Phosgene
Boron trichloride	Ethanamine	Phosphine
Boron trifluoride	Ethane	Propadiene
Bromoethene	Ethanedinitrile	Propane
1,3-Butadiene	Ethene	Propylene
n-Butane	Ethyl chloride	Propyne
iso-Butane	Ethyl formate	Silicon tetrachloride
1-Butene	Fluorine	Silicon tetrafluoride
cis-2-Butene	1,1,1,2,3,3,3-Heptafluoropropane	Sulfur dioxide
iso-Butene	Hexafluoroethane	2,3,3,3-Tetrafluoro-1-Propylene
trans-2-Butene	1,1,1,3,3,3-Hexafluoropropane	trans-1,3,3,3-Tetrafluoro-1-Propylene
1-Butyne	Hydrogen	Tetrafluoromethane
Carbon dioxide	Hydrogen bromide	Trichlorosilane
Carbon monoxide	Hydrogen chloride	Trifluoroethane
Carbon oxyfluoride	Hydrogen cyanide	Trimethylamine
Carbonyl sulfide	Hydrogen fluoride	Xenon
Chlorine	Hydrogen iodide	40% Hydrogen, Balance Helium
1-Chloro-1,1-difluoroethane	Hydrogen sulfide	10% Methane, Balance Argon
1-Chloro-1,2,2,2-tetrafluoroethane	Methane	5% Methane, Balance Argon
Chlorodifluoromethane	Methoxyethene	1% Oxygen, Balance Nitrogen
Chloroethene	Methoxymethane	20 ppm Carbon Monoxide, Balance Air
Chloropentafluoroethane	Methyl bromide	450 ppb Nitric Oxide, Balance Nitrogen
Cyanic chloride	Methyl chloride	450 ppb Nitrogen Dioxide, Balance Air
Cyclopentane	Methyl formate	450 ppb Sulfur Dioxide, Balance Air
Cyclopropane	Methyl mercaptan	90 ppm Methane, Balance Nitrogen
Deuterium	Nitric oxide	5 ppm Ammonia, Balance Nitrogen
Diborane	Nitrogen	5 µm ³ Mercury, Balance Nitrogen
1,1-Dichloro-1-fluoroethane	Nitrogen dioxide	10 ppm Hydrogen Sulphide, Balance Nitrogen
2,2-Dichloro-1,1,1-trifluoroethane	Nitrogen trifluoride	1.1% Propane, Balance Air
Dichlorodifluoromethane	Nitrous oxide	2.5% Methane, Balance Air
Dichlorosilane	Oxygen	2% Hydrogen, Balance Air
1,1-Difluoroethane	Pentafluoroethane	40% Hydrogen, Balance Nitrogen
1,1-Difluoroethene	1,1,1,3,3-Pentafluoropropane	

CONSTR, construction



CONSTR

Acetylene	Dichlorodifluoromethane	Octafluoropropane
Air, synthetic	1,2-Dichlorotetrafluoroethane	Oxygen
Ammonia	1,1-Difluoroethane	Pentafluoroethane
Argon	Dimethyl ether	1,1,1,3,3-Pentafluoropropane
n-Butane	Ethane	n-Pentane
iso-Butane	Ethyl chloride	iso-Pentane
Carbon Dioxide	Ethylene	Propane
1-Chloro-1,1-difluoroethane	Fluoromethane	Propylene
1-Chloro-1,2,2,2-tetrafluoroethane	Helium	Sulfur hexafluoride
Chlorodifluoroethane	1,1,1,2,3,3,3-Heptafluoropropane	2,3,3,3-Tetrafluoro-1-Propylene
Chlorodifluoromethane	Hexafluoroethane	trans-1,3,3,3-Tetrafluoro-1-Propylene
Chloroethene	1,1,1,3,3,3-Hexafluoropropane	Tetrafluoroethane
Chloropentafluoroethane	Krypton	Tetrafluoromethane
Cyclopentane	Methane	Trifluoroethane
1,1-Dichloro-1-fluoroethane	Methyl formate	Trifluoromethane
2,2-Dichloro-1,1,1-trifluoroethane	Nitrogen	Xenon

ENERGY, electricity, gas and water



ENERGY

Air, synthetic	Hydrogen	20 ppm Carbon Monoxide, Balance Air
Ammonia	Hydrogen sulfide	450 ppb Nitric Oxide, Balance Nitrogen
n-Butane	Methane	450 ppb Nitrogen Dioxide, Balance Air
iso-Butane	Nitric oxide	450 ppb Sulfur Dioxide, Balance Air
Carbon dioxide	Nitrogen	90 ppm Methane, Balance Nitrogen
Carbon monoxide	Nitrogen dioxide	5 ppm Ammonia, Balance Nitrogen
Carbonyl sulfide	Nitrous oxide	5 µm ³ Mercury, Balance Nitrogen
Chlorine	Octafluoropropane	10 ppm Hydrogen Sulphide, Balance Nitrogen
Chloroethene	Oxygen	1.1% Propane, Balance Air
Deuterium	Propane	2.5% Methane, Balance Air
Dichlorodifluoromethane	Propylene	2% Hydrogen, Balance Air
1,2-Dichlorotetrafluoroethane	Silicon tetrafluoride	Multi-component Hydrocarbon Mixture, Balance Methane
Ethane	Sulfur dioxide	
Helium	Sulfur hexafluoride	
Hexafluoroethane	1% Oxygen, Balance Nitrogen	

FOOD, food, beverages and agriculture



FOOD

Acetylene	Epoxyethane	Pentafluoroethane
Aminomethane	Ethanedinitrile	1,1,1,3,3-Pentafluoropropane
Ammonia	Ethane	n-Pentane
Argon	Ethyl formate	iso-Pentane
Bromoethene	1,1,1,2,3,3,3-Heptafluoropropane	Phosphine
iso-Butane	1,1,1,3,3,3-Hexafluoropropane	Propane
Carbon dioxide	Hydrogen	Sulfur dioxide
Carbon monoxide	Hydrogen cyanide	2,3,3,3-Tetrafluoro-1-Propylene
Carbonyl sulfide	Hydrogen fluoride	trans-1,3,3,3-Tetrafluoro-1-Propylene
1-Chloro-1,1-difluoroethane	Methane	Trifluoroethane
1-Chloro-1,2,2,2-tetrafluoroethane	Methyl bromide	40% Hydrogen, Balance Helium
Cyclopentane	Methyl formate	10% Methane, Balance Argon
1,1-Dichloro-1-fluoroethane	Methyl mercaptan	5% Methane, Balance Argon
2,2-Dichloro-1,1,1-trifluoroethane	Nitrogen	3.4% Carbon Dioxide, 15.6% Nitrogen, Balance Helium
Dichlorodifluoromethane	Nitrogen oxide	
Dimethylamine	Oxygen	

Cross reference register

MANUF, manufacturing industries except automotive and OEM



MANUF

Acetylene
Air, synthetic
Aminomethane
Ammonia
Argon
Boron trichloride
Bromoethene
n-Butane
iso-Butane
Carbon dioxide
Carbon monoxide
Chlorine
Chlorodifluoroethane
Chlorodifluoromethane
Chloroethene
Chloropentafluoroethane
Cyclopentane
Deuterium
Diborane
Dichlorodifluoromethane
Dichlorofluoromethane
1,2-Dichlorotetrafluoroethane
1,1-Difluoroethane
Difluoromethane
Dimethylamine
Epoxyethane
Ethane
Ethanedinitrile
Ethene
Ethyl chloride

Ethyl formate
Fluorine
Fluoromethane
Helium
Hexafluoroethane
Hydrogen
Hydrogen bromide
Hydrogen chloride
Hydrogen cyanide
Hydrogen fluoride
Hydrogen sulfide
Krypton
Methane
Methyl mercaptan
Methoxyethene
Methoxymethane
Methyl bromide
Methyl chloride
Methyl formate
Neon
Nitrogen
Nitrogen trifluoride
Nitrous oxide
Octafluoropropane
Oxygen
n-Pentane
iso-Pentane
Phosgene
Phosphine
Propane

Propylene
Silane
Silicon tetrachloride
Sulfur dioxide
Sulfur hexafluoride
trans-1,3,3,3-Tetrafluoro-1-Propylene
Tetrafluoroethane
Tetrafluoromethane
Trifluoromethane
Xenon
1% Oxygen, Balance Nitrogen
20 ppm Carbon Monoxide, Balance Air
450 ppb Nitric Oxide, Balance Nitrogen
450 ppb Nitrogen Dioxide, Balance Air
450 ppb Sulfur Dioxide, Balance Air
90 ppm Methane, Balance Nitrogen
5 ppm Ammonia, Balance Nitrogen
5 µm³ Mercury, Balance Nitrogen
10 ppm Hydrogen Sulphide, Balance Nitrogen
1.1% Propane, Balance Air
2.5% Methane, Balance Air
2% Hydrogen, Balance Air
3.4% Carbon Dioxide, 15.6% Nitrogen, Balance Helium
5% Fluorine, Balance Helium
40% Hydrogen, Balance Nitrogen
Multi-component Hydrocarbon Mixture, Balance Methane

MEDICAL, hospitals and healthcare



MEDICAL

Acetylene
Air, synthetic
Argon
Carbon dioxide
Carbon monoxide
Cyclopropane
Deuterium
Epoxyethane
Ethene
Ethyl chloride

Helium
1,1,1,2,3,3,3-Heptafluoropropane
Krypton
Methyl chloride
Neon
Nitric oxide
Nitrogen
Nitrous oxide
Octafluoropropane
Oxygen

Sulfur hexafluoride
Trimethylamine
Xenon
5% Fluorine, Balance Helium
0.25% Carbon Monoxide, 18% Helium, 21% Oxygen, Balance Nitrogen
10% Carbon Dioxide, 10% Hydrogen, Balance Nitrogen
5% Carbon Dioxide, Balance Oxygen

METAL, metal industries



METAL

Air, synthetic
Ammonia
Argon
Boron trichloride
Boron trifluoride
Bromoethene
iso-Butane
Carbon dioxide
Carbon monoxide
Chlorine
Diborane
Dimethylamine
Ethane

Fluorine
Helium
Hydrogen
Hydrogen chloride
Hydrogen fluoride
Hydrogen sulfide
Methane
Methyl chloride
Nitrogen
Nitrogen trifluoride
Oxygen
Propane
Silicon tetrachloride

Silicon tetrafluoride
Sulfur dioxide
Sulfur hexafluoride
10% Methane, Balance Argon
5% Methane, Balance Argon
1.1% Propane, Balance Air
2.5% Methane, Balance Air
2% Hydrogen, Balance Air
3.4% Carbon Dioxide, 15.6% Nitrogen, Balance Helium
40% Hydrogen, Balance Nitrogen
Multi-component Hydrocarbon Mixture, Balance Methane

OEM, original analytical equipment manufacturers



OEM

Acetylene
Air, synthetic
Ammonia
Argon
n-Butane
iso-Butane
Carbon dioxide
Carbon monoxide
2,2-Dimethylpropane
Helium
Hydrogen
Hydrogen cyanide
Krypton
Methane
Neon
Nitric oxide
Nitrogen
Nitrogen dioxide

Nitrous oxide
Oxygen
Propane
Sulfur Hexafluoride
Xenon
5 ppm Ammonia, Balance Nitrogen
3.4% Carbon Dioxide, 15.6% Nitrogen, Balance Helium
40% Hydrogen, Balance Helium
10% Methane, Balance Argon
5% Methane, Balance Argon
1% Oxygen, Balance Nitrogen
20 ppm Carbon Monoxide, Balance Air
450 ppb Nitric Oxide, Balance Nitrogen
450 ppb Nitrogen Dioxide, Balance Air
450 ppb Sulfur Dioxide, Balance Air
90 ppm Methane, Balance Nitrogen
5 ppm Ammonia, Balance Nitrogen

5 µm³ Mercury, Balance Nitrogen
10 ppm Hydrogen Sulphide, Balance Nitrogen
1.1% Propane, Balance Air
2.5% Methane, Balance Air
2% Hydrogen, Balance Air
3.4% Carbon Dioxide, 15.6% Nitrogen, Balance Helium
5% Fluorine, Balance Helium
0.25% Carbon Monoxide, 18% Helium, 21% Oxygen, Balance Nitrogen
10% Carbon Dioxide, 10% Hydrogen, Balance Nitrogen
5% Carbon Dioxide, Balance Oxygen
40% Hydrogen, Balance Nitrogen
Multi-component Hydrocarbon Mixture, Balance Methane

PETRO, petrochemical industries



PETRO

Acetylene
Aminomethane
Ammonia
Boron trichloride
Boron trifluoride
Bromoethene
1,3-Butadiene
n-Butane
iso-Butane
1-Butene
cis-2-Butene
iso-Butene
trans-2-Butene
1-Butyne
Carbon dioxide
Carbon monoxide
Chlorine
1-Chloro-1,1-difluoroethane
1-Chloro-1,2,2-tetrafluoroethane
Chlorodifluoromethane
Cyclopentane
Cyclopropane
Diborane
1,1-Dichloro-1-fluoroethane
2,2-Dichloro-1,1,1-trifluoroethane
1,1-Difluoroethane
1,1-Difluoroethene
Dimethylamine
2,2-Dimethylpropane

Epoxyethane
Ethanamine
Ethane
Ethene
Ethyl chloride
Fluorine
1,1,1,2,3,3,3-Heptafluoropropane
Hexafluoroethane
1,1,1,3,3,3-Hexafluoropropane
Hydrogen
Hydrogen bromide
Hydrogen chloride
Hydrogen fluoride
Hydrogen sulfide
Methane
Methoxyethene
Methoxymethane
Methyl bromide
Methyl chloride
Methyl formate
Methyl mercaptan
Nitric oxide
Nitrogen
Oxygen
Pentafluoroethane
1,1,1,3,3-Pentafluoropropane
n-Pentane
iso-Pentane
Phosgene

Propadiene
Propane
Propylene
Propyne
Sulfur dioxide
2,3,3,3-Tetrafluoro-1-Propylene
trans-1,3,3,3-Tetrafluoro-1-Propylene
Tetrafluoroethane
Trifluoroethane
Trimethylamine
40% Hydrogen, Balance Helium
10% Methane, Balance Argon
5% Methane, Balance Argon
1% Oxygen, Balance Nitrogen
20 ppm Carbon Monoxide, Balance Air
450 ppb Nitric Oxide, Balance Nitrogen
450 ppb Nitrogen Dioxide, Balance Air
450 ppb Sulfur Dioxide, Balance Air
90 ppm Methane, Balance Nitrogen
Methyl formate
5 µm³ Mercury, Balance Nitrogen
10 ppm Hydrogen Sulphide, Balance Nitrogen
1.1% Propane, Balance Air
2.5% Methane, Balance Air
2% Hydrogen, Balance Air
40% Hydrogen, Balance Nitrogen
Multi-component Hydrocarbon Mixture, Balance Methane

Cross reference register

PHARMA, pharmaceutical industries



PHARMA

Air, synthetic	Hydrogen	Phosgene
Aminomethane	Hydrogen bromide	Propadiene
Ammonia	Hydrogen chloride	Propane
Argon	Hydrogen cyanide	Propylene
Boron trichloride	Hydrogen sulfide	Propyne
Boron trifluoride	Methane	Sulfur dioxide
Bromoethene	Methoxymethane	Tetrafluoroethane
Carbon dioxide	Methyl bromide	Trimethylamine
Carbonyl sulfide	Methyl chloride	40% Hydrogen, Balance Helium
Dimethylamine	Methyl formate	10% Methane, Balance Argon
Epoxyethane	Methyl mercaptan	5% Methane, Balance Argon
Ethanamine	Nitrogen	10% Carbon Dioxide, 10% Hydrogen, Balance Nitrogen
Ethyl formate	Nitrous oxide	5% Carbon Dioxide, Balance Oxygen
1,1,1,2,3,3,3-Heptafluoropropane	Oxygen	

R&D, research institutes and universities



R&D

All gases and gas mixtures are used or can be used for research.

SEMI, semiconductor industries



SEMI

Acetylene	Fluoromethane	Nitrous oxide
Ammonia	Helium	Octafluoropropane
Argon	Hexafluoroethane	Oxygen
Arsine	Hydrogen	Phosphine
Boron trichloride	Hydrogen bromide	Silane
Boron trifluoride	Hydrogen chloride	Silicon tetrachloride
Carbon dioxide	Hydrogen fluoride	Silicon tetrafluoride
Chlorine	Hydrogen iodide	Sulfur hexafluoride
Chloropentafluoroethane	Hydrogen sulfide	Tetrafluoromethane
Deuterium	Krypton	Trichlorosilane
Diborane	Methyl chloride	Trifluoromethane
Dichlorosilane	Neon	Xenon
1,2-Dichlorotetrafluoroethane	Nitric oxide	10% Methane, Balance Argon
Difluoromethane	Nitrogen	5% Methane, Balance Argon
Fluorine	Nitrogen trifluoride	5% Fluorine, Balance Helium

Acetylene C_2H_2

Ethyne

CAS: 74-86-2
EC: 200-816-9
UN: 1001

Purity grade	Typical purity	Typical impurities [ppm]		
		Air	PH_3	H_2S
HiQ® Acetylene 2.6 AAS	≥99.6 %	≤4,000	≤5	≤1

Typical filling pressure: 15 °C: 15 bar(g)/ 70 °F: 250 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•	•				

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
•	•		Consult local team

Characteristics

Flammable. Colourless gas with ether-like odour when very pure, otherwise garlic-like. Supplied dissolved in acetone or DMF (n,n-dimethylmethanamide). Can decompose instantaneously at pressures higher than 1 bar. Acetylene can be delivered as a non-dissolved gas for specific R&D applications. Gas density is slightly lighter than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

GHS-CLP

Signal word: DANGER



H-statements:

Dissolved Gas → H280 – Contains gas under pressure; may explode if heated; H220 – Extremely flammable gas; H230 – May react explosively even in the absence of air.

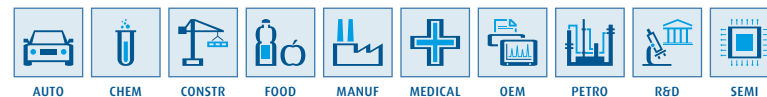
Transport of dangerous goods



ADR Class 2, 4F



DOT Class 2.1



Source

Acetylene is manufactured commercially by reaction between calcium carbide and water, and as a by-product of ethylene production.

Applications

Acetylene is used as a raw material for the production of electrically conducting plastics, such as polyacetylene.

Acetylene is used with high purity synthetic air or nitrous oxide as a fuel for the flame in atomic absorption flame spectroscopy. This is used in water, soil, food and biological research laboratories where sensitivity and accuracy of results are important.

Acetylene is most commonly used in combination with oxygen for cutting or welding materials such as mild steel, where the standard industrial grade is sufficient. Acetylene with low phosphine levels is required for lead brazing or welding.

Acetylene is used in organic synthesis (laboratory work) as well as in chemical synthesis.

Acetylene is used as carbon source in the production of molecules like fullerenes; well-known examples are buckyballs or carbon nanotubes.

Acetylene is used in the cultivation of plants; it improves the formation of new flowers.

Acetylene is used as a component in calibration gases for the gas, oil and chemical industries.

Acetylene is still used in some lighthouses as light fuel source.

Acetylene is one of the components of lung testing gases.

This unsaturated hydrocarbon exhibits high chemical reactivity, and is an important intermediate in the chemical industry. It is employed for the production of:

- acetaldehyde
- acrylic acids
- acrylic ethers
- acrylonitrile
- carbazole
- butenyne (vinyl acetylene)
- chloroethene (vinyl chloride)
- diols
- ethene
- ethenoxyethenes (vinyl ethers)
- ethenyl acetate (vinyl acetate)
- ethenyl amides (vinyl amides)
- ethenyl sulfides (vinyl sulfides)
- neoprene
- phenylethene (styrene)
- polyoxymethylene
- pyrrolidine
- trichloroethene
- very fine carbon black, called “acetylene black”.

Physical data

Molecular weight	26.038			
Boiling point	at 1.013 bar [°C]	-84.15	at 14.5 psi [°F]	-241.17
Density	at 1.013 bar, 15 °C [kg/m ³]	1.109	at 1 atm., 70 °F [lb/ft ³]	0.068
Vapour pressure	at 0 °C [bar]	26.4	at 32 °F [psi]	382.9
	at 20 °C [bar]	43.41	at 70 °F [psi]	646.21
Flammability range in air [% volume]	2.3 – 88.0			

Air, synthetic

80 % N₂ + 20 % O₂
Synthetic air

CAS: 132259-10-0
EC: not available
UN: 1002

Purity grade	Purity	Impurities [ppm]									Legend: N/D = Not Detectable
		H ₂ O	C _n H _m	CO	CO ₂	NO _x	SO ₂	NO + NO ₂	Oil	Odour	
HiQ® Air 4.0	≥99.99 %	≤5	-	-	-	-	-	-	-	-	-
HiQ® Synthetic Air 5.0	≥99.999 %	≤5	≤1	-	-	-	-	-	-	-	-
HiQ® Synthetic Air 5.0	≥99.999 %	≤3	≤0.2	≤1	≤1	-	-	-	-	-	-
Zero											
HiQ® Synthetic Air 5.5	≥99.9995 %	≤2	≤0.1	≤1	≤1	-	-	-	-	-	-
HiQ® Synthetic Air 5.5	≥99.9995 %	≤1	≤0.1	≤0.5	≤1	≤0.1	≤0.1	-	-	-	-
CEM Zero											
HiQ® Synthetic Air	≥99.999 %	≤5	≤1	≤1	≤1	≤0.1	-	-	-	-	-
Euro 6 Raw											
HiQ® Synthetic Air	≥99.999 %	≤0.5	≤0.05	≤0.1	≤0.1	≤0.02	-	-	-	-	-
Euro 6 Dilute											
VERISEQ® Process Synthetic Air (pharmaceutical grade)	≥99.5 %	≤67	-	≤10	≤500	-	≤5	≤2.5	≤0.1 mg/m ³	N/D	

Typical filling pressure: 15 °C: 200 bar(g)/ 70 °F: 2800 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•	•				

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
•	•		Consult local team

Characteristics

-

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

GHS-CLP

Substance not classified as hazardous.

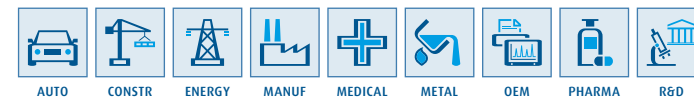
Transport of dangerous goods



ADR Class 2, 1A



DOT Class 2.2



Source

Synthetic air is produced by mixing pure oxygen (20 %) and pure nitrogen (80 %). This eliminates all kind of impurities present in normal ambient air.

Applications

Synthetic air is used as a source of oxygen for well defined industrial oxidation processes.

Synthetic air is used as zero gas in the running and calibration of environmental monitoring and test measurements where levels of sulphur and nitric oxides can affect the measurement equipment.

Synthetic air is used in medical gas mixtures. Medical air may be classified as medical gas in some geographies and managed according to the relevant regulations.

Synthetic air is regularly used as the oxidiser for flame ionisation detectors in chromatography and total hydrocarbon analysers.

Synthetic air is used together with acetylene in atomic absorption flame spectrometry.

Synthetic air is used as a balance gas for many calibration gases.

Physical data

Molecular weight	28.975			
Boiling point	at 1.013 bar [°C]	-194.3	at 14.5 psi [°F]	-317.8
Density	at 1.013 bar, 15 °C [kg/m ³]	1.21	at 1 atm., 70 °F [lb/ft ³]	0.075
Vapour pressure	at 0 °C [bar]	-	at 32 °F [psi]	-
	at 20 °C [bar]	-	at 70 °F [psi]	-
Flammability range in air [% volume]	Non combustible			

Ammonia NH₃

R-717

CAS: 7664-41-7
 EC: 231-635-3
 UN: 1005
 R-717

Purity grade	Typical purity	Typical impurities [ppm]							
		H ₂ O	O ₂	N ₂	CO	CO ₂	C _n H _m	Fe	Oil
Ammonia 3.8	≥99.98 %	≤200	-	-	-	-	-	-	≤10 % (w)
HiQ® Ammonia 4.5	≥99.995 %	≤5	≤5	≤30	≤5	≤1	≤2	-	-
HiQ® Ammonia 5.0	≥99.999 %	≤1	≤1	≤4	≤1	≤1	≤1	-	-
HiQ® Ammonia 6.0	≥99.9999 %	≤0.2	≤0.1	≤0.5	≤0.1	≤0.2	≤0.1	≤0.1	-

Typical filling pressure: 15 °C: 7.3 bar(g)/70 °F: 114 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•		•			•

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
Gaseous Withdrawal	Gaseous Withdrawal	Liquid Withdrawal	Consult local team

Characteristics

Colourless flammable liquefied gas with a penetrating and suffocating odour. Gas Density is lighter than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

GHS-CLP

Signal word: DANGER



H-statements:

Liquefied Gas → H280 – Contains gas under pressure; may explode if heated; H221 – Flammable gas; H331 – Toxic if inhaled; H314 – Causes severe skin burns and eye damage; EUH071 – Corrosive to the respiratory tract; H400 – Very toxic to aquatic life.

Transport of dangerous goods



ADR Class 2, 2TC



DOT Class 2.3



Source

Ammonia is manufactured by the Haber-Bosch process, consisting of a direct reaction between hydrogen and nitrogen in the molar ratio 3:1.

Applications

Anhydrous ammonia is one of the oldest commercial refrigerants known. It is used in both absorption and compression type systems. It has the ASHRAE number R-717. It is used extensively in soil fertilisation. In this application it is used in the form of ammonia, ammonia nitrates and urea salts. It is also added to fertilisers containing superphosphates and in making nitrogen-containing solutions which consist of ammonia and ammonium nitrate, or urea, or both in water. Anhydrous ammonia is applied to the soil by direct injection or by addition to irrigation water. Anhydrous ammonia is also used in combination with chlorine to purify municipal and industrial water supplies.

Ammonia, or rather dissociated ammonia, is used in such metal treating operations as nitriding, carbo-nitriding, bright annealing, furnace brazing, sintering, sodium hydride descaling, atomic hydrogen welding, and other applications. It is used in extracting such metals as copper, nickel and molybdenum from their ores. It is also used to reduce the atmosphere in heat treatment of metals and for the fabrication of silicon nitride.

Dissociated ammonia is also used as a convenient source of hydrogen for the hydrogenation of fats and oils. Through the controlled combustion of dissociated ammonia in air, a source of pure nitrogen is achieved.

The petroleum industry utilises anhydrous ammonia in neutralising the acid constituents of crude oil, thus protecting equipment such as bubble plate towers, heat exchangers, condensers and storage tanks from corrosion.

Higher purity grades of ammonia are produced with the help of distillation processes

Ammonia can be oxidised to nitric oxide, which is converted to nitrogen dioxide to yield nitric acid in a second reaction step (Ostwald process).

In the lead chamber process for manufacturing sulfuric acid, ammonia is oxidised to nitrogen oxides, which are needed to convert sulfur dioxide to sulfuric acid.

Most industrial and military explosives of the conventional types contain nitrogen, with ammonia as the basic source of nitrogen in their production.

As a processing agent, ammonia is used in the manufacturing of alkalis, ammonium salts, dyes, pharmaceuticals, cuprammonium rayon and nylon.

Ammonia:

- is used in the production of hydrogen cyanide.
- is a reagent in copying machines (blue print and micro film).
- is also used to produce proteins and can be used to improve the protein content of low quality hay.
- is used as a component in calibration gas mixtures for gas detection systems as well as environmental emission monitoring.
- is widely used in the semiconductor industry.
- is used in the production of blue and white LEDs (Light Emitting Diodes).
- can be used to neutralise nitric oxides emitted by diesel engines by selective catalytic reduction.
- is used as a chemical agent in CG-MS analytical equipment.

Physical data

Molecular weight	17.031			
Boiling point	at 1.013 bar [°C]	-33.43	at 14.5 psi [°F]	-241.17
Density	at 1.013 bar, 15 °C [kg/m ³]	0.728	at 1 atm., 70 °F [lb/ft ³]	0.044
Vapour pressure	at 0 °C [bar]	4.29	at 32 °F [psi]	62.21
	at 20 °C [bar]	8.55	at 70 °F [psi]	128.51
Flammability range in air [% volume]	15.0 – 30.0			

Argon Ar

CAS: 7440-37-1
 EC: 231-147-0
 UN: 1006 (Compressed)
 UN: 1951 (Refrigerated liquid)
 R-740

Purity grade	Purity	Impurities [ppm]								
		H ₂ O	O ₂	C _n H _m	CO	CO ₂	N ₂	H ₂	CH ₄	Halocarbons
HiQ® Argon 4.8	≥99.998 %	≤5	≤5	-	-	-	≤10	-	-	-
HiQ® Argon 5.0	≥99.999 %	≤3	≤2	≤0.5	-	-	≤5	-	-	-
HiQ® Argon 5.0 Zero	≥99.999 %	≤3	≤2	≤0.2	≤1	≤1	≤5	-	-	-
HiQ® Argon 6.0	≥99.9999 %	≤0.5	≤0.5	≤0.1	≤0.1	≤0.1	≤0.5	≤0.5	-	-
HiQ® Argon 7.0	≥99.99999 %	≤50	≤30	≤30	≤30	≤30	-	≤30	-	≤1
		ppb	ppb	ppb	ppb	ppb		ppb		ppb
VERISEQ® Process Argon (pharmaceutical grade)	≥99.998 %	≤0.5	≤5	-	-	-	≤10	-	≤1	-

Typical filling pressure: 15 °C: 200 bar(g)/ 70 °F: 2,800 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•	•				Cryogenic liquid

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
•	•	Cryogenic liquid	Consult local team

Characteristics

Colourless and odourless gas. Non-reactive. Inert. Asphyxiant in high concentrations. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

Proposed by the Industry

Signal word: WARNING



H-statements:

Compressed Gas → H280 – Contains gas under pressure; may explode if heated; Refrigerated Gas → H281 – Contains refrigerated gas; may cause cryogenic burns or injury; EIGA-As – Asphyxiant in high concentrations.

Transport of dangerous goods



ADR Class 2, 1A (Compressed)
 3A (Refrigerated liquid)



DOT Class 2.2



Source

The most common source of argon is an air separation plant. Air contains approx. 0.93% (vol.) argon. A crude argon stream containing up to 5% oxygen is removed from the main air separation column via a secondary ("side-arm")

Applications

Argon is one of the most common carrier gases in gas chromatography. Argon is used as a carrier gas in sputtering, plasma etching and ion implantations, and as a blanket atmosphere in crystal growth.

Argon is also the choice gas for ICP spectroscopy (Inductively Coupled Plasma spectroscopy).

One of the most common applications of argon, either pure or in various mixtures, is as a shielding gas for arc welding.

Many Geiger-counting tubes contain argon or argon mixed with organic vapours or other gases, for example 10% methane in argon.

Argon is one of the principal gases used for filling incandescent (filament) lamps, generally in a mixture with nitrogen, krypton or neon, for phosphorescent tubes in mixtures with neon, helium and mercury vapour and for thyratron radio tubes, in mixtures with neon.

The argon-oxygen decarburising (AOD) process is the most common method of refining stainless steel, and uses large quantities of both gases supplied either in liquid form or via pipeline from an on-site plant.

The pharmaceutical industry uses argon to displace oxygen in the top of intravenous drug containers, extending product shelf-life

Liquid argon is used in cryosurgery, e.g. cryoablation to destroy cancer cells.

Physical data

Molecular weight	39.948			
Boiling point	at 1.013 bar [°C]	-185.87	at 14.5 psi [°F]	-352.55
Density	at 1.013 bar, 15 °C [kg/m ³]	1.691	at 1 atm., 70 °F [lb/ft ³]	0.103
Vapour pressure	at 0 °C [bar]	-	at 32 °F [psi]	-
	at 20 °C [bar]	-	at 70 °F [psi]	-
Flammability range in air [% volume]	Non combustible			

column. The crude argon is then further purified to produce the various commercial grades required. Argon may also be recovered from the exhaust streams of certain ammonia plants.

Argon, R-740, is used in gas mixtures for non-CFC ultra-low temperature refrigeration applications.

Argon:

- is used in atomic absorption spectrometry as a blanket gas in the graphite furnace.
- is used in blends with, for example, fluorine and helium in excimer lasers.
- is used as an insulation gas in high-efficiency multi-pane windows to improve thermal insulation.
- is used in the iron and steel industry to prevent oxidation of molten metals and alloys and for degassing and desulphurization of molten steel and iron baths.
- is used, often in a mixture with hydrogen, as a protective atmosphere for the heat treatment of certain metals, particularly those which are susceptible to nitriding when treated in a nitrogen-based atmosphere. This includes stainless steels and many different specialised and therefore small-scale applications.
- is used for wine preservation to eliminate air by the heavier argon, to prevent oxidation and extend the product quality for opened bottles and barrels.
- is, sometimes in combination with nitrogen, used to inflate airbags.
- is used, often in combination with nitrogen and/or carbon dioxide, as a clean fire extinguishing gas, since the inert properties do not damage any materials extinguished.
- is used in laboratory as purge gas or balance gas in gas mixtures.

Arsine AsH₃

CAS: 7784-42-1
EC: 232-066-3
UN: 2188

Purity grade	Typical purity	Typical impurities [ppm]						
		O ₂	N ₂	CO	CO ₂	C _n H _m	H ₂ O	PH ₃
HiQ® Arsine 5.0	≥99.999 %	≤1	≤3	≤1	≤1	≤1	≤2	≤0.1

Typical filling pressure: 15 °C: 13.5 bar(g)/70 °F: 204.6 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•					

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
•	•		Consult local team

Characteristics

Flammable. Toxic substance is formed with combustion. Colourless, liquefied gas with garlic-like odour. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

GHS-CLP

Signal word: DANGER



H-statements:

Liquefied Gas → H280 – Contains gas under pressure; may explode if heated; H220 – Extremely flammable gas; H330 – Fatal if inhaled; H373 – May cause damage to upper and lower respiratory tract through prolonged or repeated inhalation; H410 – Very toxic to aquatic life with long lasting effects.

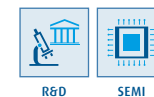
Transport of dangerous goods



ADR Class 2, 2TF



DOT Class 2.3



Source

Arsine is commercially produced by the reaction of zinc arsenide and sulfuric acid. The crude arsine produced by

this reaction is purified by a combination of distillation and catalytic absorption of the impurities.

Applications

Arsine is used in conjunction with organometallic compounds and as carrier gas in the epitaxial growth of compound semiconductors. In a Chemical Vapour Deposition (CVD) arsine reacts with trimethyl gallium to produce gallium arsenide (GaAs). It is also used for n-type doping of silicon-based semiconductors.

Arsine is commonly used in the production of solar cells, in MOCVD (Metal Organic Chemical Vapour Deposition) applications.

Arsine is also used in the production of electroluminescent diodes.

Physical data

Molecular weight	77.945			
Boiling point	at 1.013 bar [°C]	-62.48	at 14.5 psi [°F]	-80.44
Density	at 1.013 bar, 15 °C [kg/m ³]	3.334	at 1 atm., 70 °F [lb/ft ³]	0.204
Vapour pressure	at 0 °C [bar]	9.02	at 32 °F [psi]	130.9
	at 20 °C [bar]	14.74	at 70 °F [psi]	219.32
Flammability range in air [% volume]	3.9 – 77.8			

Boron trichloride BCl₃

CAS: 10294-34-5
EC: 233-658-4
UN: 1741

Purity grade	Typical purity	Typical impurities [ppm]							phosgene
		O ₂	N ₂	CO	CO ₂	C _n H _m	Fe	Cl ₂	
HiQ® Boron trichloride 3.0	≥99.9 %	-	-	-	-	-	-	≤100 % (w)	≤200 % (w)
HiQ® Boron trichloride 4.0	≥99.99 %	≤5	≤50	≤5	≤50	≤5	-	-	-
HiQ® Boron trichloride 5.0	≥99.999 %	≤1	≤2	≤1	≤5	≤1	≤0.2 % (w)	-	-

Typical filling pressure: 15 °C: 0.3 bar(g)/70 °F: 5.2 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•					

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
•	•		Consult local team

Characteristics

Liquefied gas, decomposes in water to hydrogen chloride and boric acid. Forms white fumes in humid air. Pungent odour. Highly corrosive. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

GHS-CLP

Signal word: DANGER



H-statements:

Liquefied Gas → H280 – Contains gas under pressure; may explode if heated; EUH014 – Reacts violently with water; H330 – Fatal if inhaled; H300 – Fatal if swallowed; H314 – Causes severe skin burns and eye damage; EUH071 – Corrosive to the respiratory tract.

Transport of dangerous goods



ADR Class 2, 2TC



DOT Class 2.3



Source

Boron trichloride is produced by reacting together one of the following sets of ingredients. In each case the reaction requires elevated temperatures:

- industrially produced in a direct reaction of carbon, boron oxide and chlorine at 500°C
- boric oxide plus the chloride of either sodium, potassium or lithium
- sodium boronfluoride plus magnesium chloride
- boron carbide plus chlorine.

Applications

Boron trichloride is used as a chemical reagent in the pharmaceutical industry.

Boron trichloride is used as a source of boron for p-type doping of silicon by thermal diffusion or ion implantation. It is also used for dry plasma etching of aluminium and its alloys.

Boron trichloride is used in refining metals such as aluminium, magnesium, zinc and copper alloys. By bubbling the gas through these molten metal nitrides, carbides and oxides are removed. The same technique is used to clean up castings of these metals. In this case occluded gases such as nitrogen, hydrogen and carbon monoxide are also removed from the casting.

Boron trichloride may be used in the production of optical fibres.

Boron trichloride is the starting material for the production of boron nitride, used as a refractory coating on such articles as crucibles etc.

Boron trichloride is used as a carrier gas, as a catalyst in organic reactions, and for manufacturing of electrical resistors.

Boron trichloride is also used as a starting material in the generation of elemental boron.

Boron trichloride is also used as a chemical in plasma etching of metals, such as stainless steel, copper alloys, and tungsten.

Boron trichloride plays a role in the manufacture of high energy fuels and rocket propellants to raise the Gross Calorific Value.

Physical data

Molecular weight	117.17			
Boiling point	at 1.013 bar [°C]	12.5	at 14.5 psi [°F]	54.52
Density	at 1.013 bar, 15 °C [kg/m ³]	5.162	at 1 atm., 70 °F [lb/ft ³]	0.315
Vapour pressure	at 0 °C [bar]	0.63	at 32 °F [psi]	9.09
	at 20 °C [bar]	1.33	at 70 °F [psi]	19.91
Flammability range in air [% volume]	Non combustible			

Boron trifluoride BF_3

CAS: 7637-07-2
EC: 231-569-5
UN: 1008

Purity grade	Typical purity	Typical impurities [ppm]		
		SiF_4	$\text{O}_2 + \text{N}_2$	$\text{SO}_2 + \text{SO}_3$
HiQ® Boron trifluoride 2.5	≥99.5 %	≤1,000	≤4,000	≤200

Typical filling pressure: 15 °C: 63 bar(g)/70 °F: 1200 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•					

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
•	•		Consult local team

Characteristics

Pungent odour. Highly corrosive. Forms white fumes in humid air. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

GHS-CLP

Signal word: DANGER



H-statements:

Liquefied Gas → H280 – Contains gas under pressure; may explode if heated; EUH014 – Reacts violently with water; H330 – Fatal if inhaled; H314 – Causes severe skin burns and eye damage; EUH071 – Corrosive to the respiratory tract; H373 – May cause damage to kidney through prolonged or repeated inhalation.

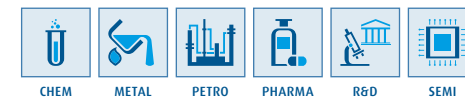
Transport of dangerous goods



ADR Class 2, 2TC



DOT Class 2.3



Source

Boron trifluoride is prepared by the reaction of a boron-containing material with a fluorine-containing substance in the presence of an acid. The traditional method uses borax, fluorspar and sulfuric acid.

Another process for manufacturing boron trifluoride is to treat fluorosulfonic acid with boric acid.

Applications

Boron trifluoride is used as a catalyst in organic synthesis for: isomerisation, alkylation, polymerisation, esterification, halogenation, sulfonation, condensation and nitration.

Boron trifluoride initiates polymerisation reactions of unsaturated compounds such as polyethers.

Boron trifluoride is used as a catalyst in the Friedel-Crafts-type reaction, in the synthesis of saturated hydrocarbons, olefins and alcohols.

Boron trifluoride is also used as a dopant in ion implantation. In the semiconductor industry, the boron atom functions as a p-type dopant in epitaxially grown silicone.

Boron trifluoride is used as a protective atmosphere for molten magnesium.

Other niche uses are found in fumigation, in soldering magnesium, in the production of diborane or in ionisation chambers as a sensitive neutron detector.

Physical data

Molecular weight	67.806			
Boiling point	at 1.013 bar [°C]	-99.8	at 14.5 psi [°F]	-147.62
Density	at 1.013 bar, 15 °C [kg/m ³]	2.882	at 1 atm., 70 °F [lb/ft ³]	0.176
Vapour pressure	at 0 °C [bar]	-	at 32 °F [psi]	-
	at 20 °C [bar]	-	at 70 °F [psi]	-
Flammability range in air [% volume]	Non combustible			

Bromoethylene C_2H_3Br

Bromoethene, Vinyl bromide

CAS: 593-60-2
EC: 209-800-6
UN: 1085

Purity grade	Typical purity	Typical impurities [ppm]
Bromoethene	on request	contact local team

Typical filling pressure: 15 °C: 0.2 bar(g)/70 °F: 3 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•					

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
•	•		Consult local team

Characteristics

Flammable. Liquefied, colourless gas with an ethereal odour. Stable, but may polymerise in sunlight. Reacts violently with all types of oxidiser. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

GHS-CLP

Signal word: DANGER



H-statements:

Liquefied Gas → H280 – Contains gas under pressure; may explode if heated; H220 – Extremely flammable gas; H350 – May cause cancer; H231 – May react explosively even in absence of air at elevated pressure and/or temperature.

Transport of dangerous goods



ADR Class 2, 2F



DOT Class 2.1



Source

Bromoethylene is produced in a reaction of acetylene, hydrogen bromide and higher brominated compounds in the presence of a contact catalyst.

Other generation routes are

- distilling a mixture of hydrogen bromide, ethyl alcohol and sulfuric acid, with the phosphorus and bromine method.
- refluxing ethanol with hydrobromic acid, or with an alkali bromide and sulfuric acid.

Applications

Bromoethylene is used in the production of polymers and co-polymers.

Bromoethylene is used in the production of fumigants.

Bromoethylene is used in the production of leather.

Bromoethylene can be used as a flame retardant and to produce flame retardant synthetic fibres.

Bromoethylene is used in the production of fabricated metal products.

Bromoethylene is used to manufacture bromopolymers, mainly polybromoethene.

Bromoethylene is used in the production of pharmaceuticals.

Bromoethylene is used in organic synthesis as an alkylation agent.

Physical data

Molecular weight	106.95			
Boiling point	at 1.013 bar [°C]	15.8	at 14.5 psi [°F]	60.46
Density	at 1.013 bar, 15 °C [kg/m ³]	4.653	at 1 atm., 70 °F [lb/ft ³]	0.284
Vapour pressure	at 0 °C [bar]	0.56	at 32 °F [psi]	8.13
	at 20 °C [bar]	1.18	at 70 °F [psi]	17.74
Flammability range in air [% volume]	5.6 – 13.5			

1,3-Butadiene C_4H_6

CAS: 106-99-0
EC: 203-450-8
UN: 1010

Purity grade	Typical purity	Typical impurities [ppm]
HiQ® 1,3-butadiene 2.5	≥99.5 %	Other C_nH_m ≤5,000

Typical filling pressure: 15 °C: 1.4 bar(g)/70 °F: 22 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•					

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
Gaseous Withdrawal	Gaseous Withdrawal	Liquid Withdrawal	Consult local team

Characteristics

Flammable. Liquefied, colourless gas. Can form explosive peroxides in air. The cylinder contains an inhibitor to prevent polymerisation. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

GHS-CLP

Signal word: DANGER



H-statements:

Liquefied Gas → H280 – Contains gas under pressure; may explode if heated; H220 – Extremely flammable gas; H350 – May cause cancer; H340 – May cause genetic defects.

Transport of dangerous goods



ADR Class 2, 2F



DOT Class 2.1



Source

1,3-Butadiene is manufactured by steam cracking of naphtha or gas oil fractions.

1,3-Butadiene is also produced by catalytic dehydrogenation of n-butene and n-butane, and by oxidative dehydrogenation of n-butene.

Applications

1,3-Butadiene has been widely used in the manufacture of synthetic rubber.

1,3-Butadiene is finding increasing usage in the resins and plastic fields. Copolymers containing a high percentage of styrene have been widely used as reinforcing and stiffening resin for rubber, as water- and solvent-based paints, and in combinations with polystyrene for high impact plastics. Mixtures of styrene-acrylonitrile resins and butadiene-acrylonitrile rubbers have produced exceptionally high impact plastics having good chemical and heat distortion properties. 1,3-Butadiene is also used in the nylon production process to create one of the intermediates.

The butadiene-containing C4-fractions obtained in these processes are then further separated. While C4-fractions readily form azeotropes, butadiene is isolated by using liquid-liquid extraction or extractive distillation.

1,3-Butadiene is useful in a variety of miscellaneous organic reactions. It is particularly useful in the Diels-Alder reaction where it combines with activated olefins to give cyclic compounds.

1,3-Butadiene is used as a component in calibration gases for the gas, oil and chemical industries.

Physical data

Molecular weight	54.092			
Boiling point	at 1.013 bar [°C]	-4.41	at 14.5 psi [°F]	24.08
Density	at 1.013 bar, 15 °C [kg/m ³]	2.359	at 1 atm., 70 °F [lb/ft ³]	0.144
Vapour pressure	at 0 °C [bar]	1.2	at 32 °F [psi]	17.43
	at 20 °C [bar]	2.40	at 70 °F [psi]	36.07
Flammability range in air [% volume]	1.4 – 16.3			

n-Butane C_4H_{10}

R-600

CAS: 106-97-8
 EC: 203-448-7
 UN: 1011
 R-600

Purity grade	Typical purity	Typical impurities [ppm]
		Other C_nH_m
n-Butane 2.5	≥99.5 %	≤5,000
HiQ® n-Butane 3.5	≥99.95 %	≤500

Typical filling pressure: 15 °C: 1.1 bar(g)/70 °F: 16.3 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•		•			

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
Gaseous Withdrawal	Gaseous Withdrawal	Liquid Withdrawal	Consult local team

Characteristics

Flammable, liquefied, colourless gas. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

GHS-CLP

Signal word: DANGER



H-statements:

Liquefied Gas → H280 – Contains gas under pressure; may explode if heated; H220 – Extremely flammable gas.

Transport of dangerous goods



ADR Class 2, 2F



DOT Class 2.1



Source

Both n-butane and iso-butane are extracted from natural gas or refinery gases. Extraction is performed by absorbing at high pressure in suitable absorber oils followed by a

fractionation to remove other hydrocarbons like propane and pentanes. The two butanes are then separated by distillation.

Applications

n-Butane is primarily used as a heating and cooking fuel.

n-Butane finds widespread use as a motor fuel, e.g. for forklifts, especially under conditions where conventional fuel exhausts would not be desirable like the inside of buildings.

n-Butane is used to fill the thermobulbs in pressure and temperature gauges.

n-Butane is used as a chemical intermediate in the manufacture of a variety of organic chemicals:

- acetic acid
- butadiene, used as a raw material for the production of synthetic rubbers
- butenes employed for the production of butadienes, butanol, maleic anhydride and polybutenes
- ethene
- propylene

n-Butane is used as a component in calibration gases for the gas, oil and chemical industries.

It is also used as a standard fuel gas for the calibration of burners.

Very pure forms of n-Butane can be used in refrigeration applications, replacing ozone depleting halocarbons. It has the ASHRAE number R-600.

n-Butane is also used as an aerosol propellant, either pure or mixed with other hydrocarbons.

n-Butane/helium mixtures are used in ionising particle counters.

n-Butane and iso-butane, pure or as blends, are used as foam blowing agents.

Physical data

Molecular weight	58.123			
Boiling point	at 1.013 bar [°C]	-0.5	at 14.5 psi [°F]	31.12
Density	at 1.013 bar, 15 °C [kg/m ³]	2.547	at 1 atm., 70 °F [lb/ft ³]	0.155
Vapour pressure	at 0 °C [bar]	1.04	at 32 °F [psi]	15.02
	at 20 °C [bar]	2.08	at 70 °F [psi]	31.29
Flammability range in air [% volume]	1.4 – 9.4			

iso-Butane C_4H_{10}

Methylpropane, R-600a

CAS: 75-28-5
 EC: 200-857-2
 UN: 1969
 R-600a

Purity grade	Typical purity	Typical impurities [ppm]
		Other C_nH_m
iso-Butane 1.8	≥98 %	-
iso-Butane 2.5	≥99.5 %	≤5,000
HiQ® iso-Butane 3.5	≥99.95 %	≤500

Typical filling pressure: 15 °C: 2 bar(g)/70 °F: 31 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•		•			

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
Gaseous Withdrawal	Gaseous Withdrawal	Liquid Withdrawal	Consult local team

Characteristics

Flammable, liquefied, colourless gas. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

GHS-CLP

Signal word: DANGER



H-statements:

Liquefied Gas → H280 – Contains gas under pressure; may explode if heated; H220 – Extremely flammable gas.

Transport of dangerous goods



ADR Class 2, 2F



DOT Class 2.1



Source

Both n-butane and iso-butane are extracted from natural gas or refinery gases. Extraction is performed by absorbing at high pressure in suitable absorber oils followed by a

fractionation to remove other hydrocarbons like propane and pentanes. The two butanes are then separated by distillation.

Applications

iso-Butane is primarily used as a heating fuel, not only in private homes, but also in agriculture, for farming and farm processing, as well as in hotels, restaurants and holiday resorts.

Industrial grade butane is a mixture of n-butane and iso-butane.

iso-Butane is used industrially as a fuel in the metallurgical, glass and ceramic industries as well as an intermediate in the manufacture of aviation fuel.

iso-Butane is a common refrigerant in domestic refrigerators. It has the ASHRAE number R-600a.

Mixed with propane, it is used as a refrigerant in water coolers, beer coolers and in domestic refrigerators. It is also used in small proportions in some HFC refrigerant blends for industrial and commercial refrigeration and air conditioning applications.

Mixed with propane, butane is also used as a fuel for internal combustion engines, e.g. in forklifts.

iso-Butane is used as a component in calibration gases for the gas, oil and chemical industries.

iso-Butane is used as a chemical intermediate in the manufacture of a variety of organic chemicals:

- acetic acid
- butadiene, used as a raw material for the production of synthetic rubbers
- iso-butene used for the production of isoprene/polyisoprene, methacrylonitrile, polyisobutene and butyl rubber
- ethene
- propylene

iso-Butane finds use as an aerosol propellant, alone or mixed with other hydrocarbons.

iso-Butane is also used to fill thermometer bulbs and for saturated vapour pressure type pressure gauges.

iso-Butane/helium mixtures are used in ionising particle counters. iso-Butane is also used in nuclear research for multi-wire proportional scintillation chambers and other particle detectors.

n-Butane and iso-Butane are used pure or in mixtures for foam blowing.

Physical data

Molecular weight	58.123			
Boiling point	at 1.013 bar [°C]	-11.72	at 14.5 psi [°F]	10.92
Density	at 1.013 bar, 15 °C [kg/m ³]	2.537	at 1 atm., 70 °F [lb/ft ³]	0.155
Vapour pressure	at 0 °C [bar]	1.59	at 32 °F [psi]	23.1
	at 20 °C [bar]	3.06	at 70 °F [psi]	45.8
Flammability range in air [% volume]	1.5 – 9.4			

1-Butene C_4H_8

Bute-1-ene, Butene-1, a-Butylene

CAS: 106-98-9

EC: 203-449-2

UN: 1012

Purity grade	Typical purity	Typical impurities [ppm]
HiQ® 1-butene 2.5	≥99.5 %	Other C_nH_m ≤5,000

Typical filling pressure: 15 °C: 1.5 bar(g)/70 °F: 23.5 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•					

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
Gaseous Withdrawal	Gaseous Withdrawal	Liquid Withdrawal	Consult local team

Characteristics

Flammable, liquefied, colourless gas. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

GHS-CLP

Signal word: DANGER



H-statements:

Liquefied Gas → H280 – Contains gas under pressure; may explode if heated; H220 – Extremely flammable gas.

Transport of dangerous goods



ADR Class 2, 2F



DOT Class 2.1



Source

1-Butene is produced by thermal or catalytic cracking of petroleum as well as by catalytic dehydrogenation of butane or dimerisation of ethylene.

1-Butene is produced either by separation from crude C4 refinery streams or from the dimerisation of ethylene. It is distilled to give a high-purity product.

Applications

1-Butene is an intermediate in the preparation of a variety of chemicals, such as detergents, plastics and synthetic rubbers, linear low-density polyethylene (LLDPE), polypropylene resins, polybutene, butylene oxide and butanone.

In the fuel industry, alkenes are polymerised by heating with catalysts to give high-octane gasolines.

1-Butene is used as a component in calibration gases for the gas, oil and chemical industries.

1-Butene is used as an intermediate in preparing organic compounds like in the industrially important Oxo process, with alkenes reacting catalytically with carbon monoxide and hydrogen to give aldehydes.

Physical data

Molecular weight	56.107			
Boiling point	at 1.013 bar [°C]	-6.25	at 14.5 psi [°F]	20.77
Density	at 1.013 bar, 15 °C [kg/m ³]	2.449	at 1 atm., 70 °F [lb/ft ³]	0.149
Vapour pressure	at 0 °C [bar]	1.29	at 32 °F [psi]	18.64
	at 20 °C [bar]	2.57	at 70 °F [psi]	38.58
Flammability range in air [% volume]	1.2 – 10.6			

cis-2-Butene C₄H₈

CAS: 590-18-1
EC: 209-673-7
UN: 1012

Purity grade	Typical purity	Typical impurities [ppm]
HiQ® cis-2-Butene 2.0	≥99 %	Other C _n H _m ≤10,000

Typical filling pressure: 15 °C: 0.8 bar(g)/70 °F: 13 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•					

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
Gaseous Withdrawal	Gaseous Withdrawal	Liquid Withdrawal	Consult local team

Characteristics

Flammable, liquefied, colourless gas. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

GHS-CLP

Signal word: DANGER



H-statements:

Liquefied Gas → H280 – Contains gas under pressure; may explode if heated; H220 – Extremely flammable gas.

Transport of dangerous goods



ADR Class 2, 2F



DOT Class 2.1



Source

Almost all commercially produced butenes are obtained as by-products from two principal processes:

- catalytic or thermal cracking, refinery processes which upgrade high boiling petroleum fractions to gasoline,
- steam cracking, which produces light olefins for chemical feedstocks by pyrolysis of saturated hydrocarbons derived from natural gas or crude oil.

The butenes obtained are withdrawn as a mixture from the C4 fraction. From this mixture butadiene and butanes are separated by extractive distillation. The remaining butenes cannot be separated by mere distillation because their boiling points are too close together.

In a first step, iso-butene is isolated either by etherification with methanol to form methyl tert-butylether (MTBE), or by hydrating iso-butene to tert-butanol (TBA). In this step, all other C4 components in the mixture remain unchanged. MTBE and TBA can then be split by reversing synthesis to produce high purity iso-butene.

Applications

cis-2-Butene is a chemical intermediate in the following processes:

- catalytic dehydrogenation to produce butadiene
- the addition of water by means of the acid sulfate leads to the formation of 2-butanol
- esterification in the presence of tungstic acid, followed by oxidation by oxygen or air, in the liquid phase, leads to the production of acetic acid
- acetic acid can also be produced through oxidation by oxygen or air in the presence of manganese acetate in the liquid phase
- condensation of iso-butane with butenes leads to the formation of 2,2,3-trimethyl pentane, a high octane fuel.

Physical data

Molecular weight	56.107			
Boiling point	at 1.013 bar [°C]	3.72	at 14.5 psi [°F]	38.72
Density	at 1.013 bar, 15 °C [kg/m ³]	2.457	at 1 atm., 70 °F [lb/ft ³]	0.150
Vapour pressure	at 0 °C [bar]	0.88	at 32 °F [psi]	12.75
	at 20 °C [bar]	1.81	at 70 °F [psi]	27.26
Flammability range in air [% volume]	1.6 – 10.0			

Once the iso-butene content has been reduced, recovery of high purity 1-butene is possible by fractionation. The remaining 2-butenes can be separated by molecular sieve absorption methods.

Other commercial processes that are sometimes used to produce specific isomers or mixtures of butenes or both, either directly or as by-products, include:

- the oxirane process for making propylene oxide (-> iso-butene)
 - the dehydrogenation of butane and iso-butane (-> 1-butene, cis-2-butene, trans-2-butene)
 - the disproportionation of olefins (-> cis-2-butene, trans-2-butene)
 - the oligomerisation of ethylene (-> 1-butene).
- All or any of them may become useful feedstock sources should the need arise.

cis-2-Butene is a member of the alkene group of hydrocarbons. Alkenes serve as intermediates in the preparation of a variety of organic compounds. Sulfuric acid and sulfur dioxide react with alkenes to give alkyl hydrogen sulfates and alkyl sulfonates, respectively, many of which are useful as detergents. In the industrially important oxo process, alkenes react catalytically with carbon monoxide and hydrogen to give aldehydes. Alkenes are polymerised by heating with catalysts to give high-octane gasolines, plastics and synthetic rubber. Alkanes react with alkenes in the presence of catalysts to form motor fuels in a process known as alkylation.

cis-2-Butene is used as a component in calibration gases.

iso-Butene C_4H_8

Isobutylene, 2-Methylpropane

CAS: 115-11-7
EC: 204-066-3
UN: 1012

Purity grade	Typical purity	Typical impurities [ppm]
HiQ® iso-Butene 3.0	≥99.9 %	Other C_nH_m ≤1,000

Typical filling pressure: 15 °C: 1.6 bar(g)/70 °F: 24 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•					

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
Gaseous Withdrawal	Gaseous Withdrawal	Liquid Withdrawal	Consult local team

Characteristics

Flammable, liquefied, colourless gas. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

GHS-CLP

Signal word: DANGER



H-statements:

Liquefied Gas → H280 – Contains gas under pressure; may explode if heated; H220 – Extremely flammable gas.

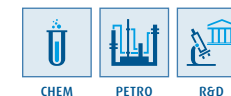
Transport of dangerous goods



ADR Class 2, 2F



DOT Class 2.1



Source

Almost all commercially produced butenes are obtained as by-products from two main processes:

- catalytic or thermal cracking, refinery processes which upgrade high boiling petroleum fractions to gasoline,
- steam cracking, which produces light olefins for chemical feedstocks by pyrolysis of saturated hydrocarbons derived from natural gas or crude oil.

The butenes obtained are withdrawn as a mixture from the C4 fraction. From this mixture butadiene and butanes are separated by extractive distillation. The remaining butenes cannot be separated by mere distillation because their boiling points are too close together.

In a first step, iso-butene is isolated either by etherification with methanol to form methyl tert-butylether (MTBE), or by hydrating iso-butene to tert-butanol (TBA). In this step, all other C4 components in the mixture remain unchanged. MTBE and TBA can then be split by reversing synthesis to produce high purity iso-butene.

Applications

iso-Butene is mainly used as a chemical intermediate.

iso-Butene reacts with methanol and ethanol, producing the gasoline oxygenates methyl tert-butyl ether (MTBE) and ethyl tert-butyl ether (ETBE). Alkylation with butane produces isooctane, another fuel additive.

iso-Butene is also used in the production of methacrolein.

Polymerisation of iso-Butene produces butyl rubber (polyisobutylene) an acid- and alkaline-resistant rubber.

Once the iso-butene content has been reduced, recovery of high purity 1-butene is possible by fractionation. The remaining 2-butenes can be separated by molecular sieve absorption methods.

Other commercial processes that are sometimes used to produce specific isomers or mixtures of butenes or both, either directly or as by-products, include:

- the oxirane process for making propylene oxide (-> iso-butene)
 - the dehydrogenation of butane and iso-butane (-> 1-butene, cis-2-butene, trans-2-butene)
 - the disproportionation of olefins (-> cis-2-butene, trans-2-butene)
 - the oligomerisation of ethylene (-> 1-butene).
- All or any of them may become useful feedstock sources should the need arise.

cis- and trans 2-Butene show very similar reactivity in most of the desired chemical reactions.

Antioxidants such as butylated hydroxytoluene (BHT) and butylated hydroxyanisole (BHA) are produced by Friedel-Crafts alkylation of phenols using isobutylene.

iso-Butene is used as a component in calibration gases for the gas, oil and chemical industries.

Physical data

Molecular weight	56.107			
Boiling point	at 1.013 bar [°C]	-6.89	at 14.5 psi [°F]	19.62
Density	at 1.013 bar, 15 °C [kg/m ³]	2.448	at 1 atm., 70 °F [lb/ft ³]	0.149
Vapour pressure	at 0 °C [bar]	1.33	at 32 °F [psi]	19.35
	at 20 °C [bar]	2.64	at 70 °F [psi]	39.59
Flammability range in air [% volume]	1.6 – 10.0			

trans-2-Butene C_4H_8

CAS: 624-64-6
EC: 210-855-3
UN: 1012

Purity grade	Typical purity	Typical impurities [ppm]
HiQ® trans-2-Butene 2.0	≥99 %	Other C_nH_m ≤10,000

Typical filling pressure: 15 °C: 1 bar(g)/70 °F: 15 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•					

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
Gaseous Withdrawal	Gaseous Withdrawal	Liquid Withdrawal	Consult local team

Characteristics

Flammable, liquefied, colourless gas. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

GHS-CLP

Signal word: DANGER



H-statements:

Liquefied Gas → H280 – Contains gas under pressure; may explode if heated; H220 – Extremely flammable gas.

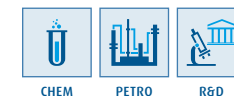
Transport of dangerous goods



ADR Class 2, 2F



DOT Class 2.1



Source

Almost all commercially produced butenes are obtained as by-products from two principal processes:

- catalytic or thermal cracking, refinery processes which upgrade high boiling petroleum fractions to gasoline,
- steam cracking, which produces light olefins for chemical feedstocks by pyrolysis of saturated hydrocarbons derived from natural gas or crude oil.

The butenes obtained are withdrawn as a mixture from the C4 fraction. From this mixture butadiene and butanes are separated by extractive distillation. The remaining butenes cannot be separated by mere distillation because their boiling points are too close together.

In a first step, iso-butene is isolated either by etherification with methanol to form methyl tert-butylether (MTBE), or by hydrating iso-butene to tert-butanol (TBA). In this step, all other C4 components in the mixture remain unchanged. MTBE and TBA can then be split by reversing synthesis to produce high purity iso-butene.

Applications

trans-2-Butene is employed as a chemical intermediate in the following processes:

- catalytic dehydrogenation that produces butadiene
- the addition of water by means of the acid sulfate leads to the formation of 2-butanol
- esterification in the presence of tungstic acid, followed by oxidation by oxygen or air in the liquid phase, leads to the production of acetic acid
- acetic acids can also be produced through oxidation by oxygen or air in the presence of manganese acetate, in the liquid phase.

trans-2-Butene is a member of the alkene group of hydrocarbons. Alkenes serve as intermediates in the

Once the iso-butene content has been reduced, recovery of high purity 1-butene is possible by fractionation. The remaining 2-butenes can be separated by molecular sieve absorption methods.

Other commercial processes that are sometimes used to produce specific isomers or mixtures of butenes or both, either directly or as by-products, include:

- the oxirane process for making propylene oxide (-> iso-butene)
 - the dehydrogenation of butane and iso-butane (-> 1-butene, cis-2-butene, trans-2-butene)
 - the disproportionation of olefins (-> cis-2-butene, trans-2-butene)
 - the oligomerisation of ethylene (-> 1-butene).
- All or any of them may become useful feedstock sources should the need arise.

cis- and trans 2-Butene show very similar reactivity in most of the desired chemical reactions.

preparation of a variety of organic compounds. Sulfuric acid and sulfur dioxide react with alkenes to give alkyl hydrogen sulfates and alkyl sulfonates, respectively, many of which are useful detergents. In the industrially important oxo process, alkenes react catalytically with carbon monoxide and hydrogen to give high octane gasolines, plastics and synthetic rubber. Alkanes react with alkenes in the presence of catalysts to form motor fuels in a process known as alkylation.

trans-2-Butene is used as a component in calibration gases for the gas, oil and chemical industries.

trans-2-Butene is also employed as a solvent.

Physical data

Molecular weight	56.107			
Boiling point	at 1.013 bar [°C]	0.88	at 14.5 psi [°F]	33.60
Density	at 1.013 bar, 15 °C [kg/m ³]	2.455	at 1 atm., 70 °F [lb/ft ³]	0.150
Vapour pressure	at 0 °C [bar]	0.98	at 32 °F [psi]	14.21
	at 20 °C [bar]	1.99	at 70 °F [psi]	29.94
Flammability range in air [% volume]	1.6 – 10.0			

1-Butyne C_4H_6

Ethylacetylene

CAS: 107-00-6
 EC: 203-451-3
 UN: 2452

Purity grade	Typical purity	Typical impurities [ppm]
1-Butyne	on request	contact local team

Typical filling pressure: 15 °C: 0.6 bar(g)/70 °F: 9.2 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•					

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
Gaseous Withdrawal	Gaseous Withdrawal	Liquid Withdrawal	Consult local team

Characteristics

Flammable, liquefied, colourless gas with garlic-like odour. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

Proposed by the Industry

Signal word: DANGER



H-statements:

Liquefied Gas → H280 – Contains gas under pressure; may explode if heated; H220 – Extremely flammable gas; H231 – May react explosively even in absence of air at elevated pressure and/or temperature.

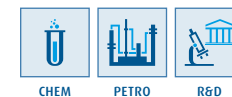
Transport of dangerous goods



ADR Class 2, 2F



DOT Class 2.1



Source

Propyne is produced industrially by thermal cracking of hydrocarbons.

It may also be obtained by treating 1,2- or 1,1-dibromobutane with alcoholic caustic alkali.

1-Butyne is also prepared by reacting sodium acetylide with diethyl sulfate.

Applications

1-Butyne is used as a component in calibration gases for the gas, oil and chemical industries.

1-Butyne is commonly used in the synthesis of organic materials.

Physical data

Molecular weight	54.090			
Boiling point	at 1.013 bar [°C]	8.1	at 14.5 psi [°F]	46.58
Density	at 1.013 bar, 15 °C [kg/m ³]	2.29	at 1 atm., 70 °F [lb/ft ³]	0.143
Vapour pressure	at 0 °C [bar]	0.73	at 32 °F [psi]	10.59
	at 20 °C [bar]	1.58	at 70 °F [psi]	23.88
Flammability range in air [% volume]	1.3 – not defined			

Carbon dioxide CO₂

R-744

CAS: 124-38-9
 EC: 204-696-9
 UN: 1013
 UN: 2187 (Refrigerated liquid)
 R-744

Purity grade	Purity	Impurities [ppm]															
		H ₂ O	O ₂	N ₂	CO	NH ₃	NO _x	H ₂ S	SO ₂	O ₂ +N ₂	C ₁ H ₄	C ₁ H ₆ (as CH ₄)	C ₁ H ₈ (as C ₁ 6H _{3,4})	Total Sulfur	Non-volatile residue	Halocarbons	
HiQ® Carbon dioxide 4.0	≥99.99 %	≤10	≤10	≤50	-	-	-	-	-	-	-	-	-	-	-	-	-
HiQ® Carbon dioxide 4.5	≥99.995 %	≤5	≤5	≤10	-	-	-	-	-	-	≤2	-	-	-	-	-	-
HiQ® Carbon dioxide 4.5 SFC	≥99.995 %	≤1	≤5	-	-	-	-	-	-	-	≤5	≤50	-	≤1	≤10	-	-
HiQ® Carbon dioxide 5.0	≥99.999 %	≤2	≤2	≤5	≤1	-	-	-	-	≤1	-	-	-	-	-	-	-
HiQ® Carbon dioxide 5.0 SFE	≥99.999 %	≤1	≤2	-	-	-	-	-	-	-	≤1	≤10	-	≤1	≤2	-	-
VERISEQ® Process Carbon dioxide (pharmaceutical grade)	≥99.5 %	≤67	-	-	≤5	≤25	≤2	≤1	≤2	-	-	-	-	≤1	-	-	-
VERISEQ® Research Carbon dioxide (pharmaceutical grade)	≥99.99 %	≤10	-	-	≤5	≤25	≤2	≤1	≤2	≤50	-	-	-	≤1	-	-	-

Typical filling pressure: 15 °C: 56 bar(g)/70 °F: 839 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•	•				•

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
Gaseous Withdrawal	Gaseous Withdrawal	Liquid Withdrawal	Consult local team

Characteristics

Liquefied, colourless gas. Asphyxiant in high concentrations. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

Proposed by the Industry

Signal word: WARNING



H-statements:

Compressed Gas → H280 – Contains gas under pressure; may explode if heated; Refrigerated Gas → H281 – Contains refrigerated gas; may cause cryogenic burns or injury; EIGA-As – Asphyxiant in high concentrations.

Transport of dangerous goods



ADR Class 2, 2A
3A (Refrigerated liquid)



DOT Class 2.2



Source

Carbon dioxide is recovered from many different sources. It is obtained as an off-gas from fermentation processes, lime-stone kilns, natural CO₂ springs, as well as gas streams from chemical

and petrochemical operations. Recently, CO₂ is also recaptured from the off-gas from power plants.

Applications

Carbon dioxide is used extensively as a neutralizing agent for pH control, for example, in cement curing water treatment and in many other commercially important chemical applications.

Carbon dioxide is used as media for supercritical fluid extraction (SFE) in sample preparation and as a carrier gas for analytical and preparative supercritical fluid chromatography (SFC).

Carbon dioxide is used in many consumer products ranging from aerosol packaging to air guns that require pressurised gas because it is inexpensive and non-flammable; in the operation of pneumatic equipment and for the transfer of hazardous and flammable liquids.

Liquid carbon dioxide is becoming increasingly used as a refrigerant in mechanical refrigerating systems due to its environmental credentials. It has the ASHRAE number R-744. "Dry ice", or solid CO₂ is commonly used for refrigeration.

Owing to its stimulating effect on the nerve centres, carbon dioxide is employed in medicine in mixtures with oxygen, for reanimating victims of asphyxiation. It also serves in the treatment of certain skin affections.

Liquid/solid carbon dioxide is used for cooling gas chromatography ovens.

Possible refrigerant for MAC (Mobile Air Conditioning) due to European phase out of tetrafluoroethane (R-134a).

A substantial volume of carbon dioxide is used for carbonating beverages such as beer and many soft drinks and conservation of wine, unfermented grape juice and various fruit juices.

Carbon dioxide:

- is used for the chemical vapour deposition of silicon dioxide.
- is used for foam blowing.
- is used in Coleman nitrogen analysers.
- is used in mixtures for car emission monitoring and environmental monitoring.
- is used for fire extinguishing.
- is often used in combination with ethylene oxide for sterilizing purposes.
- is also used for blood analysis and dehydration of penicillin.
- is used for production of paints and varnishes.

Carbon dioxide is used to modify atmospheres, for example in green houses where it increases plant growth rates or combined with nitrogen to prolong quality in food packaging applications (MAP – Modified Atmosphere Packaging).

Carbon dioxide, when mixed with helium and nitrogen, is used as the active medium in carbon dioxide lasers.

Carbon dioxide is used as an inerting agent for various mild steel welding operations, often in combination with argon.

Note:

Carbon dioxide is listed in the Kyoto Protocol, an international Framework Convention with the objective of reducing greenhouse gases.

Physical data

Molecular weight	44.01			
Boiling point	at 1.013 bar [°C]	-78.5	at 14.5 psi [°F]	-109.3
Density	at 1.013 bar, 15 °C [kg/m ³]	1.872	at 1 atm., 70 °F [lb/ft ³]	0.114
Vapour pressure	at 0 °C [bar]	34.5	at 32 °F [psi]	505.3
	at 20 °C [bar]	57.3	at 70 °F [psi]	853.7
Flammability range in air [% volume]	Non combustible			

Carbon monoxide CO

CAS: 630-08-0
EC: 211-128-3
UN: 1016

Purity grade	Typical purity	Typical impurities [ppm]						
		N_2	H_2	O_2	Ar	$\text{O}_2 + \text{Ar}$	C_nH_m	H_2O
Carbon monoxide 2.0	≥99 %	≤4,000	≤1,500	-	-	≤3,000	≤500	-
HiQ® Carbon monoxide 3.0	≥99.9 %	≤750	≤250	-	-	≤60	≤50	-
HiQ® Carbon monoxide 3.7	≥99.97 %	≤300	≤100	≤10	≤20	-	≤10	≤10
HiQ® Carbon monoxide 4.7	≥99.997 %	≤10	≤1	≤5	≤15	-	≤2	≤5

Typical filling pressure: 15 °C: 200 bar(g)/ 70 °F: 2,800 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•	•			•	

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
•	•		Consult local team

Characteristics

Flammable. Odourless and colourless gas. Gas density is heavier than air. Corrosion effects due to the simultaneous presence of carbon monoxide, traces of carbon dioxide and moisture.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

GHS-CLP

Signal word: DANGER



H-statements:

Compressed Gas → H280 – Contains gas under pressure; may explode if heated; H220 – Extremely flammable gas; H360D – May damage the unborn child / Repr. 1A; H331 – Toxic if inhaled; H372 – Causes damage to the earth through prolonged or repeated inhalation.

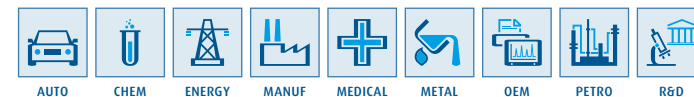
Transport of dangerous goods



ADR Class 2, 1TF



DOT Class 2.3



Source

The most common carbon monoxide production plants are “reformers” in which natural gas and steam react to produce CO and hydrogen.

Another industrial source of carbon monoxide is producer gas, a mixture containing mostly carbon monoxide and nitrogen, formed by combustion of carbon in air at high temperature.

Applications

Carbon monoxide is largely used in the chemical industry to yield a wide variety of chemicals such as esters, ketones, aldehydes and glycols as well as phosgene, an important chemical intermediate. Usually, the carbon monoxide volumes needed at chemical production sites are so large that the gas is produced on-site, though occasionally supplies in tube trailers may be viable.

Some types of electronic components, such as reed relay switches, are encapsulated in a glass enclosure which is sealed by direct heating with a flame. In these cases, it is important that no water is produced in the flame as this would be sealed in the enclosure and lead to failure of the component. Hydrogen and hydrocarbon fuels are therefore not suitable and so carbon monoxide is used instead.

Carbon monoxide is used in large quantities in the primary metals industry in many different ways, e.g. as a chemical reducing agent for the recovery of metals from ores or in the purification of aluminium waste or in the manufacture of high purity powdered metals by thermal decomposition of their metal carbonyls.

Methanol is produced by the hydrogenation of carbon monoxide. In a related reaction, the hydrogenation of

A third industrial source is “water gas”, a mixture of hydrogen and carbon monoxide produced via the endothermic reaction of steam and carbon.

There are also many other production techniques such as incomplete combustion of natural gas and, for smaller quantities, the dehydration of formic acid using either sulfuric or phosphoric acid.

carbon monoxide yields liquid hydrocarbon fuels. This technology allows coal or biomass to be converted to diesel fuels.

Acetic acid is industrially produced in a catalytic reaction of carbon monoxide and methanol.

Carbon monoxide also serves for the production and regeneration of catalysts such as nickel carbonyl.

Carbon monoxide is also used in both organic and inorganic chemical synthesis.

Carbon monoxide is a component in gas mixtures for lung diffusion.

Carbon monoxide is a component in laser gas mixtures. Carbon monoxide is a component in calibration gas mixtures.

A necessity in the production of solar cells is super clean silicon, which is produced with the aid of carbon monoxide.

Physical data

Molecular weight	28.01			
Boiling point	at 1.013 bar [°C]	-191.45	at 14.5 psi [°F]	-312.59
Density	at 1.013 bar, 15 °C [kg/m ³]	1.185	at 1 atm., 70 °F [lb/ft ³]	0.072
Vapour pressure	at 0 °C [bar]	-	at 32 °F [psi]	-
	at 20 °C [bar]	-	at 70 °F [psi]	-
Flammability range in air [% volume]	10.9 – 76			

Carbonyl fluoride CF_2O

Carbon oxyfluoride

CAS: 353-50-4

EC: 206-534-2

UN: 2417

Purity grade	Typical purity	Typical impurities [ppm]
HiQ® Carbonyl fluoride 2.0	≥99 %	contact local team

Typical filling pressure: 15 °C: 51 bar(g)/70 °F: 763 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•					

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
•	•		Consult local team

Characteristics

Liquefied, colourless gas. Hygroscopic with pungent odour. Contact with combustible material may cause fire. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

Proposed by the Industry

Signal word: DANGER



H-statements:

Liquefied Gas → H280 – Contains gas under pressure; may explode if heated; H330 – Fatal if inhaled; H314 – Causes severe skin burns and eye damage; EUH071 – Corrosive to the respiratory tract.

Transport of dangerous goods



ADR Class 2, 2TC



DOT Class 2.3



Source

Carbonyl fluoride is prepared by reacting carbon monoxide and fluorine, or carbon tetrafluoride and water at high temperature.

Oxidation of carbon monoxide with silver difluoride is commonly used.

Applications

Carbonyl fluoride is used as a fluorine source in laboratories.

Carbonyl fluoride is an important intermediate for the preparation of organic fluorine compounds.

Carbonyl fluoride is used as an etching gas in the semiconductor industry as well as a cleaning agent for chemical vapour deposition chambers.

Physical data

Molecular weight	66.01			
Boiling point	at 1.013 bar [°C]	-83	at 14.5 psi [°F]	-117
Density	at 1.013 bar, 15 °C [kg/m ³]	2.89	at 1 atm., 70 °F [lb/ft ³]	18.04
Vapour pressure	at 0 °C [bar]	30.66	at 32 °F [psi]	444.6
	at 20 °C [bar]	52.10	at 70 °F [psi]	777.8
Flammability range in air [% volume]	Non combustible			

Carbonyl sulfide COS

CAS: 463-58-1
EC: 207-340-0
UN: 2204

Purity grade	Typical purity	Typical impurities [ppm]
Carbonyl sulfide 2.0	≥99 %	contact local team

Typical filling pressure: 15 °C: 10 bar(g)/70 °F: 150 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•					

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
•	•		Consult local team

Characteristics

Flammable. Liquefied gas with the odour of rotten eggs. Decomposes in water. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

Proposed by the Industry

Signal word: DANGER



H-statements:

Liquefied Gas → H280 – Contains gas under pressure; may explode if heated; H220 – Extremely flammable gas; H331 – Toxic if inhaled.

Transport of dangerous goods



ADR Class 2, 2TF



DOT Class 2.3



Source

Carbonyl sulfide is formed by many high temperature reactions of carbon compounds with donors of oxygen and sulfur.

Another well-known synthetic procedure involves the reaction of a potassium thiocyanite solution with sulfuric acid followed by a purification process.

One patented method describes the manufacturing of carbonyl sulfide by the reaction of methanol with sulfur at 500–800°C.

Applications

Carbonyl sulfide is particularly useful in the synthesis of thioacids, sulfur trisubstituted carbinols, substituted thiazoles and substituted thiocarbamic acids (salts). High yields are obtained in the synthesis of substituted thiazoles.

Carbonyl sulfide is gaining recognition in fumigation as a potential replacement for phosphine and methyl bromide.

Carbonyl sulfide occurs as a by-product in the manufacture of carbon disulfide. It is also known as an impurity in many manufactured fuel gases, in refinery gases and in combustion products of sulfur-containing fuels. You will find it as a contaminant in some natural gas sources. These COS traces may lead to unwanted corrosion in plant elements or cause poisoning of catalysts.

In mixtures it is employed in the laboratory as a component in calibration gases for process control and environmental monitoring.

Carbonyl sulfide can be used as an odoriser for natural gas transport as well as for liquid petroleum gas (LPG).

Physical data

Molecular weight	60.076			
Boiling point	at 1.013 bar [°C]	-50.15	at 14.5 psi [°F]	-58.25
Density	at 1.013 bar, 15 °C [kg/m ³]	2.574	at 1 atm., 70 °F [lb/ft ³]	0.157
Vapour pressure	at 0 °C [bar]	6.0	at 32 °F [psi]	92.42
	at 20 °C [bar]	11.06	at 70 °F [psi]	164.96
Flammability range in air [% volume]	6.5 – 29.0			

Chlorine Cl₂

CAS: 7782-50-5
EC: 231-959-5
UN: 1017

Purity grade	Typical purity	Typical impurities [ppm]						
		H ₂ O	O ₂	N ₂	CO	CO ₂	C _n H _m	Fe
Chlorine 2.8	≥99.8 %	contact local team						
HiQ® Chlorine 4.0	≥99.99 %	≤1	≤5	≤40	≤5	≤50	≤5	-
HiQ® Chlorine 5.0	≥99.999 %	≤1	≤1	≤2	≤1	≤5	≤1	≤0.5

Typical filling pressure: 15 °C: 5.8 bar(g)/70 °F: 86 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•		•			

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
Gaseous Withdrawal	Gaseous Withdrawal	Liquid Withdrawal	Consult local team

Characteristics

Yellowish-green liquefied gas with irritating odour. Corrosive. Heavy oxidizing agent. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

GHS-CLP

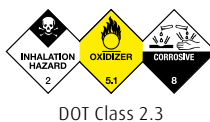
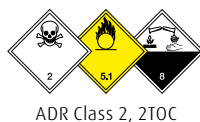
Signal word: DANGER



H-statements:

Liquefied gas → H280 – Contains gas under pressure; may explode if heated; H270 – May cause or intensify fire; oxidiser; H330 – Fatal if inhaled; H319 – Causes serious eye irritation; EUH071 – Corrosive to the respiratory tract; H315 – Causes skin irritation; H400 – Very toxic to aquatic life.

Transport of dangerous goods



Source

Chlorine is produced commercially by the electrolysis of salt solutions (either sodium, potassium or magnesium

chlorides). The production of chlorine is therefore usually accompanied by production of hydrogen.

Applications

Chlorine is used in relatively large quantities for the production of a wide variety of chemicals such as chloroethene, hydrochloric acid, carbon tetrachloride, trichloroethylene, etc. For many of these, which may themselves be only intermediates rather than end products, the chlorine may be produced on-site, with excess quantities being available for shipment into the merchant market.

As chlorine has the capability to bleach various materials, it is used in both the paper and textile industries for this purpose.

Chlorine is used for water purification in a variety of circumstances, including the “production” of drinking water by local water authorities, the treatment of swimming pools and waste water treatment by many types of industrial companies.

High purity chlorine is used in the electronics industry for etching. It may also be used as an additive during other processes to keep surfaces clean, for example during oxidation process steps – hence preventing the incorporation of impurities in the oxidation layer.

Chlorine may require registration/authorisation to comply with local legal requirements on biocidal products, such as those described in the Biocidal Products Regulation (No 528/2012) of the European Union.

Chlorine is used in the manufacture of fibre optics, phosgene and synthetic rubber.

Chlorine is used as component in gas mixtures.

Chlorine blended with argon is used for degassing molten aluminium. It is also used for the purification of gold and other precious metals.

Physical data

Molecular weight	70.905			
Boiling point	at 1.013 bar [°C]	-34.03	at 14.5 psi [°F]	-29.23
Density	at 1.013 bar, 15 °C [kg/m ³]	3.042	at 1 atm., 70 °F [lb/ft ³]	0.186
Vapour pressure	at 0 °C [bar]	3.70	at 32 °F [psi]	53.61
	at 20 °C [bar]	6.80	at 70 °F [psi]	101.64
Flammability range in air [% volume]	Non combustible			

1-Chloro-1,2,2,2-tetrafluoroethane C_2HClF_4

HCFC-124, R-124

CAS: 2837-89-0

EC: 220-629-6

UN: 1021

R-124

Purity grade	Typical purity	Typical impurities [ppm]
1-Chloro-1,2,2,2-tetrafluoroethane	≥99.8 %	H ₂ O ≤20 ppm(w)

Typical filling pressure: 21.1 °C: 2.3 bar(g)/70 °F: 33.2 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•					

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
Gaseous Withdrawal	Gaseous Withdrawal	Liquid Withdrawal	Consult local team

Characteristics

Colourless liquified gas with a slight ether-like smell. Stable at normal temperatures and storage conditions. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

Proposed by the Industry

Signal word: WARNING



H-statements:

H280 - Contains gas under pressure; may explode if heated; H420 - Harms public health and the environment by destroying ozone in the upper atmosphere.

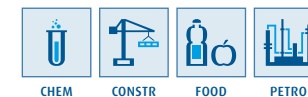
Transport of dangerous goods



ADR Class 2, 2A



DOT Class 2.2



Source

Many HCFCs and HFCs are manufactured via similar synthesis routes from common feedstocks. Many synthesis routes for 2-chloro-1,1,1,2-tetrafluoroethane use

trichloroethylene and/or tetrachloroethylene (also known as perchloroethylene, PCE), which is reacted with HF, often in the presence of a catalyst.

Applications

1-chloro-1,2,2,2-tetrafluoroethane is commonly used as a refrigerant gas. It is a hydrochlorofluorocarbon (HCFC) and is given the ASHRAE number R-124. It is used in both a pure form, as a retrofit replacement for CFC-114 in certain applications, and as a component in a number of HCFC refrigerant blends.

Note:

1-chloro-1,2,2,2-tetrafluoroethane is controlled under the Montreal Protocol on Substances that Deplete the Ozone Layer.

Physical data

Molecular weight	136.48	
Boiling point	at 1.013 bar [°C]	-10.8
	at 14.5 psi [°F]	12.6
Density	at 1.013 bar, 15 °C [kg/m ³]	5.877
	at 1 atm., 60 °F [lb/ft ³]	0.3669
Vapour pressure	at 0 °C [bar]	1.6
	at 32 °F [psi]	23.7
	at 20 °C [bar]	3.3
	at 70 °F [psi]	47.9
Flammability range in air [% volume]	Not combustible	

Chlorodifluoroethane $C_2H_3ClF_2$

1-Chloro-1,1-difluoroethane, HCFC-142b, R-142b

CAS: 75-68-3
 EC: 200-891-8
 UN: 2517
 R-142b

Purity grade	Typical purity	Typical impurities [ppm]	Air
Chlorodifluoroethane 1.8	≥98 %		≤20,000

Typical filling pressure: 15 °C: 2.4 bar(g)/70 °F: 34.5 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•					

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
Gaseous Withdrawal	Gaseous Withdrawal	Liquid Withdrawal	Consult local team

Characteristics

Flammable. Colourless, liquefied gas. Dry gas is not corrosive. Decomposes at high temperatures to toxic substances. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

Proposed by the Industry

Signal word: DANGER



H-statements:

Liquefied Gas → H280 – Contains gas under pressure; may explode if heated; H220 – Extremely flammable gas; H420 – Harms public health and the environment by destroying ozone in the upper atmosphere.

Transport of dangerous goods



ADR Class 2, 2F



DOT Class 2.1



Source

Many HCFCs and HFCs are manufactured via similar synthesis routes from common feedstocks. A common synthesis route for chlorodifluoroethane uses

dichloroethylene which is reacted with HF in the presence of a catalyst.

Applications

Chlorodifluoroethane is used as a refrigerant gas. It is a hydrochlorofluorocarbon (HCFC) and is given the ASHRAE number R-142b. It is commonly used in refrigerant blends such as HCFC-409A and HCFC-409B.

Other applications include chlorodifluoroethane as a foam blowing agent for polyurethane foams and extruded polystyrene foams.

Note:

Chlorodifluoroethane is controlled under the Montreal Protocol on Substances that Deplete the Ozone Layer.

Physical data

Molecular weight		100.5	
Boiling point	at 1.013 bar [°C]	-9.2	at 14.5 psi [°F] 15.4
Density	at 1.013 bar, 15 °C [kg/m ³]	4.357	at 1 atm., 70 °F [lb/ft ³] 0.272
Vapour pressure	at 0 °C [bar]	1.49	at 32 °F [psi] 21.6
	at 20 °C [bar]	3.39	at 70 °F [psi] 49.2
Flammability range in air [% volume]		6.3 – 17.9	

Chlorodifluoromethane CHClF_2

HCFC-22, R-22

CAS: 75-45-6
EC: 200-871-9
UN: 1018
R-22

Purity grade	Typical purity	Typical impurities [ppm]	Air
Chlorodifluoromethane 3.0	≥99.9 %		≤1,000

Typical filling pressure: 15 °C: 7.8 bar(g)/70 °F: 119.4 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•		•			

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
Gaseous Withdrawal	Gaseous Withdrawal	Liquid Withdrawal	Consult local team

Characteristics

Colourless, odourless, liquefied gas. Decomposes at high temperatures to toxic substances. Asphyxiant in high concentrations. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

Proposed by the Industry

Signal word: WARNING



H-statements:

Liquefied Gas → H280 – Contains gas under pressure; may explode if heated; H420 – Harms public health and the environment by destroying ozone in the upper atmosphere; EIGA-As – Asphyxiant in high concentrations.

Transport of dangerous goods



ADR Class 2, 2A



DOT Class 2.2



Source

Chlorodifluoromethane is prepared by treating chloroform with anhydrous hydrogen fluoride in the

presence of a small amount of antimony chloride at elevated temperatures and pressures.

Applications

Chlorodifluoromethane (R-22) is a versatile refrigerant used extensively for a wide range of temperatures in many types of refrigeration and stationary air conditioning systems in industrial, commercial and domestic applications.

Chlorodifluoromethane may also be used in the production of fluorinated polymers and for leak detection.

In some geographies, the sale and/or use of R22 may be restricted or even prohibited (Montreal Protocol). Phase-out processes may exceptionally allow the use of recycled product.

Chlorodifluoromethane is used as an intermediate in the production of Teflon®.

As an aerosol propellant, chlorodifluoromethane is only used in special cases, such as for very low temperature spraying.

Note:

Chlorodifluoromethane is controlled under the Montreal Protocol on Substances that Deplete the Ozone Layer.

Physical data

Molecular weight	86.468			
Boiling point	at 1.013 bar [°C]	-40.83	at 14.5 psi [°F]	-41.47
Density	at 1.013 bar, 15 °C [kg/m ³]	3.719	at 1 atm., 70 °F [lb/ft ³]	0.227
Vapour pressure	at 0 °C [bar]	4.94	at 32 °F [psi]	71.69
	at 20 °C [bar]	8.97	at 70 °F [psi]	134.12
Flammability range in air [% volume]	Non combustible			

Chloroethene C_2H_3Cl

Chloroethylene, Vinyl chloride

CAS: 75-01-4
 EC: 200-831-0
 UN: 1086
 R-1140

Purity grade	Typical purity	Typical impurities [ppm]
HiQ® Chloroethene 3.7	≥99.97 %	contact local team

Typical filling pressure: 15 °C: 2.3 bar(g)/70 °F: 36.6 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•					

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
•	•		Consult local team

Characteristics

Flammable, colourless, liquefied gas with pleasurable sweet odour in high concentrations. Polymerizes in the presence of air or sunlight. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

GHS-CLP

Signal word: DANGER



H-statements:

Liquefied Gas → H280 – Contains gas under pressure; may explode if heated; H220 – Extremely flammable gas; H231 – May react explosively even in absence of air at elevated pressure and/or temperature; H350 – May cause cancer.

Transport of dangerous goods



ADR Class 2, 2F



DOT Class 2.1



Source

Chloroethene is industrially produced using many different reaction paths as there are

- catalytic chlorination reacting ethene and chlorine
- high-temperature chlorination of ethane with chlorine with a chlorine/ oxygen blend and last but not least with a hydrogen chloride/oxygen mixture

- catalytic chlorination of acetylene in with hydrogen chloride
- catalytic oxychlorination reacting acetylene , hydrogen chloride and oxygen
- thermal decomposition of 1,2-dichloroethane industrially produced in a direct reaction of carbon, boron oxide and chlorine at 500°C.

Applications

Chloroethene is largely used as an intermediate in organic synthesis.

Chloroethene is used as a component in mixtures for workspace and industrial emission control.

Chloroethene is used as a raw material in the polymerisation of ethenyl resins (polyvinyl chloride, PVC). This polymerisation occurs in various ways, depending on the type of product which is desired:

- mass or block polymerisation; the final product is very pure and serves primarily as a rigid, high-quality material.
- solution polymerisation; the final product appears in a stable solution with a low index of viscosity. Hence it can be employed in the cement, lacquer and paint industries.
- precipitation polymerisation; a pure, homogeneous product is obtained with a low index of viscosity, hence its suitability for use in the paint and glue industry.
- emulsion polymerisation; the product obtained may be polluted by water-soluble impurities. This process is satisfactory for plastisols.
- suspension polymerisation; a pure product is obtained, which may be used for perfectly transparent articles.

Chloroethene has been used as a refrigerant and has the ASHRAE number R-1140.

Physical data

Molecular weight	62.499			
Boiling point	at 1.013 bar [°C]	-13.37	at 14.5 psi [°F]	7.95
Density	at 1.013 bar, 15 °C [kg/m ³]	2.703	at 1 atm., 70 °F [lb/ft ³]	0.165
Vapour pressure	at 0 °C [bar]	1.7	at 32 °F [psi]	25.32
	at 20 °C [bar]	3.42	at 70 °F [psi]	51.26
Flammability range in air [% volume]	3.8 – 31.0			

Chloropentafluoroethane C_2ClF_5

CFC-115, R-115

CAS: 76-15-3
 EC: 200-938-2
 UN: 1020
 R-115

Purity grade	Typical purity	Typical impurities [ppm]	Air
HiQ®	≥99.9 %		≤1,000
Chloropentafluoroethane			
3.0			

Typical filling pressure: 15 °C: 7 bar(g)/70 °F: 104.8 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•					

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
Gaseous Withdrawal	Gaseous Withdrawal	Liquid Withdrawal	Consult local team

Characteristics

Colourless, odourless, liquefied gas. Can decompose to toxic substances at high temperature. Asphyxiant in high concentrations. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

Proposed by the Industry

Signal word: WARNING



H-statements:

Liquefied Gas → H280 – Contains gas under pressure; may explode if heated; H420 – Harms public health and the environment by destroying ozone in the upper atmosphere; EIGA-As – Asphyxiant in high concentrations.

Transport of dangerous goods



ADR Class 2, 2A



DOT Class 2.2



Source

Commercial production of chlorofluoroalkanes employs halogen exchange, with hydrogen fluoride in the liquid phase in the presence of a catalyst. Different starting materials are used depending on the desired product. Some commonly used starting materials are carbon tetrachloride, chloroform, tetrachloroethylene and trichloroethylene. The main catalysts used are antimony halides with low volatility.

More recently developed exchange processes are carried out continuously in the gas phase at 100–400°C, using catalysts based on chromium, aluminium or iron.

The composition of the product can be controlled within wide limits by varying temperature, pressure, residence time, catalysts and the portions of the reactants.

Applications

Chloropentafluoroethane is used as:

- a refrigerant
- a propellant in aerosols
- a chemical intermediate.

Note:

Chloropentafluoroethane is controlled under the Montreal Protocol on Substances that Deplete the Ozone Layer.

Unreacted material is separated from the crude mixture by fractional distillation and recycled. Further treatment of the products includes washing, drying and distillation.

In the Montedison chlorofluorination process, reaction of C_1 and C_2 hydrocarbons with chlorine and hydrogen fluoride takes place in a single step in a fluidised bed reactor. The catalyst used is based on aluminium chloride.

Commercial production of chlorofluoroalkanes is also possible by the electrochemical fluorination process developed by Phillips Petroleum.

Physical data

Molecular weight	154.47			
Boiling point	at 1.013 bar [°C]	–39.11	at 14.5 psi [°F]	–38.38
Density	at 1.013 bar, 15 °C [kg/m ³]	6.687	at 1 atm., 70 °F [lb/ft ³]	0.408
Vapour pressure	at 0 °C [bar]	4.4	at 32 °F [psi]	64.5
	at 20 °C [bar]	8.0	at 70 °F [psi]	119.5
Flammability range in air [% volume]	Non combustible			

Cyanic chloride CNCl

Cyanogen chloride

CAS: 506-77-4
EC: 208-052-8
UN: 1589

Purity grade	Typical purity	Typical impurities [ppm]
HiQ® Cyanic chloride 2.0	≥99 %	contact local team

Typical filling pressure: 15 °C: 0.3 bar(g)/70 °F: 5.7 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•					

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
•	•		Consult local team

Characteristics

Liquefied colourless gas with a pungent odour. Forms white fumes in humid air. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

Proposed by the Industry

Signal word: DANGER



H-statements:

Liquefied Gas → H280 – Contains gas under pressure; may explode if heated; H330 – Fatal if inhaled; H314 – Causes severe skin burns and eye damage; EUH071 – Corrosive to the respiratory tract.

Transport of dangerous goods



ADR Class 2, 2TC



DOT Class 2.3



Source

Cyanic chloride is prepared by oxidation of sodium cyanide with chlorine.

Cyanic chloride can also be prepared by chlorinating an aqueous suspension of potassium zinc cyanide.

Applications

Cyanic chloride is a precursor to sulfonyl cyanides and chlorosulfonyl isocyanate.

Cyanic chloride is a useful reagent in organic synthesis.

Physical data

Molecular weight	61.47			
Boiling point	at 1.013 bar [°C]	12.85	at 14.5 psi [°F]	55.20
Density	at 1.013 bar, 15 °C [kg/m ³]	2.678	at 1 atm., 70 °F [lb/ft ³]	0.163
Vapour pressure	at 0 °C [bar]	0.59	at 32 °F [psi]	8.61
	at 20 °C [bar]	1.35	at 70 °F [psi]	20.41
Flammability range in air [% volume]	Non combustible			

Cyclopentane C_5H_{12}

Pentamethylene

CAS: 287-92-3
EC: 206-016-6
UN: 1146

Purity grade	Typical purity	Typical impurities [ppm]
Cyclopentane	≥95 %	H ₂ O ≤100 ppm(w)

Typical filling pressure: Filled as liquid

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•		•			

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
		•	Consult local team

Characteristics

Flammable. Colourless liquid with a petrol-like odour. Vapour is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

GHS-CLP

Signal word: DANGER



H-statements:

H225 - Highly flammable liquid and vapour; H304 - May be fatal if swallowed and enters airways; H336 - May cause drowsiness or dizziness; H412 - Harmful to aquatic life with long lasting effects; EUH066 - Repeated exposure may cause skin dryness or cracking.

Transport of dangerous goods



ADR Class 3, F1



DOT Class 3



Source

Cyclopentane can be formed by catalytic reforming. This specific process reforms iso-Pentane (2-methylbutane) using a platinum catalyst.

Applications

Pentanes are some of the primary blowing agents used in the production of polystyrene foam and other foams. Often a mixture of n-Pentane, i-Pentane and increasingly cyclopentane is used. They have replaced fluorocarbon gases due to their zero ozone depletion and low global warming potential.

Physical data

Molecular weight	72.15	
Boiling point	at 1.013 bar [°C]	49.3 at 14.5 psi [°F]
Density	at 1.013 bar, 20 °C [kg/m ³]	0.74 at 1 atm., 70 °F [lb/ft ³]
Vapour pressure	at 0 °C [bar]	0.14 at 32 °F [psi]
	at 20 °C [bar]	0.35 at 70 °F [psi]
Flammability range in air [% volume]	1.1 – 8.7	

Cyclopropane C_3H_6

CAS: 75-19-4
EC: 200-847-8
UN: 1027

Purity grade	Typical purity	Typical impurities [ppm]
HiQ® Cyclopropane 2.0	≥99 %	Other C_nH_m ≤10,000

Typical filling pressure: 15 °C: 5.3 bar(g)/70 °F: 79 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•					

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
•	•		Consult local team

Characteristics

Flammable, liquefied, colourless gas with a characteristic odour. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

GHS-CLP

Signal word: DANGER



H-statements:

Liquefied Gas → H280 – Contains gas under pressure; may explode if heated; H220 – Extremely flammable gas.

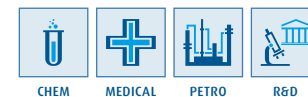
Transport of dangerous goods



ADR Class 2, 2F



DOT Class 2.1



Source

Cyclopropanes can be prepared in the laboratory by organic synthesis in various ways. Many methods are simply called cyclopropanation.

Most common generation route is the catalytic reaction of 1,3-dibromopropane, e.g. in the presence of sodium or zinc.

Applications

Cyclopropane is used as a component in calibration gases for the gas, oil and chemical industries.

Cyclopropane is still used as an intermediate in organic synthesis.

Cyclopropane is used as a plasma etching agent.

Cyclopropane was used as an anaesthetic when inhaled. In modern anaesthetic practice, it has been superseded by other agents, due to its high cost and extreme reactivity under normal conditions. If used today, it may be classified as a medical device in some geographies and managed according to relevant regulations.

Physical data

Molecular weight	42.081			
Boiling point	at 1.013 bar [°C]	-32.78	at 14.5 psi [°F]	-26.98
Density	at 1.013 bar, 15 °C [kg/m ³]	1.812	at 1 atm., 70 °F [lb/ft ³]	0.111
Vapour pressure	at 0 °C [bar]	3.45	at 32 °F [psi]	50.06
	at 20 °C [bar]	6.29	at 70 °F [psi]	94.11
Flammability range in air [% volume]	2.4 – 10.4			

Deuterium D₂

CAS: 7782-39-0
 EC: 231-952-7
 UN: 1957

Purity grade	Typical purity	Typical impurities [ppm]
HiQ® Deuterium	≥99.9 % (D ₂ / (D ₂ +H ₂)>99.8 %)	

Typical filling pressure: 15 °C: 200 bar(g)/ 70 °F: 2,800 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•					

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
•	•		Consult local team

Characteristics

Flammable. Colourless and odourless. Gas density is lighter than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

Proposed by the Industry

Signal word: DANGER



H-statements:

Compressed Gas → H280 – Contains gas under pressure; may explode if heated; H220 – Extremely flammable gas.

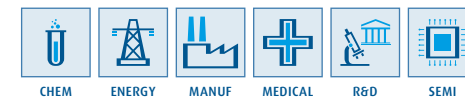
Transport of dangerous goods



ADR Class 2, 1F



DOT Class 2.1



Source

Deuterium is prepared by electrolysis of heavy water (D₂O).

Applications

Deuterium is used in nuclear research as a projectile in deuterium accelerators, and as a source of neutrons when it is irradiated with γ energy rays.

Deuterium is used in physics experiments, such as thermal fusion studies.

It is also used in chemical research, where it is used to label hydrogen-containing molecules and hence to study reactions involving these.

Deuterium is used in electronics as a replacement for hydrogen in the annealing or sintering of silicon-based semiconductors, flat panel displays and solar panels.

Deuterium is used as a trace marker of organic molecules used in CAT (Computed Axial Tomography) scanning studies.

Deuterium is used in HF/DF chemical lasers (see page 127).

Physical data

Molecular weight	4.032	
Boiling point	at 1.013 bar [°C]	-249.5
	at 14.5 psi [°F]	-417.07
Density	at 1.013 bar, 15 °C [kg/m ³]	0.171
	at 1 atm., 70 °F [lb/ft ³]	0.010
Vapour pressure	at 0 °C [bar]	-
	at 32 °F [psi]	-
	at 20 °C [bar]	-
	at 70 °F [psi]	-
Flammability range in air [% volume]	6.7 – 79.6	

Diborane B₂H₆

CAS: 19287-45-7
EC: 242-940-6
UN: 1911

Purity grade	Typical purity	Typical impurities [ppm]				
		N ₂	B _n H _{2n-2} (n>2)	CH ₄	H ₂	CO ₂
HiQ® Diborane 4.0	≥99.99 %	≤10	≤3	≤5	≤500	≤5

Typical filling pressure: 15 °C: 23 bar(g)/70 °F: 332.3 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•					

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
•	•		Consult local team

Characteristics

Colourless gas with a sickly-sweet odour. Flammable, unstable. Gas density is slightly lighter than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

Proposed by the Industry

Signal word: DANGER



H-statements:

Liquefied Gas → H280 – Contains gas under pressure; may explode if heated; H220 – Extremely flammable gas; H330 – Fatal if inhaled.

Transport of dangerous goods



ADR Class 2, 2TF



DOT Class 2.3



Source

Diborane is manufactured by addition of boron trifluoride to a solution of sodium borohydride in diethylene glycol dimethyl ether.

Another industrial reaction path uses the hydrogenation of diboron trioxide in the presence of catalytic aluminium in a high-pressure hydrogen atmosphere.

Applications

Diborane is a catalyst for ethylenic, styrene, acrylic and vinyl polymerisation.

Diborane is used for conversion of olefins to trialkyl boranes and primary alcohols.

Diborane serves as a strong but selective reducing agent in organic chemistry. Typical products synthesised are nitriles, aldehydes, ketones, esters, epoxides and amides.

The addition of diborane to olefins (hydroboration) has great significance in preparative chemistry. In the presence of an ether, diborane forms an alkyl borane, in an anti-Markownikoff mode.

Diborane is used as a rubber vulcaniser. Diborane is used as a reducing agent.

Further areas of application for diborane are the doping of semiconductor silicon and germanium.

Diborane is used as a flame speed accelerator.

Diborane is an intermediate for preparation of boron hydrides of higher molecular weight.

Diborane is used in the process of creating hardened metal surfaces for better wear resistance.

Diborane may be used in rocket propellants as a reducing agent.

Physical data

Molecular weight	27.67			
Boiling point	at 1.013 bar [°C]	-92.5	at 14.5 psi [°F]	-134.48
Density	at 1.013 bar, 15 °C [kg/m ³]	1.181	at 1 atm., 70 °F [lb/ft ³]	0.072
Vapour pressure	at 0 °C [bar]	26.8	at 32 °F [psi]	388
	at 20 °C [bar]	43.5	at 70 °F [psi]	588
Flammability range in air [% volume]	0.9 – 98.0			

1,1-Dichloro-1-fluoroethane



HCFC-141b, R-141b

CAS: 1717-00-6
 EC: 404-080-1
 UN: not applicable
 R-141b

Purity grade	Typical purity	Typical impurities [ppm]
1,1-Dichloro-1-fluoroethane	≥99.9 %	H ₂ O ≤50 ppm(w)

Typical filling pressure: 21.1 °C: 1.3 bar(g)/70 °F: 18.5 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•					

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
		•	Consult local team

Characteristics

Colourless liquid with a slight ethereal smell. Flammable only under specific conditions. Vapour is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

GHS-CLP

Signal word: WARNING



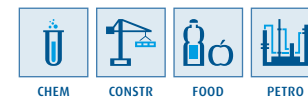
H-statements:

H412 - Harmful to aquatic life with long lasting effects; H420 - Harms public health and the environment by destroying ozone in the upper atmosphere.

Transport of dangerous goods

ADR not applicable

DOT not applicable



Source

Many HCFCs and HFCs are manufactured via similar synthesis routes from common feedstocks. A common synthesis route for 1,1-dichloro-1-fluoroethane uses

dichloroethylene which is reacted with HF in the presence of a catalyst.

Applications

1,1-dichloro-1-fluoroethane (HCFC-141b) is widely used as a foam blowing agent. It was also used historically as a solvent. It is also sometimes used as a refrigerant gas, and is given the ASHRAE number R-141b.

Note:

1,1-dichloro-1-fluoroethane is controlled under the Montreal Protocol on Substances that Deplete the Ozone Layer.

Physical data

Molecular weight	116.95	
Boiling point	at 1.013 bar [°C]	32 at 14.5 psi [°F]
Density	at 1.013 bar, 10 °C [kg/m ³]	1.25 at 1 atm., 50 °F [lb/ft ³]
Vapour pressure	at 0 °C [bar]	0.28 at 32 °F [psi]
	at 20 °C [bar]	0.65 at 70 °F [psi]
Flammability range in air [% volume]	5.6 - 17.7	

2,2-Dichloro-1,1,1-trifluoroethane $C_2HCl_2F_3$

HCFC-123, R-123

CAS: 306-83-2
 EC: 206-190-3
 UN: not applicable
 R-123

Purity grade	Typical purity	Typical impurities [ppm]
2,2-Dichloro-1,1,1-trifluoroethane	≥99.8 %	H ₂ O ≤10 ppm(w)

Typical filling pressure: Filled as liquid

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•					

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
		•	Consult local team

Characteristics

Colourless liquid with a slight ether-like smell. Stable at normal temperatures and storage conditions. Vapour is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

Proposed by the Industry

Signal word: WARNING



H-statements:

H371 - May cause damage to CNS, liver; H373 - May cause damage to liver through prolonged or repeated exposure; H420 - Harms public health and the environment by destroying ozone in the upper atmosphere.

Transport of dangerous goods

ADR not applicable

DOT not applicable



Source

Many HCFCs and HFCs are manufactured via similar synthesis routes from common feedstocks. Many synthesis routes for 2,2-dichloro-1,1,1-trifluoroethane use

trichloroethylene and/or tetrachloroethylene (also known as perchloroethylene, PCE), which is reacted with HF, often in the presence of a catalyst.

Applications

2,2-dichloro-1,1,1-trifluoroethane is commonly used as a refrigerant gas. It is a hydrochlorofluorocarbon (HCFC) and is given the ASHRAE number R-123. It is used as a retrofit alternative to CFC-11 and CFC-113 in low pressure centrifugal chillers.

Note:

2,2-dichloro-1,1,1-trifluoroethane is controlled under the Montreal Protocol on Substances that Deplete the Ozone Layer.

Physical data

Molecular weight	152.93			
Boiling point	at 1.013 bar [°C]	27.8	at 14.5 psi [°F]	82.0
Density	at 1.013 bar, 20 °C [kg/m ³]	1.48	at 1 atm., 70 °F [lb/ft ³]	0.0924
Vapour pressure	at 0 °C [bar]	0.32	at 32 °F [psi]	4.7
	at 20 °C [bar]	0.50	at 70 °F [psi]	13.81
Flammability range in air [% volume]	Not combustible			

Dichlorodifluoromethane CCl_2F_2

CFC-12, R-12

CAS: 75-71-8
 EC: 200-893-9
 UN: 1028
 R-12

Purity grade	Typical purity	Typical impurities [ppm]
Dichlorodifluoromethane	≥99.8 %	contact local team
2.8		

Typical filling pressure: 15 °C: 4.6 bar(g)/70 °F: 69.5 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•					

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
Gaseous Withdrawal	Gaseous Withdrawal	Liquid Withdrawal	Consult local team

Characteristics

Colourless, liquefied gas. Ether-like odour at high concentrations. Decomposes at high temperature to toxic substances. Asphyxiant in high concentrations. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

Proposed by the Industry

Signal word: WARNING



H-statements:

Liquefied Gas → H280 – Contains gas under pressure; may explode if heated; H412 – Harmful to aquatic life with long lasting effects; H420 – Harms public health and the environment by destroying ozone in the upper atmosphere; EIGA-As – Asphyxiant in high concentrations.

Transport of dangerous goods



ADR Class 2, 2A



DOT Class 2.2



Source

Commercial production of chlorofluoroalkanes employs halogen exchange, with hydrogen fluoride in the liquid phase in the presence of a catalyst. Different starting materials are used depending on the desired product. Some commonly used starting materials are carbon tetrachloride, chloroform, tetrachloroethylene and trichloroethylene. The main catalysts used are antimony halides with low volatility.

More recently developed exchange processes are carried out continuously in the gas phase at 100–400°C, using catalysts based on chromium, aluminium or iron.

The composition of the product can be controlled within wide limits by varying temperature, pressure, residence time, catalysts and the portions of the reactants.

Applications

Dichlorodifluoromethane (R-12) has been phased out in many geographies under the Montreal Protocol.

It can be used in the following applications:

- low-temperature air conditioning
- storage of food products
- air conditioning of offices, workshops, stores
- domestic, commercial and industrial refrigeration.

Unreacted material is separated from the crude mixture by fractional distillation and recycled. Further treatment of the products includes washing, drying and distillation.

In the Montedison chlorofluorination process, reaction of C_1 and C_2 hydrocarbons with chlorine and hydrogen fluoride takes place in a single step in a fluidised bed reactor. The catalyst used is based on aluminium chloride.

Commercial production of chlorofluoroalkanes is also possible by the electrochemical fluorination process developed by Phillips Petroleum.

It may also be used as:

- an aerosol propellant
- a swelling agent (rigid foam production)
- a leak detector
- a gas phase dielectric.

Note:

Dichlorodifluoromethane is controlled under the Montreal Protocol on Substances that Deplete the Ozone Layer.

Physical data

Molecular weight	120.91			
Boiling point	at 1.013 bar [°C]	-29.79	at 14.5 psi [°F]	-21.60
Density	at 1.013 bar, 15 °C [kg/m ³]	5.231	at 1 atm., 70 °F [lb/ft ³]	0.319
Vapour pressure	at 0 °C [bar]	3.08	at 32 °F [psi]	44.67
	at 20 °C [bar]	5.63	at 70 °F [psi]	84.23
Flammability range in air [% volume]	Non combustible			

Dichlorofluoromethane CHCl_2F

HCFC-21, R-21

CAS: 75-43-4
EC: 200-869-8
UN: 1029
R-21

Purity grade	Typical purity	Typical impurities [ppm]	Air
HiQ®	≥99.9 %		≤1,000
Dichlorofluoromethane 3.0			

Typical filling pressure: 15 °C: 0.5 bar(g)/70 °F: 8.3 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•					

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
Gaseous Withdrawal	Gaseous Withdrawal	Liquid Withdrawal	Consult local team

Characteristics

Colourless, liquefied gas. Can decompose to toxic substances at high temperatures. Asphyxiant in high concentrations. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

Proposed by the Industry

Signal word: WARNING



H-statements:

Liquefied Gas → H280 – Contains gas under pressure; may explode if heated; H420 – Harms public health and the environment by destroying ozone in the upper atmosphere; EIGA-As – Asphyxiant in high concentrations.

Transport of dangerous goods



ADR Class 2, 2A



DOT Class 2.2



Source

Commercial production of chlorofluoroalkanes employs halogen exchange, with hydrogen fluoride in the liquid phase in the presence of a catalyst. Different starting materials are used depending on the desired product. Some commonly used starting materials are carbon tetrachloride, chloroform, tetrachloroethylene and trichloroethylene. The main catalysts used are antimony halides with low volatility.

More recently developed exchange processes are carried out continuously in the gas phase at 100–400°C, using catalysts based on chromium, aluminium or iron.

The composition of the product can be controlled within wide limits by varying temperature, pressure, residence time, catalysts and the portions of the reactants.

Applications

Dichlorofluoromethane (R-21) has been set to be phased out in many geographies under the Montreal Protocol.

Dichlorofluoromethane (R-21) is used as a refrigerant for the air conditioning of very hot atmospheres.

Note:

Dichlorofluoromethane is controlled under the Montreal Protocol on Substances that Deplete the Ozone Layer.

Unreacted material is separated from the crude mixture by fractional distillation and recycled. Further treatment of the products includes washing, drying and distillation.

In the Montedison chlorofluorination process, reaction of C_1 and C_2 hydrocarbons with chlorine and hydrogen fluoride takes place in a single step in a fluidised bed reactor. The catalyst used is based on aluminium chloride.

Commercial production of chlorofluoroalkanes is also possible by the electrochemical fluorination process developed by Phillips Petroleum.

It has been mainly used as:

- an aerosol propellant
- a solvent
- a chemical intermediate.

Physical data

Molecular weight	102.92			
Boiling point	at 1.013 bar [°C]	8.9	at 14.5 psi [°F]	48.04
Density	at 1.013 bar, 15 °C [kg/m ³]	4.493	at 1 atm., 70 °F [lb/ft ³]	0.274
Vapour pressure	at 0 °C [bar]	0.71	at 32 °F [psi]	10.26
	at 20 °C [bar]	1.53	at 70 °F [psi]	23.0
Flammability range in air [% volume]	Non combustible			

Dichlorosilane SiH_2Cl_2

CAS: 4109-96-0
EC: 223-888-3
UN: 2189



Purity grade	Typical purity	Typical impurities [ppm]					Other chlorosilane
		C	Fe	B	P	As	
HiQ® Dichlorosilane 2.0	≥99 % (by weight) – Resistivity >50 Ω/cm	≤5 ppm(w)	≤50 ppb(w)	≤0.5 ppb(w)	≤0.5 ppb(w)	≤0.5 ppb(w)	≤1 %
HiQ® Dichlorosilane 3.0	≥99.9 % (by weight) – Resistivity >150 Ω/cm	≤1 ppm(w)	≤25 ppb(w)	≤0.1 ppb(w)	≤0.2 ppb(w)	≤0.3 ppb(w)	≤0.1 %

Typical filling pressure: 15 °C: 0.5 bar(g)/70 °F: 8.2 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•					

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
•	•		Consult local team

Characteristics

Flammable. Liquefied gas with pungent odour. Highly corrosive in humid conditions. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

Proposed by the Industry

Signal word: DANGER



H-statements:

Liquefied Gas → H280 – Contains gas under pressure; may explode if heated; H220 – Extremely flammable gas; H330 – Fatal if inhaled; H314 – Causes severe skin burns and eye damage; EUH071 – Corrosive to the respiratory tract.

Transport of dangerous goods



ADR Class 2, 2TFC



DOT Class 2.3

Source

Dichlorosilane is produced (along with other chlorosilanes, such as trichlorosilane) by the reaction of a mixture of hydrogen and hydrogen chloride with silicon at high temperatures.

It is also prepared (5% yield) by disproportionation of trichlorosilane by heating to 300–400°C in the presence of catalysts, e.g. aluminium chloride, ferric chloride and boron trifluoride.

Applications

Used in the manufacturing of organosilicon compounds (silane coupling agents).

Dichlorosilane is used as a silicon source for low-pressure chemical vapour deposition of polysilicon, silicon dioxide, silicon nitride and epitaxial silicon.

Physical data

Molecular weight	101.01			
Boiling point	at 1.013 bar [°C]	8.3	at 14.5 psi [°F]	46.96
Density	at 1.013 bar, 15 °C [kg/m ³]	4.426	at 1 atm., 70 °F [lb/ft ³]	0.217
Vapour pressure	at 0 °C [bar]	0.73	at 32 °F [psi]	10.59
	at 20 °C [bar]	1.52	at 70 °F [psi]	22.90
Flammability range in air [% volume]	2.5 – 80.0			

1,2-Dichlorotetrafluoroethane $C_2Cl_2F_4$

CFC-114, R-114

CAS: 76-14-2
 EC: 200-869-8
 UN: 1958
 R-114

Purity grade	Typical purity	Typical impurities [ppm]
1,2-Dichlorotetrafluoroethane	on request	contact local team

Typical filling pressure: 15 °C: 0.7 bar(g)/70 °F: 12.7 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•					

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
Gaseous Withdrawal	Gaseous Withdrawal	Liquid Withdrawal	Consult local team

Characteristics

Colourless, liquefied gas. Decomposes at high temperatures to toxic substances. Asphyxiant in high concentrations. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

Proposed by the Industry

Signal word: WARNING



H-statements:

Liquefied Gas → H280 – Contains gas under pressure; may explode if heated; H420 – Harms public health and the environment by destroying ozone in the upper atmosphere; EIGA-As – Asphyxiant in high concentrations.

Transport of dangerous goods



ADR Class 2, 2A



DOT Class 2.2



Source

1,2-Dichlorotetrafluoroethane is obtained by treating hexachloroethane with anhydrous hydrogen

fluoride under high pressure in the presence of small amounts of antimony chloride.

Applications

1,2-Dichlorotetrafluoroethane (R-114) is used in small refrigeration systems with rotary compressors, and in large industrial water cooling and air conditioning systems using multi-stage centrifugal compressors.

1,2-Dichlorotetrafluoroethane is used for foam blowing.

1,2-Dichlorotetrafluoroethane is used for heat pumps.

1,2-Dichlorotetrafluoroethane finds widespread use, either alone or in mixtures with dichlorodifluoromethane, as an aerosol propellant, particularly for cosmetics as it is practically odourless and causes no undesirable effect when applied to the skin.

1,2-Dichlorotetrafluoroethane is also used for cleaning of electronic parts.

Note:

1,2-Dichlorotetrafluoroethane is controlled under the Montreal Protocol on Substances that Deplete the Ozone Layer.

Physical data

Molecular weight	170.92			
Boiling point	at 1.013 bar [°C]	3.77	at 14.5 psi [°F]	38.81
Density	at 1.013 bar, 15 °C [kg/m ³]	7.532	at 1 atm., 70 °F [lb/ft ³]	0.459
Vapour pressure	at 0 °C [bar]	0.88	at 32 °F [psi]	12.81
	at 20 °C [bar]	1.84	at 70 °F [psi]	27.43
Flammability range in air [% volume]	Non combustible			

1,1-Difluoroethane $C_2H_4F_2$

Difluoroethane, Ethylidene difluoride, HFC-152a, R-152a

CAS: 75-37-6
EC: 200-866-1
UN: 1030
R-152a

Purity grade	Typical purity	Typical impurities [ppm]
1,1-Difluoroethane 3.0	≥99.9 %	contact local team

Typical filling pressure: 15 °C: 4.2 bar(g) / 70 °F: 62.9 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•		•			

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
•	•		Consult local team

Characteristics

Flammable. Colourless, liquefied gas. Dry gas is not corrosive. Decomposes at high temperatures to toxic substances. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

Proposed by the Industry

Signal word: DANGER



H-statements:

Liquefied Gas → H280 – Contains gas under pressure; may explode if heated; H220 – Extremely flammable gas.

Transport of dangerous goods



ADR Class 2, 2F



DOT Class 2.1



Source

1,1-Difluoroethane is manufactured by catalytic addition of hydrogen fluoride to acetylene.

Applications

1,1-Difluoroethane (R-152a) is used:

- in the formulation of aerosol dispersants with stringent environmental VOC demands
- as a low-temperature solvent
- in refrigeration systems where its flammability is not a major factor and as a component in some hydrochlorofluorocarbon (HCFC) refrigerant blends (HCFCs replace chlorofluorocarbons (CFCs))
- as an organic synthesis intermediate.

Note:

1,1-Difluoroethane is listed in the Kyoto Protocol, an international Framework Convention with the objective of reducing greenhouse gases.

Physical data

Molecular weight	66.051	
Boiling point	at 1.013 bar [°C]	-25.8 at 14.5 psi [°F]
Density	at 1.013 bar, 15 °C [kg/m ³]	2.857 at 1 atm., 70 °F [lb/ft ³]
Vapour pressure	at 0 °C [bar]	2.69 at 32 °F [psi]
	at 20 °C [bar]	5.17 at 70 °F [psi]
Flammability range in air [% volume]	4.0 – 20.2	

1,1-Difluoroethylene $C_2H_2F_2$

1,1-Difluoroethene, HFC-1132a, R-1132a

CAS: 75-38-7
 EC: 200-867-7
 UN: 1959
 R-1132a

Purity grade	Typical purity	Typical impurities [ppm]
1,1-Difluoroethylene 2.0	≥99 %	contact local team

Typical filling pressure: 15 °C: 35 bar(g)/70 °F: 521.8 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•					

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
•	•		Consult local team

Characteristics

Flammable. Colourless, liquefied gas. Dry gas is not corrosive. Can decompose to toxic substances at high temperatures. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

Proposed by the Industry

Signal word: DANGER



H-statements:

Liquefied Gas → H280 – Contains gas under pressure; may explode if heated; H220 – Extremely flammable gas.

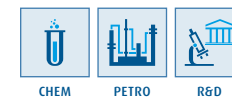
Transport of dangerous goods



ADR Class 2, 2F



DOT Class 2.1



Source

1,1-Difluoroethylene can be obtained by dehydrochlorination of 1-chloro-1,1-difluoroethane (R-142b).

Two other reaction paths use dechlorination of 1,2-dichloro-1,1-difluoroethane (R152a) or the dehydrofluorination of 1,1,1-trifluoroethane (R143a).

1,1-Difluoroethylene is produced by passing a mixture of hydrogen and 1,2-dichloro-1,1-difluoroethane over nickel wire at an elevated temperature.

Applications

1,1-Difluoroethylene is used for the preparation of polymers like polyvinylidene polymers and for copolymers together with chlorotrifluoroethylene or hexafluoropropylene (TFB).

1,1-Difluoroethylene is used as an intermediate in organic synthesis.

Physical data

Molecular weight	64.035			
Boiling point	at 1.013 bar [°C]	-85.65	at 14.5 psi [°F]	14.42
Density	at 1.013 bar, 15 °C [kg/m ³]	2.732	at 1 atm., 70 °F [lb/ft ³]	0.174
Vapour pressure	at 0 °C [bar]	22.6	at 32 °F [psi]	327.7
	at 20 °C [bar]	36.1	at 70 °F [psi]	536.5
Flammability range in air [% volume]	4.7 – 25.1			

Difluoromethane CH_2F_2

Methylene fluoride, HFC-32, R-32

CAS: 75-10-5
 EC: 200-839-4
 UN: 3252
 R-32

Purity grade	Typical purity	Typical impurities [ppm]
Difluoromethane 3.0	≥99.9 %	contact local team

Typical filling pressure: 15 °C: 13.6 bar(g)/70 °F: 205 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•					

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
•	•		Consult local team

Characteristics

Flammable. Liquefied gas. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

Proposed by the Industry

Signal word: DANGER



H-statements:

Liquefied Gas → H280 – Contains gas under pressure; may explode if heated; H220 – Extremely flammable gas.

Transport of dangerous goods



ADR Class 2, 2F



DOT Class 2.1



Source

Difluoromethane is produced by reacting methyl chloride with hydrogen fluoride in the presence of a catalyst.

Applications

Difluoromethane is used in plasma etching of silicon layers.

Difluoromethane (R-32) has been mainly used as a refrigerant.

Difluoromethane may also be used in cooling aerosols.

Note:

Difluoromethane is listed in the Kyoto Protocol, an international Framework Convention with the objective of reducing greenhouse gases.

Physical data

Molecular weight		52.02		
Boiling point	at 1.013 bar [°C]	-51.65	at 14.5 psi [°F]	-60.97
Density	at 1.013 bar, 15 °C [kg/m ³]	2.180	at 1 atm., 70 °F [lb/ft ³]	0.136
Vapour pressure	at 0 °C [bar]	8.1	at 32 °F [psi]	117.5
	at 20 °C [bar]	14.7	at 70 °F [psi]	219.8
Flammability range in air [% volume]		14.0 – 33.0		

Dimethyl ether C_2H_6O

Methoxymethane, Dimethyl oxide

CAS: 115-10-6
EC: 204-065-8
UN: 1033

Purity grade	Typical purity	Typical impurities [ppm]
Dimethyl ether 3.0	≥99.9 %	contact local team

Typical filling pressure: 15 °C: 4.3 bar(g)/70 °F: 62.3 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•		•			

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
Gaseous Withdrawal	Gaseous Withdrawal	Liquid Withdrawal	Consult local team

Characteristics

Flammable. Liquefied colourless gas with ether like odour. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

GHS-CLP

Signal word: DANGER



H-statements:

Liquefied Gas → H280 – Contains gas under pressure; may explode if heated; H220 – Extremely flammable gas.

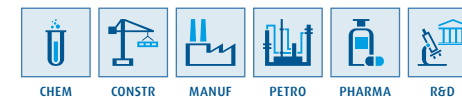
Transport of dangerous goods



ADR Class 2, 2F



DOT Class 2.1



Source

Dimethyl ether is prepared from synthesis gas either in a one-step or a two-step process. The intermediate methanol may also be gained from biomass. This calls either for a single catalyst (1-step) or a dual catalyst (2-step) reaction

Applications

Dimethyl ether finds commercial use as a refrigerant.

Dimethyl ether is used as a solvent, as an extraction agent and as a propellant in aerosols, especially those for personal care products such as hairsprays.

Dimethyl ether is also used as a fuel for forklifts and for welding, cutting and brazing.

Dimethyl ether readily forms complexes with inorganic compounds, e.g. boron trifluoride. It is an excellent methylating agent, e.g. for conversion of aniline into dimethylaniline in the dye industry.

Dimethyl ether is used in the chemical industry in the manufacture of synthetic rubber.

system. The latter reaction does not require methanol separation and purification, but does entail a higher start-up cost.

Dimethyl ether is industrially important as the starting material in the production of dimethyl sulfate. (Dimethyl sulfate is employed as a methylating agent.)

Dimethyl ether reacted with carbon monoxide could be used in the large-scale production of acetic acid in place of methanol.

Future industrial uses of dimethyl ether include the production of olefins in the presence of zeolitic catalysts. The production of saturated hydrocarbons can be carried out by an analogous process.

Dimethyl ether is also used in the methanol to gasoline conversion process, and is under consideration for use in European biofuel mixtures.

Physical data

Molecular weight	46.069			
Boiling point	at 1.013 bar [°C]	-24.84	at 14.5 psi [°F]	-12.69
Density	at 1.013 bar, 15 °C [kg/m ³]	1.988	at 1 atm., 70 °F [lb/ft ³]	0.121
Vapour pressure	at 0 °C [bar]	2.65	at 32 °F [psi]	38.42
	at 20 °C [bar]	5.09	at 70 °F [psi]	76.35
Flammability range in air [% volume]	2.7 – 32.0			

Dimethylamine (CH₃)₂NH

CAS: 124-40-3
EC: 204-697-4
UN: 1032

Purity grade	Typical purity	Typical impurities [ppm]	Other amines
Dimethylamine 2.0	≥99 %		≤1 %

Typical filling pressure: 15 °C: 0.75 bar(g)/70 °F: 11 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•					

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
•	•		Consult local team

Characteristics

Flammable. Liquefied colourless gas with strong ammonia/fish-like odour. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

GHS-CLP

Signal word: DANGER



H-statements:

Liquefied Gas → H280 – Contains gas under pressure; may explode if heated; H220 – Extremely flammable gas; H332 – Harmful if inhaled; H335 – May cause respiratory irritation; H315 – Causes skin irritation; H318 – Causes serious eye damage.

Transport of dangerous goods



ADR Class 2, 2F



DOT Class 2.1



Source

Dimethylamine is prepared commercially either by a reaction between methanol and ammonia, or alternatively by a reaction of a carbonyl compound and ammonia.

Monomethylamine and trimethylamine are formed in the same reaction and the three products are then separated by distillation.

Applications

Dimethylamine has been used as a de-hairing agent in tanning.

Dimethylamine is an important intermediate in the synthesis of a broad range of products, e.g. propellants, monomers, solvents, catalysts, insecticides, surfactants and ion-exchange resins.

Dimethylamine:

- is used as an acid gas absorbent.
- is used as a flotation agent.
- is used as a gasoline stabiliser.
- is used as a raw material in pharmaceuticals.
- is used in rubber accelerators.
- is used in soaps and cleaning compounds.
- is used in the treatment of cellulose acetate rayon.
- is used in organic synthesis.
- is used as a raw material in producing water treatment chemicals.
- is used as an agricultural fungicide. For this use, it may require registration/authorisation to comply with local legal requirements on biocidal products.
- is used for electroplating.
- is used as an anti-oxidising agent.
- is also used for preparation of dyes.

Physical data

Molecular weight	45.084			
Boiling point	at 1.013 bar [°C]	6.88	at 14.5 psi [°F]	44.40
Density	at 1.013 bar, 15 °C [kg/m ³]	1.965	at 1 atm., 70 °F [lb/ft ³]	0.120
Vapour pressure	at 0 °C [bar]	0.74	at 32 °F [psi]	10.75
	at 20 °C [bar]	1.68	at 70 °F [psi]	25.47
Flammability range in air [% volume]	2.8 – 14.4			

2,2-Dimethylpropane C_5H_{12}

Neopentane

CAS: 463-82-1
EC: 207-343-7
UN: 2044

Purity grade	Typical purity	Typical impurities [ppm]
HiQ® 2,2-dimethylpropane 2.0	≥99 %	contact local team

Typical filling pressure: 15 °C: 0.45 bar(g)/70 °F: 7 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•					

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
•	•		Consult local team

Characteristics

Flammable. Liquefied colourless gas with petrol like odour. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

GHS-CLP

Signal word: DANGER



H-statements:

Liquefied Gas → H280 – Contains gas under pressure; may explode if heated; H220 – Extremely flammable gas; H411 – Toxic to aquatic life with long lasting effects.

Transport of dangerous goods



ADR Class 2, 2F



DOT Class 2.1



Source

2,2-Dimethylpropane can be isolated from the C5 mixture or derived from liquid components of natural gas or from light gasoline (naphtha). The separation is carried out either by

molecular sieve separation or by super-fractionation and specific distillation.

Applications

2,2-Dimethylpropane is used as raw material in the production of iso-butene, which in turn is used to manufacture synthetic butyl rubber.

2,2-Dimethylpropane is used as calibration standard for NMR (Nuclear Magnetic Resonance) spectroscopy.

2,2-Dimethylpropane is used as a solvent and a synthesis intermediate.

2,2-Dimethylpropane is used as a component in calibration gases for the gas, oil and chemical industries.

Physical data

Molecular weight	72.15	
Boiling point	at 1.013 bar [°C]	9.5 at 14.5 psi [°F] 49.12
Density	at 1.013 bar, 15 °C [kg/m ³]	3.193 at 1 atm., 70 °F [lb/ft ³] 0.195
Vapour pressure	at 0 °C [bar]	0.71 at 32 °F [psi] 10.34
	at 20 °C [bar]	1.46 at 70 °F [psi] 21.93
Flammability range in air [% volume]	1.3 – 7.5	

Ethane C_2H_6

R-170

CAS: 74-84-0
 EC: 200-814-8
 UN: 1035
 UN: 1961 (Refrigerated liquid)
 R-170

Purity grade	Typical purity	Typical impurities [ppm]
Ethane 2.5	≥99.5 %	Other C_nH_m ≤5,000
HiQ® Ethane 3.5	≥99.95 %	≤450

Typical filling pressure: 15 °C: 36 bar(g)/70 °F: 544 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•	•				

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
•	•		Consult local team

Characteristics

Flammable. Liquefied, odourless, colourless gas. Gas density is slightly heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

GHS-CLP

Signal word: DANGER



H-statements:

Liquefied Gas → H280 – Contains gas under pressure; may explode if heated; Refrigerated Gas → H281 – Contains refrigerated gas; may cause cryogenic burns or injury; H220 – Extremely flammable gas.

Transport of dangerous goods



ADR Class 2, 2F
 3F (Refrigerated liquid)



DOT Class 2.1



Source

The main commercial source of ethane is natural gas. Ethane is isolated either by absorption or by partial condensation,

followed by distillation. Relatively small volumes of ethane are also gained as a by-product in oil refining processes.

Applications

The main industrial use for ethane is the production of ethene by steam-cracking.

Ethane is used as a refrigerant for extremely low temperature refrigeration systems. It has the ASHRAE number R-170.

It is commonly used as a raw material for the manufacture of halogenated ethane.

Ethane is used in metallurgy for heat treatments.

Ethane is used in the chemical industry for the production of ethanol, epoxyethane, glycol, acetaldehyde, ethenyl acetate, ethyl chloride, dichloroethane, styrene, polyethylene, thermopolymers and higher alcohols.

Ethane is used as a calibration gas for combustion research.

Ethane is used as a component in calibration gases for the automotive, gas, oil and chemical industries.

Physical data

Molecular weight	30.07			
Boiling point	at 1.013 bar [°C]	-88.6	at 14.5 psi [°F]	-127.46
Density	at 1.013 bar, 15 °C [kg/m ³]	1.283	at 1 atm., 70 °F [lb/ft ³]	0.078
Vapour pressure	at 0 °C [bar]	23.87	at 32 °F [psi]	346.2
	at 20 °C [bar]	37.69	at 70 °F [psi]	559.92
Flammability range in air [% volume]	2.4 – 14.3			

Ethanedinitrile C_2N_2

Cyanogen, Oxalonitrile, EDN

CAS: 460-19-5
EC: 207-306-5
UN: 1026

Purity grade	Typical purity	Typical impurities [ppm]
Ethanedinitrile 2.0	≥99 %	contact local team

Typical filling pressure: 15 °C: 3.9 bar(g)/70 °F: 58.9 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•					

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
•	•		Consult local team

Characteristics

Colourless, liquefied gas with an odour of bitter almonds. Poor warning properties at low concentrations. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

GHS-CLP

Signal word: DANGER



H-statements:

Liquefied Gas → H280 – Contains gas under pressure; may explode if heated; H220 – Extremely flammable gas; H330 – Fatal if inhaled; H410 – Very toxic to aquatic life with long lasting effects.

Transport of dangerous goods



ADR Class 2, 2TF



DOT Class 2.3



Source

Ethanedinitrile is typically generated from cyanide compounds. Alternatively, one can combine solutions of copper(II) salts (such as copper(II) sulfate) with cyanides. An unstable copper(II) cyanide is formed which rapidly decomposes into copper(I) cyanide and ethanedinitrile.

Applications

Ethanedinitrile has a long history and was probably first generated by Carl Scheele around 1782 in the course of his studies of hydrogen cyanide. The first confirmed synthesis was reported in 1802, when it was used to make what we now know as cyanic chloride (cyanogen chloride). It attained importance with the growth of the fertiliser industry in the late nineteenth century.

Ethanedinitrile is used as a stabiliser in the production of nitrocellulose.

Ethanedinitrile is used as a fumigant for a number of applications; it has a better efficacy and allows faster replanting when compared to other fumigants.

Industrially, it is made by the oxidation of hydrogen cyanide, usually using chlorine over an activated silicon dioxide catalyst or nitrogen dioxide over a copper salt. It is also formed when nitrogen (N_2) and acetylene (C_2H_2) are forced to react by an electrical spark or discharge.

Ethanedinitrile may require registration/authorisation to comply with local legal requirements on pesticides/biocides.

Ethanedinitrile is also used for special welding, due to the second highest known flame temperature (4,527°C, 8,180°F) when it burns in oxygen.

Ethanedinitrile is an important intermediate in the production of many fertilisers.

Physical data

Molecular weight	52.035			
Boiling point	at 1.013 bar [°C]	-21.2	at 14.5 psi [°F]	-6.14
Density	at 1.013 bar, 15 °C [kg/m ³]	2.24	at 1 atm., 70 °F [lb/ft ³]	0.140
Vapour pressure	at 0 °C [bar]	2.44	at 32 °F [psi]	35.35
	at 20 °C [bar]	4.90	at 70 °F [psi]	73.58
Flammability range in air [% volume]	3.9 – 36.6			

Ethyl chloride C_2H_5Cl

Chloroethane

CAS: 75-00-3
 EC: 200-830-5
 UN: 1037
 R-160

Purity grade	Typical purity	Typical impurities [ppm]	
HiQ® Ethyl chloride 3.0	≥99.9 %	H ₂ O	Acidity (as HCl)
		≤100	≤10

Typical filling pressure: 15 °C: 0.3 bar(g)/70 °F: 5.6 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•					

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
•	•		Consult local team

Characteristics

Flammable. Liquefied colourless gas with an ethereal odour. Poor warning properties at low concentrations. Gas density is heavier than air.

GHS-CLP

Signal word: DANGER



H-statements:

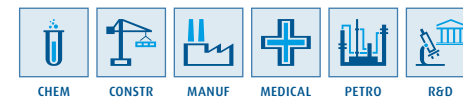
Liquefied Gas → H280 – Contains gas under pressure; may explode if heated; H220 – Extremely flammable gas; H351 – Suspected of causing cancer; H412 – Harmful to aquatic life with long lasting effects.



ADR Class 2, 2F



DOT Class 2.1



Source

Ethyl chloride is produced by the reaction of chlorine on ethene in the presence of chlorides of copper, iron, antimony and calcium.

Some Ethyl chloride is generated as a by-product of polychloroethene production.

Ethyl chloride can also be prepared photochemically by the reaction of chlorine and ethene in the presence of light and hydrogen chloride.

Applications

Ethyl chloride has been used as a foaming agent, anaesthetic, refrigerant and propellant, and in tetraethyl lead manufacturing.

Ethyl chloride is used industrially in treating cellulose to make ethyl cellulose, a thickening agent and binder in paints, cosmetics and similar products.

Ethyl chloride is used as an alkylating agent. Ethyl chloride is used as an intermediate in organic synthesis.

Physical data

Molecular weight	64.514			
Boiling point	at 1.013 bar [°C]	12.27	at 14.5 psi [°F]	54.09
Density	at 1.013 bar, 15 °C [kg/m ³]	2.819	at 1 atm., 70 °F [lb/ft ³]	0.176
Vapour pressure	at 0 °C [bar]	0.62	at 32 °F [psi]	9.03
	at 20 °C [bar]	1.34	at 70 °F [psi]	20.25
Flammability range in air [% volume]	3.6 – 14.8			

Ethyl formate $C_3H_6O_2$

CAS: 109-94-4
EC: 203-721-0
UN: 1190

Purity grade	Typical purity	Typical impurities [ppm]
Ethyl formate 2.0	≥99 %	contact local team

Typical filling pressure: Filled as liquid

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•					

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
		•	Consult local team

Characteristics

Flammable, colourless liquid with distinct and alcoholic odour. Heavier than air. Vapour is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

GHS-CLP

Signal word: DANGER



H-statements:

H225 – Highly flammable liquid and vapour; H332 – Harmful if inhaled;

H302 – Harmful if swallowed; H319 – Causes serious eye irritation;

H335 – May cause respiratory irritation.

Transport of dangerous goods



ADR Class 3, F1



DOT Class 3



Source

The main method is the conversion of ethanol and formic acid in the presence of a catalyst like sulfuric acid. The

water formed is extracted on a continuous basis off the formed ethyl formate.

Applications

Ethyl formate is used as a flavouring for lemonade and essences, it has a typical smell associated with rum. Ethyl formate is considered to be a GRAS (= generally considered as safe) additive by the EPA.

In industry, it is used as a solvent for cellulose nitrate, cellulose acetate, oils and greases. It can be used as a solvent to substitute acetone, for example. In the pharmaceutical industry, it is widely used as a fragrance and it is used in chemical synthesis as an intermediate.

Ethyl formate can be used as a fumigant for dried fruits, tobacco, cereals, fresh fruit, cut flowers and many more. For such use it may require registration/authorisation to comply with local legal requirements on pesticides/biocides. Blends of ethyl formate are registered in countries like Australia and the Philippines for this application.

Physical data

Molecular weight	74.09	
Boiling point	at 1.013 bar [°C]	53.00 at 14.5 psi [°F]
Density	at 1.013 bar, 15 °C [kg/m ³]	916.80 at 1 atm., 70 °F [lb/ft ³]
Vapour pressure	at 0 °C [bar]	0.0961 at 32 °F [psi]
	at 20 °C [bar]	0.256 at 70 °F [psi]
Flammability range in air [% volume]	2.6 – 18.2	

Ethylamine (C₂H₅)NH₂

Ethanamine, Aminoethane

CAS: 75-04-7
EC: 200-834-7
UN: 1036

Purity grade	Typical purity	Typical impurities [ppm]
Ethylamine 2.0	≥99 %	contact local team

Typical filling pressure: 15 °C: 0.19 bar(g) /70 °F: 2.8 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•					

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
•	•		Consult local team

Characteristics

Flammable. Liquefied colourless gas with strong ammonia/rotten fish-like odour. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

GHS-CLP

Signal word: DANGER



H-statements:

Liquefied Gas → H280 – Contains gas under pressure; may explode if heated; H220 – Extremely flammable gas; H332 – Harmful if inhaled; H319 – Causes serious eye irritation; H335 – May cause respiratory irritation.

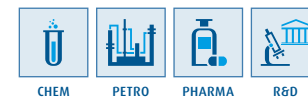
Transport of dangerous goods



ADR Class 2, 2F



DOT Class 2.1



Source

Ethylamine is produced industrially from ethanol/bio ethanol and ammonia with the help of an oxide catalyst. In a subsequent purification step it may be separated from the co-produced diethyl amine and triethyl amine.

Ethylamine is further prepared in a reaction of ethyl iodide and liquid ammonia.

An alternative reaction path uses the reductive amination of acetaldehyde.

Applications

Ethylamine is widely used in organic chemistry as a reactive molecule or precursor in many syntheses.

Ethylamine is a major precursor in herbicide production.

Ethylamine is used to produce flotation agents, mining chemicals and as a chain stopper in the production of polyurethane.

Ethylamine:

- is used as a solvent in lithium chemistry.
- is used as a stabiliser for rubber latex.
- is used as an intermediate in dye stuff.
- is used as an intermediate in pharma production.

Physical data

Molecular weight	45.084			
Boiling point	at 1.013 bar [°C]	16.58	at 14.5 psi [°F]	61.86
Density	at 1.013 bar, 15 °C [kg/m ³]	1.970	at 1 atm., 70 °F [lb/ft ³]	0.120
Vapour pressure	at 0 °C [bar]	0.49	at 32 °F [psi]	7.10
	at 20 °C [bar]	1.15	at 70 °F [psi]	17.45
Flammability range in air [% volume]	3.5 – 13.9			

Ethylene C_2H_4

Ethene

CAS: 74-85-1
 EC: 200-815-3
 UN: 1962
 UN: 1038 (Refrigerated liquid)
 R-1150

Purity grade	Typical purity	Typical impurities [ppm]		
		O ₂	N ₂	Other C _n H _m
Ethylene 3.0	≥99.9 %	≤30	≤150	≤1100
HiQ® Ethylene 3.5	≥99.95 %	≤15	≤50	≤450

Typical filling pressure: 15 °C: 80 bar(g)/ 70 °F: 1,200 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•	•				

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
Gaseous Withdrawal	Gaseous Withdrawal	Liquid Withdrawal	Consult local team

Characteristics

Flammable. Colourless gas with slight odour. Gas density is slightly lighter than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

GHS-CLP

Signal word: DANGER



H-statements:

Liquefied Gas → H280 – Contains gas under pressure; may explode if heated; Refrigerated Gas → H281 – Contains refrigerated gas; may cause cryogenic burns or injury; H220 – Extremely flammable gas; H336 – May cause drowsiness or dizziness.

Transport of dangerous goods



ADR Class 2, 2F
 3F (Refrigerated liquid)



DOT Class 2.1



Source

Ethylene is mainly produced in chemical refineries by different cracking processes depending on the raw material/product stream used. In this process, heavier hydrocarbons are broken up at high temperature to form C₂ and C₃ hydrocarbons, mainly unsaturated ethylene. Combined compression and distillation steps yield pure ethylene.

Smaller volumes of ethylene are produced by passing ethyl alcohol vapours over dehydrating catalysts at 360–470°C.

Ethylene may also be produced by the pyrolysis of ethane.

Applications

Ethylene is the starting material for many industrial syntheses. It is employed as an intermediate in the chemical industry and for the production of a huge variety of plastics.

Ethylene is used for the production of many major chemicals:

- acetaldehyde
- acetic acid
- chloroethene (vinyl chloride)
- dichloroethane
- 1,1-dichloroethene (vinylidene chloride)
- epoxyethane (ethylene oxide)
- ethanediol (ethylene glycol)
- ethanol
- ethoxyethane
- ethyl chloride
- ethylbenzene
- phenylethene (styrene)
- polychloroethene (polyvinyl chloride)
- polyethene
- propanoic acid
- tetraethyl lead
- trichloroethane

Ethylene may be employed for welding and cutting, but it is not used for this purpose industrially.

Ethylene is used for controlled ripening of fruit, especially bananas. Concentrations of a few ppm only are used in warehouse atmospheres. Because of flammability considerations, it is strongly recommended to use a mixture of ethylene in nitrogen in this application. Ethylene may require registration/authorisation to comply with local legal requirements on plant protection/growth regulator products.

Ethylene has also been used in agriculture to promote crop growth: in these cases the gas is injected directly into the soil.

Ethylene is still used as an anaesthetic (in the US). Ethylene for this purpose may be classified as a medical gas in some geographies and managed according to the relevant regulation.

Ethylene is used as a refrigerant, especially in the petrochemical industry. It has the ASHRAE number R-1150.

Ethylene is used as a component in calibration gases for the automotive, gas, oil and chemical industries.

Physical data

Molecular weight	28.054			
Boiling point	at 1.013 bar [°C]	-103.68	at 14.5 psi [°F]	-154.60
Density	at 1.013 bar, 15 °C [kg/m ³]	1.194	at 1 atm., 70 °F [lb/ft ³]	0.073
Vapour pressure	at 0 °C [bar]	40.95	at 32 °F [psi]	593.9
	at 20 °C [bar]	-	at 70 °F [psi]	-
Flammability range in air [% volume]	2.4 – 32.6			

Ethylene Oxide C_2H_4O

Epoxyethane, Oxirane

CAS: 75-21-8
EC: 200-849-9
UN: 1040

Purity grade	Typical purity	Typical impurities [ppm]	
HiQ® Ethylene oxide 3.0	≥99.9 %	H ₂ O ≤200 % (w)	CO ₂ ≤200

Typical filling pressure: 15 °C: 0.47 bar(g)/70 °F: 7.3 psi(g) normally pressurised with nitrogen at 6-7 bar

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•		•			

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
Gaseous Withdrawal	Gaseous Withdrawal	Liquid Withdrawal	Consult local team

Characteristics

Flammable. Odourless and colourless gas. Heavier than air. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

GHS-CLP

Signal word: DANGER



H-statements:

Liquefied Gas → H280 – Contains gas under pressure; may explode if heated; H220 – Extremely flammable gas; H230 – May react explosively even in absence of air; H350 – May cause cancer; H340 – May cause genetic defects; H331 – Toxic if inhaled; H319 – Causes serious eye irritation; H335 – May cause respiratory irritation; H315 – Causes skin irritation.

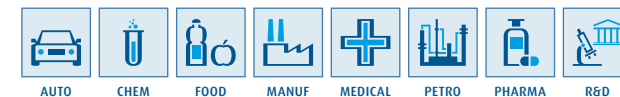
Transport of dangerous goods



ADR Class 2, 2TF



DOT Class 2.3



Source

Ethylene oxide is usually manufactured by direct oxidation of ethylene using oxygen at high temperature in the presence of silver catalysts.

Applications

The main use of ethylene oxide is in the manufacture of ethene glycol (ethylene glycol) and higher alcohols which find important applications in automotive antifreeze.

Other main chemical products synthesised are glycol ethers, ethanolamines, ethoxylates and acrylonitriles. Typical uses are as solvents and in the production of scrubber fluids, surfactants and synthetic rubber.

It is also used in the production of explosives, cellophane, detergents, lubricants and hydraulic fluids.

As a pharmaceutical intermediate, ethylene oxide is used in the synthesis of choline, thiamine and procaine.

Ethylene oxide may be used as a fumigant by applying EtO mixtures with either carbon dioxide or halocarbon propellants. Its use for such applications may be restricted in many geographies, e.g. EtO is banned as a pesticide in the EU. Thus EtO may require registration/authorisation to comply with local legal requirements on biocidal products.

Note:

Ethylene oxide is listed in the Rotterdam Convention. There may be import/export restrictions.

Physical data			
Molecular weight		44.053	
Boiling point	at 1.013 bar [°C]	10.45	at 14.5 psi [°F] 50.81
Density	at 1.013 bar, 15 °C [kg/m ³]	1.91	at 1 atm., 70 °F [lb/ft ³] 0.117
Vapour pressure	at 0 °C [bar]	0.66	at 32 °F [psi] 9.61
	at 20 °C [bar]	1.47	at 70 °F [psi] 22.1
Flammability range in air [% volume]		2.6 – 100	

Ethylene oxide is widely used as a sterilisation agent for medical devices. Typical products sterilised with ethylene oxide are: medicine bottles, food containers, disposable nappies, sanitary towels, packaged sterile medical devices, surgeons gloves and instruments, first aid bandages, etc.

Ethylene oxide is used in fermentation processes and in the preparation of antibiotics.

Fluorine F_2

CAS: 7782-41-4
EC: 231-954-8
UN: 1045

Purity grade	Typical purity	Typical impurities [ppm]
		HF
Fluorine 1.8	≥98 %	≤5,000
		$N_2 + O_2$
		≤10,000

Typical filling pressure: 15 °C: 28 bar(g)/70 °F: 300 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•					

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
•	•		Consult local team

Characteristics

Pale yellow gas with sharp odour. Ignites most organic materials and metals. Highly corrosive. See comprehensive handling directives. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

GHS-CLP

Signal word: DANGER



H-statements:

Compressed Gas → H280 – Contains gas under pressure; may explode if heated; H270 – May cause or intensify fire; oxidiser; H330 – Fatal if inhaled; H314 – Causes severe skin burns and eye damage; EUH071 – Corrosive to the respiratory tract.

Transport of dangerous goods



ADR Class 2, 2TOC



DOT Class 2.3



Source

Fluorine is produced by electrolysis of a solution of potassium fluoride and anhydrous hydrogen fluoride at elevated temperature.

Applications

The primary use for fluorine is in the refining of uranium. During the process, fluorine reacts with uranium to produce uranium hexafluoride, which may then be purified in the gaseous state before being converted back to uranium.

Fluorine is also required in the production of a variety of fluorinated compounds such as sulfur hexafluoride, boron trifluoride and metal fluorides. Fluorine is used in HF/DF chemical lasers.

Fluorine and graphite heated generate carbon monofluoride (graphite fluoride), which is used as a dry lubricant or as a material for electrodes.

Fluorine is used for fluorination in the production of:

- fluorinated hydrocarbons (Freon®, Forane®, etc.) and plastics (Teflon®, Kel-F®, etc.)
- fluorosilicates used to opacify and reduce the viscosity of certain glasses
- perfluoro acids used to obtain wetting agents
- inorganic fluorinated compounds such as tungsten hexafluoride used for metal coatings, iodine pentafluoride used in the manufacture of special fabrics and antimony pentafluoride used to replace tetraethyl lead in automobile fuels.

When diluted to a concentration of about 1% in nitrogen, fluorine is used during the blow moulding of polyethylene containers to create an impervious barrier on the inner walls of the blown vessels. These containers are then more suitable for storage of solvents or other chemicals.

Fluorine is used for chamber cleaning in the semiconductor industry.

Physical data

Molecular weight	37.997			
Boiling point	at 1.013 bar [°C]	-188.2	at 14.5 psi [°F]	-306.74
Density	at 1.013 bar, 15 °C [kg/m ³]	1.608	at 1 atm., 70 °F [lb/ft ³]	0.098
Vapour pressure	at 0 °C [bar]	-	at 32 °F [psi]	-
	at 20 °C [bar]	-	at 70 °F [psi]	-
Flammability range in air [% volume]	Non combustible			

Fluoromethane CH_3F

Methyl fluoride, HFC-41, R-41

CAS: 593-53-3
EC: 209-796-6
UN: 2454
R-41

Purity grade	Typical purity	Typical impurities [ppm]		
		H_2O	O_2	N_2
Fluoromethane 2.5	≥99.5 %	≤100	≤1,200	≤3,600

Typical filling pressure: 15 °C: 33 bar(g)/70 °F: 485.8 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•					

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
•	•		Consult local team

Characteristics

Flammable. Liquefied, colourless gas with a sweet odour. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

Proposed by the Industry

Signal word: DANGER



H-statements:

Liquefied Gas → H280 – Contains gas under pressure; may explode if heated; H220 – Extremely flammable gas.

Transport of dangerous goods



ADR Class 2, 2F



DOT Class 2.1



Source

Fluoromethane is prepared by heating fluorosulfonic acid methyl ester with potassium fluoride.

Fluoromethane is produced industrially by catalytically reacting ethane and hydrogen fluoride in the presence of aluminium trichloride.

Applications

Fluoromethane is used in plasma etching of silicon compound films in semiconductor manufacturing.

Fluoromethane has been used as a refrigerant and was previously used as a propellant.

Note:

Fluoromethane is listed in the Kyoto Protocol, an international Framework Convention with the objective of reducing greenhouse gases.

Physical data

Molecular weight	34.03	
Boiling point	at 1.013 bar [°C]	-78.4
	at 14.5 psi [°F]	-109.1
Density	at 1.013 bar, 15 °C [kg/m ³]	1.452
	at 1 atm., 70 °F [lb/ft ³]	0.089
Vapour pressure	at 0 °C [bar]	19.80
	at 32 °F [psi]	287.2
	at 20 °C [bar]	33.56
	at 70 °F [psi]	500.5
Flammability range in air [% volume]	5.6 – 22.2	

Helium He

CAS: 7440-59-7
 EC: 231-168-5
 UN: 1046 (Compressed)
 UN: 1963 (Refrigerated liquid)
 R-704

Purity grade	Purity	Impurities [ppm]										Legend: N/D = Not Detectable		
		H ₂ O	O ₂	C _n H _m	CO	CO ₂	N ₂	H ₂	O ₂ + N ₂	CH ₄	Odour	Halocarbons		
HiQ® Helium 4.6	≥99.996 %	≤5	≤5	-	-	-	-	-	-	-	-	-	-	-
HiQ® Helium 5.0	≥99.999 %	≤3	≤2	≤0.5	-	-	≤5	-	-	-	-	-	-	-
HiQ® Helium 5.0 Zero	≥99.999 %	≤3	≤2	≤0.2	≤1	≤1	≤5	-	-	-	-	-	-	-
HiQ® Helium 5.5 ECD	≥99.9995 %	≤1	≤1	≤0.1	≤0.5	≤0.5	≤2	-	-	-	-	-	≤1	ppb
HiQ® Helium 6.0	≥99.9999 %	≤0.5	≤0.5	≤0.1	≤0.1	≤0.1	≤0.5	≤0.5	-	-	-	-	-	-
HiQ® Helium 7.0	≥99.99999 %	≤50	≤30	≤30	≤30	≤30	-	≤30	-	-	-	-	≤1	ppb
VERISEQ® Process Helium (pharmaceutical grade)	≥99.5 %	≤67	≤50	-	≤10	-	-	-	≤10,000	≤50	N/D	-	-	-

Typical filling pressure: 15 °C: 200 bar(g)/ 70 °F: 2,800 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•	•		Cryogenic liquid	•	

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
•	•	Cryogenic liquid	Consult local team

Characteristics

Colourless and odourless gas. Non-reactive. Asphyxiant in high concentrations. Gas density is lighter than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

Proposed by the Industry

Signal word: WARNING



H-statements:

Compressed Gas → H280 – Contains gas under pressure; may explode if heated; Refrigerated Gas → H281 – Contains refrigerated gas; may cause cryogenic burns or injury; EIGA-As – Asphyxiant in high concentrations.

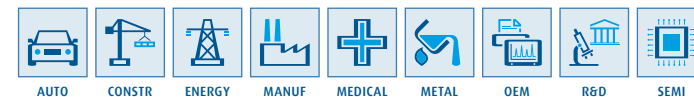
Transport of dangerous goods



ADR Class 2, 1A (Compressed)
 3A (Refrigerated liquid)



DOT Class 2.2



Source

The primary source of helium is from natural gas wells. It is obtained by a liquefaction and stripping operation.

Due to the world shortage in helium, many applications have recovery systems to reclaim the helium.

Applications

Helium is inert and the least soluble of all gases in liquids and is therefore used as a pressurisation gas for:

- cryogenic rocket propellants in space/missile applications
- heavy water in nuclear reactors
- for all liquids at room or low temperatures.

Helium mixtures with hydrocarbons are used in flushing Geiger counters used for the detection of α , β , γ and X-rays.

Helium is used as a carrier gas or as a purge gas for a variety of semiconductor processes.

Helium is added to neutral atmospheres, e.g. in heat treatment applications requiring a protective atmosphere.

Helium is used as a calibration and balance gas in calibration mixtures, a carrier gas in gas chromatography and purge and zero (span) gas for analytical instruments.

Helium is used extensively in the welding industry as an inert shielding gas for arc welding. It is also used in conjunction with helium ("leak") detectors to test the integrity of fabricated components and systems.

Various mixtures of helium and oxygen are used as breathing gases for divers who must work at great depths and therefore high pressures. The use of helium to dilute the oxygen instead of nitrogen, as in air, prevents nitrogen being dissolved in the blood, which is the cause of nitrogen narcosis (also known as "bends").

Helium is used to fill large balloons for upper atmosphere and cosmic ray studies. Small helium balloons are used by weather forecasters to carry meteorological instruments.

Due to nonflammability and low density, this gas is ideal for filling toy balloons (in mixtures with nitrogen), airplane tyres, advertising blimps, geostationary balloons (certain projects are under way for the realisation of balloons designed to serve as television transmission and observation relays).

Helium is used:

- as a combined cooling and shielding medium for the pulling of optical fibres.
- for cooling uranium rods in nuclear reactors.
- in various types of gas lasers as a buffer or carrier gas.
- in mixtures with neon and argon for filling electronic tubes such as the familiar neon sign.
- for epitaxial crystal growth (inert atmosphere).
- for vacuum breaking in heat treatment furnaces.
- as an airbag inflating gas in high-pressure capsules.
- to create inert furnace atmospheres in special glass processing and valuable metals applications.

Liquid helium is used to cool the superconductive magnets in NMR (Nuclear Magnetic Resonance) for analytical or medical purposes and in the R&D to study processes around absolute Zero.

Physical data

Molecular weight	4.003			
Boiling point	at 1.013 bar [°C]	-268.93	at 14.5 psi [°F]	-452.05
Density	at 1.013 bar, 15 °C [kg/m ³]	0.169	at 1 atm., 70 °F [lb/ft ³]	0.010
Vapour pressure	at 0 °C [bar]	-	at 32 °F [psi]	-
	at 20 °C [bar]	-	at 70 °F [psi]	-
Flammability range in air [% volume]	Non combustible			

1,1,1,2,3,3,3-Heptafluoropropane C_3HF_7

HFC-227ea, R-227ea

CAS: 431-89-0

EC: 207-079-2

UN: 3296

R-227ea

Purity grade	Typical purity	Typical impurities [ppm]
1,1,1,2,3,3,3-Heptafluoropropane	≥99.9 %	H ₂ O ≤10 ppm(w)

Typical filling pressure: 15 °C: 3 bar(g)/70 °F: 43.9 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•					

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
•	•		Consult local team

Characteristics

Colourless liquefied gas with an ethereal smell and slight odour warning effect at low concentration. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

Proposed by the Industry

Signal word: WARNING



H-statements:

H280 - Contains gas under pressure; may explode if heated.

Transport of dangerous goods



ADR Class 2, 2A



DOT Class 2.2



Source

Many HCFCs and HFCs are manufactured via similar synthesis routes from common feedstocks. A common synthesis route for 1,1,1,2,3,3,3-heptafluoropropane uses

hexafluoropropene (HFC-236fa) which is reacted with HF in an inert gas.

Applications

1,1,1,2,3,3,3-heptafluoropropane (HFC-227ea) can be used as a refrigerant, a propellant (especially in medical applications) and as a fire suppressant.

Note:

1,1,1,2,3,3,3-heptafluoropropane is listed in the Kyoto Protocol, an international framework convention with the objective of reducing greenhouse gases.

Physical data

Molecular weight	170.03			
Boiling point	at 1.013 bar [°C]	-17.3	at 14.5 psi [°F]	0.86
Density	at 1.013 bar, 15 °C [kg/m ³]	7.3525	at 1 atm., 60 °F [lb/ft ³]	0.4590
Vapour pressure	at 0 °C [bar]	1.95	at 32 °F [psi]	28.3
	at 20 °C [bar]	3.99	at 70 °F [psi]	58.6
Flammability range in air [% volume]	Not combustible			

Hexafluoroethane C_2F_6

Perfluoroethane, FC-116, R-116

CAS: 76-16-4
EC: 200-939-8
UN: 2193
R-116

Purity grade	Typical purity	Typical impurities [ppm]					
		H ₂ O	O ₂ + N ₂	CO	CO ₂	Other Halocarbons	Acidity
HiQ® Hexafluoroethane 2.8	≥99.8 %	-	-	-	-	-	-
HiQ® Hexafluoroethane 3.5	≥99.95 %	≤5	≤300	-	-	≤200	≤1 % (w)
HiQ® Hexafluoroethane 5.0	≥99.999 %	≤1	≤5	≤1	≤1	≤5	≤0.1 % (w)

Typical filling pressure: 15 °C: 29 bar(g)/70 °F: 420.6 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•					

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
•	•		Consult local team

Characteristics

Colourless, odourless, liquefied gas. Asphyxiant in high concentrations. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

Proposed by the Industry

Signal word: WARNING



H-statements:

Liquefied Gas → H280 – Contains gas under pressure; may explode if heated; EIGA-As – Asphyxiant in high concentrations.

Transport of dangerous goods



ADR Class 2, 2A



DOT Class 2.2



Source

Hexafluoroethane may be obtained as a by-product of CFC production, or by direct fluorination of ethane.

Applications

Hexafluoroethane may be used as a raw material for the production of monomers. In chemical synthesis it is employed to introduce fluorine into molecules.

Hexafluoroethane is used in electrical and electronic equipment as a gaseous dielectric.

Hexafluoroethane is used for dry etching of silicon dioxide on silicon and for stripping photoresists in semiconductor production.

Note:

Hexafluoroethane is listed in the Kyoto Protocol, an international Framework Convention with the objective of reducing greenhouse gases.

Hexafluoroethane (R-116) is used as a refrigerant in certain low-temperature applications as well as a component in a few refrigerant blends.

Hexafluoroethane is used as a propellant, very often functioning as a gaseous insulator in foams.

Physical data

Molecular weight	138.01			
Boiling point	at 1.013 bar [°C]	-78.2	at 14.5 psi [°F]	-108.74
Density	at 1.013 bar, 15 °C [kg/m ³]	5.912	at 1 atm., 70 °F [lb/ft ³]	0.361
Vapour pressure	at 0 °C [bar]	18.64	at 32 °F [psi]	270.3
	at 20 °C [bar]	30.01	at 70 °F [psi]	435.3
Flammability range in air [% volume]	Non combustible			

1,1,1,3,3,3-Hexafluoropropane

C₃H₂F₆
HFC-236fa, R-236fa

CAS: 690-39-1
EC: 425-320-1
UN: 3163
R-236fa

Purity grade	Typical purity	Typical impurities [ppm]
1,1,1,3,3,3-Hexafluoropropane	≥99.99 %	H ₂ O ≤10 ppm(w)

Typical filling pressure: 15 °C: 1.7 bar(g)/70 °F: 24.5 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•					

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
•	•		Consult local team

Characteristics

Colourless liquefied gas with a slight ether-like smell. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

Proposed by the Industry

Signal word: WARNING



H-statements:

H280 - Contains gas under pressure; may explode if heated.

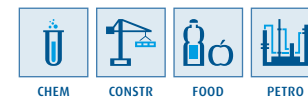
Transport of dangerous goods



ADR Class 2, 2A



DOT Class 2.2



Source

Many HCFCs and HFCs are manufactured via similar synthesis routes from common feedstocks. One synthesis route for 1,1,1,3,3,3-hexafluoropropane involves using

1,1,1,3,3,3-hexachloropropane reacted with HF using a chromium catalyst.

Applications

1,1,1,3,3,3-hexafluoropropane (HFC-236fa) has a wide range of niche applications. These include as a fire suppression agent, a foaming agent and a refrigerant or heat transfer fluid.

Note:

1,1,1,3,3,3-hexafluoropropane is listed in the Kyoto Protocol, an international framework convention with the objective of reducing greenhouse gases.

Physical data

Molecular weight	152.04			
Boiling point	at 1.013 bar [°C]	-2.0	at 14.5 psi [°F]	28.4
Density	at 1.013 bar, 22.4 °C [kg/m ³]	6.18	at 1 atm., 72.3 °F [lb/ft ³]	0.3558
Vapour pressure	at 0 °C [bar]	1.59	at 32 °F [psi]	23.1
	at 25 °C [bar]	2.7	at 77 °F [psi]	39.2
Flammability range in air [% volume]	Not combustible			

Hydrogen H₂

CAS: 1333-74-0
 EC: 215-605-7
 UN: 1049 (Compressed)
 UN: 1966 (Refrigerated liquid)
 R-702

Purity grade	Purity	Impurities [ppm]							Halocarbons
		H ₂ O	O ₂	C _n H _m	CO	CO ₂	N ₂		
HiQ® Hydrogen 4.6	≥99.996 %	≤5	≤5	-	-	-	-	-	-
HiQ® Hydrogen 5.0	≥99.999 %	≤3	≤2	≤0.5	-	-	-	≤5	-
HiQ® Hydrogen 5.0 Zero	≥99.999 %	≤3	≤2	≤0.2	≤1	≤1	≤5	-	-
HiQ® Hydrogen 5.5 ECD	≥99.9995 %	≤1	≤1	≤0.1	≤0.5	≤0.5	-	≤1	ppb
HiQ® Hydrogen 6.0	≥99.9999 %	≤0.5	≤0.5	≤0.1	≤0.1	≤0.1	≤0.5	-	-
HiQ® Hydrogen 7.0	≥99.99999 %	≤50	≤30	≤30	≤30	≤30	-	-	-
		ppb	ppb	ppb	ppb	ppb			

Typical filling pressure: 15 °C: 200 bar(g)/ 70 °F: 2,800 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•	•			•	

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
•	•		Consult local team

Characteristics

Flammable. Odourless and colourless gas. Gas density is lighter than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

GHS-CLP

Signal word: DANGER



H-statements:

Compressed Gas → H280 – Contains gas under pressure; may explode if heated; Refrigerated Gas → H281 – Contains refrigerated gas; may cause cryogenic burns or injury; H220 – Extremely flammable gas.

Transport of dangerous goods



ADR Class 2, 1F (Compressed)
 3F (Refrigerated liquid)



DOT Class 2.1



Source

Hydrogen is most frequently produced for on-site usage by steam reforming of natural gas. Such plants may also be used as sources of hydrogen for the merchant market. Other sources are the chlor-alkali process that electrolyses sodium

chloride solution to produce chlorine, and various waste gas recovery plants, such as at oil refineries or steel plants (coke oven gas). Hydrogen is also produced by electrolysis of water.

Applications

High-purity hydrogen finds widespread usage in the electronics industry as a reducing agent and as a carrier gas.

Hydrogen is used for combustion;

- in industry, it is used to supply oxygen-hydrogen torches for glass working (quartz, Pyrex®, etc), in the fabrication of artificial precious stones (ruby, etc), and for under water oxycutting
- in the laboratory, it is used in analyzer flames, reducing flame photometry detection instruments, flame ionisation detection instruments, and fuel cells.

High-purity hydrogen is used as a carrier gas in gas chromatography.

Hydrogen finds some usage in the welding and cutting of metals.

Hydrogen is used in large quantities, (bulk supply or on-site generation) for the hydrogenation of vegetable and animal oils to produce margarine and other fats, hydro-treatment of petroleum products, and hydrosulfuration of fuels in order to eliminate sulfur.

Extremely pure hydrogen is used in the chemical industry for fine reduction processes.

Liquefied hydrogen is used as a rocket fuel. In the laboratory liquid hydrogen is employed for solid physics research.

Hydrogen in large quantities is used in petrochemical processes that include hydrodealkylation, hydrosulfurisation, hydrotreatment.

In the nuclear industry para-hydrogen is employed to fill bubble chambers.

Hydrogen is used in leak testing applications.

In electrical power plants hydrogen is used as a coolant gas in turbogenerators.

Hydrogen is used in HF/DF chemical lasers (see page 121).

Hydrogen is used for synthesis of ammonia.

Hydrogen is used extensively in the metals industries because of its ability to reduce metal oxides and prevent oxidation of metals during heat treatment. It may be used either pure, as is often the case when heat treating stainless steel, or in a mixture with inert gases, argon or nitrogen. It is used in the production of carbon steels, special metals and semiconductors.

Hydrogen is used as a reagent to produce high-purity water.

Hydrogen is used as fuel in fuel cell applications.

Hydrogen is used as component in gas mixtures.

Physical data

Molecular weight	2.016			
Boiling point	at 1.013 bar [°C]	-252.76	at 14.5 psi [°F]	-422.95
Density	at 1.013 bar, 15 °C [kg/m ³]	0.0852	at 1 atm., 70 °F [lb/ft ³]	0.005
Vapour pressure	at 0 °C [bar]	-	at 32 °F [psi]	-
	at 20 °C [bar]	-	at 70 °F [psi]	-
Flammability range in air [% volume]	4.0 – 77.0			

Hydrogen bromide HBr

CAS: 10035-10-6
EC: 233-113-0
UN: 1048

Purity grade	Typical purity	Typical impurities [ppm]									
		HCl	H ₂ O	O ₂	N ₂	CO	CO ₂	C _n H _m	CH ₄	Fe	
HiQ® Hydrogen bromide 2.8	≥99.8 %	≤2,000	-	-	-	-	-	-	-	-	-
HiQ® Hydrogen bromide 4.5	≥99.995 %	-	≤5	≤3	≤10	≤1	≤20	≤10	-	≤1 % (w)	
HiQ® Hydrogen bromide 5.0	≥99.999 %	-	≤1	≤1	≤2	≤1	≤5	-	≤1	≤1 % (w)	

Typical filling pressure: 15 °C: 20 bar(g)/70 °F: 310 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•					

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
•	•		Consult local team

Characteristics

Highly corrosive. Liquefied gas with pungent odour. Forms white fumes in humid air. Highly corrosive under humid conditions. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

GHS-CLP

Signal word: DANGER



H-statements:

Liquefied Gas → H280 – Contains gas under pressure; may explode if heated; H331 – Toxic if inhaled; H314 – Causes severe skin burns and eye damage; EUH071 – Corrosive to the respiratory tract.

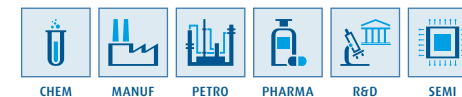
Transport of dangerous goods



ADR Class 2, 2TC



DOT Class 2.3



Source

Hydrogen bromide is obtained as a by-product during the bromination of organic compounds such as methyl bromide.

Applications

Hydrogen bromide is used both as a reagent and as a catalyst in a variety of organic reactions. It is also used for the preparation of numerous inorganic bromides.

Hydrogen bromide is also used for hydrobromination in the chemical and pharmaceutical industries.

Hydrogen bromide is used in the production process of lamps (so called “iodine” automobile headlights, electrostatic photocopy machine lamps, etc.).

Hydrogen bromide is used in the manufacturing of semiconductor components as an etchant.

Physical data

Molecular weight	80.912			
Boiling point	at 1.013 bar [°C]	-66.7	at 14.5 psi [°F]	-88.04
Density	at 1.013 bar, 15 °C [kg/m ³]	3.45	at 1 atm., 70 °F [lb/ft ³]	0.211
Vapour pressure	at 0 °C [bar]	13	at 32 °F [psi]	187.9
	at 20 °C [bar]	21.8	at 70 °F [psi]	324.57
Flammability range in air [% volume]	Non combustible			

Hydrogen chloride HCl

CAS: 7647-01-0
EC: 231-595-7
UN: 1050

Purity grade	Typical purity	Typical impurities [ppm]						
		H ₂ O	O ₂	N ₂	CO	CO ₂	C _n H _m	Fe
Hydrogen chloride 3.0	≥99.9 %	≤10	-	-	-	-	-	-
HiQ® Hydrogen chloride 4.5	≥99.995 %	≤2	≤5	≤10	≤2	≤40	≤2	-
HiQ® Hydrogen chloride 5.0	≥99.999 %	≤2	≤1	≤4	≤1	≤3	≤1	≤1
HiQ® Hydrogen chloride 5.5	≥99.9995 %	≤1	≤0.5	≤1	≤0.5	≤1	≤0.5	≤0.1

Typical filling pressure: 15 °C: 41 bar(g)/ 70 °F: 611 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•		•			

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
Gaseous Withdrawal	Gaseous Withdrawal	Liquid Withdrawal	Consult local team

Characteristics

Colourless, liquefied gas with pungent odour. Forms white fumes in humid air. Corrosive in humid conditions. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

GHS-CLP

Signal word: DANGER



H-statements:

Liquefied Gas → H280 – Contains gas under pressure; may explode if heated; H331 – Toxic if inhaled; H314 – Causes severe skin burns and eye damage; EUH071 – Corrosive to the respiratory tract.

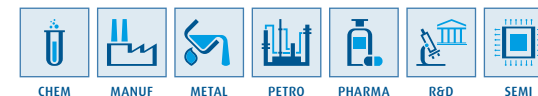
Transport of dangerous goods



ADR Class 2, 2TC



DOT Class 2.3



Source

Hydrogen chloride is usually prepared in commercial quantities by the direct combination of chlorine and hydrogen. This is achieved by “burning” chlorine in an atmosphere of hydrogen. Most of the hydrogen chloride

produced in this way is dissolved directly in water to produce hydrochloric acid. Lesser quantities are collected as anhydrous hydrogen chloride, especially for use in the semiconductor industry and pharmaceutical production.

Applications

Hydrogen chloride is used to remove the remaining fibres from cotton seeds after the cotton wool has been separated and before the seed is stored for resowing next season. Hydrogen chloride is also used in separating cotton from wood.

Hydrogen chloride is used as a thermal etchant in the semiconductor industry to remove material from unmasked areas, thus preparing wafer surfaces for epitaxial deposition.

Hydrogen chloride is used in the manufacture of inorganic chlorides.

High-purity hydrogen chloride gas is widely used in the electronics industry. It is a chlorine carrier produced by high-temperature cracking. It is used in the following applications:

Hydrogen chloride is used as chlorine donor in excimer lasers.

- scouring furnaces (quartz chambers)
- dissolved in water as an aqueous cleaning agent to prepare metal surfaces for electroplating
- selective etching of windows in electronic microcircuits
- carrier for non-volatile elements in the form of gaseous chloride.

Hydrogen chloride is used to promote and regenerate catalysts in the petrochemical industry and in lubricants/oil production to add viscosity to oils.

Hydrogen chloride is used as a reactive agent in pharmaceutical synthesis.

Hydrogen chloride is used for hydrochlorination (e.g. production of methyl chloride) and oxychlorination (e.g. production of chloroethene). It is also employed to produce chlorosulfonic acid and synthetic rubbers.

Hydrogen chloride is also used for production of hard metals.

Physical data

Molecular weight	36.461			
Boiling point	at 1.013 bar [°C]	-85.1	at 14.5 psi [°F]	-120.98
Density	at 1.013 bar, 15 °C [kg/m ³]	1.552	at 1 atm., 70 °F [lb/ft ³]	0.095
Vapour pressure	at 0 °C [bar]	25.6	at 32 °F [psi]	371.1
	at 20 °C [bar]	42.02	at 70 °F [psi]	625.37
Flammability range in air [% volume]	Non combustible			

Hydrogen cyanide HCN

Hydrocyanic acid

CAS: 74-90-8
EC: 200-821-6
UN: 1051

Purity grade	Typical purity	Typical impurities [ppm]
HiQ® Hydrogen cyanide 2.0 (stabilised)	≥99.9 %	H ₂ SO ₄ or H ₃ PO ₄ (Stabiliser) ≤0.95

Typical filling pressure: Filled as liquid

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•					

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
		•	Consult local team

Characteristics

Flammable liquid. Colourless liquid/vapour with the characteristic odour of bitter almonds. Slightly lighter than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

GHS-CLP

Signal word: DANGER



H-statements:

H224 – Extremely flammable liquid and vapour; H330 – Fatal if inhaled;

H331 – Fatal in contact with skin; H410 – Very toxic to aquatic life with long lasting effects.

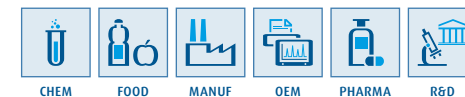
Transport of dangerous goods



ADR Class 6.1, TF1



DOT Class 6.1



Source

The main method of manufacturing hydrogen cyanide is by reacting methane, ammonia and air over a platinum catalyst at 1,000-2,000°C.

Many fruits with a pit such as almonds, apples and apricots contain small levels of HCN.

Applications

The largest use is in the manufacture of acrylonitrile, but it is also used in the manufacture of methyl methacrylate, adiponitrile (for nylon), as a precursor in the production of sodium and potassium cyanide and last but not least in generating ferrocyanides.

HCN is used as a component in calibration gases for environmental control of coal fired power plants.

HCN is also used as a fumigant in certain geographies. HCN may require registration/authorisation to comply with local legal requirements on pesticides/biocides.

Hydrogen cyanide is an important raw material in the chemical industry, helping to synthesise a large family of fluorine-containing molecules.

Physical data

Molecular weight	27.03			
Boiling point	at 1.013 bar [°C]	26.70	at 14.5 psi [°F]	78.30
Density	at 1.013 bar, 15 °C [kg/m ³]	687.00	at 1 atm., 70 °F [lb/ft ³]	42.89
Vapour pressure	at 0 °C [bar]	0.37	at 32 °F [psi]	5.37
	at 20 °C [bar]	0.83	at 70 °F [psi]	12.04
Flammability range in air [% volume]	5.4 – 46.6			

Hydrogen fluoride HF

CAS: 7664-39-3
EC: 231-634-8
UN: 1052

Purity grade	Typical purity	Typical impurities [ppm]			
		H ₂	SO ₂	H ₂ SO ₄	H ₂ SiF ₆
HiQ® Hydrogen fluoride 3.5	≥99.95 %	≤200 ppm(w)	≤10 ppm(w)	≤300 ppm(w)	≤20 ppm(w)

Typical filling pressure: 15 °C: 0 bar(g)/70 °F: 0.8 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•		•			

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
Gaseous Withdrawal	Gaseous Withdrawal	Liquid Withdrawal	Consult local team

Characteristics

Highly corrosive. Liquefied gas with pungent odour. Forms white fumes in humid air. Highly corrosive under humid conditions. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

GHS-CLP

Signal word: DANGER



H-statements:

H330 – Fatal if inhaled; H310 – Fatal in contact with skin; H300 – Fatal if swallowed; H314 – Causes severe skin burns and eye damage; EUH071 – Corrosive to the respiratory tract.

Transport of dangerous goods



ADR Class 8, CT1



DOT Class 8



Source

Hydrogen fluoride is prepared industrially by direct reaction of sulfuric acid and fluorspar (CaF₂). It is most commonly used in its anhydrous form.

Applications

Hydrogen fluoride is used in hydrogen fluoride lasers (HF/DF – hydrogen fluoride/deuterium fluoride lasers). These are infrared chemical lasers that can deliver continuous output power in the megawatt range.

It also serves as a catalyst in alkylation, acylation and isomerisation reactions, and as a dehydrating agent in cyclisation reactions.

Hydrogen fluoride may be used as a fumigant. For such purpose it may require registration/authorisation to comply with local legal requirements on pesticides/biocides.

Hydrogen fluoride is furthermore used:

- to produce fluorine
- to process uranium isotopes
- as a fluorinating agent to produce a variety of organic and inorganic chemicals
- to manufacture low-ash-content analytical filter paper
- for pickling of electronic components
- for etching in the production of semiconductor integrated circuits
- for etching and polishing glass
- to prepare fluoridised compounds
- for polymerisation and hydrolytic reactions
- for manufacturing of aluminium fluoride and synthetic cryolite (sodium alumina fluoride Na₃AlF₆).

Physical data

Molecular weight	20.006			
Boiling point	at 1.013 bar [°C]	19.52	at 14.5 psi [°F]	67.16
Density	at 1.013 bar, 15 °C [kg/m ³]	0.92	at 1 atm., 70 °F [lb/ft ³]	0.053
Vapour pressure	at 0 °C [bar]	0.48	at 32 °F [psi]	6.97
	at 20 °C [bar]	1.04	at 70 °F [psi]	15.48
Flammability range in air [% volume]	Non combustible			

Hydrogen iodide HI

Hydroiodic acid

CAS: 10034-85-2

EC: 233-109-9

UN: 2197

Purity grade	Typical purity	Typical impurities [ppm]
HiQ® Hydrogen iodide 3.0	≥99.9 %	contact local team

Typical filling pressure: 15 °C: 5.9 bar(g)/ 70 °F: 85.5 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•					

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
•	•		Consult local team

Characteristics

Highly corrosive. Liquefied colourless gas with pungent odour. Forms white fumes in humid air. Highly corrosive under humid conditions. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

GHS-CLP

Signal word: DANGER



H-statements:

Liquefied Gas → H280 – Contains gas under pressure; may explode if heated; H331 – Toxic if inhaled; H314 – Causes severe skin burns and eye damage; EUH071 – Corrosive to the respiratory tract.

Transport of dangerous goods



ADR Class 2, 2TC



DOT Class 2.3



Source

The industrial preparation of hydrogen iodide involves the reaction of iodine with hydrazine, which also yields nitrogen gas.

Applications

Hydrogen iodide is used in semiconductor dry etching applications.

Hydrogen iodide is used in organic and inorganic synthesis as one of the primary sources of iodine, mostly as reducing agent.

Hydrogen iodide is mostly used for the production of hydroiodic acid, which is mainly used in chemical reactions because of its very strong acidity-induced reactivity.

Hydrogen iodide is also employed as a catalyst.

Physical data

Molecular weight	127.912			
Boiling point	at 1.013 bar [°C]	-35.4	at 14.5 psi [°F]	-31.72
Density	at 1.013 bar, 15 °C [kg/m ³]	5.48	at 1 atm., 70 °F [lb/ft ³]	0.342
Vapour pressure	at 0 °C [bar]	3.80	at 32 °F [psi]	55.16
	at 20 °C [bar]	6.91	at 70 °F [psi]	100.2
Flammability range in air [% volume]	Non combustible			

Hydrogen sulfide H₂S

CAS: 7783-06-4
EC: 231-977-3
UN: 1053

Purity grade	Typical purity	Typical impurities [ppm]	
		COS	methane
Hydrogen sulfide 1.8	≥98 %	≤4000	≤500

Typical filling pressure: 15 °C: 18 bar(g) 70 °F: 259.8 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•					

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
•	•		Consult local team

Characteristics

Flammable. Extremely offensive odour, liquefied gas. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

GHS-CLP

Signal word: DANGER



H-statements:

Liquefied Gas → H280 – Contains gas under pressure; may explode if heated; H220 – Extremely flammable gas; H330 – Fatal if inhaled; H335 – May cause respiratory irritation; H400 – Very toxic to aquatic life.

Transport of dangerous goods



ADR Class 2, 2TF



DOT Class 2.3



Source

Hydrogen sulfide occurs as a by-product from many chemical processes. It is an off-gas in the production of viscose rayon, synthetic rubber, various petroleum products and dyes, as well as leather processing.

Hydrogen sulfide can also be manufactured by treatment of many metallic sulfides with a mineral acid such as hydrochloric or sulfuric acid.

Applications

Small quantities of hydrogen sulfide are used as a dopant for indium phosphide and gallium arsenide semiconductors, and as a precursor for the growth of zinc sulfide semiconductors.

Hydrogen sulfide is the main source for production of elemental sulfur.

Hydrogen sulfide is also employed for the production of additives in high-pressure lubricants and cutting oils.

Hydrogen sulfide is used for metal separation, removal of metallic impurities, and for preparation of metallic sulfides. In hot wire galvanising it is used in conjunction with natural gas to speed up the galvanising process.

Hydrogen sulfide is used in the chemical industry for production of sulfurated compounds, as mercaptans, sulfides, etc.

Hydrogen sulfide is used to regenerate certain types of catalysts used in the petrochemical industry.

Hydrogen sulfide is also used as a solvent and as an odorant in town gas.

Hydrogen sulfide is used in calibration mixtures for the petrochemical industry.

Hydrogen sulfide is used in the separation of heavy water from normal water in nuclear power stations.

Hydrogen sulfide is used in mixtures for emission control applications.

Hydrogen sulfide is used for surface treatment of metals.

Hydrogen sulfide is used as an analytical reagent in chemical analysis.

Physical data

Molecular weight	34.082			
Boiling point	at 1.013 bar [°C]	-60.35	at 14.5 psi [°F]	-76.61
Density	at 1.013 bar, 15 °C [kg/m ³]	1.454	at 1 atm., 70 °F [lb/ft ³]	0.089
Vapour pressure	at 0 °C [bar]	10.64	at 32 °F [psi]	154.40
	at 20 °C [bar]	18.40	at 70 °F [psi]	274.52
Flammability range in air [% volume]	3.9 – 45.5			

Krypton Kr

CAS: 7439-90-9
 EC: 231-098-5
 UN: 1056 (Compressed)
 UN: 1970 (Refrigerated liquid)

Purity grade	Typical purity	Typical impurities [ppm]									
		H ₂ O	O ₂	C _n H _m	CO + CO ₂	H ₂	N ₂	Ar	CF ₄	Xe	
HiQ® Krypton 3.0 Window	≥99.9 %	≤10	≤60	≤30	-	-	-	-	-	-	
HiQ® Krypton 4.0	≥99.99 %	≤5	≤10	≤5	-	-	≤30	-	-	-	
HiQ® Krypton 5.0	≥99.999 %	≤2	≤0.5	≤0.5	≤1	≤1	≤2	≤1	≤1	≤1	

Typical filling pressure: 15 °C: 150 bar(g) 70 °F: 2,000 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•					

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
•	•		Consult local team

Characteristics

Colourless and odourless gas. Non-reactive. Asphyxiant in high concentrations. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

Proposed by the Industry

Signal word: WARNING



H-statements:

Compressed Gas → H280 – Contains gas under pressure; may explode if heated; Refrigerated Gas → H281 – Contains refrigerated gas; may cause cryogenic burns or injury; EIGA-As – Asphyxiant in high concentrations.

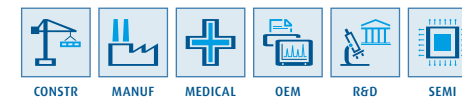
Transport of dangerous goods



ADR Class 2, 1A (Compressed)
 3A (Refrigerated liquid)



DOT Class 2.2



Source

Krypton is obtained from air separation plants. In view of its very low natural concentration in air, it is only economically viable to recover krypton from larger plants. In these cases

a stream containing a mixture of crude krypton and xenon is extracted from the plant and processed in a separate purification and distillation system.

Applications

Krypton is used in various research programmes.

In laboratories krypton is used for calibration standards for mass spectrometry and specific area measurements in adsorption applications.

Krypton is used for certain ion lasers and in mixtures with halides and helium or neon for excimer laser applications.

In neurology krypton is used to obtain brain X-ray pictures.

Krypton is used in incandescent lamps, mixed with nitrogen and argon or nitrogen, argon and xenon. Krypton is also used in mixtures with argon as a filling gas for fluorescent tubes.

Krypton is used as a triggering agent in discharge type electronic tubes (e.g. TFT screens; TFT LCD = Thin-Film Transistor Liquid Crystal Display).

Krypton is used as a filling gas for various halogen lamps, such as those used in cars, on airfields and in low-voltage display lamps.

Krypton is also used as an insulation gas in windows to reduce noise and heat transfer.

Physical data

Molecular weight	83.80			
Boiling point	at 1.013 bar [°C]	-153.35	at 14.5 psi [°F]	-244.01
Density	at 1.013 bar, 15 °C [kg/m ³]	3.552	at 1 atm., 70 °F [lb/ft ³]	0.217
Vapour pressure	at 0 °C [bar]	-	at 32 °F [psi]	-
	at 20 °C [bar]	-	at 70 °F [psi]	-
Flammability range in air [% volume]	Non combustible			

Methane CH₄

CAS: 74-82-8
 EC: 200-812-7
 UN: 1971 (Compressed)
 UN: 1972 (Refrigerated liquid)
 R-50

Purity grade	Typical purity	Typical impurities [ppm]				
		O ₂	N ₂	H ₂	Other C _n H _m	H ₂ O
Methane 2.5	≥99.5 %	≤100	≤600	≤500	≤3,000	-
HiQ® Methane 3.5	≥99.95 %	≤30	≤200	≤20	≤300	-
HiQ® Methane 4.5	≥99.995 %	≤5	≤20	≤5	≤20	≤5
HiQ® Methane 5.5	≥99.9995 %	≤0.5	≤4	≤0.1	≤1	≤2

Typical filling pressure: 15 °C: 200 bar(g)/ 70 °F: 2,800 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•	•				

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
•	•		Consult local team

Characteristics

Flammable. Colourless and odourless gas. Gas density is lighter than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

GHS-CLP

Signal word: DANGER



H-statements:

Compressed Gas → H280 – Contains gas under pressure; may explode if heated; Refrigerated Gas → H281 – Contains refrigerated gas; may cause cryogenic burns or injury; H220 – Extremely flammable gas.

Transport of dangerous goods



ADR Class 2, 1F (Compressed)
3F (Refrigerated liquid)



DOT Class 2.1



Source

Methane is the principal constituent of natural gas (typically natural gas is 87% methane). It is therefore commonly produced by purifying natural gas.

Pure methane may also be obtained from the cracking of petroleum fractions in petrochemical refineries.

Applications

Methane is used as a heating fuel for domestic purposes and above all for industrial heating:

- in the steel industry, with open hearth furnaces, in the presence of fuel oil, and in reheating furnaces for semi-products prior to rolling or forging, oxycutting of metal, for heat treatment of nonferrous metals, and supply to infrared heating elements used for surface treatment
- in thermal power plants
- in glass making, annealing kilns for pharmaceutical ampoules, ceramic kilns
- in the textile industry
- in the chemical industry, petrochemical furnaces, heating of tanks containing resins for paints, vulcanisation of plastics
- in food and farm industries, coffee roasting ovens, malt drying in breweries, dehydration of plant fodder, powdered milk production
- in cement plants
- in paper mills

In the chemical field, methane serves as a raw material for the production of methanol, synthetic ammonia, acetylene, carbon black, carbon disulfide, hydrocyanic acid, methyl chloride, methylene chloride, carbon tetrachloride and chloroform.

In the steel industry, natural gas is used for direct reduction of powdered minerals, and to produce hard metal.

Methane finds extensive use in various mixtures for quality control laboratories in the petrochemical and fuel gas industries.

Methane:

- is used as a fuel gas in flame photometers (high-purity).
- is used in gas cooled nuclear reactors. The methane is used to dope the carbon dioxide coolant in order to prevent erosion of the carbon control rods in the nuclear core.
- is used for efficiency testing of gas burners and engines.
- is also used in synthetic town gas mixtures.
- Liquid methane is used as a rocket fuel.

Methane was employed in gas batteries used by the Apollo space missions.

When mixed with argon or xenon, methane is used as a gas filling for proportional counters and other types of radiation detectors.

Methane mixtures are commonly used for calibrations in the automotive industry and in the environmental field.

As natural gas it is also used as a fuel for vehicles.

Methane mixed with argon is used as make-up gas in electro-chemical detectors (EC detectors).

Note:

Methane is listed in the Kyoto Protocol, an international Framework Convention with the objective of reducing greenhouse gases.

Physical data

Molecular weight	16.043			
Boiling point	at 1.013 bar [°C]	-161.49	at 14.5 psi [°F]	-258.66
Density	at 1.013 bar, 15 °C [kg/m ³]	0.680	at 1 atm., 70 °F [lb/ft ³]	0.042
Vapour pressure	at 0 °C [bar]	-	at 32 °F [psi]	-
	at 20 °C [bar]	-	at 70 °F [psi]	-
Flammability range in air [% volume]	4.4 – 15.0			

Methyl bromide CH_3Br

Bromomethane

CAS: 74-83-9
EC: 200-813-2
UN: 1062

Purity grade	Typical purity	Typical impurities [ppm]		
		H_2O	Methanol	Acid as HBr
Methyl bromide 2.5	≥99.5 %	≤150 % (w)	≤150 % (w)	≤100 % (w)

Typical filling pressure: 15 °C: 0.8 bar(g)/70 °F: 13 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•					

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
Gaseous Withdrawal	Gaseous Withdrawal	Liquid Withdrawal	Consult local team

Characteristics

Colourless liquefied gas, odourless in small concentrations. Has a chloroform type odour at high concentrations. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

GHS-CLP

Signal word: DANGER



H-statements:

Liquefied Gas → H280 – Contains gas under pressure; may explode if heated; H221 – Flammable gas; H341 – Suspected of causing genetic defects; H330 – Fatal if inhaled; H301 – Toxic if swallowed; H373 – May cause damage to CNS and muscle through prolonged or repeated exposure; H319 – Causes serious eye irritation; H335 – May cause respiratory irritation; H315 – Causes skin irritation; H400 – Very toxic to aquatic life; H420 – Harms public health and the environment by destroying ozone in the upper atmosphere.

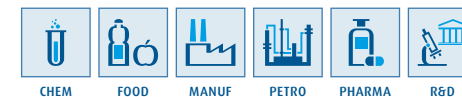
Transport of dangerous goods



ADR Class 2, 2TC



DOT Class 2.3



Source

Commercial and laboratory methods of manufacturing Methyl bromide are generally similar and are based primarily on the reaction of hydrobromic acid (HBr) with methanol.

Other methods involve the treatment of bromine with a reducing agent, such as sulfur dioxide or phosphorus, in the presence of water.

Applications

Methyl bromide is used as a methylation agent in organic synthesis and also as a low-boiling solvent.

Methyl bromide is still widely used in fumigation of soils, seeds, flowers and fresh vegetables/fruits as well as for products manufactured from natural materials (e.g. wood, sisal).

Note:

Methyl bromide is controlled under the Montreal Protocol on Substances that Deplete the Ozone Layer.

More recently proposed processes involve the reaction of hydrogen bromide with excess methyl chloride.

Methyl bromide is already banned in many geographies for use in agriculture according to the phase-out process agreed under the Montreal Protocol.

Critical-use exemptions are listed for fumigation, quarantine and pre-shipment, as well as for emergency uses. To get a specific authorisation, a local registration may be required.

Physical data

Molecular weight	94.939			
Boiling point	at 1.013 bar [°C]	3.56	at 14.5 psi [°F]	38.43
Density	at 1.013 bar, 15 °C [kg/m ³]	4.106	at 1 atm., 70 °F [lb/ft ³]	0.251
Vapour pressure	at 0 °C [bar]	0.88	at 32 °F [psi]	12.76
	at 20 °C [bar]	1.84	at 70 °F [psi]	27.76
Flammability range in air [% volume]	8.6 – 20.0			

Methyl chloride CH_3Cl

Chloromethane

CAS: 74-87-3
EC: 200-817-4
UN: 1063
R-40

Purity grade	Typical purity	Typical impurities [ppm]
HiQ® Methyl chloride 2.8	≥99.8 %	contact local team

Typical filling pressure: 15 °C: 4 bar(g)/70 °F: 59 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•					

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
•	•		Consult local team

Characteristics

Flammable. Liquefied, odourless gas with slight ether-like odour. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

GHS-CLP

Signal word: DANGER



H-statements:

Liquefied Gas → H280 – Contains gas under pressure; may explode if heated; H220 – Extremely flammable gas; H351 – Suspected of causing cancer; H373 – May cause damage to CNS, urogenital tract and liver through prolonged or repeated inhalation; H361 – Suspected of damaging fertility or the unborn child.



ADR Class 2, 2F



DOT Class 2.1



Source

Methyl chloride is manufactured in commercial quantities by two principle processes:

- chlorination of methane
- reaction between hydrogen chloride and methanol.

Several variants of both processes are used. The methanol-hydrogen chloride reaction yields methyl chloride as the sole product. Chlorination of methane yields other

Applications

Methyl chloride is used as:

- a catalyst solvent in butyl rubber production
- a reagent in silicone production
- in organic synthesis
- in the manufacturing of tetramethyl lead
- a solvent
- a starting material in the manufacturing of such chemicals as methyl mercaptan, methylene chloride, chloroform, carbon tetrachloride, various bromochloromethanes and chlorofluoromethanes
- in therapeutic treatment of local anaesthesia
- a solvent or extraction agent for heat sensitive products
- an aerosol propellant
- tool hardening and salt bath rectification.

Methyl chloride is an important chemical intermediate in the production of silicone polymers.

chlorohydrocarbons in substantial amounts. Because the co-products, e.g. methylene chloride, chloroform, and carbon tetrachloride, are as commercially important as methyl chloride, methane chlorination can be regarded as a multiple-product process rather than one with several by-products. Hydrogen chloride is often the determining factor in choosing a route to produce methyl chloride.

Methyl chloride is used in the production of quaternary ammonium compounds for use as anti-static agents in fabric softeners. It is also used for the manufacturing of methyl cellulose and in the production of Grignard reagents for the synthesis of pharmaceutical compounds. It also used in the preparation of fragrances, perfumes and herbicides.

Methyl chloride is used for side wall passivation in plasma etching to give anisotropic etching under plasma conditions: similar to reactive ion etching, but without the damage.

Methyl chloride is used to extract grease, wax, essential oils and resins during the production of textile and carpet materials.

Physical data

Molecular weight	50.487			
Boiling point	at 1.013 bar [°C]	-24.22	at 14.5 psi [°F]	-11.58
Density	at 1.013 bar, 15 °C [kg/m ³]	2.173	at 1 atm., 70 °F [lb/ft ³]	0.133
Vapour pressure	at 0 °C [bar]	2.59	at 32 °F [psi]	37.59
	at 20 °C [bar]	4.95	at 70 °F [psi]	74.28
Flammability range in air [% volume]	7.6 – 19.0			

Methyl formate $C_2H_4O_2$

Methyl methanoate

CAS: 107-31-3
 EC: 203-481-7
 UN: 1243
 R-611

Purity grade	Typical purity	Typical impurities [ppm]
Methyl formate	≥97 %	H ₂ O ≤500 ppm(w)

Typical filling pressure: Filled as liquid

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•					

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
		•	Consult local team

Characteristics

Flammable. Colourless liquid with an agreeable odour. Vapour is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

GHS-CLP

Signal word: DANGER



H-statements:

H224 - Extremely flammable liquid and vapour; H302+H332 - Harmful if swallowed or if inhaled; H319 - Causes serious eye irritation; H335 - May cause respiratory irritation.

Transport of dangerous goods



ADR Class 3, F1



DOT Class 3



Source

Industrial methyl formate is usually produced by the combination of methanol and carbon monoxide (carbonylation) in the presence of a strong base, such as sodium methoxide.

Applications

Methyl formate is used primarily to manufacture formamide, formic acid and dimethylformamide. Because of its high vapour pressure, it is used for quick-drying finishes. It is also used as an insecticide and to manufacture certain pharmaceuticals. It is also used as a blowing agent for foam insulation, and as a replacement for CFCs, HCFCs or HFCs, with zero ODP and <25 GWP.

Physical data

Molecular weight	60.05	
Boiling point	at 1.013 bar [°C]	32 at 14.5 psi [°F] 89.6
Density	at 1.013 bar, 20 °C [kg/m ³]	0.98 at 1 atm., 70 °F [lb/ft ³] 0.0612
Vapour pressure	at 0 °C [bar]	0.21 at 32 °F [psi] -
	at 20 °C [bar]	0.64 at 70 °F [psi] 9.86
Flammability range in air [% volume]	5.0 - 23.0	

Methyl mercaptan CH_3SH

Methanethiol

CAS: 74-93-1
EC: 200-822-1
UN: 1064

Purity grade	Typical purity	Typical impurities [ppm]	Other S-comp.
HiQ® Methyl mercaptan 2.5	≥99.5 %		≤5,000

Typical filling pressure: 15 °C: 0.7 bar(g) 70 °F: 11 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•					

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
•	•		Consult local team

Characteristics

Flammable. Colourless, liquefied, gas with strong repugnant odour. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

GHS-CLP

Signal word: DANGER



H-statements:

Liquefied Gas → H280 – Contains gas under pressure; may explode if heated; H220 – Extremely flammable gas; H331 – Toxic if inhaled; H410 – Very toxic to aquatic life with long lasting effects.

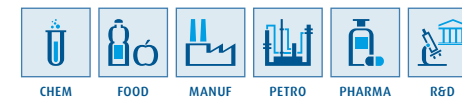
Transport of dangerous goods



ADR Class 2, 2TF



DOT Class 2.3



Source

Methyl mercaptan is manufactured by reaction between hydrogen sulfide and methanol. The reaction is usually carried out over solid acidic catalysts at elevated temperatures.

Applications

Methyl mercaptan has been used in organic synthesis. It is also employed as an intermediate for jet fuels, fungicides and methionine, an essential amino acid allowed in some geographies as a nutrition supplement for animals.

Methyl mercaptan is employed as an additive to improve the quality of elastomers.

Methyl mercaptan is also used as an odorant in a variety of odourless gases to allow easy leak detection.

Methyl mercaptan is used as starting material in the manufacture of other chemicals such as petroleum chemical products.

Physical data

Molecular weight	48.109			
Boiling point	at 1.013 bar [°C]	5.96	at 14.5 psi [°F]	42.75
Density	at 1.013 bar, 15 °C [kg/m ³]	2.084	at 1 atm., 70 °F [lb/ft ³]	0.127
Vapour pressure	at 0 °C [bar]	0.78	at 32 °F [psi]	11.29
	at 20 °C [bar]	1.70	at 70 °F [psi]	25.67
Flammability range in air [% volume]	4.1 – 21.0			

Methyl vinyl ether C_3H_6O

Methoxyethene, Vinyl methyl ether

CAS: 107-25-5
EC: 203-475-4
UN: 1087

Purity grade	Typical purity	Typical impurities [ppm]
HiQ® Methyl vinyl ether 2.5	≥99.5 %	H ₂ O ≤1,000

Typical filling pressure: 15 °C: 0.7 bar(g) 70 °F: 11.6 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•					

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
•	•		Consult local team

Characteristics

Flammable. Liquefied and colourless gas with a sweetish odour. Poor warning properties at low concentrations. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

GHS-CLP

Signal word: DANGER



H-statements:

Liquefied Gas → H280 – Contains gas under pressure; may explode if heated; H220 – Extremely flammable gas; H231 – May react explosively even in absence of air at elevated pressure and/or temperature.

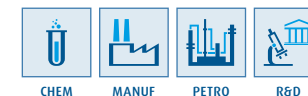
Transport of dangerous goods



ADR Class 2, 2F



DOT Class 2.1



Source

Methyl vinyl ether is obtained commercially by a vinylation reaction, that is treating ethyne (acetylene) with methanol in the presence of potassium hydroxide.

It is also prepared by converting acetaldehyde into dimethoxyethane, and subjecting the acetal to pyrolysis.

Applications

Methyl vinyl ether is used as an intermediate in organic synthesis.

Methyl vinyl ether is used as a plasticiser for nitrocellulose and other plastics.

Methyl vinyl ether is used to prepare homopolymers and copolymers like PFEs (perfluoroelastomers) or mixtures of MVE and maleic acid.

Physical data

Molecular weight	58.074	
Boiling point	at 1.013 bar [°C]	5.5 at 14.5 psi [°F]
Density	at 1.013 bar, 15 °C [kg/m ³]	2.537 at 1 atm., 70 °F [lb/ft ³]
Vapour pressure	at 0 °C [bar]	0.81 at 32 °F [psi]
	at 20 °C [bar]	1.74 at 70 °F [psi]
Flammability range in air [% volume]	2.2 – 28.2	

Methylamine (CH₃)NH₂

Monomethylamine, Aminomethane

CAS: 74-89-5
 EC: 200-820-0
 UN: 1061
 R-630

Purity grade	Typical purity	Typical impurities [ppm]	Other amines
Methylamine 2.0	≥99 %		≤1%

Typical filling pressure: 15 °C: 2 bar(g)/ 70 °F: 29 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•					

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
•	•		Consult local team

Characteristics

Flammable. Liquefied colourless gas with ammonia/fish-like odour. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

GHS-CLP

Signal word: DANGER



H-statements:

Liquefied Gas → H280 – Contains gas under pressure; may explode if heated; H220 – Extremely flammable gas; H332 – Harmful if inhaled; H335 – May cause respiratory irritation; H315 – Causes skin irritation; H318 – Causes serious eye damage.

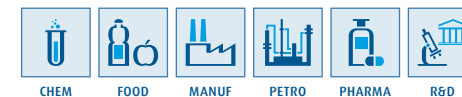
Transport of dangerous goods



ADR Class 2, 2F



DOT Class 2.1



Source

Methylamine is produced industrially either by a reaction of methanol and ammonia in the presence of a catalyst or by a reaction between a carbonyl compound and ammonia.

Dimethylamine and trimethylamine are also formed in the same reaction. The three products are separated by distillation.

Applications

Methylamine is an intermediate in the synthesis of pharmaceuticals (e.g. ephedrine or theophylline) and pesticides (carbaryl, metam sodium, carbofuran).

Liquid methylamine can be used either as a solvent or in generating the solvents N-methylformamide or N-methylpyrrolidone.

Methyl amine is also employed to produce surfactants and photographic developers.

Physical data

Molecular weight	31.057			
Boiling point	at 1.013 bar [°C]	-6.33	at 14.5 psi [°F]	20.63
Density	at 1.013 bar, 15 °C [kg/m ³]	1.31	at 1 atm., 70 °F [lb/ft ³]	0.082
Vapour pressure	at 0 °C [bar]	1.34	at 32 °F [psi]	19.46
	at 20 °C [bar]	2.96	at 70 °F [psi]	44.63
Flammability range in air [% volume]	4.9 – 20.7			

Neon Ne

CAS: 7440-01-9
 EC: 231-110-9
 UN: 1065 (Compressed)
 UN: 1913 (Refrigerated liquid)
 R-720

Purity grade	Typical purity	Typical impurities [ppm]				
		H ₂ O	O ₂	C _n H _m	N ₂	He
HiQ® Neon 4.5	≥99.995 %	≤3	≤2	≤0.2	≤5	≤20
HiQ® Neon 5.0	≥99.999 %	≤2	≤1	≤0.1	≤2	≤5

Typical filling pressure: 15 °C: 200 bar(g)/ 70 °F: 2,800 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•	•				

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
•	•		Consult local team

Characteristics

Colourless and odourless gas. Non-reactive. Asphyxiant in high concentrations. Gas density is lighter than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

Proposed by the Industry

Signal word: WARNING



H-statements:

Compressed Gas → H280 – Contains gas under pressure; may explode if heated; Refrigerated Gas → H281 – Contains refrigerated gas; may cause cryogenic burns or injury; EIGA-As – Asphyxiant in high concentrations.

Transport of dangerous goods



ADR Class 2, 1A (Compressed)
 3A (Refrigerated liquid)



DOT Class 2.2



Source

Neon is obtained from air separation plants. In view of its very low natural concentration in air, it is only economically viable to recover neon from larger air separation plants. In

these cases small quantities of neon are recovered by splitting a crude neon stream from the plant and processing this in a separate purification and distillation system.

Applications

Neon is used as a filling gas in:

- spark chamber particle detectors, in mixtures with helium and other particle detectors
- Geiger tubes and other detectors
- fluorescent lamps
- sodium discharge lamps
- digital display tubes (Dixie tubes)
- stroboscope lights
- signs, in mixtures with argon (hence the term Neon Lights)
- low-consumption glow lamps (night lights)
- filament lamps
- telephone line surge arrestors

Neon is used as a carrier gas in chromatography for special applications.

Neon-oxygen breathing mixtures are used in diving, with the advantage of not causing vocal deformation.

Liquid neon is employed in the following applications:

- liquid hydrogen replacement studies at about 30 K to satisfy safety considerations
- cryo-sorption and cryo-pumping
- nuclear particle detection in bubble chambers
- lung diffusion gas

Neon is used in plasma TV screens.

Neon is also used as either a buffer gas or the active medium in various types of gas lasers such as helium/neon, excimer and copper vapour lasers.

Physical data

Molecular weight	20.18			
Boiling point	at 1.013 bar [°C]	-246.06	at 14.5 psi [°F]	-410.89
Density	at 1.013 bar, 15 °C [kg/m ³]	0.853	at 1 atm., 70 °F [lb/ft ³]	0.052
Vapour pressure	at 0 °C [bar]	-	at 32 °F [psi]	-
	at 20 °C [bar]	-	at 70 °F [psi]	-
Flammability range in air [% volume]	Non combustible			

Nitric oxide NO

Nitrogen monoxide

CAS: 10102-43-9
EC: 233-271-0
UN: 1660

Purity grade	Typical purity	Typical impurities [ppm]
HiQ® Nitric oxide 2.5	≥99.5 %	contact local team

Typical filling pressure: 15 °C: 35 bar(g)/ 70 °F: 500 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•					

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
•	•		Consult local team

Characteristics

Colourless gas with slight odour. Gas density is slightly heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

Proposed by the Industry

Signal word: DANGER



H-statements:

Compressed Gas → H280 – Contains gas under pressure; may explode if heated; H270 – May cause or intensify fire; oxidiser; H330 – Fatal if inhaled; H314 – Causes severe skin burns and eye damage; EUH071 – Corrosive to the respiratory tract.

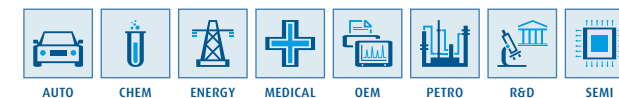
Transport of dangerous goods



ADR Class 2, 1TOC



DOT Class 2.3



Source

Nitric oxide is industrially produced by catalytic burning of ammonia.

Applications

Nitric oxide is used as a polymerisation inhibitor.

Nitric oxide is used in the bleaching of rayon fabrics.

Nitric oxide is used for oxidation of semiconductors in the electronics industry.

Nitric oxide is used

- for chemical synthesis
- in the preparation of metal nitril carbonyls.

Nitric oxide gas mixtures with concentrations down to a ppb level are widely used to test and calibrate pollution and emission control analysers.

Nitric oxide gas mixtures are used therapeutically in neonatal, paediatric and adult medical therapies.

Nitric oxide may be classified as a medical gas in some geographies and managed according to the relevant regulations.

Physical data

Molecular weight	30.006			
Boiling point	at 1.013 bar [°C]	-151.77	at 14.5 psi [°F]	-241.17
Density	at 1.013 bar, 15 °C [kg/m ³]	1.27	at 1 atm., 70 °F [lb/ft ³]	0.078
Vapour pressure	at 0 °C [bar]	-	at 32 °F [psi]	-
	at 20 °C [bar]	-	at 70 °F [psi]	-
Flammability range in air [% volume]	Non combustible			

Nitrogen N₂

CAS: 7727-37-9
 EC: 231-783-9
 UN: 1066 (Compressed)
 UN: 1977 (Refrigerated liquid)
 R-728

Purity grade	Purity	Impurities [ppm]										Legend:	N/D = Not Detectable			
		H ₂ O	O ₂	C _n H _m	CO	CO ₂	H ₂	Ar	NO _x	SO ₂	NO			Odour	Halocarbons	
HiQ® Nitrogen 4.6	≥99.996 %	≤5	≤5	-	-	-	-	-	-	-	-	-	-	-	-	-
HiQ® Nitrogen 5.0	≥99.999 %	≤3	≤2	≤0.5	-	-	-	-	-	-	-	-	-	-	-	-
HiQ® Nitrogen 5.0 Zero	≥99.999 %	≤3	≤2	≤0.2	≤1	≤1	-	-	-	-	-	-	-	-	-	-
HiQ® Nitrogen 5.5 ECD	≥99.9995 %	≤1	≤1	≤0.1	≤0.5	≤0.5	-	-	-	-	-	-	-	-	≤1	ppb
HiQ® Nitrogen 5.5 CEM Zero	≥99.9995 %	≤1	≤0.5	≤0.1	≤0.5	≤1	-	-	≤0.1	≤0.1	-	-	-	-	-	-
HiQ® Nitrogen 6.0	≥99.9999 %	≤0.5	≤0.5	≤0.1	≤0.1	≤0.1	≤0.5	-	-	-	-	-	-	-	-	-
HiQ® Nitrogen 7.0	≥99.99999 %	≤50	≤30	≤30	≤30	≤30	≤30	-	-	-	-	-	-	-	≤1	ppb
HiQ® Nitrogen Euro 6 Raw	≥99.999 %	≤3	≤2	≤0.5	≤1	≤1	-	-	-	-	≤0.1	-	-	-	-	-
HiQ® Nitrogen Euro 6 Dilute	≥99.9999 %	≤0.5	≤0.5	≤0.05	≤0.1	≤0.1	-	-	-	-	≤0.02	-	-	-	-	-
VERISEQ® Process Nitrogen (pharmaceutical grade)	≥99.5 %	≤5	≤5	-	≤5	≤300	-	≤0.5 %	-	-	-	-	N/D	-	-	-
VERISEQ® Research Nitrogen (pharmaceutical grade)	≥99.999 %	≤3	≤3	≤1	≤5	≤300	-	≤0.5 %	-	-	-	-	N/D	-	-	-

Typical filling pressure: 15 °C: 200 bar(g)/ 70 °F: 2,800 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•	•				• Cryogenic liquid

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
•	•	Cryogenic liquid	Consult local team

Characteristics

Colourless and odourless gas. Asphyxiant in high concentrations. Gas density is slightly lighter than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

Proposed by the Industry

Signal word: WARNING



H-statements:

Compressed Gas → H280 – Contains gas under pressure; may explode if heated; Refrigerated Gas → H281 – Contains refrigerated gas; may cause cryogenic burns or injury; EIGA-As – Asphyxiant in high concentrations.

Transport of dangerous goods



ADR Class 2, 1A (Compressed)
 3A (Refrigerated liquid)



DOT Class 2.2



Source

Nitrogen is produced in large quantities at air separation plants which liquefy and subsequently distil air into nitrogen, oxygen and argon. If very high purity nitrogen is required the nitrogen produced may need to go through

a secondary purification process. The lower range of nitrogen purities can also be produced with membrane techniques, and medium to high purities with pressure swing adsorption (PSA) techniques.

Applications

Nitrogen is used in large quantities in the chemical industry for blanketing, purging and pressure transfer of flammable chemicals.

Nitrogen is used as a fire extinguishing gas in mines.

Nitrogen is used to fill tires to reduce wear and limit the risks of blow-outs.

High-purity nitrogen is used in large quantities by the semiconductor industry as a purge or carrier gas as well as for blanketing equipment such as furnaces when not in production.

Liquid nitrogen is used in cold traps to improve the efficiency of vacuum pumps by condensing or solidifying residual gases in the vacuum.

Nitrogen is used as a purge gas.

Liquid nitrogen may be used for shrink fitting of close tolerance components.

Nitrogen is commonly used as carrier gas in gas chromatography.

Liquid nitrogen is used to freeze a wide variety of delicate food, such as hamburgers, strawberries, shrimps etc.

Nitrogen is used as zero gas for analytical instruments. Nitrogen is commonly used as a balance gas in mixtures. Nitrogen is used in the electronic industry for inerting of epitaxial reactors.

Liquid nitrogen may also be used for cryogenic grinding of plastics, rubbers and some other chemicals products.

Nitrogen is used in mixtures with carbon dioxide for modified atmosphere packaging (MAP) of food stuffs.

Liquid nitrogen is used in the nuclear industry, for scientific research.

Nitrogen is used extensively, either pure or, more commonly, in a mixture with a reducing gas such as hydrogen or natural gas, to provide an oxygen free atmosphere during heat treatment of various metals.

Liquid nitrogen is used to store biological materials like tissue, cells etc.

Liquid nitrogen is also used for cryo surgery.

Liquid nitrogen is used in the area of superconductivity.

Nitrogen is used in the Haber-Bosch process for production of ammonia.

Nitrogen is used in Liquid chromatography-mass spectrometry.

Physical data

Molecular weight	28.014			
Boiling point	at 1.013 bar [°C]	-195.8	at 14.5 psi [°F]	-320.42
Density	at 1.013 bar, 15 °C [kg/m ³]	1.185	at 1 atm., 70 °F [lb/ft ³]	0.072
Vapour pressure	at 0 °C [bar]	-	at 32 °F [psi]	-
	at 20 °C [bar]	-	at 70 °F [psi]	-
Flammability range in air [% volume]	Non combustible			

Nitrogen dioxide NO₂

CAS: 10102-44-0
EC: 233-272-6
UN: 1067

Purity grade	Typical purity	Typical impurities [ppm]
HiQ® Nitrogen dioxide 2.0	≥99 %	H ₂ O ≤3,000

Typical filling pressure: 15 °C: 0.95 bar(a)/70 °F: 14.66 psi(a)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•					

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
Gaseous Withdrawal	Gaseous Withdrawal	Liquid Withdrawal	Consult local team

Characteristics

Reddish-brown liquefied gas with an asphyxiating odour. Corrosive in humid conditions. Heavy oxidising agent. Mixtures with organic materials can be explosive. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

GHS-CLP

Signal word: DANGER



H-statements:

Liquefied Gas → H280 – Contains gas under pressure; may explode if heated; H270 – May cause or intensify fire; oxidiser; H330 – Fatal if inhaled; H314 – Causes severe skin burns and eye damage; EUH071 – Corrosive to the respiratory tract.

Transport of dangerous goods



ADR Class 2, 2TOC



DOT Class 2.3



Source

Industrial production of nitrogen dioxide employs the Ostwald process (catalytic combustion of ammonia) and is the initial step in the production of nitric acid.

Other commercial processes for producing nitrogen dioxide are the oxidation of nitrosyl chloride yielding nitrogen dioxide and chlorine, and the treatment of sodium nitrite

with nitric acid and oxidation of the liberated nitrogen monoxide to nitrogen dioxide.

High-purity nitrogen dioxide is obtained during the production of sodium nitrate from sodium chloride and nitric acid.

Applications

Nitrogen dioxide is employed in the production of calibration standards used in the inspection of combustion gases.

Nitrogen dioxide is used in calibration mixtures for the automotive industry.

Nitrogen dioxide is used in calibration mixtures for environmental monitoring in many process areas.

Nitrogen dioxide in the form of its dimer dinitrogen tetroxide is used as an oxidant in rocket fuels.

Nitrogen dioxide is employed in laboratories as an oxidising agent.

Nitrogen dioxide may also be used as a non-aqueous solvent in chemical extractions or as a reagent in chemical synthesis.

Physical data

Molecular weight	46.006			
Boiling point	at 1.013 bar [°C]	20.85	at 14.5 psi [°F]	69.55
Density	at 1.013 bar, 15 °C [kg/m ³]	1.98	at 1 atm., 70 °F [lb/ft ³]	0.121
Vapour pressure	at 0 °C [bar]	0.35	at 32 °F [psi]	5.09
	at 20 °C [bar]	0.96	at 70 °F [psi]	14.66
Flammability range in air [% volume]	Non combustible			

Nitrogen trifluoride NF_3

CAS: 7783-54-2
EC: 232-007-1
UN: 2451

Purity grade	Typical purity	Typical impurities [ppm]						
		H ₂ O	O ₂	N ₂	CO ₂	CF ₄	SF ₆	N ₂ O
HiQ® Nitrogen trifluoride 4.0	≥99.99 %	≤1	≤5	≤50	≤15	≤50	≤10	≤10

Typical filling pressure: up to 15 °C: 98 bar(g) 70 °F: 1450 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•					

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
•	•		Consult local team

Characteristics

Colourless gas with characteristic mouldy odour. Highly oxidising at increased temperatures, can then ignite organic material. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

Proposed by the Industry

Signal word: DANGER



H-statements:

Liquefied Gas → H280 – Contains gas under pressure; may explode if heated; H270 – May cause or intensify fire; oxidiser; H332 – Harmful if inhaled; H373 – May cause damage to the blood through prolonged or repeated inhalation.

Transport of dangerous goods



ADR Class 2, 20



DOT Class 2.2



Source

Nitrogen trifluoride is prepared by direct catalytic fluorination of ammonia. It may also be obtained by electrolysis of molten ammonium bifluoride.

Known, but no longer used, is the direct combination of the elements nitrogen and fluorine using an electrical discharge at low temperatures.

Applications

Nitrogen trifluoride is used as a high-speed, selective etchant in silicon processing. It is used to etch silicon, polysilicon, silicon nitride and silicon oxide as well as refractory metals and silicides.

Nitrogen trifluoride is sometimes used as the fluorine source in HF/DF chemical lasers.

Nitrogen trifluoride is used as a fluorinating agent. Nitrogen trifluoride is also used for fibre treatment.

Nitrogen trifluoride is used in cleaning chemical vapour reaction chambers for solar cell and LED screen production.

Nitrogen trifluoride has recently become of interest as a nitrogen source in generating nitride layers by chemical vapour deposition.

Physical data

Molecular weight	71.002			
Boiling point	at 1.013 bar [°C]	-129.05	at 14.5 psi [°F]	-200.29
Density	at 1.013 bar, 15 °C [kg/m ³]	3.015	at 1 atm., 70 °F [lb/ft ³]	0.184
Vapour pressure	at 0 °C [bar]	-	at 32 °F [psi]	-
	at 20 °C [bar]	-	at 70 °F [psi]	-
Flammability range in air [% volume]	Non combustible			

Nitrous oxide N_2O

CAS: 10024-97-2
 EC: 233-032-0
 UN: 1070
 UN: 2201 (Refrigerated liquid)
 R-744A

Purity grade	Typical purity	Typical impurities [ppm]						
		Air	H ₂ O	O ₂	N ₂	CO	CO ₂	C _n H _m
Nitrous oxide 2.5	≥99.5 %	contact local team						
HiQ® Nitrous oxide 2.5 AAS	≥99.5 %	≤5,000 ppm	-	-	-	-	-	-
HiQ® Nitrous oxide 4.5	≥99.995 %	-	≤5	≤5	≤25	≤1	≤10	≤2
HiQ® Nitrous oxide 5.0	≥99.999 %	-	≤1	≤1	≤5	≤1	≤1	≤1

Typical filling pressure: 15 °C: 45 bar(g)/ 70 °F: 745 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•					

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
•	•		Consult local team

Characteristics

Oxidiser. Colourless and odourless gas. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

Proposed by the Industry

Signal word: DANGER



H-statements:

Compressed Gas → H280 – Contains gas under pressure; may explode if heated; Refrigerated Gas → H281 – Contains refrigerated gas; may cause cryogenic burns or injury; H270 – May cause or intensify fire; oxidiser.

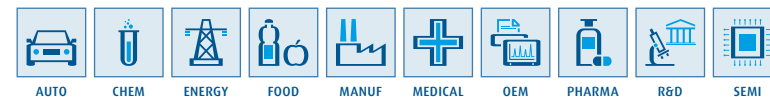
Transport of dangerous goods



ADR Class 2, 20
30 (Refrigerated liquid)



DOT Class 2.2



Source

Nitrous oxide is obtained most commonly by the thermal decomposition of ammonium nitrate.

Nitrous oxide may also be obtained by controlled

reduction of nitrites or nitrates, by the slow decomposition of hyponitrites, or by the thermal decomposition of hydroxylamine.

Applications

Nitrous oxide (also known as “laughing gas”) is commonly used as a general anaesthetic in both medical and dental surgeries. To be effective as an anaesthetic, nitrous oxide must be inhaled in relatively high concentrations mixed with air or oxygen. Nitrous oxide may be classified as a medical gas in some geographies and managed according to the relevant regulations.

Nitrous oxide serves in industry as a leak detector for vacuum and pressurised enclosures, buried piping, etc.

Nitrous oxide is used as an oxygen source in the chemical vapour deposition of silicon oxynitride layers.

Nitrous oxide is used in calibration mixtures for environmental control.

The nitrous oxide-acetylene flame is employed in the laboratory for the analysis of refractory elements such as aluminium, vanadium, titanium and calcium oxides, by flame emission spectrometry. The use of this flame also permits determination of a certain number of trace metals by atomic absorption spectrometry.

Note:

Nitrous oxide is listed in the Kyoto Protocol, an international Framework Convention with the objective of reducing greenhouse gases.

Nitrous oxide is used as an oxidiser in some types of analytical instruments.

Nitrous oxide may be used as an aerosol/propellant in various fields:

- for whipped cream (because it improves the foaming characteristics of the cream), syrups, concentrates of coffee, chocolate and various flavours, sauces for grilled meats, vinaigrette, etc.
- in pharmaceutical sprays
- in cosmetics (perfumes, eau de cologne, hair spray, etc.)
- in household products, paints and varnishes, insecticides
- in aerosols for use at low temperatures, such as de-icers, engine starting boosters, etc.

Nitrous oxide is used as an oxygen enrichment medium for high-performance internal combustion engines (drag racing).

Nitrous oxide is used as oxidising component in the production of rocket fuels.

Nitrous oxide is used in the production of optical fibre.

Physical data

Molecular weight	44.013			
Boiling point	at 1.013 bar [°C]	-88.48	at 14.5 psi [°F]	-127.24
Density	at 1.013 bar, 15 °C [kg/m ³]	1.873	at 1 atm., 70 °F [lb/ft ³]	0.114
Vapour pressure	at 0 °C [bar]	37.5	at 32 °F [psi]	543.9
	at 20 °C [bar]	58.5	at 70 °F [psi]	848.5
Flammability range in air [% volume]	Non combustible			

Octafluoropropane C_3F_8

Perfluoropropane, FC-218, R-218

CAS: 76-19-7
EC: 200-941-9
UN: 2424
R-218

Purity grade	Typical purity	Typical impurities [ppm]			Acidity ppm(w)
		H ₂ O	N ₂ + O ₂	Other halocarbons	
HiQ® Octafluoropropane 3.5	≥99.95 %	≤10	≤300	≤200	≤1

Typical filling pressure: 15 °C: 6.7 bar(g)/ 70 °F: 100 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•					

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
•	•		Consult local team

Characteristics

Colourless liquefied gas with an ethereal odour. Poor warning properties at low concentrations. Asphyxiant in high concentrations. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

Proposed by the Industry

Signal word: WARNING



H-statements:

Liquefied Gas → H280 – Contains gas under pressure; may explode if heated; EIGA-As – Asphyxiant in high concentrations.

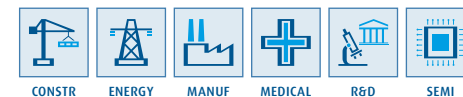
Transport of dangerous goods



ADR Class 2, 2A



DOT Class 2.2



Source

Perfluoroalkanes can be produced by a variety of routes. Indirect fluorination of hydrocarbons with cobalt (III) fluoride or silver (II) fluoride is carried out in a steel or nickel tube with stirring. The hydrocarbon vapours are passed at 150–450 °C over the fluorinating agent, which is regenerated in a fluorine stream. This process is suitable

for the production of perfluoroalkanes containing up to 20 carbon atoms.

Perfluoroalkanes can also be produced electrochemically by the Phillips Petroleum process or the electrochemical fluorination of organic compounds by the Simon's process.

Applications

Octafluoropropane is useful for high-voltage insulation.

Octafluoropropane is also used for eye surgery.

Octafluoropropane is used in mixture with oxygen in semiconductor applications as an etching material for silicon dioxide layers. Oxides are selectively etched versus their metal substrates.

It may be classified as a medical device in some geographies and managed according to the relevant regulations.

Octafluoropropane (R-218) is a component in refrigeration mixtures.

Note:

Octafluoropropane is listed in the Kyoto Protocol, an international Framework Convention with the objective of reducing greenhouse gases.

Physical data

Molecular weight	188.02	
Boiling point	at 1.013 bar [°C]	-36.75
	at 14.5 psi [°F]	-34.13
Density	at 1.013 bar, 15 °C [kg/m ³]	8.163
	at 1 atm., 70 °F [lb/ft ³]	0.498
Vapour pressure	at 0 °C [bar]	4.17
	at 32 °F [psi]	60.46
	at 20 °C [bar]	7.69
	at 70 °F [psi]	115.05
Flammability range in air [% volume]	Non combustible	

Oxygen O_2

CAS: 7782-44-7
 EC: 231-956-9
 UN: 1072 (Compressed)
 UN: 1073 (Refrigerated liquid)
 R-732

Purity grade	Purity	Impurities [ppm]						
		H ₂ O	C _n H _m	CO	CO ₂	N ₂	Ar	Odour
HiQ® Oxygen 3.5	≥99.95 %	≤5	-	-	-	-	-	-
HiQ® Oxygen 4.8	≥99.998 %	≤3	≤1	-	-	≤10	≤10	-
HiQ® Oxygen 5.0 Zero	≥99.999 %	≤3	≤0.2	≤1	≤1	≤5	≤5	-
HiQ® Oxygen 6.0	≥99.9999 %	≤0.5	≤0.1	≤0.1	≤0.1	≤0.5	≤1	-
VERISEQ® Process Oxygen (pharmaceutical grade)	≥99.5 %	≤67	-	≤5	≤300	-	-	N/D

Typical filling pressure: 15 °C: 200 bar(g)/ 70 °F: 2,800 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•	•				Cryogenic liquid

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
•	•	Cryogenic liquid	Consult local team

Characteristics

Colourless and odourless gas. Many materials burn in oxygen that do not normally burn in air. Reduces the flash-point temperature and increases the combustion speed. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

GHS-CLP

Signal word: DANGER



H-statements:

Compressed Gas → H280 – Contains gas under pressure; may explode if heated; Refrigerated Gas → H281 – Contains refrigerated gas; may cause cryogenic burns or injury; H270 – May cause or intensify fire; oxidiser.

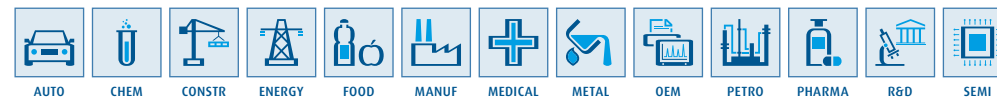
Transport of dangerous goods



ADR Class 2, 10 (Compressed)
30 (Refrigerated liquid)



DOT Class 2.2



Source

Oxygen is obtained on a commercial scale by the liquefaction and subsequent distillation of air. For very high purity oxygen it is normally necessary to take the product from an air separation plant through a secondary

purification and distillation stage. Alternatively high-purity oxygen may be produced by the electrolysis of water. Lower purities of oxygen can also be produced with membrane technique.

Applications

Many oxidation reactions in the chemical industry use pure oxygen rather than air in order to benefit from higher reaction rates, easier product separation, higher yields, or smaller equipment size.

non-ferrous, glass and concrete industries amongst many others.

High-purity oxygen is used for the formation of silicon dioxide and metal oxide, as an etchant for photoresist, and in mixtures with halocarbons for etching silicon. Oxygen is also used in conjunction with hydrogen to fuel torches for welding, brazing, glass blowing and tube sealing for a variety of electronic components such as reed relay switches.

Oxygen is used for flame sealing of glass ampoules for finished products for the pharmaceutical industry and the chemical industry.

In the food industry, oxygen is used in the transportation of live fish and seafoods.

Oxygen is used for enrichment of air during fermentation.

High-purity oxygen is used in conjunction with high-purity methane in Advanced Gas Cooled (AGR) nuclear reactors to maintain an appropriate carbon balance in the (CO₂) gas coolant in the nuclear core.

Mixed with other gases, oxygen serves in the production of breathable atmospheres (O₂ + CO₂: reanimation; O₂ + He or O₂ + N₂: underwater diving).

High-purity oxygen is used in the optical fibre production process.

Oxygen is used in some cases for modified atmosphere packaging (MAP) of food stuffs. It is used either pure or in mixtures with carbon dioxide and/or nitrogen.

Injecting oxygen into sewage treatment plants accelerates the decomposition of sewage.

Liquid oxygen is used in liquid oxygen explosives, and as a comburent in space propulsion.

Oxygen is used for chemical synthesis.

Oxygen is used in the medical field, as pure gas and in mixtures.

Oxygen is used as an oxidiser.

Oxygen is also used in calibration gas.

Oxygen is used to supplement or replace air in burners used in many different industries in order to obtain increased temperatures. Typical applications are found in the steel,

Oxygen is used in metal treating laser applications. Oxygen is used in cutting and welding.

Physical data

Molecular weight	31.999			
Boiling point	at 1.013 bar [°C]	-182.98	at 14.5 psi [°F]	-297.34
Density	at 1.013 bar, 15 °C [kg/m ³]	1.354	at 1 atm., 70 °F [lb/ft ³]	0.083
Vapour pressure	at 0 °C [bar]	-	at 32 °F [psi]	-
	at 20 °C [bar]	-	at 70 °F [psi]	-
Flammability range in air [% volume]	Non combustible			

Pentafluoroethane C_2HF_5

HFC-125, R-125

CAS: 354-33-6

EC: 206-557-8

UN: 3220

R-125

Purity grade	Typical purity	Typical impurities [ppm]
Pentafluoroethane	≥99.5 %	H ₂ O ≤10 ppm(w)

Typical filling pressure: 15 °C: 11.2 bar(g)/70 °F: 165.7 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•					

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
•	•		Consult local team

Characteristics

Colourless liquefied gas with a slight ethereal smell. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

Proposed by the Industry

Signal word: WARNING



H-statements:

H280 - Contains gas under pressure; may explode if heated.

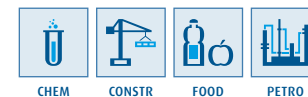
Transport of dangerous goods



ADR Class 2, 2A



DOT Class 2.2



Source

Many HCFCs and HFCs are manufactured via similar synthesis routes from common feedstocks. Many synthesis routes for pentafluoroethane use trichloroethylene

and/or tetrachloroethylene (also known as perchloroethylene, PCE), which is reacted with HF, often in the presence of a catalyst.

Applications

Pentafluoroethane is commonly used as a refrigerant gas. It is a hydrofluorocarbon (HFC) and is given the ASHRAE number R-125. It is used as a component in many HFC refrigerant gas blends, including R404A, R410A, R407A,C and F and many R22 retrofit replacements.

Pentafluoroethane is also used in its pure form as a fire suppression agent.

Note:

Pentafluoroethane is listed in the Kyoto Protocol, an international framework convention with the objective of reducing greenhouse gases.

Physical data

Molecular weight	120.02			
Boiling point	at 1.013 bar [°C]	-68.5	at 14.5 psi [°F]	-91.3
Density	at 1.013 bar, 20 °C [kg/m ³]	5.83	at 1 atm., 70 °F [lb/ft ³]	0.3640
Vapour pressure	at 0 °C [bar]	6.7	at 32 °F [psi]	113.6
	at 20 °C [bar]	12.4	at 70 °F [psi]	180.4
Flammability range in air [% volume]	Not combustible			

1,1,1,3,3-Pentafluoropropane $C_3H_3F_5$

HFC-245fa, R-245fa

CAS: 460-73-1

EC: 419-170-6

UN: 3163

R-245fa

Purity grade	Typical purity	Typical impurities [ppm]
1,1,1,3,3-Pentafluoropropane	≥99.8 %	H ₂ O ≤20 ppm(w)

Typical filling pressure: 15 °C: 11 bar(g)/70 °F: 163.3 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•					

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
•	•		Consult local team

Characteristics

Colourless liquified gas with a slight smell. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

Proposed by the Industry

Signal word: WARNING



H-statements:

H280 - Contains gas under pressure; may explode if heated.

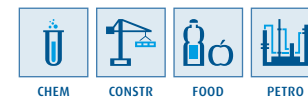
Transport of dangerous goods



ADR Class 2, 2A



DOT Class 2.2



Source

Many HCFCs and HFCs are manufactured via similar synthesis routes from common feedstocks. A common synthesis route for 1,1,1,3,3-pentafluoropropane

involves reacting 1,1,1,3,3-hexafluoropropane (HFC-236fa) with a source of hydrogen.

Applications

1,1,1,3,3-pentafluoropropane (HFC-245fa) is used primarily for foam blowing applications. It is a non-ozone-depleting alternative to R141b.

Note:

1,1,1,3,3-pentafluoropropane is listed in the Kyoto Protocol, an international framework convention with the objective of reducing greenhouse gases.

Physical data

Molecular weight	134.05			
Boiling point	at 1.013 bar [°C]	15.3	at 14.5 psi [°F]	59.5
Density	at 1.013 bar, 20 °C [kg/m ³]	1.32	at 1 atm., 70 °F [lb/ft ³]	0.0824
Vapour pressure	at 0 °C [bar]	0.53	at 32 °F [psi]	7.7
	at 20 °C [bar]	12.27	at 70 °F [psi]	178.0
Flammability range in air [% volume]	Not combustible			

n-Pentane C_5H_{12}

Pentane

CAS: 109-66-0
 EC: 203-692-4
 UN: 1265
 R-601

Purity grade	Typical purity	Typical impurities [ppm]
n-Pentane	≥95 %	H ₂ O ≤100 ppm(w)

Typical filling pressure: Filled as liquid

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•		•			

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
		•	Consult local team

Characteristics

Flammable. Colourless, nearly odourless liquid. Vapour is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

GHS-CLP

Signal word: DANGER



H-statements:

H224 - Extremely flammable liquid and vapour; H304 - May be fatal if swallowed and enters airways; H336 - May cause drowsiness or dizziness; H411 - Toxic to aquatic life with long lasting effects; EUH066 - Repeated exposure may cause skin dryness or cracking.

Transport of dangerous goods



ADR Class 3, F1



DOT Class 3



Source

n-Pentane is mainly produced/separated by fractional distillation in refineries.

Applications

Pentanes are some of the primary blowing agents used in the production of polystyrene foam and other foams. The pentanes are sold in pure form, and within blends. They have replaced fluorocarbon gases in many applications due to their zero ozone depletion and low global warming potential.

Physical data

Molecular weight	72.15	
Boiling point	at 1.013 bar [°C]	36.06 at 14.5 psi [°F]
Density	at 1.013 bar, 20 °C [kg/m ³]	0.62638 at 1 atm., 70 °F [lb/ft ³]
Vapour pressure	at 0 °C [bar]	0.24 at 32 °F [psi]
	at 20 °C [bar]	0.59 at 70 °F [psi]
Flammability range in air [% volume]	1.4 – 8.0	

iso-Pentane C_5H_{12}

2-methylbutane

CAS: 78-78-4
 EC: 201-142-8
 UN: 1265
 R-601a

Purity grade	Typical purity	Typical impurities [ppm]
iso-Pentane	≥95 %	H ₂ O ≤100 ppm(w)

Typical filling pressure: Filled as liquid

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•		•			

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
		•	Consult local team

Characteristics

Flammable. Colourless liquid with a petrol-like odour. Vapour is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

GHS-CLP

Signal word: DANGER



H-statements:

H224 - Extremely flammable liquid and vapour; H304 - May be fatal if swallowed and enters airways; H336 - May cause drowsiness or dizziness; H411 - Toxic to aquatic life with long lasting effects; EUH066 - Repeated exposure may cause skin dryness or cracking.

Transport of dangerous goods



ADR Class 3, F1



DOT Class 3



Source

iso-Pentane is mainly produced via catalytic isomerisation of n-Pentane.

Applications

Pentanes are some of the primary blowing agents used in the production of polystyrene foam and other foams. Often a mixture of n-Pentane, i-Pentane and increasingly cyclopentane is used. They have replaced fluorocarbon gases due to their zero ozone depletion and low global warming potential.

Physical data

Molecular weight	72.15	
Boiling point	at 1.013 bar [°C]	27.8 at 14.5 psi [°F]
Density	at 1.013 bar, 20 °C [kg/m ³]	0.62 at 1 atm., 70 °F [lb/ft ³]
Vapour pressure	at 0 °C [bar]	0.35 at 32 °F [psi]
	at 20 °C [bar]	0.76 at 70 °F [psi]
Flammability range in air [% volume]	1.4 – 7.6	

Phosgene

COCl₂
 Carbonyl chloride, Dichloromethanal

CAS: 75-44-5
 EC: 200-870-3
 UN: 1076

Purity grade	Typical purity	Typical impurities [ppm]
HiQ® Phosgene 2.0	≥99 %	HCl+Cl ₂ ≤10,000

Typical filling pressure: 15 °C: 0.6 bar(g)/70 °F: 10.7 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•					

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
•	•		Consult local team

Characteristics

Corrosive. Colourless, liquefied gas with a damp hay-like odour. Decomposes in water to hydrogen chloride and carbon dioxide. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

GHS-CLP

Signal word: DANGER



H-statements:

Liquefied Gas → H280 – Contains gas under pressure; may explode if heated; H330 – Fatal if inhaled; H314 – Causes severe skin burns and eye damage; EUH071 – Corrosive to the respiratory tract; H400 – Very toxic to aquatic life.

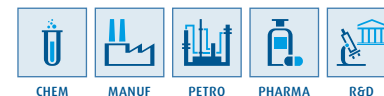
Transport of dangerous goods



ADR Class 2, 2TC



DOT Class 2.3



Source

Phosgene is obtained commercially by passing carbon monoxide and chlorine over a catalytic bed of activated carbon. The produced phosgene is liquefied in a condenser

and the residual product gases are carefully scrubbed for removal of remaining phosgene.

Applications

Phosgene is widely used in organic synthesis to prepare, e.g.:

- acyl halides as intermediates
- intermediate isocyanates (MDI and TDI) in the preparation of polyurethanes
- polycarbonate resins (thermoplastics)
- ethyl, isopropyl, diethylene glycol and n-butyl chloroformates
- dyes
- pharmaceuticals
- synthetic foams
- urea and substituted ureas
- carbodiimides

Phosgene is also used in the production of insecticides, herbicides and pesticides. For such use, phosgene may require registration/authorisation to comply with local legal requirements on biocides/pesticides.

Phosgene also serves in the bleaching of sand for the glass industry. It is a chlorinating agent.

Physical data

Molecular weight	98.916			
Boiling point	at 1.013 bar [°C]	7.56	at 14.5 psi [°F]	45.63
Density	at 1.013 bar, 15 °C [kg/m ³]	4.308	at 1 atm., 70 °F [lb/ft ³]	0.263
Vapour pressure	at 0 °C [bar]	0.75	at 32 °F [psi]	10.8
	at 20 °C [bar]	1.59	at 70 °F [psi]	24.0
Flammability range in air [% volume]	Non combustible			

Phosphine PH_3

Hydrogen phosphide

CAS: 7803-51-2
EC: 232-260-8
UN: 2199

Purity grade	Typical purity	Typical impurities [ppm]						
		O_2	N_2	CO	CO_2	C_nH_m	H_2O	AsH_3
HiQ® Phosphine 5.0	≥99.999 %	≤1	≤3	≤1	≤1	≤2	≤1	≤2

Typical filling pressure: 15 °C: 34 bar(g)/70 °F: 507.4 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•					

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
•	•		Consult local team

Characteristics

Flammable. Liquefied, colourless gas with an odour similar to rotten fish. Ignites spontaneously in air. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

GHS-CLP

Signal word: DANGER



H-statements:

Liquefied Gas → H280 – Contains gas under pressure; may explode if heated; H220 – Extremely flammable gas; H330 – Fatal if inhaled; H314 – Causes severe skin burns and eye damage; EUH071 – Corrosive to the respiratory tract; H400 – Very toxic to aquatic life.

Transport of dangerous goods



ADR Class 2, 2TF



DOT Class 2.3



Source

Phosphine may be prepared by a number of routes including hydrolysis of metal phosphides or direct combination of the elements under pressure.

Phosphine is industrially produced either by reaction of white phosphorous with sodium or potassium hydroxide at

elevated temperature or acid-catalysed disproportioning of white phosphorus.

Higher purity phosphine may be generated by the reaction of potassium hydroxide with phosphonium iodide (PH4I).

Applications

Phosphine is used as a fumigant to kill insect infestation in grain silos. Phosphine may require registration/authorisation for such usage to comply with local legal requirements on biocides/pesticides.

Phosphine is used as an n-type dopant in the epitaxial deposition and diffusion of silicon. It is also used for the epitaxial growth of InP and GaInAsP for the production of semiconductors.

Phosphine is used for charging of silica linings.

In the chemical industry, phosphine finds use in the preparation of flame-retarding compounds.

Phosphine-containing mixtures are used in halogen lamp production as bulb filling.

Physical data

Molecular weight	33.998			
Boiling point	at 1.013 bar [°C]	-87.74	at 14.5 psi [°F]	-125.91
Density	at 1.013 bar, 15 °C [kg/m ³]	1.449	at 1 atm., 70 °F [lb/ft ³]	0.089
Vapour pressure	at 0 °C [bar]	22.37	at 32 °F [psi]	324.4
	at 20 °C [bar]	35.16	at 70 °F [psi]	522.11
Flammability range in air [% volume]	1.6 – 98.0 Pyrophoric			

Propadiene C_3H_4

Allene, 1,2-Propadiene

CAS: 463-49-0

EC: 207-335-3

UN: 2200

Purity grade	Typical purity	Typical impurities [ppm]	
		Other C_nH_m	H_2O
HiQ® Propadiene 2.5	≥99.5 %	≤5,000	≤100

Typical filling pressure: 15 °C: 5.2 bar(g) / 70 °F: 80.0 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•					

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
•	•		Consult local team

Characteristics

Flammable. Colourless, liquefied gas with slightly sweetish odour. Poor warning properties at low concentrations. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

Proposed by the Industry

Signal word: DANGER



H-statements:

Liquefied Gas → H280 – Contains gas under pressure; may explode if heated; H220 – Extremely flammable gas; H231 – May react explosively even in absence of air at elevated pressure and/or temperature.

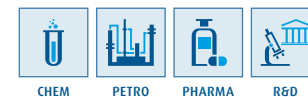
Transport of dangerous goods



ADR Class 2, 2F



DOT Class 2.1



Source

Propadiene occurs in jointly, +exists in equilibrium with methylacetylene as a side product, often an undesirable one, of cracking propane to produce propylene, an important feedstock in the chemical industry.

Propadiene can also be obtained by debromination of 2,3-dibromopropene or dechlorination of 2,3-dichloropropene.

Propadiene is produced through the pyrolysis of isobutane at elevated temperature and controlled pressure.

Applications

Propadiene is of interest in organic synthesis and is used in the manufacture of pharmaceutical intermediates and in the production of insecticides.

Propadiene mixtures are used as cutting gas in the manufacturing industry.

Propadiene is used as a component in calibration gases for the gas, oil and chemical industries.

Physical data

Molecular weight	40.065			
Boiling point	at 1.013 bar [°C]	-34.5	at 14.5 psi [°F]	-30.08
Density	at 1.013 bar, 15 °C [kg/m ³]	1.725	at 1 atm., 70 °F [lb/ft ³]	0.105
Vapour pressure	at 0 °C [bar]	3.55	at 32 °F [psi]	51.54
	at 20 °C [bar]	6.34	at 70 °F [psi]	94.72
Flammability range in air [% volume]	1.9 – 17.0			

Propane C_3H_8

R-290

CAS: 74-98-6
EC: 200-827-9
UN: 1978

Purity grade	Typical purity	Typical impurities [ppm]	Other C_nH_m
Propane 1.5	≥95 %		-
Propane 2.5	≥99.5 %		≤5,000
HiQ® Propane 3.5	≥99.95 %		≤500

Typical filling pressure: 15 °C: 6.3 bar(g)/ 70 °F: 109 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•		•			

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
Gaseous Withdrawal	Gaseous Withdrawal	Liquid Withdrawal	Consult local team

Characteristics

Flammable. Colourless, liquefied gas. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

GHS-CLP

Signal word: DANGER



H-statements:

Liquefied Gas → H280 – Contains gas under pressure; may explode if heated; H220 – Extremely flammable gas.

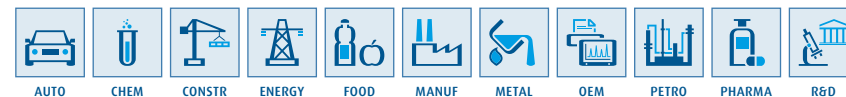
Transport of dangerous goods



ADR Class 2, 2F



DOT Class 2.1



Source

Propane is a constituent of crude petroleum and natural gas, from which it is obtained by refining and processing operations.

Applications

Propane is a main component in liquid petroleum gas (LPG).

Propane is of interest as a specialty gas mainly in mixtures used to calibrate process control analysers in the petrochemical industry.

Propane is also used in its pure form as the fuel gas in flame photometers.

Propane is used:

- for heating of industrial premises and apartments
- as fuel supply to hot air generators used in farming for drying harvests
- for heating animal breeding areas
- for cooking in hotels and restaurants
- in portable heating units at work sites, markets, etc.
- in the iron and steel industry: burners for heat treatment furnaces, radiation panels for surface treatment, metal oxycutting
- in the chemical industry, e.g. burners for ceramic kilns, in paintwork finishing installations, incinerators in petrochemical furnaces
- as a clean fuel for intra-plant vehicles, such as forklift trucks, where petrol fumes or soot would be considered unpleasant
- extensively as a refrigerant in chemical, petroleum refining and gas processing operations
- as a refrigerant in high/medium/low temperature applications for commercial and industrial refrigeration and A/C

- in heat pumps, and mixed with iso-butane in high/medium temperature commercial and domestic refrigeration applications
- in metallurgy to create controlled atmospheres. It is employed in gaseous cementation processes
- as an aerosol propellant mixed with iso-butane.

Propane as a refrigerant has the ASHRAE number R-290.

It is also used in small proportions as a component in some hydrochlorofluorocarbon and hydrofluorocarbon (HCFC, HFC) refrigerant blends for industrial and commercial refrigeration and air conditioning applications in order to facilitate oil return in the system.

In the chemical industry, propane is used in the production of: ethylene, propylene, which is an intermediate product in the manufacture of isopropanol, propylene oxide, propylene glycol, acrolein, acrylic acid, acrylonitrile, isopropylbenzene, allyl chloride, epichlorohydrin and polypropylene.

Propane and its blends are used for efficiency testing of gas burners and engines.

Propane is used in mixtures for emission control in the automotive industry.

Propane is used as a component in calibration gases for the gas, oil and chemical industries.

Physical data

Molecular weight	44.097			
Boiling point	at 1.013 bar [°C]	-42.04	at 14.5 psi [°F]	-43.65
Density	at 1.013 bar, 15 °C [kg/m ³]	1.901	at 1 atm., 70 °F [lb/ft ³]	0.116
Vapour pressure	at 0 °C [bar]	4.76	at 32 °F [psi]	69.01
	at 20 °C [bar]	8.39	at 70 °F [psi]	125.24
Flammability range in air [% volume]	1.7 – 10.8			

Propylene C_3H_6

Propene

CAS: 115-07-1
 EC: 204-062-1
 UN: 1077
 R-1270

Purity grade	Typical purity	Typical impurities [ppm]	Other C_nH_m
Propylene 2.5	≥99.5 %	contact local team	
HiQ® Propylene 2.8	≥99.8 %		≤1,000

Typical filling pressure: 15 °C: 9 bar(g)/ 70 °F: 136 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•					

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
Gaseous Withdrawal	Gaseous Withdrawal	Liquid Withdrawal	Consult local team

Characteristics

Flammable. Colourless, liquefied gas with a sweetish odour. Poor warning properties at low concentrations (stenchant often added). Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

GHS-CLP

Signal word: DANGER



H-statements:

Liquefied Gas → H280 – Contains gas under pressure; may explode if heated; H220 – Extremely flammable gas.

Transport of dangerous goods



ADR Class 2, 2F



DOT Class 2.1



Source

Propylene is obtained during the refining of gasoline, and to a lesser extent by the splitting, cracking and reforming of hydrocarbon mixtures.

Propylene is a by-product of oil refining and natural gas processing. It may also be taken from naphtha cracking.

Applications

Propylene is used in organic synthesis to produce, e.g. the following materials:

- acetone
- isopropanolacrylonitrile
- propylene oxide

Propylene in major quantities is polymerised to form polypropylene plastics.

It is used as a refrigerant in high/medium/low temperature applications including commercial refrigeration and air-conditioning. It has the ASHRAE number R-1270.

Propylene is used in mixtures for the calibration of process control instruments in the petrochemical/chemical industry.

Propylene is separated by fractional distillation from hydrocarbon fractions. For higher product qualities, further distillation is required.

The shale gas industry opened up an alternative production path by dehydrogenating propane to yield Propylene.

Propylene is widely used as a chemical intermediate.

Propylene is used in emission calibration mixtures for the automotive industry.

Propylene is used in the efficiency testing of gas burners and engines.

Propylene is used as a component in calibration gases for the chemical industry.

Physical data

Molecular weight	42.081			
Boiling point	at 1.013 bar [°C]	-47.69	at 14.5 psi [°F]	-53.82
Density	at 1.013 bar, 15 °C [kg/m ³]	1.809	at 1 atm., 70 °F [lb/ft ³]	0.111
Vapour pressure	at 0 °C [bar]	5.88	at 32 °F [psi]	85.26
	at 20 °C [bar]	10.24	at 70 °F [psi]	152.86
Flammability range in air [% volume]	1.8 – 11.2			

Propyne C_3H_4

Allylene, Methylacetylene

CAS: 74-99-7
EC: 200-828-4
UN: 1060

Purity grade	Typical purity	Typical impurities [ppm]
Propyne	on request	contact local team

Typical filling pressure: 15 °C: 3.3 bar(g)/70 °F: 59.4 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•					

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
•	•		Consult local team

Characteristics

Flammable. Colourless, liquefied gas with a garlic like odour. Poor warning properties at low concentrations. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

Proposed by the Industry

Signal word: DANGER



H-statements:

Liquefied Gas → H280 – Contains gas under pressure; may explode if heated; H220 – Extremely flammable gas; H231 – May react explosively even in absence of air at elevated pressure and/or temperature.

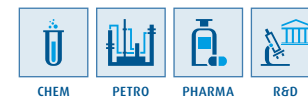
Transport of dangerous goods



ADR Class 2, 2F



DOT Class 2.1



Source

Propyne can be produced by thermal or catalytic pyrolysis of propylene.

Cracking of hydrocarbons yields blends containing propyne and propadiene which are recovered by solvent extraction. From these enriched C3 fractions propyne is further enriched by low temperature fractional distillation.

Applications

Propyne is used in the chemical industry as a synthesis intermediate.

Propyne is used as a component in calibration gases for the gas, oil and chemical industries.

As an intermediate it is also used in the synthesis of vitamin E.

Alternatively it is also extracted by selective hydrogenation. In cracked gas (for example, from steam cracking of hydrocarbons), propyne, together with propadiene, can be

recovered by solvent extraction and enriched by low temperature fractional distillation of C3 mixtures, or removed by selective hydrogenation.

Propyne may be used together with liquid oxygen as a high-performing rocket fuel.

Propyne blends are used as a cutting and welding gas in the manufacturing industry.

Physical data

Molecular weight	40.065			
Boiling point	at 1.013 bar [°C]	-23.21	at 14.5 psi [°F]	-9.76
Density	at 1.013 bar, 15 °C [kg/m ³]	1.728	at 1 atm., 70 °F [lb/ft ³]	0.106
Vapour pressure	at 0 °C [bar]	2.55	at 32 °F [psi]	36.92
	at 20 °C [bar]	4.94	at 70 °F [psi]	74.09
Flammability range in air [% volume]	1.8 – 16.8			

Silane SiH_4

Silicon hydride, Monosilane

CAS: 7803-62-5
EC: 232-263-4
UN: 2203

Purity grade	Typical purity	Typical impurities [ppm]						
		SiH_3Cl	H_2O	O_2	N_2	$\text{CO} + \text{CO}_2$	C_nH_m	H_2
HiQ® Silane 4.0	≥99.99 % – Resistivity >300 Ω/cm	≤2	≤2	≤1	≤20	≤5	≤5	≤200
HiQ® Silane 5.0	≥99.999 % – Resistivity >2000 Ω/cm	≤0.5	≤1	≤1	≤3	≤1	≤0.5	≤50

Typical filling pressure: 15 °C: 50-100 bar(g)/70 °F: 700 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•					

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
•	•		Consult local team

Characteristics

Flammable. Colourless gas with repulsive odour. Forms white fumes at leakage. Mixtures with more than 3% silane ignites spontaneously in air. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

Proposed by the Industry

Signal word: DANGER



H-statements:

Liquefied Gas → H280 – Contains gas under pressure; may explode if heated; H220 – Extremely flammable gas.

Transport of dangerous goods



ADR Class 2, 2F



DOT Class 2.1



Source

Silane is industrially produced through many differing reaction routes. A two-step process starts with reacting powdered silicon and hydrogen chloride at elevated temperature. The generated trichlorosilane in a subsequent reaction step catalytically forms silane by further heating.

High-purity silane used in the generation of semiconductor grade silicon is yielded in a complex redistribution reaction starting off with metallurgical grade silicon reacted with silicon tetrachloride and hydrogen.

Silane is also commercially produced by reduction of SiF_4 with sodium hydride or reduction of SiCl_4 with lithium aluminium hydride.

Applications

Silane is used in the production of specialty glasses to provide a reflective coating like in the automotive industry.

Silane is one of the basic materials in the silicon-based semiconductor industry. It is used as a source of silicon for growing polycrystalline and epitaxial (monocrystalline) silicon, silicon dioxide, silicon nitride and doping of gallium arsenide.

Silane is also used as a dopant in the production of compound semiconductor devices, for chemical vapour deposition of refractory metal silicides, and for deposition of amorphous silicon on photocopier drums.

Another commercial synthesis involves reduction of silicon dioxide in a mixture of sodium chloride and aluminium chloride in the presence of aluminium and gaseous hydrogen at high pressure.

Silane in smaller volumes is produced by the reduction of silicon tetrachloride by metal hydrides such as lithium or calcium aluminium hydride.

Silane can also be produced by treatment of magnesium silicide with hydrochloric acid.

Silane is also used in the production of photovoltaic cells.

Silane is used in the production process of optical fibres. Silane is used as a reducing reagent in organic and organo-metallic chemistry.

Physical data

Molecular weight	32.117			
Boiling point	at 1.013 bar [°C]	-112.15	at 14.5 psi [°F]	-169.85
Density	at 1.013 bar, 15 °C [kg/m ³]	1.366	at 1 atm., 70 °F [lb/ft ³]	0.085
Vapour pressure	at 0 °C [bar]	-	at 32 °F [psi]	-
	at 20 °C [bar]	-	at 70 °F [psi]	-
Flammability range in air [% volume]	1.0 – 96.0 Pyrophoric			

Silicon tetrachloride SiCl_4

Tetrachlorosilane

CAS: 10026-04-7
EC: 233-054-0
UN: 1818

Purity grade	Typical purity	Typical impurities [ppm]					
		SiH_nCl_m	Al	B	C	Fe	P + As
HiQ® Silicon tetrachloride 3.5	≥99.95 % – Resistivity >100 Ω/cm	≤600 ppm	≤50 ppb	≤0.2 ppb	≤1 ppb	≤25 ppb	≤2 ppb

Typical filling pressure: Filled as liquid

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•					

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
		•	Consult local team

Characteristics

Colourless liquid with a pungent odour. Hydrolyses in moist air to form hydrogen chloride and silicon dioxide. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

GHS-CLP

Signal word: WARNING



H-statements:

EUH014 – Reacts violently with water; H301 – Toxic if swallowed; H331

– Toxic if inhaled; H314 – Causes severe skin burns and eye damage;

EUH071 – Corrosive to the respiratory tract.

Transport of dangerous goods



ADR Class 8, C1



DOT Class 8



Source

Silicon tetrachloride is commonly obtained by chlorination of ferrosilicon. Alternatively, silicon carbide or silicon dioxide/carbon mixtures are used as feedstock.

Silicon tetrachloride may also be obtained by reacting silicon with chlorine and hydrogen chloride.

Applications

Silicon tetrachloride is used as raw material/intermediate in the production of high purity silicon, silicon dioxide, polysilanes and other silicon-based substances.

Silicon tetrachloride is used as starting material for manufacturing fused silica fibres.

Silicon tetrachloride is also used for surface treatment of metals and polymers.

Silicon tetrachloride can be used for chemical vapour deposition of silicon oxide, nitride or carbide layers.

Silicon tetrachloride can be used to produce smoke screens in warfare.

Physical data

Molecular weight	169.89			
Boiling point	at 1.013 bar [°C]	57.6	at 14.5 psi [°F]	135.7
Density	at 1.013 bar, 15 °C [kg/m ³]	7.733	at 1 atm., 70 °F [lb/ft ³]	0.483
Vapour pressure	at 0 °C [bar]	0.10	at 32 °F [psi]	1.47
	at 20 °C [bar]	0.26	at 70 °F [psi]	3.89
Flammability range in air [% volume]	Non combustible			

Silicon tetrafluoride SiF_4

Tetrafluorosilane

CAS: 7783-61-1
EC: 232-015-5
UN: 1859

Purity grade	Typical purity	Typical impurities [ppm]				
		O_2	N_2	CO_2	CO	CH_4
HiQ® Silicon tetrafluoride 4.8	≥99.998 %	≤3	≤3	≤3	≤3	≤10

Typical filling pressure: 15 °C: 62 bar(g)/70 °F: 900 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•					

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
•	•		Consult local team

Characteristics

Liquefied and colourless gas with a pungent odour. Hydrolyses in moist air to form hydrogen fluoride and silicon dioxide. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

Proposed by the Industry

Signal word: DANGER



H-statements:

Liquefied Gas → H280 – Contains gas under pressure; may explode if heated; H330 – Fatal if inhaled; H314 – Causes severe skin burns and eye damage; EUH071 – Corrosive to the respiratory tract.

Transport of dangerous goods



ADR Class 2, 2TC



DOT Class 2.3



Source

Silicon tetrafluoride is commercially extracted as a by-product of the exhaust gases from phosphate fertiliser production.

Silicon tetrafluoride is alternatively produced by heating barium hexafluorosilicate.

Silicon tetrafluoride is obtained by treating silicon dioxide and calcium fluoride with concentrated sulfuric acid.

Applications

Silicon tetrafluoride is used to produce sodium hexafluoroaluminate (synthetic cryolite) and aluminium fluoride.

Silicon tetrafluoride is used for low temperature silicon deposition and for plasma etching of aluminium in the semiconductor industry.

Silicon tetrafluoride is used as a silicon source in the manufacture of optical fibres.

Silicon tetrafluoride is used in organic synthesis.

Silicon tetrafluoride is used for water fluorination.

Physical data

Molecular weight	104.08			
Boiling point	at 1.013 bar [°C]	-95.14	at 14.5 psi [°F]	-139.25
Density	at 1.013 bar, 15 °C [kg/m ³]	4.431	at 1 atm., 70 °F [lb/ft ³]	0.271
Vapour pressure	at 0 °C [bar]	-	at 32 °F [psi]	-
	at 20 °C [bar]	-	at 70 °F [psi]	-
Flammability range in air [% volume]	Non combustible			

Sulfur dioxide SO₂

CAS: 7446-09-5

EC: 231-195-2

UN: 1079

Purity grade	Typical purity	Typical impurities [ppm]					
		Moisture (water)	Acidity	Non volatile residue	Halogene	Organic substances	Heavy metals
Sulfur dioxide 3.0	≥99.9 %	contact local team					
HiQ® Sulfur dioxide 3.8	≥99.98 %	≤50 ppm	≤10 ppm	≤50 ppm	≤1 ppm	≤1 ppm	≤1 ppm
Sulfur dioxide E220 (food grade)	≥99.98 %	≤50 ppm	≤10 ppm	≤50 ppm	≤1 ppm	≤1 ppm	≤1 ppm

Typical filling pressure: 15 °C: 2.4 bar(g)/70 °F: 36 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•		•			

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
Gaseous Withdrawal	Gaseous Withdrawal	Liquid Withdrawal	Consult local team

Characteristics

Colourless, liquefied gas with pungent odour. Dry gas is not corrosive. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

GHS-CLP

Signal word: DANGER



H-statements:

Liquefied Gas → H280 – Contains gas under pressure; may explode if heated; H331 – Toxic if inhaled; H314 – Causes severe skin burns and eye damage; EUH071 – Corrosive to the respiratory tract.

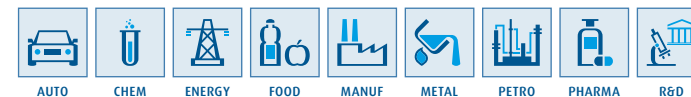
Transport of dangerous goods



ADR Class 2, 2TC



DOT Class 2.3



Source

Sulfur dioxide may be produced by a variety of routes, such as the combustion of sulfur or pyrites. Alternatively, it is gained as a by-product of smelter operations.

Sulfur dioxide is commonly obtained by burning sulfur with oxygen. It is primarily produced for sulfuric acid manufacture.

Applications

Sulfur dioxide is used in the manufacture of sulfite, hydrogen sulfites and sulfuric acid.

Sulfur dioxide is used as a component in environmental calibration gases.

Sulfur dioxide is used in magnesium foundries as protection gas (an alternative to SF₆).

Sulfur dioxide may be used:

- as a refrigerant
- in laboratory research on corrosion problems
- to remove excess chlorine in textile bleaching and water treatment
- in preparation of chrome leather tanning
- as a solvent.

Sulfur dioxide is used as an antioxidant for certain types of dried food, and also to bleach glue, sugar, textiles, fats and oils.

Sulfur dioxide is used to sterilise wine and beer making equipment in order to inhibit the growth of moulds and bacteria, and to control wine fermentation. Sulfur dioxide may be used in a variety of disinfecting and fumigation applications.

Sulfur dioxide is used in the pharmaceutical industry as a reaction agent.

Sulfur dioxide is used in gas mixtures for car emission monitoring.

For any of the food and sterilisation applications above, registration/authorisation may be needed to comply with local legal requirements on biocidal products.

Sulfur dioxide is also used in the float glass manufacturing process.

Physical data

Molecular weight	64.065			
Boiling point	at 1.013 bar [°C]	-10.02	at 14.5 psi [°F]	13.98
Density	at 1.013 bar, 15 °C [kg/m ³]	2.759	at 1 atm., 70 °F [lb/ft ³]	0.169
Vapour pressure	at 0 °C [bar]	1.55	at 32 °F [psi]	22.51
	at 20 °C [bar]	3.36	at 70 °F [psi]	50.67
Flammability range in air [% volume]	Non combustible			

Sulfur hexafluoride SF₆

CAS: 2551-62-4
EC: 219-854-2
UN: 1080

Purity grade	Typical purity	Typical impurities [ppm]					
		Air	H ₂ O	O ₂ + N ₂	CF ₄	Acidity (HF)	Hydrolysable fluoride
Sulfur hexafluoride 3.0	≥99.9 %	≤500 ppm(w)	≤5 ppm(w)	-	≤500 ppm(w)	≤0.3 ppm(w)	≤1 ppm(w)
HiQ® Sulfur hexafluoride 4.5	≥99.995 %	-	≤5	≤10	≤40	≤0.5 ppm(w)	-
HiQ® Sulfur hexafluoride 4.8	≥99.998 %	-	≤2	≤5	≤15	≤0.5 ppm(w)	-
HiQ® Sulfur hexafluoride 5.0	≥99.999 %	-	≤1	≤5	≤5	≤0.1 ppm(w)	-

Typical filling pressure: 15 °C: 19 bar(g)/ 70 °F: 307 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•		•			

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
Gaseous Withdrawal	Gaseous Withdrawal	Liquid Withdrawal	Consult local team

Characteristics

Colourless and odourless gas. Asphyxiant in high concentrations. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

Proposed by the Industry

Signal word: WARNING



H-statements:

Liquefied Gas → H280 – Contains gas under pressure; may explode if heated; EIGA-As – Asphyxiant in high concentrations.

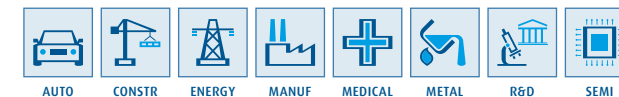
Transport of dangerous goods



ADR Class 2, 2A



DOT Class 2.2



Source

Sulfur hexafluoride is manufactured by direct fluorination of pure (elemental) sulfur, generally by companies which produce fluorine for other purposes such as the production of fluorocarbons.

Applications

A major application of sulfur hexafluoride is using the gas as a dielectric medium/insulator in circuit breakers, switch gears, power substations and gas-insulated transmission lines. For these applications, the gas used must meet or exceed ASTM D2472 and IEC specifications.

Sulfur hexafluoride is used as a plasma etching gas.

Sulfur hexafluoride is often used as a filling gas in double glazing to reduce sound transmissions and heat transfer.

Certain HF/DF chemical lasers (see page XXX) use sulfur hexafluoride as fluorine source. This type of laser is typically used in R&D applications.

As sulfur hexafluoride is both inert and considerably denser than air, it is suitable for blanketing open baths of certain molten metals, particularly magnesium.

Sulfur hexafluoride is used in laboratories as a carrier gas medium in supercritical fluid chromatography (SFC), and as a medium in supercritical fluid extraction (SFE) for sample preparation.

Note:

Sulfur hexafluoride is listed in the Kyoto Protocol, an international Framework Convention with the objective of reducing greenhouse gases.

Physical data

Molecular weight	146.06			
Boiling point	at 1.013 bar [°C]	-63.9	at 14.5 psi [°F]	-83.0
Density	at 1.013 bar, 15 °C [kg/m ³]	6.261	at 1 atm., 70 °F [lb/ft ³]	0.382
Vapour pressure	at 0 °C [bar]	12.90	at 32 °F [psi]	187.2
	at 20 °C [bar]	21.60	at 70 °F [psi]	321.70
Flammability range in air [% volume]	Non combustible			

Depending on the purity grade needed, further purification steps like distillation or extraction are applied.

Sulfur hexafluoride is being used for medical purposes such as a contrasting agent for ultrasonic examinations, and in retinal surgery. If classified as a medical device in a geography, sulfur hexafluoride will be managed according to the relevant local regulations.

Sulfur hexafluoride is used in a wide variety of applications as a leak detection gas. Typically it is employed in testing aluminium beer barrels, water supply pipelines or parts of airplanes and automobiles.

Sulfur hexafluoride is also used:

- as filling in loudspeakers
- as tyre filling gas.

Sulfur hexafluoride is also used as tracer gas to test the effectiveness of ventilation systems.

2,3,3,3-Tetrafluoro-1-propene $C_3H_2F_4$

Polyhaloalkene, HFO-1234yf, R-1234yf

CAS: 754-12-1
EC: 468-710-7
UN: 3161
R-1234yf

Purity grade	Typical purity	Typical impurities [ppm]
2,3,3,3-Tetrafluoro-1-propene	≥99.5 %	H ₂ O ≤20 ppm(w)

Typical filling pressure: 15 °C: 4.8 bar(g)/70 °F: 70.4 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•					

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
Gaseous Withdrawal	Gaseous Withdrawal	Liquid Withdrawal	Consult local team

Characteristics

Flammable. Colourless liquefied gas with a faint smell. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

Proposed by the Industry

Signal word: DANGER



H-statements:

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

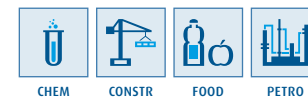
Transport of dangerous goods



ADR Class 2, 2F



DOT Class 2.1



Source

2,3,3,3-tetrafluoro-1-propene can be synthesised by the catalytic pyrolysis of methyl chloride and either tetrafluoroethylene or chlorodifluoromethane (HCFC-22). It can also be produced by reacting tetrafluoroethylene,

formaldehyde and HF in the presence of a TiF₄ catalyst and limonene. Finally, a further process reacts HFO-1233xd with HF via two catalytic reactions.

Applications

2,3,3,3-tetrafluoro-1-propene is a next generation refrigerant gas. It is given the ASHRAE number R-1234yf. Whilst technically an HFC, it is often referred to as a sub-group, HFO, to distinguish its lower environmental impact. It is being chosen by many automotive OEMs as the low GWP refrigerant of choice, replacing HFC-134a.

Physical data

Molecular weight	114.04			
Boiling point	at 1.013 bar [°C]	-29	at 14.5 psi [°F]	-20.2
Density	at 1.013 bar, 25 °C [kg/m ³]	1.1	at 1 atm., 77 °F [lb/ft ³]	0.0687
Vapour pressure	at 0 °C [bar]	3.14	at 32 °F [psi]	45.5
	at 20 °C [bar]	5.87	at 70 °F [psi]	85.1
Flammability range in air [% volume]	6.2 - 12.3			

trans-1,3,3,3-Tetrafluoro-1-propene $C_3H_2F_4$

HFO-1234ze(E), R-1234ze

CAS: 29118-24-9

EC: 471-480-0

UN: 3163

R-1234ze

Purity grade	Typical purity	Typical impurities [ppm]
trans-1,3,3,3-Tetrafluoro-1-propene	≥99.5 %	H ₂ O ≤50 ppm(w)

Typical filling pressure: 15 °C: 3 bar(g)/70 °F: 46.1 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•					

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
•	•		Consult local team

Characteristics

Colourless liquefied gas with an ether-like odour. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

Proposed by the Industry

Signal word: WARNING



H-statements:

H280 - Contains gas under pressure; may explode if heated.

Transport of dangerous goods



ADR Class 2, 2A



DOT Class 2.2



Source

trans-1,3,3,3-tetrafluoro-1-propene can be synthesised by dehydrofluorination of 1,1,1,3,3-pentafluoropropane (HFC-245fa) using an alkaline solution or a gas phase catalysed process.

Applications

trans-1,3,3,3-tetrafluoro-1-propene (HFO-1234ze) is a next generation low global warming potential refrigerant and foam blowing agent. It is given the ASHRAE number R-1234ze(E). Whilst technically an HFC, it is often referred to as a sub-group, HFO, to distinguish its lower environmental impact.

Physical data

Molecular weight	114.04	
Boiling point	at 1.013 bar [°C]	-19
	at 14.5 psi [°F]	-2.2
Density	at 1.013 bar, 21.1 °C [kg/m ³]	1.17
	at 1 atm., 70 °F [lb/ft ³]	0.0730
Vapour pressure	at 0 °C [bar]	2.17
	at 32 °F [psi]	31.4
	at 20 °C [bar]	4.19
	at 70 °F [psi]	60.8
Flammability range in air [% volume]	Not combustible	

Tetrafluoroethane $C_2H_2F_4$

1,1,1,2-Tetrafluoroethane, Norflurane, R-134a

CAS: 811-97-2
 EC: 212-377-0
 UN: 3159
 R-134a

Purity grade	Typical purity	Typical impurities [ppm]
Tetrafluoroethane 2.8	≥99.8 %	contact local team

Typical filling pressure: 15 °C: 3.9 bar(g) / 70 °F: 84 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•		•			

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
Gaseous Withdrawal	Gaseous Withdrawal	Liquid Withdrawal	Consult local team

Characteristics

Colourless, odourless, liquefied gas. Can decompose to toxic substances at high temperatures. Asphyxiant in high concentrations. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

Proposed by the Industry

Signal word: WARNING



H-statements:

Liquefied Gas → H280 – Contains gas under pressure; may explode if heated; EIGA-As – Asphyxiant in high concentrations.

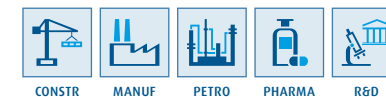
Transport of dangerous goods



ADR Class 2, 2A



DOT Class 2.2



Source

Tetrafluoroethane is produced commercially by reacting hydrogen fluoride with Trichloroethylene.

distillation of the initial substances carbon tetrachloride and hydrofluoric acid.

Tetrafluoroethane can be manufactured by fractional

Applications

Tetrafluoroethane (R-134a) and its mixtures are used as refrigerants in commercial, automotive and domestic refrigeration. Its use in automotive refrigeration is restricted in some geographies due to its global warming potential (Kyoto Protocol).

Tetrafluoroethane is also used as reference medium in optical smoke detectors.

Tetrafluoroethane is employed in chemical extraction processes, liquid and supercritical, e.g. for fragrances.

Tetrafluoroethane is also employed as a propellant in aerosols and also as a blowing agent for polymers, e.g. extruded polystyrene foams.

Tetrafluoroethane is also used in cryogenic and astrophysics particle detectors.

Pharma grade tetrafluoroethane is used in Metered Dose aerosol Inhalers (MDI).

Tetrafluoroethane can be used as an alternative shielding gas in magnesium smelting.

Note:

Tetrafluoroethane is listed in the Kyoto Protocol, an international Framework Convention with the objective of reducing greenhouse gases.

Physical data

Molecular weight	102.03			
Boiling point	at 1.013 bar [°C]	-26	at 14.5 psi [°F]	-14.78
Density	at 1.013 bar, 15 °C [kg/m ³]	4.415	at 1 atm., 70 °F [lb/ft ³]	0.270
Vapour pressure	at 0 °C [bar]	2.92	at 32 °F [psi]	42.2
	at 20 °C [bar]	5.71	at 70 °F [psi]	85.7
Flammability range in air [% volume]	Non combustible			

Tetrafluoromethane CF_4

Carbon tetrafluoride, R-14

CAS: 75-73-0
EC: 200-896-5
UN: 1982
R-14

Purity grade	Typical purity	Typical impurities [ppm]								
		H_2O	$\text{O}_2 + \text{N}_2$	O_2	N_2	$\text{CO} + \text{CO}_2$	CO	CO_2	Other halocarbons	Acidity
Tetrafluoromethane 2.8	$\geq 99.8\%$	contact local team								
HiQ® Tetrafluoromethane 3.5	$\geq 99.95\%$	≤ 5	≤ 400	-	-	≤ 10	-	-	≤ 100	≤ 1
HiQ® Tetrafluoromethane 4.5	$\geq 99.995\%$	≤ 5	-	≤ 5	≤ 20	≤ 5	-	-	≤ 20	-
HiQ® Tetrafluoromethane 5.0	$\geq 99.999\%$	≤ 1	≤ 5	-	-	-	≤ 1	≤ 1	≤ 5	≤ 0.1

Typical filling pressure: 15 °C: 110 bar(g)/70 °F: 2,000 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•					

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
•	•		Consult local team

Characteristics

Colourless, odourless, compressed gas. Asphyxiant in high concentrations. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

Proposed by the Industry

Signal word: WARNING



H-statements:

Liquefied Gas → H280 – Contains gas under pressure; may explode if heated; EIGA-As – Asphyxiant in high concentrations.

Transport of dangerous goods



ADR Class 2, 2A



DOT Class 2, 2A



Source

Tetrafluoromethane may be obtained by the direct fluorination of carbon (burning carbon in a fluorine

atmosphere) or by an electrochemical process using acetic acid dissolved in liquid hydrogen fluoride.

Applications

Tetrafluoromethane (R-14) is used as a cryogenic fluid in low temperature refrigeration.

Tetrafluoromethane is used, either pure or in mixture with oxygen, as an etchant for silicon oxide, silicon nitride, refractory metals and metal silicides.

Tetrafluoromethane (R-14) is also used as:

- neutral, inert gas
- refrigerant
- heat transfer agent
- solvent
- propellant
- chemical intermediate.

Tetrafluoromethane is used in the electronics industry for plasma degreasing of multilayer printed circuit boards.

Tetrafluoromethane is used in the optical fibre production process.

Note:

Tetrafluoromethane is listed in the Kyoto Protocol, an international Framework Convention with the objective of reducing greenhouse gases.

Physical data

Molecular weight	88.005			
Boiling point	at 1.013 bar [°C]	-128.06	at 14.5 psi [°F]	-198.49
Density	at 1.013 bar, 15 °C [kg/m ³]	3.737	at 1 atm., 70 °F [lb/ft ³]	0.228
Vapour pressure	at 0 °C [bar]	-	at 32 °F [psi]	-
	at 20 °C [bar]	-	at 70 °F [psi]	-
Flammability range in air [% volume]	Non combustible			

Trichlorosilane SiHCl_3

TCS

CAS: 10025-78-2

EC: 233-042-5

UN: 1295

Purity grade	Typical purity	Typical impurities [ppm]			
		$\text{SiH}_3\text{Cl} + \text{SiH}_2\text{Cl}_2$	C	B	Fe
HiQ® Trichlorosilane 3.5	≥99.95 % – Resistivity >600 Ω/cm	≤50 ppm	≤5 ppm	≤0.06 ppb	≤5 ppb

Typical filling pressure: Filled as liquid

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•					

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
		•	Consult local team

Characteristics

Flammable. Colourless liquid with a sharp acidic odor. Highly corrosive in humid conditions. Vapour is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

GHS-CLP

Signal word: DANGER



H-statements:

H224 – Extremely flammable liquid and vapour; H250 – Catches fire spontaneously if exposed to air; EUH014 – Reacts violently with water; EUH029 – Contact with water liberates toxic gas; H331 – Toxic if inhaled; H302 – Harmful if swallowed; H314 – Causes severe skin burns and eye damage; EUH071 – Corrosive to the respiratory tract.

Transport of dangerous goods



ADR Class 4.3, WFC



DOT Class 4.3



Source

Trichlorosilane is commercially produced by reacting a ferrosilicon bed with hydrogen chloride at elevated temperature. Purification of trichlorosilane is usually achieved by distillation.

Trichlorosilane may also be obtained by a reaction of silicon, silicon tetrachloride and hydrogen.

Applications

Trichlorosilane is an intermediary material in the production of epitaxial wafers, polycrystalline silicon, silicone resin and organic chemical compounds.

Trichlorosilane is a precursor to organosilicon compounds, such as octadecyltrichlorosilane (OTS),

perfluorooctyltrichlorosilane (PFOTCS) and perfluorodecyltrichlorosilane (FDTS) used for coating processes in surface science and in nano-technology, e.g. for micro-electrochemical systems (MEMS) and in nanoimprint lithography (NIL).

Physical data

Molecular weight	135.45			
Boiling point	at 1.013 bar [°C]	31.9	at 14.5 psi [°F]	89.4
Density	at 1.013 bar, 15 °C [kg/m ³]	6.016	at 1 atm., 70 °F [lb/ft ³]	0.366
Vapour pressure	at 0 °C [bar]	0.29	at 32 °F [psi]	4.17
	at 20 °C [bar]	0.66	at 70 °F [psi]	9.92
Flammability range in air [% volume]	1.2 – 90.5			

Trifluoroethane $C_2H_3F_3$

1,1,1-Trifluoroethane, HFC-143a, R-143a

CAS: 420-46-2

EC: 206-996-5

UN: 2035

R-143a

Purity grade	Typical purity	Typical impurities [ppm]
Trifluoroethane	≥99.8 %	H ₂ O ≤50 ppm(w)

Typical filling pressure: 15 °C: 9.6 bar(g)/70 °F: 142 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•					

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
•	•		Consult local team

Characteristics

Flammable. Colourless liquefied gas with a sweetish smell and slight odour warning effect at low concentration. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

Proposed by the Industry

Signal word: DANGER



H-statements:

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

Transport of dangerous goods



ADR Class 2, 2F



DOT Class 2.1



Source

Many HCFCs and HFCs are manufactured via similar synthesis routes from common feedstocks. A common

synthesis route for trifluoroethane uses dichloroethylene, which is reacted with HF in the presence of a catalyst.

Applications

Trifluoroethane is used as a refrigerant gas. It is a hydrofluorocarbon (HFC) and is given the ASHRAE number R-143a. It is used either in pure form, or more commonly as a component of blended mixtures including R404A and R507A.

Note:

Trifluoroethane is listed in the Kyoto Protocol, an international framework convention with the objective of reducing greenhouse gases.

Physical data

Molecular weight	84.04			
Boiling point	at 1.013 bar [°C]	-47.4	at 14.5 psi [°F]	-53.3
Density	at 1.013 bar, 15 °C [kg/m ³]	3.564	at 1 atm., 60 °F [lb/ft ³]	0.2224
Vapour pressure	at 0 °C [bar]	6.2	at 32 °F [psi]	89.9
	at 20 °C [bar]	10.80	at 70 °F [psi]	156.7
Flammability range in air [% volume]		7.0 - 16.1		

Trifluoromethane CHF_3

Fluoroform, HFC-23, R-23

CAS: 75-46-7
EC: 200-872-4
UN: 1984
R-23

Purity grade	Typical purity	Typical impurities [ppm]					Acidity
		H_2O	$\text{O}_2 + \text{N}_2$	CO	CO_2	Other halocarbons	
Trifluoromethane 2.8	≥99.8 %	contact local team					
HiQ® Trifluoromethane 3.5	≥99.95 %	≤5	≤400	-	-	≤100	≤1 ppm(w)
HiQ® Trifluoromethane 4.8	≥99.998 %	≤1	≤5	≤1	≤10	≤5	≤0.1 ppm(w)
HiQ® Trifluoromethane 5.0	≥99.999 %	≤1	≤3	≤1	≤3	≤5	≤0.1 ppm(w)

Typical filling pressure: 15 °C: 40 bar(g)/70 °F: 611 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•					

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
•	•		Consult local team

Characteristics

Colourless, liquefied gas with an ethereal odour. Poor warning properties at low concentrations. Asphyxiant in high concentrations. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

Proposed by the Industry

Signal word: WARNING



H-statements:

Liquefied Gas → H280 – Contains gas under pressure; may explode if heated; EIGA-As – Asphyxiant in high concentrations.

Transport of dangerous goods



ADR Class 2, 2A



DOT Class 2.2



Source

Trifluoromethane is obtained as a by-product of generating chlorodifluoromethane. Alternatively, it may be produced

by reacting chloroform with hydrogen fluoride in the presence of a chromium catalyst.

Applications

Trifluoromethane (R-23) and its mixtures are used in low temperature refrigeration.

Trifluoromethane has been used as a fire suppressant.

Trifluoromethane is used in plasma etching of silicon oxide or nitride layers in the semiconductor industry.

Note:

Trifluoromethane is listed in the Kyoto Protocol, an international Framework Convention with the objective of reducing greenhouse gases.

Physical data

Molecular weight	70.014			
Boiling point	at 1.013 bar [°C]	-82.16	at 14.5 psi [°F]	-115.87
Density	at 1.013 bar, 15 °C [kg/m ³]	2.986	at 1 atm., 70 °F [lb/ft ³]	0.182
Vapour pressure	at 0 °C [bar]	24.94	at 32 °F [psi]	361.8
	at 20 °C [bar]	41.97	at 70 °F [psi]	625.6
Flammability range in air [% volume]	Non combustible			

Trimethylamine (CH₃)₃N

CAS: 75-50-3
EC: 200-875-0
UN: 1083

Purity grade Typical purity Typical impurities [ppm]

Trimethylamine 2.0	≥99 %	contact local team
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Typical filling pressure: 15 °C: 0.8 bar(g)/70 °F: 12.8 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•					

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
•	•		Consult local team

Characteristics

Flammable. Liquefied colourless gas with strong ammonia/fish-like odour. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

GHS-CLP

Signal word: DANGER



H-statements:

Liquefied Gas → H280 – Contains gas under pressure; may explode if heated; H220 – Extremely flammable gas; H332 – Harmful if inhaled; H335 – May cause respiratory irritation; H315 – Causes skin irritation; H318 – Causes serious eye damage.

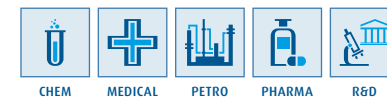
Transport of dangerous goods



ADR Class 2, 2F



DOT Class 2.1



Source

Trimethylamine is prepared commercially either by a reaction of methanol and ammonia or by a reaction of a carbonyl compound and ammonia. Mono-, di and

trimethylamine are formed in parallel in the same reaction. The three products are separated by distillation.

Applications

Trimethylamine is used in organic synthesis, in the manufacture of disinfectants, to prepare quaternary ammonium compounds, as a corrosion inhibitor, and in preparation of trimethylamine-borane addition compounds.

Trimethylamine is used in the chemical industry as an intermediate in the production of:

- insecticides
- wetting agents
- flotation agents
- disinfectants
- synthetic resins
- emulsifiers
- herbicides

Aqueous solutions containing 25% trimethylamine are employed in medical treatment as antihistamines.

Trimethylamine is used in manufacturing of:

- choline salts
- cationic starches
- intense sweeteners
- ion-exchange resins

Trimethylamine is used in the pharmaceutical industry for the preparation of active ingredients.

Physical data

Molecular weight	59.111			
Boiling point	at 1.013 bar [°C]	2.87	at 14.5 psi [°F]	37.19
Density	at 1.013 bar, 15 °C [kg/m ³]	2.59	at 1 atm., 70 °F [lb/ft ³]	0.158
Vapour pressure	at 0 °C [bar]	0.90	at 32 °F [psi]	13.04
	at 20 °C [bar]	1.83	at 70 °F [psi]	27.52
Flammability range in air [% volume]	2.0 – 11.6			

Xenon Xe

CAS: 7440-63-3
 EC: 231-172-7
 UN: 2036
 UN: 2591 (Refrigerated liquid)

Purity grade	Typical purity	Typical impurities [ppm]									
		H ₂ O	O ₂	C ₂ H ₆	CO + CO ₂	H ₂	N ₂	Ar	CF ₄	Kr	C ₂ F ₆
HiQ® Xenon 4.0	≥99.99 %	≤5	≤10	≤5	-	-	≤30	-	-	-	-
HiQ® Xenon 5.0	≥99.999 %	≤2	≤0.5	≤0.5	≤1	≤1	≤1	≤1	≤1	≤1	≤1

Typical filling pressure: 15 °C: 56 bar(g)/70 °F: 800 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•					

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
•	•		Consult local team

Characteristics

Colourless and odourless gas. Non-reactive. Inert. Asphyxiant in high concentrations. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

Proposed by the Industry

Signal word: WARNING



H-statements:

Liquefied Gas → H280 – Contains gas under pressure; may explode if heated; Refrigerated Gas → H281 – Contains refrigerated gas; may cause cryogenic burns or injury; EIGA-As – Asphyxiant in high concentrations.

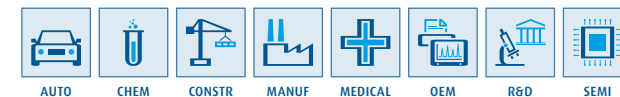
Transport of dangerous goods



ADR Class 2, 2A (Compressed)
3A (Refrigerated liquid)



DOT Class 2.2



Source

Xenon is obtained from air separation plants. In view of its very low natural concentration in air, it is only economically viable to recover xenon from larger plants. In these cases

a stream containing a mixture of crude xenon and krypton is extracted from the plant and processed in a separate purification and distillation system.

Applications

Xenon is used in some types of ion and excimer lasers. These are used for medical, semiconductor and industrial applications, and for research.

For neutron counters, a mixture with xenon and ¹⁰Bf₃ is used.

It is also used for x- and γ-ray counters.

The major application for xenon is in the lighting industry. Both sodium and mercury lamps, which are used extensively for outdoor lighting, such as on motorways and other roads, are filled with pure xenon. Xenon is also used for:

- incandescent lamps
- iodine lamps (car headlights)
- arc lights
- flash bulbs
- cinema projection lamps
- Klieg lights for filming (sunlight simulation)
- illumination of large areas, e.g. sports grounds
- space simulations lamps

Xenon is used in a broad range of research programmes.

Xenon-based chemical compounds (fluoride, trioxide, perxenate) serve as fluorinating and oxidising agents in certain specific applications.

Xenon is also used for mass spectrometer calibration.

Xenon isotopes are used as trace markers in MRI (Magnetic Resonance Imaging) scans.

Xenon can be used as a general anaesthetic.

When mixed with oxygen, xenon is used in CAT (Computed Axial Tomography) scanners for blood flow mapping.

Xenon has been used by both European as well as NASA spacecraft as rocket fuel for small ion thrusters to position satellites in orbit.

When mixed with methane, xenon is used as a fill gas for proportional counters and other types of radiation detectors (ionisation chambers, detection of radioactive iodine planted on the thyroid in the examination of tumours).

Xenon can be used as purging gas in the etching production steps in chip production instead of argon. Due to the high cost, a xenon recovery system is necessary.

Physical data

Molecular weight	131.29			
Boiling point	at 1.013 bar [°C]	-108.12	at 14.5 psi [°F]	-162.60
Density	at 1.013 bar, 15 °C [kg/m ³]	5.586	at 1 atm., 70 °F [lb/ft ³]	0.341
Vapour pressure	at 0 °C [bar]	41.37	at 32 °F [psi]	600
	at 20 °C [bar]	-	at 70 °F [psi]	-
Flammability range in air [% volume]	Non combustible			

40% Hydrogen, Balance Helium

40% H₂/Bal He

UN: 1954

Product specification

Concentration	Component	CAS Number	Formula
40%	Hydrogen	1333-74-0	H ₂
Balance Gas	Helium	7440-59-7	He

Impurities: Total Hydrocarbons < 5 ppm

Typical filling pressures: 15 °C: 150 or 200 bar(g)/70 °F: 2,000 or 2,800 psi(g)

Recommended Ancilliary Equipment

(For more information - [visit the HiQ website](#))

Pressure Control Valve	Type	Material	Distribution panel/manifold	Attachments
Cylinder Regulator	Two stage	Brass	Manual or automatic changeover	fitted with purge

Characteristics

Compressed gas mixture. Flammable, asphyxiant. Odourless and colourless. Lighter than air.

Category: Instrument mixture

Applications of this gas mixture

HiQ 40% hydrogen in helium is typically used as a fuel gas for flame ionisation detectors (FID). These detectors are often used in gas chromatography for measuring hydrocarbons present in a sample and therefore the gases used must have minimum hydrocarbon impurities.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

Reg. 1272/2008 (CLP)

Signal word: DANGER



H-statements:

Compressed Gas → H280 – Contains gas under pressure; may explode if heated; H220 – Extremely flammable gas.



PHARMA R&D

Transport of dangerous goods



ADR Class 2, 1F



DOT Class 2.1

10% Methane, Balance Argon

10% CH₄/Bal Ar

P10 mixture

UN: 1954

Product specification

Concentration	Component	CAS Number	Formula
10%	Methane	74-82-8	CH ₄
Balance Gas	Argon	7440-37-1	Ar

Typical filling pressure: 15 °C: 150 or 200 bar(g)/70 °F: 2,000 or 2,800 psi(g)

Recommended Ancilliary Equipment

(For more information - [visit the HiQ website](#))

Pressure Control Valve	Type	Material	Distribution panel/manifold	Attachments
Cylinder Regulator	Two stage	Brass	Manual or automatic changeover	fitted with purge

Characteristics

Compressed gas mixture. Flammable, asphyxiant. Odourless and colourless. Heavier than air.

Category: Instrument mixture

Applications of this gas mixture

10% methane in argon (P10 gas mixture) is typically used:

- as carrier gas in nuclear counter instruments to check radioactivity for environmental and/or other specific purposes
 - in the detectors of X-ray fluorescence spectroscopy, which is widely used in mining, metallurgy, cement production, ceramic & glass manufacturing, petroleum industry, geological and environmental studies.
- Gas flow proportional detectors typically use the P 10 gas mixture.



PETRO PHARMA R&D SEMI

Transport of dangerous goods



ADR Class 2, 1F



DOT Class 2.1

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

Reg. 1272/2008 (CLP)

Signal word: DANGER



H-statements:

Compressed Gas → H280 – Contains gas under pressure; may explode if heated; H220 – Extremely flammable gas.

5% Methane, Balance Argon

5% CH₄/Bal Ar

P5 mixture

UN: 1954

Product specification

Concentration	Component	CAS Number	Formula
5%	Methane	74-82-8	CH ₄
Balance Gas	Argon	7440-37-1	Ar

Typical filling pressure: 15 °C: 150 or 200 bar(g)/70 °F: 2,000 or 2,800 psi(g)

Recommended Ancilliary Equipment

(For more information - [visit the HiQ website](#))

Pressure Control Valve	Type	Material	Distribution panel/manifold	Attachments
Cylinder Regulator	Two stage	Brass	Manual or automatic changeover	fitted with purge

Characteristics

Compressed gas mixture. Flammable, asphyxiant. Odourless and colourless. Heavier than air.

Category: Instrument mixture

Applications of this gas mixture

5% methane in argon (P 5 gas mixture) is typically used as:

- a carrier gas for proportional counter to measure particles of ionizing radiation. The particles can originate from diverse sources such as smoke, ash, dust, oil, metals or biological contaminants, for example mould or micro-organisms
- special gas mixtures for filling Geiger-Müller counters to allow nuclear radiation to be measured
- make up gas in electron capture detector for gas chromatography, which has high sensitivity for the specific detection of halogenated compounds with a detection limit in the sub-ppb range
- filling gas for ionisation chamber

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

Reg. 1272/2008 (CLP)

Signal word: DANGER



H-statements:

Compressed Gas → H280 – Contains gas under pressure; may explode if heated; H220 – Extremely flammable gas.



Transport of dangerous goods



ADR Class 2, 1F



DOT Class 2.1

1% Oxygen, Balance Nitrogen

1% O₂/Bal N₂

UN: 1956

Product specification

Concentration	Component	CAS Number	Formula
1%	Oxygen	7782-44-7	O ₂
Balance Gas	Nitrogen	7727-37-9	N ₂

Typical filling pressure: 15 °C: 150 or 200 bar(g)/70 °F: 2,000 or 2,800 psi(g)

Recommended Ancilliary Equipment

(For more information - [visit the HiQ website](#))

Pressure Control Valve	Type	Material	Distribution panel/manifold	Attachments
Cylinder Regulator	Single stage	Brass	Manual or automatic changeover	fitted with purge

Characteristics

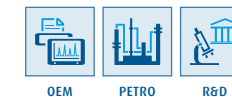
Compressed gas mixture. Asphyxiant. Odourless and colourless. Slightly lighter than air. Contains oxygen.

Category: Environmental mixture

Applications of this gas mixture

1% oxygen in nitrogen is typically used as:

- an environmental monitoring gas mixture
- calibration gas mixture in smoke stack exhaust control at industrial & power generation facilities
- span gas for calibration and bump testing of gas detection equipment
- is defined as a US EPA(United States Environmental Protection Agency) protocol gas standard



Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

Reg. 1272/2008 (CLP)

Signal word: WARNING



H-statements:

Compressed Gas → H280 – Contains gas under pressure; may explode if heated.

Transport of dangerous goods



ADR Class 2, 1A



DOT Class 2.2

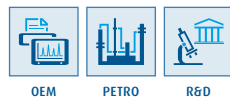
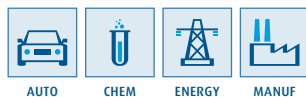
20 ppm Carbon Monoxide, Balance Air

20 ppm CO/Bal Air

UN: 1956

Product specification

Concentration	Component	CAS Number	Formula
20 ppm	Carbon Monoxide	630-08-0	CO
Balance Gas	Synthetic Air	132259-10-0	Air



Typical filling pressure: 15 °C: 150 or 200 bar(g)/70 °F: 2,000 or 2,800 psi(g)

Recommended Ancilliary Equipment

(For more information - [visit the HiQ website](#))

Pressure Control Valve	Type	Material	Distribution panel/manifold	Attachments
Cylinder Regulator	Single stage	Stainless Steel	Manual or automatic changeover	fitted with purge

Characteristics

Compressed gas mixture. Odourless and colourless. Contains carbon monoxide.

Category: Environmental mixture

Applications of this gas mixture

20 ppm carbon monoxide in air is typically used as:

- an environmental monitoring gas mixture
- calibration gas mixture in smoke stack exhaust control at industrial & power generation facilities
- span gas for calibration and bump testing of gas detection equipment
- is defined as a US EPA(United States Environmental Protection Agency) protocol gas standard

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

Reg. 1272/2008 (CLP)

Signal word: WARNING



H-statements:

Compressed Gas → H280 – Contains gas under pressure; may explode if heated.

Transport of dangerous goods



ADR Class 2, 1A



DOT Class 2.2

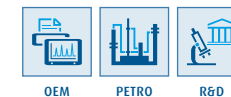
450 ppb Nitric Oxide, Balance Nitrogen

450 ppb NO/Bal N₂

UN: 1956

Product specification

Concentration	Component	CAS Number	Formula
450 ppb	Nitric Oxide	10102-43-9	NO
Balance Gas	Nitrogen	7727-37-9	N ₂



Typical filling pressure: 15 °C: 150 or 200 bar(g)/70 °F: 2,000 or 2,800 psi(g)

Recommended Ancilliary Equipment

(For more information - [visit the HiQ website](#))

Pressure Control Valve	Type	Material	Distribution panel/manifold	Attachments
Cylinder Regulator	Single stage	Stainless Steel	Manual or automatic changeover	fitted with purge

Characteristics

Compressed gas mixture. Asphyxiant. Odourless and colourless. Slightly lighter than air. Contains nitric oxide.

Category: Environmental mixture

Applications of this gas mixture

450 ppb nitric oxide in nitrogen is an ambient air monitoring standard mixture.

It is recognised that even very low levels of certain pollutants in ambient air pose a long term risk to public health

The composition of the air is monitored by state or local government authorities to determine the health and safety risks for the surrounding area. Often, a network of measurement points is used to monitor a large area. Such a network can also be used to derive possible sources of pollution, such as nitric oxide 450 ppb nitric oxide in nitrogen is one of the standard calibration gases used to calibrate these network analysers at regular intervals.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

Reg. 1272/2008 (CLP)

Signal word: WARNING



H-statements:

Compressed Gas → H280 – Contains gas under pressure; may explode if heated.

Transport of dangerous goods



ADR Class 2, 1A



DOT Class 2.2

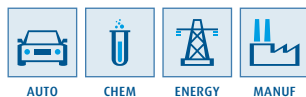
450 ppb Nitrogen Dioxide, Balance Air

450 ppb NO₂/Bal Air

UN: 1956

Product specification

Concentration	Component	CAS Number	Formula
450 ppb	Nitrogen Dioxide	10102-44-0	NO ₂
Balance Gas	Synthetic Air	132259-10-0	Air

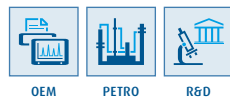


Typical filling pressure: 15 °C: 150 or 200 bar(g)/70 °F: 2,000 or 2,800 psi(g)

Recommended Ancilliary Equipment

(For more information - [visit the HiQ website](#))

Pressure Control Valve	Type	Material	Distribution panel/manifold	Attachments
Cylinder Regulator	Single stage	Stainless Steel	Manual or automatic changeover	fitted with purge



Characteristics

Compressed gas mixture. Odourless and colourless. Contains nitrogen dioxide.

Category: Environmental mixture

Applications of this gas mixture

450 ppb nitrogen dioxide, balance air is an ambient air monitoring standard mixture.

It is recognised that even very low levels of certain pollutants in ambient air pose a long term risk to public health

The composition of the air is monitored by state or local government authorities to determine the health and safety risks for the surrounding area. Often, a network of measurement points is used to monitor a large area. Such a network can also be used to derive possible sources of pollution, such as nitric oxide 450 ppb nitrogen dioxide, balance air is one of the standard calibration gases used to calibrate these network analysers at regular intervals.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

Reg. 1272/2008 (CLP)

Signal word: WARNING



H-statements:

Compressed Gas → H280 – Contains gas under pressure; may explode if heated.

Transport of dangerous goods



ADR Class 2, 1A



DOT Class 2.2

450 ppb Sulfur Dioxide, Balance Air

450 ppb SO₂/Bal Air

UN: 1956

Product specification

Concentration	Component	CAS Number	Formula
450 ppb	Sulfur Dioxide	7446-09-5	SO ₂
Balance Gas	Synthetic Air	132259-10-0	Air

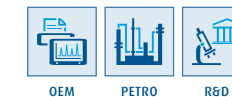


Typical filling pressure: 15 °C: 150 or 200 bar(g)/70 °F: 2,000 or 2,800 psi(g)

Recommended Ancilliary Equipment

(For more information - [visit the HiQ website](#))

Pressure Control Valve	Type	Material	Distribution panel/manifold	Attachments
Cylinder Regulator	Single stage	Stainless Steel	Manual or automatic changeover	fitted with purge



Characteristics

Compressed gas mixture. Odourless and colourless. Contains sulfur dioxide.

Category: Environmental mixture

Applications of this gas mixture

450 ppb sulfur dioxide, balance air is an ambient air monitoring standard mixture.

It is recognised that even very low levels of certain pollutants in ambient air pose a long term risk to public health

The composition of the air is monitored by state or local government authorities to determine the health and safety risks for the surrounding area. Often, a network of measurement points is used to monitor a large area. Such a network can also be used to derive possible sources of pollution, such as nitric oxide 450 ppb sulfur dioxide, balance air is one of the standard calibration gases used to calibrate these network analysers at regular intervals.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

Reg. 1272/2008 (CLP)

Signal word: WARNING



H-statements:

Compressed Gas → H280 – Contains gas under pressure; may explode if heated.

Transport of dangerous goods



ADR Class 2, 1A



DOT Class 2.2

90 ppm Methane, Balance Nitrogen

90 ppm CH₄/Bal N₂

UN: 1956

Product specification

Concentration	Component	CAS Number	Formula
90 ppm	Methane	74-82-8	CH ₄
Balance Gas	Nitrogen	7727-37-9	N ₂

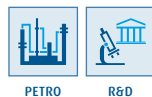


Typical filling pressure: 15 °C: 150 or 200 bar(g)/70 °F: 2,000 or 2,800 psi(g)

Recommended Ancilliary Equipment

(For more information - [visit the HiQ website](#))

Pressure Control Valve	Type	Material	Distribution panel/manifold	Attachments
Cylinder Regulator	Single stage	Brass	Manual or automatic changeover	fitted with purge



Characteristics

Compressed gas mixture. Asphyxiant. Odourless and colourless. Slightly lighter than air. Contains methane.

Category: Environmental mixture

Applications of this gas mixture

90 ppm methane, balance nitrogen is typically used as:

- an environmental monitoring gas mixture
- calibration gas mixture in smoke stack exhaust control at industrial & power generation facilities
- span gas for calibration and bump testing of gas detection equipment
- is defined as a US EPA(United States Environmental Protection Agency) protocol gas standard

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

Reg. 1272/2008 (CLP)

Signal word: WARNING



H-statements:

Compressed Gas → H280 – Contains gas under pressure; may explode if heated.

Transport of dangerous goods



ADR Class 2, 1A



DOT Class 2.2

5 ppm Ammonia, Balance Nitrogen

5 ppm NH₃/Bal N₂

UN: 1956

Product specification

Concentration	Component	CAS Number	Formula
5 ppm	Ammonia	7664-41-7	NH ₃
Balance Gas	Nitrogen	7727-37-9	N ₂

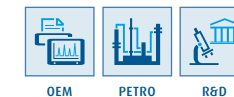


Typical filling pressure: 15 °C: 150 or 200 bar(g)/70 °F: 2,000 or 2,800 psi(g)

Recommended Ancilliary Equipment

(For more information - [visit the HiQ website](#))

Pressure Control Valve	Type	Material	Distribution panel/manifold	Attachments
Cylinder Regulator	Single stage	Stainless Steel	Manual or automatic changeover	fitted with purge



Characteristics

Compressed gas mixture. Asphyxiant. Colourless with very pungent odour. Slightly lighter than air. Contains ammonia.

Category: Environmental mixture

Applications of this gas mixture

5 ppm ammonia in nitrogen is typically used as:

- a calibration gas mixture in the automotive emissions testing and engine development industry. Euro 6 legislation that came into force on 1 Sept 2014 requires all cars sold in Europe to comply with strict emissions regulations. Euro 6 introduces ammonia as a new emissions testing chemical species. This move was prompted by rising ammonia emissions from newer cars fitted with Selective Catalytic Reduction (SCR) technology

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

Reg. 1272/2008 (CLP)

Signal word: WARNING



H-statements:

Compressed Gas → H280 – Contains gas under pressure; may explode if heated.

Transport of dangerous goods



ADR Class 2, 1A



DOT Class 2.2

5 µg/m³ Mercury, Balance Nitrogen

5 µg/m³ Hg/Bal N₂

UN: 1956

Product specification

Concentration	Component	CAS Number	Formula
5 µg/m ³	Mercury	7439-97-6	Hg
Balance Gas	Nitrogen	7727-37-9	N ₂

5 µg/m³ Hg equates to 0.6 ppb Hg

Typical filling pressure: 15 °C: 150 or 200 bar(g)/70 °F: 2,000 or 2,800 psi(g)

Recommended Ancillary Equipment

(For more information - [visit the HiQ website](#))

Pressure Control Valve	Type	Material	Distribution panel/manifold	Attachments
Cylinder Regulator	Single stage	Stainless Steel	Manual or automatic changeover	fitted with purge

Characteristics

Compressed gas mixture. Asphyxiant. Odourless and colourless. Slightly lighter than air. Contains mercury.

Category: Environmental mixture

Applications of this gas mixture

5 µg/m³ mercury in nitrogen is typically used:

- as calibration gas mixture, where the mercury is present in the metallic state, Hg₀, for monitoring and detecting mercury emissions from power generation plants
- to calibrate regularly the analytical instruments such as atomic absorption spectrometers (AAS) and inductively coupled plasma (ICP) mass spectrometers to ensure the analysis accuracy. The AAS is generally used to determine the mercury content of raw natural gas coming into a facility from the oil and gas fields. The instrument also plays a key role in natural gas processing, to ensure that mercury has been successfully removed before the gas enters the compression train

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

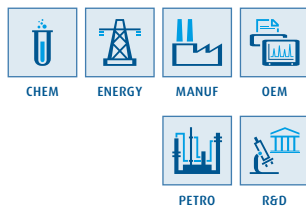
Reg. 1272/2008 (CLP)

Signal word: WARNING



H-statements:

Compressed Gas → H280 – Contains gas under pressure; may explode if heated.



Transport of dangerous goods



ADR Class 2, 1A



DOT Class 2.2

10 ppm Hydrogen Sulphide, Balance Nitrogen

10 ppm H₂S/Bal N₂

UN: 1956

Product specification

Concentration	Component	CAS Number	Formula
10 ppm	Hydrogen Sulfide	7783-06-4	H ₂ S
Balance Gas	Nitrogen	7727-37-9	N ₂

Typical filling pressure: 15 °C: 150 or 200 bar(g)/70 °F: 2,000 or 2,800 psi(g)

Recommended Ancillary Equipment

(For more information - [visit the HiQ website](#))

Pressure Control Valve	Type	Material	Distribution panel/manifold	Attachments
Cylinder Regulator	Single stage	Stainless Steel	Manual or automatic changeover	fitted with purge

Characteristics

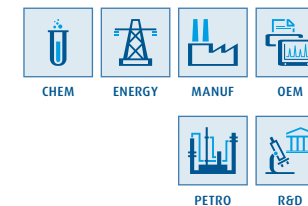
Compressed gas mixture. Asphyxiant. Colourless with very strong odour of rotten eggs. Slightly lighter than air. Contains hydrogen sulphide.

Category: Environmental mixture

Applications of this gas mixture

10 ppm hydrogen sulfide in nitrogen is typically used to calibrate the fixed and portable gas detection equipment to monitor and safeguard the workplace 10 ppm hydrogen sulfide is 50% of the maximum limit value for exposure in general industry, and therefore a typical point in the linear area of testing the detection devices.

Calibration gas mixture for stack emissions monitoring.



Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

Reg. 1272/2008 (CLP)

Signal word: WARNING



H-statements:

Compressed Gas → H280 – Contains gas under pressure; may explode if heated.

Transport of dangerous goods



ADR Class 2, 1A



DOT Class 2.2

1.1% Propane, Balance Air

1.1% C₃H₈/Bal Air

UN: 1956

Product specification

Concentration	Component	CAS Number	Formula
1.1%	Propane	74-98-6	C ₃ H ₈
Balance Gas	Synthetic Air	132259-10-0	Air

Typical filling pressure: 15 °C: 150 bar(g)/70 °F: 2,000 psi(g)

Recommended Ancilliary Equipment

(For more information - [visit the HiQ website](#))

Pressure Control Valve	Type	Material	Distribution panel/manifold	Attachments
Cylinder Regulator	Single stage	Brass	Manual or automatic changeover	fitted with purge

Characteristics

Compressed gas mixture. Odourless and colourless. Contains propane.

Category: Workplace detector mixture

Applications of this gas mixture

1.1% propane in air (50% LEL) is typically used:

- for the application of explosimetry, which means the measurement of flammable or explosive conditions. Both above ground in petrochemical and natural gas processing and below ground in a wide range of mining activities, the risks of flammable and explosive gas leaks building up to dangerous levels are mitigated by detection of these flammable or explosive gases at levels below the LEL (Lower Explosive Limit). 1.1% propane in air is 50% of its LEL and can ensure an "early warning" system is in place
- to calibrate the portable gas detection equipment in workplace

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

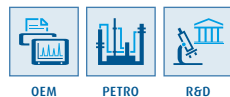
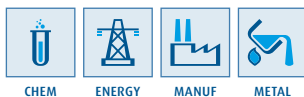
Reg. 1272/2008 (CLP)

Signal word: WARNING



H-statements:

Compressed Gas → H280 – Contains gas under pressure; may explode if heated.



Transport of dangerous goods



ADR Class 2, 1A



DOT Class 2.2

2.5% Methane, Balance Air

2.5% CH₄/Bal Air

UN: 1956

Product specification

Concentration	Component	CAS Number	Formula
2.5%	Methane	74-82-8	CH ₄
Balance Gas	Synthetic Air	132259-10-0	Air

Typical filling pressure: 15 °C: 150 bar(g)/70 °F: 2,000 psi(g)

Recommended Ancilliary Equipment

(For more information - [visit the HiQ website](#))

Pressure Control Valve	Type	Material	Distribution panel/manifold	Attachments
Cylinder Regulator	Single stage	Brass	Manual or automatic changeover	fitted with purge

Characteristics

Compressed gas mixture. Odourless and colourless. Contains methane.

Category: Workplace detector mixture

Applications of this gas mixture

2.5% methane in air (50% LEL) is typically used:

- for the application of explosimetry, which means the measurement of flammable or explosive conditions. Both above ground in petrochemical and natural gas processing and below ground in a wide range of mining activities, the risks of flammable and explosive gas leaks building up to dangerous levels are mitigated by detection of these flammable or explosive gases at levels below the LEL (Lower Explosive Limit). 2.5% propane in air is 50% of its LEL and can ensure an "early warning" system is in place
- to calibrate the portable gas detection equipment in workplace

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

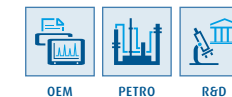
Reg. 1272/2008 (CLP)

Signal word: WARNING



H-statements:

Compressed Gas → H280 – Contains gas under pressure; may explode if heated.



Transport of dangerous goods



ADR Class 2, 1A



DOT Class 2.2

2% Hydrogen, Balance Air

2% H₂/Bal Air

UN: 1956

Product specification

Concentration	Component	CAS Number	Formula
2%	Hydrogen	1333-06-4	H ₂
Balance Gas	Synthetic Air	132259-10-0	Air

Typical filling pressure: 15 °C: 150 bar(g)/70 °F: 2,000 psi(g)

Recommended Ancillary Equipment

(For more information - [visit the HiQ website](#))

Pressure Control Valve	Type	Material	Distribution panel/manifold	Attachments
Cylinder Regulator	Single stage	Brass	Manual or automatic changeover	fitted with purge

Characteristics

Compressed gas mixture. Odourless and colourless. Contains hydrogen.

Category: Workplace detector mixture

Applications of this gas mixture

2% hydrogen in air (50% LEL) is typically used:

- for the application of explosimetry, which means the measurement of flammable or explosive conditions. Both above ground in petrochemical and natural gas processing and below ground in a wide range of mining activities, the risks of flammable and explosive gas leaks building up to dangerous levels are mitigated by detection of these flammable or explosive gases at levels below the LEL (Lower Explosive Limit). 2% hydrogen in air is 50% of its LEL and can ensure an "early warning" system is in place
- to calibrate the portable gas detection equipment in workplace

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

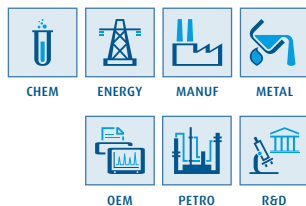
Reg. 1272/2008 (CLP)

Signal word: WARNING



H-statements:

Compressed Gas → H280 – Contains gas under pressure; may explode if heated.



3.4% Carbon Dioxide, 15.6% Nitrogen, Balance Helium

3.4% CO₂/15.6% N₂/Bal He

UN: 1956

Product specification

Concentration	Component	CAS Number	Formula
3.4%	Carbon Dioxide	124-38-9	CO ₂
15.6%	Nitrogen	7727-37-9	N ₂
Balance Gas	Helium	7440-59-7	He

Typical filling pressure: 15 °C: 150 or 200 bar(g)/70 °F: 2,000 or 2,800 psi(g)

Recommended Ancillary Equipment

(For more information - [visit the HiQ website](#))

Pressure Control Valve	Type	Material	Distribution panel/manifold	Attachments
Cylinder Regulator	Contact Linde	Contact Linde	Manual or automatic changeover	fitted with purge

Characteristics

Compressed gas mixture. Asphyxiant. Odourless and colourless. Lighter than air. Contains carbon dioxide.

Category: Laser mixture

Applications of this gas mixture

3.4% carbon dioxide and 15.6% nitrogen in helium is typically used in lasers for laser cutting. Lasers using this gas mixture are very suitable for cutting through thin materials such as the mild and stainless steels used in the automotive and food industry, but are also suitable for cutting through other metals such as aluminium and titanium used in the aerospace manufacturing process. These lasers emit laser light when excited by an electrical or radio-frequency (RF) discharge through the gases mixture. The light is produced by the carbon dioxide, while the other gas components are needed to optimize the efficiency of the transfer of electrical or RF energy into laser light.

Transport of dangerous goods



ADR Class 2, 1A



DOT Class 2.2

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

Reg. 1272/2008 (CLP)

Signal word: WARNING



H-statements:

Compressed Gas → H280 – Contains gas under pressure; may explode if heated.

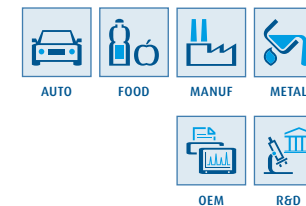
Transport of dangerous goods



ADR Class 2, 1A



DOT Class 2.2



5% Fluorine, Balance Helium

5% Fluorine/Bal He

UN: 3306

Product specification

Concentration	Component	CAS Number	Formula
5%	Fluorine	7782-41-4	F ₂
Balance Gas	Helium	7440-59-7	He



Typical filling pressure: 15 °C: 150 or 200 bar(g)/70 °F: 2,000 or 2,800 psi(g)

Recommended Ancillary Equipment

(For more information - [visit the HiQ website](#))

Pressure Control Valve	Type	Material	Distribution panel/manifold	Attachments
Cylinder Regulator	Contact Linde	Contact Linde	Manual or automatic changeover	Contact Linde

Characteristics

Compressed gas mixture. Toxic, corrosive and oxidiser. Pale yellow with pungent irritating odour. Lighter than air. Contains fluorine.

Category: Laser mixture

Applications of this gas mixture

5 % fluorine in helium is a standard halogen Excimer laser gas mixture. Excimer lasers are typically used:

- in Deep Ultra Violet (DUV) lithography, micromachining, annealing cleaning, marking, drilling and etching in electronics industry
- to manufacture mobile phone displays and drill microscopic holes in the nozzles of inkjet printers
- in Laser Photo Refractive Keratectomy (PRK) & Laser Angioplasty in medical areas

In eye surgery for vision correction, excimer lasers can produce radiation which has the ability to break inter-molecular bonds within the corneal tissue of the eye to permanently improve the patient's vision.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

Reg. 1272/2008 (CLP)

Signal word: DANGER



H-statements:

Compressed Gas → H280 – Contains gas under pressure; may explode if heated; H270 – May cause or intensify fire; oxidizer; H314 – Causes severe skin burns and eye damage; H331 – Toxic if inhaled.

Transport of dangerous goods



ADR Class 2, 1TOC



DOT Class 2.3

0.25% Carbon Monoxide, 18% Helium, 21% Oxygen, Balance Nitrogen

0.25% CO/18% He/21% O₂/Bal N₂

UN: 1956

Product specification

Concentration	Component	CAS Number	Formula
0.25%	Carbon Monoxide	630-08-0	CO
18%	Helium	7440-59-7	He
21%	Oxygen	10024-97-2	O ₂
Balance Gas	Nitrogen	7727-37-9	N ₂



Typical filling pressure: 15 °C: 150 or 200 bar(g)/70 °F: 2,000 or 2,800 psi(g)

Recommended Ancillary Equipment

(For more information - [visit the HiQ website](#))

Pressure Control Valve	Type	Material	Distribution panel/manifold	Attachments
Cylinder Regulator	Single stage	Brass	Manual or automatic changeover	fitted with purge

Characteristics

Compressed gas mixture. Odourless and colourless. Lighter than air. Contains carbon monoxide.

Category: Lung function mixture

Applications of this gas mixture

0.25% carbon monoxide and 18% helium and 21% oxygen in nitrogen is a typical lung function test gas. The pulmonary or lung function tests measure how well the lungs take in air and how well they transport gases such as oxygen from the atmosphere into the body's circulation. The amount of carbon monoxide in the exhaled air is measured and indicates the lung functionality, while helium helps to determine the lung volume. Since patients' health and condition often depend on the accuracy of these readings, this highly specialised gas mixture is also used to calibrate the equipment on a regular basis.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

Reg. 1272/2008 (CLP)

Signal word: WARNING



H-statements:

Compressed Gas → H280 – Contains gas under pressure; may explode if heated.

Transport of dangerous goods



ADR Class 2, 1A



DOT Class 2.2

10% Carbon Dioxide, 10% Hydrogen, Balance Nitrogen

10% CO₂/10% H₂/Bal N₂

UN: 1954

Product specification

Concentration	Component	CAS Number	Formula
10%	Carbon Dioxide	124-38-9	CO ₂
10%	Hydrogen	1333-06-4	H ₂
Balance Gas	Nitrogen	7727-37-9	N ₂



Typical filling pressure: 15 °C: 150 or 200 bar(g)/70 °F: 2,000 or 2,800 psi(g)

Recommended Ancillary Equipment

(For more information - [visit the HiQ website](#))

Pressure Control Valve	Type	Material	Distribution panel/manifold	Attachments
Cylinder Regulator	Single stage	Brass	Manual or automatic changeover	fitted with purge

Characteristics

Compressed gas mixture. Flammable, asphyxiant. Odourless and colourless. Lighter than air. Contains carbon dioxide.

Category: Anaerobic mixture

Applications of this gas mixture

10% carbon dioxide and 10% hydrogen in nitrogen is typically used in biological growth control, such as anaerobic incubation, in life science industry & pharmaceutical industry. Incubators are used to maintain the integrity of body parts and tissue destined for transplants and for growing certain cultures to create an anaerobic or anaerobic cell growth environment. When anaerobe organisms are cultivated, the atmospheres are based on nitrogen or carbon dioxide. This gas mixture also has a carbon source for maximizing the growth.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

Reg. 1272/2008 (CLP)

Signal word: DANGER



H-statements:

Compressed Gas → H280 – Contains gas under pressure; may explode if heated; H220 – Extremely flammable gas.

Transport of dangerous goods



ADR Class 2, 1F



DOT Class 2.1

5% Carbon Dioxide, Balance Oxygen

5% CO₂/Bal O₂

UN: 3156

Product specification

Concentration	Component	CAS Number	Formula
5%	Carbon Dioxide	124-38-9	CO ₂
Balance Gas	Oxygen	7782-44-7	O ₂



Typical filling pressure: 15 °C: 150 or 200 bar(g)/70 °F: 2,000 or 2,800 psi(g)

Recommended Ancillary Equipment

(For more information - [visit the HiQ website](#))

Pressure Control Valve	Type	Material	Distribution panel/manifold	Attachments
Cylinder Regulator	Single stage	Brass	Manual or automatic changeover	fitted with purge

Characteristics

Compressed gas mixture. Colourless and odourless. Toxic for reproduction. Oxidising. Lighter than air. Contains carbon monoxide.

Category: Aerobic mixture

Applications of this gas mixture

5% carbon dioxide in oxygen is typically used in biological growth control, such as aerobic incubation, in life science industry & pharmaceutical industry. In modern biotechnology, the cultivation of bacteria's is a common practice. In order to do this, it is important to have a controlled atmosphere that supports the process. When growing aerobic organisms the ambient atmosphere is based on oxygen or air. The 5% carbon dioxide provides a carbon source for maximizing the growth.

Aerobic mixtures are also often mixtures containing three components; carbon dioxide, oxygen and nitrogen. One important application for this three component aerobic mixture is as an atmosphere for embryonic cultivation for In Vitro Fertilisation (IVF) treatment. A 5% Oxygen, 6% Carbon Dioxide, Balance Nitrogen mixture is typically used for this application

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

Reg. 1272/2008 (CLP)

Signal word: DANGER



H-statements:

Compressed Gas → H280 – Contains gas under pressure; may explode if heated; H270 – May cause or intensify fire; oxidizer.

Transport of dangerous goods



ADR Class 2, 10 (compressed)



DOT Class 2.2

40% Hydrogen, Balance Nitrogen

40% H₂/Bal N₂

UN: 1954

Product specification

Concentration	Component	CAS Number	Formula
40%	Hydrogen	1333-06-4	H ₂
Balance Gas	Nitrogen	7727-37-9	N ₂

Typical filling pressure: 15 °C: 150 or 200 bar(g)/70 °F: 2,000 or 2,800 psi(g)

Recommended Ancilliary Equipment

(For more information - [visit the HiQ website](#))

Pressure Control Valve	Type	Material	Distribution panel/manifold	Attachments
Cylinder Regulator	Two stage	Brass	Manual or automatic changeover	fitted with purge

Characteristics

Compressed gas mixture. Flammable, asphyxiant. Odourless and colourless. Lighter than air.

Category: Forming gas mixture

Applications of this gas mixture

HiQ 40% hydrogen in nitrogen is typically used as:

- as a forming gas in metal heat treatment processes where a hydrogen atmosphere is necessary to achieve certain metal properties (annealing) or surface finishes
- it is also used as a fuel gas for flame ionisation detectors (FID) as an alternative method of delivering hydrogen to the FID flame than using pure hydrogen

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

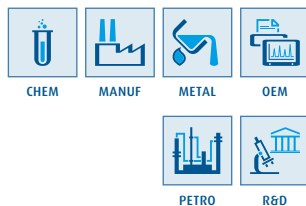
Reg. 1272/2008 (CLP)

Signal word: DANGER



H-statements:

Compressed Gas → H280 – Contains gas under pressure; may explode if heated; H220 – Extremely flammable gas.



Multi-component Hydrocarbon Mixture, Balance Methane

Natural Gas Mixture

UN: 1954

Product specification

Concentration	Component	CAS Number	Formula
0.2%	Carbon Dioxide	124-38-9	CO ₂
1.0%	Nitrogen	7727-37-9	N ₂
7.0%	ethane	74-84-0	C ₂ H ₆
1.5%	propane	74-98-6	C ₃ H ₈
0.25%	iso-Butane	75-28-5	i-C ₄ H ₁₀
0.35%	n-Butane	106-97-8	n-C ₄ H ₁₀
0.05%	iso-Pentane	78-78-4	i-C ₅ H ₁₂
0.05%	n-Pentane	109-66-0	n-C ₅ H ₁₂
0.05%	neo-Pentane	463-82-1	neo-C ₅ H ₁₂
0.05%	n-hexane	110-54-3	n-C ₆ H ₁₄
89.50%	Methane	74-82-8	CH ₄

Typical filling pressure: 15 C: 75 bar(g)/70 F 1200 psi(g)

Recommended Ancilliary Equipment

(For more information - [visit the HiQ website](#))

Pressure Control Valve	Type	Material	Distribution panel/manifold	Attachments
Cylinder Regulator	Two stage	Stainless Steel	Manual or automatic changeover	fitted with purge

Characteristics

Compressed gas mixture. Flammable, asphyxiant. Odourless and colourless. Lighter than air. Contains methane. Mixture could be subject to condensation and composition change if used at temperatures below manufacturers recommendation.

Category: Natural gas mixture

Applications of this gas mixture

This type of hydrocarbon gas mixture is used to calibrate analytical instruments which measure the composition of typically natural gas in a pipeline or in a liquified natural gas (LNG) application. Knowing the composition of the natural gas allows the energy content to be calculated, typically expressed as the Wobbe number or calorific value of the gas and this allows the monetary value of the gas to be calculated for commercial or fiscal purposes. For commercial or fiscal applications, these hydrocarbon mixtures are often produced as accredited mixtures conforming to ISO standards such as ISO 17025.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

Reg. 1272/2008 (CLP)

Signal word: DANGER



H-statements:

Compressed Gas → H280 – Contains gas under pressure; may explode if heated; H220 – Extremely flammable gas.

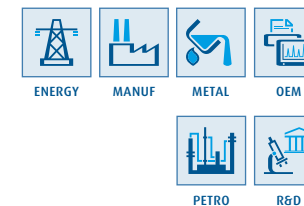
Transport of dangerous goods



ADR Class 2, 1F



DOT Class 2.1



Transport of dangerous goods



ADR Class 2, 1F



DOT Class 2.1

Appendix 01 - Material compatibility

Terms and definitions:

A = acceptable: material/gas combination that is safe under normal conditions of use

N = not acceptable: material/single gas combination that is not safe under all normal conditions of use

Blank space = There is no data provided in ISO 11114-1:2012 and ISO 11114-2:2013

Metallic materials (ISO 11114-1:2012):

AA = Aluminium alloys

Cu = Copper

SS = Austenitic type stainless steels

Ni = Nickel alloys

Non-metallic materials (ISO 11114-2:2013):

PTFE = Polytetrafluoroethylene

PA = Polyamide

PVC = Polyvinyl chloride

IIR = Butyl rubber

NBR = Nitrile rubber











Gas	Metallic materials						Non-metallic materials				Elastomers			
	Aluminium	Brass	Carbon steel	Copper	Stainless steel	Nickel	Plastics				Elastomers			
							Teflon®	Kel-F®	Nylon®	PVC	Butyl rubber	Buna® N	Neoprene®	Viton®
AA	B	CS	Cu	SS	Ni	PTFE	PCTFE	PA	PVC	IIR	NBR	CR	FKM	
Acetylene	A	A	A	N	A	A	A	A	A	A	N	N	N	N
Air, synthetic**	A	A	A	A	A	A	A	A	A	A	A	A	A	A
Ammonia	A	N	A		A	A	A	A	A	A	N	A	N	
Argon	A	A	A		A	A	A	A	A	A	A	A	A	A
Arsine	A	A	A		A	A	A	A	A	A	A	A	A	A
Boron trichloride	N	N	A		A	A	N	A		N	N	N	A	
Boron trifluoride	N	N	A		A	A	N	A		N	N	N	A	
1,3-Butadiene	A	A	A		A	A	A	A	A	N	N	N	A	
n-Butane	A	A	A		A	A	A	A	A	N	A	A	A	
iso-Butane	A	A	A		A	A	A	A	A	N	A	A	A	
1-Butene	A	N	A		A									
cis-2-Butene	A	A	A		A									
iso-Butene						A	A	A	N	N	A	N	N	
trans-2-Butene	A	A	A		A									
Carbon dioxide	A	A	A		A	A	A	A	A	N	N	N	N	
Carbon monoxide	A	A	A		A	A	A	A	A	A	A	A	N	
Carbonyl fluoride						A	A	N	N	A	A	N	A	
Carbonyl sulfide	A	A	A		A	A	A	A	A	N	N	N	A	
Chlorine	N	A	A		A	A	N	N		N	N	N	A	
Chlorodifluoromethane	A	A	A		A	A	A	N		A	N	A	N	
Chloropentafluoroethane						A	A	A	N					
Cyclopropane	A	A	A		A	A	A	A		N	A	N	A	
Deuterium	A	A	A		A	A	A	A		A	A	A	A	
Diborane	A	A	A		A	A	A	A		A	A	A	A	
Dichlorodifluoromethane	A	A	A		A	A	A	N		N	N	A	A	
1,1-Dichloro-1-fluoroethane						A	A	A	N					
Dichlorofluoromethane	A	A	A		A	A	A	N		N	N	N	N	
Dichlorosilane	N	N	A		A	A	N	N		N	N	N	A	
1,2-Dichlorotetrafluoroethane	A	A	A		A									
1,1-Difluoroethane	A	A	A											
1,1-Difluoroethylene	A	A	A		A									
Dimethyl ether	A	A	A		A	A	N	N		N	N	N	N	
Dimethylamine	A	N	A		A	A	A	N		A	N	N	N	

Gas	Metallic materials						Non-metallic materials				Elastomers			
	Aluminium	Brass	Carbon steel	Copper	Stainless steel	Nickel	Plastics				Elastomers			
							Teflon®	Kel-F®	Nylon®	PVC	Butyl rubber	Buna® N	Neoprene®	Viton®
AA	B	CS	Cu	SS	Ni	PTFE	PCTFE	PA	PVC	IIR	NBR	CR	FKM	
Ethane	A	A	A		A					A	A	A	A	
Ethanedinitrile	A	N	A		A	A				A	A	A	A	
Ethylamine	A	N	A		A	A				A	A	N	N	
Ethylene	A	A	A		A					A	A	A	A	
Ethylene oxide	A	A	A		A					A	A	N	N	
Fluorine	N	A	A		A	A				N	N	N	N	
Fluoromethane	A	A	A		A									
Helium	A	A	A		A					A	A	A	A	
1,1,1,2,3,3,3-Heptafluoropropane										A	A	A	A	
Hexafluoroethane										A	A	A	N	
Hydrogen	A	A	A		A					A	A	A	A	
Hydrogen bromide	N	N	A		A	A				A	A	N	A	
Hydrogen chloride	N	N	A		A	A				A	A	N	A	
Hydrogen cyanide	A	A	A		A					A	A	N	A	
Hydrogen fluoride	N	N	A		A	A				A	A	N	A	
Hydrogen iodide	N	N	A		A	A				A	A	N	A	
Hydrogen sulfide	A	N	A		A					A	A	A	A	
Krypton	A	A	A		A					A	A	A	A	
Methane	A	A	A		A					A	A	A	A	
Methylamine	A	N	A		A	A				A	A	A	N	
Neon	A	A	A		A					A	A	A	A	
Nitric oxide	N	N	A		A					A	A	N	N	
Nitrogen	A	A	A		A					A	A	A	A	
Nitrogen dioxide	N	N	A		A					A	A	N	N	
Nitrogen trifluoride	A	A	A		A					A	A	N	N	
Nitrous oxide	A	A	A		A					A	A	A	N	
Octafluoropropane	A	A	A		A					A	A	A	N	
Oxygen***														
Pentafluoroethane										A	A	A	A	
Phosgene	N	A	A		A					A	A	N	N	
Phosphine	A	A	A		A					A	A	N	A	
Propadiene	A	A	A		A					A	A	N	A	
Propane	A	A	A		A					A	A	A	N	
Propylene	A	A	A	N	A					A	A	A	N	
Silane	A	A	A		A					A	A			
Silicon tetrachloride	N	A	A		A					A	A	N	N	
Silicon tetrafluoride	N	A	A		A					A	A	N	N	
Sulfur dioxide	A	A	A		A	A				A	A	N	N	
Sulfur hexafluoride	A	A	A		A									
Tetrafluoromethane										A	A	A	N	
Trichlorosilane	N	A	A		A	A				A	A	N	N	
Trifluoroethane	A	A	A		A					A	A	N	N	
Trifluoromethane	N	A	A		A									
Trimethylamine	A	N	A		A	A				A	N	N	A	
Xenon	A	A	A		A					A	A	A	A	

** - Not referenced in ISO 11114 - 1:2012















*** - Please consult your local Linde representative

Appendix 02 - GHS safety symbols and hazard statements

	Old EC Classification ¹		New GHS-CLP Classification ²						
	Symbol	R-phrases	Symbol	Signal word	H-statements				
PHYSICAL HAZARDS	EXPLOSIVE	 (R2, R3)	 DANGER	H200 H201, H202, H203 H240, H241					
		No symbol	No phrase	WARNING	H204				
	FLAMMABLE	No symbol	R10	WARNING	H221, H223, H226				
			R11	DANGER	H225, H228 (cat.1), H228 (cat.2)				
			R12	DANGER	H220, H222, H224				
	CHEMICALLY UNSTABLE	R6	R5	No additional signal word	H230	H231			
	PYROPHORIC SELF HEATING		R17 (R15)	 DANGER	H250 DANGER	H260, H261 (cat.2) WARNING	H261 (cat.3) DANGER	H241, H242 (type C,D), H251 WARNING	H242 (type E,F), H252
	ORGANIC PEROXIDE		R7	DANGER	H241, H242 (type C,D), WARNING	H242 (type E,F)			
	OXIDISING		R8	 DANGER	H250 DANGER	H271, H272 (cat.2), WARNING	H272 (cat.3)		
	GASES UNDER PRESSURE	No symbol	No phrase	 WARNING	H280 H281				
CORROSIVE TO METALS	No symbol	No phrase	 WARNING	H290					

¹EC: Directive 67/548/EEC

²GHS-CLP: Globally Harmonized System for Classification & Labelling – Regulation (EC) No 1272/2008

	Old EC Classification ¹		New GHS-CLP Classification ²		
	Symbol	R-phrases	Symbol	Signal word	H-statements
HEALTH HAZARDS	TOXIC	 R28 R27 R26 R25 R24 R23	 DANGER	H300 H310 H330 H301 H311 H331	
			DANGER	H340 H350 H370 H360 H372 H304 H334	
	CARCINOGENIC MUTAGENIC TOXIC FOR REPR.	R46 R45, R49 R39 R60, R61 R48		WARNING	H305 H371, H373 H351 H373 H361
	HARMFUL	No symbol			No phrase
		R42		WARNING	H302 H312 H332
		R65			
		R68 R40			
		R48 R62, R63 R64 R22 R21 R20			
	CORROSIVE	 R34, R35	 DANGER	H314	
	IRRITANT	 R41 R38 R36 R43 R37		WARNING	H315 H319 H317 H335
No symbol		R67			H336
HAZARDOUS TO AQUATIC ENVIRONMENT		 R50 R50/53 R51/53			
	 R59		WARNING	H411 H420	

Appendix 02 - GHS safety symbols and hazard statements

R-phrases

R1	Explosive when dry
R2	Risk of explosion by shock, friction, fire or other sources of ignition
R3	Extreme risk of explosion by shock, friction, fire or other sources of ignition
R4	Forms very sensitive explosive metallic compounds
R5	Heating may cause an explosion
R6	Explosive with or without contact with air
R7	May cause fire
R8	Contact with combustible material may cause fire
R9	Explosive when mixed with combustible material
R10	Flammable
R11	Highly flammable
R12	Extremely flammable
R14	Reacts violently with water
R15	Contact with water liberates extremely flammable gases
R16	Explosive when mixed with oxidising substances
R17	Spontaneously flammable in air
R18	In use, may form flammable/explosive vapour-air mixture
R19	May form explosive peroxides
R20	Harmful by inhalation
R21	Harmful in contact with skin
R22	Harmful if swallowed
R23	Toxic by inhalation
R24	Toxic in contact with skin
R25	Toxic if swallowed
R26	Very toxic by inhalation
R27	Very toxic in contact with skin
R28	Very toxic if swallowed
R29	Contact with water liberates toxic gas
R30	Can become highly flammable in use
R31	Contact with acids liberates toxic gas
R32	Contact with acids liberates very toxic gas
R33	Danger of cumulative effects

R-phrases

R34	Causes burns
R35	Causes severe burns
R36	Irritating to eyes
R37	Irritating to respiratory system
R38	Irritating to skin
R39	Danger of very serious irreversible effects
R40	Limited evidence of a carcinogenic effect
R41	Risk of serious damage to eyes
R42	May cause sensitisation by inhalation
R43	May cause sensitisation by skin contact
R44	Risk of explosion if heated under confinement
R45	May cause cancer
R46	May cause inheritable genetic damage
R48	Danger of serious damage to health by prolonged exposure
R49	May cause cancer by inhalation
R50	Very toxic to aquatic organisms
R51	Toxic to aquatic organisms
R52	Harmful to aquatic organisms
R53	May cause long-term adverse effects in the aquatic environment
R54	Toxic to flora
R55	Toxic to fauna
R56	Toxic to soil organisms
R57	Toxic to bees
R58	May cause long-term adverse effects in the environment
R59	Dangerous for the ozone layer
R60	May impair fertility
R61	May cause harm to the unborn child
R62	Possible risk of impaired fertility
R63	Possible risk of harm to the unborn child
R64	May cause harm to breast-fed babies
R65	Harmful: may cause lung damage if swallowed
R66	Repeated exposure may cause skin dryness or cracking
R67	Vapours may cause drowsiness and dizziness
R68	Possible risk of irreversible effects

H-statements

H200	Unstable explosive
H201	Explosive; mass explosion hazard
H202	Explosive; severe projection hazard
H203	Explosive; fire, blast or projection hazard
H204	Fire or projection hazard
H205	May mass explode in fire
H220	Extremely flammable gas
H221	Flammable gas
H222	Extremely flammable aerosol
H223	Flammable aerosol
H224	Extremely flammable liquid and vapour
H225	Highly flammable liquid and vapour
H226	Flammable liquid and vapour
H227	Combustible liquid
H228	Flammable solid
H229	Pressurised container: may burst if heated
H230	May react explosively even in the absence of air
H231	May react explosively even in the absence of air at elevated pressure and/or temperature
H240	Heating may cause an explosion
H241	Heating may cause a fire or explosion
H242	Heating may cause a fire
H250	Catches fire spontaneously if exposed to air
H251	Self-heating; may catch fire
H252	Self-heating in large quantities; may catch fire
H260	In contact with water releases flammable gases which may ignite spontaneously
H261	In contact with water releases flammable gas
H270	May cause or intensify fire; oxidiser
H271	May cause fire or explosion; strong oxidiser
H272	May intensify fire; oxidiser
H280	Contains gas under pressure; may explode if heated
H281	Contains refrigerated gas; may cause cryogenic burns or injury
H290	May be corrosive to metals
H300	Fatal if swallowed
H301	Toxic if swallowed
H302	Harmful if swallowed
H303	May be harmful if swallowed
H304	May be fatal if swallowed and enters airways
H305	May be harmful if swallowed and enters airways
H310	Fatal in contact with skin

H-statements

H311	Toxic in contact with skin
H312	Harmful in contact with skin
H313	May be harmful in contact with skin
H314	Causes severe skin burns and eye damage
H315	Causes skin irritation
H316	Causes mild skin irritation
H317	May cause an allergic skin reaction
H318	Causes serious eye damage
H319	Causes serious eye irritation
H320	Causes eye irritation
H330	Fatal if inhaled
H331	Toxic if inhaled
H332	Harmful if inhaled
H333	May be harmful if inhaled
H334	May cause allergy or asthma symptoms or breathing difficulties if inhaled
H335	May cause respiratory irritation
H336	May cause drowsiness or dizziness
H340	May cause genetic defects
H341	Suspected of causing genetic defects
H350	May cause cancer
H351	Suspected of causing cancer
H360	May damage fertility or the unborn child
H361	Suspected of damaging fertility or the unborn child
H361d	Suspected of damaging the unborn child
H362	May cause harm to breast-fed children
H370	Causes damage to organs
H371	May cause damage to organs
H372	Causes damage to organs through prolonged or repeated exposure
H373	May cause damage to organs through prolonged or repeated exposure
H400	Very toxic to aquatic life
H401	Toxic to aquatic life
H402	Harmful to aquatic life
H410	Very toxic to aquatic life with long lasting effects
H411	Toxic to aquatic life with long lasting effects
H412	Harmful to aquatic life with long lasting effects
H413	May cause long lasting harmful effects to aquatic life
H420	Harms public health and the environment by destroying ozone in the upper atmosphere

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7440-59-7; [See Helium](#)
7440-63-3; [See Xenon](#)
7446-09-5; [See Sulfur dioxide](#)
74-82-8; [See Methane](#)
74-83-9; [See Methyl bromide](#)
74-84-0; [See Ethane](#)
74-85-1; [See Ethylene](#)
74-86-2; [See Acetylene](#)
74-87-3; [See Methyl chloride](#)
74-89-5; [See Methylamine](#)
74-90-8; [See Hydrogen cyanide](#)
74-93-1; [See Methyl mercaptan](#)
74-98-6; [See Propane](#)
74-99-7; [See Propyne](#)
75-00-3; [See Ethyl chloride](#)
75-01-4; [See Chloroethene](#)
75-04-7; [See Ethylamine](#)
75-10-5; [See Difluoromethane](#)
75-19-4; [See Cyclopropane](#)
75-21-8; [See Ethylene oxide](#)
75-28-5; [See iso-Butane](#)
75-37-6; [See 1,1-Difluoroethane](#)
75-38-7; [See 1,1-Difluoroethylene](#)
75-43-4; [See Dichlorodifluoromethane](#)
75-44-5; [See Phosgene](#)
75-45-6; [See Chlorodifluoromethane](#)
75-46-7; [See Trifluoromethane](#)
75-50-3; [See Trimethylamine](#)
75-68-3; [See Chlorodifluoroethane](#)
75-71-8; [See Dichlorodifluoromethane](#)
75-73-0; [See Tetrafluoromethane](#)
754-12-1; [See 2,3,3,3-Tetrafluoro-1-propene](#)
76-14-2; [See 1,2-Dichlorotetrafluoroethane](#)
76-15-3; [See Chloropentafluoroethane](#)
76-16-4; [See Hexafluoroethane](#)
76-19-7; [See Octafluoropropane](#)
7637-07-2; [See Boron trifluoride](#)
7647-01-0; [See Hydrogen chloride](#)
7664-39-3; [See Hydrogen fluoride](#)
7664-41-7; [See Ammonia](#)
7727-37-9; [See Nitrogen](#)
7782-39-0; [See Deuterium](#)
7782-41-4; [See Fluorine](#)
7782-44-7; [See Oxygen](#)
7782-50-5; [See Chlorine](#)
7783-06-4; [See Hydrogen sulfide](#)
7783-54-2; [See Nitrogen trifluoride](#)
7783-61-1; [See Silicon tetrafluoride](#)
7784-42-1; [See Arsine](#)
78-78-4; [See iso-Pentane](#)
7803-51-2; [See Phosphine](#)
7803-62-5; [See Silane](#)
811-97-2; [See Tetrafluoroethane](#)

EC numbers

200-812-7; See Methane
 200-813-2; See Methyl bromide
 200-814-8; See Ethane
 200-815-3; See Ethylene
 200-816-9; See Acetylene
 200-817-4; See Methyl chloride
 200-820-0; See Methylamine
 200-821-6; See Hydrogen cyanide
 200-822-1; See Methyl mercaptan
 200-827-9; See Propane
 200-828-4; See Propyne
 200-830-5; See Ethyl chloride
 200-831-0; See Chloroethene
 200-834-7; See Ethylamine
 200-839-4; See Difluoromethane
 200-847-8; See Cyclopropane
 200-849-9; See Ethylene oxide
 200-857-2; See iso-Butane
 200-866-1; See Difluoroethane
 200-867-7; See 1,1-Difluoroethylene
 200-869-8; See
 Dichlorodifluoromethane
 200-869-8; See
 Dichlorotetrafluoroethane
 200-870-3; See Phosgene
 200-871-9; See
 Chlorodifluoromethane
 200-872-4; See Trifluoromethane
 200-875-0; See Trimethylamine
 200-891-8; See Chlorodifluoroethane
 200-893-9; See
 Dichlorodifluoromethane
 200-896-5; See Tetrafluoromethane
 200-938-2; See
 Chloropentafluoroethane
 200-939-8; See Hexafluoroethane
 200-941-9; See Octafluoropropane
 201-142-8; See iso-Pentane
 203-448-7; See n-Butane
 203-449-2; See 1-Butene
 203-450-8; See 1,3-Butadiene
 203-451-3; See 1-Butyne
 203-475-4; See Methyl vinyl ether
 203-481-7; See Methyl formate
 203-692-4; See n-Pentane
 203-721-0; See Ethyl formate
 204-062-1; See Propylene
 204-065-8; See Dimethyl ether
 204-066-3; See iso-Butene

204-696-9; See Carbon dioxide
 204-697-4; See Dimethylamine
 206-016-6; See Cyclopentane
 206-190-3; See 2,2-Dichloro-1,1,1-trifluoroethane
 206-557-8; See Pentafluoroethane
 206-534-2; See Carbonyl fluoride
 206-996-5; See Trifluoroethane
 207-079-2; See
 1,1,1,2,3,3,3-Heptafluoropropane
 207-306-5; See Ethanedinitrile
 207-335-3; See Propadiene
 207-340-0; See Carbonyl sulfide
 207-343-7; See 2,2-Dimethylpropane
 208-052-8; See Cyanic chloride
 209-673-7; See cis-2-Butene
 209-796-6; See Fluoromethane
 209-800-6; See Bromoethylene
 210-855-3; See trans-2-Butene
 211-128-3; See Carbon monoxide
 212-377-0; See Tetrafluoroethane
 215-605-7; See Hydrogen
 219-854-2; See Sulfur hexafluoride
 220-629-6; See 1-Chloro-1,2,2,2-tetrafluoroethane
 223-888-3; See Dichlorosilane
 231-098-5; See Krypton
 231-110-9; See Neon
 231-147-0; See Argon
 231-168-5; See Helium
 231-172-7; See Xenon
 231-195-2; See Sulfur dioxide
 231-569-5; See Boron Trifluoride
 231-595-7; See Hydrogen chloride
 231-634-8; See Hydrogen fluoride
 231-635-3; See Ammonia
 231-783-9; See Nitrogen
 231-952-7; See Deuterium
 231-954-8; See Fluorine
 231-956-9; See Oxygen
 231-959-5; See Chlorine
 231-977-3; See Hydrogen sulfide
 232-007-1; See Nitrogen trifluoride
 232-015-5; See Silicon tetrafluoride
 232-066-3; See Arsine
 232-260-8; See Phosphine
 232-263-4; See Silane
 233-032-0; See Nitrous oxide
 233-042-5; See Trichlorosilane

233-054-0; See Silicon tetrachloride
 233-109-9; See Hydrogen iodide
 233-113-0; See Hydrogen bromide
 233-271-0; See Nitric oxide
 233-272-6; See Nitrogen dioxide
 233-658-4; See Boron Trichloride
 242-940-6; See Diborane
 404-080-1; See 1,1-Dichloro-1-fluoroethane
 419-170-6; See
 1,1,1,3,3-Pentafluoropropane
 425-320-1; See
 1,1,1,3,3,3-Hexafluoropropane
 468-710-7; See 2,3,3,3-Tetrafluoro-1-propene
 471-480-0; See trans-1,3,3,3-Tetrafluoro-1-propene

UN numbers

1001; See Acetylene
 1002; See Air, synthetic
 1005; See Ammonia
 1006; See Argon
 1008; See Boron trifluoride
 1010; See 1,3-Butadiene
 1011; See n-Butane
 1012; See trans-2-Butene, iso-Butene, cis-2-Butene, 1-Butene
 1013; See Carbon dioxide
 1016; See Carbon monoxide
 1017; See Chlorine
 1018; See Chlorodifluoromethane
 1020; See Chloropentafluoroethane
 1021; See 1-Chloro-1,2,2,2-tetrafluoroethane
 1026; See Ethanedinitrile
 1027; See Cyclopropane
 1028; See Dichlorodifluoromethane
 1029; See Dichlorofluoromethane
 1030; See 1,1-Difluoroethane
 1032; See Dimethylamine
 1033; See Dimethyl ether
 1035; See Ethane
 1036; See Ethylamine
 1037; See Ethyl chloride
 1038; See Ethylene
 1040; See Ethylene oxide
 1045; See Fluorine
 1046; See Helium
 1048; See Hydrogen bromide
 1049; See Hydrogen
 1050; See Hydrogen chloride
 1051; See Hydrogen cyanide
 1052; See Hydrogen fluoride
 1053; See Hydrogen sulfide
 1056; See Krypton
 1060; See Propyne
 1061; See Methylamine
 1062; See Methyl bromide
 1063; See Methyl chloride
 1064; See Methyl mercaptan
 1065; See Neon
 1066; See Nitrogen
 1067; See Nitrogen dioxide
 1070; See Nitrous oxide
 1072; See Oxygen
 1073; See Oxygen
 1076; See Phosgene

1077; See Propylene
 1079; See Sulfur dioxide
 1080; See Sulfur hexafluoride
 1083; See Trimethylamine
 1085; See Bromoethylene
 1086; See Chloroethene
 1087; See Methyl vinyl ether
 1090; See Ethyl formate
 1146; See Cyclopentane
 1190; See Ethyl formate
 1243; See Methyl formate
 1265; See n-Pentane/iso-Pentane
 1295; See Trichlorosilane
 1589; See Cyanic chloride
 1660; See Nitric oxide
 1741; See Boron trichloride
 1818; See Silicon tetrachloride
 1859; See Silicon tetrafluoride
 1911; See Diborane
 1913; See Neon
 1951; See Argon
 1954; See 40% Hydrogen, Balance Helium/10% Methane, Balance Argon/5% Methane, Balance Argon/10% Carbon Dioxide, 10% Hydrogen, Balance Nitrogen/40% Hydrogen, Balance Nitrogen/Multi-component Hydrocarbon Mixture, Balance Methane
 1956; See 1% Oxygen, Balance Nitrogen/20 ppm Carbon Monoxide, Balance Air/450 ppb Nitric Oxide, Balance Nitrogen/450 ppb Nitrogen Dioxide, Balance Air/450 ppb Sulfur Dioxide, Balance Air/90 ppm Methane, Balance Nitrogen/5 ppm Ammonia, Balance Nitrogen/5 ppm Mercury, Balance Nitrogen/10 ppm Hydrogen Sulphide, Balance Nitrogen/1.1% Propane, Balance Air/2.5% Methane, Balance Air/2% Hydrogen, Balance Air/3.4% Carbon Dioxide, 15.6% Nitrogen, Balance Helium/0.25% Carbon Monoxide, 18% Helium, 21% Oxygen, Balance Nitrogen
 1957; See Deuterium
 1958; See
 1,2-Dichlorotetrafluoroethane
 1959; See 1,1-Difluoroethylene
 1961; See Ethane
 1962; See Ethylene
 1963; See Helium
 1966; See Hydrogen
 1969; See iso-Butane
 1970; See Krypton
 1971; See Methane
 1972; See Methane
 1977; See Nitrogen
 1978; See Propane
 1982; See Tetrafluoromethane
 1984; See Trifluoromethane
 2035; See Trifluoroethane
 2036; See Xenon
 2044; See 2,2-Dimethylpropane
 2187; See Carbon dioxide
 2188; See Arsine
 2189; See Dichlorosilane
 2193; See Hexafluoroethane
 2197; See Hydrogen iodide
 2199; See Phosphine
 2200; See Propadiene
 2201; See Nitrous oxide
 2203; See Silane
 2204; See Carbonyl sulfide
 2417; See Carbonyl fluoride
 2424; See Octafluoropropane
 2451; See Nitrogen trifluoride
 2452; See 1-Butyne
 2454; See Fluoromethane
 2517; See Chlorodifluoroethane
 2591; See Xenon
 3156; See 5% Carbon Dioxide, Balance Oxygen
 3159; See Tetrafluoroethane
 3161; See 2,3,3,3-Tetrafluoro-1-propene
 3163; See
 1,1,1,3,3,3-Hexafluoropropane/
 1,1,1,3,3,3-Pentafluoropropane/
 trans-1,3,3,3-Tetrafluoro-1-propene
 3220; See Pentafluoroethane
 3252; See Difluoromethane
 3296; See
 1,1,1,2,3,3,3-Heptafluoropropane
 3306; See 5% Fluorine, Balance Helium

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With its innovative concepts, Linde is playing a pioneering role in the global market. As a technology leader, it is our task to constantly raise the bar. Traditionally driven by entrepreneurship, we are working steadily on new high-quality products and innovative processes.

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If you want to keep pace with tomorrow's competition, you need a partner by your side for whom top quality, process optimization, and enhanced productivity are part of daily business. We define partnership not merely as being there for you, but being with you. After all, joint activities form the core of commercial success.

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