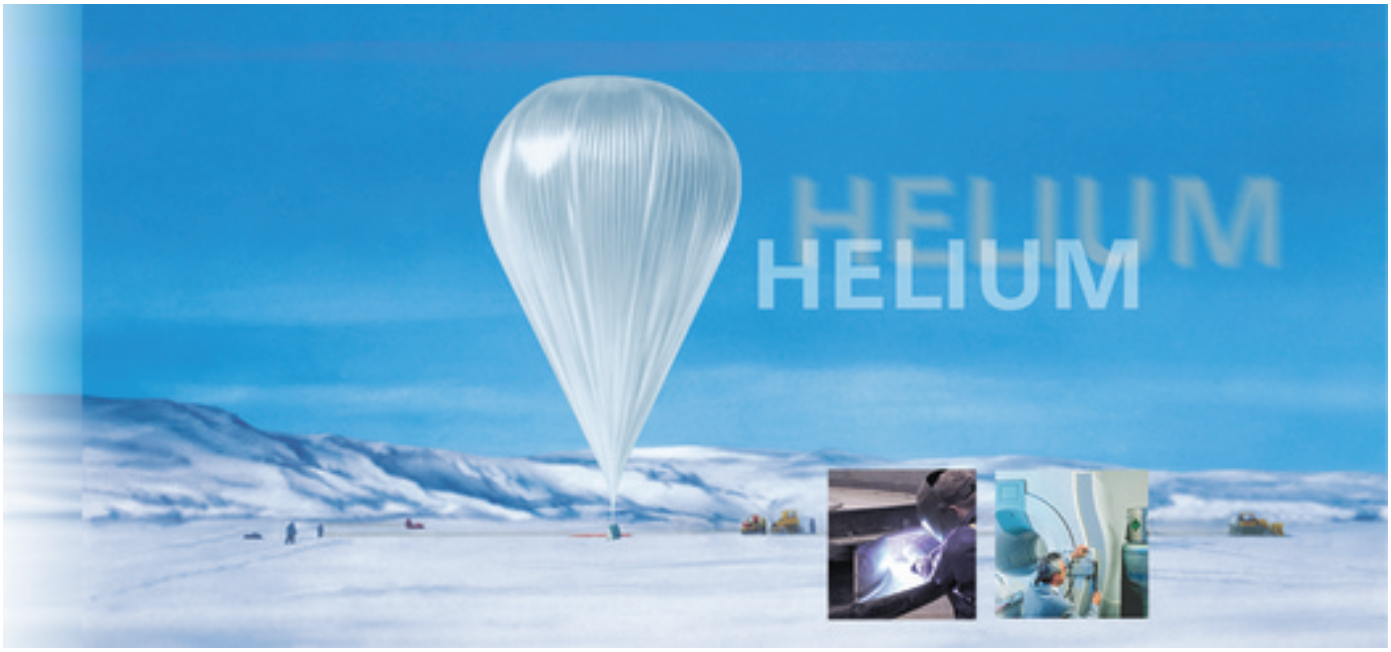


Helium – the special element

Unique properties
The inert gas helium has properties that make it indispensable for many applications.

Helium ...

- has the lowest molecular weight after hydrogen
- is an absolutely inert gas. It does not form chemical compounds even at high temperatures
- is hardly soluble in metals and molten metals
- penetrates even the smallest gaps and pores due to its small atomic diameter
- has the lowest boiling point of all gases in a liquid state at 4.2 Kelvin or - 269 °C, making the coldest liquid on earth. It is therefore the refrigerant used for producing the lowest temperatures, e.g. in the research or applications of superconductivity.

Physical data

Molecular weight	4.003 kg/kmol
Liquid density at boiling point	0.125 kg/l
Boiling point	4,22 K (-269 °C)
Latent heat of vaporization	20,41 kJ/kg
Critical point	5,2 K (-268 °C) 2,27 bar
Density ratio to air	0,138
Gaseous density at 15 °C, 1 bar	0,167 kg/m³
Specific heat capacity (25 °C)	5,19 kJ/kg *K
Thermal conductivity (25 °C)	150 mW/m K

Extraction from the ground

There are only traces of helium in the atmosphere (5 vpm = 0.0005 %), making the extraction of helium from the air very complicated and uneconomical. For this reason, helium is only extracted from helium-rich natural gas sources. These natural gas sources are only found in a few locations on earth with special geological conditions. At present, helium is extracted from natural gas in the USA, Russia, Algeria, Qatar and a smaller source in Poland. Large helium liquefiers are operated at each of these locations.

Worldwide logistics

To transport liquid helium (LHe) economically, Messer uses special super vacuum insulated tank containers (TCs) with a maximum capacity of ca. 40,000 l each. The Messer Group operates 12 such special containers.

The tank containers are filled directly at the liquefier of the given helium source. Helium liquefaction is a continuous process with a steady production output, which is why the TCs have to be filled in accordance with a specified schedule. Filling slots are therefore allocated by the producer companies, which have to be adhered exactly.

Once they are filled, the TCs are transported by road and, if necessary, by sea to the filling plants of the Messer Group. These are located in Mitry-Mory (France), Lenzburg (Switzerland), Gumpoldskirchen (Austria) in Europe, and in Wujiang (China). There is also a filling station for gaseous helium in Machelen (Belgium).

Filling in line with demand

At the filling plants, the contents of the TCs are transferred to smaller containers using special filling equipment. The choice of containers is based on the quantity required by customers and whether they want it supplied in gaseous or liquid form. Messer has a wide range of containers: For liquid transportation super vacuum insulated container (dewars) are used, sizes range from 30 to 450 liters, while for helium gas transportation there is a wide range of possibilities, from 1 liter pressure cans to 200 and 300 bar cylinders and bundles up to tube trailers that can take 2000 m^3 - 3000 m^3 of helium gas at 200 bar. Since the filling of liquid helium also gives rise to gaseous helium as a result of evaporation, it is necessary to maintain a balanced ratio of gas and liquid filling.

Filling station for liquid helium

Furthermore, it is possible to purify the helium gas in the filling plants (mainly by low temprature adsorption) in order to satisfy the highest standards of quality or allow recycling of the contaminated gas. Finally, the customers are supplied directly from the filling plants or via regional distribution centers.

Perfected equipment

In order to prevent losses by evaporation, the liquid helium is delivered in special vacuum insulated transport containers (dewars). These are forwarded to users in trucks fitted with special loading and unloading equipment which guarantees safe transportation by road.

In order to withdraw the liquid helium, the dewars generally have to be fitted with a suitable stinger. By connecting a helium gas cylinder the pressure in the dewar is increased until the liquid helium can be withdrawn through the outlet.

If required, specially trained liquid helium service technicians from Messer can provide support during the transfer process (partial service) or carry it out themselves on behalf of the user (full service).

Liquid helium service vehicle

Many applications are now inconceivable without helium

Due to its special properties, helium is also used in a large number of very specialized applications.

The table on the next page provides an overview of these.

Liquid helium is used as a cooling agent wherever extremely low temperatures (below -200°C) need to be produced but where conventional refrigerators cannot be used for economic reasons. Often these are applications connected with superconductivity.

Of greatest technical importance are magnetic resonance imaging (MRI) or nuclear magnetic resonance analysis (NMR) and various applications in research and development.

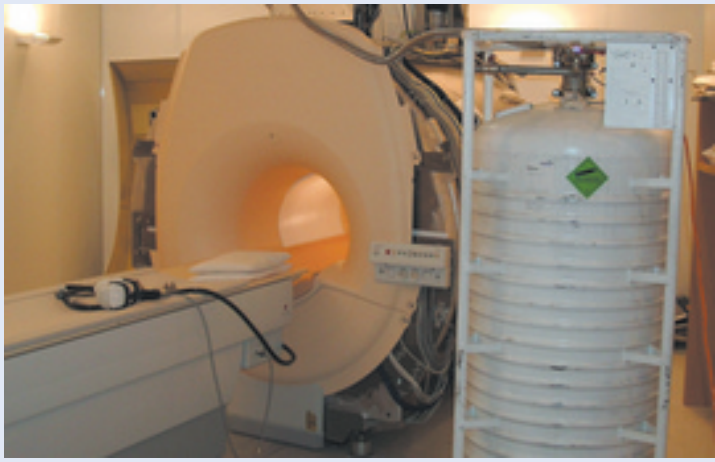
Apart from what is probably its best known use as a lifting gas for balloons and airships, gaseous helium is also used in a wide range of technical applications.

Example of magnetic resonance imaging

One of the most important applications for liquid helium is magnetic resonance imaging, which has established itself as a safe imaging procedure in medical diagnostics. The helium is used to cool the superconducting high-performance solenoid.
For the filling of magnetic resonance tomographs, Messer predominantly uses special dewars such as the Stratos 380 SL with its special equipment.

The advantages of the Stratos 380 SL:

- extremely light (total weight of just 145 kg when carrying 380 liters of LHe)
- fits through every door and elevator thanks to its compact size
- integrated stinger can also easily be used in rooms with low ceilings
- integrated, electrically controlled pressure build-up system eliminates the need for separate lifting gas and therefore the handling of additional gas cylinders



Filling a magnetic resonance tomograph

Applications of gaseous helium
Cutting and welding: - Shielding gas - Working gas for laser applications
Laser technology: - Resonator gas component
Metrology: - Carrier and purging gas in gas chromatography - Calibration and test gas in analysis - Detection gas for leak detection
Diving: - Breathing gas component in diving gas mixtures
Cooling agent for reactors and generators, e.g. in the manufacture of optical fibers
Heat treatment of metals or components
- For balloons (weather observation, sport) and airships

Applications of cryogenic liquid helium
Metrology: - Nuclear magnetic resonance analysis (NMR) - Superconducting magnetic field probes - Cooling of sensors
Medicine: - Magnetic resonance imaging - Magneto-encephalography
Research and development: - Nuclear fusion and particle physics - Low temperature physics - Superconducting energy storage - Superconducting materials and sensors - Materials research at low temperatures - Materials testing
Technology and industrial applications: - Strong-field magnetic separator - Production of high vacuum - Magnetic melt stabilization

Thus helium is used in many processes in cutting and welding as well as laser technology due to its high thermal conductivity. One of the major single applications (in terms of quantity) is as a coolant in the manufacturing of optical fibers. However, its high diffusibility also makes it, for example, an ideal carrier gas in gas chromatography or the most widely used detection gas in leak detection.

Just as there are many different applications, there are also widely differing requirements regarding the quality and the form in which the gaseous helium is to be delivered. The purity of the helium ranges from balloon gas to "6.0", i.e. a purity of 99.9999%, and the form of delivery from 1 liter pressure cans to cylinders and bundles up to whole trailers. Details of this can be found on the data sheet.

Expert advice and service

Since helium is a scarce and valuable product, it must be used as efficiently as possible. Our technical customer service team provides support in optimizing helium use and thus minimizing helium losses. You can benefit from this expertise in the following areas:

- Product properties and applications
- Effective and low-loss logistics including suitable transfer systems
- Process optimization for economical use of helium
- Helium recovery systems, taking back included

Messer Group GmbH
Gahlingspfad 31
47803 Krefeld
Tel. +49 2151 7811-0
Fax +49 2151 7811-501
info@messergroup.com
www.messergroup.com