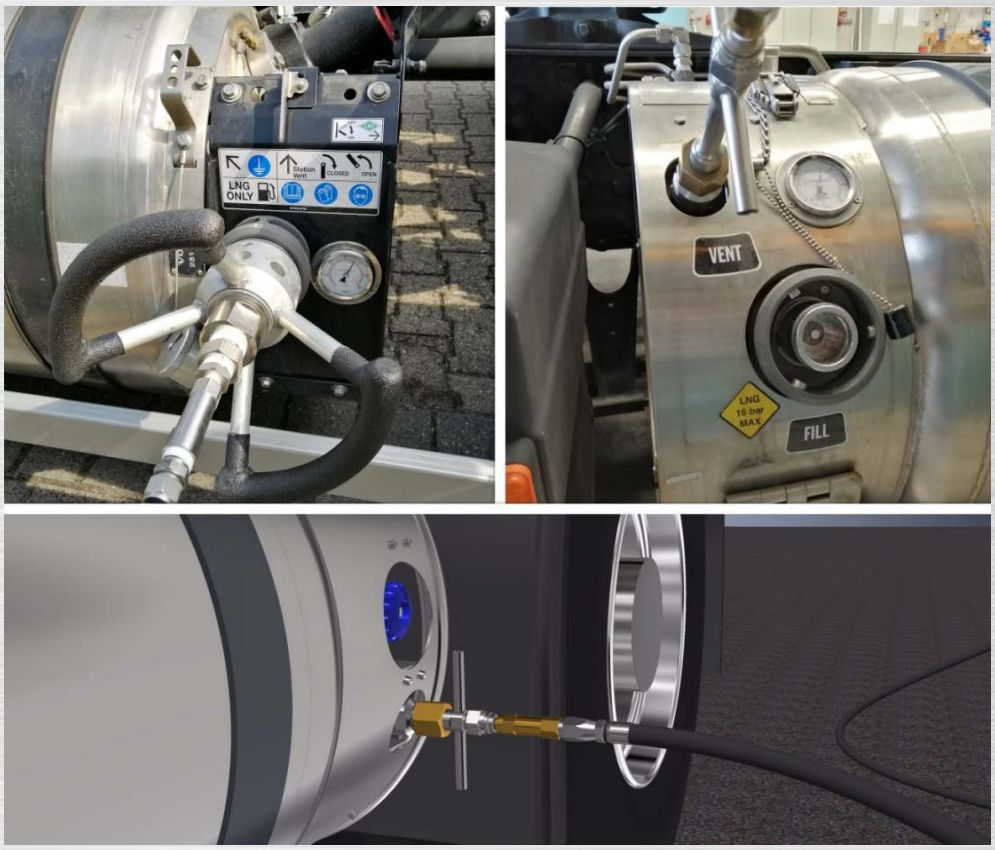
**Unautorisierte Übersetzung**




# Occupational safety and equipment for the maintenance and repair of vehicles with LNG system
# - Manual for automotive workshops -

TAK

DGUV
Deutsche Gesetzliche Unfallversicherung
Spitzenverband

KRAFTFAHRZEUG GEWERBE

Prepared in cooperation with the Wood and Metal Division of the woodworking and metalworking division of the German Social Accident Insurance (DGUV).

# Imprint

**Publisher:**

Academy of the German Motor Trade GmbH (TAK), Franz-Lohe-Str. 19, 53129 Bonn

E-mail: info@tak.de
Internet: www.tak.de

**On behalf of:**

German Federation for Motor Trades and Repairs (ZDK)
Franz-Lohe-Straße 21, 53129 Bonn, Germany

Mohrenstraße 20/21
10117 Berlin

Telefon: 0228 9127-0
Telefax: 0228 9127-150
E-Mail: zdk@kfzgewerbe.de
Internet: www.kfzgewerbe.de

**Author:**
Dominik Lutter, ZDK

**Editorial:**
Johannes Müller, TAK
Olaf Pfeiffer, DGUV FBHM c/o BGHM
Sven Träger, DGUV FBHM c/o BGHM

**Illustrations:**
Daimler AG - Forschung und Technologie
GasCom
ZDK



Publication date: January 2020

*Page*

Bonn, January 2020

Dear colleagues,

Due to the ongoing discussion on reducing $CO_2$ emissions and the increasing regulation of pollutant emissions from motor vehicles by European standards, alternative drive systems and fuels are becoming more and more important. Natural gas/methane in the form of CNG (Compressed Natural Gas) and LNG (Liquefied Natural Gas) are already existing alternatives or transitional technologies that offer enormous savings potential in terms of reducing CO2 emissions. In the heavy commercial vehicle sector, the focus is increasingly on LNG.

Methane as a fuel must not be reduced to natural gas obtained from fossil sources. Biogas/biomethane, synthesis gas and natural gas always involve the same hydrocarbon, namely methane. It is precisely the biologically or synthetically produced gases, which always involve methane, that offer considerable potential for reducing greenhouse gases. To promote alternative drive technologies, the German government decided in 2018 to exempt vehicles powered by CNG/LNG from tolls from 01.01.2019 until the end of 2020. This promotes the placing on the market of heavy commercial vehicles with LNG drives, so that these vehicles will also soon have to be serviced and repaired in motor vehicle workshops.

This guideline is intended to support all motor vehicle entrepreneurs in creating the occupational health and safety conditions for working on LNG vehicles without endangering the safety of their employees.

During the development of the guide, we were competently supported by experts from the employers' liability insurance associations and from the automotive industry. We would like to express our gratitude for this support.

Werner Steber Dominik Lutter

# 1 Introduction

This manual refers to the occupational health and safety measures, the equipment of motor vehicle workshops and the qualification of personnel for activities on motor vehicles with LNG propulsion. This manual is not applicable to LNG gas systems that do not serve to drive the vehicle (e.g. mobile tank installations, trailers with LNG tank containers).

LNG (Liquefied Natural Gas) is liquefied natural gas (approx. 90 % methane). In no case LNG should be confused with LPG (liquefied petroleum gas/car gas). As the LNG in the vehicle tank inevitably heats up, resulting in an unavoidable increase in pressure, LNG (boil-off gas) may escape when the vehicle is stationary for a longer period of time.

This manual is intended to give entrepreneurs and supervisors in motor vehicle workshops advice on how to determine the necessary technical and organizational occupational safety measures, workshop equipment and the necessary qualification requirements of employees for the work on motor vehicles with LNG gas systems in service workshops on the basis of the risk assessment.

We expressly point out that the procedures described in this manual are exemplary and represent a practicable solution for boil-off management. If other effective solutions for boil-off management exist, these can also be applied.

# 2 Entrepreneurial duties

Employers and supervisors must determine the hazards to which employees are exposed through their activities when working on vehicles and must derive and implement the corresponding measures.

These include, among others

- The implementation of the risk assessment
- The documentation of the risk assessment
- The creation of a suitable organization
- The provision of the necessary resources and information
- The preparation of operating instructions based on the results of the risk assessment (e.g. for work on gas systems; usually required for each gas system used)
- The selection and qualification of employees
- The instruction and training of employees

Employers and supervisors may delegate in writing the occupational safety and health tasks resulting from their duties to reliable and competent persons (§ 13 ArbSchG [3]). The prerequisites for this include the necessary qualification (expertise) of the persons concerned. A copy of the assignment shall be handed over to them (Section 13 ArbSchG [3]). (Note: ArbschG means the national implementation of the Council Directive on the introduction of measures to encourage improvements in the safety and health of workers at work (89/391/EEC).)

The contractor shall check whether the persons intended for the assignment of duties are reliable and competent before the assignment.

Skilled persons are those designated for the delegation of duties who have the relevant expertise and practical experience to carry out the tasks incumbent upon them properly

# 3 Qualification and instruction of employees

However, special hazards also arise when using gases as a propulsion fuel. They occur during the assembly, installation or removal, maintenance, repair, testing and operation of gas systems in vehicles. Entrepreneurs are responsible for ensuring that employees in service companies are qualified in such a way that they are able to assess and safely carry out work on vehicles with gas drive systems.

The German Social Accident Insurance (DGUV) document Fachbereich AKTUELL FBHM-099 "Gas propulsion systems in motor vehicles - Qualification for work on vehicles with gas propulsion" describes the qualification measures for work on vehicles with gas propulsion.

Basically, the work on LNG-powered motor vehicles can be divided into four stages, which are shown in the figure below:

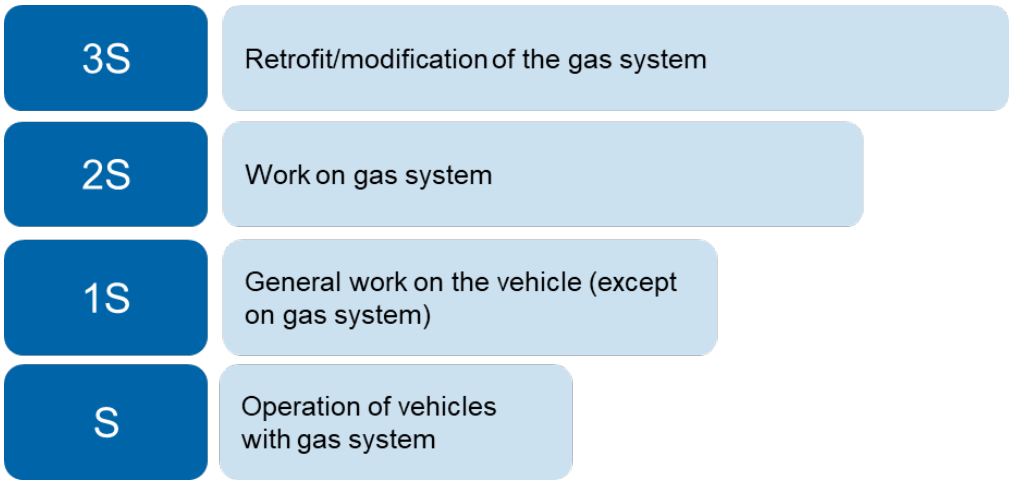



Figure 3-1: Qualification levels for work on gas vehicles

Employers and supervisors must provide employees with sufficient and appropriate instruction on safety and health protection during their working hours. The instruction shall include instructions and explanations specifically geared to the employee's workplace or area of responsibility. The instruction must be given when the employee is hired, when there are changes in the scope of duties, the introduction of new work equipment or a new technology before the employee starts work.

The basis for the instruction are the findings from the risk assessment.

Further information can be found in the document Fachbereich AKTUELL FBHM-099 "Gas propulsion systems in motor vehicles - Qualification for work on vehicles with gas propulsion" (https://publikationen.dguv.de/dguv/pdf/10002/12760-1.pdf).

# 4 LNG as a fuel

Liquefied methane (LNG) as a fuel enables the storage of larger amounts of energy due to its higher density. Compared to petrol and diesel fuels, the combustion of methane produces far lower CO2 and particulate emissions. Particularly in the commercial vehicle sector, the use of liquefied methane has proven to be a sensible alternative to the currently dominant diesel drive, as the storage of larger amounts of energy also makes longer ranges possible.

Already today, but also in the near future, commercial vehicle manufacturers and importers are increasingly relying on LNG as a fuel.

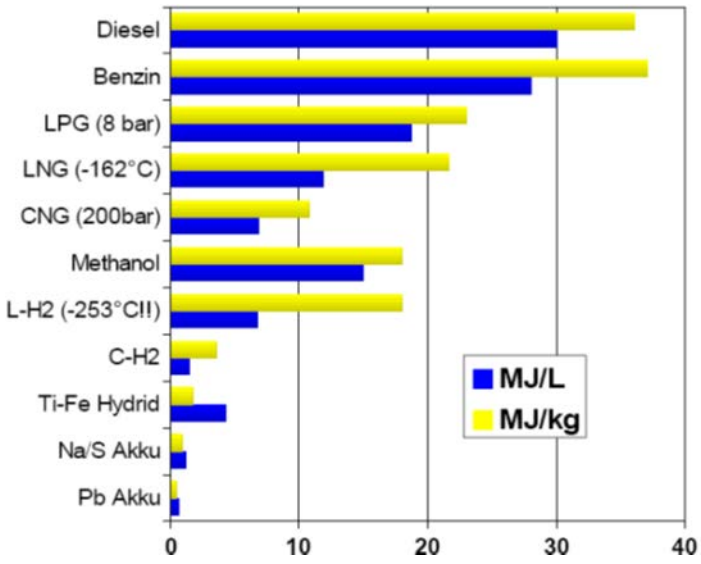



Figure 4-1: Energy density incl. storage medium (tank);
source: Daimler AG - Research and Technology

## 4.1 Facts and figures on LNG (Liquefied Natural Gas)

- Consists of approx. 90 % methane
- Produced by the liquefaction of upgraded methane (natural gas, biogas (bio-LNG) or synthetic gas).
- Boiling point -161 °C to -164 °C in the standard state
- The volume of 1 kg of LNG is approx. 1/600 of 1 kg of gaseous methane. (Example: The volume of 1 l of LNG increases to 600 l after outflow under normal conditions).
- The energy content of 1 l of LNG is roughly equivalent to that of 3 l of compressed methane (CNG ~ 200 bar storage pressure) or 0.6 l of diesel fuel

| Gas type | Tank pressure | Flammable limit [Vol %] | | Auto-ignition temperature [$^0$C] | Odourless | | Odorised | | Memory status | | Standard-tight [kg/m$^3$] | Standard-tight/liquid phase [kg/m$^3$] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Normal [bar] | Lower | Upper | | Yes | No | Yes | No | Liquid | Gaseous | (0 $^0$C/ 1013 mbar) | ($T_{Boiling\ point}$ $^0$C/ 1013 mbar) |
| LNG | 1 – 10 | 4,1 | 16,5 | approx. 520 | X | | | X | X | | 0,83 | 470 |

Figure 4-2: LNG characteristics (Liquefied Natural Gas)

## 4.2 Storage of LNG in motor vehicles

In order for methane to be stored in liquid form, it is necessary to cool the methane below the boiling point of approx. -162 °C. In order to maintain this temperature over a certain period of time, specially insulated, so-called cryogenic tanks are used. Active cooling via a cooling unit is not used because of the high energy requirements.


Figure 4-3: LNG tank (cryotank); source: ZDK

# 5 Risk assessment "Work on vehicles with LNG drive"

LNG vehicles contain permanently technically sealed plant components as well as technically sealed plant components with operational leakage of flammable substances (boil-off gas).

In principle, the following aspects must be considered in the risk assessment for the maintenance of LNG vehicles:

1. General work that does not affect the gas system. These works are e.g.:

   - Work on the brake system
   - Service and maintenance work (except service work on the gas system)
   - Wheel/tire service

2. Work that exclusively concerns the gas system; this may also be the case if the gas system has to be disconnected/drained for general work. These works are e.g.:

   - Service/maintenance work on the gas system
   - Disconnecting gas-carrying lines (not tank system)
   - Emptying/unclamping LNG tank containers

3. Boil-off management due to cryogenic/LNG tank systems

   - The Boil-Off Management describes the further handling with the vented gas.
   - Deep-frozen methane changes its aggregate state from the liquid to the gaseous phase after a certain period of time under circumstances that are difficult to calculate, whereby the internal tank pressure rises and a "boil-off" (controlled blow-off of methane) occurs at a certain pressure (approx. 16 bar). In this process, the gas is blown off into the environment via a blow-off lance on the vehicle side behind the driver's cab (see Figure 5-1).

Figure 5-1: Blow-off lance behind the driver's cab; source: ZDK

To prevent boil-off gas from entering the workshop environment, the vehicle can be connected to a separate blow-off device as a technical measure for all work (e.g. wheel replacement, brake replacement) performed on LNG vehicles (see chapter 6.2). The vehicle should - as an organisational measure - be connected to the blow-off device at the latest 15 minutes after entering the workshop. With this blow-off device, it is possible to safely lead the gas out of the workshop in case of a boil-off. This means that vehicles can be kept indoors for several days without any problems.

Boil-off management must be considered in buildings independently of fire and explosion protection measures during the maintenance of (LNG) gas vehicles.

If work is carried out on the gas system (e.g. replacement of gas-carrying lines), during which gas may escape in a controlled manner, this work must be carried out in a separate gas vehicle work area (gas vehicle work area for defined activities). The requirements for a gas vehicle work area can be found in the practical guidebook "Occupational Safety and Gas Vehicles - Guidelines for Motor Vehicle Workshops", 4th revised version of September 2014, chapter 6.1.1 "Natural Gas/Hydrogen Work Area".

Furthermore, the liquid methane, which is cooled down to -162 °C, poses the risk of wetting clothing and the risk of burns/freezing by touching gas-carrying components. Appropriate personal protective equipment (PPE) is necessary, but at least face and hand protection; the manufacturer's specifications must be observed.

# 6 Moving LNG-powered vehicles into halls/workshops

## 6.1 Preparatory measures

If a motor vehicle with LNG drive is to be taken to a hall/workshop for maintenance and servicing, it must be ensured in advance that there are no leaks in the vehicle's gas system. Furthermore, the vehicle tank must be checked for obvious damage (e.g. ice formation on the outer tank shell). Leaks in LNG systems can be detected with a suitable portable gas detector (methane detector), as LNG is odourless. Any leakage or ice formation on the outer tank shell on a vehicle must be reported immediately to the responsible person in charge (competent management).

A leak detection spray may not be suitable under certain circumstances as it can freeze on gas-carrying pipes. If a suitable leak detection spray for cryogenic temperatures is available, this can also be used.

If a leak has been detected in the gas system beforehand, the motor vehicle must not be started or driven into the hall/workshop. The manufacturer's specifications must be observed. The tank pressure must not exceed 12 bar before entering the workshop. If the tank pressure is higher than 12 bar, the tank pressure must first be reduced below 12 bar according to the manufacturer's specifications

## 6.2 Install the blow-off device to the LNG tank

The drained methane is discharged into the environment via the roof of the hall/workshop by means of a permanently installed chimney (see Figure 6-1).

The blow-off device must be installed by a competent person. The connection must then be checked by a responsible person (competent management) to be appointed by the company. After connecting the blow-off device, the vehicle must be provided with the respective identification plate (see Figure 6-4).

The design of the chimney and the design of the blow-off device must be individually adapted to the structural conditions of the hall/workshop.

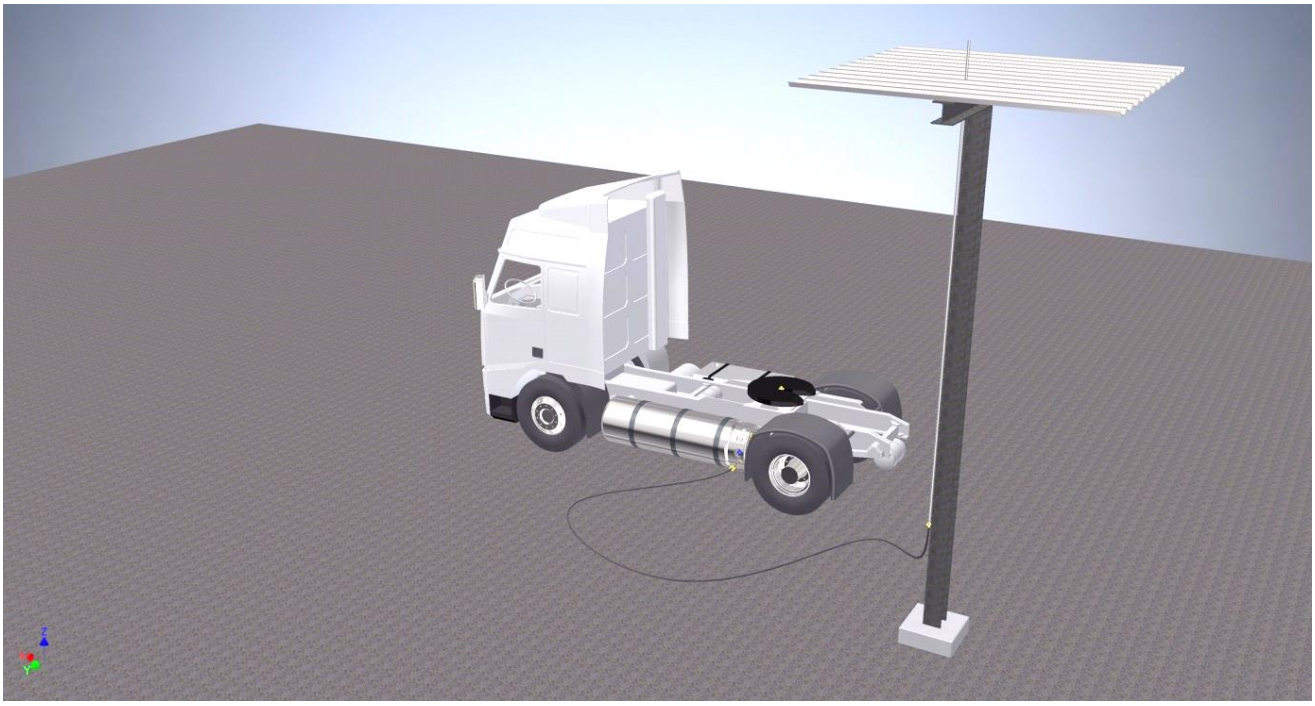


Figure 6-1: Connection diagram "Blow-off device and canopy chimney"; source: GasCom

### 6.2.1 Vehicles with tank systems of the brand Chart

If a motor vehicle with LNG drive has been brought into a hall/workshop, the simple discharge of boil-off gas must be ensured via a blow-off device that is connected gas-tight to the "Vent" connection of the LNG system. The blow-off device has a pressure valve that opens at an absolute pressure of 14 bar. This ensures that the permanently installed relief valve on the LNG tank, which diverts the boil-off gas via the blow-off lance behind the driver's cab and opens at approx. 16 bar, is not triggered.

### 6.2.2 Procedure description - Connecting the blow-off device on chart LNG tanks

**Step 1**

Connect the blow-off device to the connection of the pressure compensation valve "Vent" on the LNG tank.

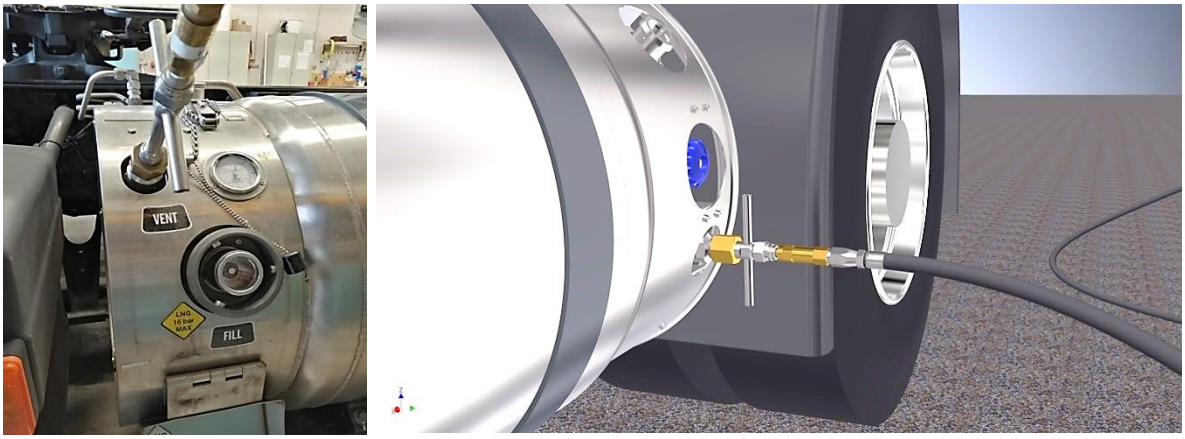



Figure 6-2: Installed blow-off device chart LNG tank (attached);
source: ZDK (left figure)/GasCom (right figure)

**Step 2**

Open the grey manual shut-off valve "Vent" at the rear of the tank. It is imperative that this valve is open otherwise the absolute tank pressure will not be applied to the "Vent connection".

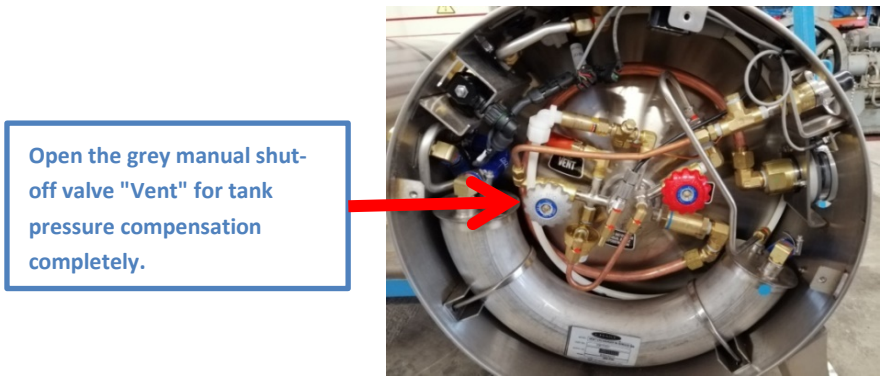



Figure 6-3: Grey manual shut-off valve "Vent"; source: ZDK

**Step 3**

Clear marking by means of identification plate "White" if

- the vehicle is connected to the blow-off device and the grey manual shut-off valve "Vent" is completely open (applies to general work not concerning the gas system "White sign").


Figure 6-4: Identification of vehicles with LNG drive in the workshop; source: ZDK

**After the motor vehicle has been connected to the blow-off device connected to the canopy chimney, the grey manual shut-off valve "Vent" shall be turned completely open and the vehicle shall be clearly marked according to the work to be carried out.**

**Connecting to the exhaust extraction system is strictly prohibited. There is a risk of explosion.**

**Since methane is lighter than air due to its low density, the methane rises automatically through the connecting tube via the chimney into the environment.**

### 6.2.3 Draining the gas-carrying lines from the LNG vehicle tank (chart LNG tanks

**Step 1**

- Connect the blow-off device to the vehicle tank (pressure compensation valve "Vent") and open the grey manual shut-off valve ("Vent").
- Close the red manual shut-off valve.

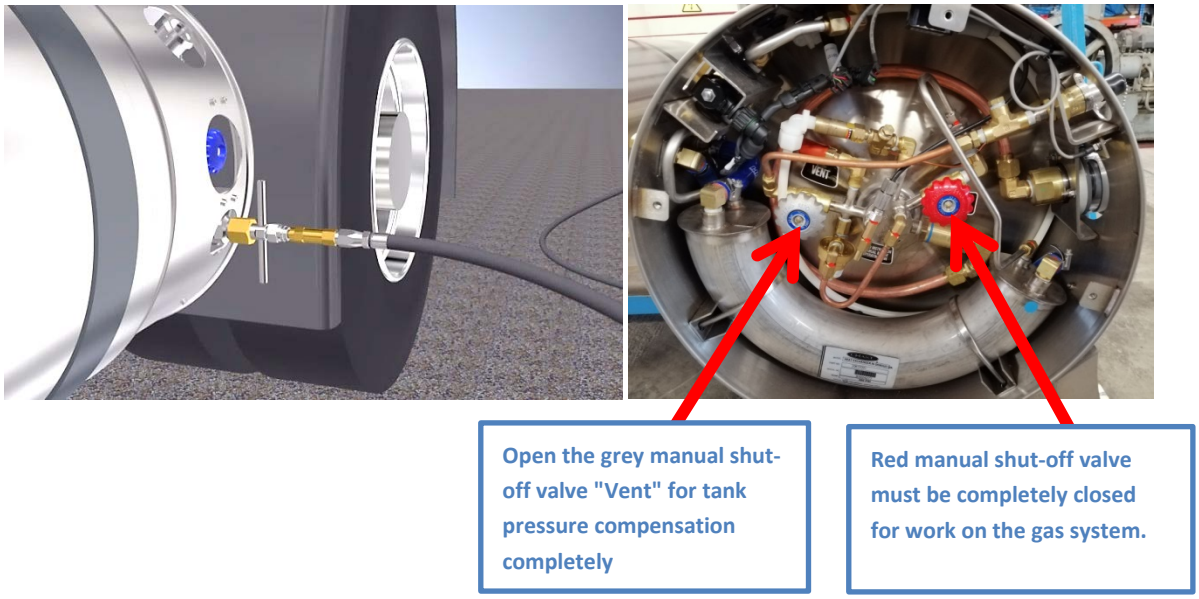



Figure 6-5: Blow-off device and manual shut-off valves; source: ZDK

**Step 2**

Run the combustion engine until it switches itself off due to lack of gas.

**Step 3**

Clear marking by means of identification plate "Red" if

- the vehicle is connected to the blow-off device and the grey manual shut-off valve "Vent" is completely open (applies to work involving the gas system) and the red manual shut- off valve is closed ("Red sign").


Figure 6-6: Warning sign "Red"; source: ZDK

### 6.2.4 Vehicles with Westport brand tank systems

If a motor vehicle with LNG propulsion drive has been brought into a hall/workshop, the simple discharge of boil-off gas must be ensured via a blow-off device which, in the case of Westport tank systems, is connected in a gas-tight manner to the tank connection of the LNG system. The blow-off device has a pressure valve that opens at an absolute pressure of 14 bar. This ensures that the permanently installed relief valve on the LNG tank, which diverts the boil-off gas via the blow-off lance behind the cab and opens at approx. 16 bar is not triggered.

The drained methane must be discharged into the environment via the roof of the hall/workshop by means of a permanently installed chimney.

### 6.2.5 Procedure Description - Install the Blowdown Device on Westport LNG Tanks

**Step 1**

Install the blow-off device to the tank connection on the LNG tank


Figure 6-7: Connection of the blow-off device; source: ZDK

**Step 2**

Open the grey manual shut-off valve ("Station Vent") at the front of the tank. It is imperative that this valve is open otherwise the absolute tank pressure will not be applied to the tank connection.


Figure 6-8: "Station Vent" - valve on the tank; source: ZDK

**Step 3**

Clearly mark the vehicle by means of the white identification plate if

- the vehicle is connected to the blow-off device and the "Station Vent" manual shut-off valve is open ("White Tag" applies to general work not involving the gas system).


Figure 6-9: Identification of vehicles with LNG drive in the workshop; source: ZDK

### 6.2.6 Draining the gas-carrying lines from the LNG vehicle tank (Westport LNG tank)

Before starting work on the gas system, the gas lines must be safely drained. For the safe draining of the gas-carrying lines on vehicles equipped with Westport tank systems, only the repair specifications of the respective vehicle manufacturer must be observed.

Before emptying the gas-carrying lines from the vehicle tank, connect the vehicle to the blow-off device and clearly mark the vehicle by means of the red identification plate if

- the vehicle is connected to the blow-off device, the manual shut-off valve "Station Vent" is open and the gas-carrying lines from the tank have been drained in accordance with chapter 6.2.6 ("Red sign" applies to work affecting the gas system).


Figure 6-10: Warning sign "Red"; source: ZDK

# Notes


KRAFTFAHRZEUG
GEWERBE