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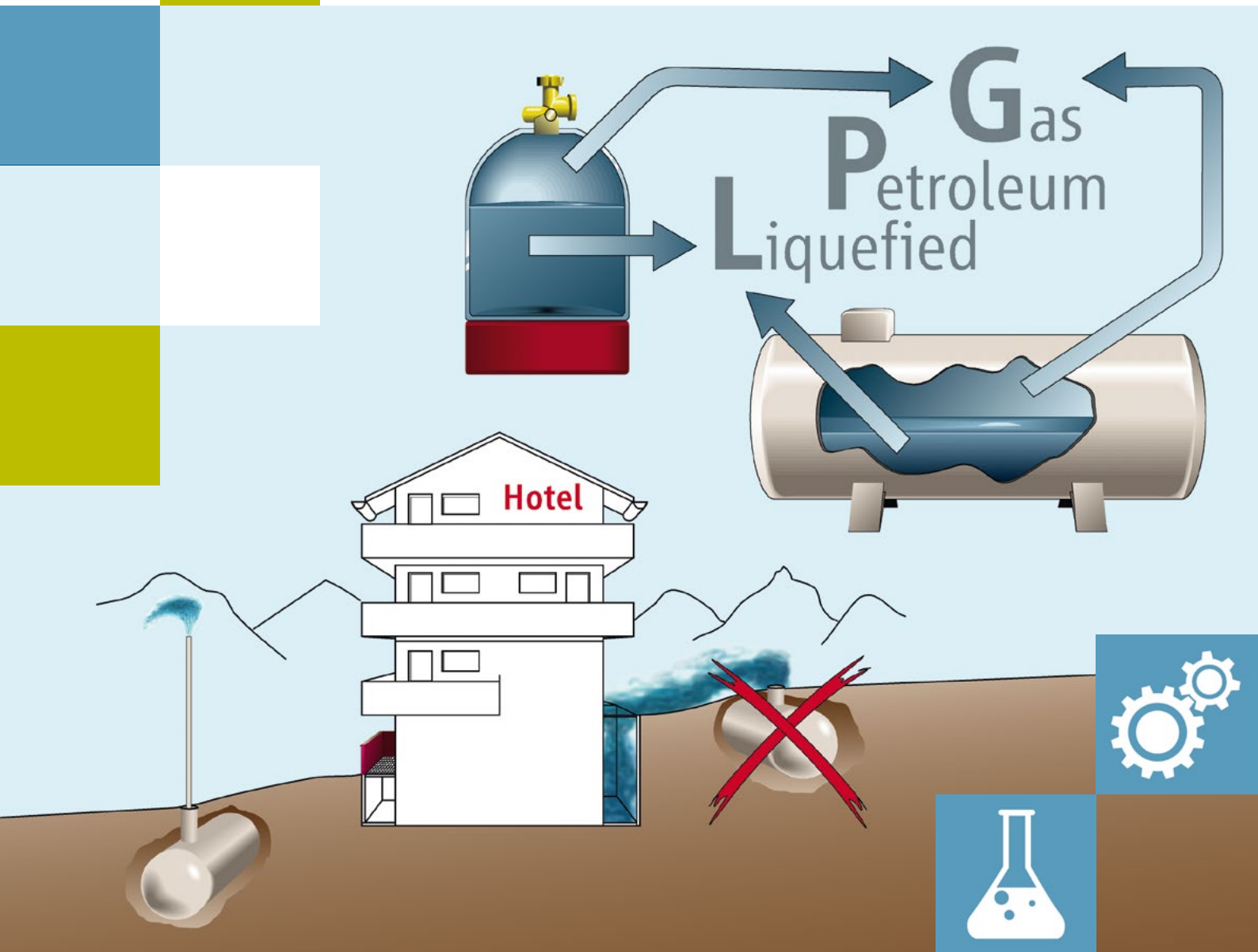
Section on Prevention in the Chemical Industry
Section on Machine and System Safety

Safety of liquefied petroleum gas systems

Propane and butane



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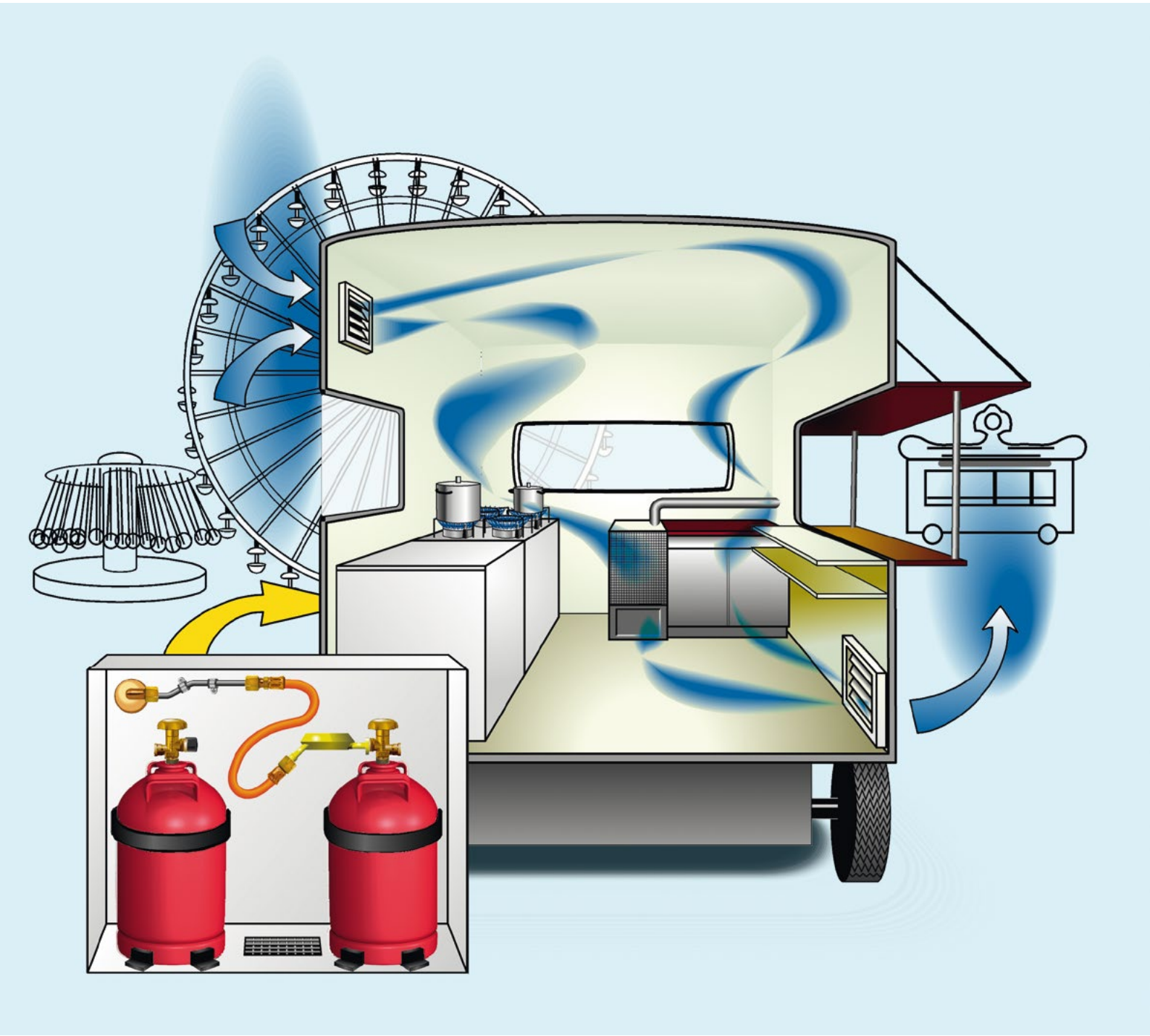
Safety of liquefied petroleum gas systems

Propane and butane

Legislation refers to both the employer and the entrepreneur. The two terms are not completely identical because entrepreneurs do not necessarily have employees. In the context of the present topic, this does not result in any relevant differences, so that these terms are used synonymously.

To facilitate readability, the forms chosen for personal designations (e.g. employer, entrepreneur) apply to both genders in this brochure.

Content



Safety of liquefied petroleum gas systems: Propane and butane

Foreword

This compendium was developed in close cooperation with experts on liquefied petroleum gas from the ISSA Sections Chemical Industry and Machine and System Safety. It is intended to enable project engineers, plant managers, safety specialists, etc., without special knowledge in the field of liquefied petroleum gas, to assess whether hazards may arise from liquefied petroleum gas in their own plant or during the construction, equipment and installation of liquefied petroleum gas systems.

The compendium is not intended to answer the question of which protective measures are required in each case, as it is often not possible to make binding statements due to the very different national regulations. Rather, it identifies the problems and formulates possible solutions to achieve the protection goals.

Thomas Köhler
President of the Section on
Prevention in the Chemical Industry

Jürgen Schulin
President of the Section on
Machine and System Safety

General

The figures created in this brochure are for worldwide information. The figures have been drawn in a simplified manner for clear and uniform presentation. For example, when depicting pressure regulating devices, single-stage pressure regulators are shown and details, such as safety labels, are only shown if they are necessary to understand the figure.

Please observe your national rules and regulations for the use of liquefied petroleum gas in commercial and private areas!

Definitions

What is understood by liquefied petroleum gas?

For the purposes of this brochure, liquefied petroleum gas (LPG) is defined as combustible gases that can be liquefied under pressure, such as propane, butane and their mixtures.

Strictly speaking, there is a contradiction in the term "liquefied petroleum gas". According to the laws of physics, matter at certain temperatures and pressures can only exist in either a solid, liquid or gaseous state. However, since low-boiling hydrocarbons are present in a pressure vessel in the liquid – as well as in the gaseous – phase, the term "liquefied petroleum gas" has come into usage for this two-phase state.

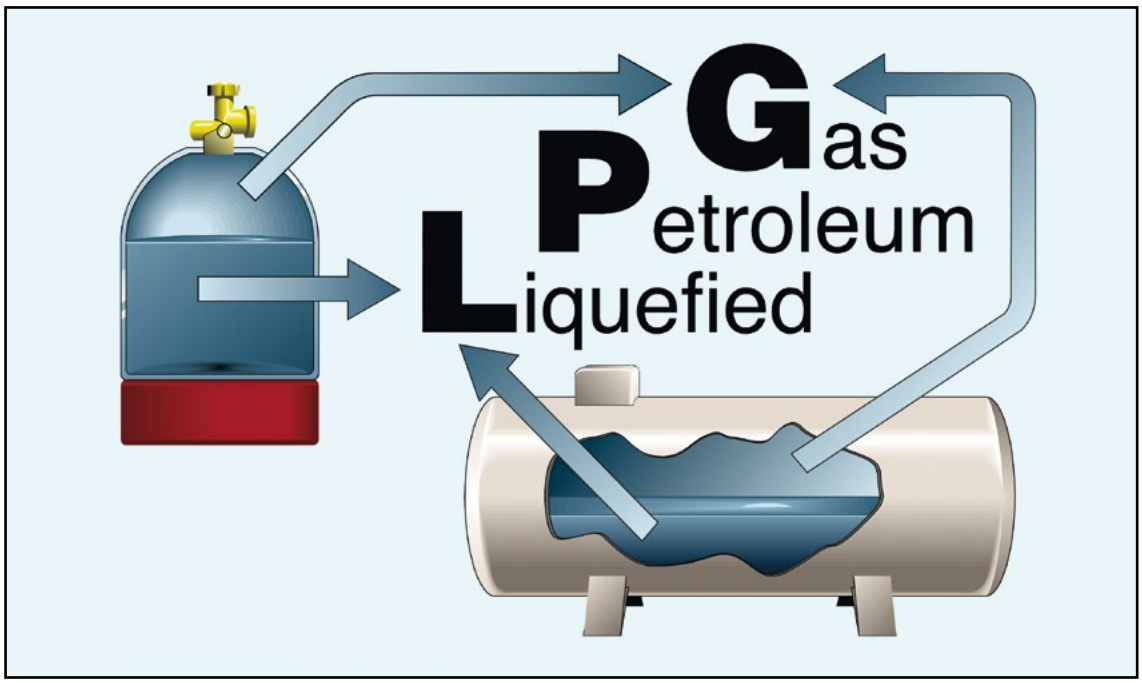


Figure 1:
Two-phase state of liquefied petroleum gas

What is understood by LPG systems?

For the purposes of this brochure, LPG systems are understood to be the supply and consumption systems connected as a unit (this also includes supply systems with compressed gas cartridges (disposable containers). LPG systems are used in particular for fuel gas purposes (extraction from the gaseous phase, e.g. for heating, cooking or hand-held burners (Fig. 4)) and propellant gas purposes (extraction from the liquid phase, e.g. for driving forklift trucks (Fig. 5).

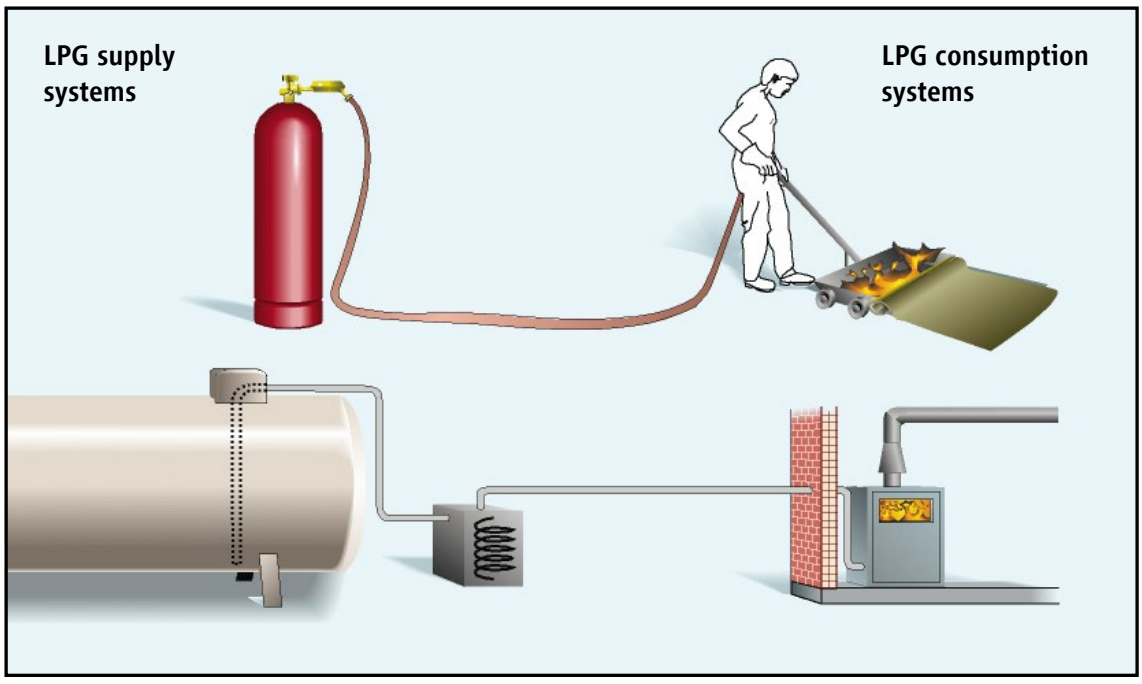


Figure 2:
LPG supply and consumption systems

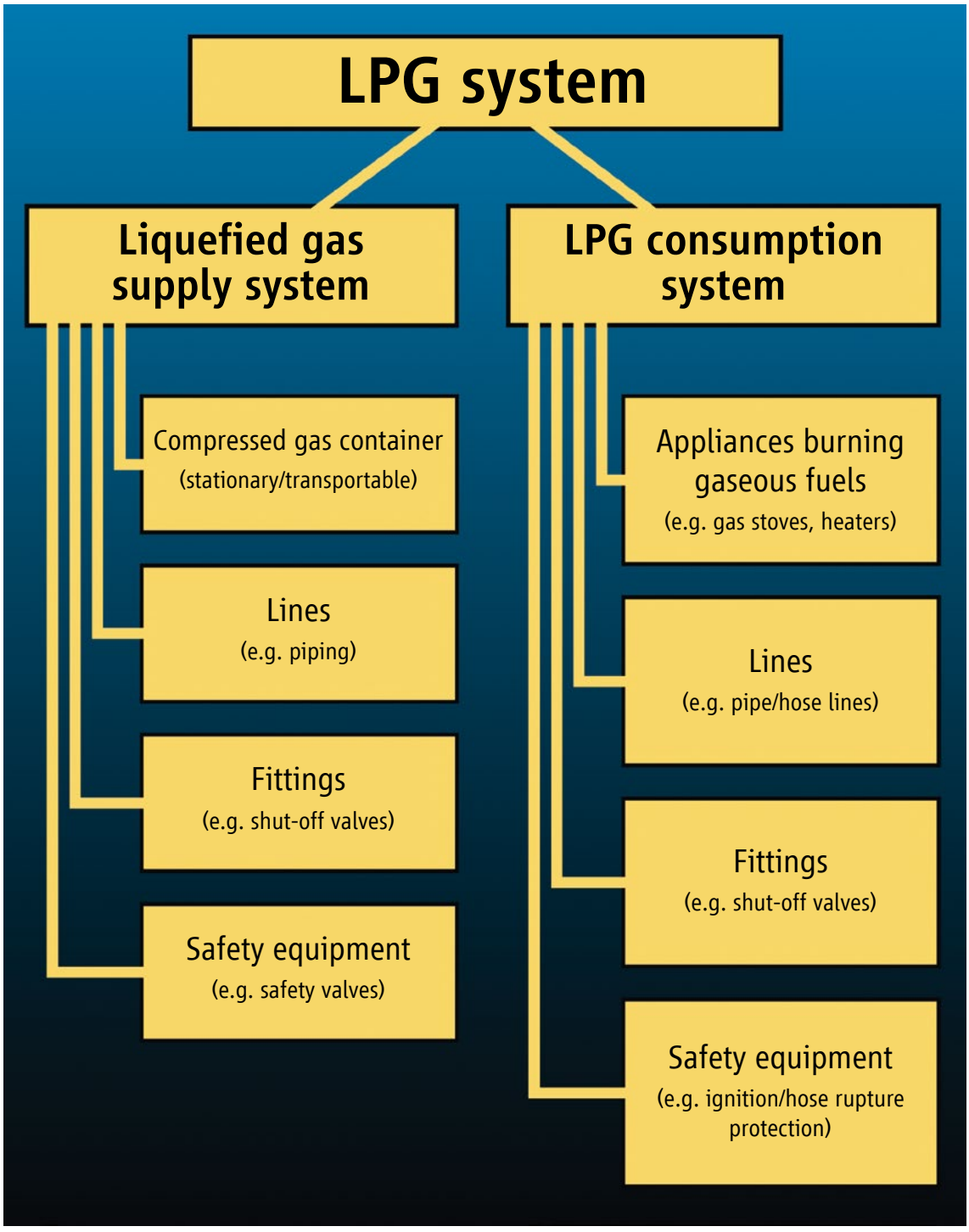


Figure 3:
Parts of LPG systems

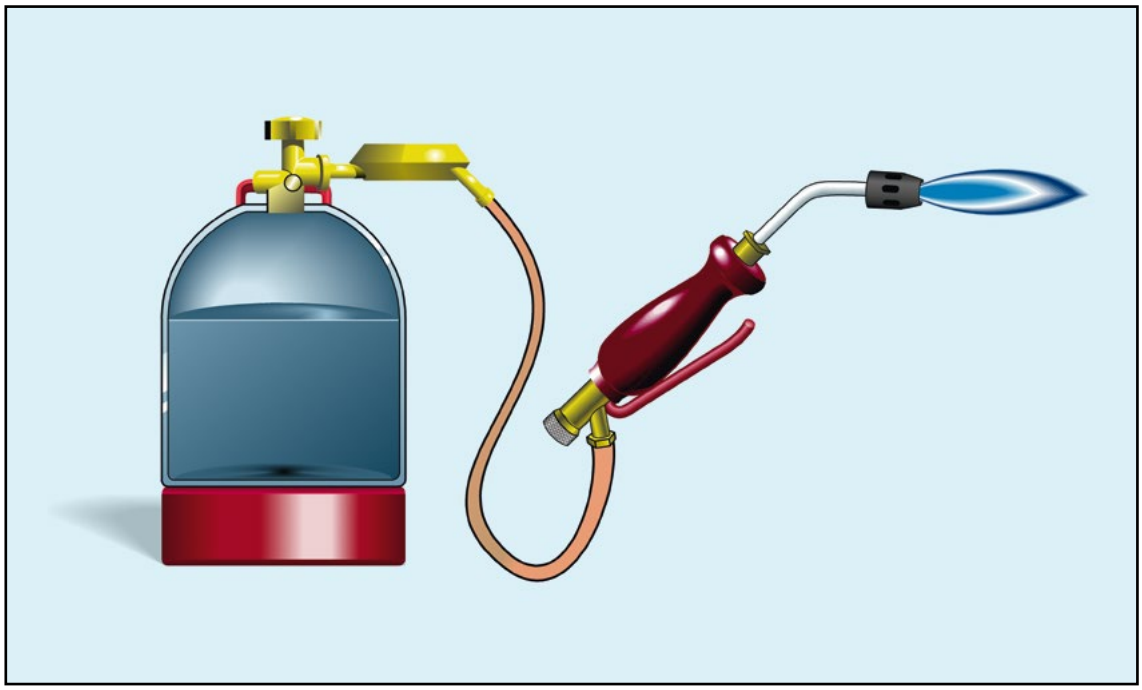


Figure 4:
Fuel gas cylinder application – supply from the gas phase

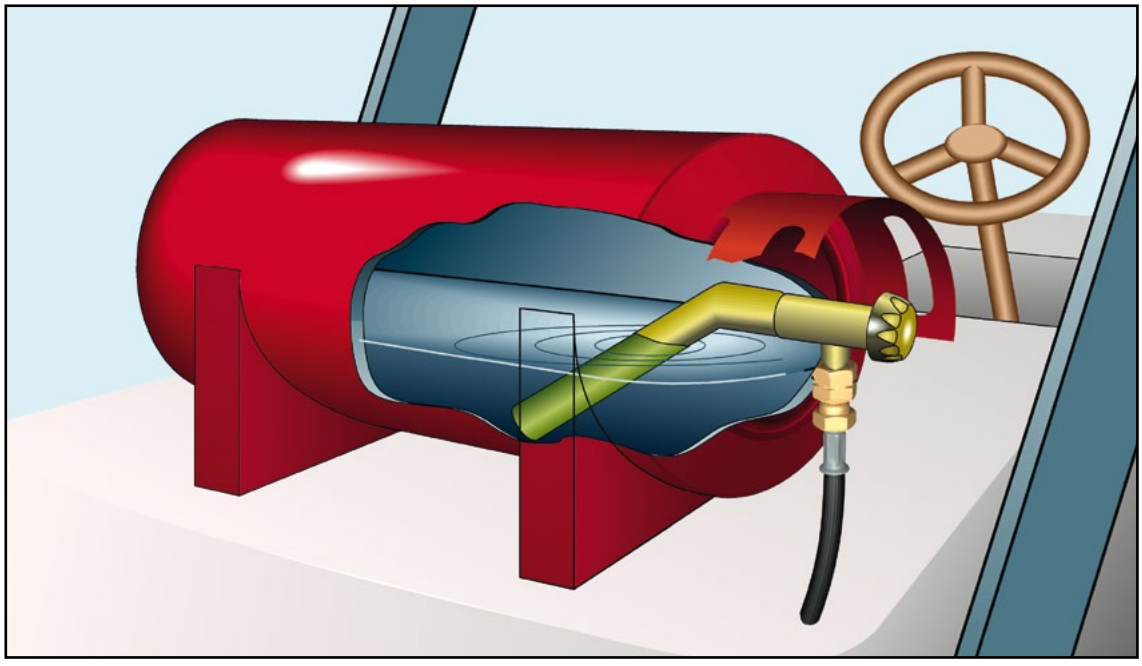


Figure 5:
Propellant gas cylinder application – supply from the liquid phase

What are LPG supply systems?

LPG supply systems include all compressed gas containers (e.g. tanks, cylinder batteries or cylinders) used to supply consumption systems. The supply systems also include the associated piping and equipment.

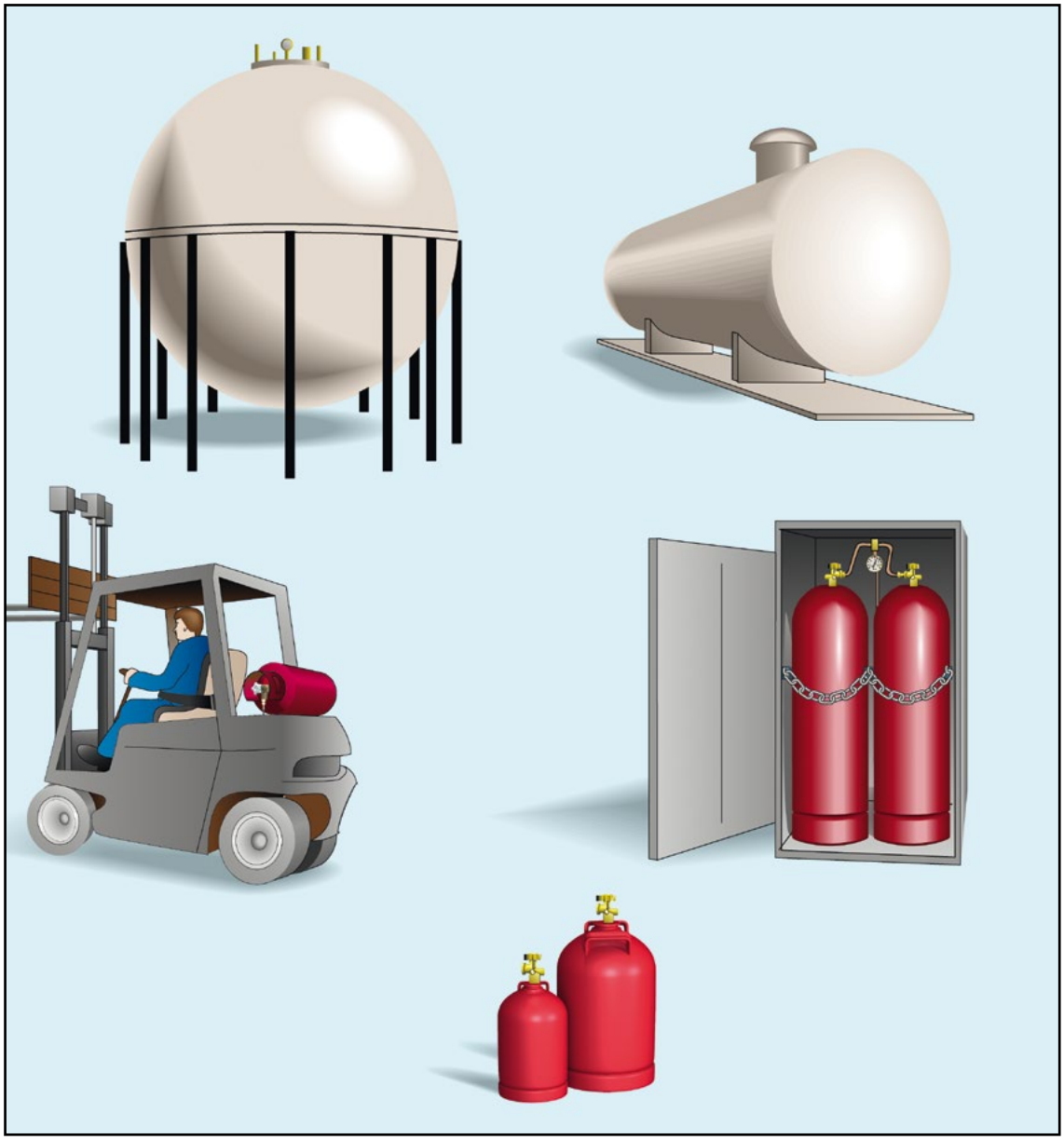


Figure 6:
LPG supply systems

What are LPG consumption systems?

LPG consumption systems include the appliances burning gaseous fuels (e.g. gas stoves, heaters) including their equipment parts and the associated piping network.

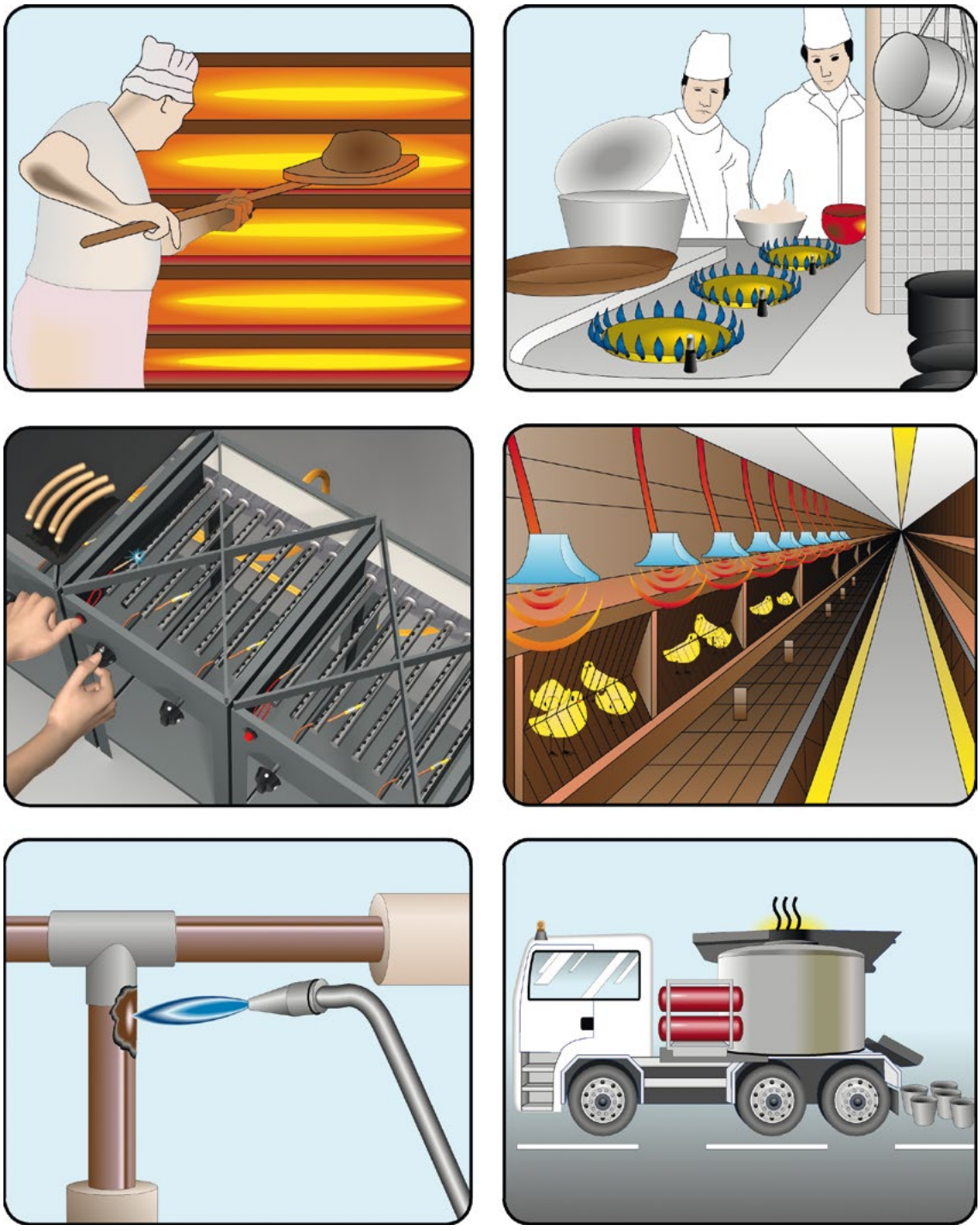


Figure 7:
LPG consumption systems

Properties and hazards

What are the main properties of LPG?

The proper and safe use of the energy carrier LPG requires knowledge of the most important chemical and physical properties.

The properties of LPG relevant to safety can be summarized as follows:

- LPG is an extremely flammable gas that can form explosive mixtures with air or oxygen (Fig. 8).
- The density numbers of propane, butane and air show that LPG in the gaseous state is about twice as heavy as air, so it can sink to the ground and flow like a liquid to the lowest point, e.g. to lower-lying rooms (Fig. 9). For this reason, LPG systems, for example, may only be installed below ground level under certain conditions.

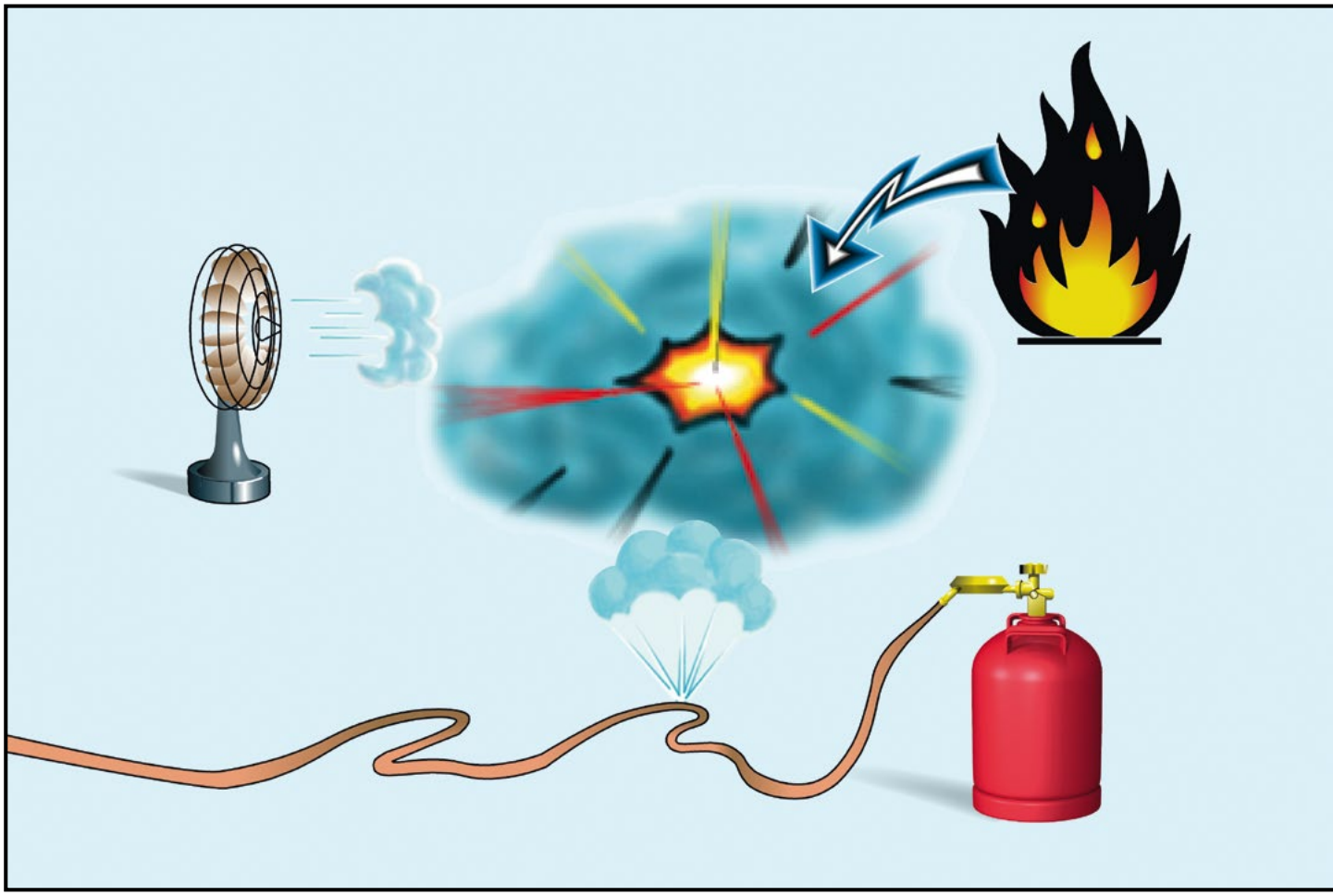


Figure 8:
Preconditions for the occurrence of LPG explosions

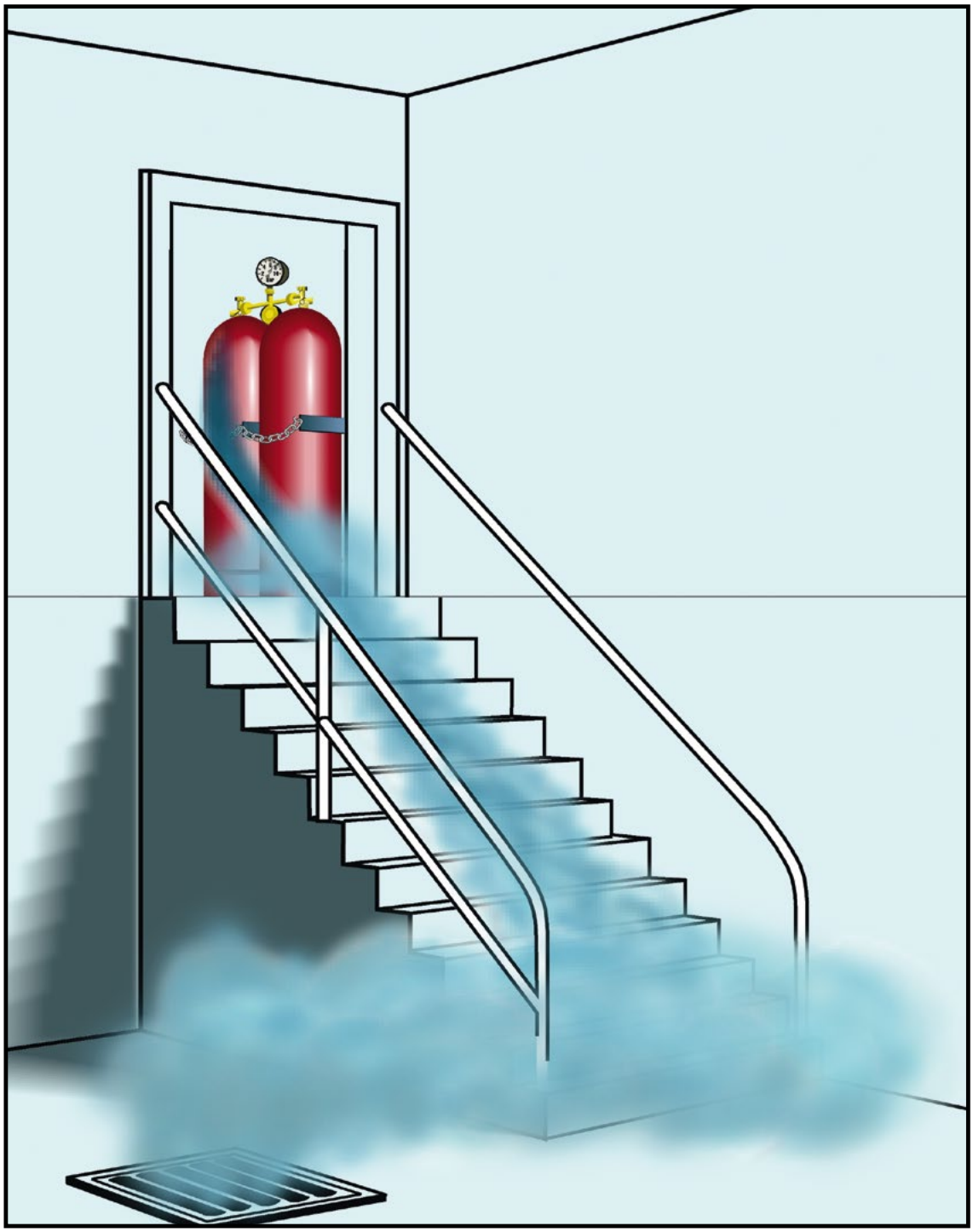


Figure 9:
Dispersion behavior of LPG

- LPG is colorless and therefore invisible.
- LPG can be converted from a gaseous to a liquid state at relatively low pressure.
- LPG exhibits special behavior with regard to its volume:
  - The thermal expansion of the liquid phase (compared to other liquids, e.g. water) is extraordinarily high.
  - The increase in volume during evaporation is considerable: 0.5 kg of liquid propane has a volume of about 1 liter in the liquid state. 0.5 kg (1 liter) of liquid propane has a volume of approx. 260 liters in the gaseous state (Fig. 12).

Since pure LPG is odorless, a small amount of an odorant is added to it so that leaked gas can be easily detected.

LPG (propane and butane) are invisible, extremely flammable gases that are heavier than air.

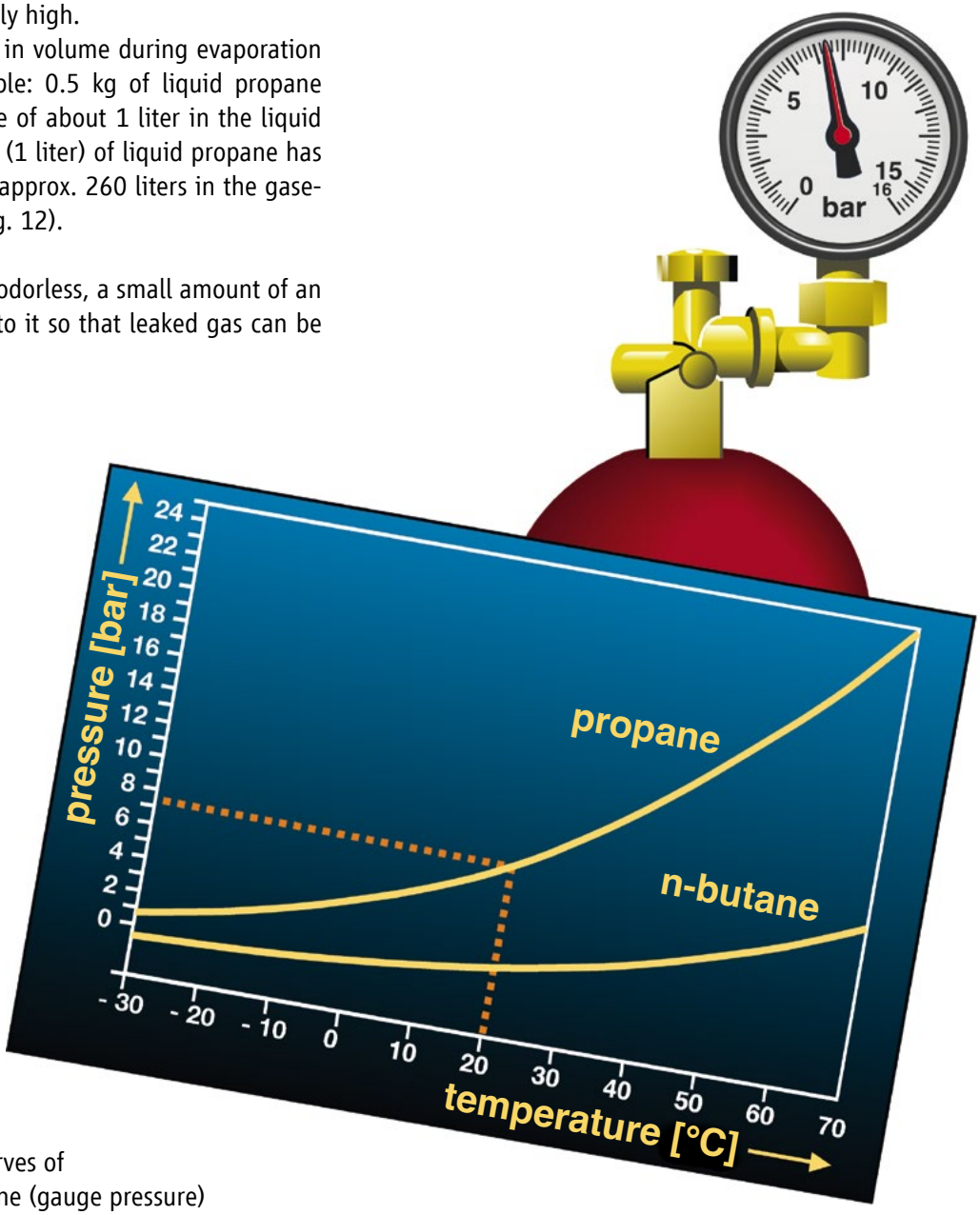


Figure 10:
Vapor pressure curves of
propane and butane (gauge pressure)

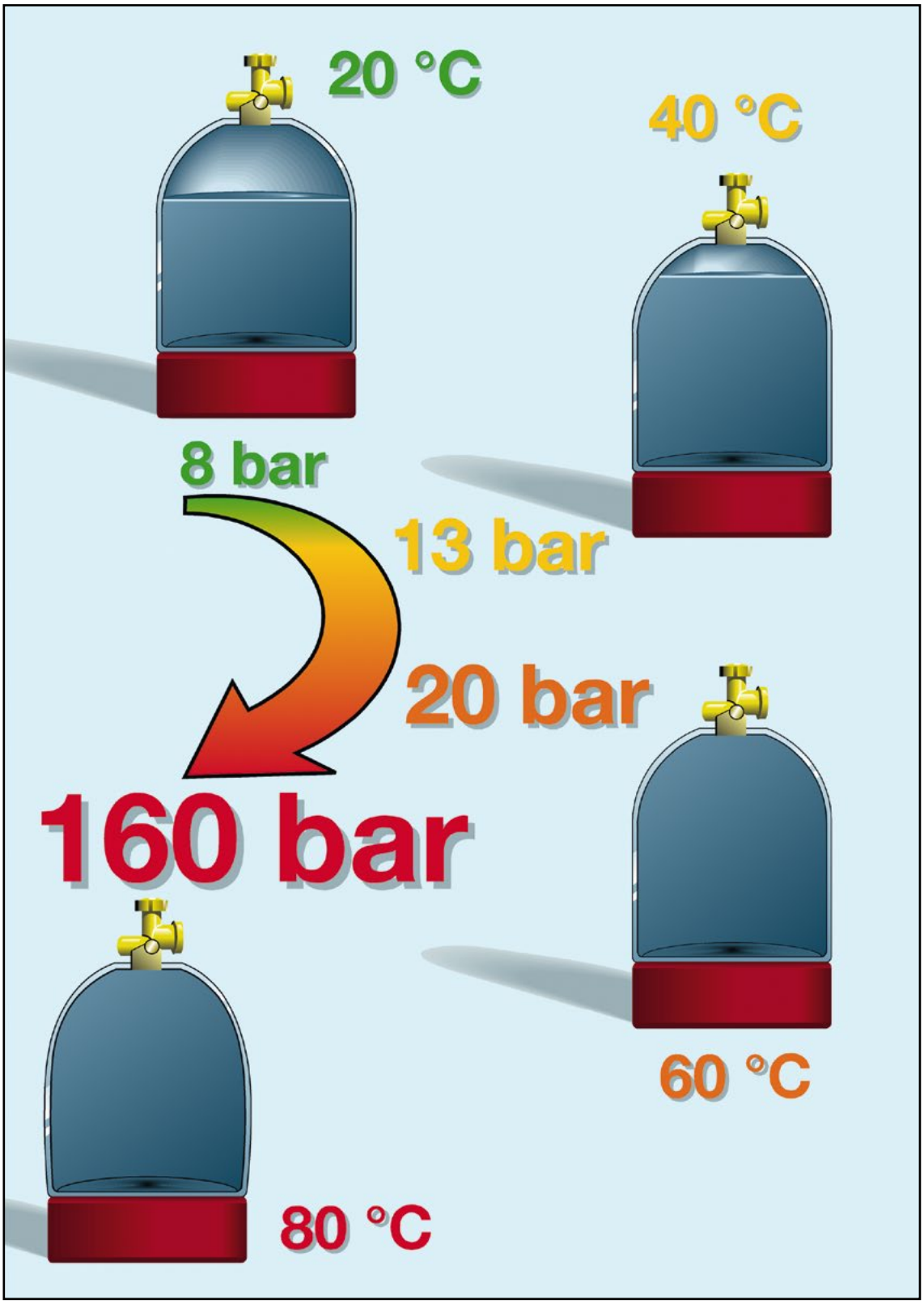


Figure 11:
Pressure increase within a propane vessel as temperature increases. The volume of the liquid phase increases, while the compressible gas phase decreases until it disappears completely.

Figure 12:
Volume increase during evaporation of propane

What are the hazards of storing and using LPG?

Uncontrolled liquid or gaseous LPG leaks and incomplete combustion are the two main sources of danger when storing and using LPG.

The hazards involved are:
- Explosion and fire hazard,
- Risk of poisoning, especially from carbon monoxide.

In addition, hazards from asphyxiation and cold burns (severe heat extraction leading to skin burns) should be noted. Cold burns can occur, for example, when refueling forklift trucks by leakage of the liquid phase onto unprotected skin.

Figure 13:
Main hazards associated with the storage and use of LPG: Explosion, fire and poisoning hazards, exploding gas cylinders

When do fire and explosion hazards have to be expected?

Escaping LPG can be ignited by an effective ignition source. The risk is particularly high when LPG can accumulate in depressions such as cellars, pits, manholes, or sewers.

- The pressure in compressed gas containers for LPG, such as tanks or cylinders, is temperature-dependent (cf. vapor pressure curves, Fig. 10). The overpressure of propane at 20 °C is approx. 7.4 bar; at 50 °C the overpressure is approx. 16.3 bar! Strong heating of the container (e.g. by external fire or internal heating) leads to a massive pressure increase in the container (see Figs. 11 and 15).

Under circumstances, the following may occur:

- a large LPG leakage from the safety valve or in case of missing or non-functioning safety valve
- bursting of the container, which can result in particularly severe damage.

- As the temperature increases, the volume of the liquid medium also increases. For safety reasons, a gas cushion is therefore always required in the LPG container (Fig. 16).
- The volume of the liquid phase of LPG is extremely temperature-dependent. A temperature rise of 10 °C leads to a pressure rise of 70–80 bar in a container filled with liquid phase (unless there is a functioning safety valve). If a part of the system, e.g. a pipeline, is destroyed due to this pressure increase, a large quantity of LPG gas is released abruptly.

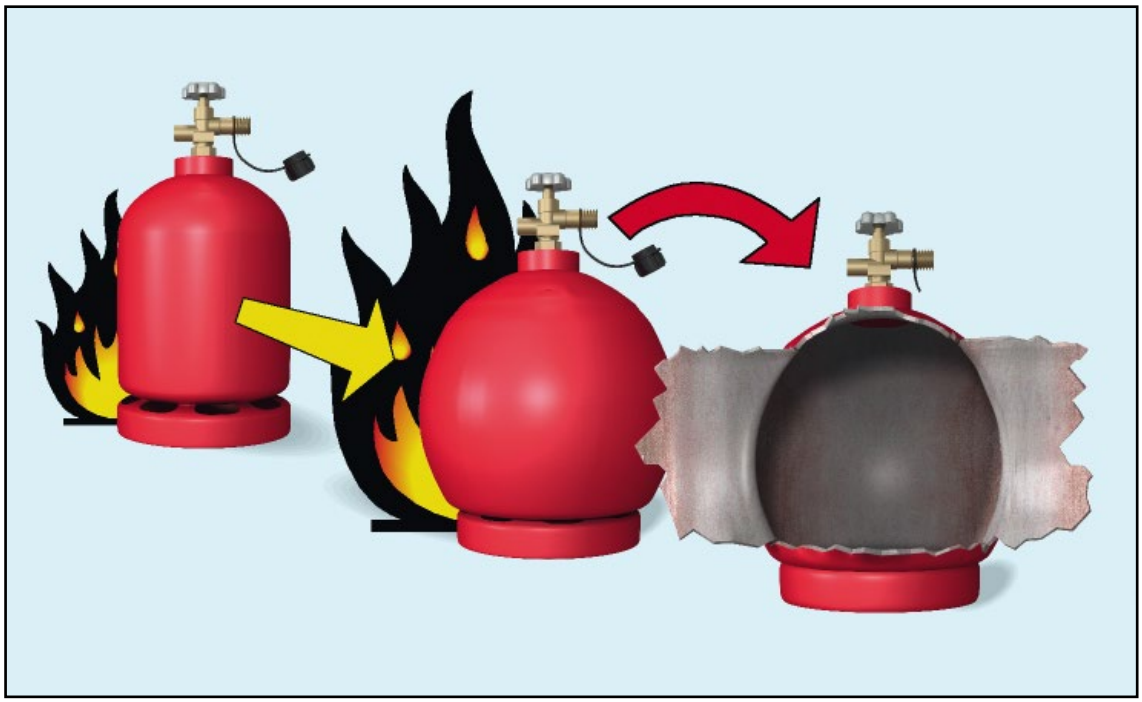


Figure 14:
Effect of fire on an LPG gas cylinder

The subsequent evaporation process causes an increase in volume by a factor of about 260.

- In the case of appliances burning gaseous fuels (e.g. gas stoves and heaters) without flame monitoring (ignition safeguard), LPG can escape unburned and form explosive mixtures.
- Improper handling of systems of this kind (e.g. transport with a burning flame) can cause a fire in a fire-prone environment (Fig. 17).

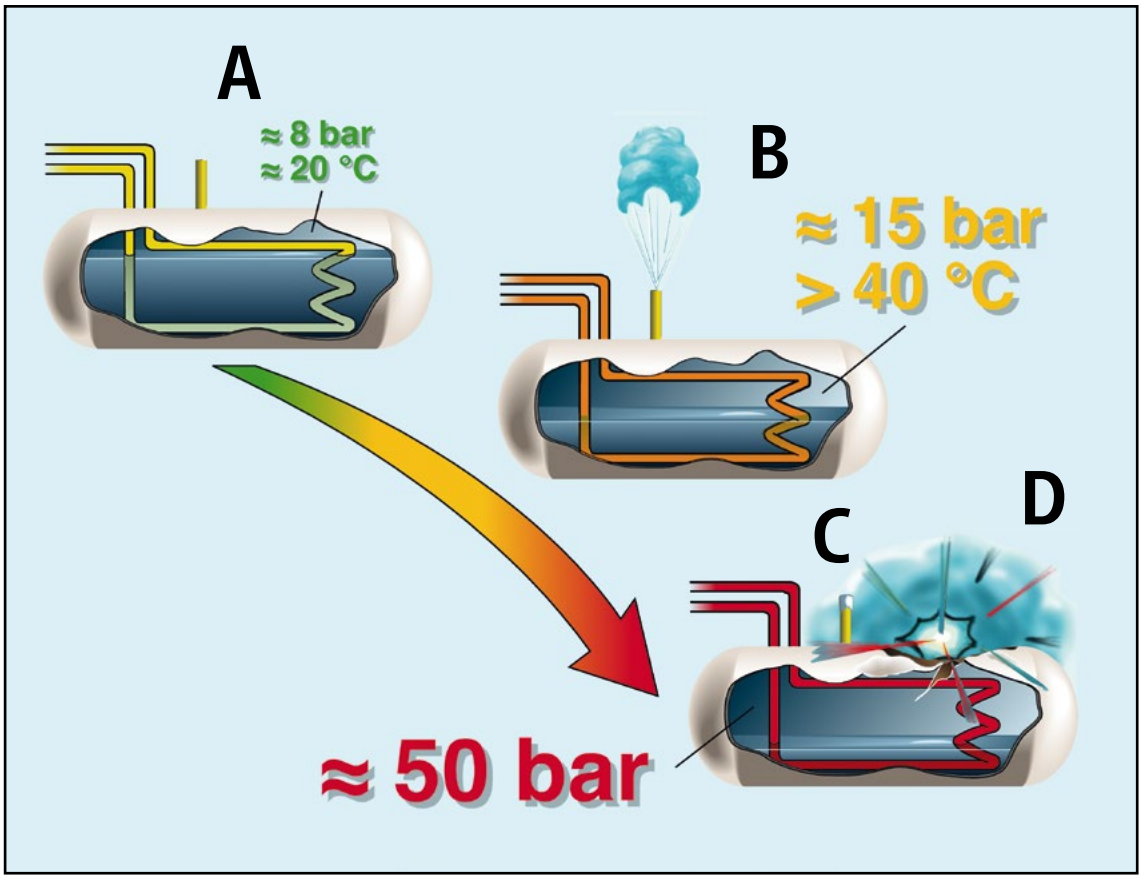


Figure 15:
A) Excessive heating of a compressed gas container with internal heating
B) Response of the safety valve
C) Possibly, icing of the safety valve
D) Bursting of the container

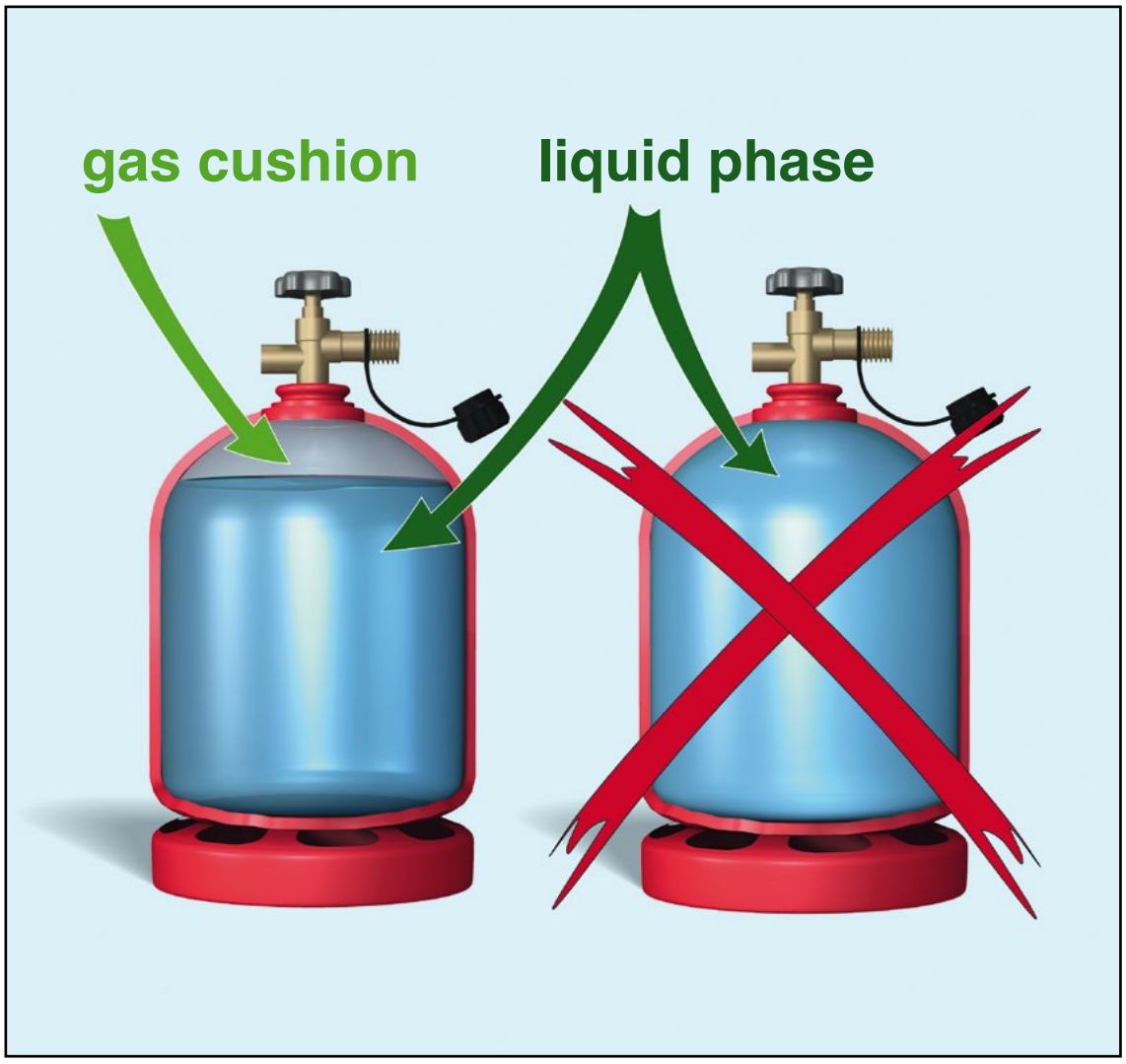


Figure 16:
Gas cushions in compressed gas containers as a safety measure (filling level in accordance with national regulations)

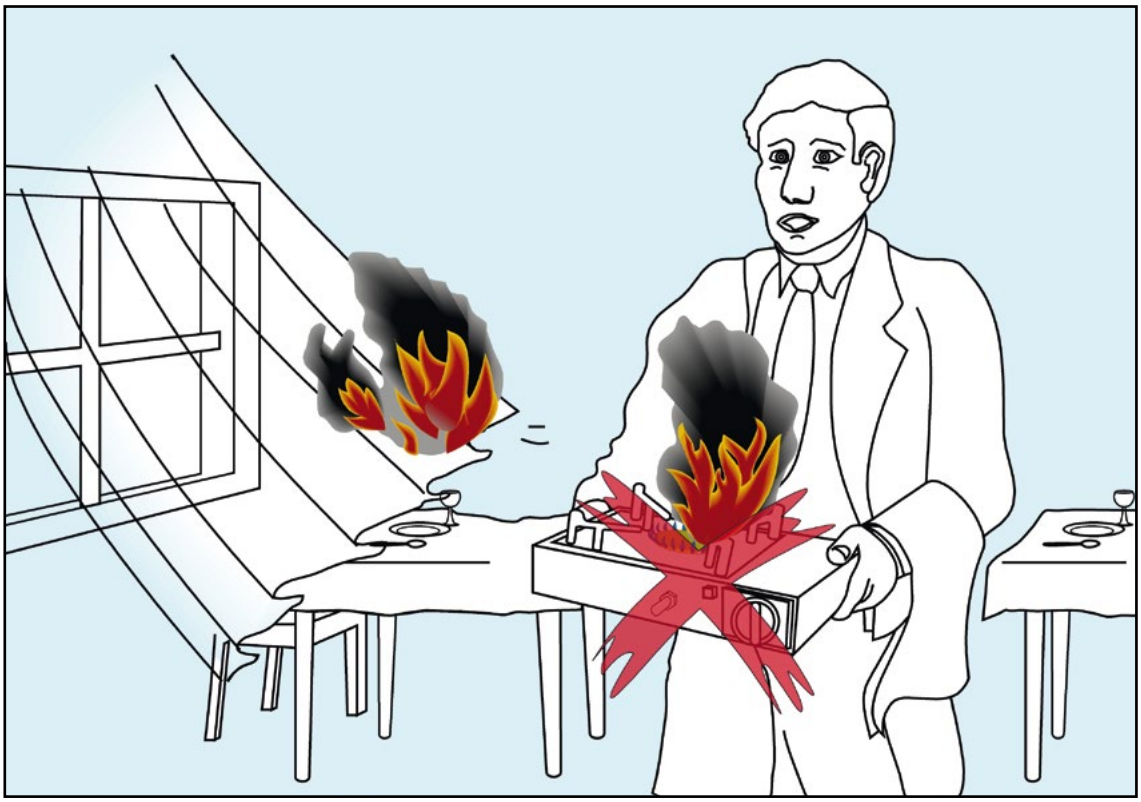


Figure 17:
Improper transportation of appliances burning gaseous fuels

How can the risk of poisoning occur?

Poisoning hazards are generally not caused by the LPG itself, but by its incomplete combustion – recognizable by a yellow combustion flame. Burning LPG requires large amounts of air (for 1 kg of liquefied gas about 15 m^3 air).

The dangerous carbon monoxide (CO) can be formed in hazardous quantities if

- there is a lack of sufficient air supply in appliances burning gaseous fuels and there is no exhaust duct to the outside,
- there is insufficient ventilation in the installation rooms or the combustion products are not safely discharged into the open air,
- dirty, incorrectly adjusted or defective appliances burning gaseous fuels are used.

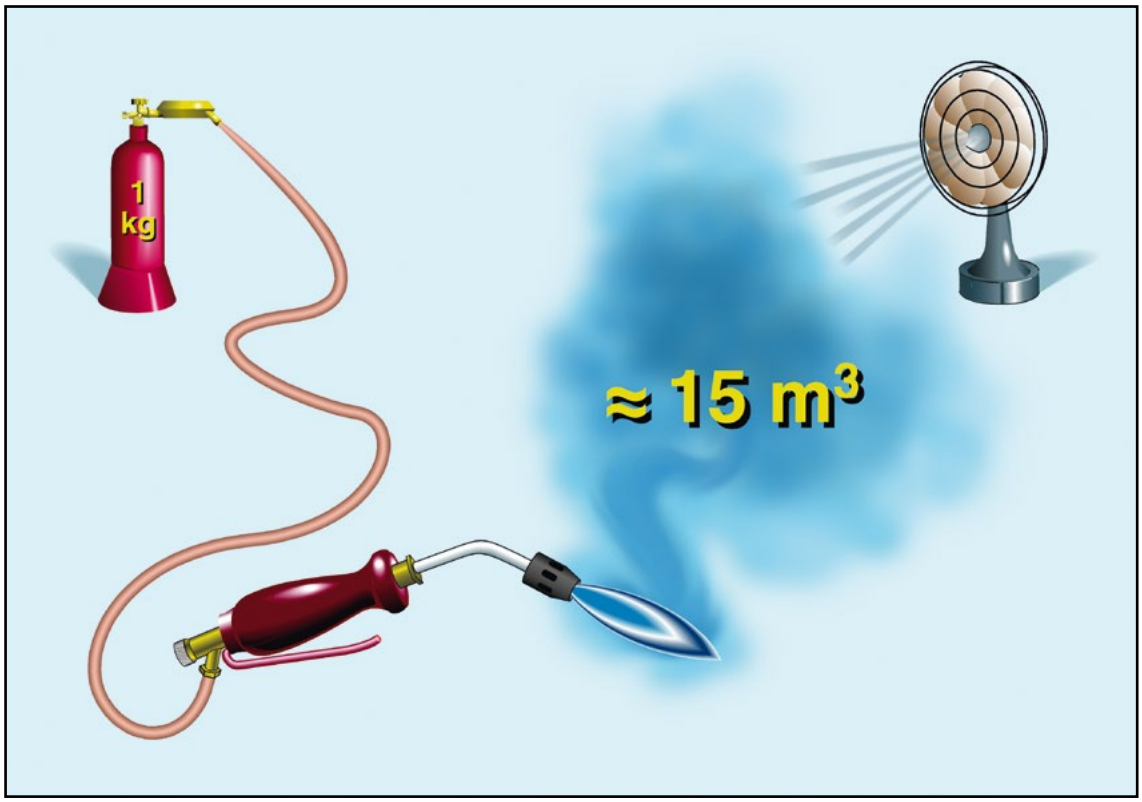


Figure 18:
Air requirement when burning LPG

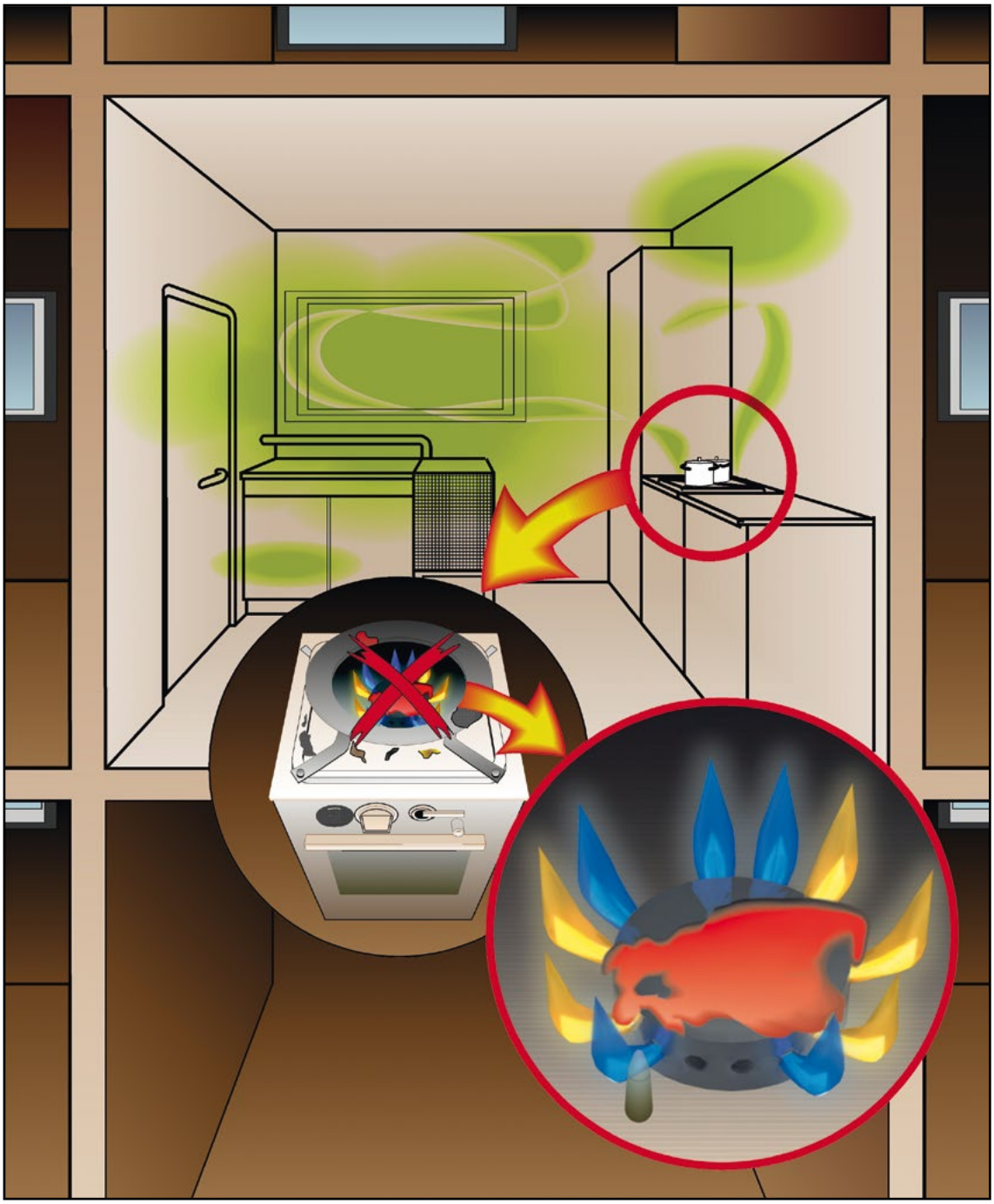


Figure 19:
Emergence of carbon monoxide as a result of dirty burners

Danger of poisoning due to incomplete combustion requires proper procedure in compliance with safety regulations when handling LPG.

Installation and safety measures

General

What should be considered with regard to leak tightness and material selection of LPG systems?

LPG systems must be designed to withstand the pressures and stresses to be expected and to be sufficiently tight based on the intended mode of operation and the properties of LPG.
The materials of the LPG systems must be made of non-combustible and non-brittle material as far as possible. System components that come into contact with LPG must, among other things, be resistant to LPG.

A major part of the accidents is due to leaks at the previously loosened joints after the cylinder change. If a leak should occur, a dangerous explosive atmosphere may form.

What must be observed particularly when setting up LPG systems?

- LPG system components such as compressed gas containers, fittings, lines or appliances burning gaseous fuels must be installed or supplemented with suitable structural or ventilation measures so that escaping LPG cannot flow into rooms below ground level, ducts, shafts, pits and the like and accumulate there.
- The placement of LPG cylinders in escape routes, passageways and thoroughfares is generally not permitted.
- LPG cylinders must not be placed in areas where there is a high fire potential (e.g. highly flammable or spontaneously combustible substances).
- LPG cylinders must be placed with the valve pointing upwards and secured against tipping over. This does not apply to propellant gas cylinders (horizontal operation, e.g. on forklift trucks).
- Connections of LPG system lines that are not in use must be tightly sealed with caps, plugs and the like.

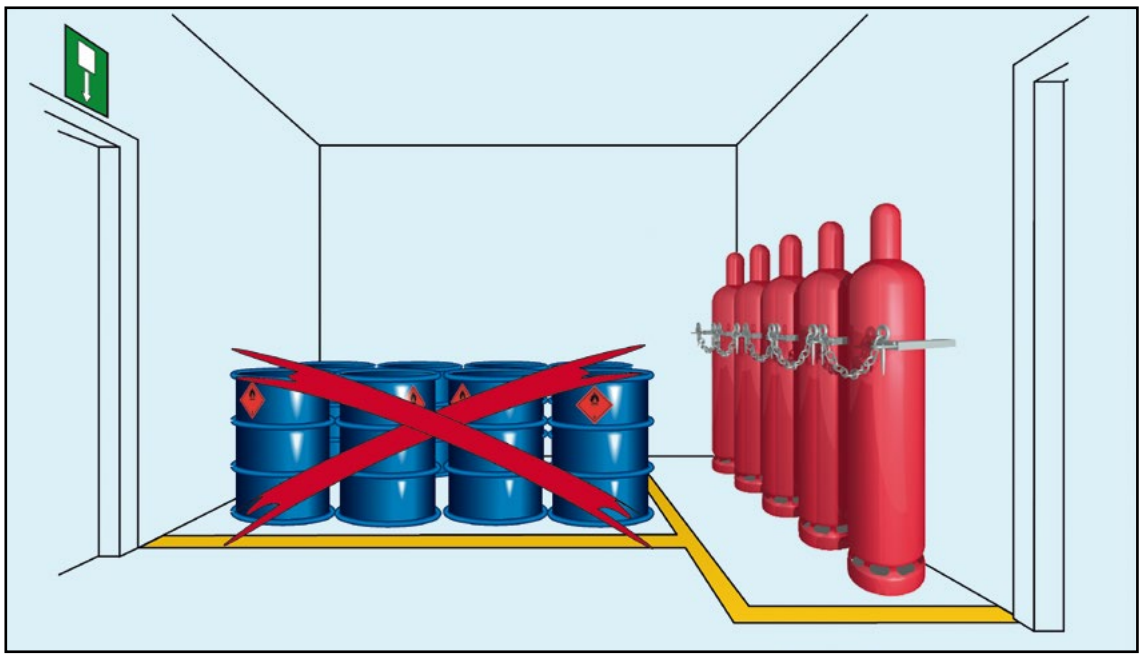


Figure 20:
Setting up of pressurized gas containers, e.g. LPG cylinders

What are the priorities when setting up LPG cylinders?

Decisive factors include the ventilation conditions at the installation site. These conditions are naturally better outdoors than indoors. For this reason, you must observe the following "installation priority":

1. Setting up the compressed gas containers outdoors (separately from the appliances burning gaseous fuels indoors).
2. Setting up the compressed gas containers in a separate installation room.
3. If setting up according to 1. or 2. is not possible, setting up in the workroom can be carried out in exceptional cases. The maximum permissible number of compressed gas containers installed is specified in corresponding national regulations or codes of practice.

What technical protective measures must be taken into account when installing LPG systems?

According to national regulations, protective measures must be taken in consideration of the use and local conditions, e.g.:

- Room ventilation
- Appliances burning gaseous fuels with thermoelectric ignition fuse (Figs. 21 and 35)
- Leakage gas safety devices (Figs. 22 and 23)
- Hose rupture safety devices
- Gas warning devices

What measures must be taken if LPG consumption systems have to be installed in rooms below ground level?

Due to the properties of LPG, it is not advisable to install the LPG supply systems below ground level!

If, in exceptional cases, an LPG consumption system is installed below ground level, further protective measures must be taken in accordance with national regulations, e.g.:

- technical ventilation of the room
- gas supply only with monitored effective ventilation (coupling; Fig. 21)

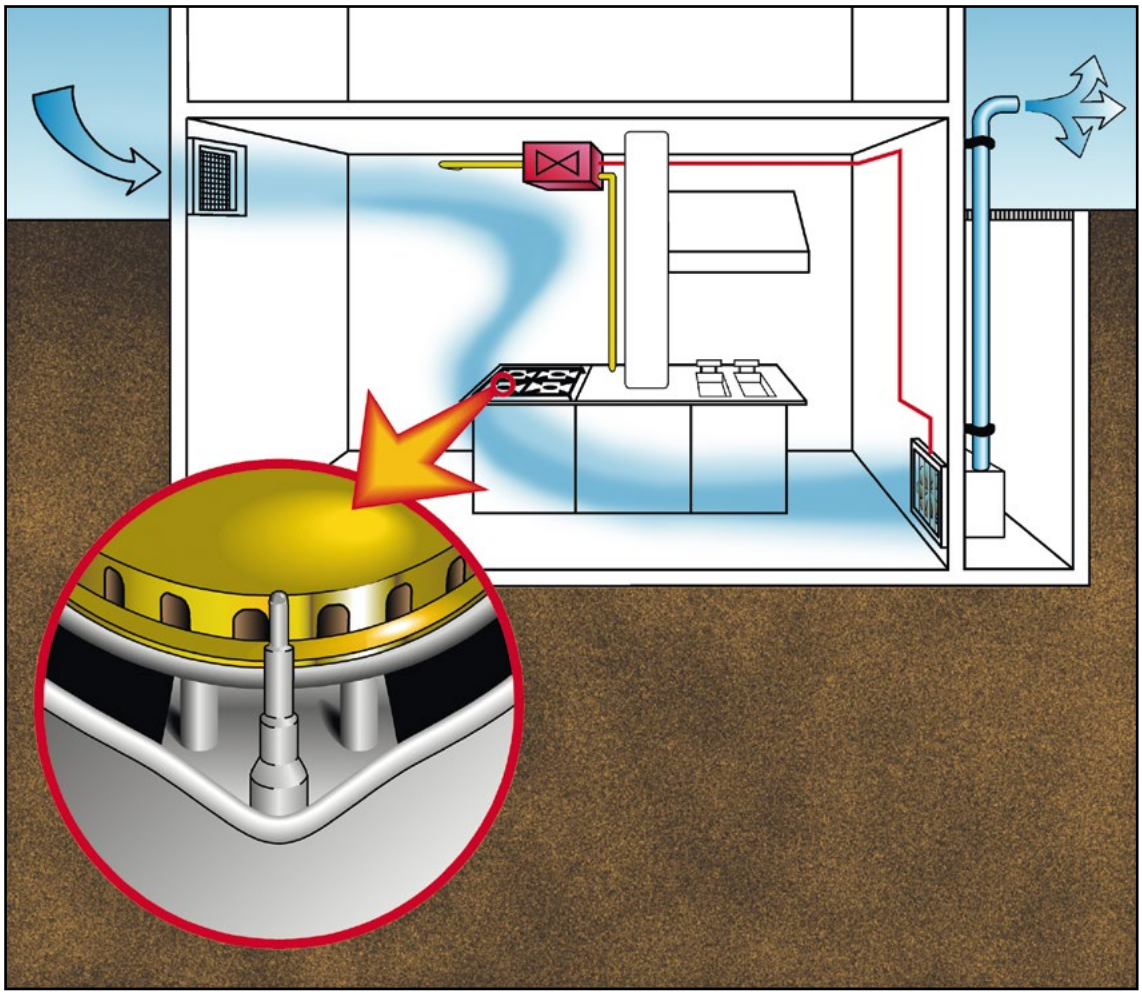


Figure 21:
Coupling the gas supply of appliances burning gaseous fuels with the ventilation system, e.g. in rooms below ground level. The cutout shows the thermoelectric ignition fuse.

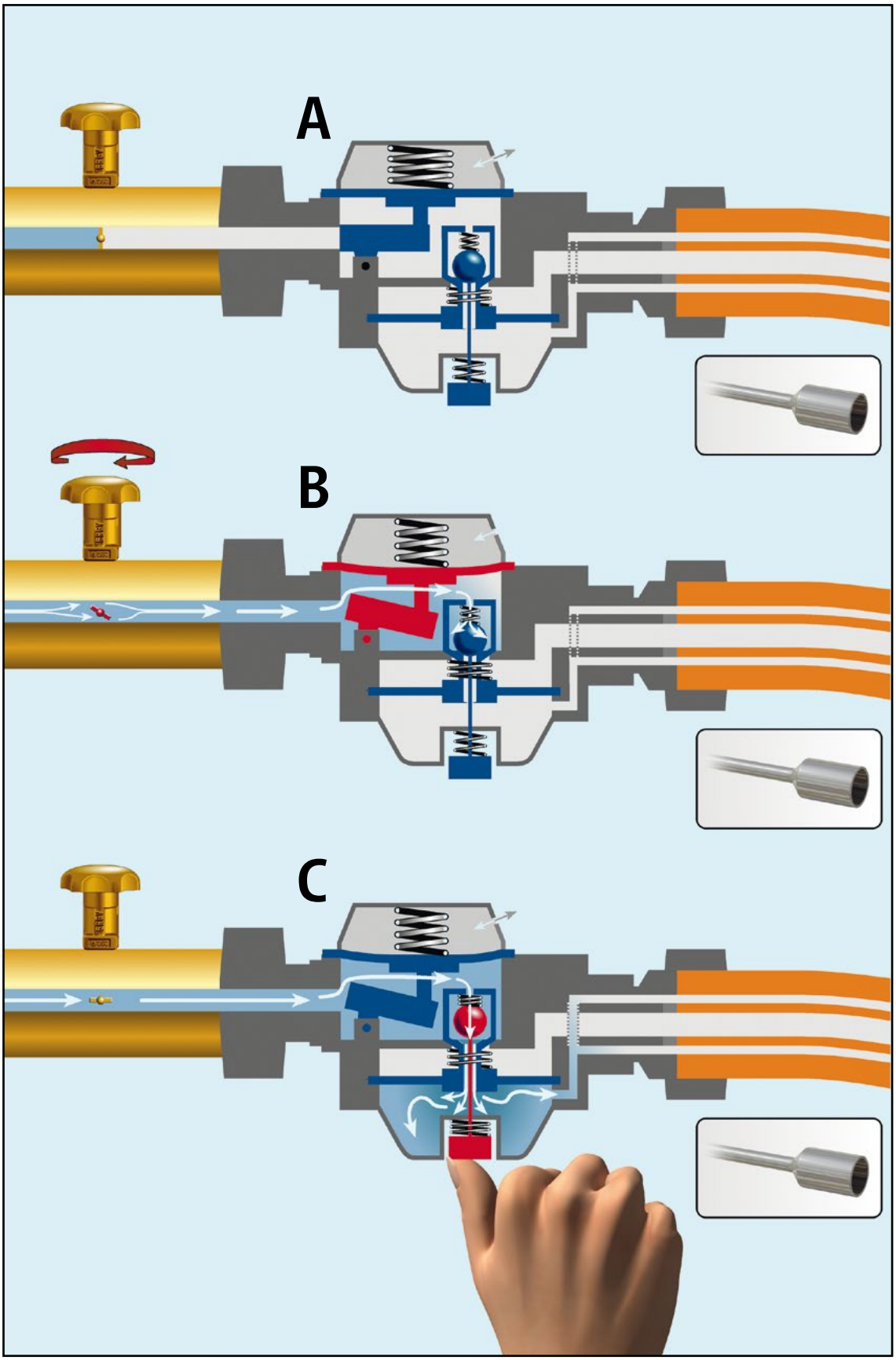
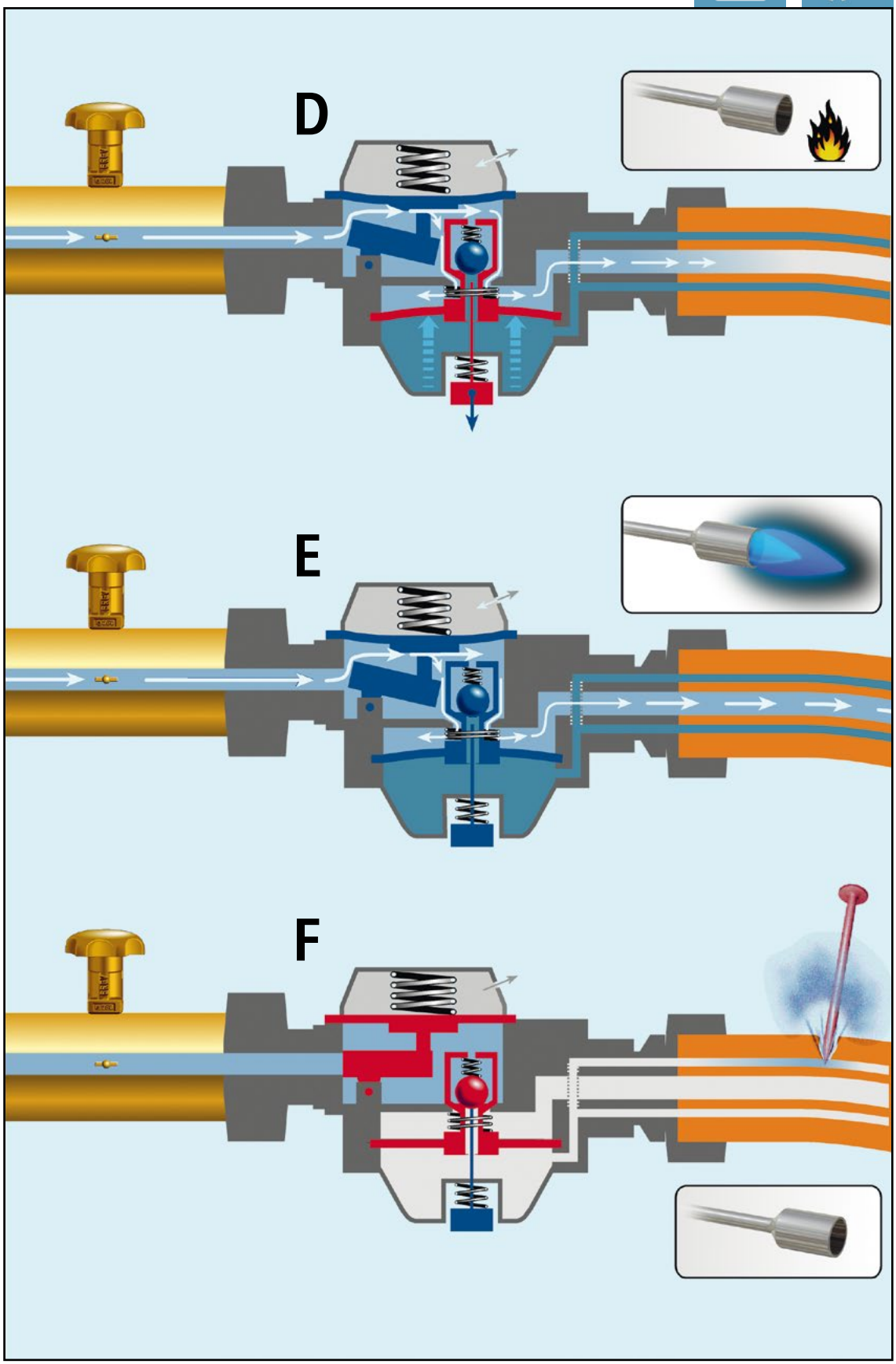


Figure 22:
Functionality of a leakage gas safety device (schematic)
A) Not in operation
B) Gas supply to the controller is opened
C) By manually opening the ball valve, the leakage gas chamber including the continuation into the hose is filled with gas



D) If the pressure in the leakage gas chamber is sufficiently high (dynamic pressure in the leakage gas chamber is higher than the flow pressure in the line to the consumption device), the gas supply to the appliance burning gaseous fuels opens
E) Normal operation
F) Shutting off the gas supply to the appliance burning gaseous fuels by closing the valve in the regulator as a result of sudden pressure drop in the leakage gas chamber due to hose damage with gas leakage

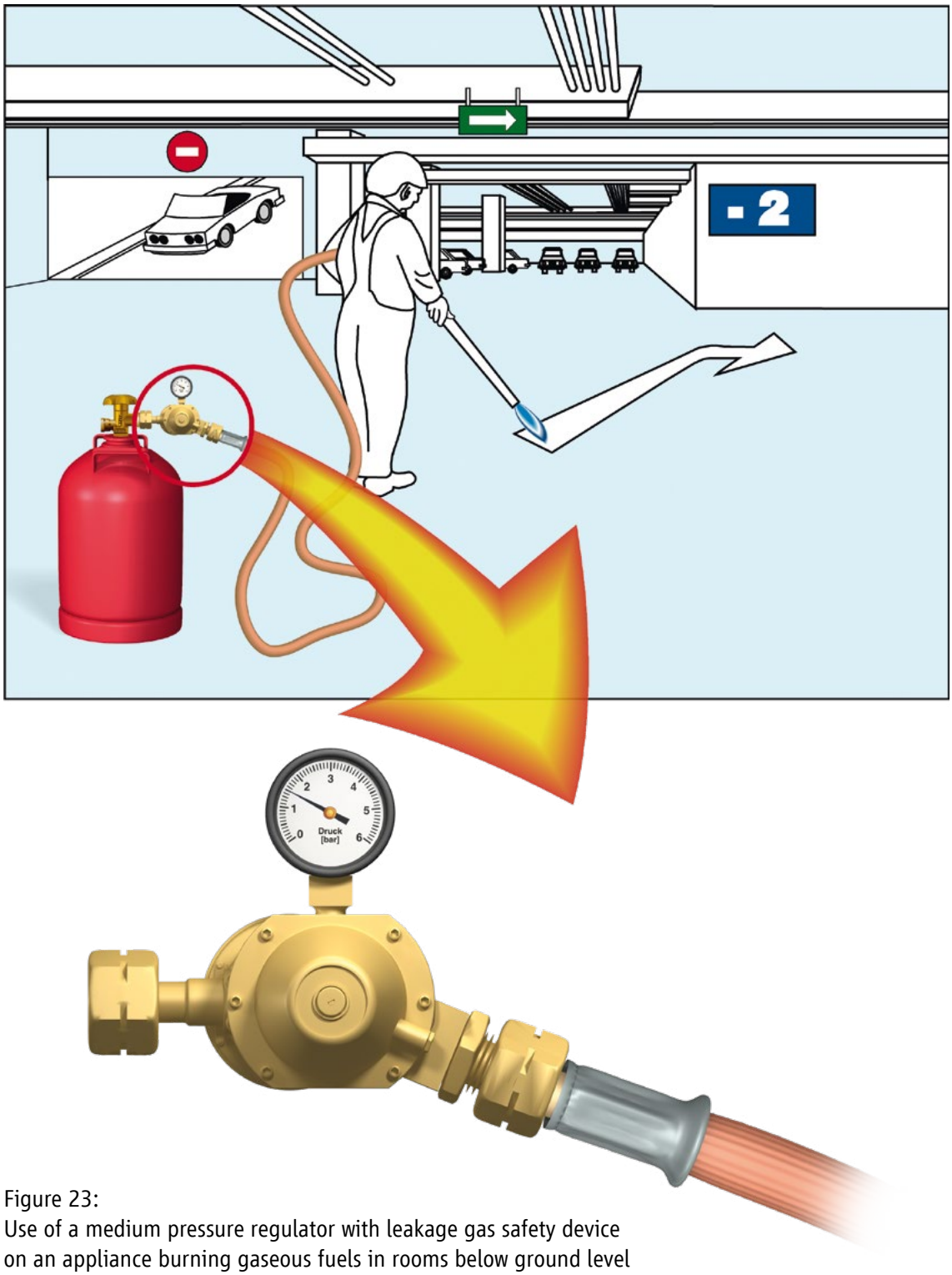


Figure 23:
Use of a medium pressure regulator with leakage gas safety device on an appliance burning gaseous fuels in rooms below ground level

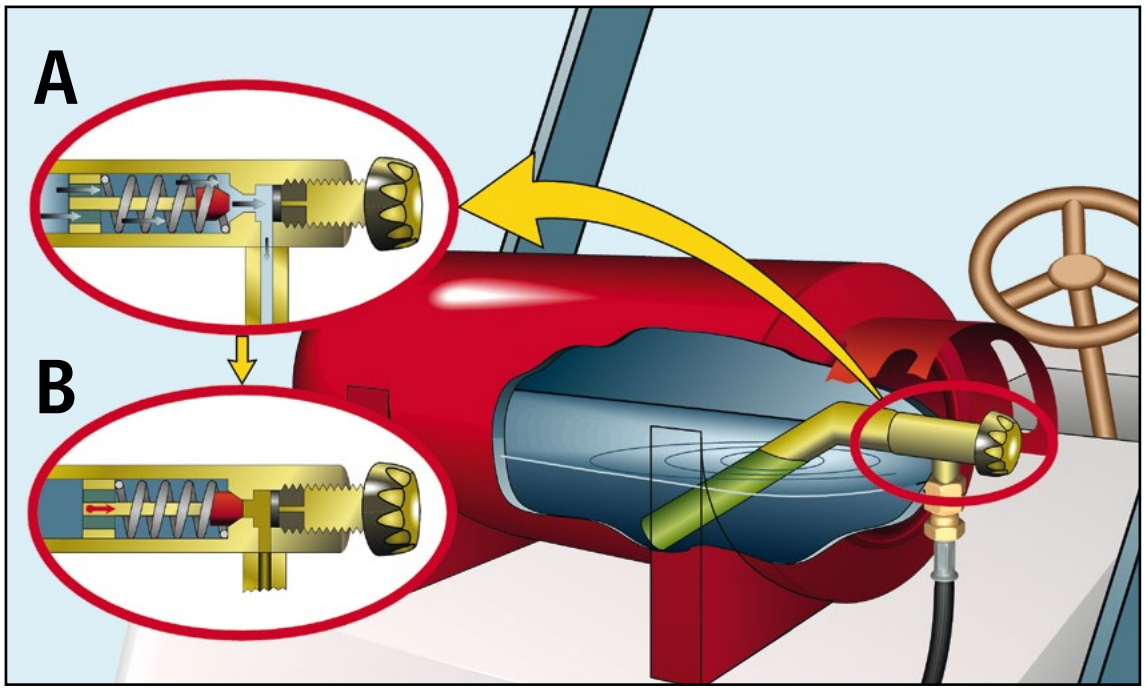


Figure 24:
Forklift truck with pipe rupture protection on the propellant gas tank
A) Normal operation
B) In case of hose or pipe damage, pipe rupture protection closed

When should gas warning devices be used?

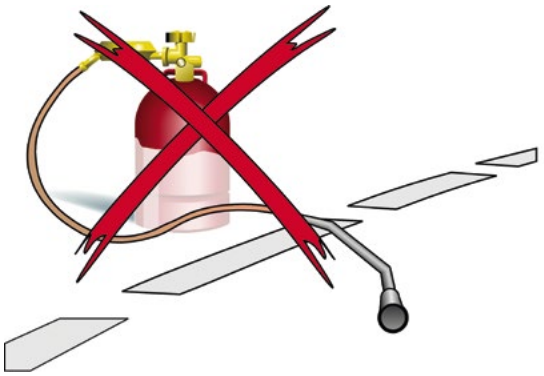
LPG supply systems, e.g. with large storage capacities or whose technical tightness cannot be guaranteed on a permanent basis, and LPG consumption systems that cannot be constantly monitored (e.g. that are installed in rooms below ground level), must be equipped with gas warning devices if necessary.

How can the required extraction capacity be ensured without danger?

Always use an LPG supply system designed for the required extraction capacity. If the extraction rate is too high for the installed compressed gas container, the compressed gas container will ice up. The possible extraction capacity increases with the size and parallel number of compressed gas containers.

When extracting from the liquid phase, an evaporator must be installed if necessary. The installation of compressed gas containers and compressed gas cartridges in the immediate vicinity of heat sources or spot heating, e.g. by hand torches, is not permitted under any circumstances.

Supply system with insufficient extraction capacity



Supply system with sufficiently dimensioned extraction capacity

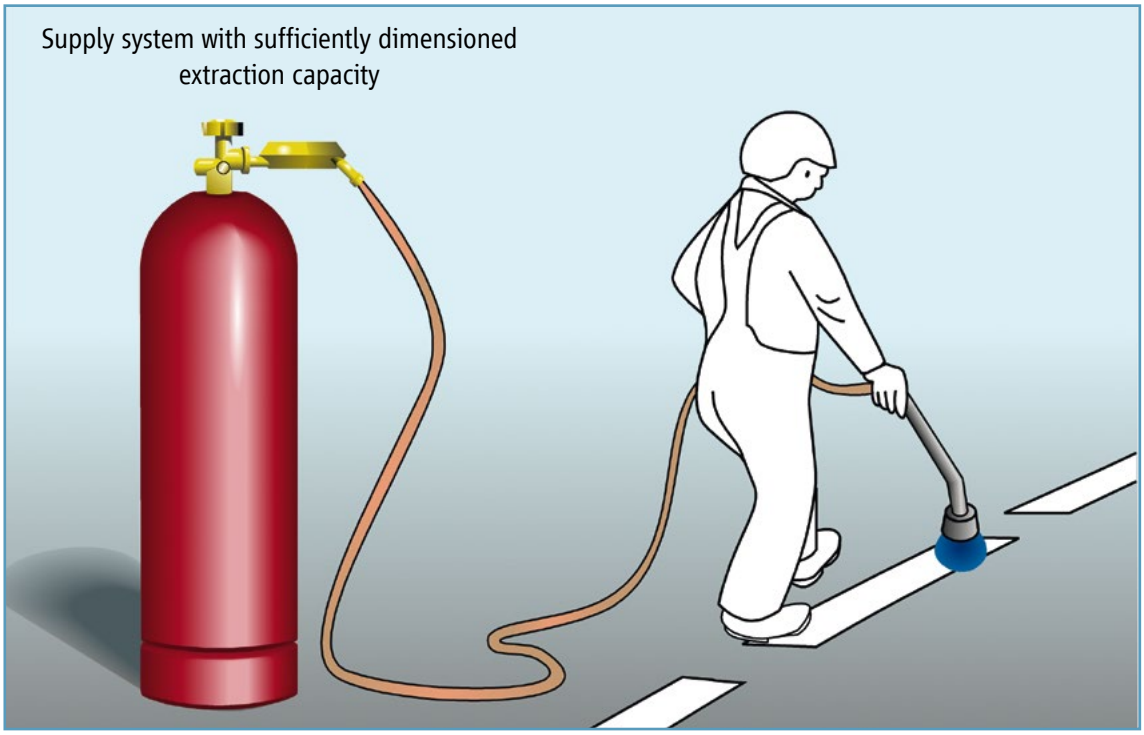


Figure 25:
Measure to ensure the extraction capacity without danger

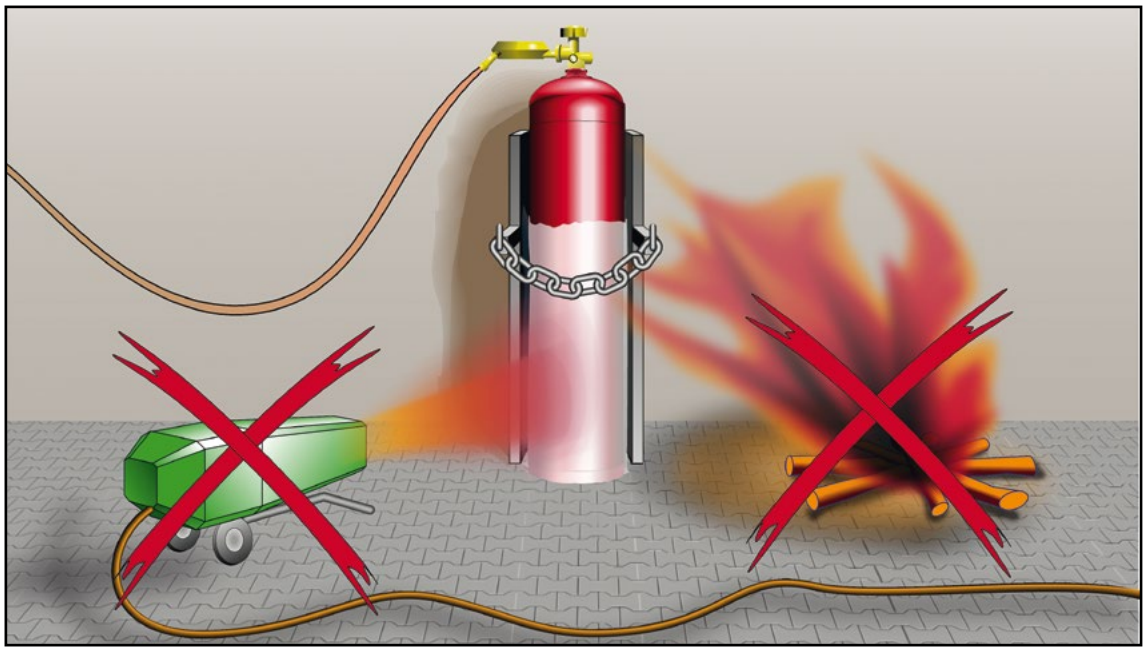


Figure 26:
Impermissible heating of compressed gas containers

Who is authorized to install LPG systems?

LPG systems and the equipment required for them may only be installed by persons who have the necessary expertise in the properties of LPG and installation technology. With regard to the necessary qualifications, the national regulations must be observed.

When is the notification or permit of an LPG system mandatory and/or a license required?

Based on national regulations, appropriate permits are required for

- compressed gas containers and appliances burning gaseous fuels as well as
- their location and
- their installation.

LPG supply systems

What requirements must compressed gas containers such as LPG tanks or LPG cylinders meet?

Concerning the design and equipment of compressed gas containers, the national regulations must be observed, in particular:

- the pressure resistance must be ensured according to the gas and the permissible temperature.
- in the case of stationary compressed gas containers (LPG tanks), high-performance safety valves must be installed to ensure pressure relief in the event of excessive pressures (temperatures)

What must be taken into account when setting up LPG supply systems with regard to escaping gas?

When installing LPG supply systems, the following must be taken into account with regard to escaping gas:

- The compressed gas containers or their blow-off lines must be set up and arranged in such a way that escaping gas is discharged without danger and cannot accumulate (among other things, to prevent underfiring).
- In LPG systems where the escape of unburned gas and thus the formation of a dangerous explosive atmosphere cannot be reliably prevented, no ignition sources may be present in a defined area around the possible gas escape points. These range distances can be found in the national regulations.

  If the boundary conditions are unfavorable and the hazard area is close to buildings and/or sewer openings, manholes, pits, or the like, a combination of several protective measures may be necessary, e.g.
  - guiding the blow-off upwards or
  - gas-tight walls in conjunction with a distance according to national regulations.

Hazardous areas must be defined according to the compressed gas containers used, the installation site and the given situation.

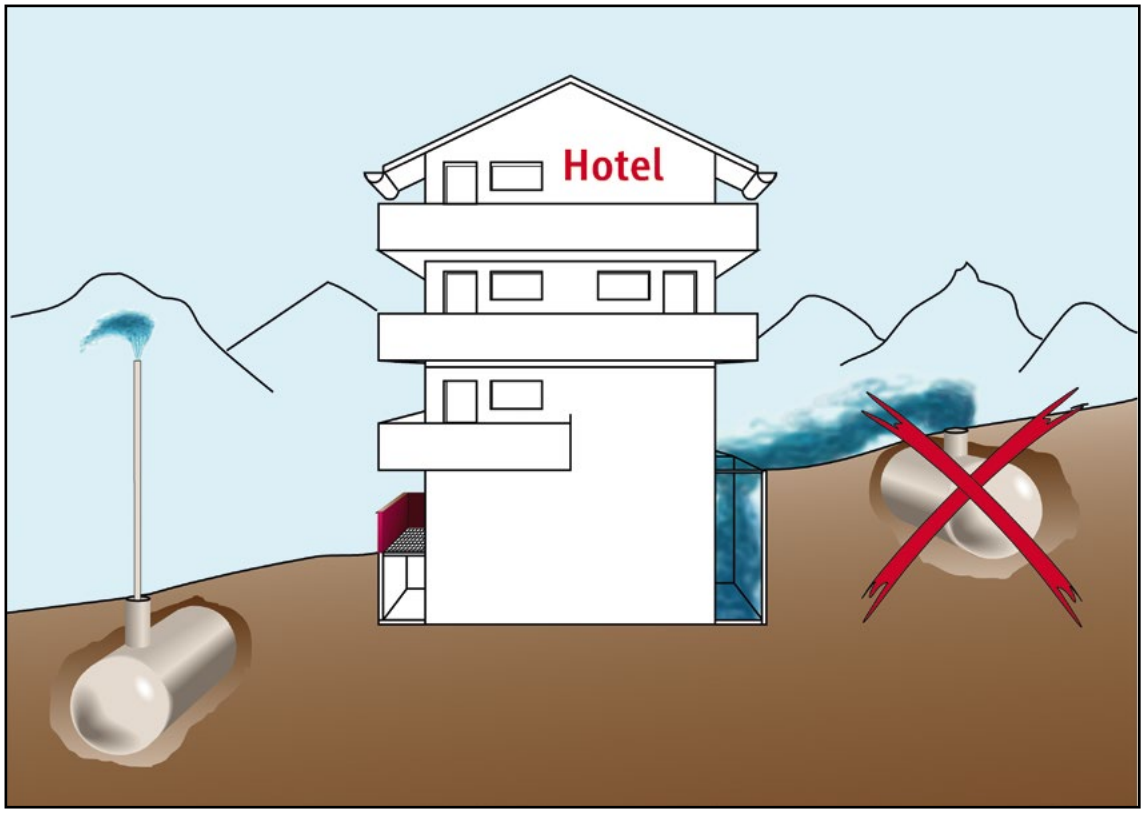


Figure 27:
Arrangement of the compressed gas tanks and their blow-off lines

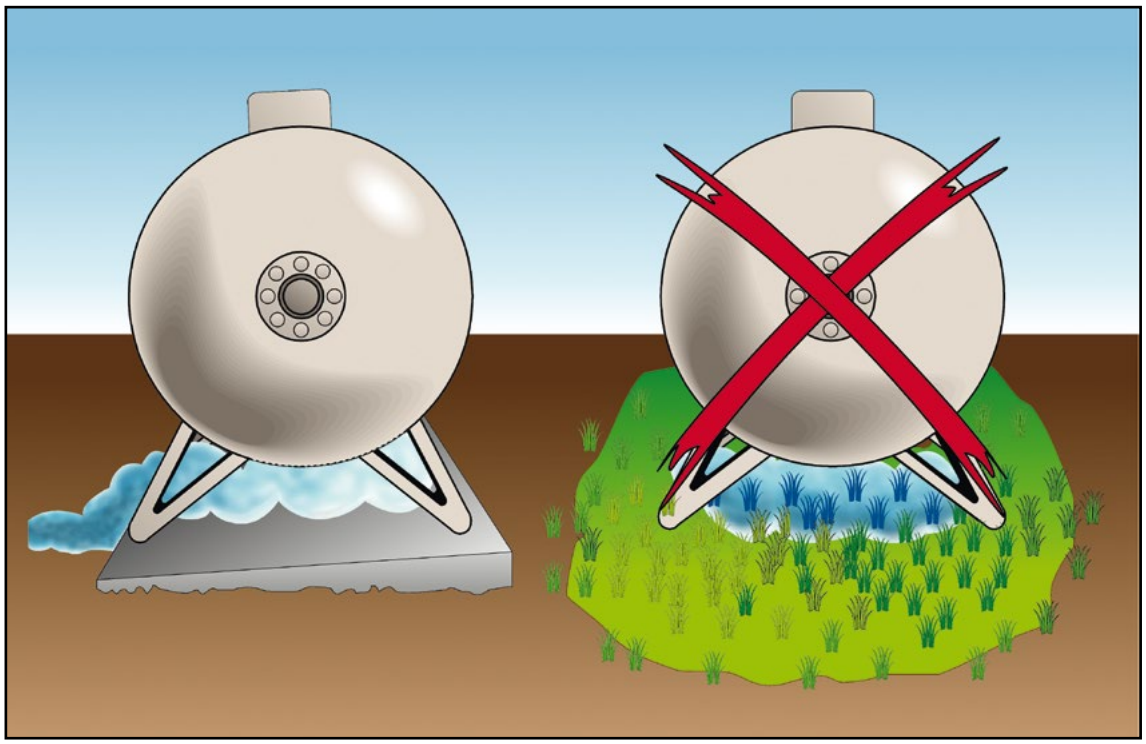


Figure 28:
Preventing underfiring of stationary compressed gas containers, e.g. by sloping under the tank in a non-hazardous direction

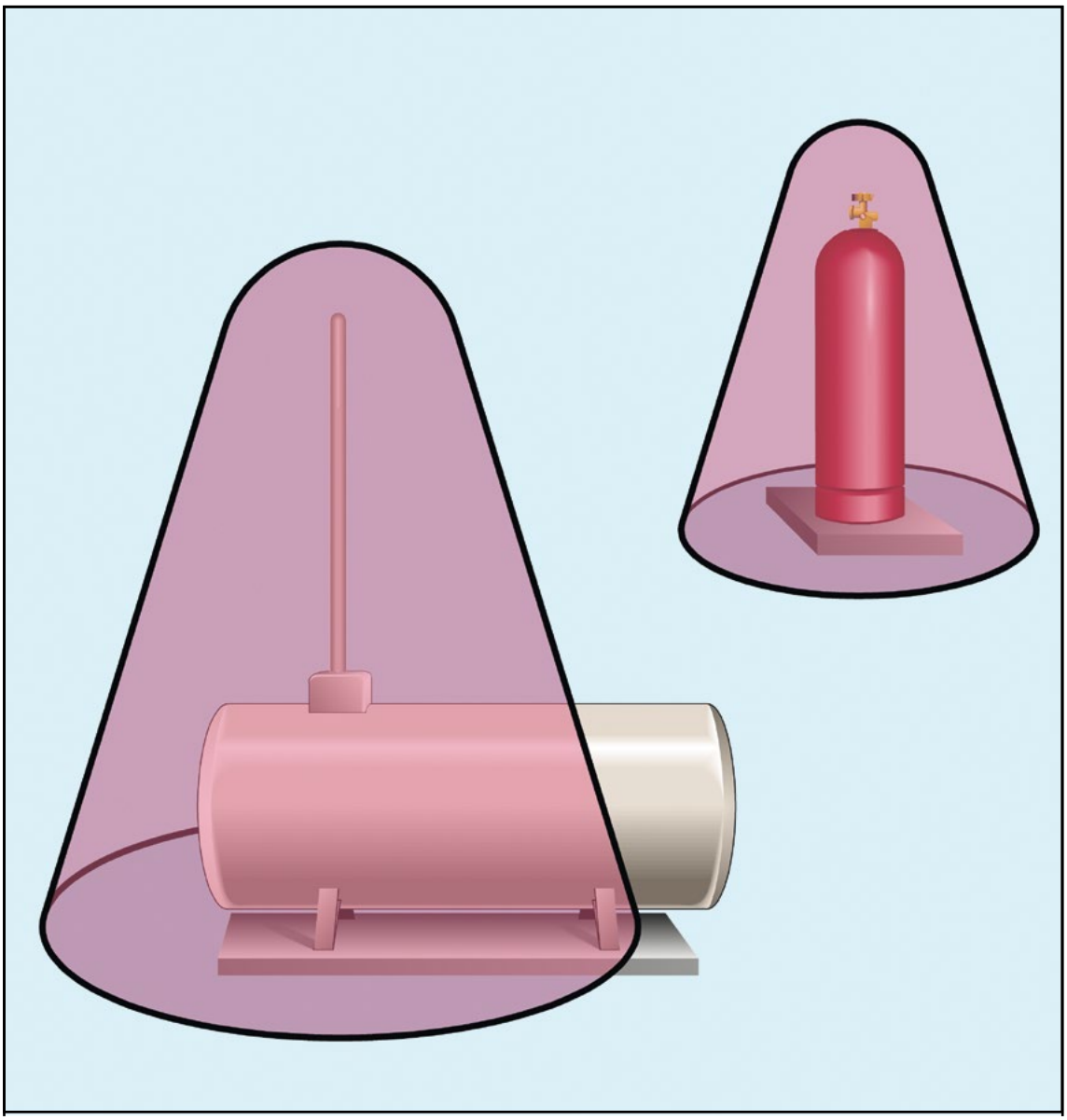


Figure 29:
Hazardous areas around LPG supply systems

How can stationary containers be protected against impermissible heat exposure?

Stationary compressed gas containers must be protected in accordance with national regulations against inadmissible heat effects, e.g. by fire from neighboring objects, as follows:

- Earth cover (earth-covered and earth-laid)
- Cooling LPG tanks by means of a water sprinkler system
- Thermal protection coating for installation above ground level
- Thermal insulation (fire protection insulation) with sufficient fire resistance when installed above ground level
- Observing protective distances

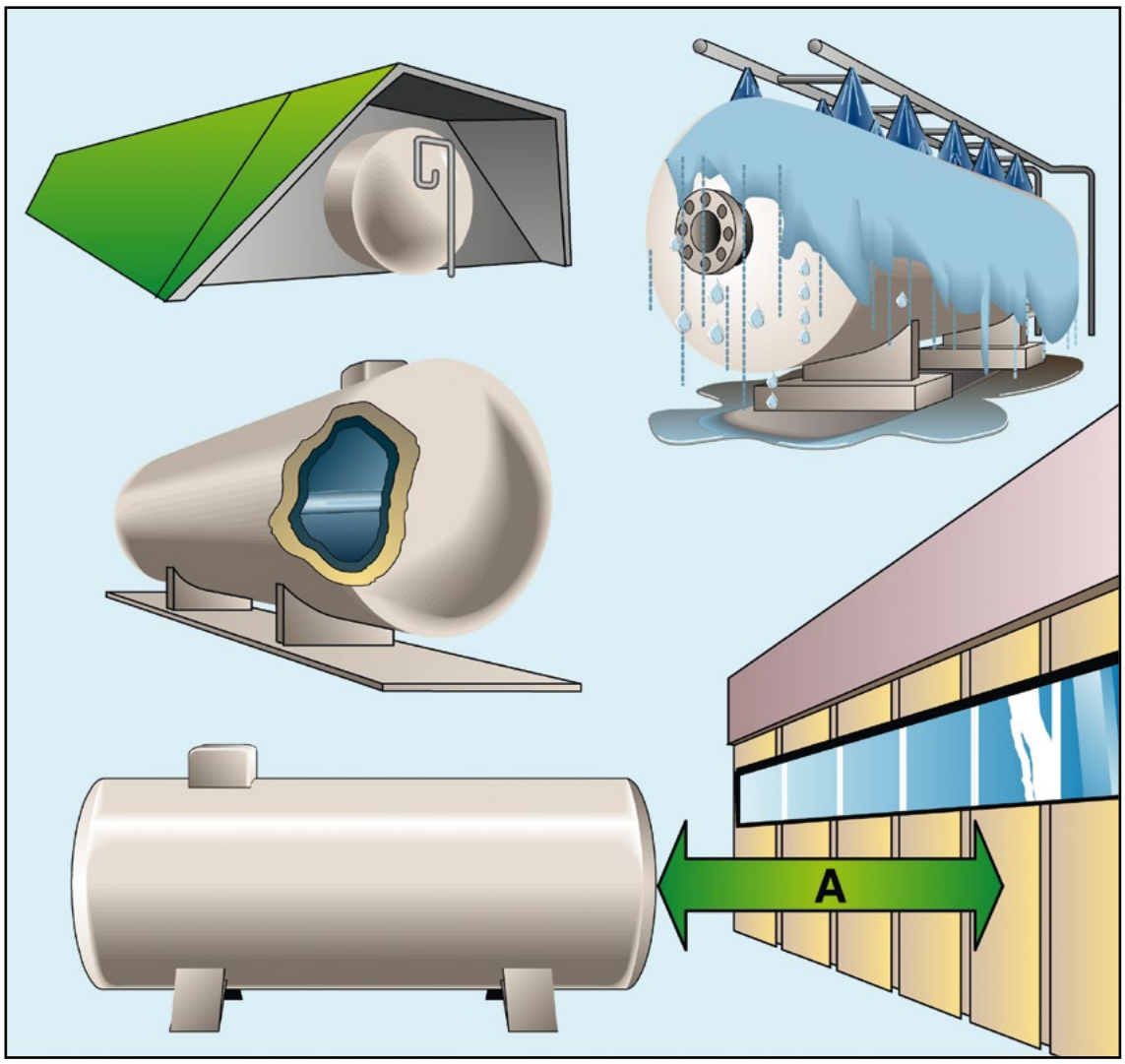


Figure 30:
Protective measures against impermissible heat exposure
A = Protective distance

How can the protective distances required for fire protection be determined?

Possible criteria are:

- The greater the LPG storage capacity, the greater the protective distances.
- In the case of neighboring objects, the design is of crucial importance: The lower their fire resistance, the greater the protective distances.
- The use of neighboring objects must be taken into account. The greater the fire potential and the more personnel involved, the greater the protective distances.

What precautions must be taken if the necessary protective distances cannot be maintained?

By erecting apertureless protective walls with sufficient fire resistance, the radiant heat on the adjacent object is massively reduced in the event of a fire, which also allows the protective distances to be reduced accordingly. It should be noted that the height and length of the protective wall is adapted to the expansions of compressed gas containers and the adjacent object.

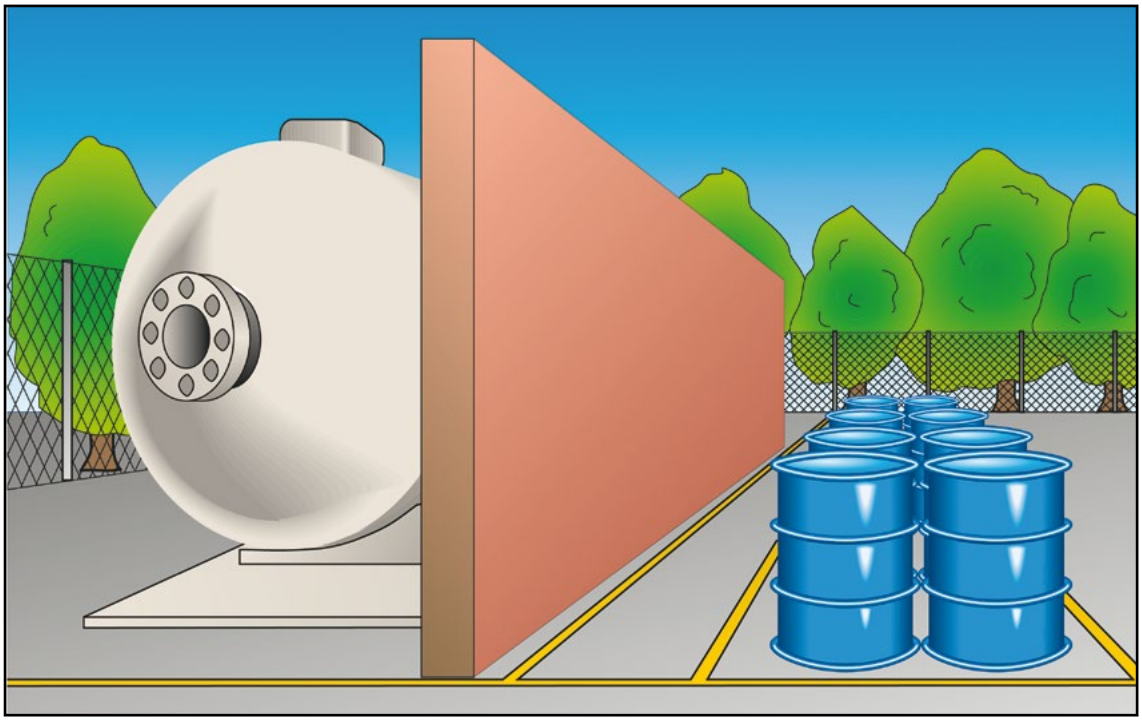


Figure 31:
Protective wall to adjacent objects

How can LPG supply systems be protected against mechanical impact?

LPG supply systems (e.g. LPG tanks, cylinder batteries or LPG cylinders) that are set up in exposed locations, such as in the area of traffic routes or internal crane systems, must be protected against being hit, e.g. by means of crash barriers.

How can access by unauthorized persons be prevented?

The fittings of compressed gas containers and the compressed gas containers themselves must be protected against unauthorized access, e.g. by a

- lockable protective hood
- container fencing
- fencing of the company area
- monitoring

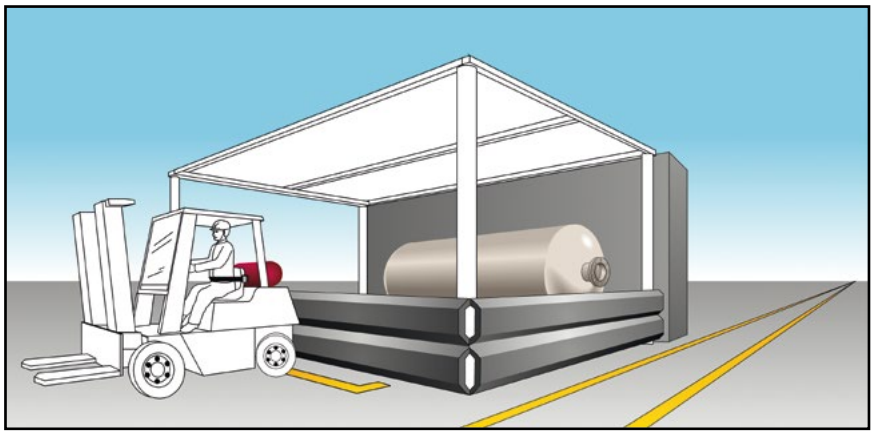


Figure 32:
Protection of the supply system against mechanical impact

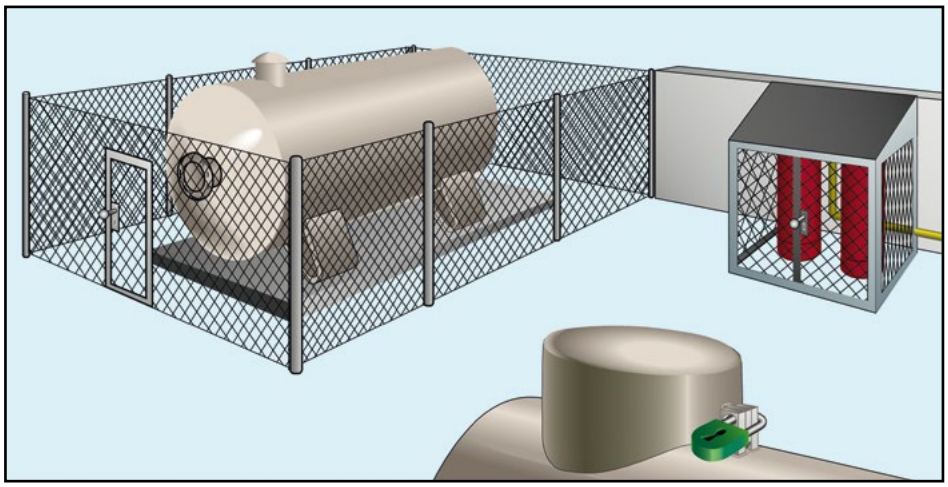


Figure 33:
Protection of the compressed gas containers and their fittings against unauthorized access

What are the requirements for rooms in which LPG is stored?

Storage rooms for LPG must, among other things
- be separated from adjacent rooms with sufficient fire resistance,
- have escape routes that are arranged or designed so that they can be used quickly and safely at all times. They must be clearly marked,
- be vented to a sufficient extent by technical or natural ventilation

and
- be equipped in accordance with the requirements for potentially explosive atmospheres.

The respective national rules and regulations must be observed.

When do additional risk assessments have to be carried out with a view to possible incidents?

Depending on the size and complexity of the system, additional risk assessments must be carried out in accordance with national regulations and, if necessary, safety concepts must be defined. Appropriate technical and organizational protective measures must be implemented.

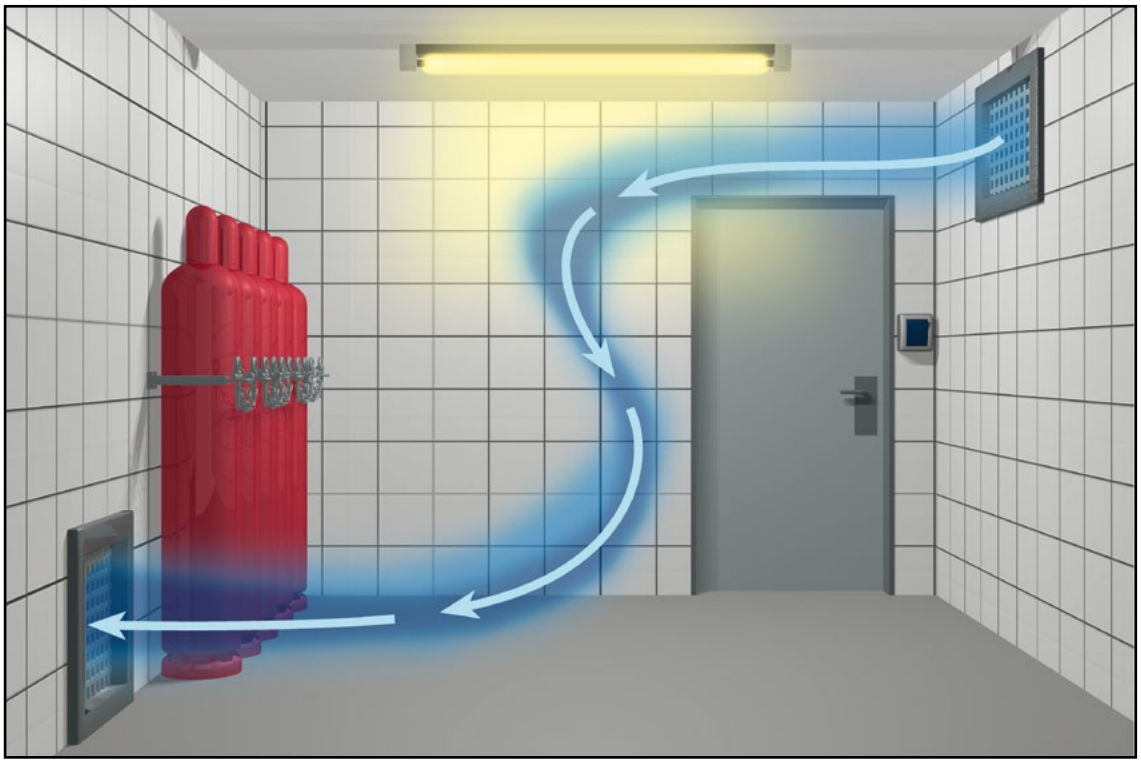


Figure 34:
Requirements for storage rooms (ventilation openings to the outside)

LPG consumption systems

What should be considered when dimensioning LPG consumption systems?

When dimensioning LPG consumption systems, the nominal diameters of the LPG lines must be dimensioned in such a way that the appliances burning gaseous fuels are supplied with the necessary pressure as well as the required quantity of LPG. The exhaust pipes must be laid and dimensioned in such a way that the exhaust gases can be discharged safely into the open air.

What requirements must appliances burning gaseous fuels meet?

Only appliances burning gaseous fuels that have been tested or approved by a competent body should be installed. These appliances burning gaseous fuels must be equipped with safety devices (e.g. flame monitors) that interrupt the gas supply as soon as the flame goes out. This prevents the further escape of LPG. For instance Bunsen burners, where the flame is constantly observed, can be excluded.

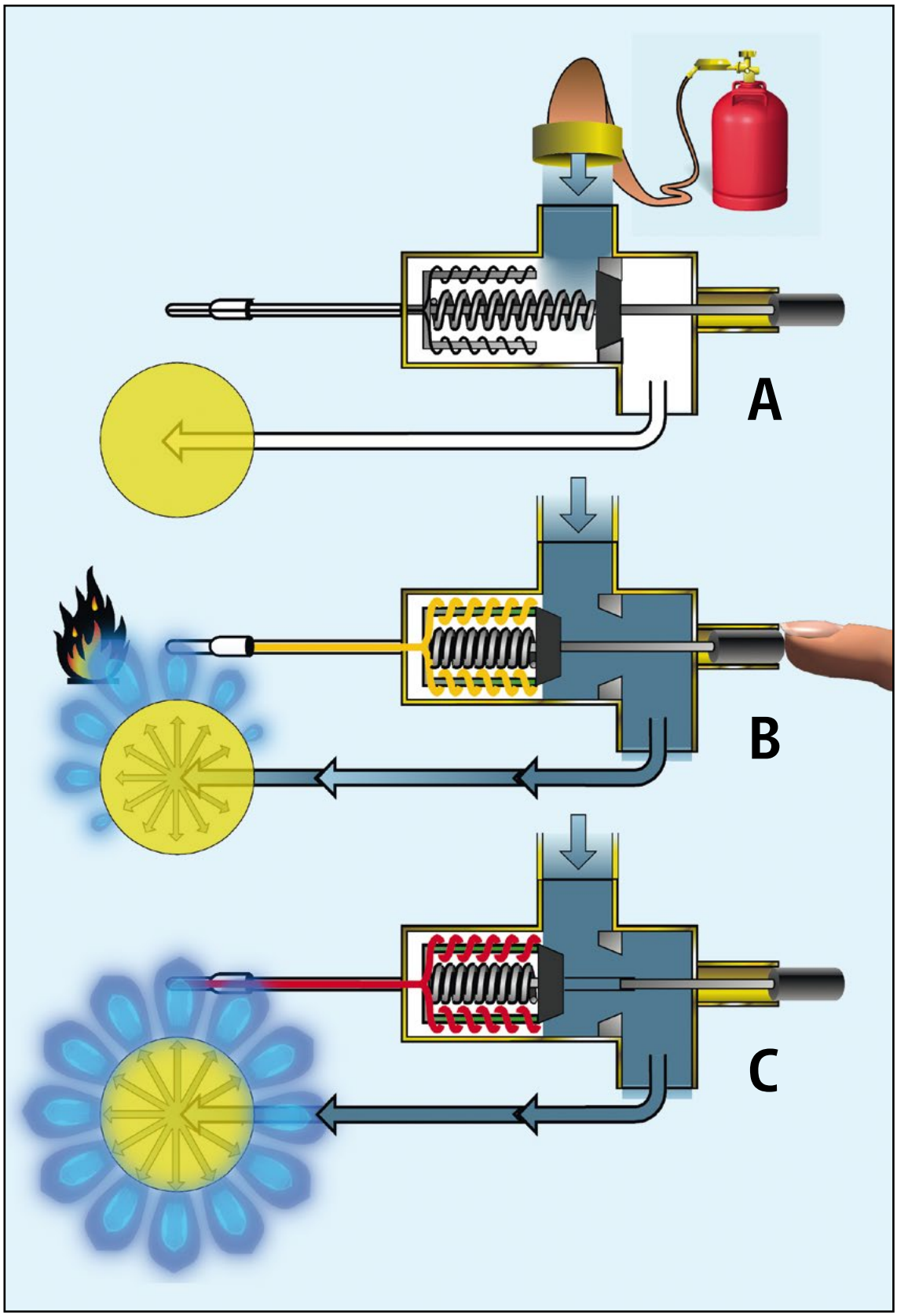


Figure 35:
Mode of operation of a flame monitor (thermoelectric ignition protection)
A) Idle state (no flame) B) Ignition phase C) Continuous operation

What needs be considered when setting up appliances burning gaseous fuels?

Appliances burning gaseous fuels must be installed and fixed in such a way that the surrounding materials cannot be heated to an inadmissible extent. Heat protection has to be installed, if necessary.

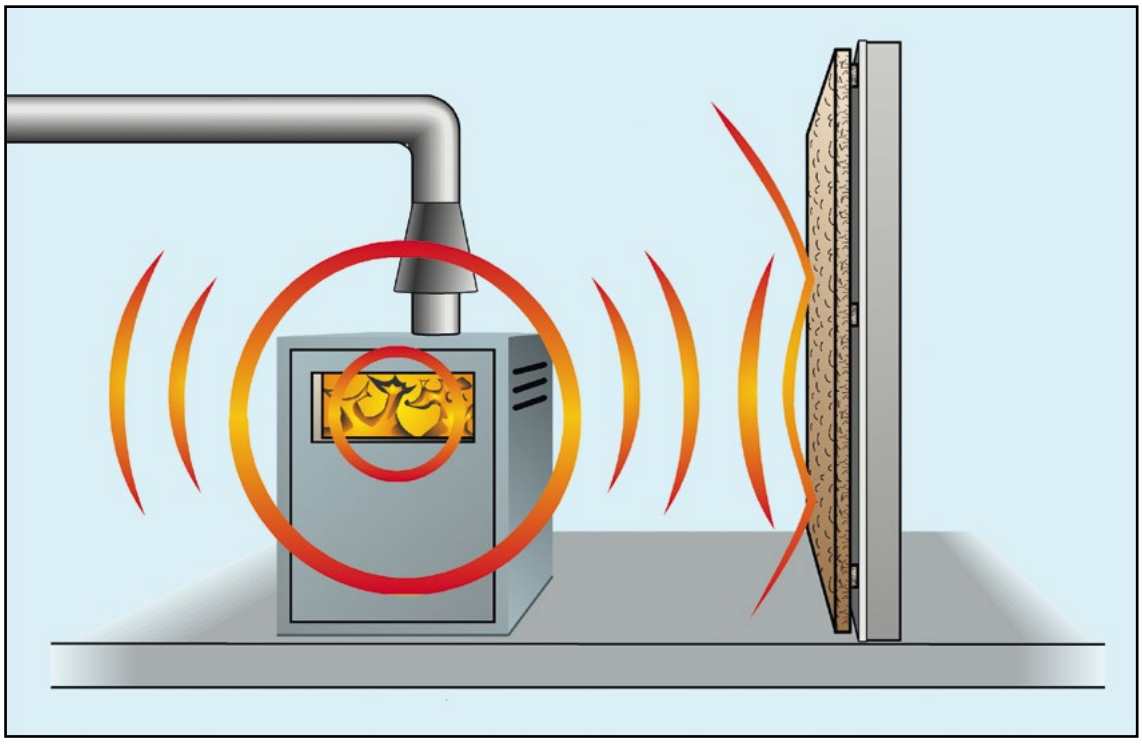


Figure 36:
Thermal protection for an appliance burning gaseous fuels

What are the ventilation requirements for rooms with appliances burning gaseous fuels to ensure fresh air supply?

With respect to appliances burning gaseous fuels that meet fresh air requirements due to the installation room and its existing (natural) openings, the requirements depend on the rated heat load (output) of the appliance and the room size. Please also observe the information provided by the manufacturer of the LPG consumption system.

Rooms with LPG consumption systems must be ventilated in such a way that no atmosphere hazardous to health can occur in the room air.

- Under favorable conditions, natural room ventilation may be sufficient. Such favorable conditions may exist, for example, if the walls have two permanently open ventilation openings, preferably opposite each other, located at the top and bottom.
- If there are no favorable conditions, the requirement for sufficient ventilation can be achieved by technical ventilation measures.

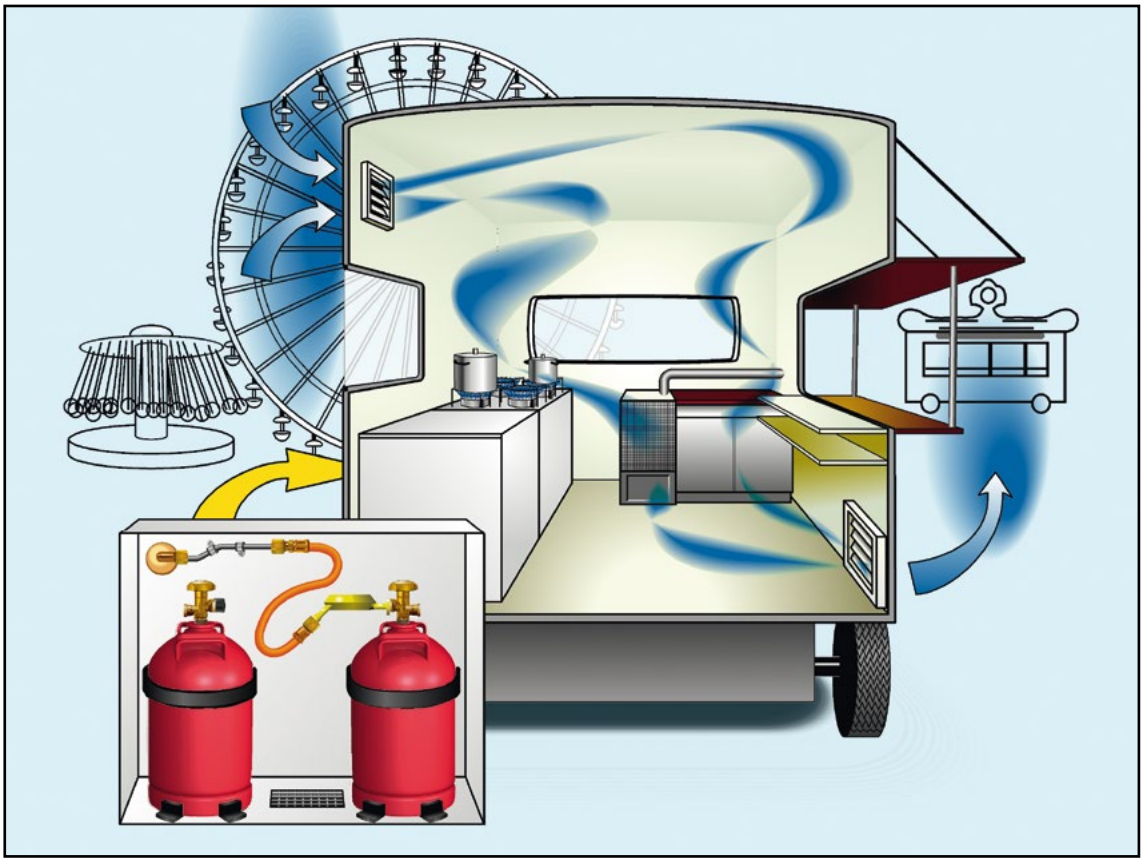


Figure 37:
Ventilation of rooms e.g. in vehicles with appliances burning gaseous fuels

When may hose lines be used and what requirements must they meet?

As a rule, hose lines may only be installed in LPG systems as a connection between the LPG supply system and the permanently installed pipelines (or appliances burning gaseous fuels). They are only permissible if fixed pipelines are unsuitable due to lack of mobility or for other operational reasons.

Hose lines must be as short as necessary, gas-tight, pressure-tested and designed to be resistant to LPG. Reinforced hose lines are used for mobile appliances burning gaseous fuels where hose damage cannot be ruled out.

For LPG under high pressure, a hose line with a special insert that can withstand increased pressure loads is essential. Above a certain length of hose line, national regulations require the use of hose rupture safety devices.

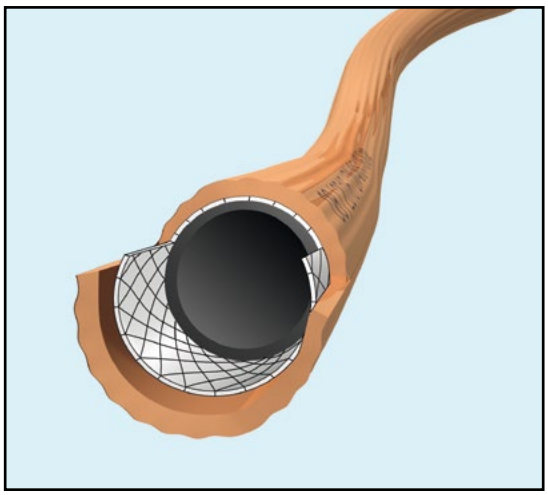


Figure 39:
Reinforced liquid gas hose marked according to European standard EN 16436-1.

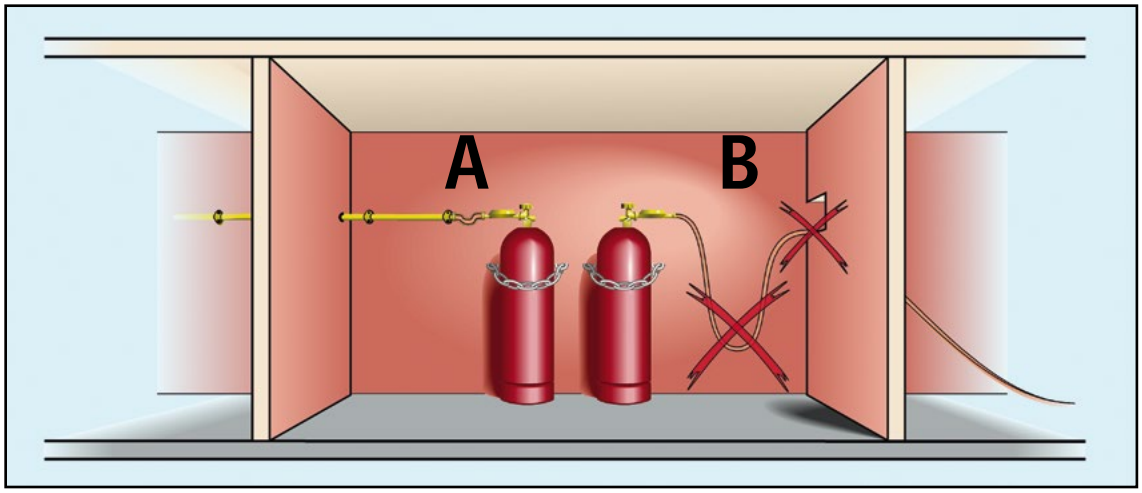


Figure 38:
Use of hose lines: A) Permitted use B) Impermissible use

Operation and maintenance – Operation

Who is allowed to operate LPG systems?

In order to be allowed to operate LPG systems, persons must be instructed about the hazards associated with the work when handling LPG before starting their work and at recurring intervals.

What needs to be considered when connecting LPG cylinders?

Before mounting the pressure regulating device to the cylinder valve, check the condition of the seal and the hose line for visible damage.

After mounting, a leakage check must be carried out at the connection point using, for example, foam-forming agents (leak detection spray) under cylinder pressure (Fig. 40).

When must the valves of the compressed gas containers be closed?

The valves must be closed:

- prior to longer work interruptions
- after the LPG has been used up
- before unscrewing the pressure regulating device
- in case of malfunctions

Figure 40:
Leak test on LPG systems

How do “empty” compressed gas containers have to be handled?

Emptied or supposedly emptied compressed gas containers must never be put away or stored with the valve open, as a renewed escape of liquid gas and the associated hazards can be expected when the ambient temperature rises (see chapter “Properties and hazards”, p. 15).

“Empty” cylinders must be stored with valves closed and valve protection caps in place.

What is important when filling very small cylinders?

Due to the extreme temperature dependence of the volume of LPG (in the liquid phase), it must be ensured that there is always a gas cushion above the liquid phase. This means that the compressed gas containers may only be filled to a maximum of 85%. The filling level must be monitored by suitable means (e.g. dip valve, automatic filling stopper). The filling process must be stopped immediately after reaching the maximum permitted filling level at the latest.

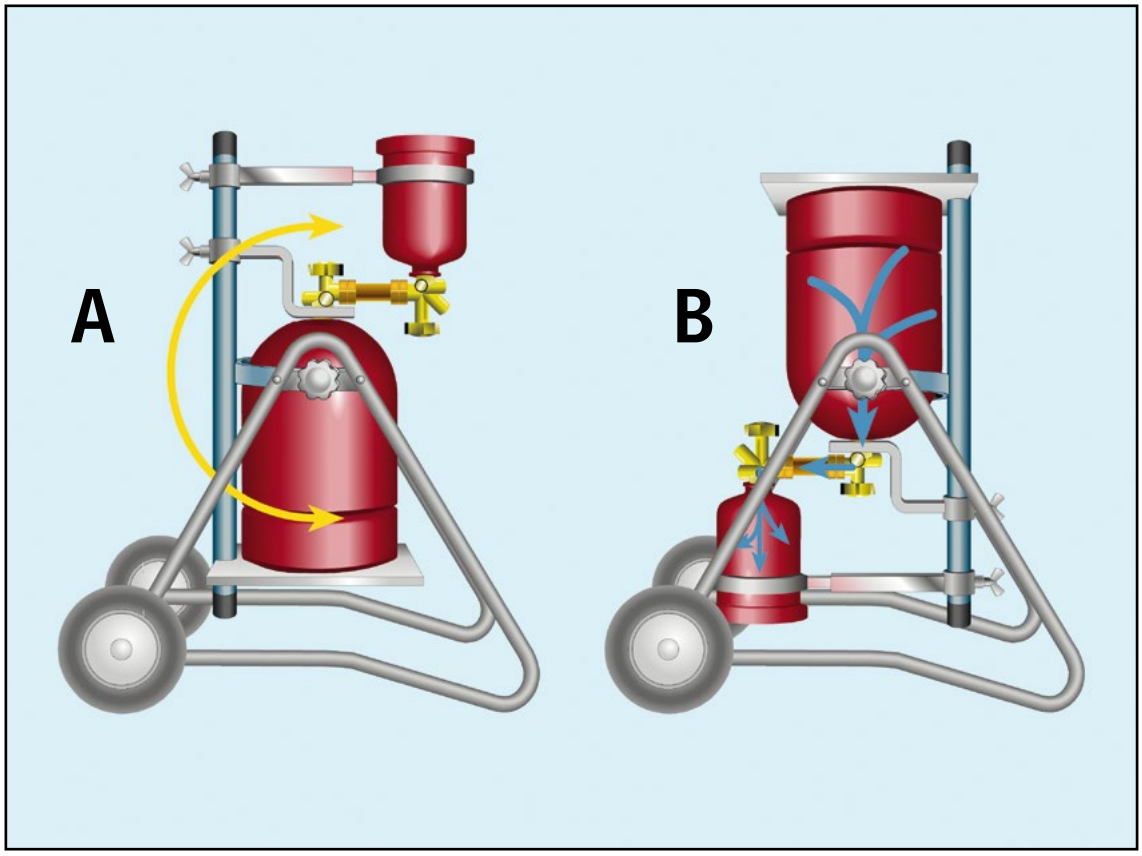


Figure 41:
Filling LPG into very small cylinders (national regulations must be observed)
A) before filling B) filling process

What measures must be taken to avoid poisoning when using mobile appliances burning gaseous fuels?

The use of mobile appliances burning gaseous fuels also requires well-ventilated areas or rooms. Opening windows or otherwise ensuring that there is always enough fresh air remains the very most important precaution against the risk of poisoning.

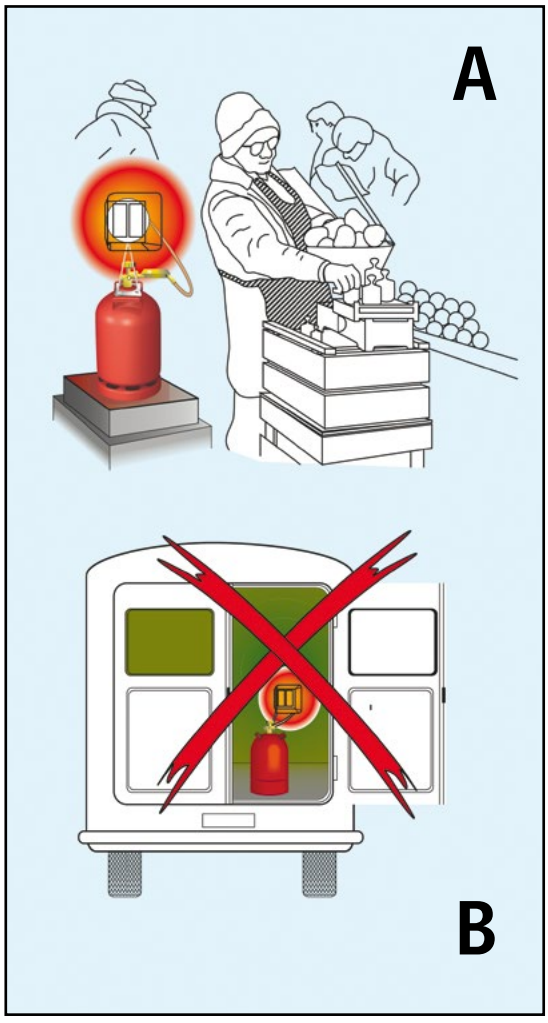


Figure 42:
Use of mobile appliances burning gaseous fuels
A) outdoors
B) in insufficiently ventilated areas

What must be observed for appliances burning LPG designed exclusively for operation from the gas phase?

These appliances burning gaseous fuels must not be supplied with gas from the liquid phase.

This means that propellant gas cylinders for driving forklift trucks, for example, must not be used for other purposes (for operating other LPG consumption systems). Otherwise, there is a risk that, in the case of stationary propellant gas cylinders, the withdrawal valve tube will protrude into the liquid phase of the gas, so that gas in liquid form can reach the appliances burning gaseous fuels and burn violently in an uncontrolled manner (flash fire). The same risk exists if the withdrawal is made from a full, horizontal compressed gas container (fuel gas cylinder or propellant gas cylinder).

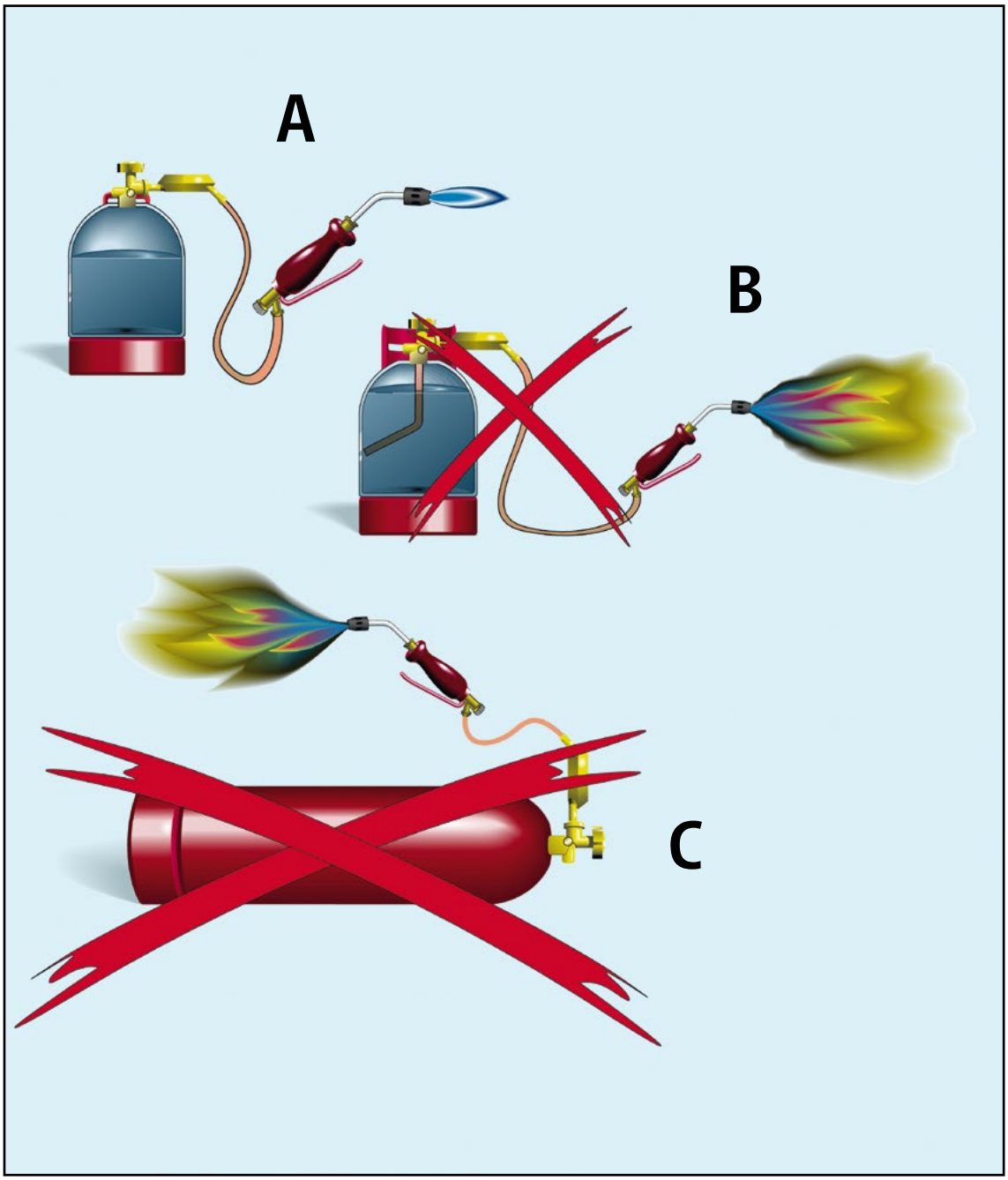


Figure 43:
Correct and incorrect use of LPG cylinders
A) Correct use: fuel gas cylinder used standing
B) Incorrect use: propellant gas cylinder standing upright, used as fuel gas cylinder
C) incorrect use: fuel gas cylinder used horizontally

What needs to be considered when using manual torches?

Manual torches that are in operation or still hot must not be placed on pressurized gas containers, hose lines or in their immediate vicinity. They must be hung, for example, in special suspension devices or placed only on suitable depositing devices made of non-combustible materials.

Neither the flame nor hot parts of the device must come into contact with flammable substances.
In case of major work interruptions or breaks, the torches must always be shut down and the cylinder valve must be closed.

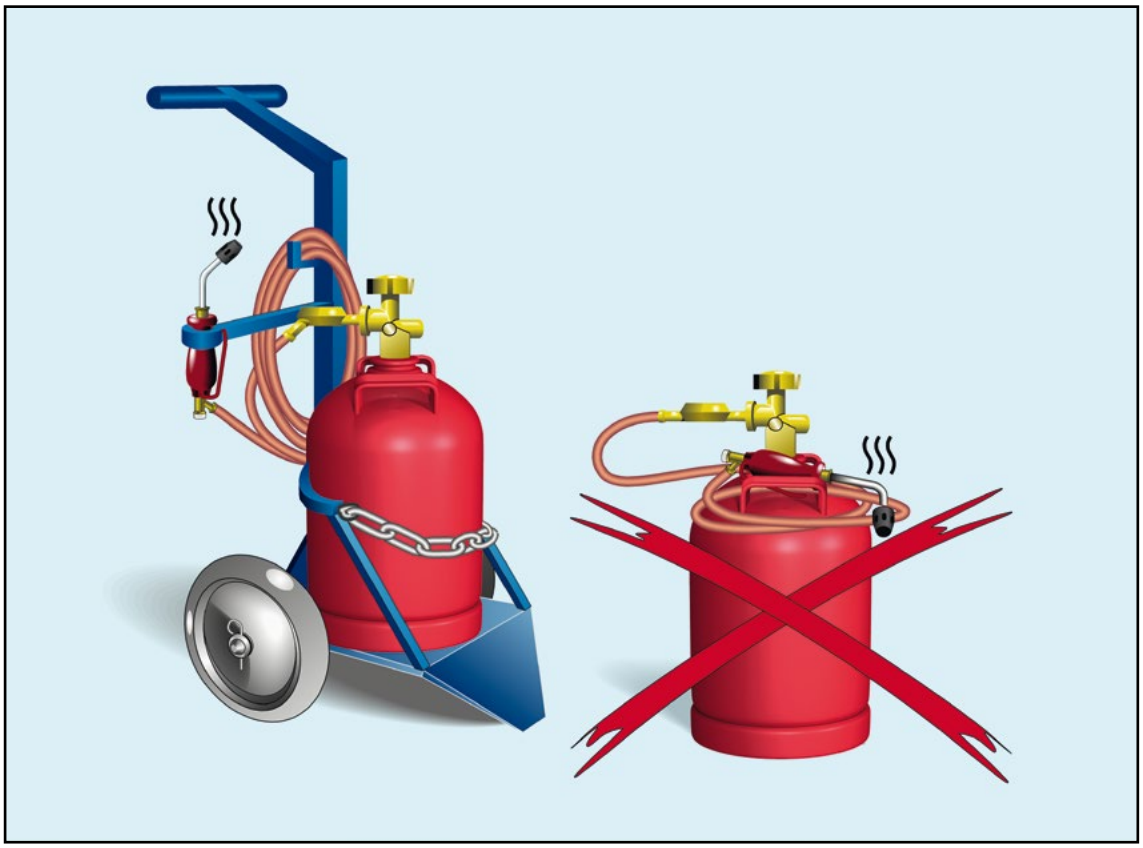


Figure 44:
Putting down hot manual torches

The safety instructions (e.g. on the liquid gas cylinder) must be observed. The cylinder valve must be closed after each withdrawal of liquid gas.

Operation and maintenance – Maintenance

What needs to be considered in the maintenance of LPG systems

The maintenance of the LPG systems must be carried out by qualified persons who are trained according to your national regulations.

What needs to be considered in the maintenance of LPG hose lines?

Only suitable LPG hose lines in perfect condition are permitted. Damaged, brittle, cracked and too old LPG hose lines must not be repaired and must be replaced.

The specifications of the hose manufacturer must be observed.

What must be observed during welding or grinding work in the vicinity of LPG systems

Special protective measures, e.g. covering, partitions against flying sparks, must be taken when carrying out welding or grinding work in the vicinity of LPG systems.

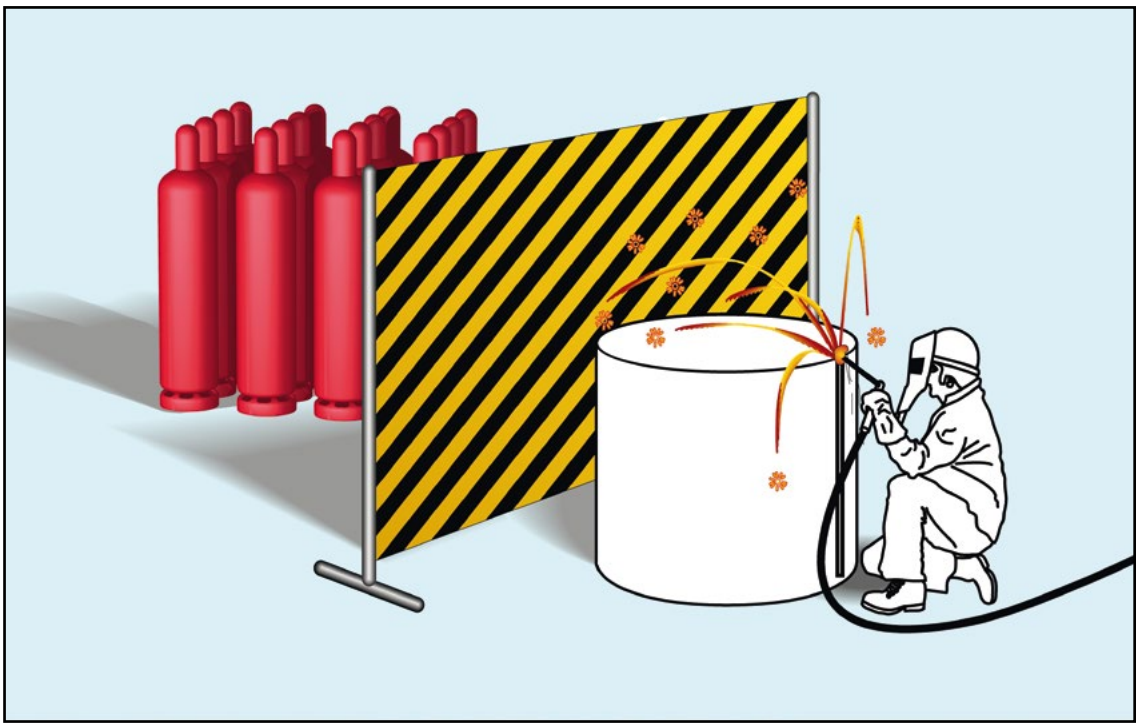


Figure 45:
Special protective measures for welding in explosion and fire hazard areas

Measures in case of LPG leakage with or without fire

What preventive measures must be taken with respect to the occurrence of fire?

Precautions must be taken to extinguish fires. Among other things, LPG systems must be equipped with suitable fire extinguishing equipment.

Fire extinguishing equipment and fire protection systems (or their release devices) must be located in a suitable place so that they can be safely reached and operated in case of danger.

What must be done in case of an LPG leak without fire?

- Immediately close all shut-off valves to cut off the gas supply.
- Ignition sources of any kind must be avoided. Electrical switches and the like must not be operated. If necessary, the main electrical switches located outside the hazardous area must be operated and/or the main electrical fuses must be removed. Open flames must be extinguished if present, do not smoke.
- Fire departments and other specialists, such as the Gas Emergency Service, must be alerted.
- In the event of an LPG leak outdoors, cordon off the endangered areas over a wide area.
- In the event of LPG leaks in rooms, additional ventilation options must be used.
- Unless persons are endangered, remove leaking cylinders from the premises and move them to a safe place in the open air.

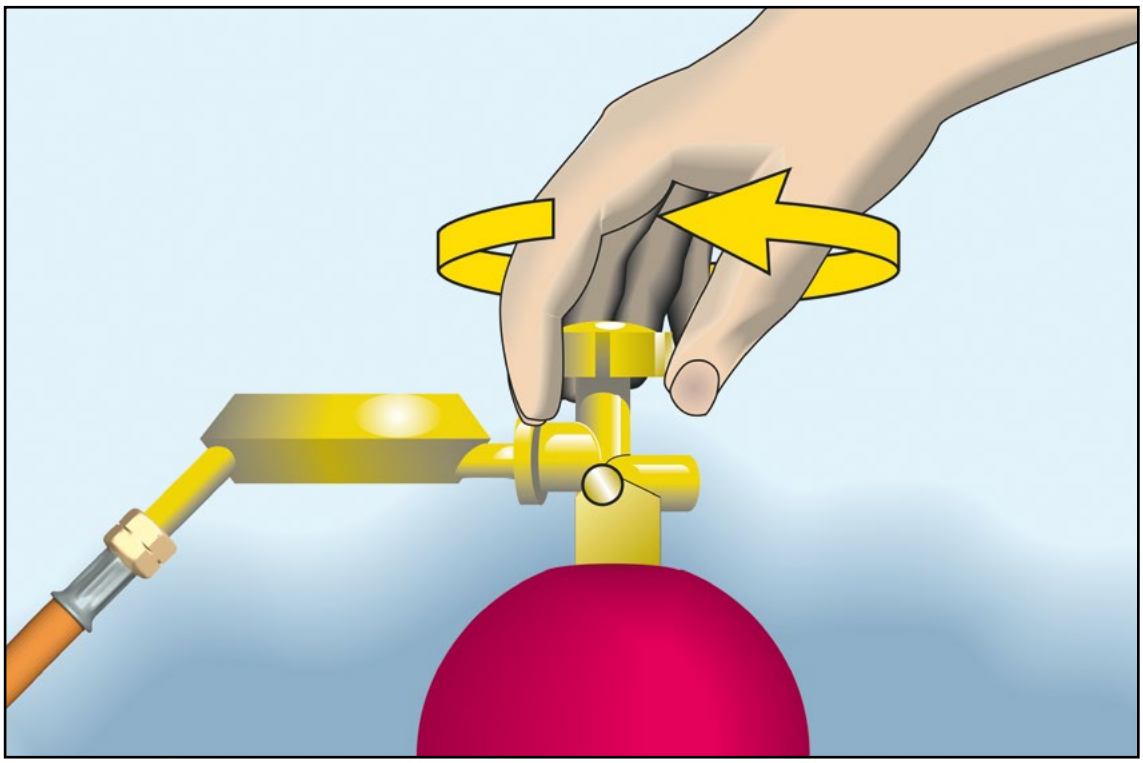


Figure 46:
Close the shut-off valves in case of gas leakage

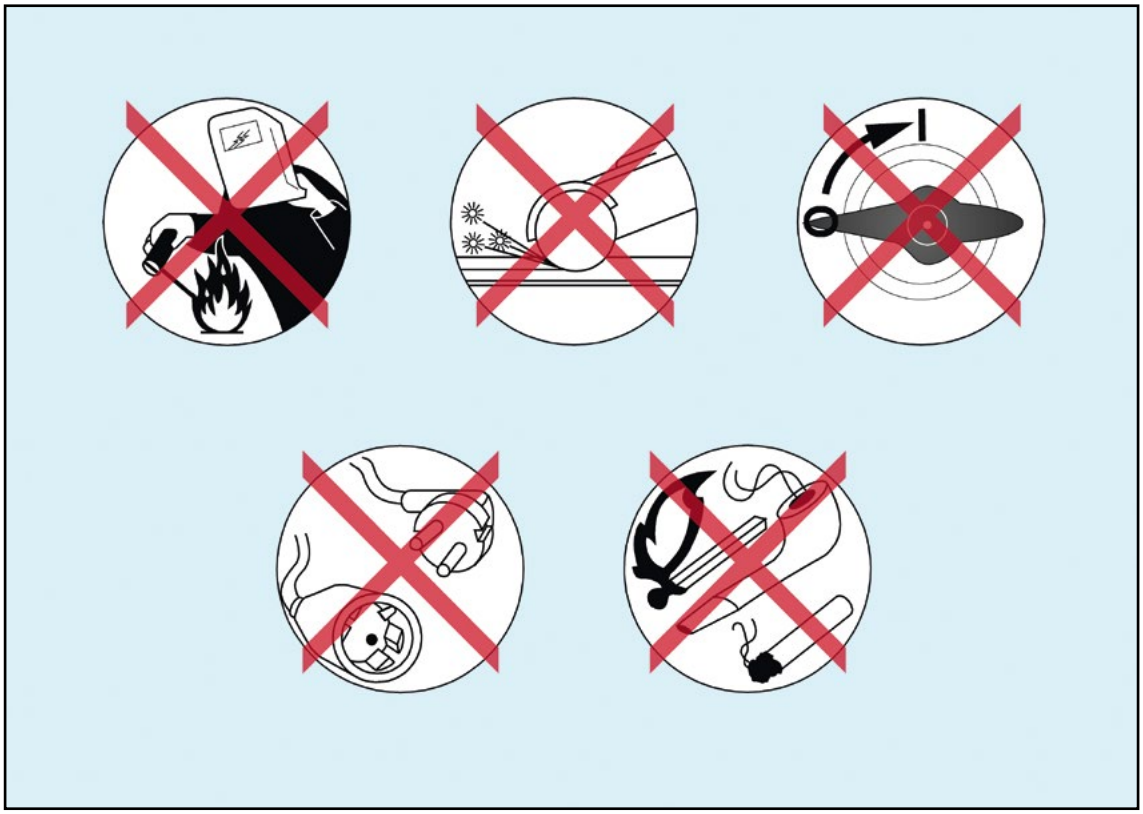


Figure 47:
Avoid ignition sources in case of gas leakage

What must be done in the event of a gas leak with fire at the LPG system?

- Immediately close all shut-off valves to shut off the gas supply, provided they are safely accessible.
- Fire departments and other specialists, such as the Gas Emergency Service, must be alerted.
- Compressed gas containers and objects endangered by the effects of fire must be cooled with water and, if necessary, removed from the endangered area.
- Burning cylinders whose valves can no longer be closed must be taken outdoors to a safe place, if this is possible without risk.

What measures must be taken in the event of a fire in the adjacent area of LPG systems?

- Alert.
- Stationary compressed gas containers and equipment must be cooled (e.g. with a stationary sprinkler system).
- Movable compressed gas containers (liquid gas cylinders) must be removed from the hazardous area or, if this is not possible, cooled.
- Fires in the adjacent area of the LPG system must be extinguished.

Only extinguish burning LPG at the point of escape if the leak can be sealed (avoid risk of explosion)

Testing of LPG systems

When do LPG systems need to be tested?

LPG systems must be tested in accordance with national regulations.

For LPG supply systems (compressed gas containers as well as their equipment and lines), this usually means that

- before initial commissioning,
- after repair work

and

- at regular intervals

a test (e.g. internal test or pressure test) is performed.

LPG consumption plants must be tested in particular

- for safe setup,
- safe installation,
- tightness

and

- safe function.

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The ISSA

Providing social security

ISSA, the International Social Security Association is the world's leading umbrella organization for institutions, government agencies and authorities concerned with social security.

In a narrower sense, social security means protection against the consequences of "social risks". In addition to reduction in earning capacity due to occupational accident, occupational disease and occupational disability, this also includes illness, unemployment, assumption of family burdens, ageing and death of employed persons. In a broader sense, social security also includes an active labor market policy, a public education system and a balancing tax policy.

The ISSA was founded in 1927 by 17 European non-governmental organizations as the "International Conference of National Unions of Mutual Benefit Societies and Sickness Insurance Funds". Today, the ISSA has around 350 institutions, government agencies and authorities in more than 150 countries on all continents and is based at the United Nations International Labour Organization (ILO) in Geneva. The substantive work is carried out in 13 specialist committees, including those focusing on occupational accidents and diseases, health benefits and health insurance, employment policy and unemployment insurance, and family benefits and survivors' insurance.

Preventing occupational risks

The "Special Commission on Prevention" plays an important role within the ISSA. It consists of 14 international sections and deals with work-related risks in various sectors such as the chemical industry, mining, electricity and transport industry, but also with cross-cutting issues such as machine and system safety, information and prevention culture. The Special Commission coordinates the joint activities of the International Sections on Risk Prevention and other ISSA prevention activities.

As one of the first sections of the Special Commission, the International Section on Prevention in the Chemical Industry was founded in Frankfurt am Main in June 1970. It is committed to the prevention of occupational accidents and diseases in the chemical and allied industries, particularly in plastics and rubber, paints and coatings, pharmaceuticals and cosmetics, and specialty chemicals and petroleum refining. The chair and secretariat are held by the Berufsgenossenschaft Rohstoffe und chemische Industrie in Heidelberg.

In 1975, the ISSA International Section on Machine and System Safety was founded. Its objective is to increase safety and health protection at work worldwide in the field of machine and system safety. The chair and secretariat are held by the Berufsgenossenschaft Nahrungsmittel und Gastgewerbe in Mannheim.

Chemical Industry | Machine and System Safety | Transport | Construction Industry | Information | Mining Industry | Agriculture

Safety of liquefied petroleum gas systems: Propane and butane

Communicating expertise

A special thematic focus in many industries, e.g. chemical industry, food industry, is the handling of explosion risks. In 1978, therefore, the working groups "Hazardous Substances" and "Explosion Protection" were formed at the Section on Prevention in the Chemical Industry. In order to exploit synergy effects and increase efficiency, the "Explosion Protection" working group merged with the corresponding working group of the Section on Machine and System Safety in 2008.

Intensive informal discussions are held in the working group, and brochures and instructional media are also produced and workshops organized in order to promote the international exchange of experience among experts and to develop target-oriented solutions for specific problems.

In this way, the Section on Prevention in the Chemical Industry and Section on Machine and System Safety want to contribute to a high level of technology that is comparable among industrialized countries and pass on their knowledge to countries that are still less developed industrially.

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Safety of liquefied petroleum gas systems

Propane and butane

Due to its properties of being liquefiable under pressure at room temperature and its extreme flammability, LPG is used as a refrigerant, propellant for aerosol cans, and especially as a fuel for heating, cooking, and powering vehicles (e.g., forklift trucks).

This brochure deals with the use of LPG as a fuel in LPG systems. The properties and hazards of LPG are graphically illustrated. The properties of LPG involve potential hazards during storage and use. Unfortunately, serious accidents due to fires, explosions or poisoning occur time and again in connection with LPG. In this brochure you will find examples of the measures to be taken when handling LPG in order to avoid accidents. In addition, it gives advice on how to act in the event of damage.

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