

Handling chlorine

Safety and functioning of chlorination systems



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1. Symbols used in this document

1.1 Warnings against hazards involving risk of death or personal injury

**DANGER**

Indicates a hazardous situation which, if not avoided, will result in death or serious personal injury.

**WARNING**

Indicates a hazardous situation which, if not avoided, could result in death or serious personal injury.

**CAUTION**

Indicates a hazardous situation which, if not avoided, could result in minor or moderate personal injury.

1.2 Other important notes



A blue or grey circle with a white graphical symbol indicates that an action must be taken.



If these instructions are not observed, it may result in malfunction or damage to the equipment.

2. Physical and chemical data of chlorine

Under normal conditions of pressure and temperature, chlorine is a yellowish green gas with a pungent odour. It exists as diatomic molecule Cl_2 .

Chlorine is not flammable, but can promote the flammability of metals, hydrocarbons, etc.

Atomic weight	35.457 g/mol
Molecular weight	70.914 g/mol
Odour threshold	0.06 - 0.2 ml/m ³
Density (liquid)	1.57 g/cm ³ at -34.05 °C
Density (gaseous)	3.214 g/l at 0 °C, 1 bar
1 l liquid chlorine at 0 °C	corresponds to 457 l (0.457 m ³) gaseous chlorine
1 kg liquid chlorine at 0 °C	corresponds to 311 l (0.311 m ³) gaseous chlorine
Boiling point	-34.05 °C (1 bar)
Melting point	-100.98 °C
Evaporation heat	20.4 kJ/mol
Heat conductivity	0.0089 W/m K
Critical temperature	144.0 °C
Critical pressure	77.0 bar
Critical density	0.573 g/cm ³
Degree of purity (DIN EN 937)	99.5 %
AGW (occupational exposure limit value according to local regulations)	1.5 mg/m ³ 0.5 ml/m ³
Water pollution class	2

Pressure [bar]

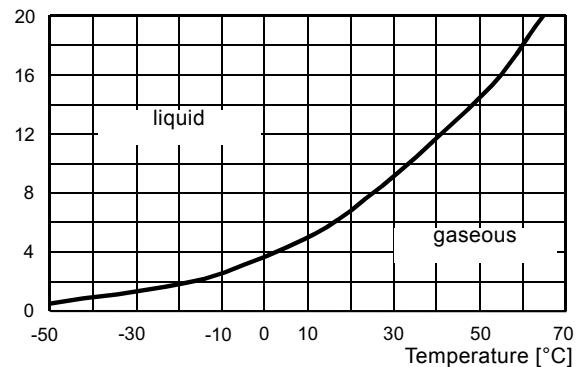


Fig. 1 Vapour pressure curve of chlorine

Solubility [g/l]

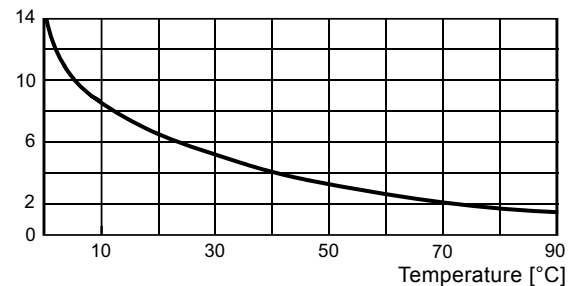


Fig. 2 Solubility of chlorine gas in water (at 1013 mbar)

T.M04 0691 0908

T.M04 0692 0908

3. Occupational safety and first aid

3.1 Hazards and safety instructions

Chlorine gas is toxic. Concentrations of more than 30 ml/m³ in the indoor air mean an acute danger to life.

3.1.1 Classification of chlorine gas according to GHS

GHS: Globally Harmonized System of Classification and Labelling of Chemicals

DANGER



H statements (hazard statements):

- H270: May cause or intensify fire; oxidizer.
- H280: Contains gas under pressure; may explode if heated.
- H330: Fatal if inhaled.
- H315: Causes skin irritation.
- H319: Causes serious eye irritation.
- H335: May cause respiratory irritation.
- H400: Very toxic to aquatic life.

EUH statements (supplementary hazard statements):

EUH071: Corrosive to the respiratory tract.

P statements (precautionary statements):

- P260: Do not breathe dust/fumes/gas/mist/vapours/spray.
- P220: Keep/Store away from clothing/.../combustible materials.
- P280: Wear protective gloves/protective clothing/eye protection/face protection.
- P244: Keep valves and fittings free from oil and grease.
- P273: Avoid release to the environment.
- P304-P340: If inhaled: Remove person to fresh air and keep comfortable for breathing.
- P305+P351+P338: If in eyes: Rinse cautiously with water for several minutes. Remove contact lenses if present and easy to do – continue rinsing.
- P332+P313: If skin irritation occurs: Get medical advice/attention.
- P370+P376: In case of fire: Stop leak if safe to do so.
- P302+P352: If on skin: Wash with plenty of water/....
- P315: Get immediate medical advice/attention.
- P405: Store locked up.
- P403: Store in a well ventilated place.

3.2 Instructed persons

The staff responsible for the installation, operation and service of the chlorination system as well as handling the chemicals must be appropriately qualified and trained for these tasks, and carry them out reliably.

3.3 Personal protective equipment



The operating company of a chlorination system must observe the local regulations. The following recommendations are based on the German regulations GUV-VD5.

Recommendations to the operating company of a chlorination system

The personal protective equipment listed below should be provided for the operating staff.

Personal protective equipment for each person:

- Respiratory equipment (full-sight gas mask)
 - with operative chlorine filter (B2P3), colour mark: grey with a white ring
 - at least 1 spare filter per gas mask
 - personally fitted, perfectly tight
 - labelled by name

For chlorination systems with chlorine drums:

- at least 2 protective suits with compressed-air respirators

Storage of the protective equipment:

- outside the chlorine rooms
- well visible
- easily accessible
- protected from dust and moisture

Obligations of the operating company

- Instruct the operating staff in handling the protective equipment
- Carry out exercises at least every 6 months
- Replace the filters of the gas masks regularly
 - after the expiry date
 - at least 6 months after opening (note the opening date on the filter)
 - after contact with chlorine

3.4 Rules of conduct

- Change chlorine containers only with gas mask.
- Enter contaminated rooms only with protective suit and compressed-air respirator.
- In case of flight wear gas mask, if possible. Observe wind direction!
- Eating, drinking and storing food is prohibited in chlorine rooms.

3.5 First aid in case of accidents

3.5.1 Inhalation of chlorine gas

1. Call an ambulance.
2. Take the injured out of the danger zone into the fresh air. Observe your own protection.
 - The injured should be carried or driven, even if no symptoms appear.
 - Avoid physical stress.
3. Rest the injured horizontally (rest sitting in case of respiratory distress). Protect the injured from hypothermia.
 - If unconscious but breathing, place the injured in recovery position.
 - If not breathing, provide artificial respiration with a breathing aid (e.g. resuscitation bag). Observe your own protection.
 - In case of cardiac arrest (no heartbeat, no pulse) give cardiopulmonary resuscitation immediately. Securing the vital functions (heart beating and independent breathing) is more important than all other measures.

Symptoms of poisoning may appear hours after the accident.

3.5.2 Swallowing of solutions containing chlorine

1. Call an ambulance.
2. Rinse mouth of the injured. Do not let the injured swallow the liquid.
3. If conscious, let the injured drink plenty of water.
4. Rest the injured calm. Protect the injured from hypothermia.
 - Do not induce vomiting.
 - If the injured vomits spontaneously, hold the head deep in prone position to avoid aspiration.

3.5.3 Chemical burns of the skin

After contact with aqueous solution:

1. Remove the contaminated clothes. Observe your own protection.
2. Rinse the affected skin with running water for at least 10-20 minutes.
3. Arrange for medical treatment.

After contact with cryogenic or liquefied gas:

1. Call an ambulance.
2. Take the injured out of the danger zone into the fresh air. Observe your own protection.
3. Thaw frosted clothing by rinsing with plenty of cold or tepid water. Remove carefully.
4. Rinse the affected skin with cold or tepid water. Cover with sterile material.
 - Do not rub.
 - Do not apply dry heat.

Observe the danger of inhalation. For measures see

[3.5.1 Inhalation of chlorine gas.](#)

3.5.4 Chemical burns of the eyes

1. Spread the eyelids of the injured eye widely and rinse with running water for 10 minutes. Protect the unharmed eye.
2. Take the injured to an ophthalmologist or to an eye clinic.

After contact with cryogenic or liquefied gas:

1. Rinse the injured eye carefully with running water for a short time.
 - Use cold or tepid water.
 - Do not spread the eyelids.
 - Leave the contact lenses in the eyes.
2. Take the injured to an ophthalmologist or to an eye clinic.

4. Handling chlorine

4.1 Transport and storage



WARNING

Toxic material

Death or serious personal injury

- Only experienced and well-trained staff should handle chlorine containers.

Basic rules for the transport and storage of chlorine

- Handle containers with care, do not throw.
- Protect containers from falling and rolling.
- Protect containers from direct sunlight and temperatures of more than 50 °C.
- Transport containers only with valve protection nuts and protection caps.

These rules apply to full and empty chlorine containers. Empty containers still contain rests of chlorine and are under pressure.

4.2 Pressure vessels and armatures



Observe the safety instructions and safety data sheets (SDS) of the manufacturer.

Chlorine is stored in cylinders or drums. For safety reasons, chlorine containers are only filled up to 95%.

4.2.1 Chlorine cylinders

Chlorine cylinders made of steel contain 50 kg or 65 kg of chlorine. They are equipped with a valve for extraction of gaseous chlorine from the upright cylinder.

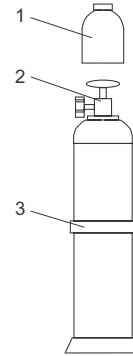


Fig. 3 Chlorine cylinder

Pos.	Description
1	Protective cap for valve
2	Valve for extraction of gaseous chlorine
3	Retaining clamp

4.2.2 Chlorine drums

Chlorine drums made of steel contain 500 kg or 1000 kg of chlorine. They are equipped with two valves:

- one valve for extraction of gaseous chlorine
- one valve for extraction of liquid chlorine

Chlorine drums are marked with colour stripes. The colour stripes must be aligned horizontally during extraction.

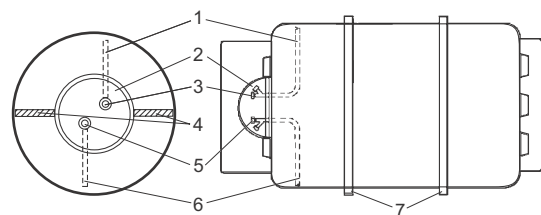


Fig. 4 Chlorine drum

Pos.	Description
1	Riser pipe for extraction of gaseous chlorine
2	Protective cap for valve
3	Valve for extraction of gaseous chlorine
4	Colour-stripe markings
5	Valve for extraction of liquid chlorine
6	Immersion pipe for extraction of liquid chlorine
7	Hoops

TM06 5688 5215

TM06 5690 0316

4.3 Extraction



WARNING

Toxic material

- Death or serious personal injury
- No modification or repair by the user.

WARNING

Toxic material



- Death or serious personal injury
- Do not open valves by force.
 - Do not use wrench extension.
 - Loosen stuck valves by wrapping with a warm cloth.
 - Return containers with stuck valves to the manufacturer.

WARNING

Oxidising material



- Death or serious personal injury
- Do not use an open flame.
 - Loosen stuck valves by wrapping with a warm cloth.
 - Return containers with stuck valves to the manufacturer.

4.3.1 Before extraction



WARNING

Toxic material

- Death or serious personal injury
- Chlorine containers must not be warmer than other parts of the system.

1. Before extraction, store chlorine containers for at least 8 hours in the chlorine storage room to let them adopt the room temperature.
2. Place the chlorine drums on their support so that the immersion pipe and the riser pipe are vertical (observe the markings on the drum).
3. Carry out a tightness check. (see [4.4 Tightness check](#))

4.3.2 Connecting the chlorine containers

1. Protect containers from falling and rolling.
2. Dry the pipes and the extraction system with dry nitrogen or dry air.
 - Do not let impurities get into the system.
3. Mount new gaskets to the connection pipe.
4. Connect the container.
5. Slowly open the container valve.

4.3.3 Extraction of gaseous chlorine



Danger of malfunction due to icing of container and piping.

Do not extract more than 1% of the container content per hour at a room temperature of 15 °C.

Keep a residual pressure of 2 bar approximately.

Container content	Extraction quantity
50 kg	500 g/h
65 kg	650 g/h
500 kg	5 kg/h
1 000 kg	10 kg/h

If more chlorine is required, connect several chlorine containers of the same temperature with header lines.

4.3.4 Extraction of liquid chlorine



Danger of malfunction due to contamination of the system when extracting deposit.

Do not empty chlorine drums completely.

Keep a residual pressure of 2 bar approximately.

- For large chlorination systems, liquid chlorine is extracted from drums.
- A chlorine evaporator must be installed.

4.3.5 Closing the chlorine container after extraction

WARNING

Toxic material



- Death or serious personal injury
- Immediately close the connecting pipes.
 - Do not let moisture get in.

1. Close the container valve.
2. Disconnect the container from the system.
3. Screw the lock nut onto the container valve.
4. Place the protective cap onto the container valve.

4.4 Tightness check

Check the tightness of the entire system before startup.

WARNING

Toxic material



- Death or serious personal injury
- Do not check the tightness before the entire system is ready for startup.

4.4.1 Checking the chlorine solution lines and the non-return valve of the injector



Observe the instruction manual of the injector.

4.4.2 Checking the vacuum lines

All lines from the vacuum regulator to the injector are vacuum lines.

1. Close all container valves.
2. Close the rate valve.
3. Open the shut-off valve at the injector and the shut-off valve at the injection armature.
4. Open the motive-water valve.
5. Switch on the booster pump.
6. Open the rate valve.
 - If the floater in the measuring tube shows a flow, or if the vacuum gauge shows more than -9 m WC, the vacuum lines are leaky.

If the vacuum lines are leaky

1. Close the rate valve.
2. Switch off the booster pump.
3. Close the motive-water valve.
4. Close the shut-off valve at the injector and the shut-off valve at the injection armature.
5. Check the vacuum lines and connections. Tighten carefully, if necessary.
6. Repeat the tightness check.
 - If the floater in the measuring tube remains at its lower stop, and the vacuum gauge shows -9 m WC or less, the vacuum lines are tight.

Other causes for insufficient operating vacuum

- The injector is too weak or defective
- The injector is obstructed
- The booster pump is too weak or defective

4.4.3 Checking the pressure lines

All lines from the gas containers to the vacuum regulator are pressure lines.

- If the chlorination system is equipped with a nitrogen rinsing device, carry out a preliminary tightness check with nitrogen.
- After this, check the tightness with ammonia.

4.4.4 Checking the tightness preliminarily with nitrogen

WARNING



Hazardous material

Death or serious personal injury

- Do not exceed the maximum nitrogen pressure of 16 bar.

1. Close all container valves.
2. Open the container connection valves and all shut-off valves until the chlorination system.
3. Open the shut-off valve of the nitrogen line to the header line.
4. Slowly open the valve of the nitrogen cylinder, until the pressure lines are pressurised with 10 bar approximately.
 - Read at the pressure gauge of the vacuum regulator.
5. Apply soap water to all pressurised components.
 - If bubbles appear, or the pressure at the pressure gauge drops, the pressure lines are leaky.

If the pressure lines are leaky

1. Depressurise the system.
2. Repair the leakage.
3. Repeat the tightness check.
 - If no bubbles appear, and the pressure at the pressure gauge drops not more than 1 bar within 30-60 minutes, the pressure lines are tight.

4.4.5 Checking the tightness with ammonia

WARNING



Toxic material

Death or serious personal injury

- Do not spill liquid ammonia on components of the system.

1. Open and immediately close all container valves and container connection valves.
2. Slowly pass the open ammonia bottle along the gas-leading components.
 - If white mist appears, the pressure lines are leaky.

If the pressure lines are leaky

1. Depressurise the system.
2. Repair the leakage.
3. Repeat the tightness check.
 - If no mist appears, the pressure lines are tight.

5. Requirements for chlorine rooms

- Overpressure lines of chlorination systems must not end in the open air.
- Chlorine rooms are not destined for the permanent stay of persons.
- Chlorine rooms are only destined for chlorine containers and the chlorination system.

5.1 Constructional requirements

Floor and exit

A chlorine room must have an even floor and a direct exit to the outside.

- The level of the exit must not be below the level of the adjacent terrain.
- The level of the exit must not be higher than the level of a loading platform.

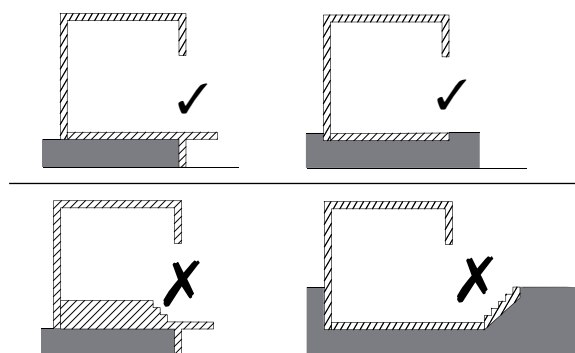


Fig. 5 Exits of chlorine rooms

Doors

Chlorine rooms must be lockable.

- Doors must open outwards.
- It must be possible to open the doors from the inside without a key.

Separation and ventilation

Chlorine rooms must be separated from other rooms.

- Chlorine rooms must have a gas-tight and fire-resistant separation from other rooms.
- Chlorine rooms may have a maximum of two ventilation openings, each with a maximum size of 20 cm².
- Chlorine gas must not get into subjacent rooms, shafts, pits, canals or aspirating holes of ventilation systems.

Water sprinkling system

A water sprinkling system for the precipitation of chlorine gas must be installed in chlorine rooms.

- Operation of the water sprinkling system must be possible manually from outside the chlorine room.
- The water sprinkling system needs sufficiently dimensioned drains with odour traps.

Chlorine gas warning device

A chlorine gas warning device must be installed outside the chlorine room. Requirements:

- Optical and acoustic alarm
- Connected to the water sprinkling system
- The connection must reactivate automatically after shutdown (e.g. for container exchange).

5.2 Signage



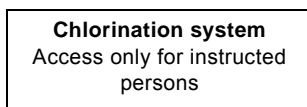
Observe the local regulations and first-aid provisions.

Signs at entrances of chlorine rooms:

- Warning sign according to ISO 7010-W16



- Supplementary sign according to GUV-VD5, annex 3, sheet 7



Signs in chlorine rooms:

- Mandatory sign according to ISO 7010-M017



5.3 Temperatures

Admissible temperatures in rooms for chlorination systems with plastic components:

- Plastic components with water contact in operation: +5 to +40°C
- Plastic components without water contact in operation: 0 to +40°C
- Transport and storage: -10 to +50°C

6. Structure and function of a chlorination system

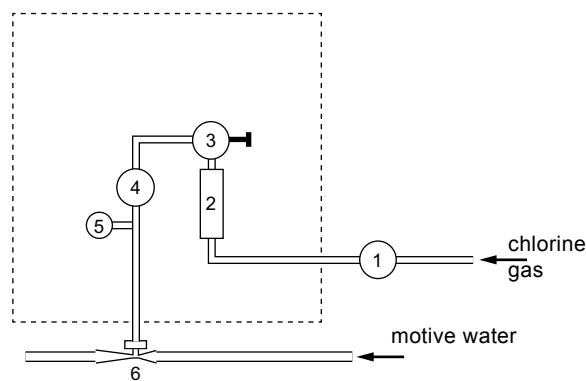


Fig. 6 Components of a chlorination system

Pos.	Component	Function
1	Vacuum regulator	Reduces the gas pressure (overpressure) below atmospheric pressure (vacuum).
2	Measuring tube	Shows the gas flow.
3	Rate valve	Manual or automatic adjustment of the required gas flow.
4	Differential pressure regulator	Keeps the difference of the pressure before and after the rate valve at a constant level. The adjusted dosing quantity remains constant, even if the injector vacuum varies.
5	Vacuum gauge	Indicates the vacuum created by the injector.
6	Injector	Creates the vacuum required for the operation of the system. Mixes the chlorine gas with the motive water.

7. List of regulations



This information document is based on the regulations mentioned below. The local regulations must be observed.

Abbreviation	Regulation	Editor
GEST 06/317	The Chlorine Reference Manual, 01.07.2008	EuroChlor
GEST 94/206	Safe Use of Chlorine from Drums & Cylinders, 01.01.2013	
GHS	Globally Harmonised System of Classification and Labelling of Chemicals	United Nations

ISO7010-W16

GUV-V D5

ISO7010-M017

TM06 6107 0916

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