



< Risk identification and safety >

Safety in Gas Tank Handling



IAMC Toolkit

Innovative approaches for the Sound Management of Chemicals
and Chemical Waste



Introduction

Gas tanks are a potential source of damage, when not properly handled. This presentation provides specific information on the handling of gaseous substances used in the chemical industry, in particular in their correct storage.

The reader will learn about potentially hazardous situations due to the presence of reactive chemicals or improper handling techniques (technical and structural measures).

Hazard Management

1. Risk identification and safety

11. Chemical classification and labelling

12. Risk assessment

13. Safety rules

14. Personal protective equipment

15. Skin protection

16. Emergency escape routes

17. Handling of solvents, acids and bases

18. Safety in gas tank handling

2. Transport and storage

21. Internal transport of chemicals

22. Internal pedestrian routes

23. Storage

3. Fire and explosion protection

31. Fire protection

32. Fire protection in welding and cutting operations

33. Explosion protection

34. Container cleaning

4. Emergency response

41. Emergency response plan

Contents

1. Context

- Types of gas cylinders
- Gas properties
- Gas classes and main hazards

2. Safety Precautions and Prevention Measures

- Technical and structural measures
- Organizational measures

3. Sources

Context

Types of Gas Cylinders

- **Gas cylinders:**

- Gas bottles used for transport (maximum capacity: 150 litres)
- Tanks under pressure (capacity ranging from 150 litres to 1,000 litres, high and low pressure)
- Cryogenic receptacles (maximum capacity: 1,000 litres)



Source: Shutterstock

Types of Gas Cylinders

- **Connected gas cylinders:**
 - Gas bottles directly connected to a gas distribution system
- **Reserve gas cylinders:**
 - Keep non-connected containers in reserve to replace exhausted connected containers and to ensure continued functioning.

Connected gas cylinders



Source: Suva

Connecting ramp

Properties of Substances

- **Special attention should be drawn to:**
- **Chemical and physical properties** of gases as they can greatly differ. The workers should be informed about these properties.
- Standard labels indicating:
 - **Density** (some gases are denser/less dense than the air)
 - **Flammability**
 - **Toxicity**
 - Other hazards (**corrosive, oxidizing, asphyxiant agents**)



Source: Suva

Gas Classes and Main Hazards

- Intoxication or asphyxiation
- Fire and explosion
- Bottles falling and pipe rupture



Source: Londoño G.

Gas classes	Asphyxiant Ex. Nitrogen, carbon dioxide	
	Oxidizing Ex. Oxygen, nitrous oxide	
	Flammable Ex. Hydrogen, ethylene, methane, acetylene	
	Toxic Ex. Chlorine, ammonia, methyl bromide	
		Source: Suva

Prevention Measures

- Technical and Structural Measures
- Organizational Measures

Materials

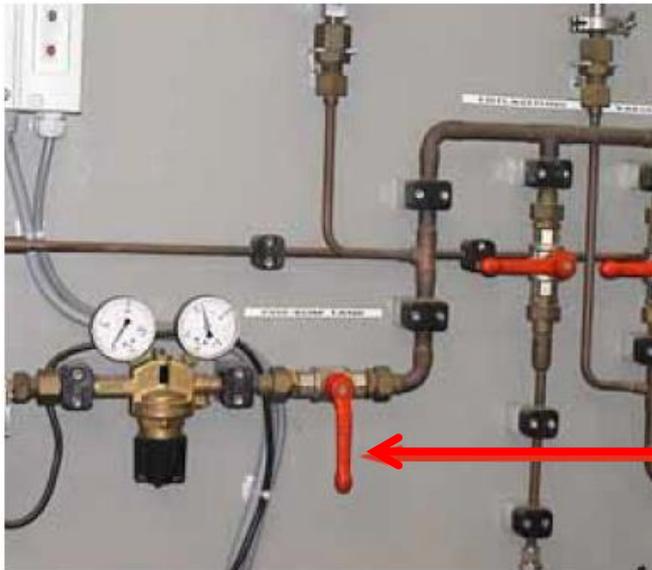
- Pipes, fittings and any other parts that might come in contact with a gas should consist of appropriate materials.

Examples of suitable combinations:

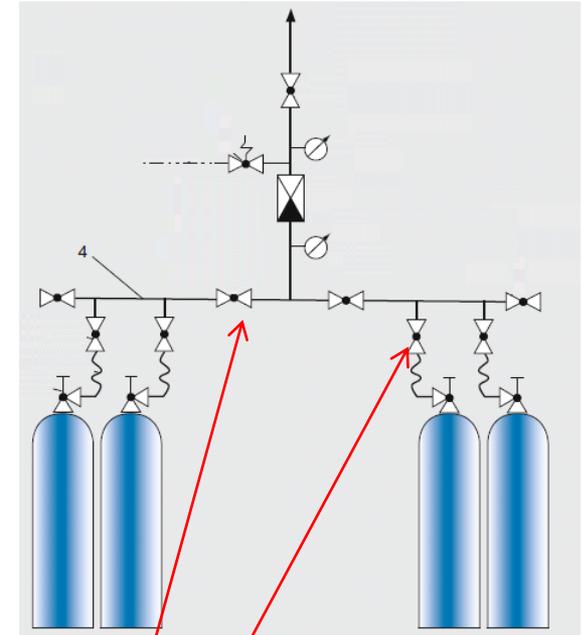
- Non-combustible materials for flammable gases
- Steel for acetylene (copper and alloys with more than 70% copper are not compatible with acetylene)
- Special plastic materials for ammonia and chlorine

Shut-Off Valves

- Shut-off valves that are fitted between connected gas cylinders allow the operator to stop the gas flow after **each use**, when **replacing an empty gas bottle** or in **case of an emergency**.



Source: Suva



Source: Suva

Shut-off valves

Transport

- When gas cylinders need to be **moved**, they should be **secured in a special carrier**.
- Bottles should be transported **upright** and should **never be rolled**.



Storage: Excluding Storage Incompatibilities

General incompatibilities

									
	O	-	-	-	-	-	+	-	-
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	-	-	+	O	-	-	-	-	-
	-	-	O	+	O	-	-	-	-
	-	-	-	O	O	O	O	O	O
	-	-	-	-	O	+	+	+	+
	+	+	-	-	O	+	+	+	+
	-	-	-	-	O	+	+	+	+
	-	-	-	-	O	+	+	+	+

Legend:



Can be stored together



Cannot be stored together



Can be stored together under certain conditions (check the SDSs)

Objective:

Avoid hazardous reactions



[D23 Storage](#)

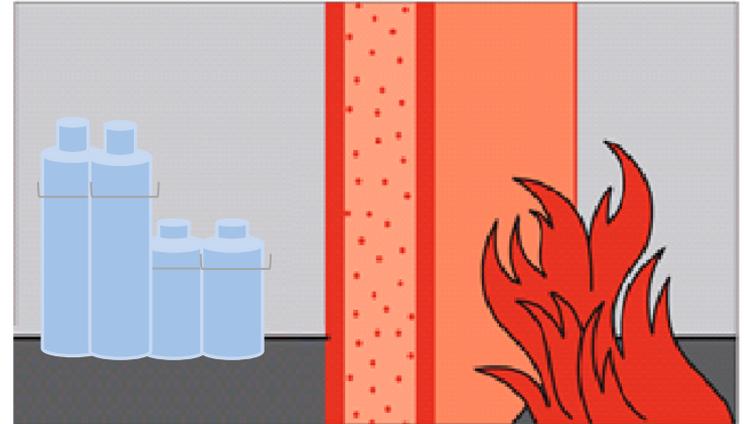
Source: Based on Neosys

Storage

- When storing gas bottles, the following **precautions** should be taken:
 - Protection against mechanical damage
 - Protection against overheating
 - Protection against the accumulation of gas in case of a leak
 - Protection against access of non-authorized persons
 - Effective natural or artificial ventilation
 - Absence of any source of ignition if combustible gases are stored
 - No communication with neighbouring premises or pipe networks
 - Warning signs
 - Acutely toxic and toxic gases should be stored in gas cabinets or in fume hoods.
- Follow **instructions** provided by the **gas supplier** on how to store the gas bottles (e.g. incompatibility with certain materials/other gases).

Storage

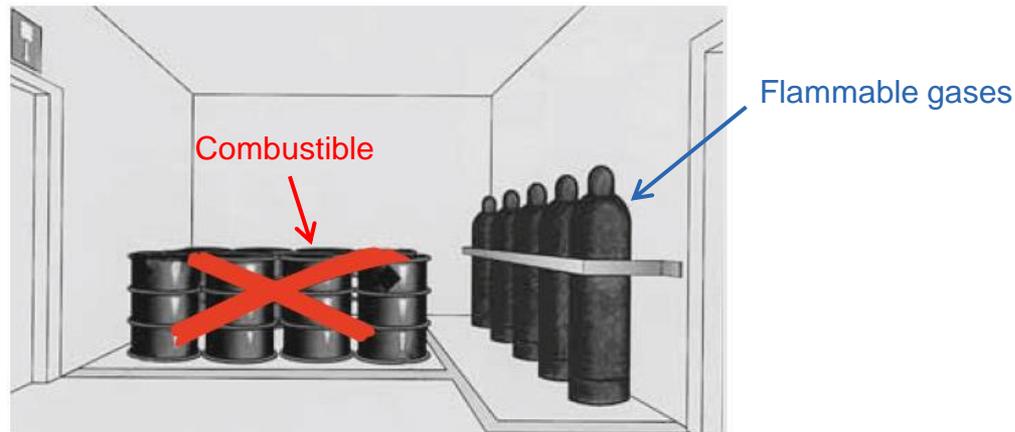
- Gas bottles, ramps and gas distribution systems should be placed **above ground level**.
- Premises where gas bottles and connected gas cylinders are stored should **resist a fire for at least 90 minutes** (doors should be able to resist 30 minutes to a fire).
- **Toxic gases** should be stored in **separate premises** only accessible from the outside or from a safe zone.



Source: Suva

Storage

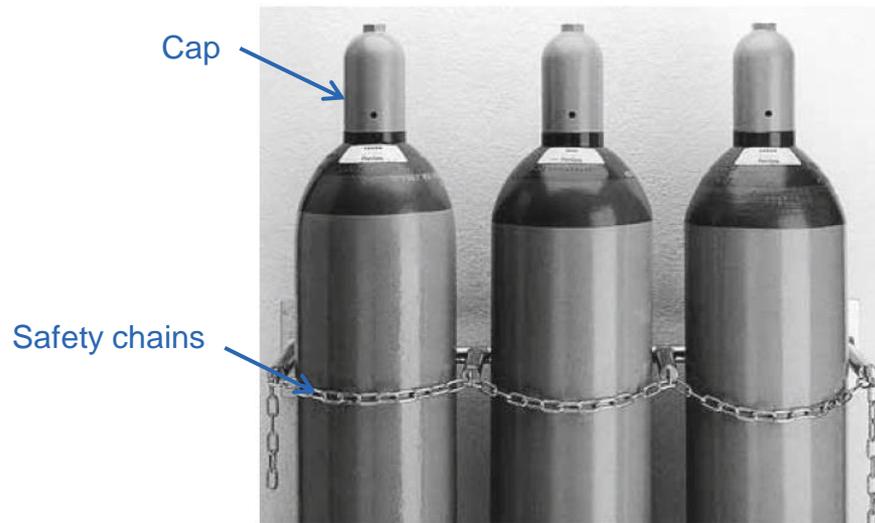
- **Combustible** materials (cardboard, paints, etc.) or **auto-flammable** materials should **not be stored with flammable gases**.
- Gas bottles should be **regrouped according to the physical and chemical properties of the contained gas** and separated from empty bottles.



Source: Suva

Storage

- Gas bottles should be **protected** against the **risk of falling** (e.g. chain, strap, etc.)
- The **valves** should be protected by a **cap**.

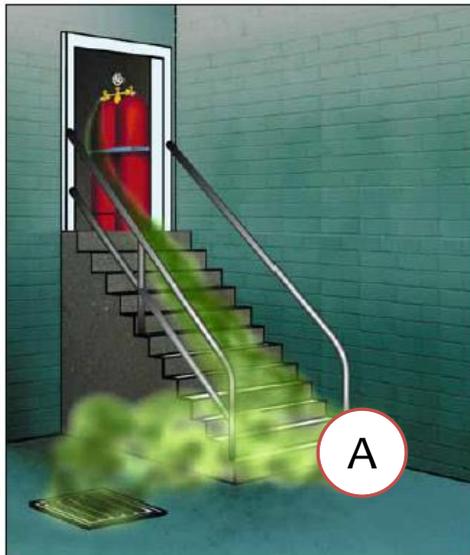


Source: Suva

Protection Against Gas Accumulation and Propagation – Ventilation

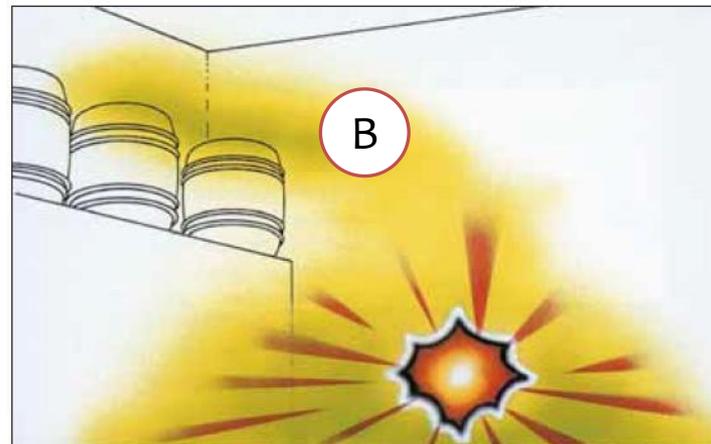
- Given the properties and the **relative density** of the substances stored, produced or used, gases will either tend to **spread at the ground level** or **rise**.

Gas denser than the air



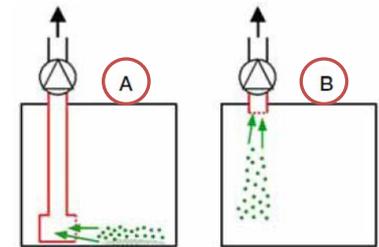
Source: Suva

Gas lighter than the air



Source: Suva

The relative density of the gas influences the design of the **ventilation system**.



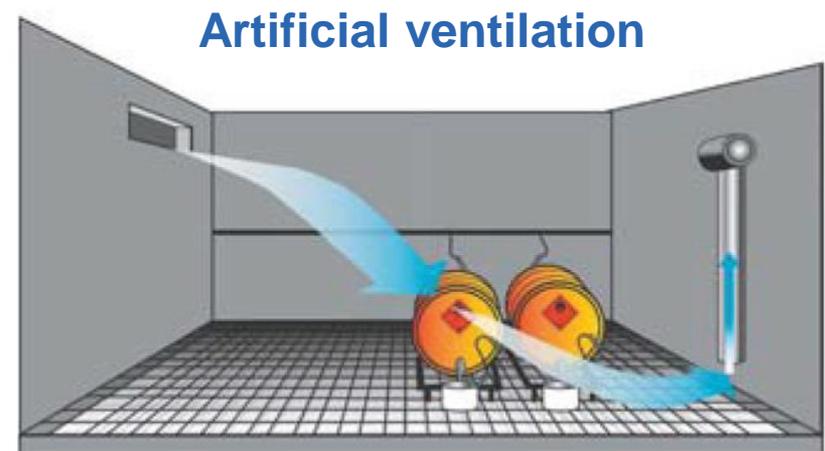
Source: Suva

Protection Against Gas Accumulation and Propagation – **Ventilation**

- **Natural** ventilation (windows, doors, openings)
- **Artificial** ventilation (general ventilation)



Source: Suva



Source: Suva

Working Premises

- Gas bottles may only be installed in working premises in:
 - Limited quantities
 - Confinement zones, cabinets, fume hoods
 - The presence of sufficient artificial ventilation
 - The presence of gas detectors

Artificial ventilation is considered **sufficient** when:

- No potentially explosive atmosphere can form
- Pollutant concentration at the workstations is lower than the allowed maximum value

Storage Cabinets

- Small quantities of gases can be stored in working areas in **non-flammable, ventilated and adequately indicated cabinets.**
- In working areas, only the **quantities required for the good functioning of the operations should be stored.**



Source: Suva

Protection Against Mechanical Damage

- **Storage zones** should be protected against mechanical damage (e.g. with a **protective slide**)
- For bottles of more than five litres, the **bottle taps** should be protected by a **cap** or a **protective cowling**.

Cap



Source: Suva

Protective cowling



Source: Suva

Protective slide



Source: Suva

Cooling Systems, Extinguishers and Water Systems

- In the presence of flammable gases, cooling systems and extinguishers should be installed.
- Premises containing gases that pose a high hazard to the environment (e.g. ammonia, chlorine) should be equipped with water systems.
- **Attention:** The size of the retention basin should also take into account the volume of the water system.

CO₂ extinguisher



Source: Suva

Water system



Source: Suva

Explosion Protection

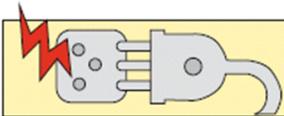
- The **zones** exposed to an **explosion hazard** should be appropriately evaluated and **preventive measures** should be taken, especially:
 - **Avoiding/Eliminating** the presence of **effective ignition sources**
 - Complying with the **hazard zone classification** and only using **authorized devices, instruments and installations** in these zones

The next slides contain a reminder of some important points from the presentation on explosion protection.



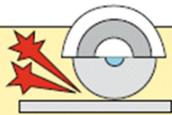
[D33_1_Explosion protection](#)

Elimination of Ignition Sources – Reminder



Sparks of electrical origin

In premises exposed to explosion risks, every **electrical device should be protected from the explosion risk.**

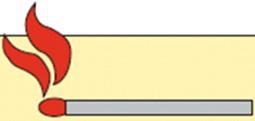


Sparks of mechanical origin

Source: Suva

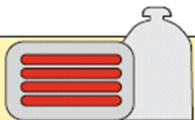
In **Zones 0 and 20**, devices that can produce sparks should not be used.
In **Zones 1 and 2**, sparks are tolerated only if special prevention measures are taken (combination of adequate materials, etc.)

Elimination of Ignition Sources – Reminder



Fire, flames, embers

- **Smoking banned**
- **Open-flame devices** should not be used in **Zones 0 and 20**. They are tolerated in **Zones 1, 2, 21, 22** only if preventive measures are taken.
- Preventing **smouldering fires**:
 - Eliminate dust deposits.
 - Maintain surfaces humid.
 - Use spark detection and extinguishing systems.

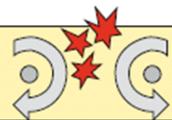


Warm surfaces

Source: Suva

- In **Zone 0**, the surface temperature should be **20% lower** than the **combustible's ignition temperature**.
- In **Zones 1 and 2**, the surface temperature should **never** be higher than **the combustible's ignition temperature**.
- In **Zones 20, 21, 22**, the surface temperature should not exceed two thirds of the **combustible's ignition temperature.***

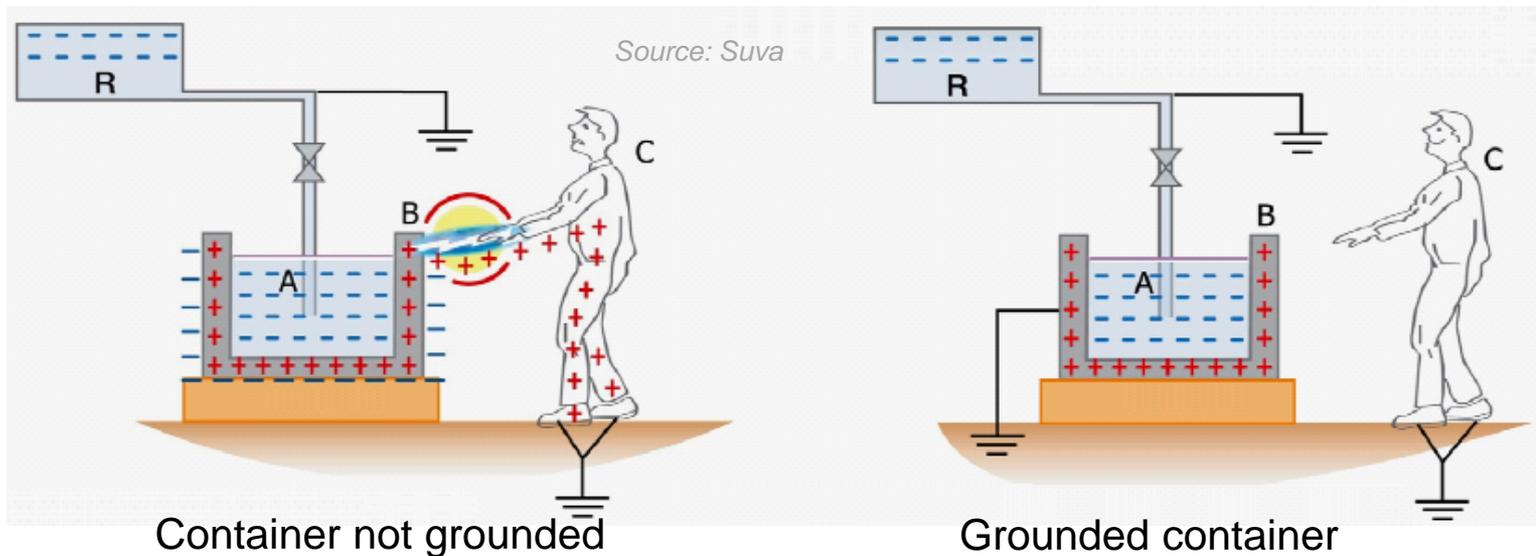
Elimination of Ignition Sources – Reminder



Static discharge

Source: Suva

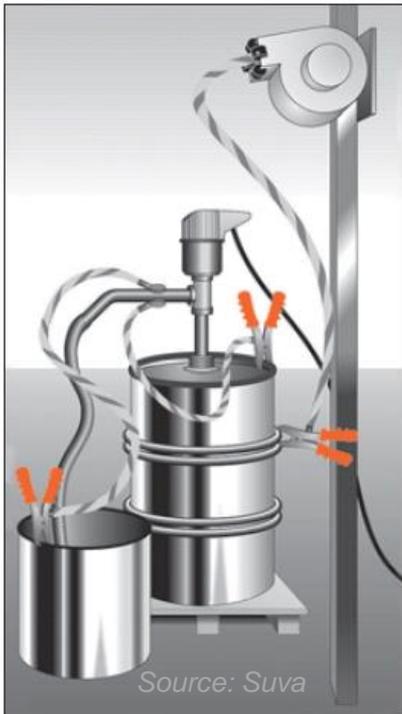
- Only use **grounded hoses, pipes, containers**, etc.
- In **Zones 1 and 21**, ground the staff by using **shoes and floors enabling the dissipation of electrostatic charges**.
- Use **grounded metal containers** when decanting flammable substances.



Elimination of Ignition Sources – Reminder

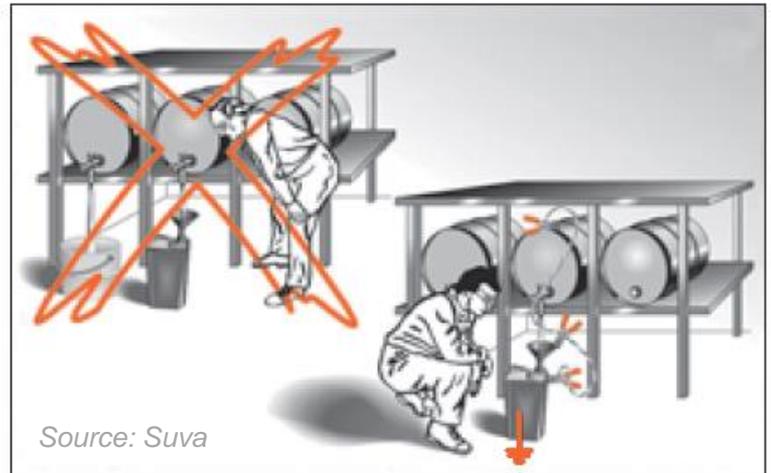


Static discharge



Grounded containers

- **Any conductor element** from any installation should be **bonded and grounded**.
- Containers and pipes should **not have insulating inner linings**.



- When **decanting flammable liquids**, the **container**, the **tank** and the other **conductor elements** should be **bonded and grounded**. The tanks' support should also be grounded.
- The **flow of the flammable substances** should be reduced to a **minimum**.

Elimination of Ignition Sources – Reminder



Lightning

- **Buildings and installations comprising explosion hazard zones** should be **protected** against lightning strikes (e.g. Faraday cage).



Chemical reactions

Source: Suva

- Improve the heat dissipation (e.g. smaller storage units, store in intermediate premises).
- Regulate the **pressure and temperature**.
- Store at **lower temperatures**.
- **Inerting**

Explosion Hazard Zones – *Reminder*

- **Classification in explosion hazard zones:**
 - To reduce the risk of explosions, areas are identified and classified in explosion hazard zones. Their **classification** defines the **requisite safety level** and the **type of equipment** that can or cannot be used within the zone.



Source: CSD

Using equipment with appropriate protection reduces the risk of igniting a potentially explosive atmosphere.

Explosion Hazard Zones – Reminder

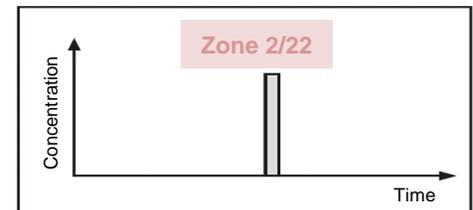
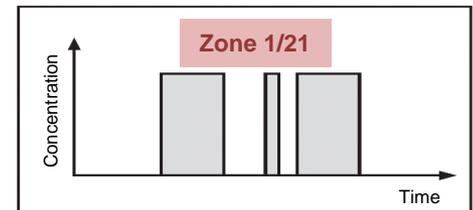
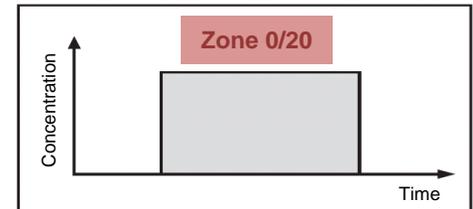
Classification in explosion hazard zones (ATEX)

Nobody should work in Zones 0 and 20



Area where a potentially explosive atmosphere occurs

<p>Zone 0 (gases/vapours) Zone 20 (dusts)</p>	<ul style="list-style-type: none"> - Constantly present - Present for long periods - Frequently present for short periods
<p>Zone 1 (gases/vapours) Zone 21 (dusts)</p>	<ul style="list-style-type: none"> - Periodically present - Occasionally present under normal operating conditions
<p>Zone 2 (gases/vapours) Zone 22 (dusts)</p>	<ul style="list-style-type: none"> - Rarely present and for short periods only
<p>Zone N.D</p>	<ul style="list-style-type: none"> - Very improbable



Source: Suva

Source: Based on Suva

Explosion Hazard Zones – Reminder

■ Equipment categories and explosion hazard zones

Equipment category	Usage zones		Requisite level of protection	Guaranteed safety
	Gases Vapours Mists	Dusts		
Category 1	Zone 0 Zone 1 Zone 2	Zone 20 Zone 21 Zone 22	Very high	Even in the event of rare incidents, these devices have protection means such that: <ul style="list-style-type: none"> - In the event of failure of one means of protection, at least an independent second means provides the requisite level of protection, - The requisite level of protection is assured in the event of two faults occurring independently of each other.
Category 2	Zone 1 Zone 2	Zone 21 Zone 22	High	In case of foreseeable disturbances
Category 3	Zone 2	Zone 22	Normal	Under normal operating conditions

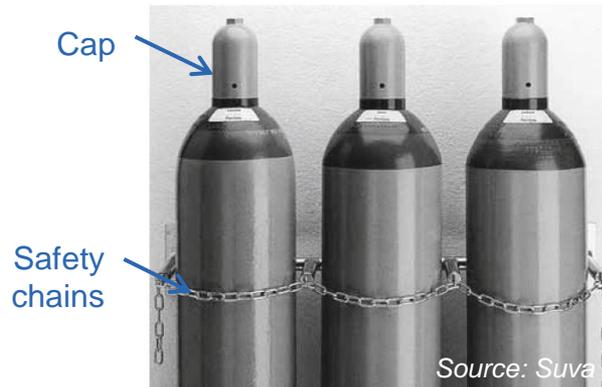
Maintenance

- Every gas installation must undergo a **leakage test** before any **commissioning** and after any **transformation** or **repair** (e.g. with a foaming product).
- The **operator** is **responsible** for the **periodical revision** of every gas installation and its safety features by qualified personnel.
- **Defective installations** have to be signalled.
- **Bottle taps** should **not be oiled**.



Escape Routes, Empty Bottles, Damaged Bottles

- Cylinders of flammable gases should not be installed in escape routes such as corridors and stairways. **Escape routes always must be clear!**
- **Empty bottles** should be stored with their **tap closed** and protected by a **cap**.



- **Damaged bottles** should not be used. They should be **marked**, and **stored outside** or in **ventilated premises**. The supplier should be informed.

Extinguishers and First Aid

- Areas where gases are handled have to be equipped with:
 - Extinguishers and cooling systems
 - First aid facilities (showers, eye-wash stations)
- These facilities have to be regularly checked.



Extinguisher

Source: CSD

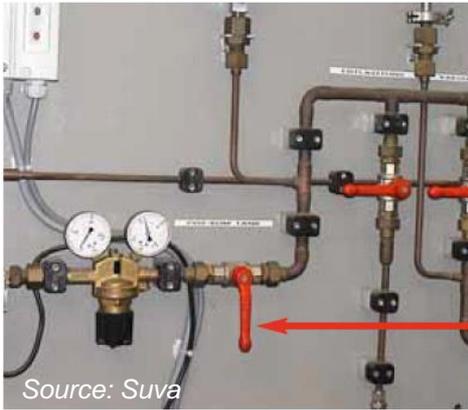


Source: Shutterstock

Replacement of an Empty Bottle – Exercise

You need to change an empty connected gas bottle.
What measures should you take
to ensure your safety?

Replacement of an Empty Bottle – Exercise



Shut-off valves



Danger: gas bottle



Mandatory hand protection



Cap



Replacement of an Empty Bottle – Exercise

1. Make sure that first aid kits and extinguishers are available close to the work area.
2. Turn the shut-off valves to switch the gas flow off.
3. Read the SDS of the substance and wear the appropriate PPE. Transport the new bottle upright in a secured carrier.
4. Switch the ventilation ON in the work area.
5. Proceed to the replacement of the gas bottle by following the instructions.
6. Close the empty bottle with its cap and place it on the secured carrier to transport it to the empty bottle storage area.
7. Switch the gas flow on.
8. Verify that there are no leaks.

Prevention Measures

- Technical and Structural Measures
- Organizational Measures

Warning Signs (GHS pictograms)

- The dangers inherent to the gases should be clearly indicated.



Danger: Gas bottle



Attention: Potentially explosive atmosphere



Danger: Flammable substances



Danger: Toxic substances



Danger: Corrosive substances



No open flame



No smoking



Mandatory eye protection



Mandatory hand protection

Source: UN GHS, 2013

Pipe Labelling

- Pipes should be appropriately identified with the **name** of the gas and the **flow direction**.



Source: Suva

Accessibility

- Exterior storage premises should be protected against the access of non-authorized persons, for instance by installing fences.



Source: Suva



Source: Suva

Staff Training and PPE

- **The company** should provide regular training on safety issues (including hazards and protection measures) to employees and staff from third-party companies to ensure that they **know how to work in safe conditions**.
- Management should ensure that **written rules** concerning the **handling** of gases and the **emergency plan** are available. They should also monitor whether **the workers comply with the rules**.
- **PPE** adapted to the hazards incurred should be **made available to the workers** (e.g. garments, shoes, eye protection, respiratory protection, gloves).



Source: Suva

Emergency Plan

- An **emergency plan** should be defined:
 - When **gases with high risk potential** are present (e.g. chlorine and ammonia)
 - For premises where **large quantities of flammable gases** are stored (more than 170 kg or more than 24 bottles of 50 litres)



- Chemical and physical properties of gases can greatly differ. The workers should be informed about these properties. Labels provide fundamental information.
- In the presence of flammable gases, cooling systems and extinguishers should be installed.
- Premises containing gases that pose a high hazard to the environment should be equipped with water systems.
- Every gas installation must undergo a leakage test before any commissioning and after any transformation or repair.
- An emergency plan should always be defined.

Sources

Sources

- CSD Engineers, Switzerland/ISSPPRO, Germany, 2015
- Suva: Bouteilles à gaz – Entrepôts, rampes, systèmes de distribution de gaz, Switzerland, 2007
- Suva: Liste de contrôle – Bouteilles de gaz, Switzerland, 2013
- Neosys: Formation matières dangereuses, Switzerland, 2011
- Waswo: www.extra.suva.ch, Switzerland, June 2015

Images

- CSD Engineers, Switzerland, 2015
- Londoño G. for NCPC Colombia, 2015
- Suva: Bouteilles à gaz – Entrepôts, rampes, systèmes de distribution de gaz, Switzerland, 2007
- Suva: Liste de contrôle – Bouteilles de gaz, Switzerland, 2013
- Neosys: Formation matières dangereuses, Switzerland, 2011
- Shutterstock, USA, 2015
- **United Nations, Globally Harmonized System of Classification and Labelling of Chemicals (GHS), accessed July 2015**

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