Explosion Protection

IAMC Toolkit
Innovative Approaches for the Sound Management of Chemicals and Chemical Waste

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION

Introduction

This presentation explains the explosion hazard and the related possibility to form a potentially explosive atmosphere.

The reader will be given information about the identification of ignition sources and the type of explosions that could occur. An introduction to the evaluation of the explosion risk and the prevention measures that can be put in place to avoid the creation of potentially explosive atmosphere is also given.

Hazard Management

1. Risk identification and safety	2. Transport and storage	3. Fire and explosion protection	4. Emergency response
1.1 Chemical classification and labelling	2.1 Internal transport of chemicals	3.1 Fire protection	4.1 Emergency response plan
1.2 Risk assessment	2.2 Internal pedestrian routes	3.2 Fire protection in welding and cutting operations	
1.3 Safety rules	2.3 Storage	**3.3 Explosion protection**	
1.4 Personal protective equipment		3.4 Container cleaning	
1.5 Skin protection			
1.6 Emergency escape routes			
1.7 Solvents, acids, bases handling			
1.8 Safety in gas tank handling			

Checklists

Contents

Explosion Hazard Concepts

Explosion Hazard

What is an explosion?

- An explosion is a very fast chemical reaction of a flammable substance releasing considerable amounts of energy.

When does an explosion occur?

Potentially explosive atmosphere

+

Effective ignition source

Mixture with air, under atmospheric conditions, of combustible substances such as **gases, vapours, mists or dusts** in which, after ignition has occurred, combustion spreads to the entire unburned mixture.

An ignition source is considered effective if it provides enough energy to the atmosphere for the combustion to go on by itself.

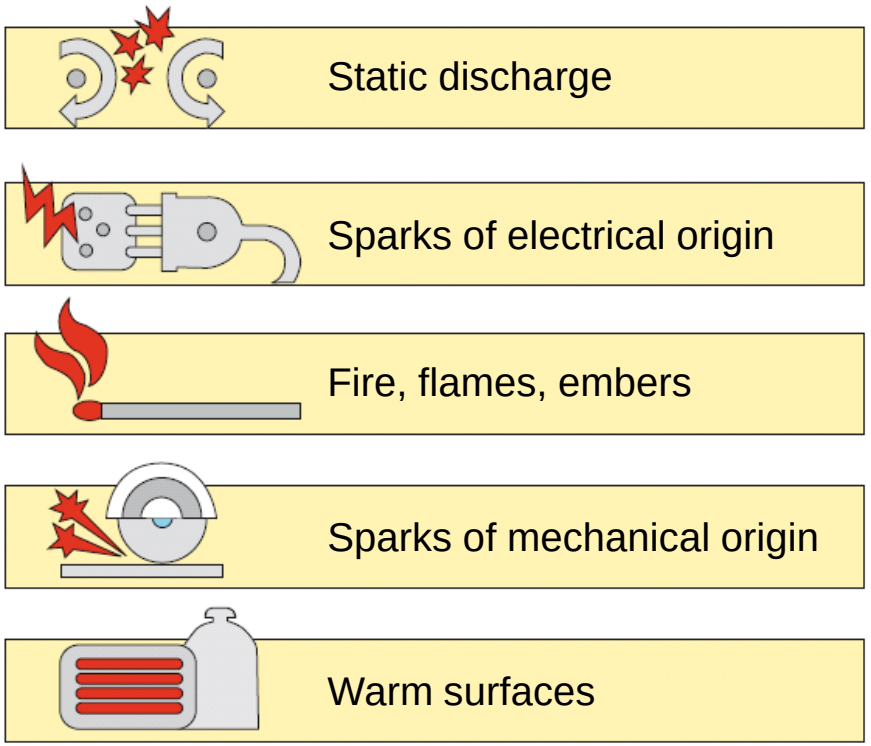
Explosion Hazard – Potentially Explosive Atmosphere

- The formation of a potentially explosive atmosphere depends on:
  - The presence of a combustible substance
  - The degree of dispersion of the combustible substance
  - Whether the concentration of the combustible substance in the air is in the explosive range
  - The presence of a potentially explosive atmosphere in such quantity that it would induce damage if ignited

Explosion Hazard – Ignition Sources

- An ignition source is effective if it provides enough energy to the potentially explosive atmosphere to cause a combustion which propagates spontaneously.

The energy of the ignition sources present in an industrial workplace is generally higher than the minimum ignition energy, which means that ignition sources are almost always effective.



Source: Suva

Explosion Hazard – Types of Explosions

- **What are the different types of explosions?**

Physical explosion

Example: explosion of a boiler containing water

- *Physical rupture of the boiler*
- *No chemical explosion of the released water*

Chemical explosion

Example: chemical reaction between two compounds, which increases the pressure in the container, leading to an explosion

BLEVE* (physical/ chemical explosion)

Example: rupture of a container (e.g. due to a pressure increase) and instant chemical explosion of flammable butane

Particularly dangerous type of explosion

Explosion Hazard – Effects of an Explosion

What are the effects of an explosion?

- Flames
- Thermal radiation
- Blast effects
- Projections
- Release of dangerous substances

WARNING: Flames propagating in a potentially explosive atmosphere can take a volume up to 10 times greater than that of the explosive atmosphere before its ignition.

The effects depend on:

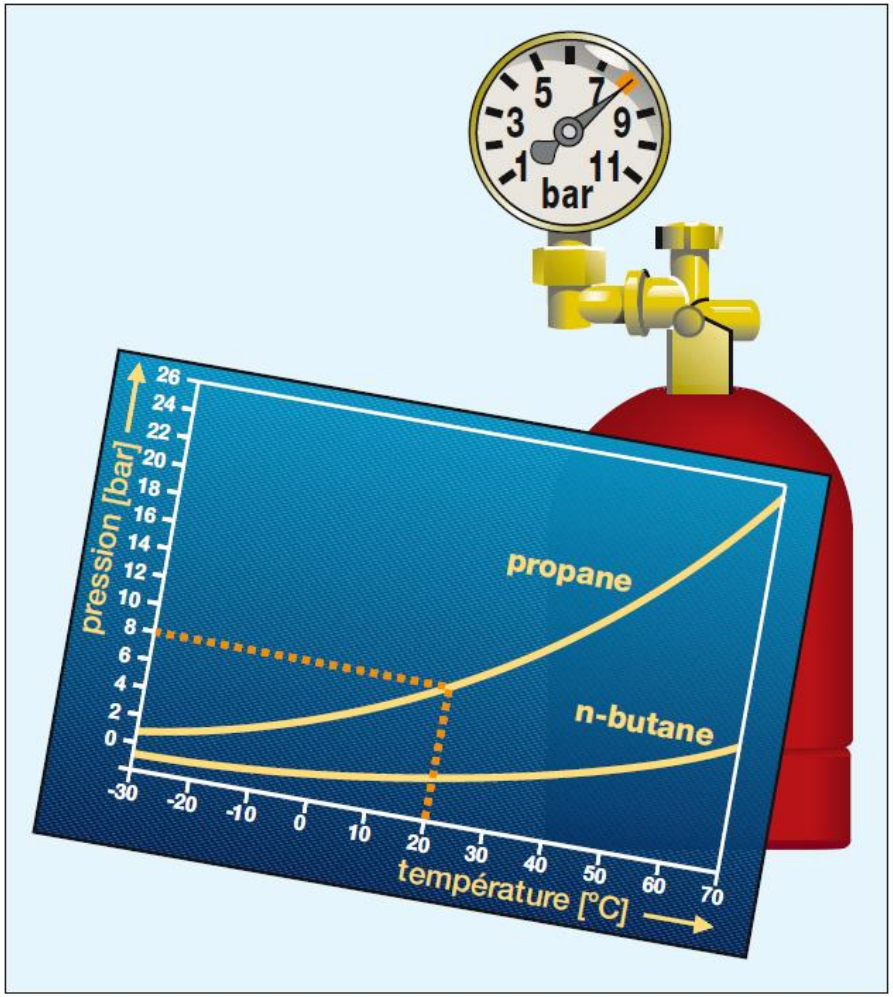
- The chemical, toxic and physical properties of the released and produced combustion products
- The quantity and the confinement of the potentially explosive atmosphere
- The geometry of the environment
- The solidity of the structures, installations and buildings
- The protective equipment worn by the staff at risk
- The physical properties of the objects at risk

Explosion Hazard – Warning

Warning:

Warning for companies producing, using or storing liquefied gases (e.g. propane, butane): The increase in pressure induced by an increase in temperature follows an exponential law!

A **slight increase in temperature** can trigger an **explosion**.

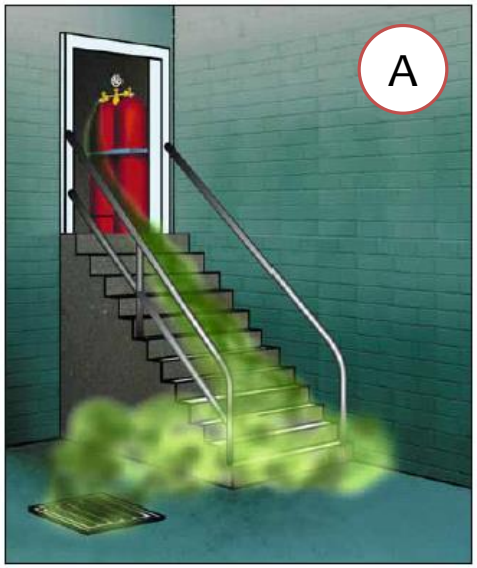


Source: Suva

Explosion Hazard – Relative Density

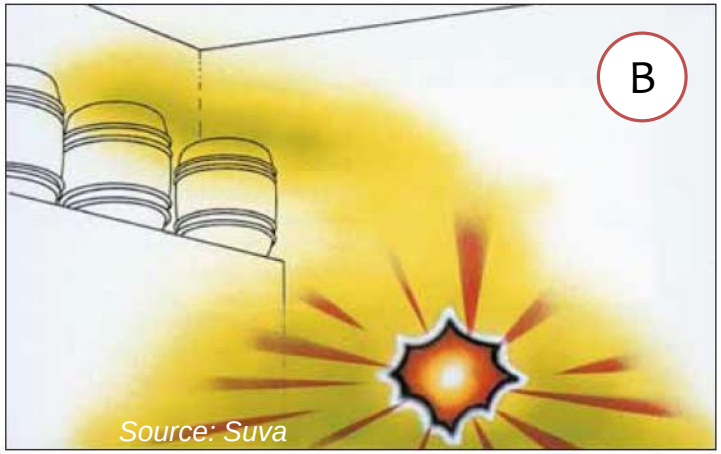
- Given the properties and the **relative density** of the substances stored, produced or used, the potentially explosive mixtures will tend to spread at the ground level or to rise.

Flow of liquefied gases



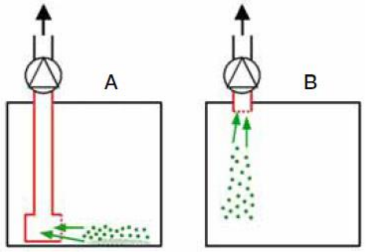
Source: Suva

Flow of solvent vapours



Source: Suva

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



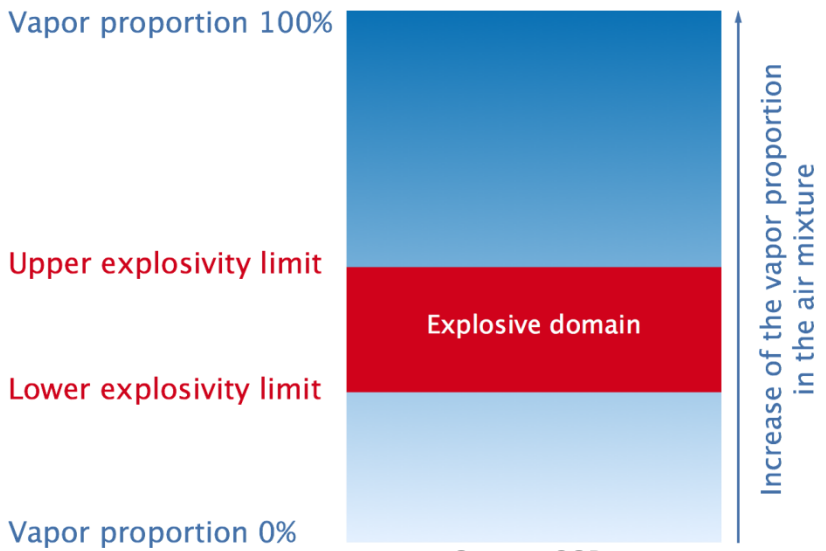
Source: Suva

Gas examples:
Higher density than air: **butane, most solvents**
Lower density than air: **ammonia, hydrogen**

Explosion Hazard – Explosive Range and Flash Point

Explosive range

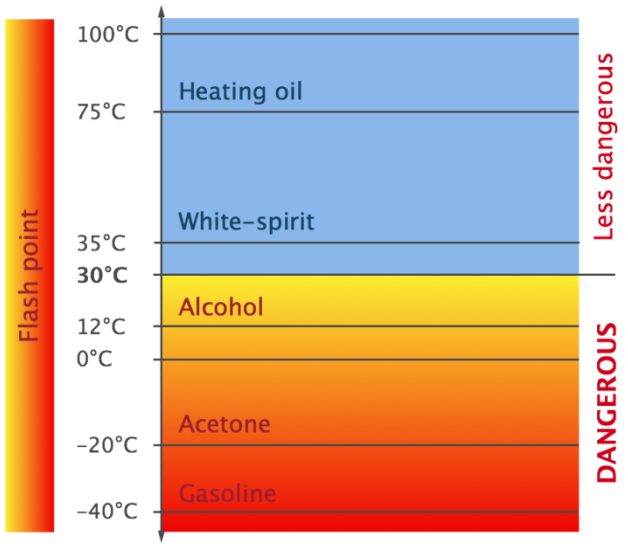
The mixtures of flammable gases/vapours with the air can only lead to a spontaneous combustion or an explosion if the vapour proportion of the mixture is in the range between the upper and lower explosive limits.



Source: CSD

Flash point

The flash point is the lowest temperature at which a liquid releases enough vapours to form a potentially explosive atmosphere at the surface. With the presence of an ignition source, the mixture ignites.



Source: Based on FOEN

Risk Assessment

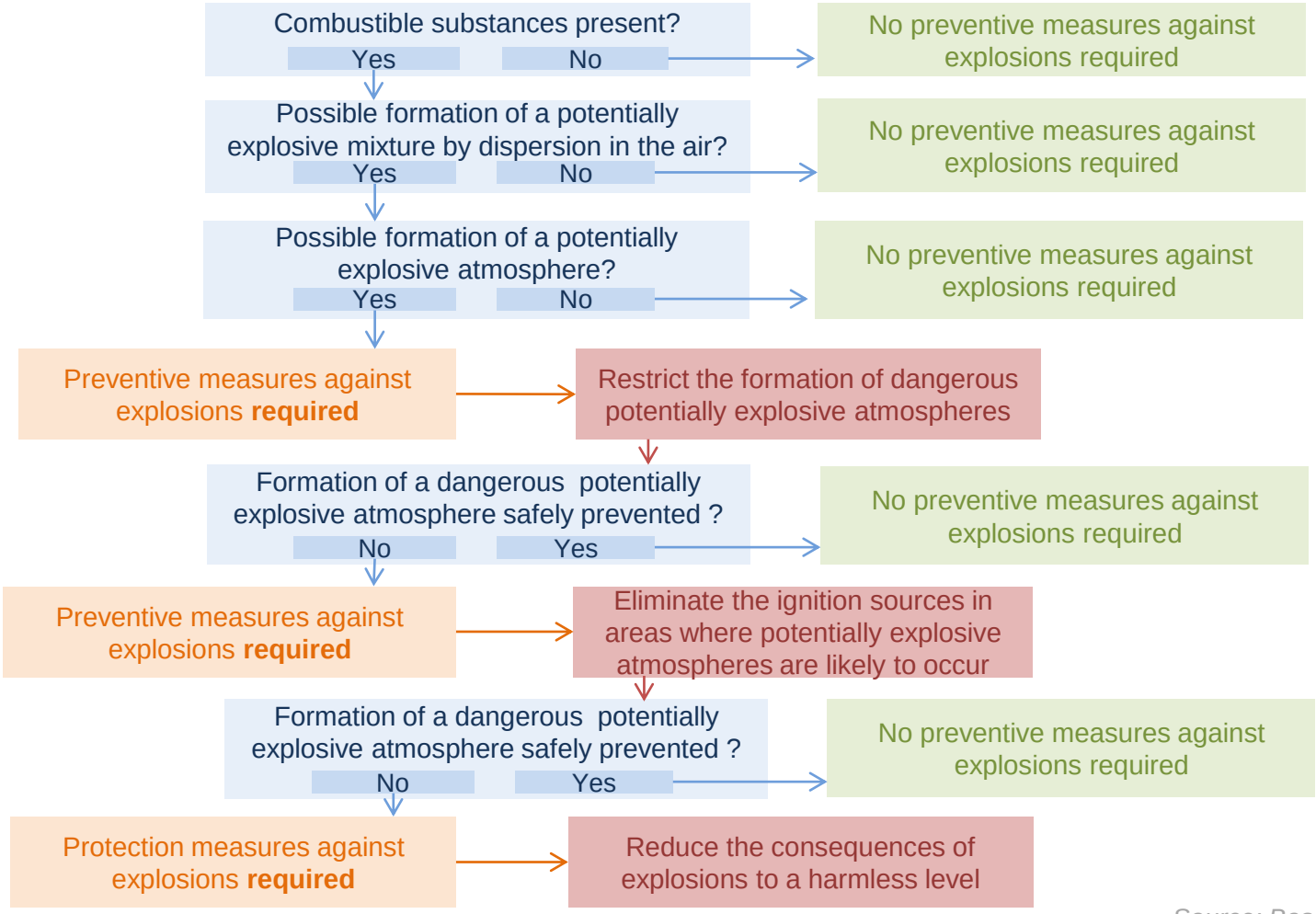
Risk Assessment

What are the elements of a risk analysis?

- To reach the expected safety level, a risk analysis should be undertaken for each specific case and include the following elements:

Identification of explosion hazards	Risk estimation	Risk evaluation	Risk reduction
Are the **substances combustible?**	Can an **explosive atmosphere form?**		**Prevention/ Protection** measures
What is their degree of **inflammability**?	Are **ignition sources** present?		
	What are the **consequences**?		

Evaluation of the Explosion Risk



Source: Bas on Suva
Source: Based on Suva

Risk Reduction Measures

Prevention Measures

- Prevention measures aim at:
  - Preventing the formation of a potentially explosive atmosphere
  - Avoiding the ignition of the potentially explosive atmosphere

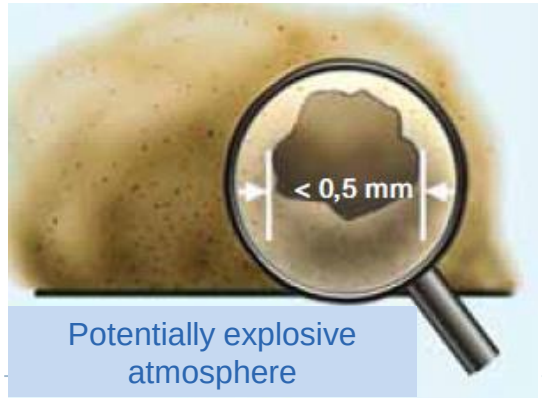
Primary measures
- Replacement
- Inerting
- Closed systems
- Ventilation
- Detection/Action

Secondary measures
- Classification in explosion hazard zones
- Elimination of the ignition sources

Tertiary measures
- Hazard-resistant construction
- Explosion relief
- Explosion suppression
- Explosion decoupling

Hazardous Substances

- Prevention measures should be taken for:
  - Flammable gases
  - Flammable liquids with a flash point lower than 30°C
  - Flammable liquids with a flash point superior to 30°C when they are heated above their flash point temperature
  - Flammable liquids appearing in the form of mists
  - Combustible dust formed by particles with a diameter inferior to 0.5 mm

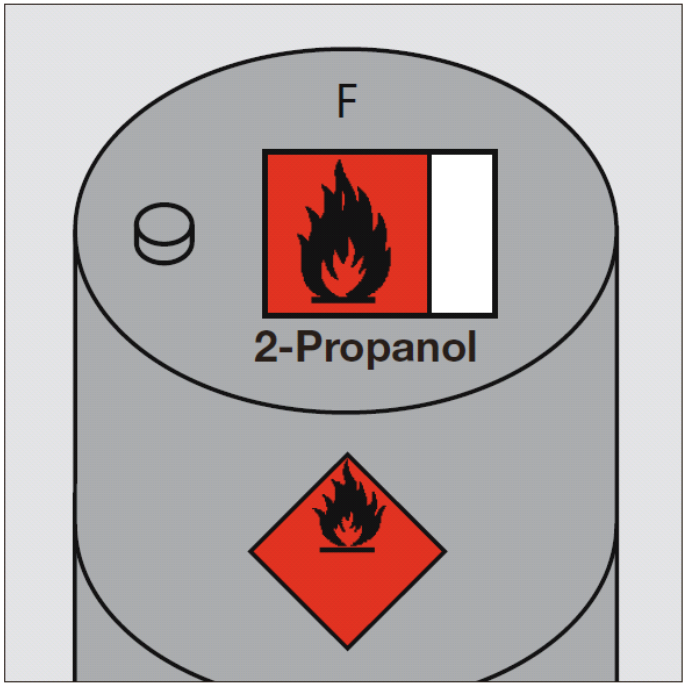


Potentially explosive atmosphere

Source: Suva

Preventing the Formation of a Potentially Explosive Atmosphere – Labelling

- The equipment (containers, tanks and pipes) should be appropriately labelled (always visible and permanently labelled).



Source: Suva

Risk Reduction Measures

- Measures Preventing the Formation of Potentially Explosive Atmospheres
- Measures Preventing the Ignition of Potentially Explosive and Dangerous Atmospheres
- Construction measures
- Organizational measures

Preventing the Formation of a Potentially Explosive Atmosphere – Substitution and Restrictions

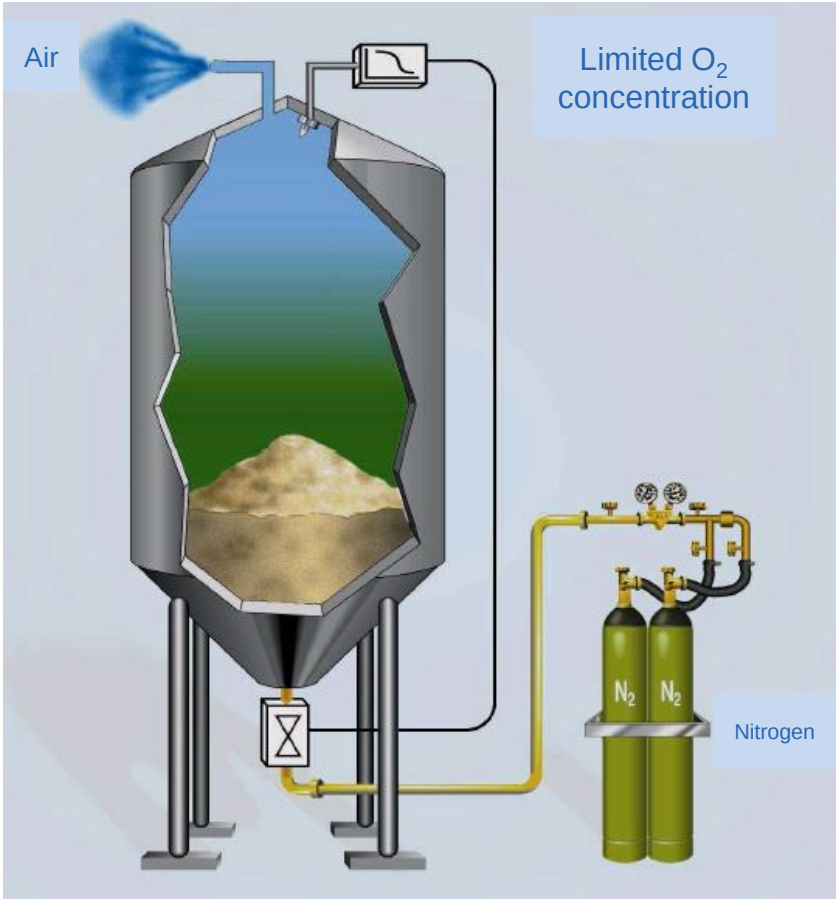
- Replace easily flammable liquids, gases and dusts by substances that do not cause a potentially explosive atmosphere:
  - Aqueous solutions
  - Non-flammable halogenated hydrocarbons
  - Solvents or mixtures with a flash point superior to 30°C and/or greater than the working temperature (15 °C higher for mixtures and 5 °C for pure liquids)
  - Low-dust materials
  - Pasty products

- Limit concentrations of flammable substances to ensure that they are not in the explosive range:
  - Maintain concentrations below the explosive limit.
  - Keep the temperature of the mixture 15°C lower than the flash point and 5°C lower for pure flammable liquids.

Preventing the Formation of a Potentially Explosive Atmosphere – Inerting

- Inert the volume of a container to ensure that the oxygen concentration is lower than the critical value (limiting oxygen concentration – LOC).

Example: Add an inert substance (nitrogen, carbon dioxide) to partially replace the oxygen in a silo containing potentially combustible dusts.

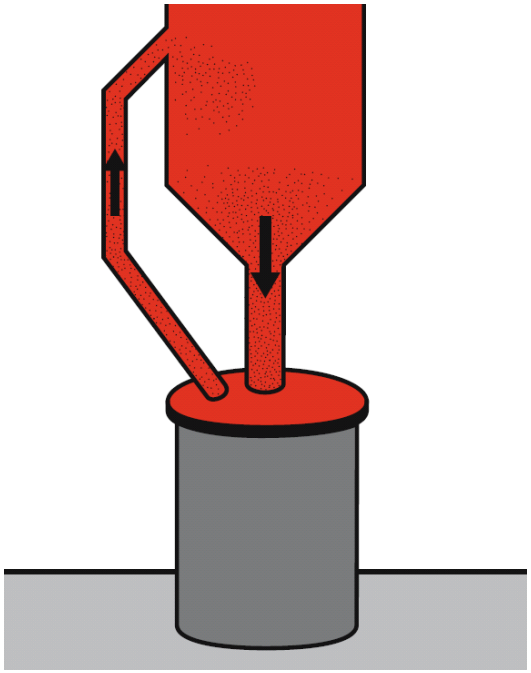


Source: Suva

Preventing the Formation of a Potentially Explosive Atmosphere – Closed Systems

- Use closed systems to avoid the formation of a potentially explosive atmosphere outside the system:
  - Gas recovery
  - Filling and emptying with a lock system
  - Soldered or welded pipes
  - Crimped pipes
  - Long-term tight equipment

- Reduce leakage:
  - Limit the number and dimensions of dismountable connections to a minimum.
  - Limit the use of flexible pipes.
  - Ensure the integrity of the piping (e.g. protection).

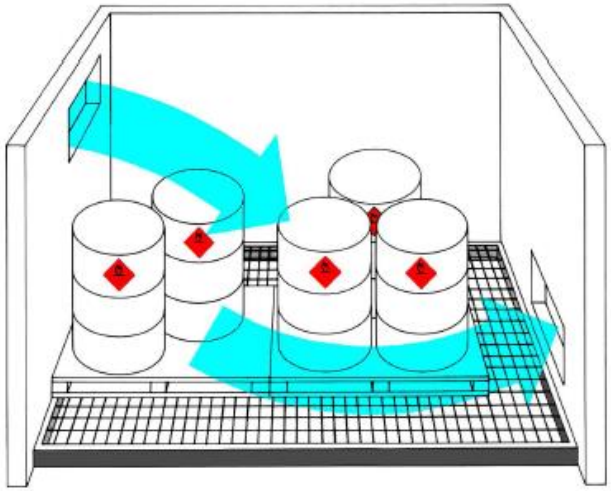


Source: Suva

Preventing the Formation of a Potentially Explosive Atmosphere – Ventilation

- Natural ventilation can be used to prevent or limit the formation of a potentially explosive atmosphere.

Natural ventilation



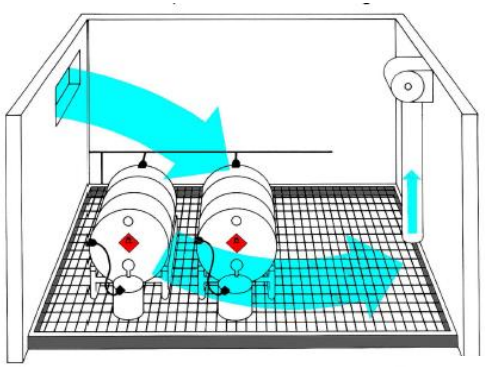
Source: Suva

- Minimum of two openings leading to the open air
- Transversal ventilation
- Position of the openings depends on the density of the substance
- Dimensions: 20 cm^2/m^2 of floor area

Preventing the Formation of a Potentially Explosive Atmosphere – Ventilation

- Artificial ventilation can be used to prevent or limit the formation of a potentially explosive atmosphere.

Artificial ventilation



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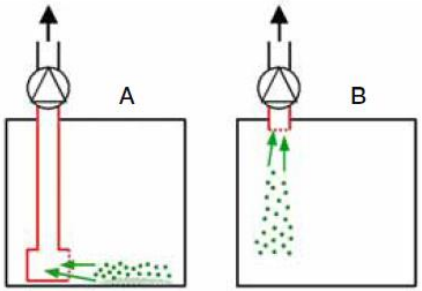
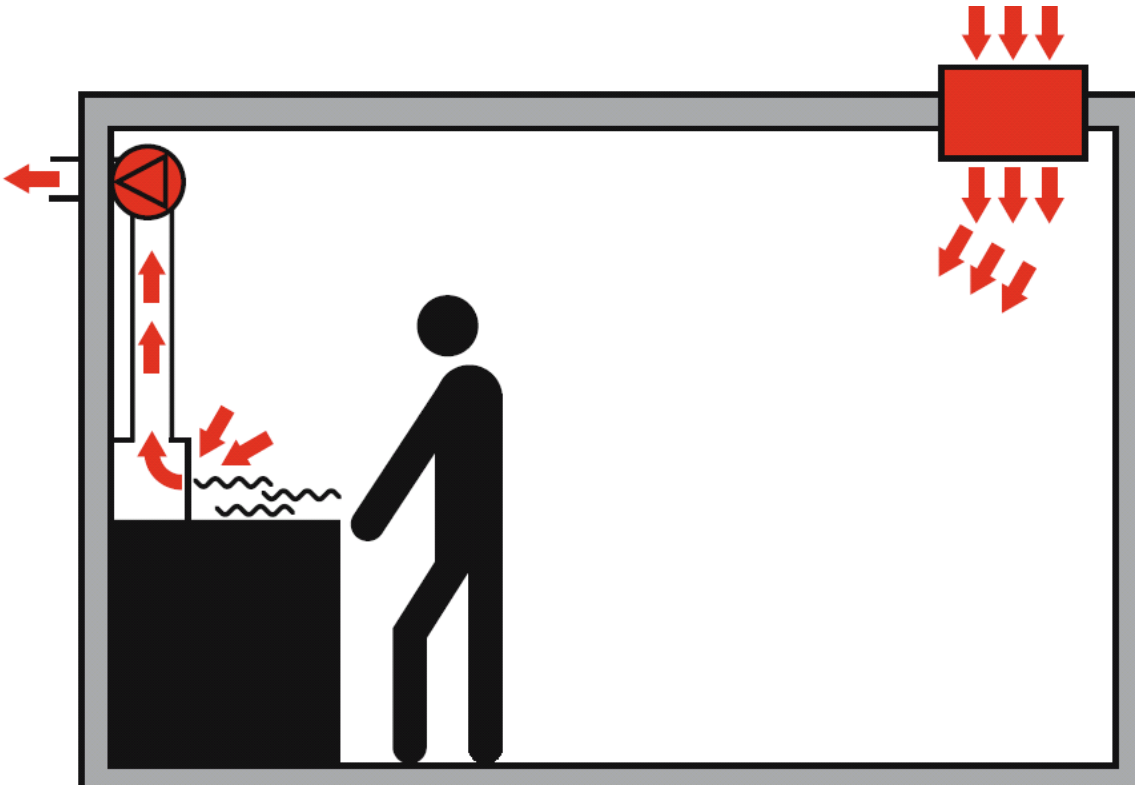


Source: Suva

- Extraction height depending on the density of the substances **(A: substances denser than the air, B: substances less dense than the air)**
- Transversal ventilation
- Evacuation to a safe area
- Air renewal
  - 3-5 times per hour (storage)
  - 10 times per hour (open handling)
- Continuous or intermittent ventilation
- Ventilation at the source if technically possible

Preventing the Formation of a Potentially Explosive Atmosphere – Ventilation

- **Artificial** ventilation

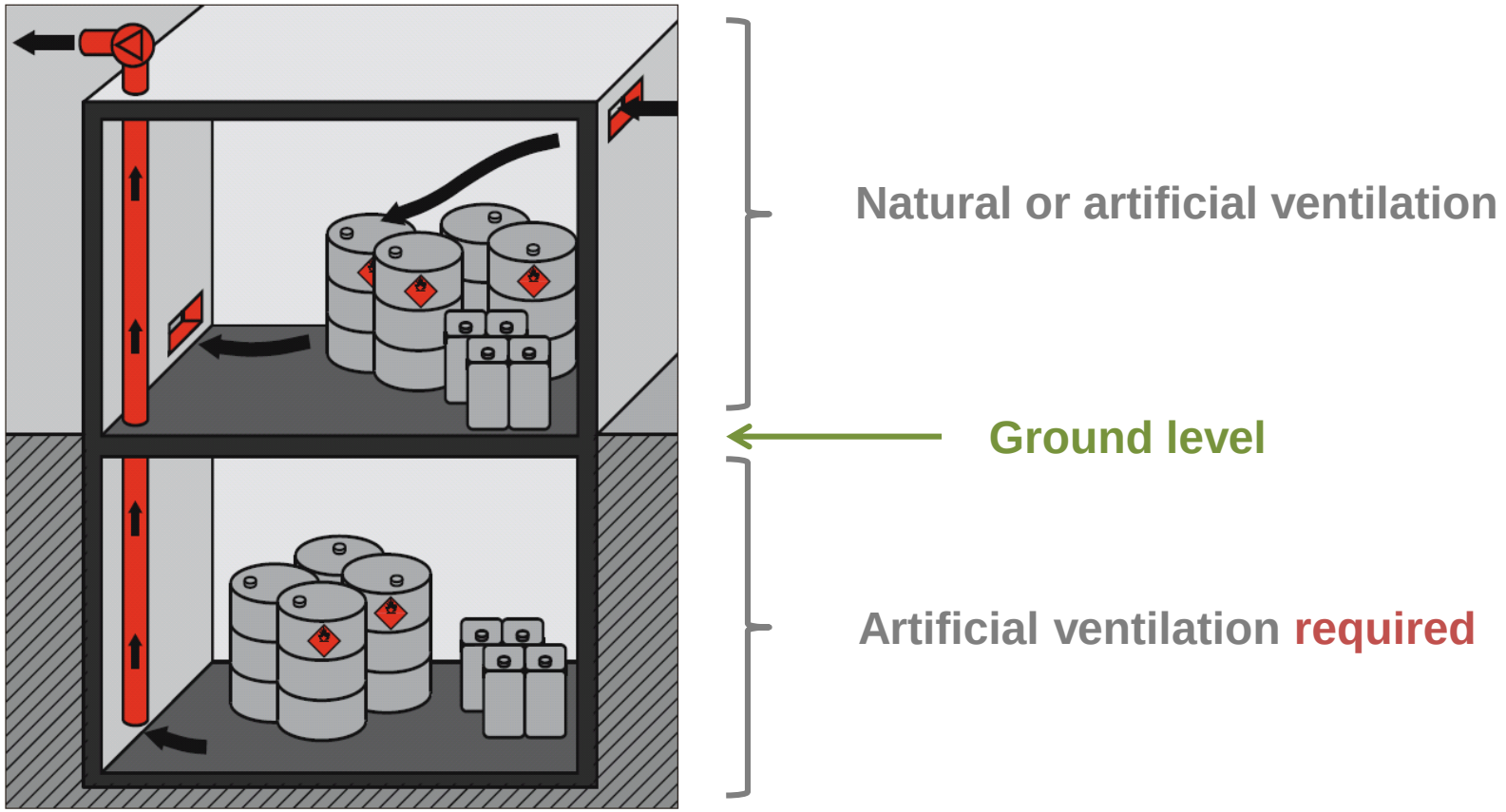


Source: Suva

If possible, the ventilation should be positioned directly where the flammable substances are mixed, treated, opened or handled.

Preventing the Formation of a Potentially Explosive Atmosphere – Ventilation

- **Artificial** and **natural** ventilation



Source: Suva

Preventing the Formation of a Potentially Explosive Atmosphere – Storage

- Flammable and highly flammable liquids as well as aqueous substances can trigger dangerous chemical reactions when mixed together. We call them incompatible substances.

Source: Suva

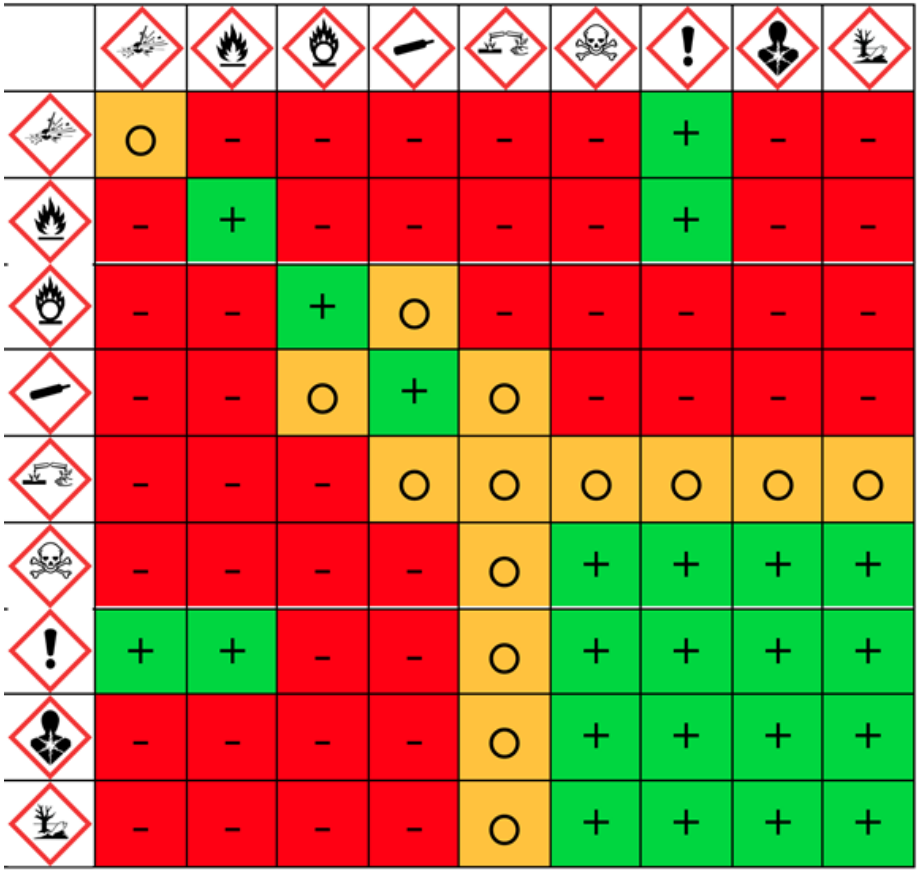
Such substances should be **stored** in a way to **prevent any contact between flammable liquids and peroxides, chromic acid, nitric acid or halogens.**

Preventing the Formation of a Potentially Explosive Atmosphere – Dusts

- Dust deposited on the floor may be dispersed in the air.
- In the presence of flammable gases or vapours, hybrid mixtures may form.

Source: Swissi

Preventing the Formation of a Potentially Explosive Atmosphere – Storage



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

Source: Based on Neosys

Legend

+ Can be stored together

- Cannot be stored together

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

Objective

Avoid dangerous reactions

D23_1_Storage

Preventing the Formation of a Potentially Explosive Atmosphere – GHS Pictograms (Reminder)

GHS hazard pictograms


Explosive


Flammable


Oxidizing


Compressed gases


Toxic

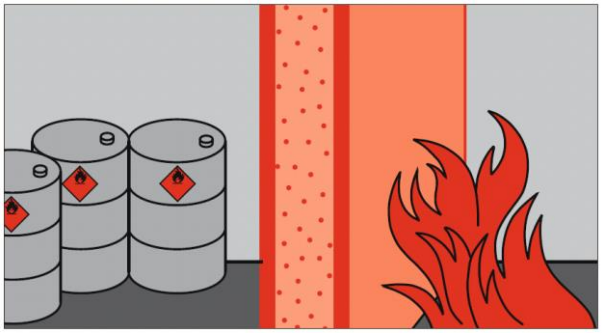

Irritant


Health hazard


Environmentally damaging

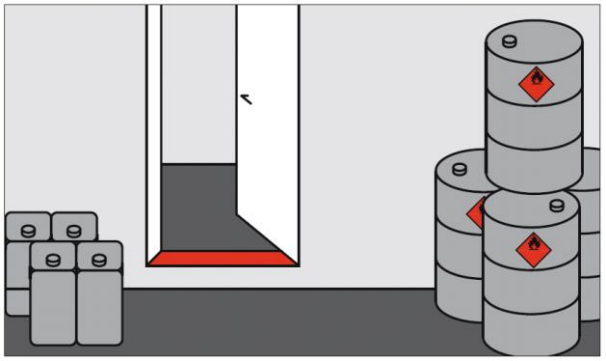
Preventing the Formation of a Potentially Explosive Atmosphere – Storage

- The equipment, installations, pipes, etc. should be protected against thermal impact:
  - Fireproof premises and doors
  - Fire compartments
  - Construction in non-flammable materials



Source: Suva

- Containment measures should be taken to prevent liquids from spreading:
  - Safety sills
  - Retention basins

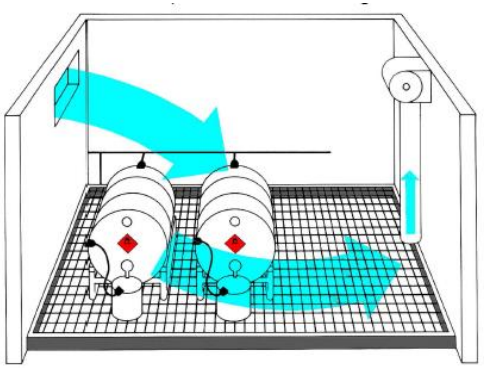


Source: Suva

Preventing the Formation of a Potentially Explosive Atmosphere – Recap

- Substitution of dangerous substances
- Limitation of concentrations
- Inerting of containers
- Use of closed systems
- Use of natural and artificial ventilation
- Appropriate labelling of containers
- Separate storage of incompatible substances
- Protecting equipment, installations and pipes against thermal impact
- Installing containment measures (safety sills, retention basins)

Artificial ventilation



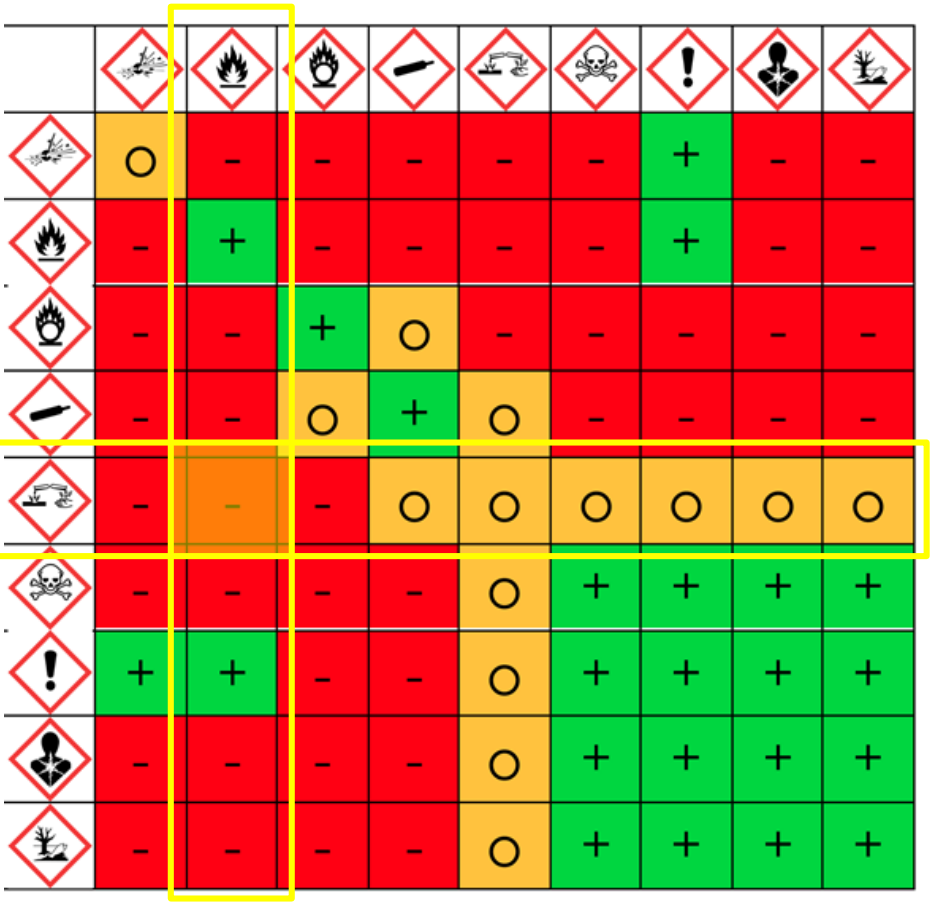
Source: Suva

Preventing the Formation of a Potentially Explosive Atmosphere – Exercise

You need to store **500 l of acetone**  and **500 l of sulphuric acid**  **.**

Which measures do you take to prevent the formation of a potentially explosive atmosphere?

Preventing the Formation of a Potentially Explosive Atmosphere – Exercise



Legend

+ Can be stored together

- Cannot be stored together

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

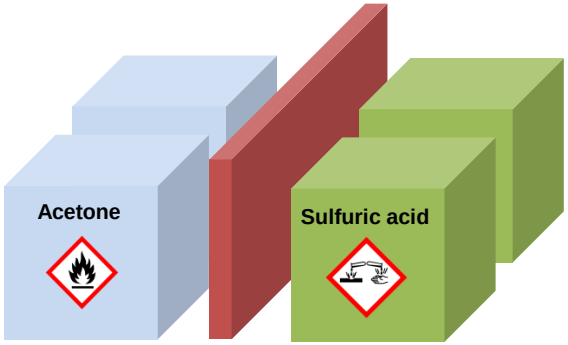
Objective:
Avoid dangerous reactions

Preventing the Formation of a Potentially Explosive Atmosphere – Exercise

What are the possible storage solutions?
What measures should be taken?

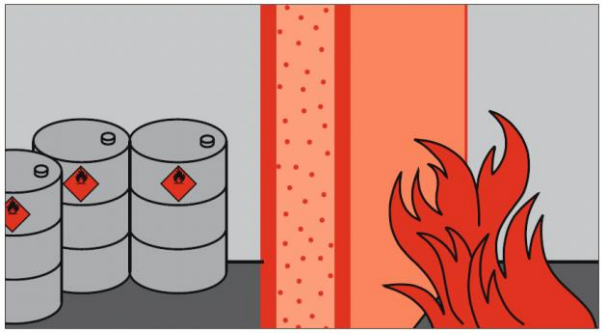
Preventing the Formation of a Potentially Explosive Atmosphere – Exercise

The two substances are incompatible so they should be stored in separate premises.



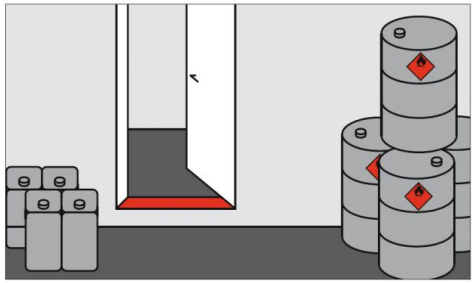
Source: CSD

Flammable substances should be isolated by firewalls.



Source: Suva

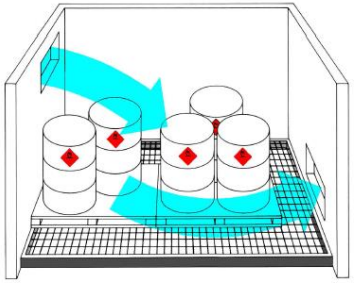
The storage premises should include retention basins and safety sills.



Source: Suva

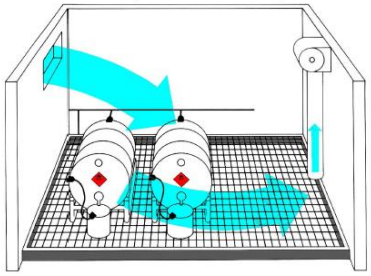
An effective ventilation system should be installed.

Natural ventilation



Source: Suva

Artificial ventilation



Source: Suva

Risk Reduction Measures

- Measures Preventing the Formation of Potentially Explosive Atmospheres
- Measures Preventing the Ignition of Potentially Explosive and Dangerous Atmospheres
- Construction measures
- Organizational measures

Preventing the Formation of a Potentially Explosive Atmosphere – Exercise

- **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 means reduces the risk of igniting a potentially explosive atmosphere.

Preventing the Ignition of a Potentially Explosive Atmosphere – Explosion Hazard Zones

- **Classification in explosion hazard zones:**
  - In Europe: ATEX
  - In USA: NFPA
    - NFPA 497: Recommended Practice for the Classification of Flammable Liquids, Gases or Vapors and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas

Preventing the Ignition of a Potentially Explosive Atmosphere – ATEX vs. NFPA Explosion Zones

- **Correspondence between ATEX and NFPA**

ATEX	NFPA
Zone 0 (gases/vapours) **Zone 1** (gases/vapours)	**Class I, Division 1**
Zone 2 (gases/vapours)	**Class I, Division 2**
Zone 20, 21, 22 (dusts)	**Class II, Divisions 1 and 2**

Preventing the Ignition of a Potentially Explosive Atmosphere – NFPA Explosion Zones (1)

- **Classification in explosion hazard zones (NFPA):**
  - **Class I, Div. 1:** Where ignitable concentrations of flammable gases, vapours or liquids are present continuously or frequently within the atmosphere under normal operation conditions.
  - **Class I, Div. 2:** Where ignitable concentrations of flammable gases, vapours, or liquids are present within the atmosphere under abnormal operating conditions.
  - **Class II, Div. 1:** Where ignitable concentrations of combustible dusts are present within the atmosphere under normal operation conditions.

Source: www.iebmedia.com

Preventing the Ignition of a Potentially Explosive Atmosphere – NFPA Explosion Zones (2)

- **Classification in explosion hazard zones (NFPA):**
  - **Class II, Div. 2:** Where ignitable concentrations of combustible dust are present within the atmosphere under abnormal operating conditions.
  - **Class III, Div. 1 (*):** Where easily ignitable fibres or materials producing combustible flyings are present within the atmosphere under normal operation conditions.
  - **Class III, Div. 2 (*):** Where easily ignitable fibres or materials producing combustible flyings are present within the atmosphere under abnormal operating conditions.

(*) – No ATEX correspondence

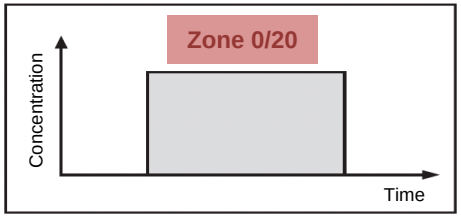
Source: www.iebmedia.com

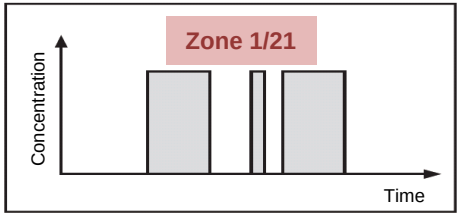
Preventing the Ignition of a Potentially Explosive Atmosphere – ATEX Explosion Zones (1)

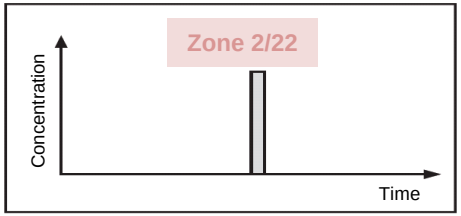
- **Classification in explosion hazard zones (ATEX)**

Nobody should work in zones 0 and 20

	Area where the potentially explosive atmosphere occurs:
Zone 0 (gases/vapours) **Zone 20** (dusts)	- Constantly present - Present for long periods - Frequently present for short periods
Zone 1 (gases/vapours) Zone 21 (dusts)	- Possible periodically - Occasionally present under normal operating conditions
Zone 2 (gases/vapours) Zone 22 (dusts)	- Rarely possible and for short periods only
Zone N.D	- Very improbable







Source: Suva

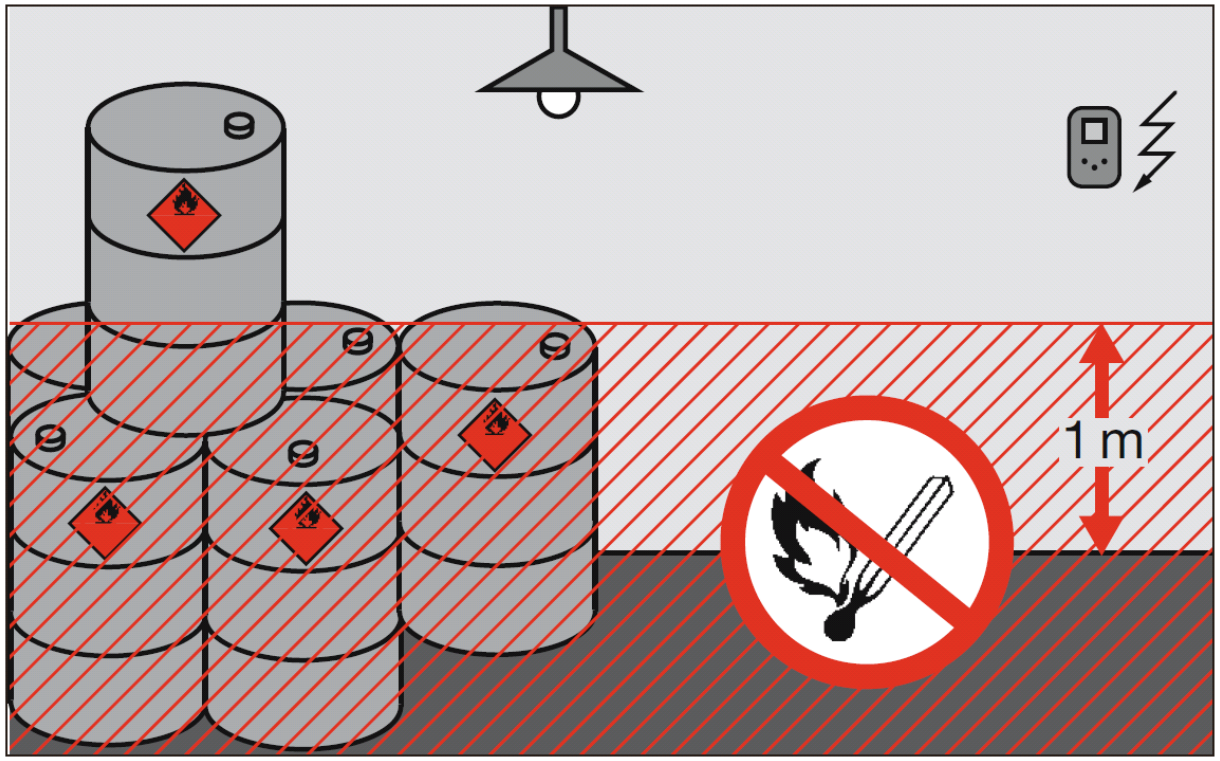
Preventing the Ignition of a Potentially Explosive Atmosphere – ATEX Explosion Zones (2)

- **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: - 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

Classification in Explosion Hazard Zones (ATEX)

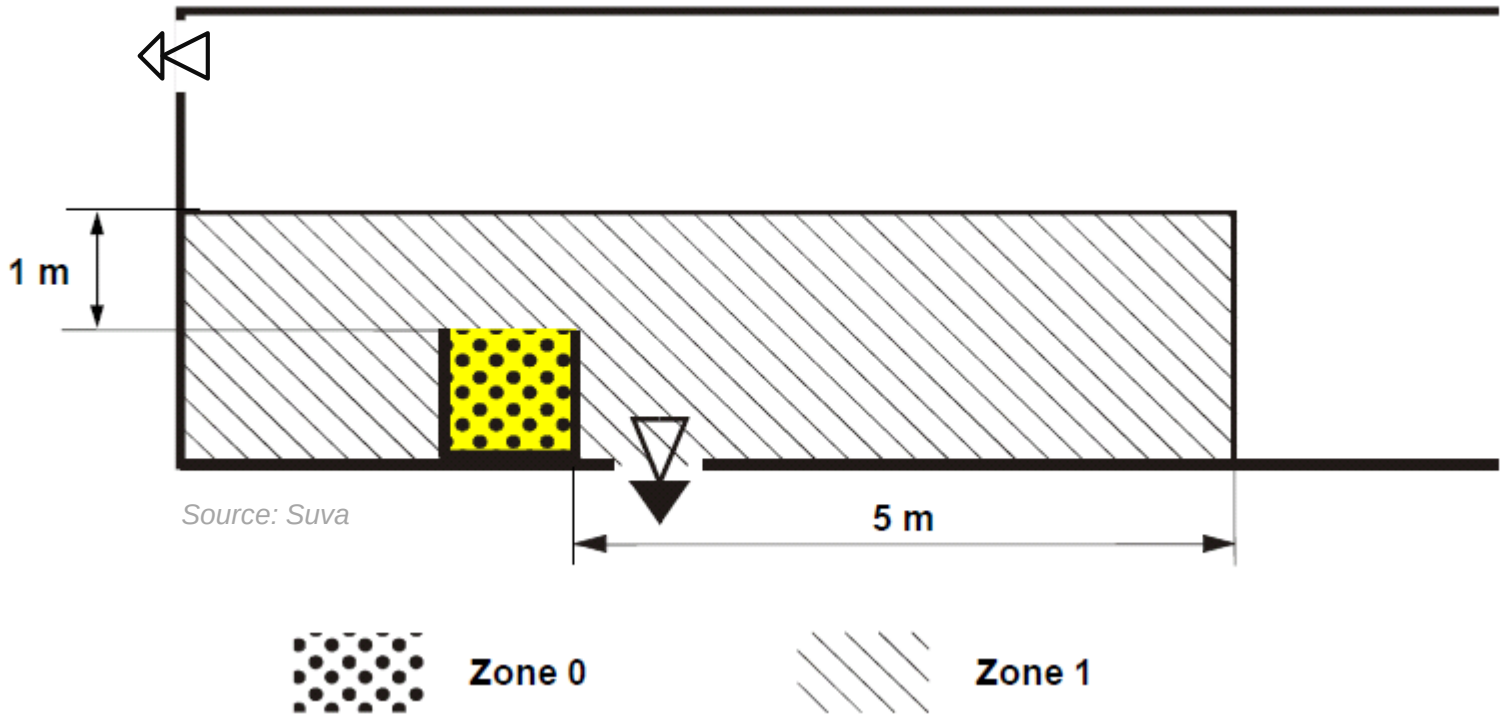
- Easily flammable liquids (storage)



Source: Suva

Classification in Explosion Hazard Zones (ATEX)

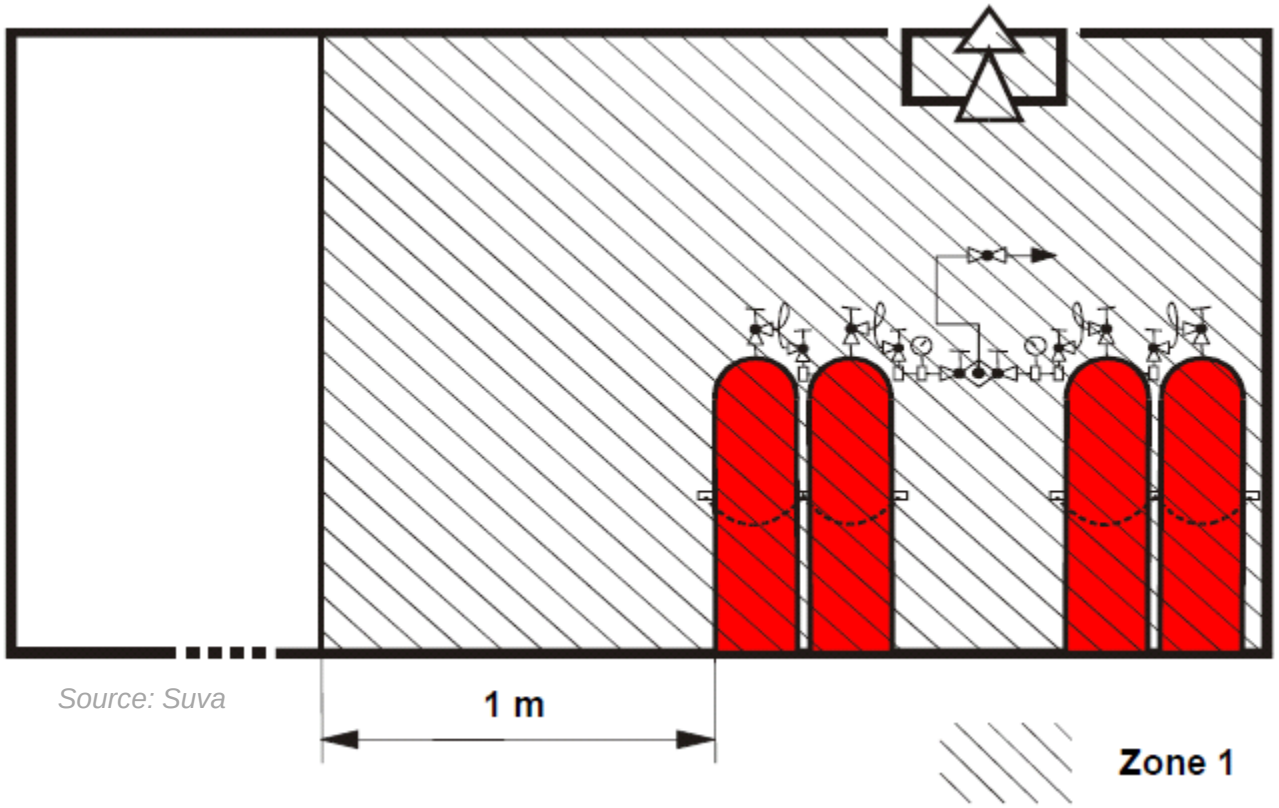
- Highly flammable liquids (e.g. blending facilities, decanting)



Source: Suva

Classification in Explosion Hazard Zones (ATEX)

- Flammable gases (for gases lighter than the air)



Source: Suva

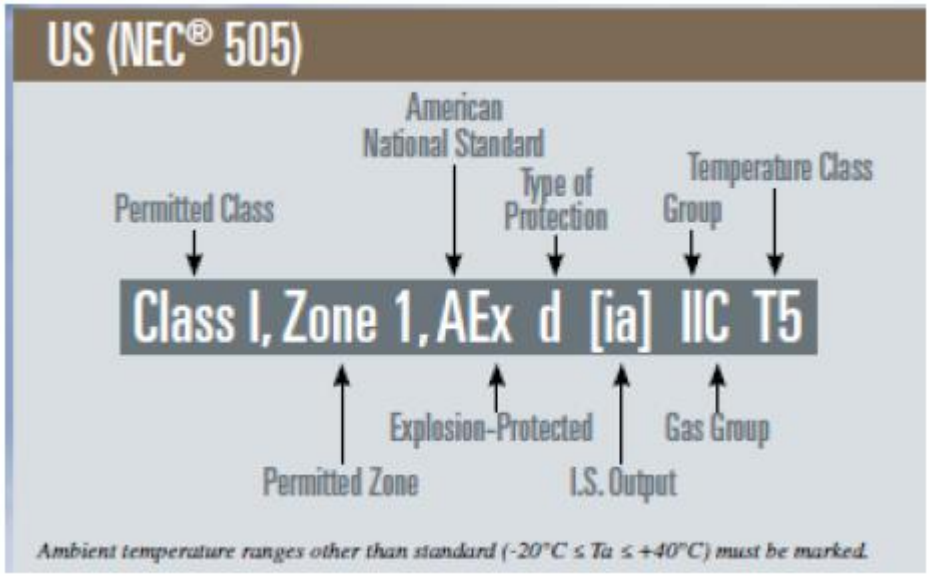
Preventing the Ignition of a Potentially Explosive Atmosphere – Equipment in Explosion Zones

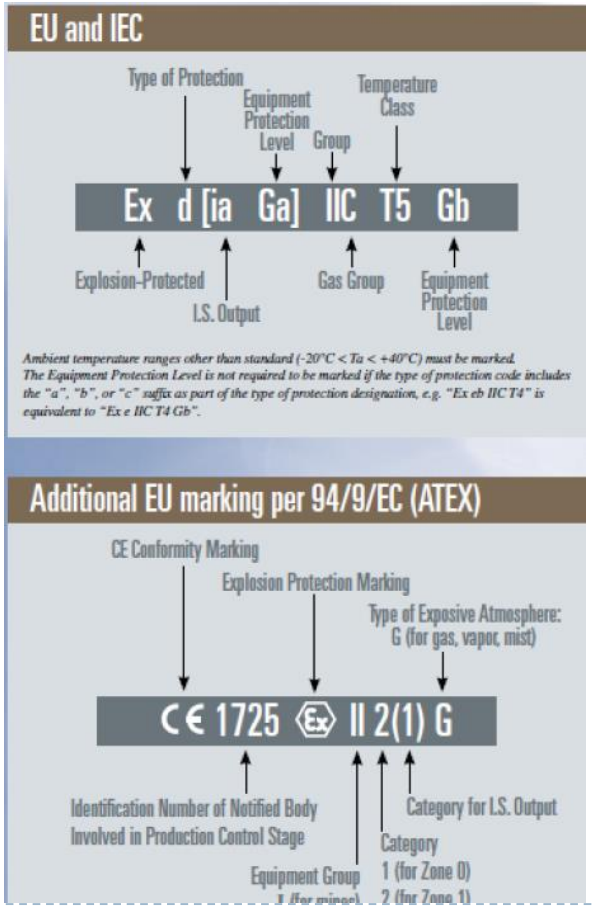
- **Use of equipment in explosion zones:**
  - USA:
    - Certification of electrical equipment according to National Electric Code (NEC)
  - Europe:
    - Certification of electrical and mechanical equipment according to ATEX
  - Rest of the world:
    - Local regulations and International Electrical Committee (IEC) standards

Preventing the Ignition of a Potentially Explosive Atmosphere – Equipment in Explosion Zones

- **Marking of explosion-proof equipment**

Flammable gas and vapour



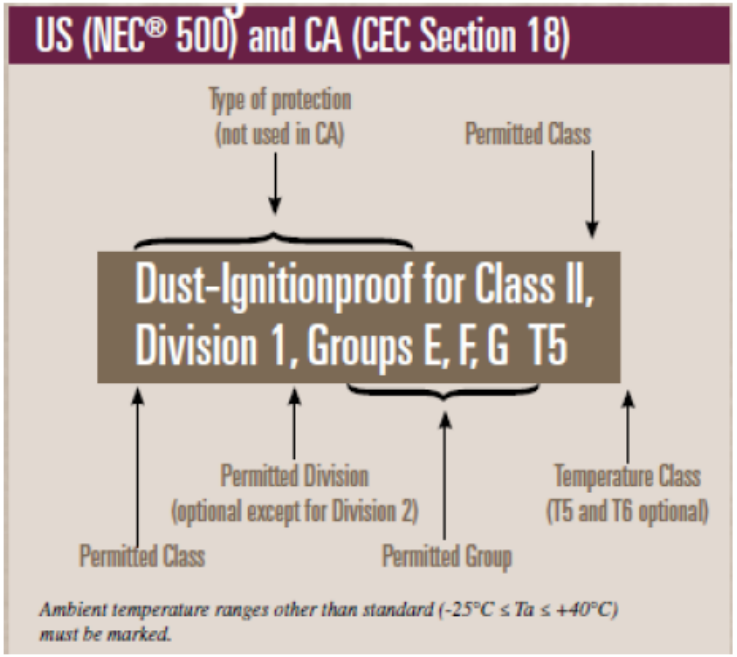


Source: SWISSI Process Safety Ltd.

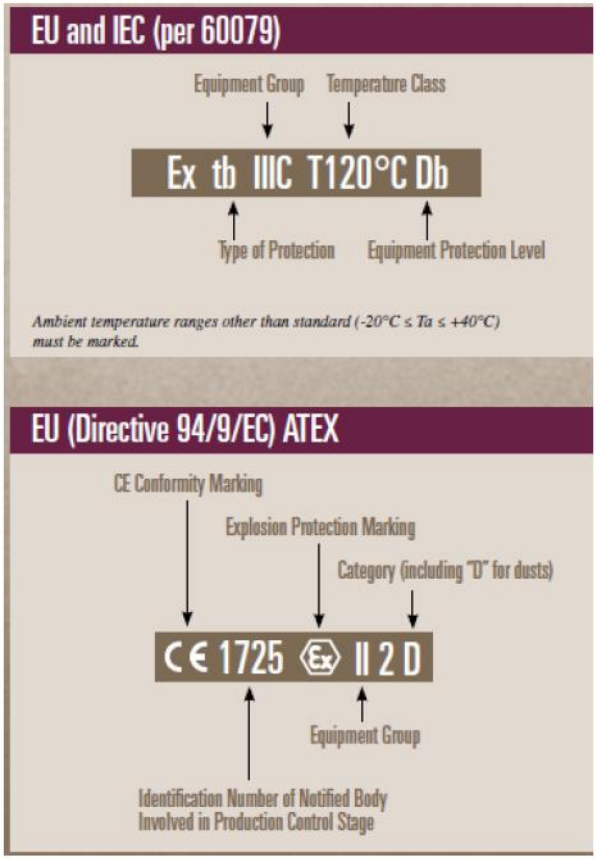
Preventing the Ignition of a Potentially Explosive Atmosphere – Equipment in Explosion Zones

- **Marking of explosion-proof equipment**

Combustible dust

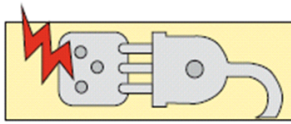


Source: SWISSI Process Safety Ltd.



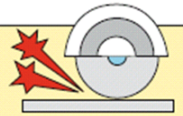
Preventing the Ignition of a Potentially Explosive Atmosphere – Measures (1)

- **Elimination of ignition sources**



Sparks of electrical origin

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



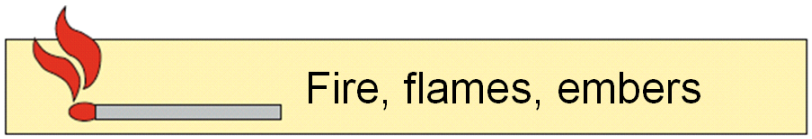
Sparks of mechanical origin

Source: Suva

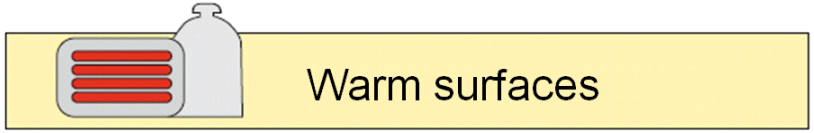
In **Zones 0 and 20**, devices that can produce sparks should not be used.
In **Zones 1 and 2**, sparks are tolerated only if special prevention measures are taken (combination of adequate materials, etc.)

Preventing the Ignition of a Potentially Explosive Atmosphere – Measures (2)

- **Elimination of ignition sources**



- Smoking banned
- Open-flame devices should not be used in explosion zones. Flame or spark generating maintenance work (e.g. cutting or welding) must be performed on clean equipment and authorized by special work permits.
- Preventing smouldering fires:
  - Eliminate dust deposits.
  - Maintain surfaces humid.
  - Use spark detection and extinguishing systems.

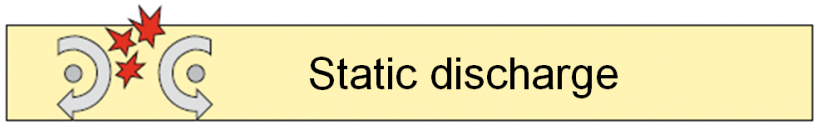


Source: Suva

- 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 minimum ignition temperature.***

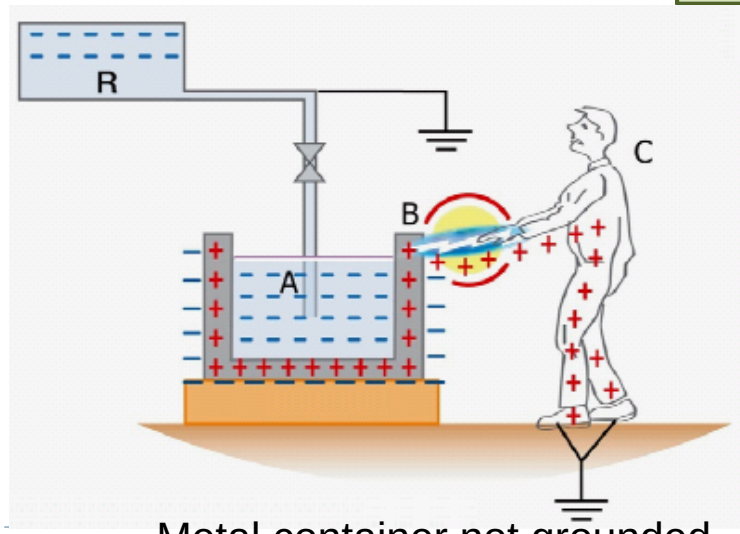
Preventing the Ignition of a Potentially Explosive Atmosphere – Measures (3)

- **Elimination of ignition sources**

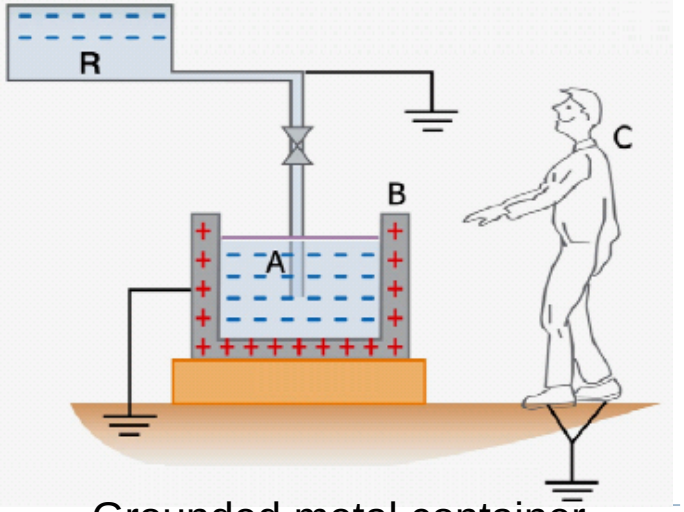


Source: Suva

- Only use grounded conductive or dissipative hoses, pipes, containers, etc. while handling flammable liquids.
- 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.



Metal container not grounded

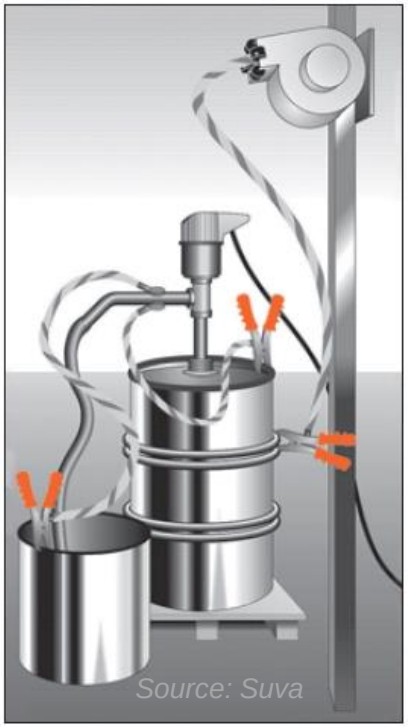


Grounded metal container

Source: Suva

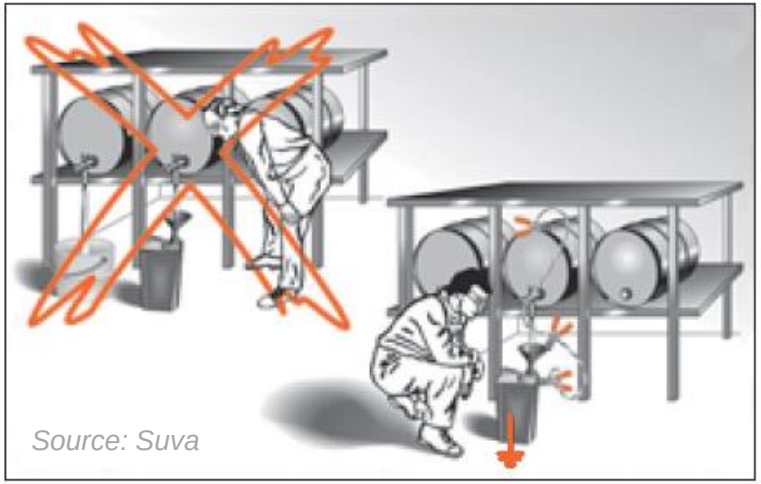
Preventing the Ignition of a Potentially Explosive Atmosphere – Measures (4)

Static discharge



Grounded containers

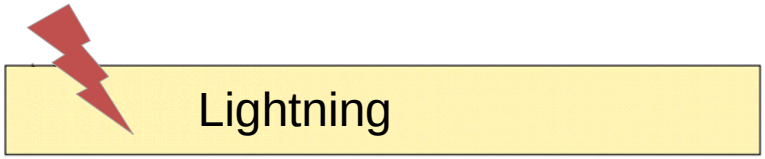
- **Any conductor element** from any installation should be **bonded** and **grounded**.
- Containers and pipes should **not have insulating inner linings***.



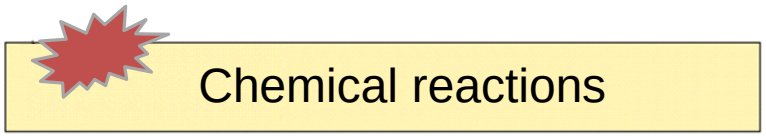
- When **decanting flammable liquids**, the **container**, the **tank** and the other **conductor elements** should be conductive, **bonded and grounded**. The tanks' support should also be grounded.
- The **flow rate of the flammable substances** should be reduced to a **minimum**.

Preventing the Ignition of a Potentially Explosive Atmosphere – Measures (5)

- **Eliminating the ignition source**



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

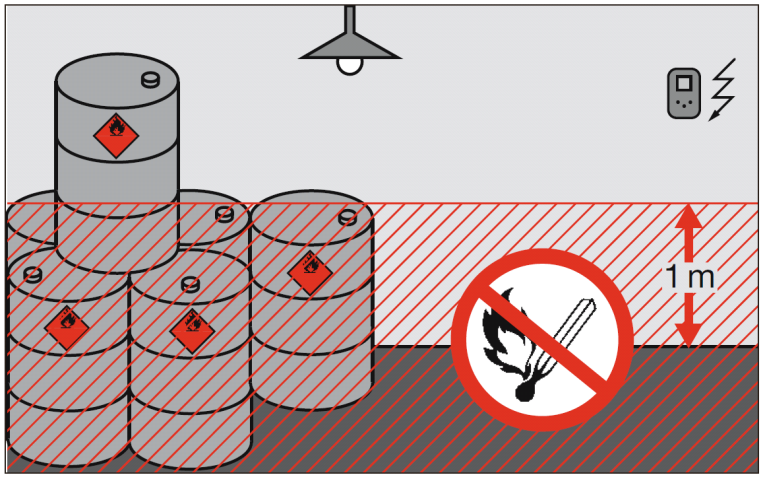


Source: Suva

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

Preventing the Ignition of a Potentially Explosive Atmosphere – Recap

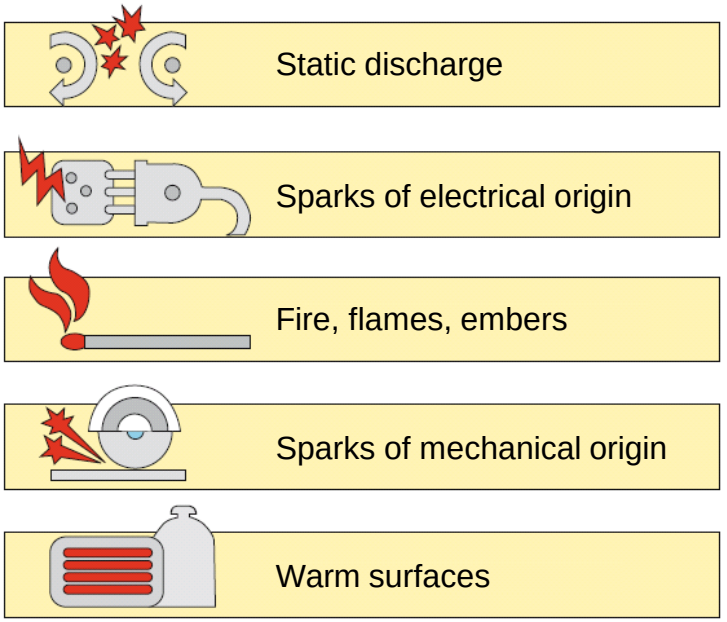
- Classification in explosion hazard zones (ATEX)
- Equipment categories and explosion hazard zones
- Elimination of ignition sources



Source: Suva

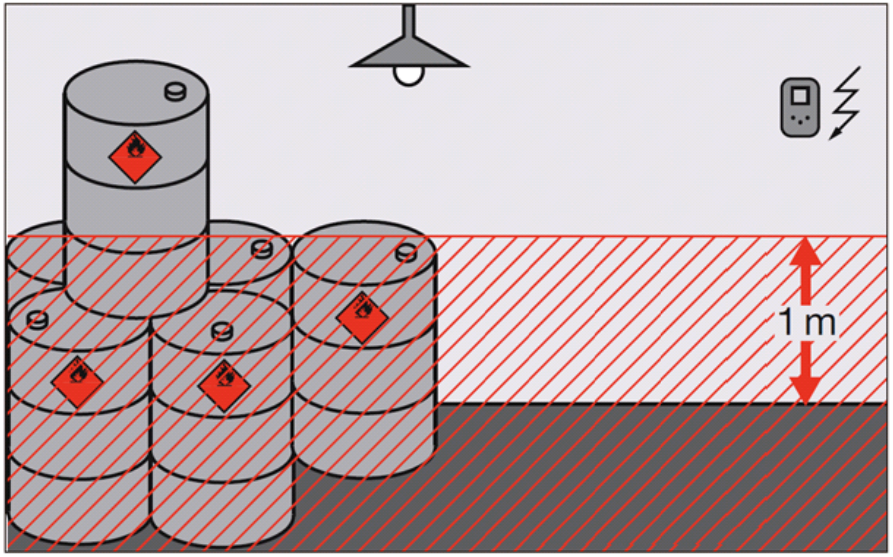
Zone 2

Ignition sources

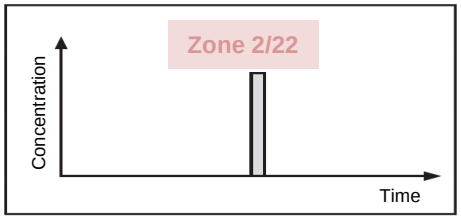


Preventing the Ignition of a Potentially Explosive Atmosphere – Question 1

A storage area containing methanol  has been classified as a Hazard Zone 2.



Source: Suva



Source: Suva

Source: Suva

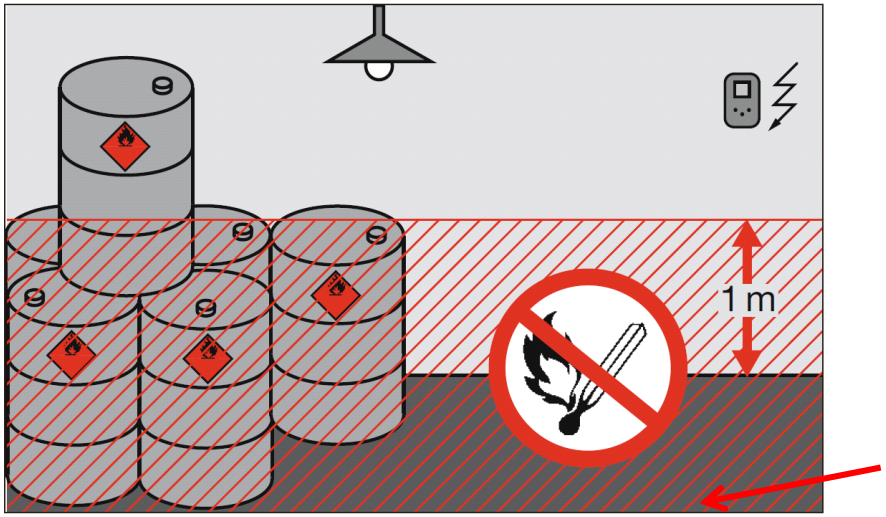
Zone 2

Preventing the Ignition of a Potentially Explosive Atmosphere – Question 1

What measures should you take to prevent the ignition of a potentially explosive atmosphere?

Preventing the Ignition of a Potentially Explosive Atmosphere – Answer

Eliminate the ignition sources.

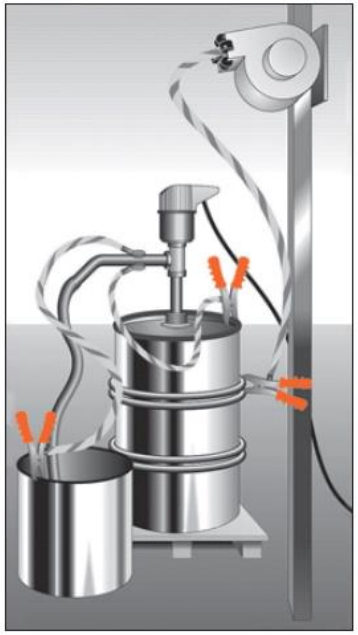


Source: Suva

Zone 2

Do not smoke.

Ground the containers to prevent the ignition by static electricity.



Source: Suva

Preventing the Ignition of a Potentially Explosive Atmosphere – Question 2

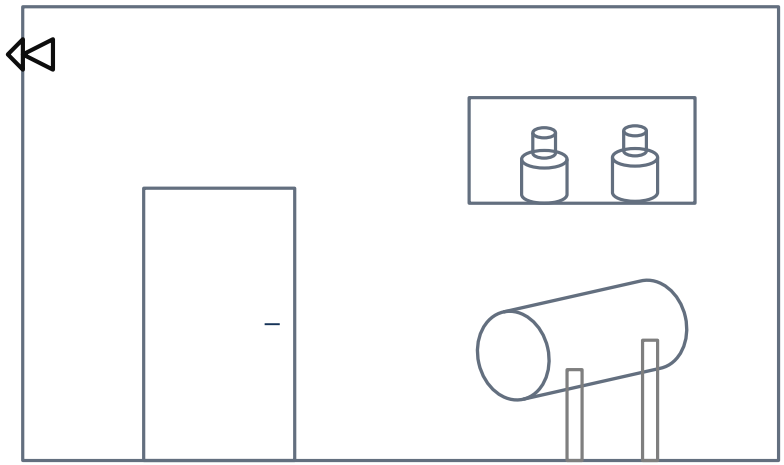
On a small site, flammable solvents are stored in a room on the ground floor. The solvents are delivered in metal drums. They are stored intermediately in a marked area outside the building. Before mounting them horizontally in the storage room, removable valves are fixed.

Employees who need a particular solvent fill the solvent directly from the drums into metal cans with a volume of up to 1 litre and small flasks with up to 2 litres. Grounding clamps are available and the floor of the solvent room is conductive.

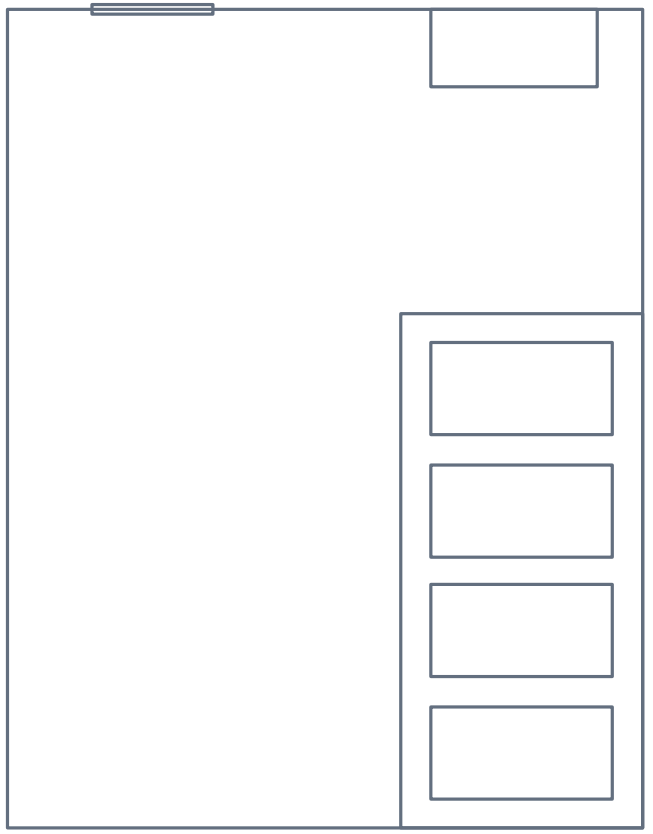
Below the drums, trays are located to contain any liquid that may leak from the drums or be spilled when the small containers are being filled.

What would the explosion zone be for this installation?

Preventing the Ignition of a Potentially Explosive Atmosphere – Question 2

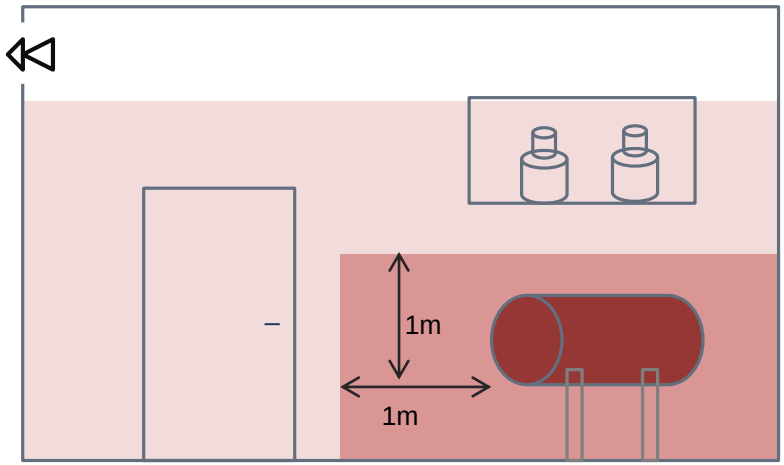


Source: CSD



Source: CSD

Preventing the Ignition of a Potentially Explosive Atmosphere – Answer

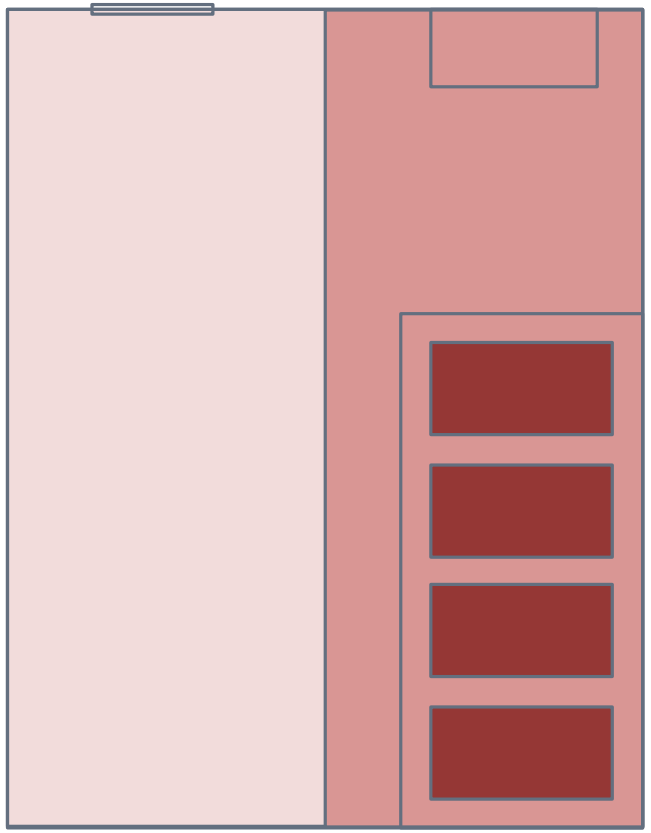


Source: CSD

Zone 0

Zone 1

Zone 2



Source: CSD

Risk Reduction Measures

- Measures Preventing the Formation of Potentially Explosive Atmospheres
- Measures Preventing the Ignition of Potentially Explosive and Dangerous Atmospheres
- Construction measures
- Organizational measures

Construction Measures

- If explosion prevention measures are not feasible, not sufficiently effective or disproportionate, construction measures can be taken.

- Construction measures do not prevent an explosion but limit its effects so that the explosion no longer presents a hazard.

Explosion-resistant construction	Explosion relief	Suppression of the explosion	Explosion decoupling

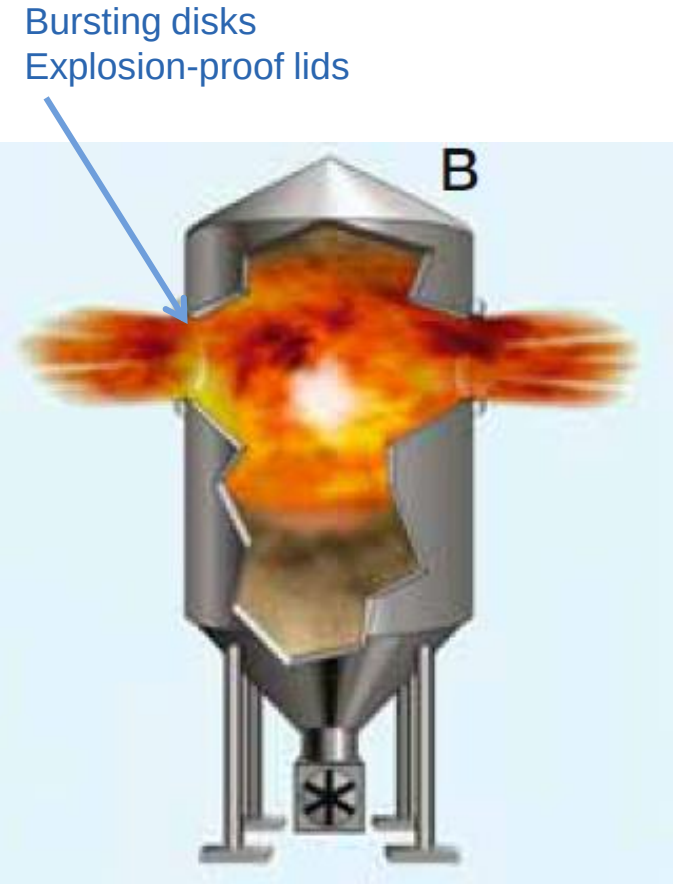
Construction Measures

- **Explosion-resistant construction/devices:**
  - Should be able to withstand the expected overpressure induced by an explosion
  - Should not be deformed

Source: Suva

Construction Measures

- **Explosion relief devices:**
  - Aim at protecting the containers from the consequences of an explosion (burst, deformation).
  - Once a given internal pressure is reached, bursting disks/explosion-proof lids open to release the pressure and avoid the explosion.
  - Explosion relief is not an option if the vented products can harm people or the environment.



Source: Suva

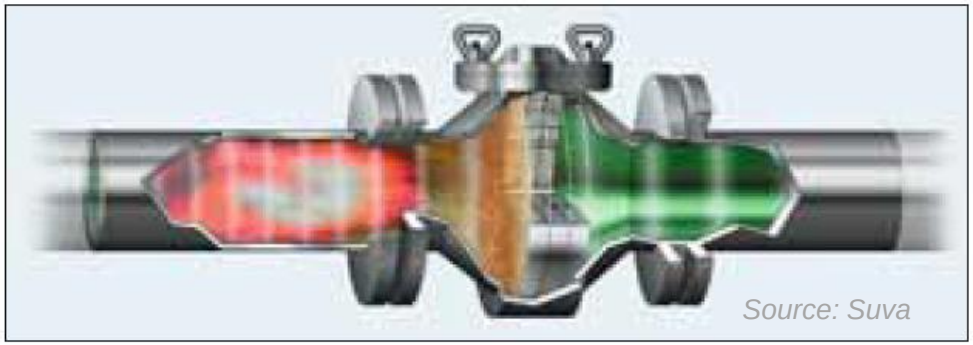
Construction Measures

- **Explosion suppression:**
  - The explosion is automatically detected by sensors and suppressed with an extinguishing agent before it reaches a destructive power.

Source: Suva

Construction Measures

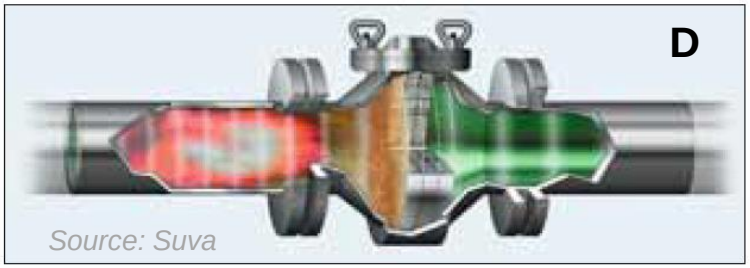
- **Explosion decoupling:**
  - Avoids and prevents the propagation of the explosion to other parts of the installation/building:
    - Rapid-action mechanical isolation (e.g. fire damper, quick-closing valves)
    - Flame extinction (e.g. flame arrestor)
    - Water seals
    - Rotary valves, etc.



Flame extinction:
The flame is cooled down until it is fully extinguished.

Construction Measures – Recap

- Explosion-resistant construction/devices (A)
- Explosion relief devices (B)
- Explosion suppression (C)
- Explosion decoupling (D)



Risk Reduction Measures

- Measures Preventing the Formation of Potentially Explosive Atmospheres
- Measures Preventing the Ignition of Potentially Explosive and Dangerous Atmospheres
- Construction measures
- Organizational measures

Organizational Measures

- The company should:
  - Document the explosion prevention measures
  - Indicate the explosion hazard zones
  - Draw up written work instructions
  - Inform and train employees about explosion prevention and provide personal protective equipment
  - Use an authorization system for the execution of dangerous activities
  - Perform necessary checks, monitoring and maintenance

Source: Suva

Organizational Measures

- Small quantities of highly flammable substances (up to 100 litres) should be stored in fire-resistant cabinets.
- Large quantities of flammable substances should not be stored in work areas.
- Containers with flammable substances should always be closed when not used.
- No smoking.
- Use explosion-proof equipment.

Source: Suva

Organizational Measures – What Not to Do

Source: UNIDO

Source: UNIDO

Source: Shutterstock

Key messages

- Explosion hazard concepts serve the identification, of the risk, that is therefore assessed to generate options. The risk reduction measures are implemented according to the selected options.

- Risk reduction measures should be take according to substances characteristics. In particular constructive and organizational measures are accompanied by measures preventing the formation of potentially explosive atmosphere and iignition of potentially explosive and dangerous atmospheres.

Sources

Sources

- CSD Engineers, Switzerland/ISSPPRO, Germany, 2015
- Suva: Prévention des explosions (principes, prescriptions minimales, zones), Switzerland, 2013
- Suva: Explosions – Risques et mesures de prévention, Switzerland, 2009
- Suva: Liste de contrôle – Risques d’explosion, Switzerland, 2013
- Suva: Liste de contrôle – Electricité statique, Switzerland, 2010

Sources

- Suva: Liste de contrôle – Big bags, grands récipients vrac souples, Switzerland, 2010
- OFEV: Guide «Entreposage des matières dangereuses», Switzerland, 2011
- Neosys: Formation matières dangereuses, Switzerland, 2011
- SWISSI Process Safety Ltd.: Explosion prevention, Switzerland, 2014
- SWISS Process Safety Ltd.: HSE training, Switzerland, 2014
- www.iebmedia.com, May 2014

Supporting documentation

- Toolkit checklist : D5_1_Checklist Explosion Prevention, Switzerland, 2015

Images

- CSD Engineers, Switzerland, 2015
- United Nations Industrial Development Organization (UNIDO), 2015
- Suva: Prévention des explosions (principes, prescriptions minimales, zones), Switzerland, 2013
- Suva: Explosions – Risques et mesures de prévention, Switzerland, 2009
- Suva: Liste de contrôle – Risques d’explosion, Switzerland, 2013

Images

- Suva: Liste de contrôle – Electricité statique, Switzerland, 2010
- Suva: Liste de contrôle – Big bags, grands récipients vrac souples, Switzerland, 2010
- Neosys: Formation matières dangereuses, Switzerland, 2011
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- SWISSI Process Safety Ltd.: Explosion prevention, Switzerland, 2014
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