Risk Assessment

IAMC Toolkit

Innovative Approaches for the Sound Management of Chemicals and Chemical Waste

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION

Introduction

This presentation gives a definition of harm, hazard and risk. The definitions are followed by a description of a risk assessment procedure for a chemical company (description of the system, definition of safe process conditions, identification of systematic hazard and hazard assessment by impact and probability, risk evaluation, establishment of a planning of measures and assessment of the residual risk).

The reader will learn how to implement the risk assessment in the process of innovative options identification.

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			

Contents

Concept and Objectives of Risk Assessment

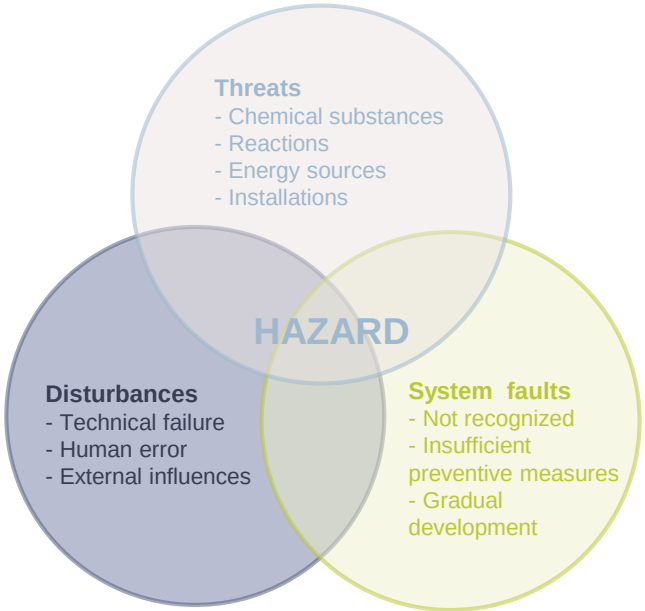
Definitions

- Harm: “Harm is a negative safety and health consequence (e.g. injury or ill health).”
- Hazard: “A hazard is anything that can cause harm (e.g. work materials, equipment, work methods and practices.”
- Risk: “The risk is the chance of harm being done (likelihood and extent of harm).”

Definitions from the European Agency for Safety and Health at Work (www.osha.europa.eu)

Concept of Risk Assessment

- **What** is considered a risk?
  - A risk is understood to be a hazard which is evaluated in relation to the probability of occurrence of the undesirable incident and the severity of the possible effects.“



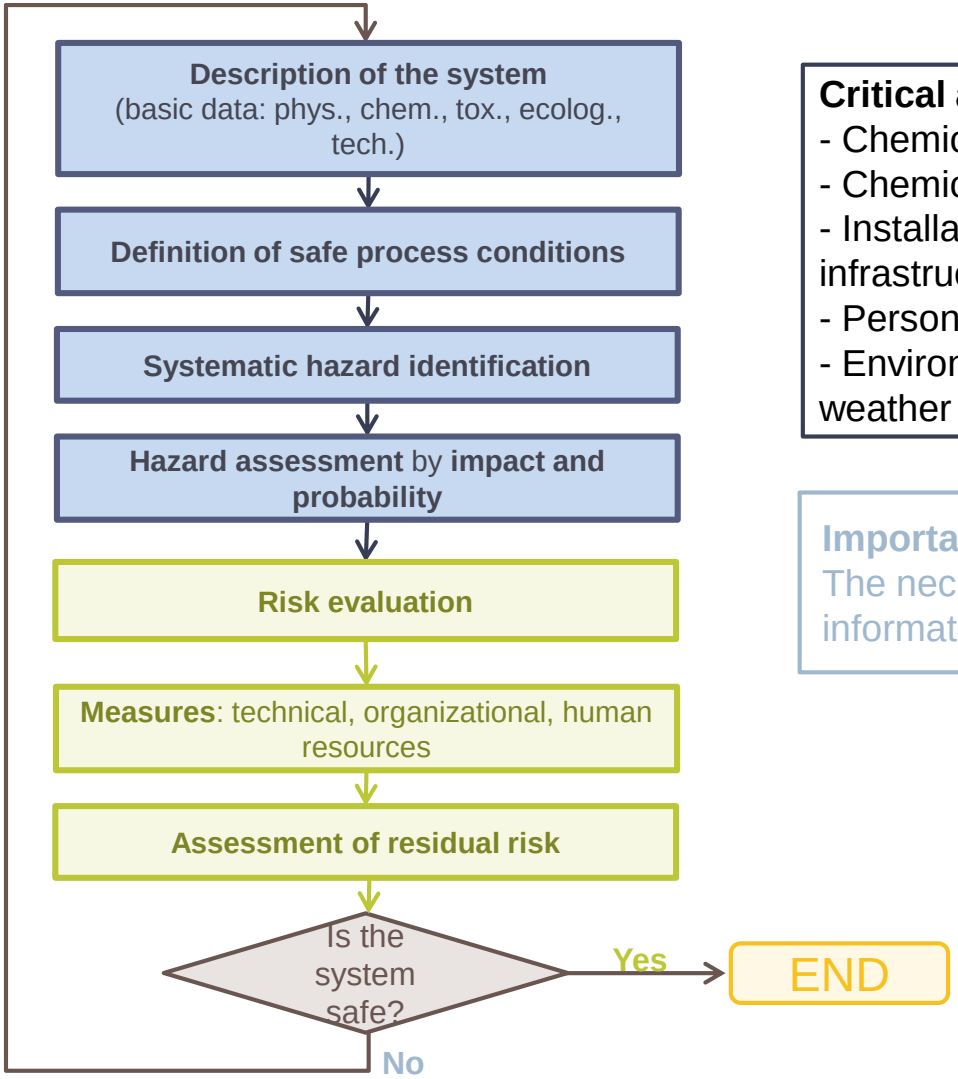
Source: based on ESCIS

Concept of Risk Assessment

- **Why** is a risk analysis conducted?
  - Obtaining essential information on safety even before technical processes are implemented
  - Ensuring the necessary level of safety by implementing targeted measures against identified risks

- **When** should a risk analysis be undertaken?
  - For new processes/installations
  - For existing processes/installations:
    - If a new hazard has been identified
    - To incorporate new experiences into the risk assessment procedure
    - To monitor/improve the safety level

What are the stages of a risk assessment?



Critical areas:
- Chemicals
- Chemical and physical processes
- Installations, energy sources, infrastructure
- Personnel, manual intervention/errors
- Environment, external influences, weather

Important:
The necessary basic data and safety information should be available.

Source: based on ESCIS

Risk Assessment Team

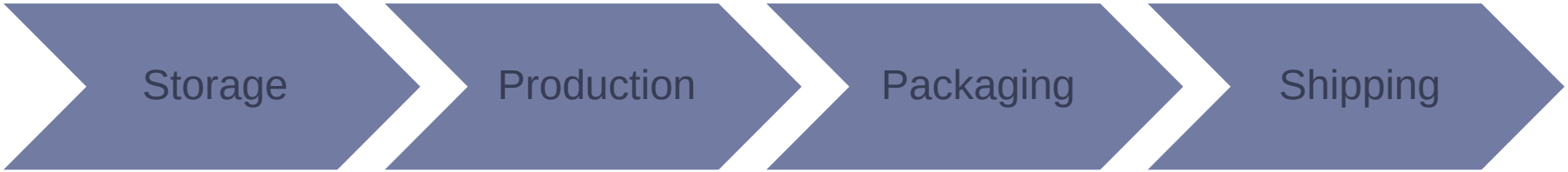
- Risk assessments should be conducted in teams of at least two persons to ensure that:
  - The assessment process benefits from the individual experiences/viewpoints of each team member
  - The assessment process and associated decisions have broader support

- The team should include:
  - Business manager
  - Operating manager
  - Design engineer/engineer providing technical support
  - Specialists in the technical areas concerned
  - Moderator not involved in the project itself (e.g. safety officer)

Risk Assessment – Definition of the system

Description of the System

- 1. Subdivide into processes, lines of services or teams
  - Example 1



  - Example 2

Description of the System

- 2. Identify the critical processes, lines of services and teams by:
  - Analyzing statistics (e.g. number of days off due to professional incidents)
  - Examining records of risk evaluation/special hazards
  - Visiting workplaces and conducting interviews with workers to identify technical or organizational deficits

Description of the System

- 3. Compile basic data – foundation of risk assessment:
  - Description of the processes, installations and process conditions (chemical reactions, etc.)
  - Safety instructions for important parts of installations
  - Safety instructions for neighbouring installations
  - Work instructions for each process/installation (normal operating conditions, special operating conditions, maintenance)
  - Properties of raw and auxiliary materials (physical, chemical, toxicity, flammability, etc.)
  - Current safety concept
  - Information on responsibilities and competences
  - External influences (temperature, climate, etc.)

Risk Assessment - Definition of Safe Process Conditions

Definition of Safe Process Conditions

- For the definition of safe process conditions, the following information should be clarified for each installation and included in the assessment process:
  - Different phases (construction, transport, commissioning, utilization, etc.)
  - Mode of operation (normal operation, installation, cleaning, repair, maintenance, etc.)
  - Limits of the installation (normal operation, cleaning, repair, maintenance, etc.)
  - Range of use
  - Training of users
  - Environment (e.g. interaction with neighbouring installations)
  - Dangerous phenomena and their impacts (employees, installations, environment)

Definition of Safe Process Conditions – Example

SUBSTANCE DATA
Properties: physical, chemical, toxicity, eco-toxicity

INTERACTION
Between substances/materials

REACTION MECHANISM
Reaction data
Secondary reactions
Thermal stability

SAFE CONDITIONS

Process: temperature, pressure, concentration, dosing sequence, chemical feed rate, etc.

Installations: minimum filling level for stirrers, equipment material, heating and cooling capacities, etc.

Source: based on ESCIS

Issues to consider for each process involving hazardous substances:

⇒ What are the properties of the substance?

⇒ What interactions with other substances and materials should be considered?

⇒ What reaction should we expect?

The answers to these questions will lead to the definition of the safe process conditions.

Risk Assessment - Systematic Hazard Identification

Systematic Hazard Identification

Hazard identification methods	
Method	**Example**
Intuitive *"What might happen?"*	• **Brainstorming** • **Checklists** • Failure mode and effect analysis • **Event tree analysis** • Decision table techniques • **Hazard and operability study**
Deductive *"How might it happen?"*	• **Analysis of potential problems** • **Operating error analysis** • **Fault tree method**

Critical areas:

- Chemicals
- Processes
- Installations
- Energy sources
- Manual intervention
- Environment, external influences, etc.

Methods in bold are used in the chemical industry

Source: based on ESCIS

Systematic Hazard Identification

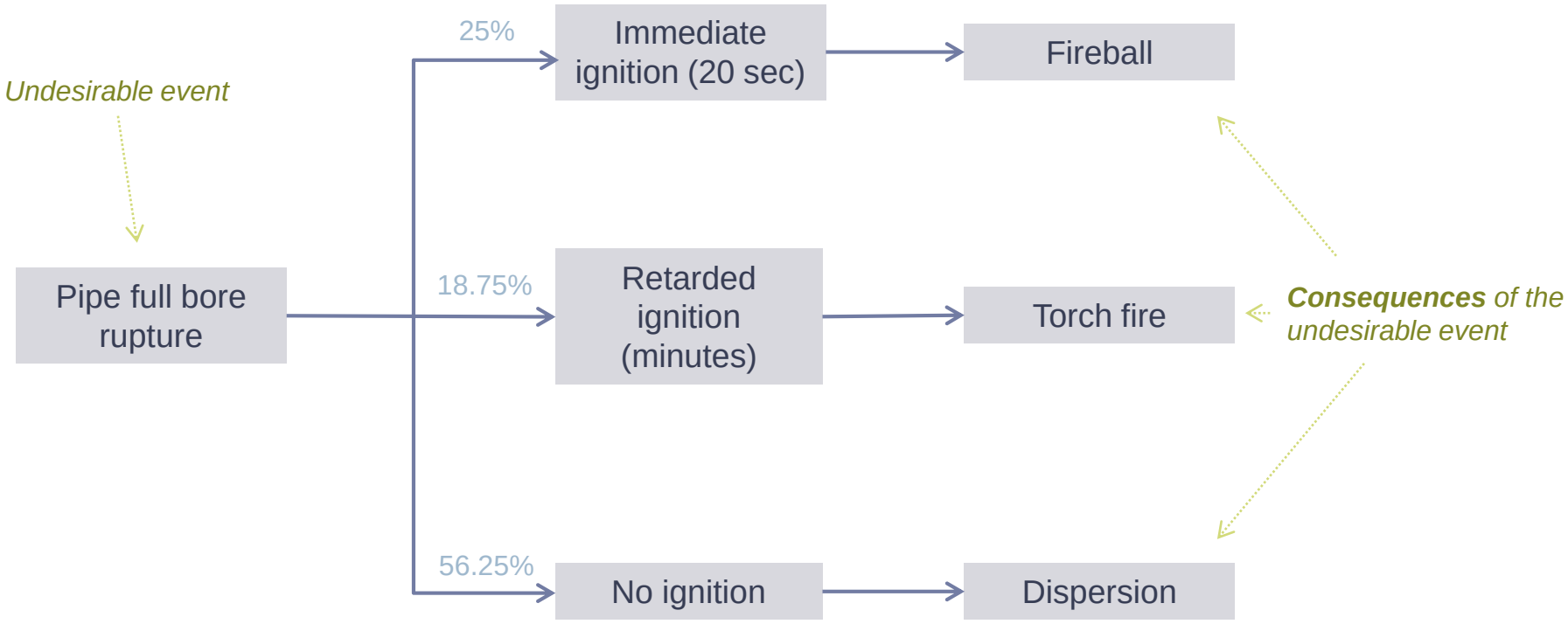
Checklist welding/cutting (example of questions)

Assessed by:	**Date:**	**Plant name:**

Hazard	**Yes**	**No**	**Comment**
Are workplaces provided with effective ventilation and/or extraction systems?			
Are suitable breathing apparatuses used whenever contaminants cannot be properly extracted?			
Are measures taken to prevent skin burns or eye injuries due to molten metal splatter, flames and hot parts?			
Do welders wear suitable goggles for protection from the glare of the welding flame as well as from hot welding sparks?			
Are welding operations carried out solely by people who are familiar with the equipment and processes, and are they regularly instructed?			

Systematic Hazard Identification

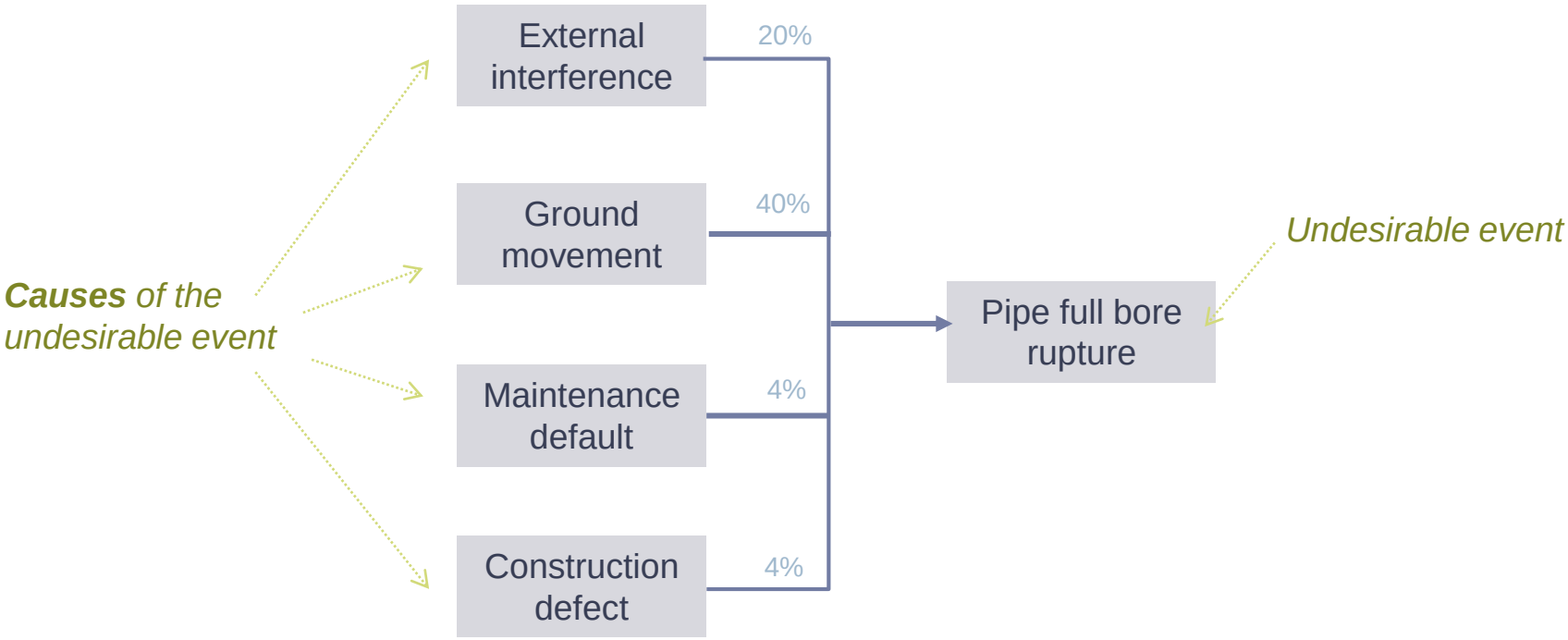
Event tree analysis



Source: CSD

Systematic Hazard Identification

Fault tree analysis



Source: CSD

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Risk Assessment – Hazard Assessment by Impact and Probability, Risk Evaluation

Hazard Assessment by **Impact**

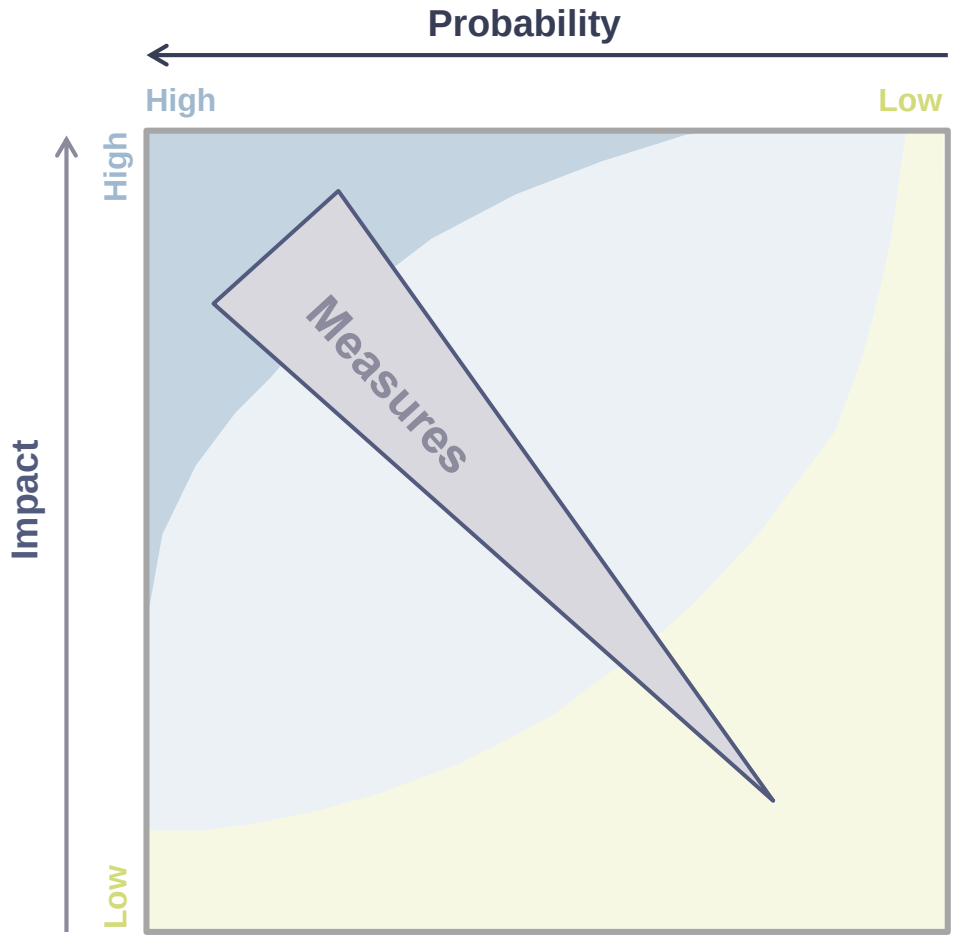
Impacts	Effects on:		
	Persons	**Environment**	**Property**
Low	Minor injury	Short-term offensive noise	Minor damage to machinery, loss of a batch
Medium	Injuries without permanent effects	Discoloration of surface water, unpleasant smell	Installation damage without prolonged interruption of operation
High	Injuries with permanent effects	Dead fish, defoliation, contamination of waste-water treatment plant	Loss of an installation , a building

Hazard Assessment by **Probability** – Example

Probability	Technical failure	Human error	Other influences
High	• Failure of analytical equipment (pH, redox, O_2 probes)	• Mix-up of products in similar packaging • Misinterpretation of verbal instructions	• Frost • Rain
Medium	• Failure of: - On-line measurement data (pressure, temperature) - Solenoid and regulating valves	• Confusion of products delivered in drums/bags • Misinterpretation of written working instructions	• Prolonged power cut • Transport accident
Low	• Failure of: - Redundant elements - Fail-safe elements	• Confusion of products supplied through pipelines • Misinterpretation of written working instructions subject to double checking	• Airplane crash onto chemical plant

Source: based on ESCIS

Risk Evaluation



Source: based on ESCIS

Graph representing the **relationship** between **risk**, **impact** and **probability** of occurrence

Risk level:

- High risk
- Medium risk
- Low risk

Risk Assessment – Planning of Measures

Planning Measures

"Safety measures should be designed to ensure that a simple human error can not lead to an incident with a major impact."

- Measures aim at reducing the risk to an acceptable level.

Example

Activity: Synthesis of a solvent-based paint

Danger: Release and spread of flammable solvent vapours

Safety objective: Preventing the ignition of the solvent vapours which would lead to an explosion or a fire

Measures: Installing an effective chamber system to capture solvent vapours

Planning Measures

- Measures for risk reduction should be planned taking into account the following priorities:

1. Select the process with the lowest risk.
2. Reduce risks by using technical means.
3. Install warning systems.
4. Take organizational and personnel measures.
5. Prepare emergency measures.

Planning Measures – Example

Area of application	Type of measures		
	Eliminative measures	Preventive measures	Measures limiting the impact
Technical	Other methods of synthesis	Technical process control, alarm systems	Explosion pressure relief, sprinklers
Organizational		Process surveillance by personnel, training and instruction on behaviour in the event of process deviations	Emergency services
Personnel	No employees in hazard areas		Instructions for emergency

Planning Measures

- Warning: In some cases, safety measures could have the required effect on a given risk, but also create new risks elsewhere. Carefully select the technical measures!

- Example: Installing safety valves on containers for toxic substances:
  - Prevents the containers from bursting
  - Danger if the valves are triggered

Risk Assessment - Assessment of the Residual Risk

Assessment of Residual Risk

- Evaluation of the risk remaining despite all the planned safety measures:
  - Risks consciously accepted
  - Risks identified but incorrectly evaluated
  - Hazards not yet identified

- No universal method exists to judge the acceptability of the residual risk. The following aspects should be taken into account:
  - Technical factors
  - Economic factors
  - Environmental and socio-economic aspects

- Emergency response measures should be established for accidents that might result from the accepted residual risks.

- If the residual risk is too uncertain or too high, a new and more detailed risk assessment must be undertaken.

Key messages

- Risk assessments is realized to obtain essential information on safety and ensure the necessary level of safety for existing or new processes or installations.

- It is composed by 6 main steps :
  - Description of the System
  - Definition of Safe Process Conditions
  - Systematic Hazard Identification
  - Hazard Assessment by Impact and Probability, Risk Evaluation
  - Planning of Measures
  - Assessment of the Residual Risk

- The evaluation of the risk remaining despite all the planned safety measures. emergency response measures should be established for accidents that might result from the accepted residual risks.

Sources

Sources

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