



< Risk identification and safety >

Risk Assessment



IAMC Toolkit

Innovative approaches for the Sound Management of Chemicals
and Chemical Waste



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

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



1. Concept of Risk Assessment
2. Risk Assessment
 - Description of the system
 - Definition of safe process conditions
 - Hazard identification
 - Hazard assessment
 - Risk evaluation
 - Measures
 - Assessment of residual risk
3. Sources

Concept and Objectives of Risk Assessment

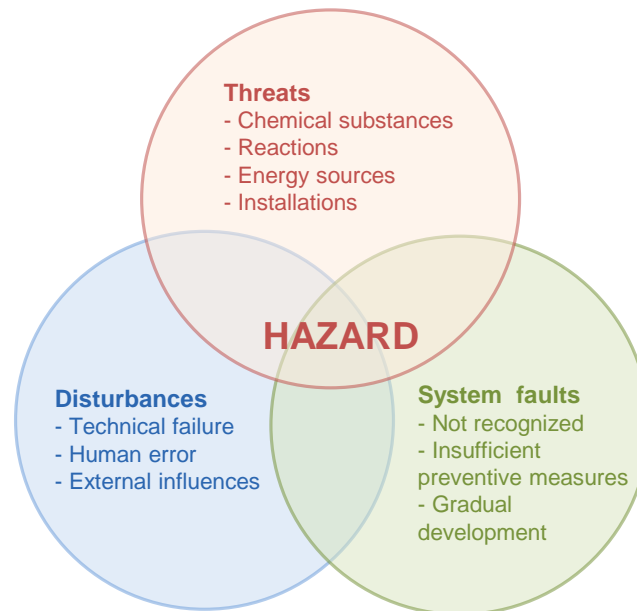
Definitions

- **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**.“



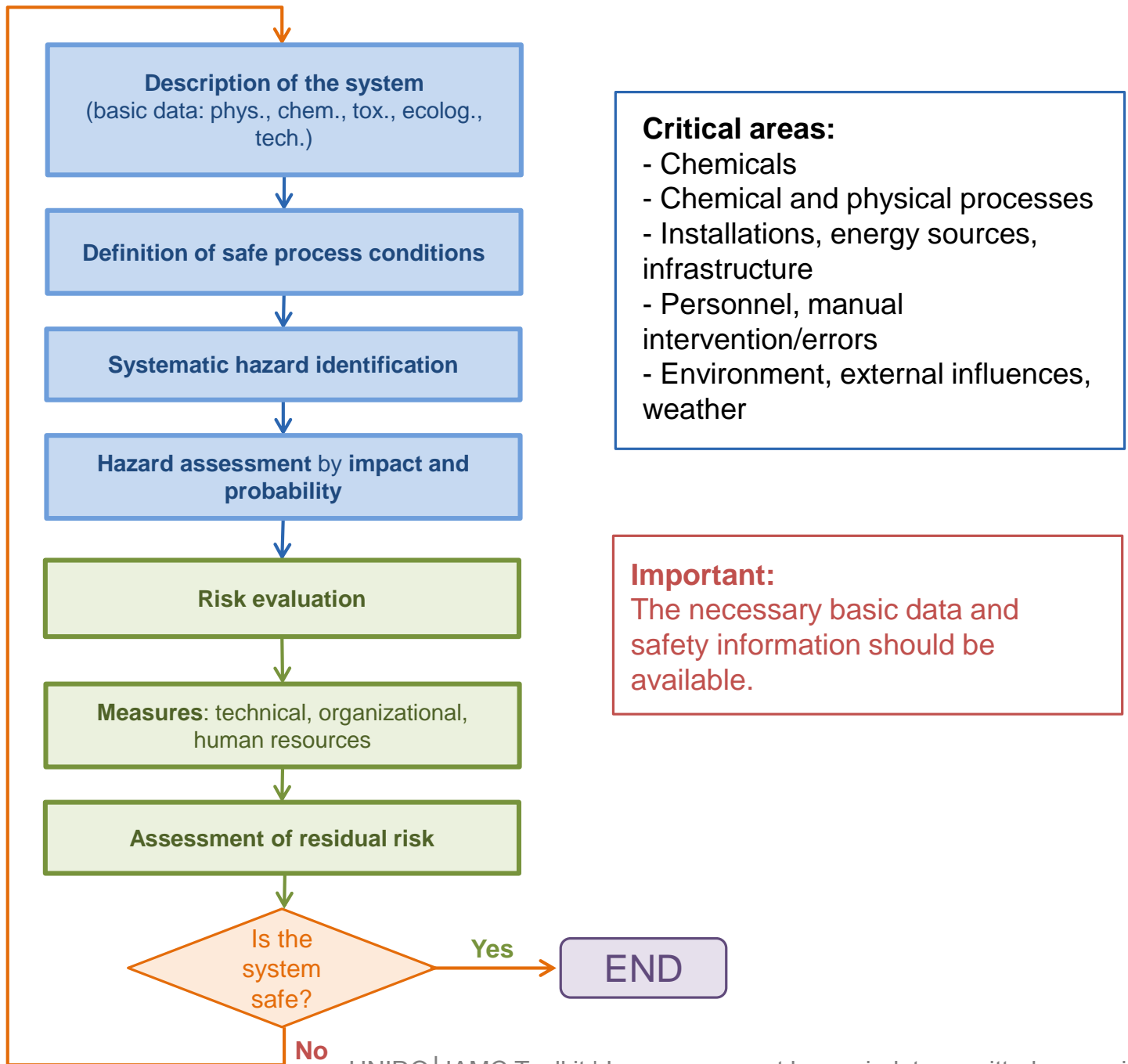
Source: based on ESCIS

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?



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

- 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

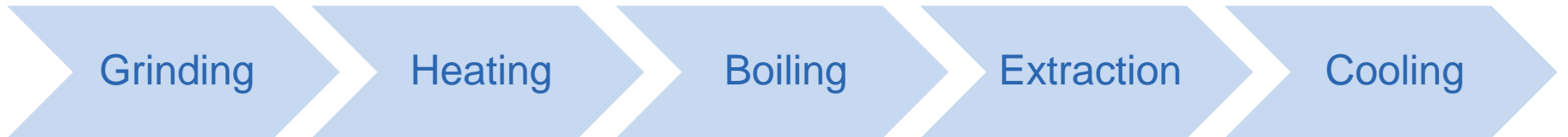
Description of the System

- 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.)

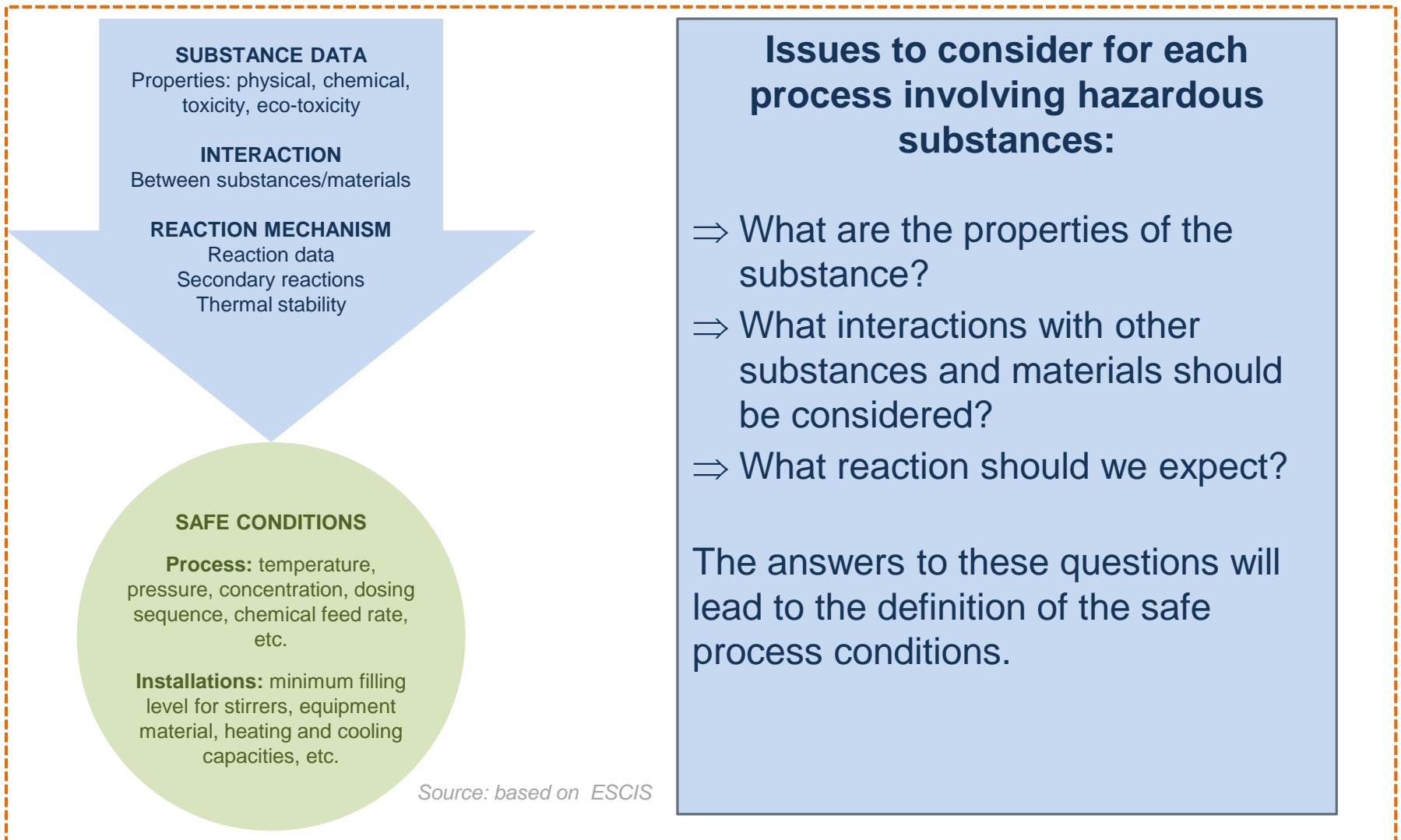
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Definition of Safe Process Conditions

- 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



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Systematic Hazard Identification

Hazard identification methods	
Method	Example
Intuitive <i>“What might happen?”</i>	<ul style="list-style-type: none">• Brainstorming• Checklists• Failure mode and effect analysis• Event tree analysis• Decision table techniques• Hazard and operability study
Deductive <i>“How might it happen?”</i>	<ul style="list-style-type: none">• 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

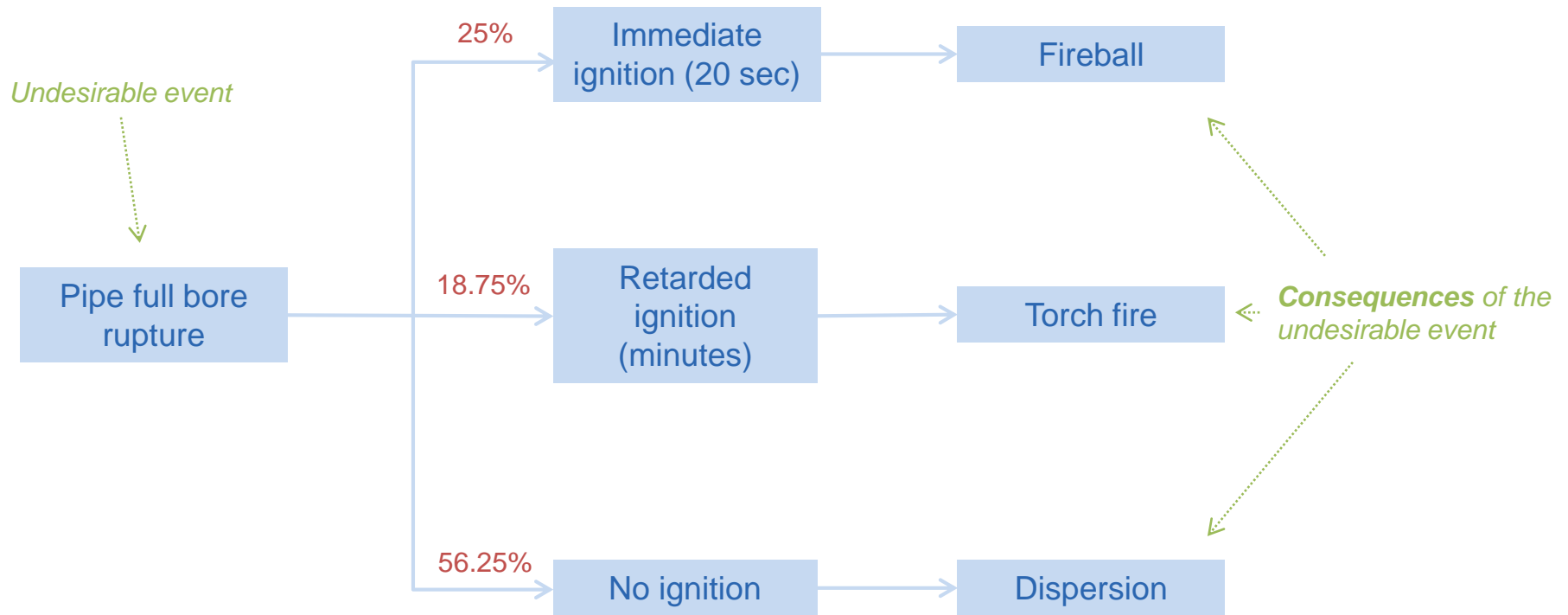
Checklist welding/cutting (example of questions)

Assessed by:	Date:	Plant name:
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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

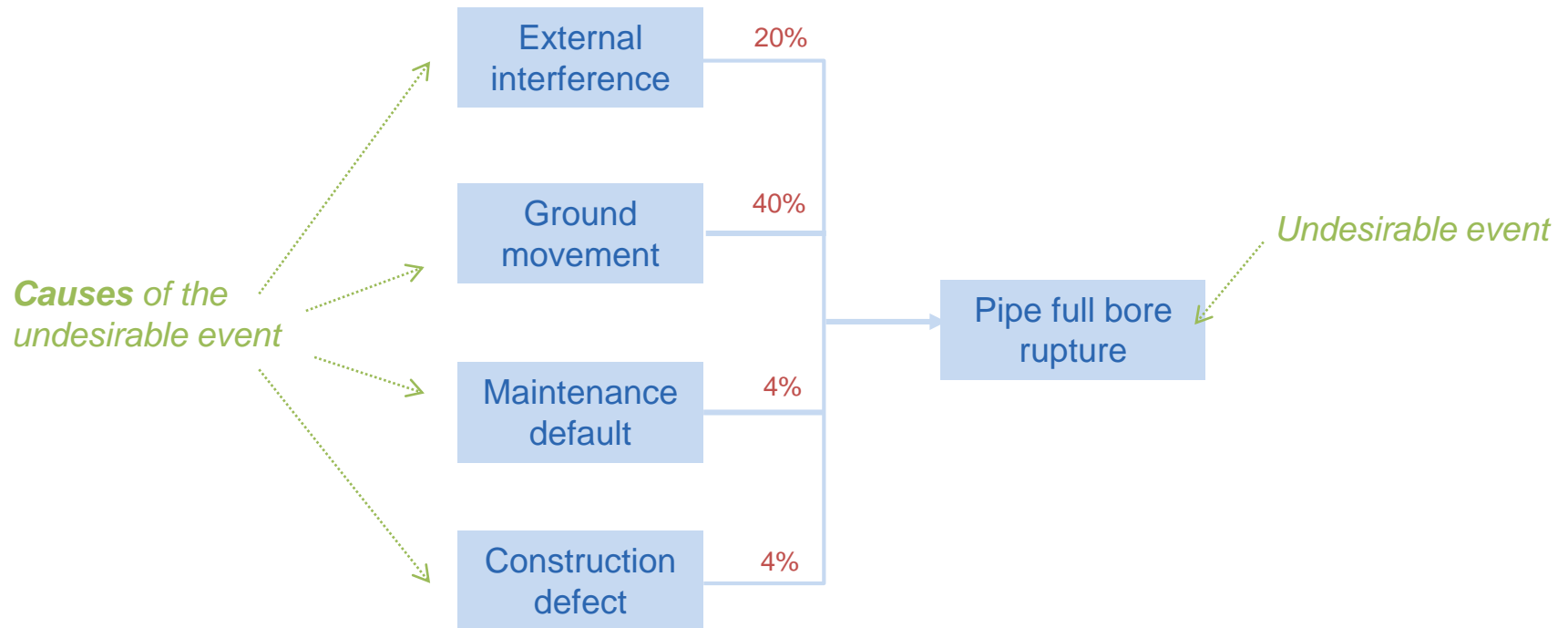
Event tree analysis



Source: CSD

Systematic Hazard Identification

Fault tree analysis



Source: CSD

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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 wastewater treatment plant	Loss of an installation , a building

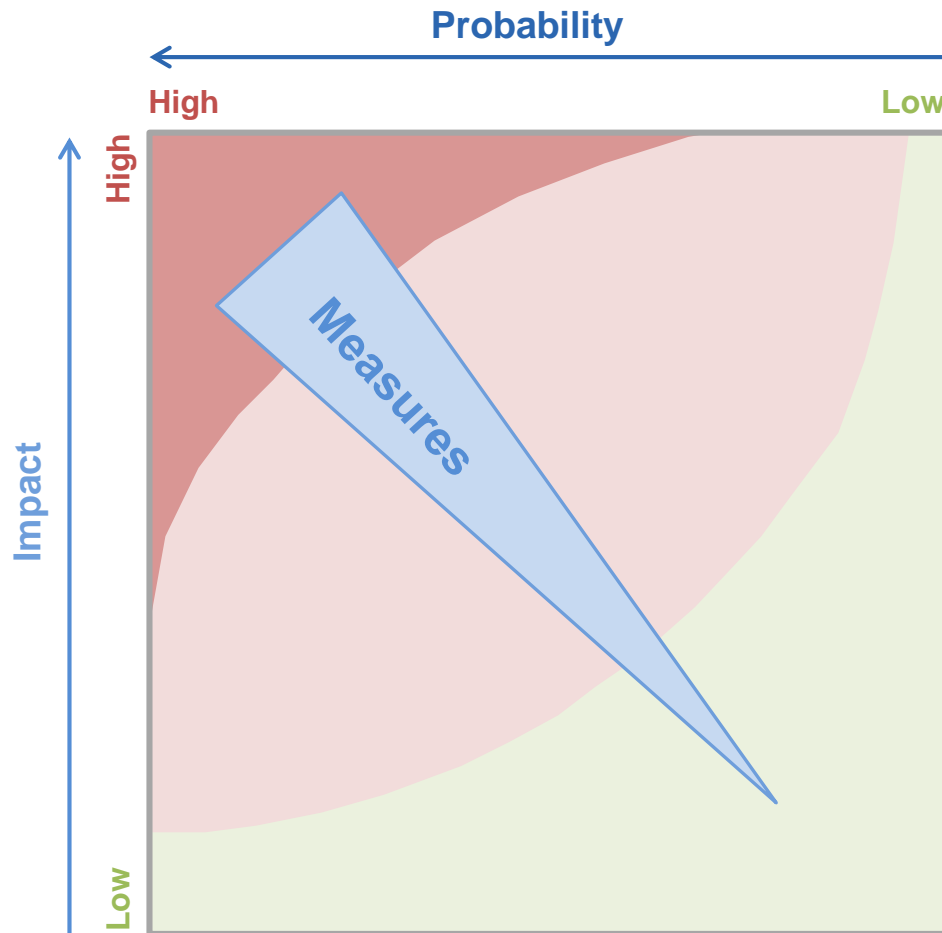
Source: based on ESCIS

Hazard Assessment by **Probability** – Example

Probability	Technical failure	Human error	Other influences
High	<ul style="list-style-type: none"> • Failure of analytical equipment (pH, redox, O₂ probes) 	<ul style="list-style-type: none"> • Mix-up of products in similar packaging • Misinterpretation of verbal instructions 	<ul style="list-style-type: none"> • Frost • Rain
Medium	<ul style="list-style-type: none"> • Failure of: <ul style="list-style-type: none"> - On-line measurement data (pressure, temperature) - Solenoid and regulating valves 	<ul style="list-style-type: none"> • Confusion of products delivered in drums/bags • Misinterpretation of written working instructions 	<ul style="list-style-type: none"> • Prolonged power cut • Transport accident
Low	<ul style="list-style-type: none"> • Failure of: <ul style="list-style-type: none"> - Redundant elements - Fail-safe elements 	<ul style="list-style-type: none"> • Confusion of products supplied through pipelines • Misinterpretation of written working instructions subject to double checking 	<ul style="list-style-type: none"> • Airplane crash onto chemical plant

Source: based on ESCIS

Risk Evaluation



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

Risk level:

- High risk
- Medium risk
- Low risk

Source: based on ESCIS

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- 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

Planning Measures



C_TRP 1 Green Chemistry and
Chemical Process Improvement

“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 (*cf. TRP 1 – Green Chemistry and Chemical Process Improvement*)

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

Source: based on ESCIS

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

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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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