3rd Chemical Process Safety Sharing (CPSS)

Topic : Process Safety within Solvay : Risk Assessment

Present Name :

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Company: Solvay group

Outline

- Brief Introduction to Solvay Group
- Introduction to Solvay Risk Assessment

Introduction to Solvay Group

WE ARE AN ADVANCED MATERIALS AND Specialty ChemicalS company

26,800 employees[2]

61 countries

135 industrial sites[2]

21 major R&I centers[2]

0.65 occupational accidents at Group sites per million hours worked[3]

€10.1bn net sales[1]

€2.2bn EBITDA[1]

5.53 greenhouse gas intensity kg CO_2 eq. per € EBITDA

49% sustainable solutions Group net sales

1. 2017 underlying results
2. Including the Polyamide business that has been accounted for in discontinued operations
3. Rate of accidents with medical treatment

SOLVAY

asking more from chemistry®

WE ARE BUILDING A MODEL OF SUSTAINABLE CHEMISTRY TO MEET THE CHALLENGES OF SOCIETY

Our activities are ORGANIZED into Operating Segments (Business Unit)



Solvay in Thailand

Production Site

- **Solvay Peroxythai (Map Ta Phut)**
  - Hydrogen Peroxide & Peracetic acid
  - Sodium Bicarbonate
- **MTP HPJV (AIE: DOW & Solvay JV)**
  - Hydrogen Peroxide (partial supply to DOW PO plant)
- **Solvay Specialty Chemical (Bangpoo)**
  - Surfactant (Personal care / Oil & gas and other)
- **Solvay Specialty Chemical (MTP-Hemmaraj)**
  - Specialty chemical (Mining)

With Head Office in Bangkok

Solvay is consistent with ISO 26000, the first global CSR standard



NORTH AMERICA

- 30% of net sales
- 23% employees*
- 38 industrial sites*
- 7 major R&I centers*

LATIN AMERICA

- 11% of net sales
- 10 % employees*
- 13 industrial sites*
- 1 major R&I center*

EUROPE

- 29% of net sales
- 48% employees*
- 52 industrial sites*
- 9 major R&I centers*

ASIA PACIFIC & ROW**

- 30% of net sales
- 19% employees*
- 32 industrial sites*
- 4 major R&I centers*

2017 underlying results

* Including the Polyamide business that has been accounted for in discontinued operations

** Rest of the World (ROW) includes Middle-East and Africa



Process Safety within Solvay

Solvay Rules

2 Red Lines

HSE-PS Rules

4 key procedures

- **Risk Analysis**
- **Risk Sheets**
- **Leaders**
- **Process Safety Management**

Application of the HSE-PS Rules

About 30 PS guidelines



Safety and Risks

- What is safety ?

  Ability of a system to operate without harming people or the environment or damaging property

- Preliminary remarks
  - Safety is a subjective concept
  - Underestimating the risk level can lead to costly improvements
  - When improvements are recommended, it is important to determine whether the benefit can justifiy the potential cost
    (ALARP: As Low As Reasonably Practicable)
  - A **quantitative** approach is essential
  - There is no such thing as zero risk : “the zero risk does not exist”
  - That asks the question about the acceptability of a risk

Hazards and Risks

- Our glossary definitions of ‘Hazard’ and ‘Risk’
  - **Hazard** : a situation with a certain inherent potential to cause harm to people, the environment and property
  - **Risk** : assessment of a hazard associating the probability of an **unwanted event** with the severity of its consequences

  (→ Risk = unwanted event)
- Example of a person walking along a cliff
  - ☞ The hazard is always present, but the risk of falling appears only when someone is **exposed to the hazard**.



Hazards and Risks

Main hazards present in industry

- Hazards related to materials
  - Toxicity ➔ Poisoning, Pollution
  - Corrosiveness ➔ Leaks, Burns,
  - Flammability ➔ Fire, Gas explosion, Dust explosion
  - Instability, reactivity ➔ Thermal runaway, Deflagration, Detonation

- Hazards related to operating conditions
  - Pressure ➔ Rupture, collapse of equipment
  - Temperature ➔ Thermal burns, rupture of equipment



Hazards and Risks

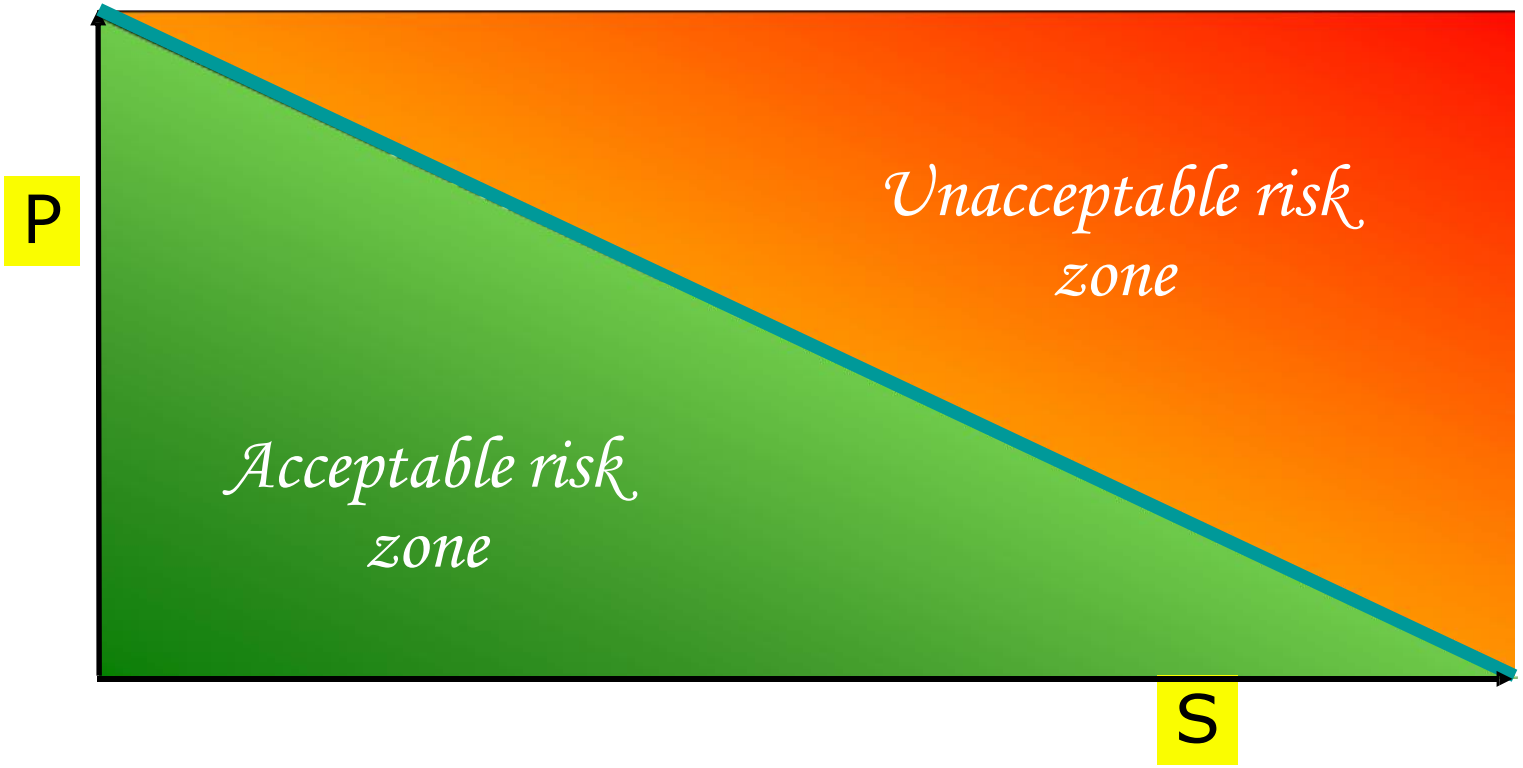
Main hazards present in industry

- ~~Hazards related to equipment~~ — Occupational safety
  - ~~Rotating machinery ➔ Mechanical injury~~
  - ~~Electricity ➔ Electrocution~~
  - ~~Radiation, EM waves ➔ Injury~~

- Hazards related to the environment of a plant
  - Nature-related hazards : atmosphere, lithosphere — Only if ➔ process deviation
  - Hazards related to human activity
    - Nearby industrial site (domino effects) — Yes, both internal & external
    - ~~Transport (railways, highways, airports, …)~~ — In principle no, but loading or unloading
    - ~~People (terrorist attack, malicious act, …)~~ — No

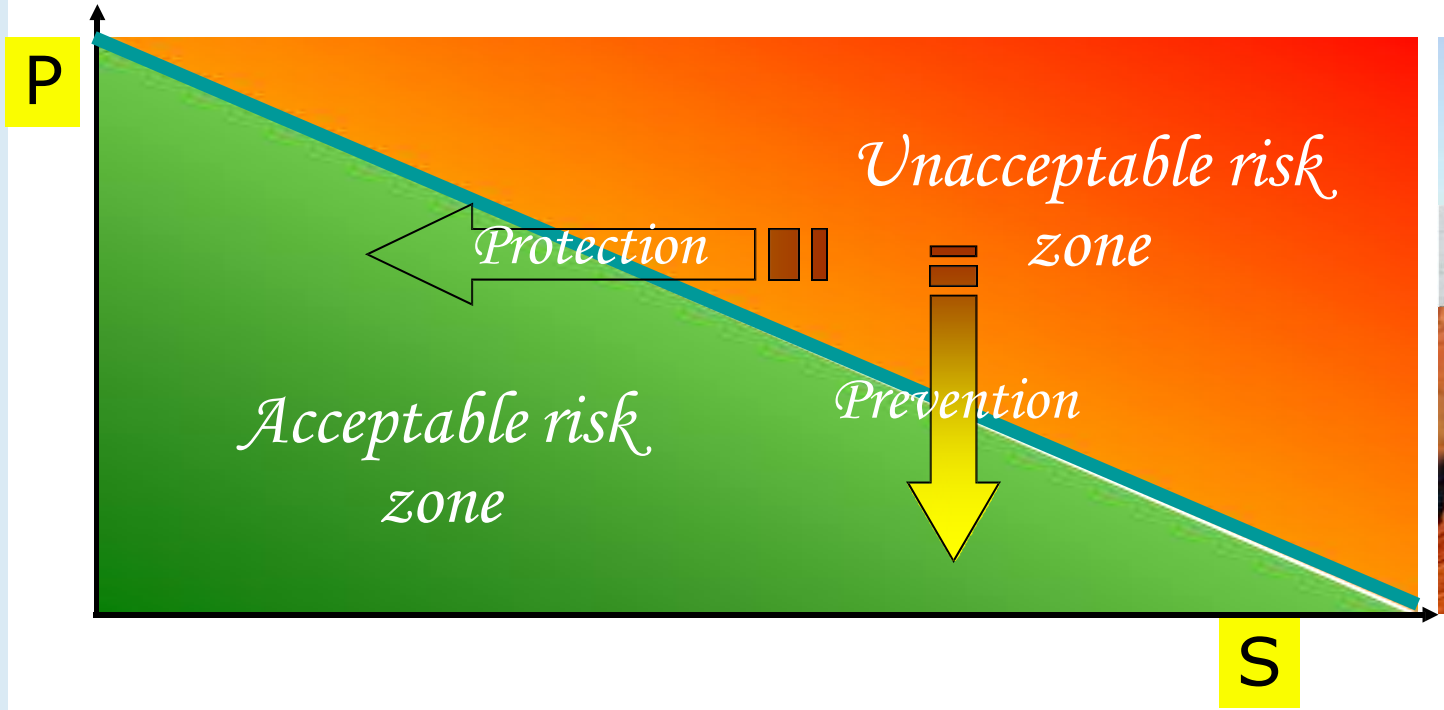
Risks and Risk Reduction

Acceptability of a risk : Relationship between severity and probability (Farmer)



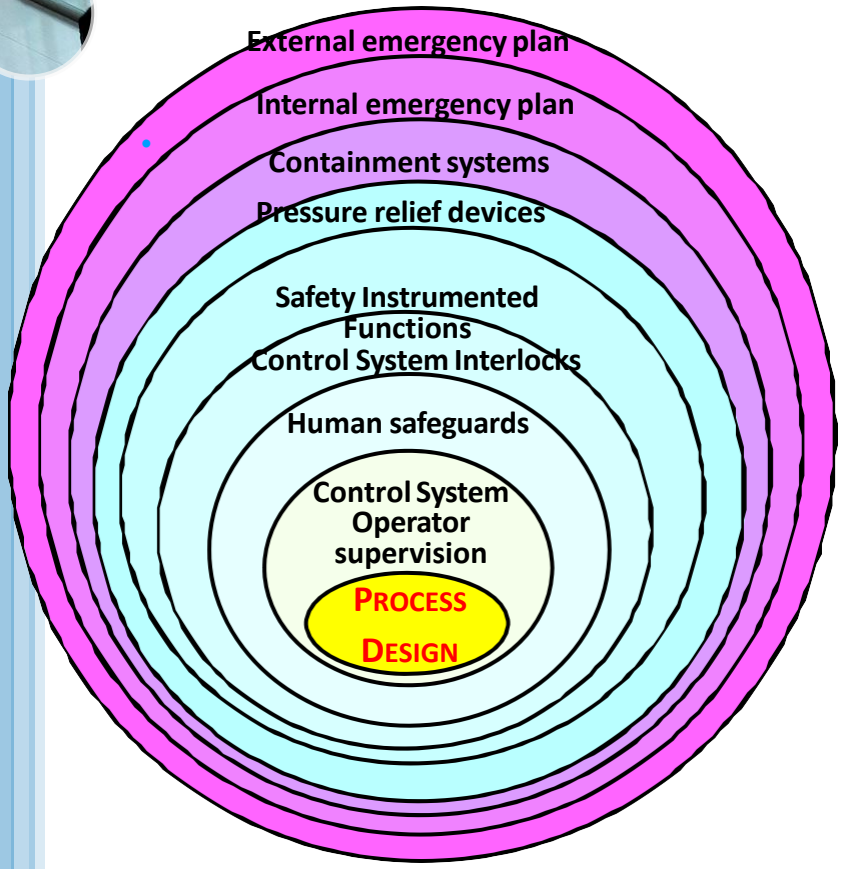
Risks and Risk Reduction

- **Risk control** = All situations in the acceptable risk zone
  - By eliminating the hazard = intrinsic safety
  - By lowering the probability and/or severity = prevention and/or protection



Layers of protection

The concept of layers of protection places **the Process Design in the center of the layers**.



The different layers of protection are used to obtain the desired level of risk during the operation of the plant.

«Layers of protection» is a generic term. It concerns various safeguards, which can be active, passive, human, material, preventive or protective.

The different layers of protection are intended to be **independent** as shown in the diagram opposite.

Process design is the first level of the process risk management



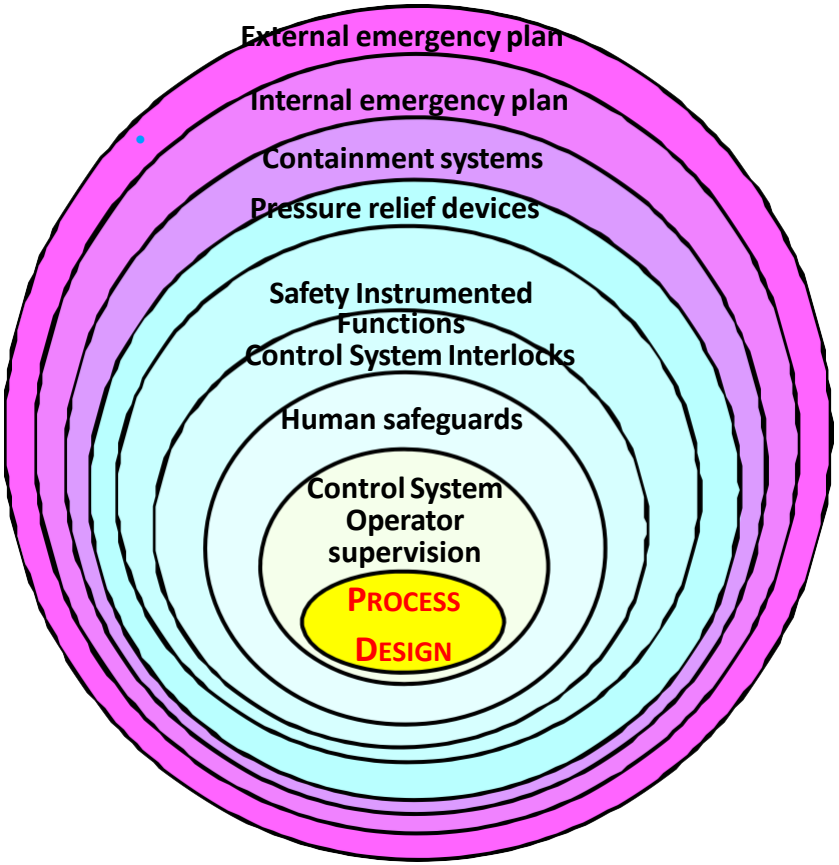
Layers of Protection

Main Characteristics

- **Independence & Reliability**

1. **Independence**: A layer that fails must not cause the others to fail

➡ no link between the layers



Layers of Protection

2. The **reliability** of a safeguard represents its capacity to function on demand.

The more a safeguard is reliable, the more the level of risk is low

The reliability of each **active safeguard** – be it **preventive** or **protective** – is measured by its **Probability of Failure on Demand** (**PFD**).
The PFD of a safeguard is based on the reliability data of each of its components.

Based on the PFD, in Solvay's process risk analysis method the reliability of any safeguard is expressed by its **Risk Reduction Class** (**RRC**) which corresponds to a range of PFD as follows:

RRC n corresponds to: $10^{-(n+1)} \leq$ PFD $< 10^{-n}$. (*)

The RRC is used to take a safeguard into account to reduce the risk level of a scenario for which the safeguard is effective.

(*) PFD can be equal to 10^{-1} for some types of RRC 1 safeguards

Recommended RRC values for active safeguards with associated requirements:

RRC 1 max. for a human safeguard

RRC 1 for a control system interlock

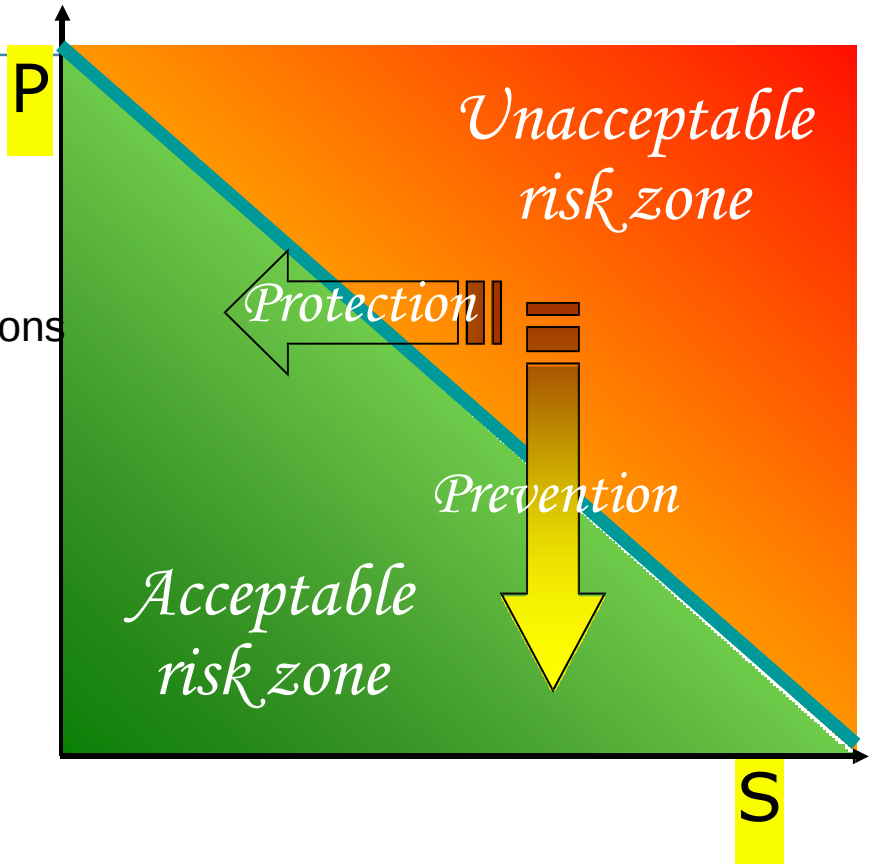
RRC 2 for a pressure safety valve

RRC 1, 2 or 3 for a safety instrumented function

Applying the Farmer curve

Risk control is ensured:

- By the design of the installations
  - That complies with rules and regulations
  - That complies with best practice and internal rules (Group, GBUs)
- By the analysis of residual risks
  - Assessment of the risk level
  - If the residual risk is not acceptable: improvements are mandatory
    - Prevention: to reduce the probability
    - Protection: to reduce the severity

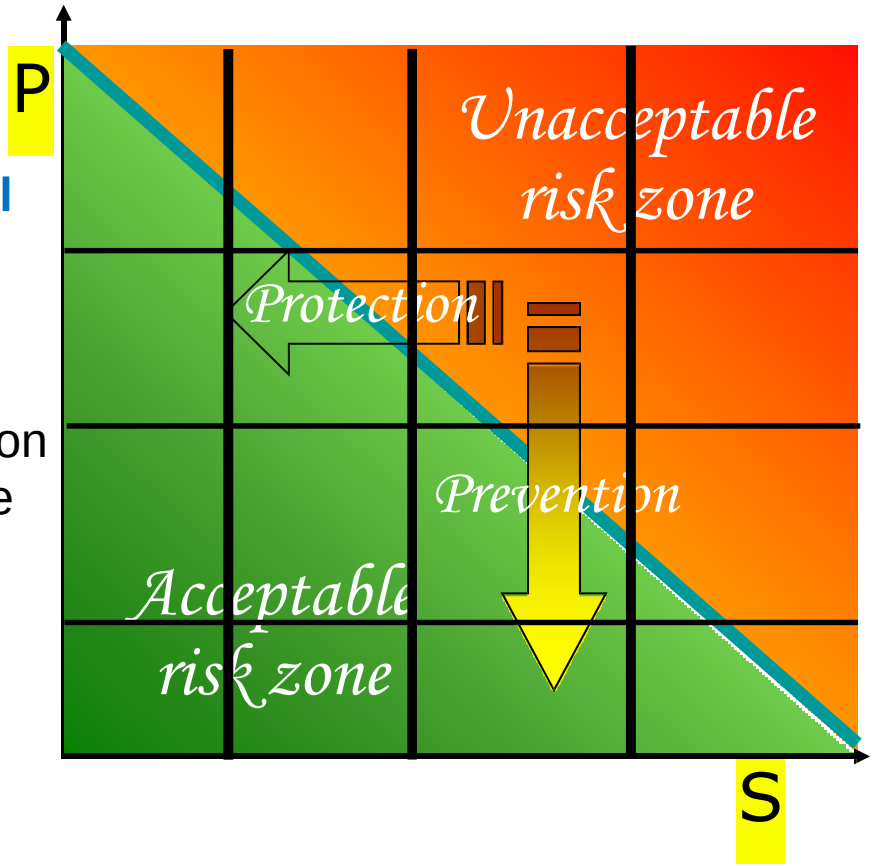


Applying the Farmer curve

- Risk must be **quantified**

- The Probability and Severity axes should therefore be split into **levels**
- This creates a chart, or a matrix with boxes
- Each box corresponds to a **risk level**

- Risk acceptability
  - Acceptability of the risk of a situation depends on the safety policy of the company



Assessing the residual Risk rR

Example

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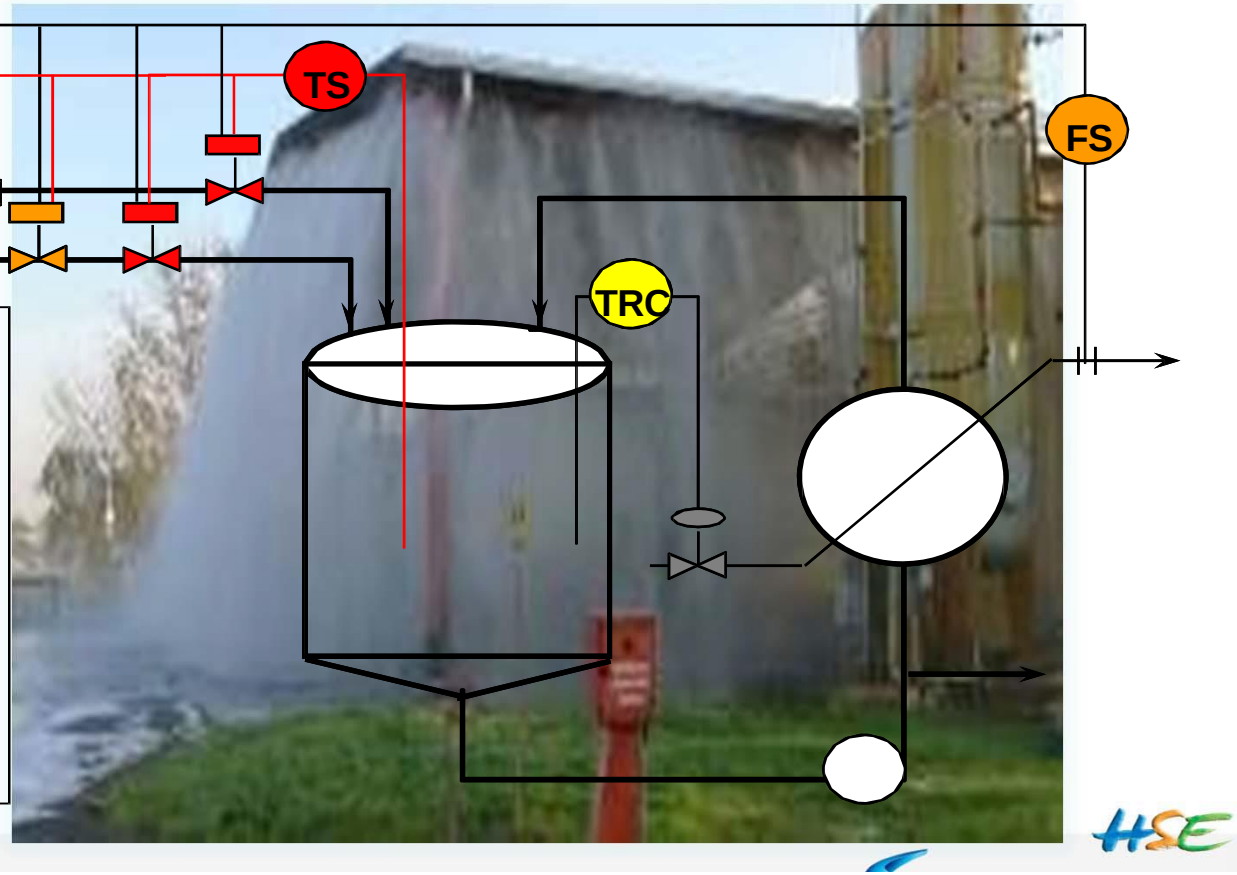
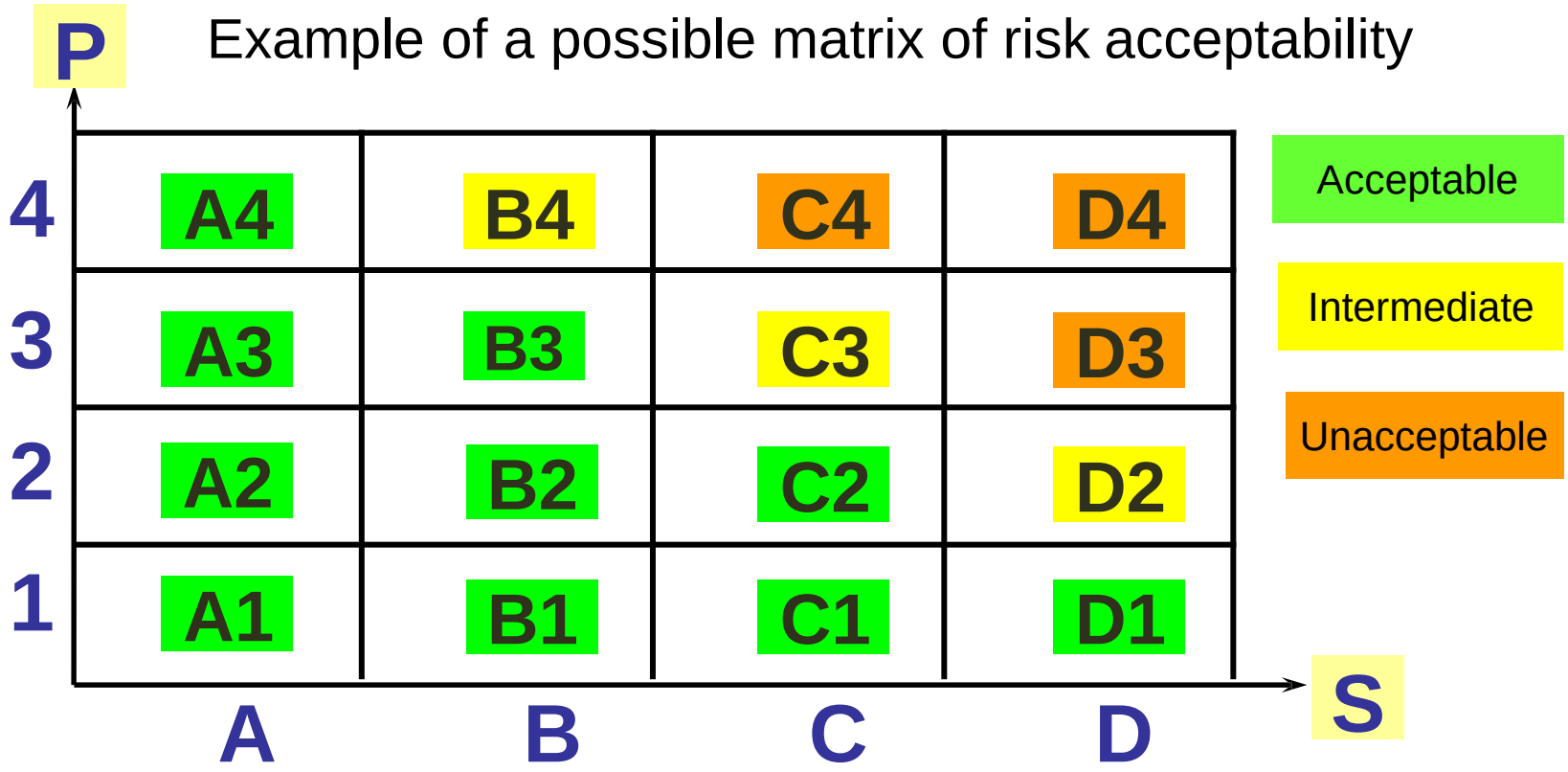


Preventive safeguard:
SIF = (TS + FS)
of RRC 2

Protective safeguard:
Sprinklers network
of RRC 2

Applying the Farmer curve

Example of a possible matrix of risk acceptability





Applying the Farmer curve

Solvay's risk acceptability matrix

Risk level 1 = Unacceptable
Risk level 2 = Intermediate
Risk level 3 = Acceptable

PROBABILITY ↓ for a one-year observation period			RISK LEVEL				
Qualitative	Value*	Level					
Highly probable (≈ Once a year)	1	1	3	2	1	1	1
≈ Once every 10 years	10^{-1}	1 – 2	3	2	1	1	1
Probable (≈ Once every 100 years)	10^{-2}	2	3	3	2	1	1
≈ Once every 1,000 years	10^{-3}	2 – 3	3	3	2	1	1
Improbable (≈ Once every 10,000 years)	10^{-4}	3	3	3	3	2	1
≈ Once every 100,000 years	10^{-5}	3 – 4	3	3	3	2	1
Extremely improbable (≈ Once every million years)	10^{-6}	4	3	3	3	3	3
SEVERITY →			L Low	M Medium	H High	C Catastrophic	D Disastrous
Human consequences							
Environmental consequences							



Internal process risk analysis method

- Identification of potential accident scenarios needs:
  - A recognized risk analysis method
  - Available data (on materials, conditions, equipment, …)
  - A multi-disciplinary working group (qualified, skilled staff)
  - Passive safeguards (PFD = 0) are taken into account while active safeguards are ignored
- Risk level assessment
  - Potential Risk pR for the potential scenario
  - Residual risk rR, taking into account the active safeguards, first preventive then protective ➡ residual scenario
- Acceptability of a risk according to the rules
- If necessary : search for improvements

SOLVAY's method: Process Hazard Analysis (PHA)



Method, Data

SOLVAY Rules

OK

YES

Causes

Consequences

Probability
Severity

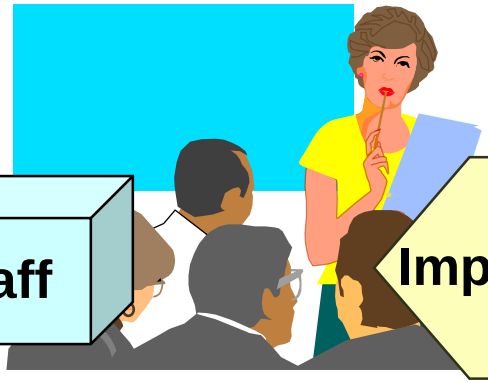
incident scenario

Risk assessment

Risk acceptable?

Unwanted event

Prevention
Protection



Qualified Staff

Improvement

NO



Internal process risk analysis method

- Usual analysis methods
  - Safety Review on Diagrams: SRD
  - Process Hazard Review: PHR
- Additional analysis methods for projects
  - What-if review before start-up

Risk analysis tools (SARA Software)

- Two main analysis tools
  1. **Table of scenarios** used in working group meetings

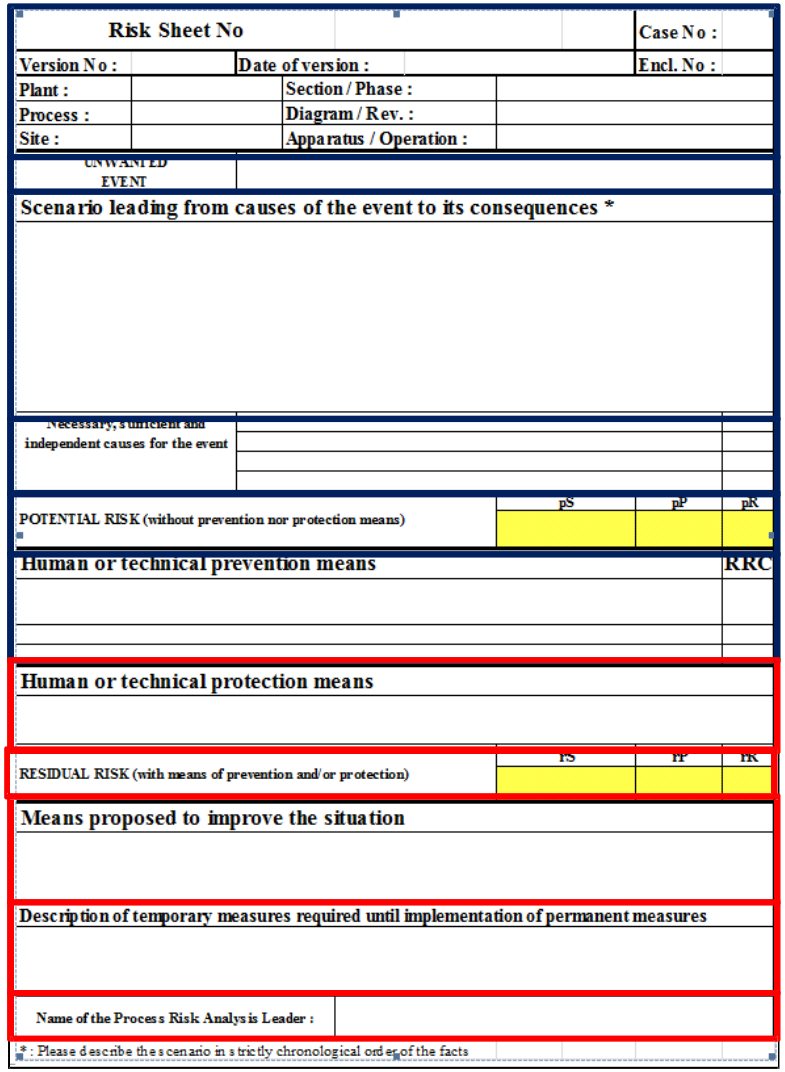
SAFETY REVIEW ON DIAGRAM - TABLE OF CASES

Plant Process Site		Section / Phase Diagram No / Rev Main apparatus		RS Prefix No Leader Date	Model. 2010 MrMrsX 26/01/2010

Case No	Apparatus Line Operation	Deviation	Initiating cause Other causes NSI	f	CASE Causes → Sequence of events → Unwanted Event → Effects → Consequences	pS	pP	pR	Existing independent preventive barriers (or addition determined in meeting if project)	RRC	rP	rR	RS No
1					Effects : Human consequences : Environmental consequences :								Model. 2010-1
			Ideas :										
2					Effects : Human consequences : Environmental consequences :								
			Ideas :										

Risk analysis tools

- Two main analysis tools
  2. **Risk assessment sheet**
     - Same information as table of scenarios +
     - Means of protection
     - Residual Severity Rrobability and Risk
     - Means proposed to improve
     - Temporary measures

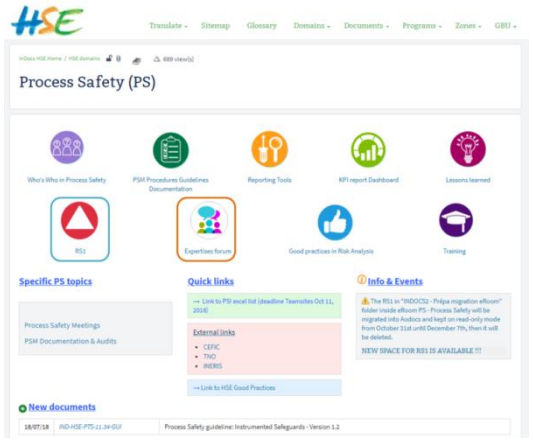


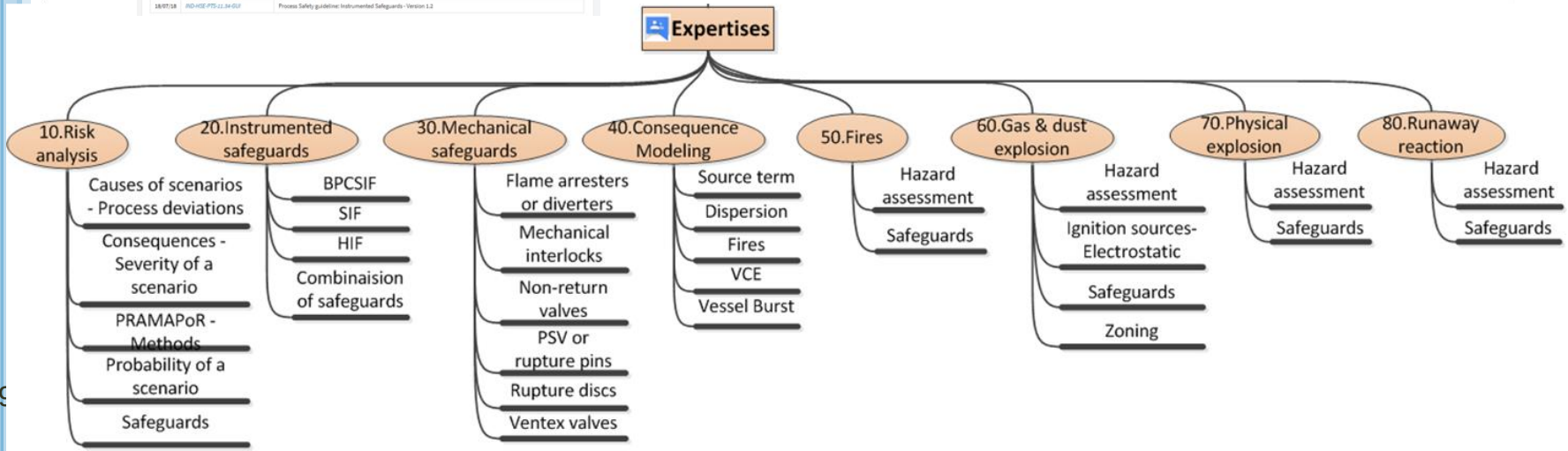
Risk Sheet No				Case No :
Version No :	Date of version :			Encl. No :
Plant :		Section / Phase :		
Process :		Diagram / Rev. :		
Site :		Apparatus / Operation :		
UNWANTED EVENT				
Scenario leading from causes of the event to its consequences *				
Necessary, sufficient and independent causes for the event				
POTENTIAL RISK (without prevention nor protection means)		pS	pP	pR
Human or technical prevention means				RRC
Human or technical protection means				
RESIDUAL RISK (with means of prevention and/or protection)		rS	rP	rR
Means proposed to improve the situation				
Description of temporary measures required until implementation of permanent measures				
Name of the Process Risk Analysis Leader :				

*: Please describe the scenario in strictly chronological order of the facts

EXPERTISE

The PS Expertise forums in INDocs (Information and documentation Center) are used by Process Risk Analysis Leaders network to ask questions. They are structured with new categories which enable easier search.

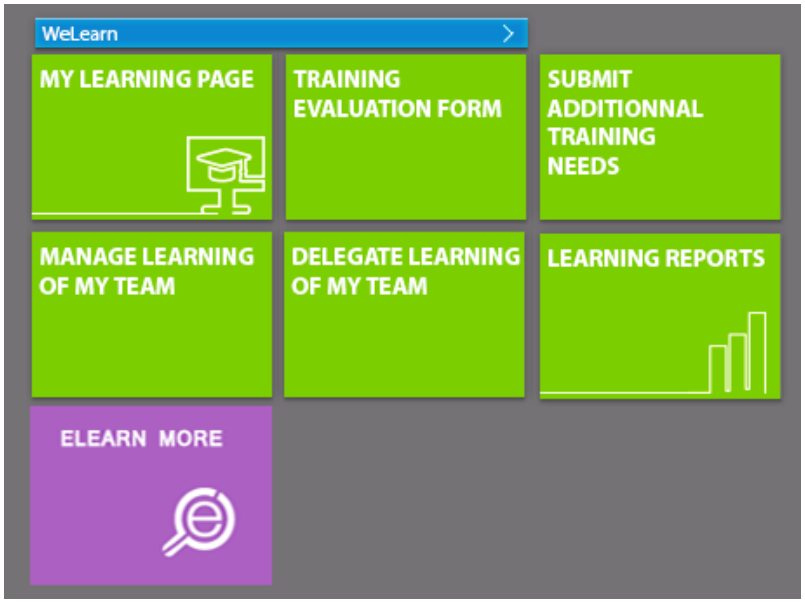




E-Learning

e-learning development for Process Safety expertise

Solvay Corporate University - Industrial Academy



See example video

Thank you for your attention