Defining ALARP in Process Safety

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Project: Global Process Hazard Analysis guideline

Center of Excellence for Process Safety

1. **"Risk" means the same for all our employees and communities**
   a. Risk tolerance, ALARP definition
   b. Risk prioritization of actions

2. **Investments are sustainable for the intended lifetime**
   a. PHA in all life cycle stages, starting from Conceptual
   b. Human Factors, Hierarchy of Control, Guided Adaptability for risk tolerance beyond ALARP
   c. Global Discretionary EHS Capital–requests comparable on Risk prioritization
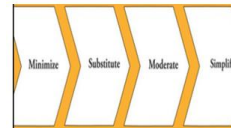   d. Mitigate operational improvement costs within the expected lifetime of investment

3. **Same PHA language: we get better at what we do**
   a. Competence requirements, inter-regional experience sharing and learning
   b. Auditable Quality requirements, risk-based approach to scope & methods

4. **Efficiency with standardization**
   a. Global development and maintenance of the standard(s), relieving the sites
   b. Complying to all our regulators
   c. Enabling Global solutions
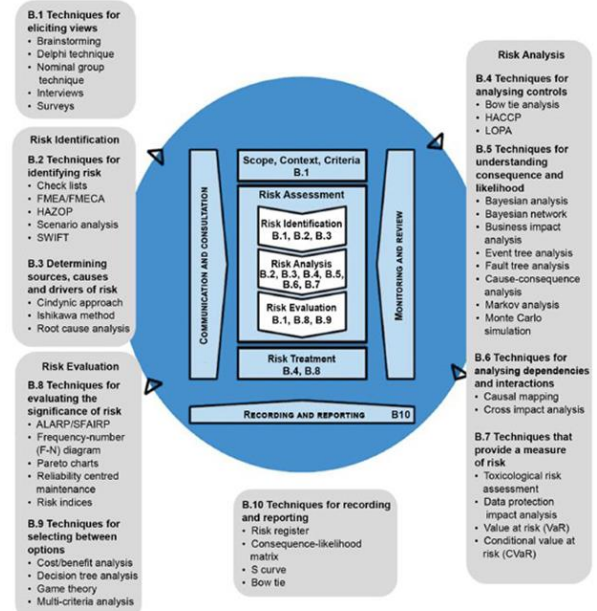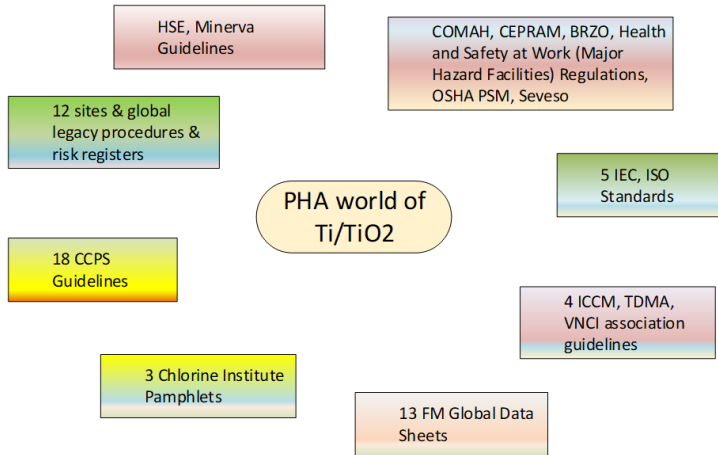
		Probability per year						
Severity (SHE)		A	B	C	D	E	F	
6	HIGH SEVERITY							
5	HIGH SEVERITY							
4	HIGH SEVERITY							
3								
2								
1								

Hierarchy of Controls

Human Factors

OperaTiO₂nal *Excellence*

Performance

Guided adaptability

Research

HSE, Minerva Guidelines

COMAH, CEPRAM, BRZO, Health and Safety at Work (Major Hazard Facilities) Regulations, OSHA PSM, Seveso

12 sites & global legacy procedures & risk registers

PHA world of Ti/TiO2

5 IEC, ISO Standards

18 CCPS Guidelines

4 ICCM, TDMA, VNCI association guidelines

3 Chlorine Institute Pamphlets

13 FM Global Data Sheets

B.1 Techniques for eliciting views
- Brainstorming
- Delphi technique
- Nominal group technique
- Interviews
- Surveys

Risk Identification

B.2 Techniques for identifying risk
- Check lists
- FMEA/FMECA
- HAZOP
- Scenario analysis
- SWIFT

B.3 Determining sources, causes and drivers of risk
- Cindynic approach
- Ishikawa method
- Root cause analysis

Risk Evaluation

B.8 Techniques for evaluating the significance of risk
- ALARP/SFAIRP
- Frequency-number (F-N) diagram
- Pareto charts
- Reliability centred maintenance
- Risk indices

B.9 Techniques for selecting between options
- Cost/benefit analysis
- Decision tree analysis
- Game theory
- Multi-criteria analysis

Risk Analysis

B.4 Techniques for analysing controls
- Bow tie analysis
- HACCP
- LOPA

B.5 Techniques for understanding consequence and likelihood
- Bayesian analysis
- Bayesian network
- Business impact analysis
- Event tree analysis
- Fault tree analysis
- Cause-consequence analysis
- Markov analysis
- Monte Carlo simulation

B.6 Techniques for analysing dependencies and interactions
- Causal mapping
- Cross impact analysis

B.7 Techniques that provide a measure of risk
- Toxicological risk assessment
- Data protection impact analysis
- Value at risk (VaR)
- Conditional value at risk (CVaR)

B.10 Techniques for recording and reporting
- Risk register
- Consequence-likelihood matrix
- S curve
- Bow tie

COMMUNICATION AND CONSULTATION

MONITORING AND REVIEW

Scope, Context, Criteria
B.1

Risk Assessment

Risk Identification
B.1, B.2, B.3

Risk Analysis
B.2, B.3, B.4, B.5, B.6, B.7

Risk Evaluation
B.1, B.8, B.9

Risk Treatment
B.4, B.8

RECORDING AND REPORTING B10

IEC

Research outcomes on fatality ALARP

Industry Association & standards "examples"

- Energy Institute PS Framework – Element 6

- IEC 61511-3 / ISA84

- IEC 31010

- CCPS

  - Guidelines for Chemical Process Quantitative Risk Analysis (2nd Edition)

  - Guidelines for Developing Quantitative Safety Risk Criteria

  - Hazard evaluation procedure [3rd edition]

  - Layer of Protection Analysis

Research outcomes on fatality ALARP

Regulators & tolerance expectations

- Seveso, Dangerous Goods, COMAH, BRZO: "Individual risk"

- CEPRAM: "Medium" < 1E-4

- Australia: "So Far As Is Reasonably Practicable"

- HSE (UK): Cost Benefit Analysis – Value of Statistical Life, Grossly disproportionate cost

ALARP demonstration [global guideline]

PS Consequences:	Occupational Health & Safety**	Process Safety	Environment	Economic

Matrix A	Hazard identification (HAZID, MOC screening)	Likelihood to occur in the life of an item (30-50years)		
Severity		Unlikely	Sometime	Often
6		M	H	H
5		M	H	H
4		M	M	H
3		L	M	H
2		L	M	M
1		L	L	M

Matrix B	Risk identification (HAZOP, MHA)	Likelihood to occur in the life of an item (30-50 years)					
		B	C	D	E	F	G
Severity		Can be assumed may not be experienced	Unlikely but possible	Possible	Sometime	Several times	Regularly
Matrix C	Barrier analysis (LOPA, SIL, ETA)	Probability per year					
Severity (SHE)		A	B	C	D	E	F	G
		10^{-6}	10^{-5}	10^{-4}	10^{-3}	10^{-2}	10^{-1}	
6 10 Fatalities	HIGH SEVERITY	P3 or ALARP	P3 or ALARP	P2 or ALARP	P1			
5 Fatality	HIGH SEVERITY	P3 or ALARP	P3 or ALARP	P3 or ALARP	P2 or ALARP	P1		
4 Life altering	HIGH SEVERITY	P3 or ALARP	P3 or ALARP	P3 or ALARP	P3 or ALARP	P2 or ALARP	P1	
3 Lost time		P4	P4	P4	P4	P3 or ALARP	P2 or ALARP	P1
2 Medical		P4	P4	P4	P4	P4	P3 or ALARP	P2 or ALARP
1 First Aid		P4	P4	P4	P4	P4	P4	P3 or ALARP

ALARP demonstrated:
Impracticability & Cost > Benefit

Semi-quantified basis including CMs and ECs: LOPA, FTA, ETA, CCA, Bow Tie

CBA: B x N x DF x P x L / [1 + (L x CO)]:
B : Benefit (Value of Statistical Life GBP 2mln) Exchange rate & cost of living rate
N : Number of victims
DF : Disproportion Factor (Goose 2006 : 4 – 10)
P : Scenario probability
L : Expected lifetime of scenario & safeguard (25yr)
CO : Cost of operation per year (2%)

Internal & EHS capital priority:
P1 : 30d. or before restart
P2 : Relative risk ranking
P3 : Relative risk ranking
P4 : Currently accepted
Metric : # open P2/P3 actions, # P2/P3 overdues

End of deck