Aalto University
School of Chemical
Engineering

HSE Engineer Work in Project Phases

7.10.2021

Tomi Sarkala

Biorefinery Investment Project

- **HSE is TEAM Work**
- **HSE Participation:**
  - HSE management within project management
  - HSE deliverables in each design phase
    - *Legislation, standards, guidance in the project*
  - Permitting related tasks (e.g. chemical permit application materials)
    - *Risk analysis, ATEX, consequence analysis, internal emergency plan, MAPP, Safety report*

LEGISLATION

Chemical Safety Legislation in Finland

SEVESO III – directive (2012/18/EU)

Act on the Safety of Handling Dangerous Chemicals and Explosives **390/2005**
(and change **358/2015**)

Decrees

Decree on the Industrial Handling and Storage of Hazardous Chemicals 685/2015
Decree on Safety of the Industrial Handling and Storage of Hazardous Chemicals 856/2012 (and its revision 686/2015)

Standards

Guidelines (e.g.TUKES-guides)

Machinery Safety Legislation in Finland

Design, Manufacturing, Supplying

–Machinery Directive 2006/42/EC

→ Finnish national Decree on the Safety of Machinery 400/2008

Responsibility of Designers, Manufacturers, Suppliers

CE

Choosing and Purchasing, Installing, Use, Inspection, Maintenance, Modification, Decommissioning

–Occupational Safety and Health Act 738/2002

Responsibility of Employers

Legislation and Standards regulate and Steer HSE Engineering

Legislation changes, e.g. (Directives) need to be followed

- **Seveso III (Directive 2012/18/EU)**
  - *Implemented in national legislation*
  - *CLP Regulation changes taken into account*
- **Pressure equipment Directive 2014/68/EU**
- **Electrical equipment Directive 2014/35/EU**
- **ATEX Equipment Directive (2014/34/EU)**
  - *Implementation by national standard ongoing (Finland)*
  - *Ignition risk analysis for old equipment in ATEX areas*
- **Machinery Directive, 2006/42/EC**

Standards Involved

Pressure equipment

Electrical equipment

Machinery safety

Dangerous chemicals

- *ATEX*
- *Natural Gas*
- *Other flammable liquids or gases…*

In Finland e.g. recent changes to the standards concerning flammable liquids control and in near future SFS käsikirja 59 and IEC 60079-10-1:2015 to be updated

VAARALLISTEN KEMIKAALIEN SÄILIÖITÄ, LAITTEITA JA KÄYTTÖÄ KOS[illegible] STANDARDI[illegible]

Päivitetty 5.3.2019

SFS-EN 12285-2: 2005	Tehdasvalmisteiset [illegible] makaavat yksi- ja k[illegible] pilaaville nesteille
SFS-EN 12573-1: 2000	Welded static non-pressurized thermoplastic tanks. Part 1: General principles
SFS-EN 12573-2: 2000	Welded static non-pressurised thermoplastic tanks. Part 2: Calculat[illegible] vertical cylindrical tanks
SFS-EN 12573-3: 2000	Welded static non-[illegible] tanks. Part 3: Design [illegible] calculation for single skin rectangular tanks
SFS-EN 12573-4: 2000	Welded static non-pressurised thermoplastic tanks. Part 4: Design a[illegible] calculation of flanged joints
SFS-EN 13121-1: 2003	GRP tanks and vessels for use above ground. Part 1: Raw materials. Specification conditions and acceptance conditions
SFS-EN 13121-2: 2003	GRP tanks and vess[illegible] above ground. Part 2: Composite materials. Chemical [illegible]
SFS-EN 13121-3: 2016	GRP tanks and vessels for use above ground. Part 3: Design and workmanship
SFS-EN 13121-4: 2005	GRP tanks and vessels for use above ground. Part 4: Delivery, installation and maintenance
SFS-EN 13341: 2011	Kestomuoviset staattiset maanpäälliset varastosäiliöt lämmitysöljyil[illegible] kerosiinille ja dieselpolttoaineille. Puhallus- ja rotaatiovaletut polyeteenisäiliöt sekä anionipolymeroidut polyamidi 6:sta valmistetut säiliöt. Vaatimukset ja koemenetelmät.
SFS-EN 13575: 2012	Static tanks made from blow moulded polyethylene. Tanks for the above ground storage of chemicals. Requirements and test methods
SFS-EN 14015: 2005	Nesteiden varastointiin vähintään ympäristön lämpötilassa käytettävän säiliön mitoitus ja rakentaminen. Paikalla rakennettava, suoraseinäinen, ympyrä- ja tasapohjainen, maanpäällinen, hitsattu metallisäiliö

Laitteet ym.

SFS 3701:1995	Putkistojen merkintä virtaavien aineiden tunnuksin. Tunnusväri
SFS-EN 267+A1: 2012	Automaattiset puhallinpolttimet nestemäisille polttoaineille
SFS-EN 298: 2012	Automatic burner control systems for burners and appliances bu[illegible] gaseous or liquid fuels
SFS-EN 13160-1:	Vuodonilmaisujärjestelmät. Osa 1. Yleiset periaatteet

Sähkölaitteistot

SFS 6000 (2017)	Pienjännitesähköasennukset *(Standardisarja, joka sisältää 39 kpl erillisiä standardeja)*
SFS 6001 (2018)	Suurjännitesähköasennukset
SFS-EN 60079-14 (2015) + AC (2016)	Räjähdysvaaralliset tilat. Osa 14: Sähköasennusten suunnittelu, laitevalinta ja asentaminen
SFS-käsikirja 604-2 (2017) Luku 3	Räjähdysvaaralliset tilat. Osa 2: Sähköasennukset, tarkastus ja huolto, Luku 3: Räjähdetilat
[illegible]	[illegible] utkien asennukset yli 1 kV mutta alle 10 kV [illegible] Yleiset vaatimukset
SFS-EN 50191 (2011)	Sähköisten testauslaitteistojen asennus ja käyttö
SFS-EN IEC 62[illegible] (2018)	Akkujen ja akkuasennusten turvallisuusvaatimukset. Osa 2: Paikalliskaut [illegible] 2-2 (2001)
SFS-EN 50119 [illegible] +A1 [illegible]	Railway applications. Fixed installations. Electric traction overhead contact lines
SFS-EN 50122-1 (2011) + A1 (2011) + A2 (2016) + A3 (2016) + A4 (2017)	Railway applications. Fixed installations. Electrical safety, earthing and bonding. Part 1: Protective provisions against electric shock
SFS-EN 50122-2 (2011)	Railway applications. Fixed installations. Electrical safety, earthing and the return circuit. Part 2: Provisions against the effects of stray currents caused by d.c. traction systems
SFS-EN 50124-1 (2017)	Railway applications. [illegible] Basic requirements. [illegible] electronic equipment
SFS-EN 50341-1 (2014) + [illegible]	[illegible] 1 kV jännitteillä. Osa 1: Yleiset vaatimukset. [illegible] Suomen kansalliset velvoittavat määrittelyt *(Standardeja sovelletaan myös enintään 1 kV:n ilmajohtoihin osan 2-7 soveltamisalan mukaisesti)*

Sähkötyöturvallisuus

SFS 6002 (2015) + A1 (2018)	Sähkötyöturvallisuus *(Lisäys A1 2018 ei varsinaisesti muuta standardin asiasisältöä)*

Kokemuksia takautuvasti voimaan tulleiden kemikaaliturvallisuuslainsäädäntövaatimusten tilanteesta yrityksissä

Varastosäiliöiden EN-standardit

SFS3357-standardi, palontorjunta

SFS3355-standardi, satamien turvallisuus

SFS3350-standardi, varastointi

SFS3353-standardi, palavien kemikaalien tuotantolaitos

Räjähdysvaarallisten tilojen tilaluokitukset

Räjähdysvaarallisteen tilojen laitteet ja laitevalinta

SFS Online

SFS-EN 61511-3:2017

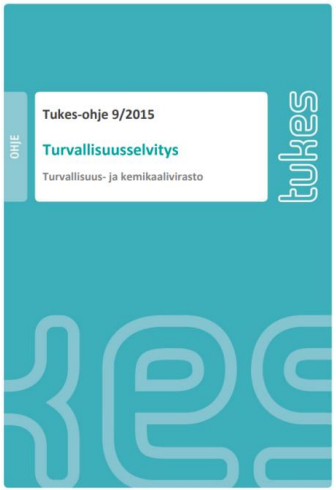
Toiminnallinen turvallisuus. Turva-automaatiojärjestelmät prosessiteollisuussektorille. Osa 3: Ohjeita vaadittavien turvallisuuden eheyden tasojen määrittämiseen

TUKES Guides for Help

The Finnish Safety And Chemicals Agency guideline: Establishment location/2015

Worst case modelling guidelines

The Guide of ”Turvallisuus selvitys” The Finnish Safety And Chemicals Agency guideline /2015



Guideline of safety reports for legislation

ATEX instruction

The Finnish Safety And Chemicals Agency (guideline 9/2015)

Explosion protection

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And many others… e.g.

- **Process safety and measuring it**
- **Dangerous chemicals in industry**
- **https://tukes.fi/tietoa-tukesista/materiaalit/kemikaalilaitokset**

AFRY
ÅF PÖYRY

SAFETY STEPWISE

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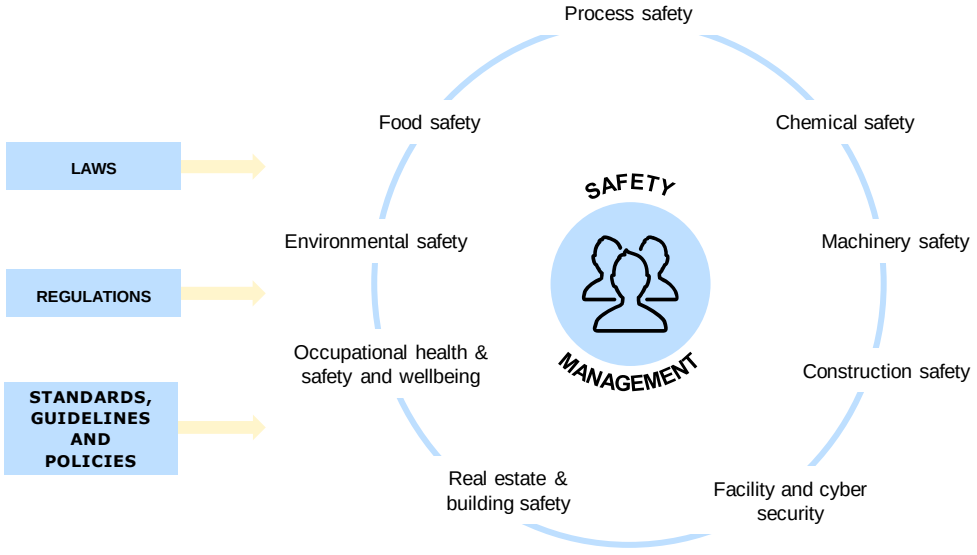
School of Chemical
Engineering

Holistic view of Health and safety



THE VALUE

Improved performance

Corporate social responsibility

Sustainability targets achieved

Improved business flexibility

Sustained value for the company and its shareholders

WE DELIVER

Comprehensive understanding of latest legislation and regulations

Support for decision making on critical safety areas

Safe solutions for industrial processes

Comprehensive project safety

AFRY

Project HSE activities

COMPLIANCE & PERMITTING

Chemicals

Machinery

Pressure equipment

Environment

Safety audits, HSE DD

Explosion protection (ATEX)

Follow-up services

SAFETY MANAGEMENT

Safety Management Systems

Safety training

Functional safety

HSE Excellence (OE)

Human factors

Safety visualisation

RISK ANALYSES

Process Hazard Analysis, PHA

Machinery safety risk assessment

Environmental risk assessment

Occupational safety evaluation

Food safety, HACCP

Consequence analysis & modelling

RAMS engineering

PROJECT HSE SERVICES

Project Safety Management (Safety Stepwise)

HSE Design review

Construction risk analysis

Site HSE management and supervising

Safety training

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Safety Stepwise™ – Hierarchical Approach

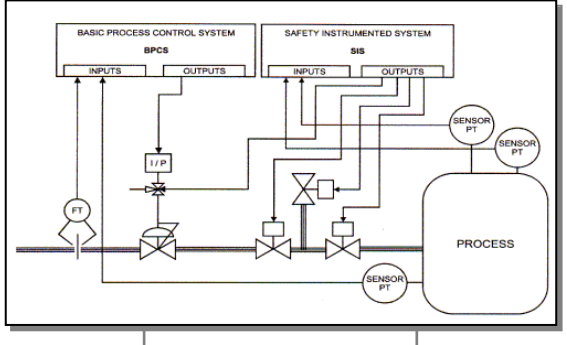
Pre-engineering	Basic Engineering	Detailed Engineering	Construction and Erection	Commissioning and Start-Up	Production

INHERENT SAFETY

- Minimization
- Substitution
- Moderation
- Simplification

PASSIVE PROTECTION

ACTIVE PROTECTION



PROCEDURES

Process safety principles

Safety Stepwise™ – Safety within a life cycle of project

1. Step	2. Step	3. Step	4. Step	5. Step	6. Step
Pre-engineering	**Basic Engineering**	**Detailed Engineering**	**Construction and Erection**	**Commissioning and Start-Up**	**Production**
Master action list • HSE criteria/Project specific requirements • Connections to authorities • Principles of Inherent safety • Chemicals and materials • Plant location • Plant structure • Emergency facilities • Empirical accident data in similar plants –Internal –external	• Master action list (update) • Preliminary risk analysis. –Hazardous scenario analysis –Potential problem analysis –Checklists –Etc. • Layout risk analysis –Safety distances (Eg. Standards and Consequence analysis) –Emergency exits/escape routes –Rescue team access –Maintenance –logistics • Fire risk analysis • Pre-ATEX study • Preliminary definition of safety automation • Safety requirements for suppliers • Safety guidelines for engineering • Fire protection classification • Permitting plan	• Master action list (update) • Detailed risk analysis –HAZOP –Human error analysis –What-if -analysis –Failure mode and effect analysis • ATEX Study –Explosion protection document –Hazardous area classification –Equipment classification (Ex) • Design of safety automation –SIL-assessment (risk graf, LOPA, etc. –Safety plan • Fire protection of structures • Process isolation procedures • 3D safety review	• Master action list (update) • Legal safety document • Site HSE plan • HSE organisation and job descriptions • Safety guidelines for contractors • Contractor's commitment for safety and contractors HSE plan • Verification of risk reduction measures • Change management • Operation and maintenance manuals (preparation) • Safety and operation training • Rescue plan • Site safety procedures –Safety instructions –Job safety analysis –Toolbox talks –Personnel equipment –Training –Reporting &investigation –Safety communication –Audits –Work permits, etc • Conformity check • Mechanical completion check	• Master action list (update) • Review of legislation and regulations • Review of safety requirements and practices –Pre-start activities –Operation and maintenance manuals (check) –Acceptance of final documentation –Work permits after mechanical completion • Emergency preparedness	• Master action list (update) • Acceptance of final documentation • Process safety file check • Learning from practical experience • Archiving • Continual improvement
Documentation collected phase by phase into the project's process safety file / system					

Risk Analyses

Risk analysis is a structured process used to identify hazards in a given facility, process or system, and to define the probability and consequences of occurrence.

Effective way to

- identify risks
- provide safe solutions
- provide information for decision makers
- fulfil requirements set by legislation and authorities.

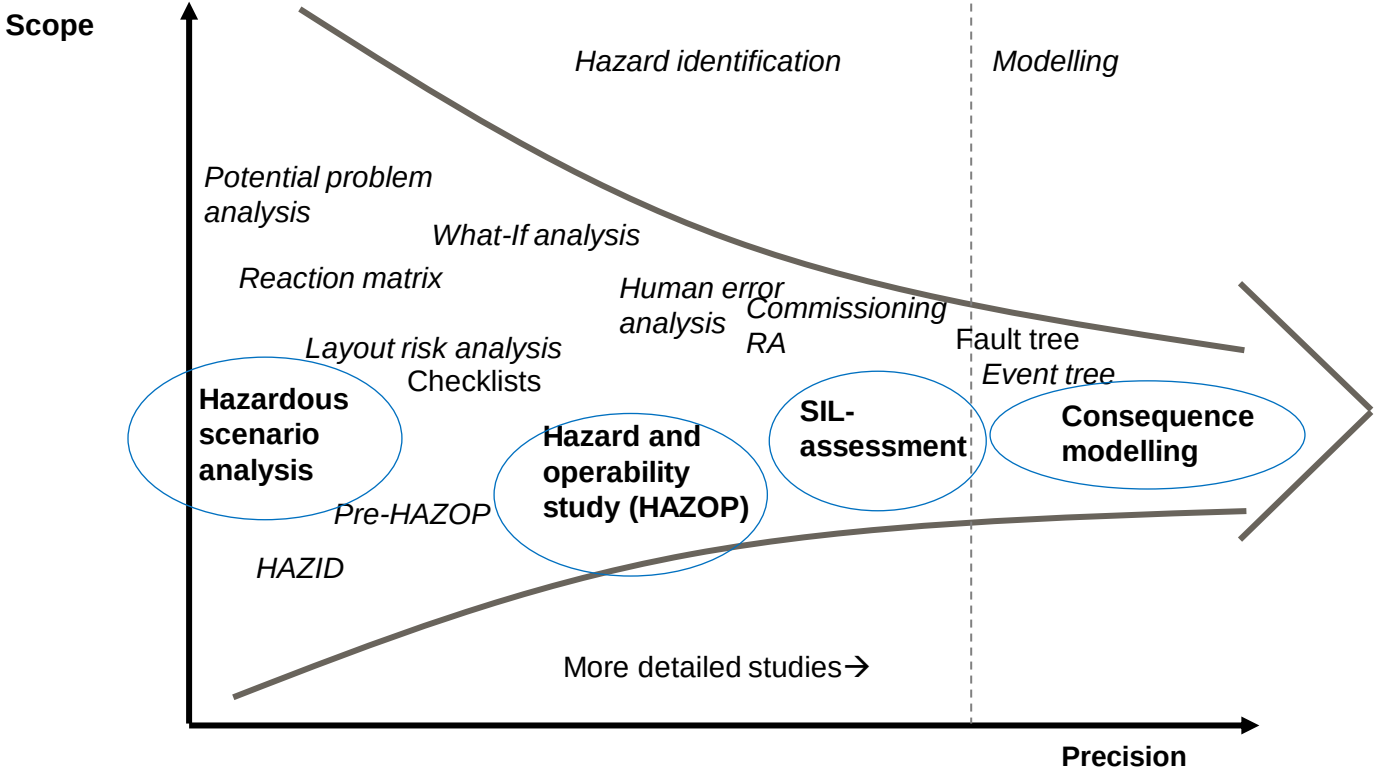
Risk analysis with several methods

- HAZID, HAZSCAN, HAZOP, HEA
- Machinery safety risk analysis
- SIL (Safety Integrity Level)
- Consequence analysis & modelling
- Safety management and communication

Benefits

- Risks identified and safe solutions provided
- Information for decision makers
- Requirements set by legislation and authorities fulfilled

Process Risk Analysis – Hierarchical Approach



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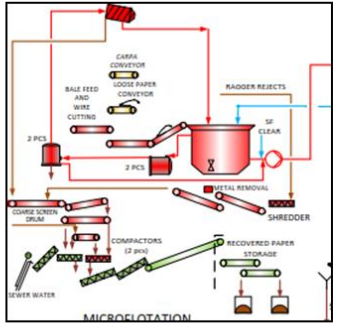
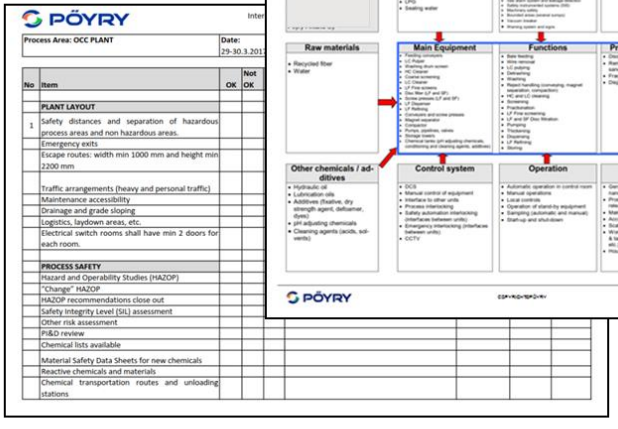
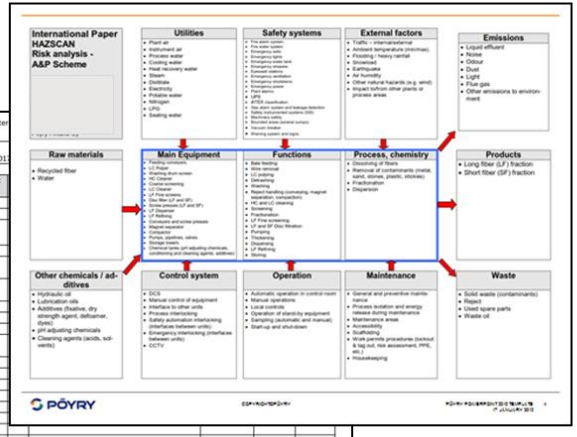
HAZSCAN (Hazardous Scenario Analysis) Methodology

Sub-processes



Check-lists



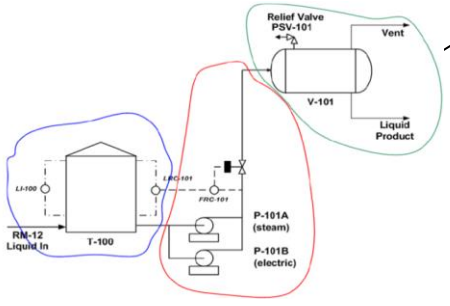


Report (PHA-Pro software)

Drawings:
101000086-R0001; 101000086-R0002; 101000086-R0003; 101000086-R0004; 101000086-R0005; 101000086-R0006; 101000086-R0007

Hazardous situation / Causes	Consequence	Safeguard	Risk Matrix C	P	R	Recommendations: Recommendation	Responsibility	Due date	Comments
1. Brake failure of crane	1. Too high speed of the crane -> possible collision -> possibility of personal injury for the crane operator or even fatality	1. Inherent safeguards in the crane	5	3	H	1. No entry to the crane operating area			
						2. Warning lights and signal	Supplier		
						3. Proper specification during	Pöyry		

Processing of HAZOP



Node: subsystem (functional entity)

- Node selection
- Deviation
- How could be caused
- Consequences
- Risk classification 1
- Safeguards [1)]
- Risk classification 2
- Recommendations

Deviation from design intend utilizing the guidewords (high flow, no flow, low level, etc.)

1) Preparedness (safeguard):

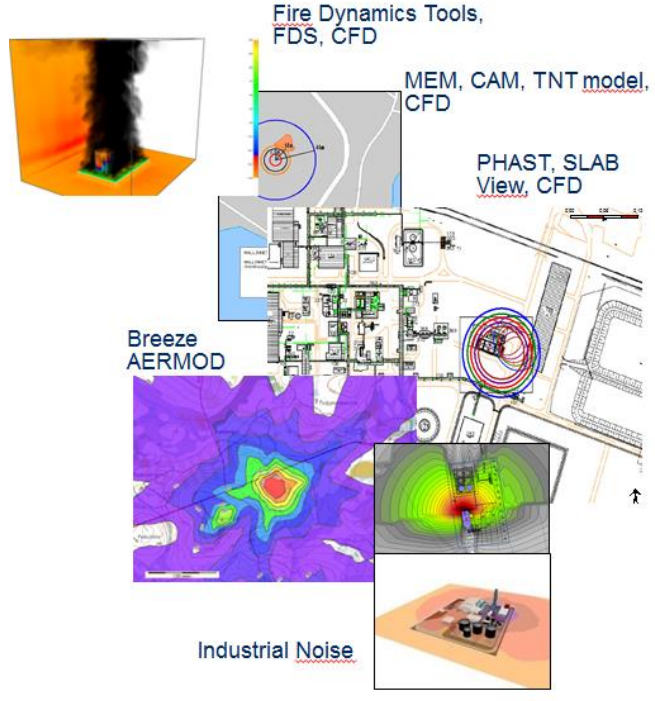
- Interlocks, controls, and other automatic protection (DCS)
- Alarms, displays
- Safety valves
- Operating instruction
- Safety Instrumented System (SIS)
- How much time to act?
- Etc.

Node: 26. HHE - Main Fuel Feeding System
Drawing: abc1; abc2; abc3;
Design Conditions/Parameters:

Deviation	Causes	Consequences	Risk Matrix			Safeguards	Risk Matrix2			Recommendations (HAZOP)					Comment
			S	L	RR		S	L	RR	Recommendations (HAZOP)	Responsibility	Status	Execution	Due Date	
1. High Flow	1. Failure of frequency controller in main conveyor	1. Blockage on biomass feeding point	S1	L3	D	1. Blockage detector in biomass belt conveyor 2. Interlock between the conveyors upstream	S1	L1	D	41. Consider adding 6 blockage detectors before main conveyor, in dropping chutes	nn.				

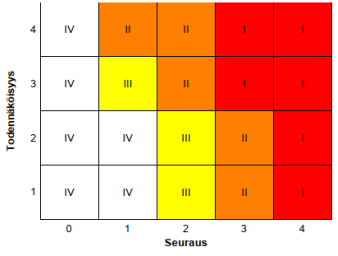
Consequence Modelling

1. Jet and pool fires → heat load calculation
2. BLEVE, gas cloud explosion, fireball → overpressure effects
3. Leaks → gas dispersion modelling
4. Noise modelling
5. Spreading to the air, soil, water



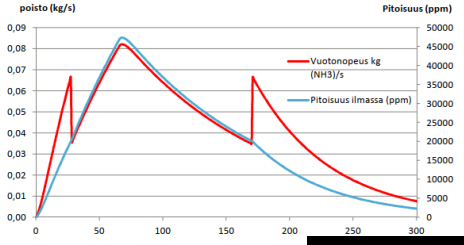
Consequence Analysis
Case: Ammonia in cooling

1. Design
2. HAZOP
3. Scenario analysis
4. Design
5. Modelling
6. Co-operation with authorities
7. Evacuation plan
8. Training

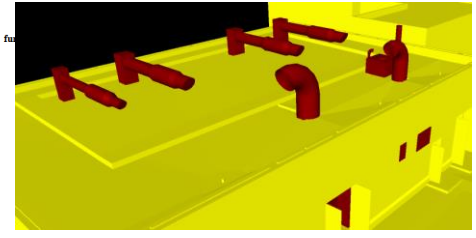


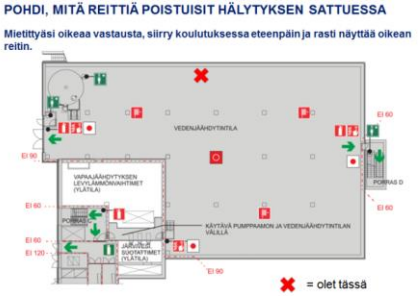
Taulukko 2. Ammoniakkipäästön 10 min ja 30 min AEGL-2 ja -3 raja-arvojen ylittyminen er
tarkastelukorkeuksilla tuulen nopeuden ollessa 5 m/s.

Ammoniakki, raja-arvo	Ilman pesuria, korkeudella:			Pesurin kanssa, korkeudella:		
	3 m	6 m	8 m	3 m	6 m	8 m
AEGL-2 (10 min)	50 m	69 m	67 m	-	41 m	37 m
AEGL-3 (10 min)	-	18 m	-	-	11 m	-
AEGL-2 (30 min)	40 m	61 m	59 m	-	38 m	32 m
						-

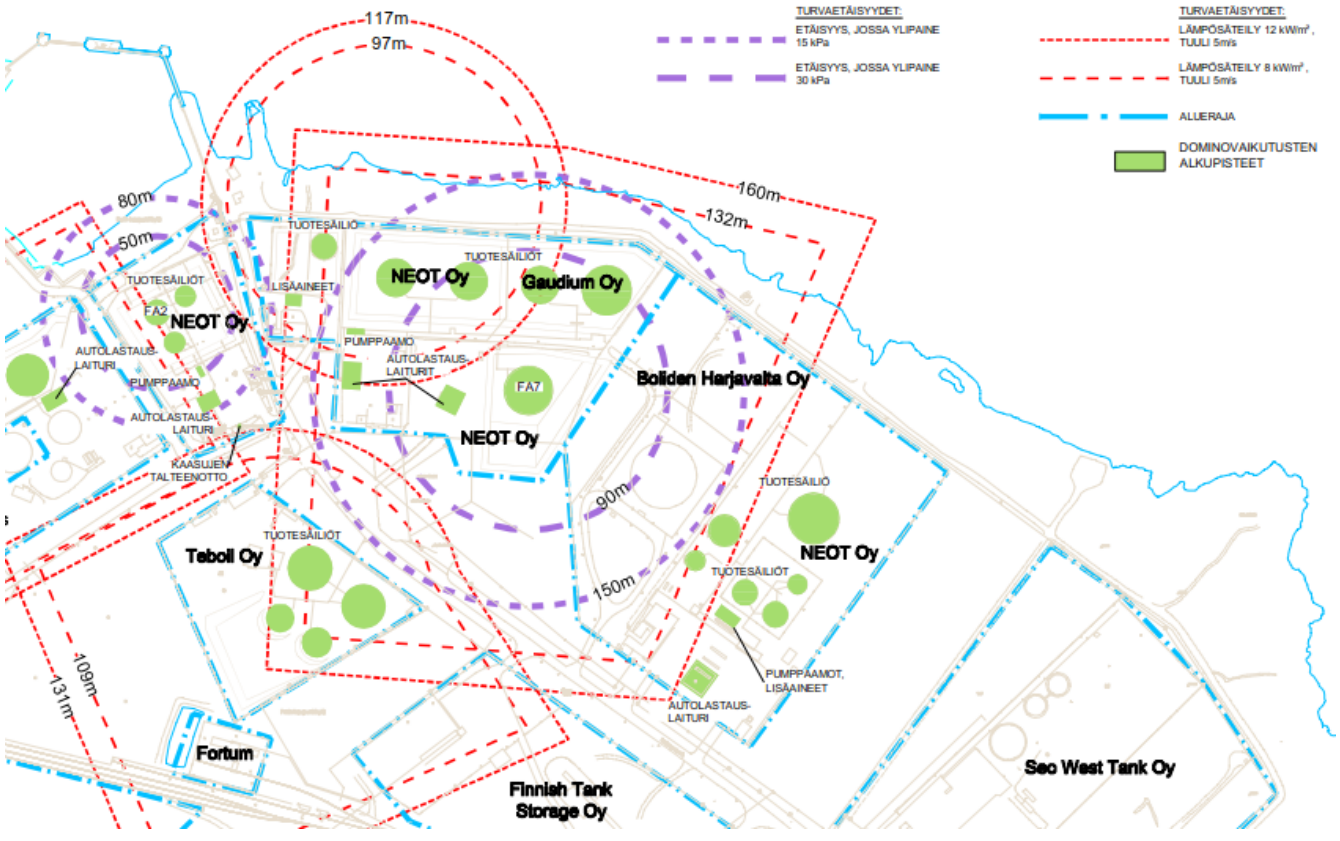


Kuva 2. Tuuletuksen poistaman ammoniakin massavirta ajan fu
ammoniakin pitoisuus huoneessa (oikea pystyakseli).





Consequence Analysis – Domino Effect



HSE ENGINEER TEST

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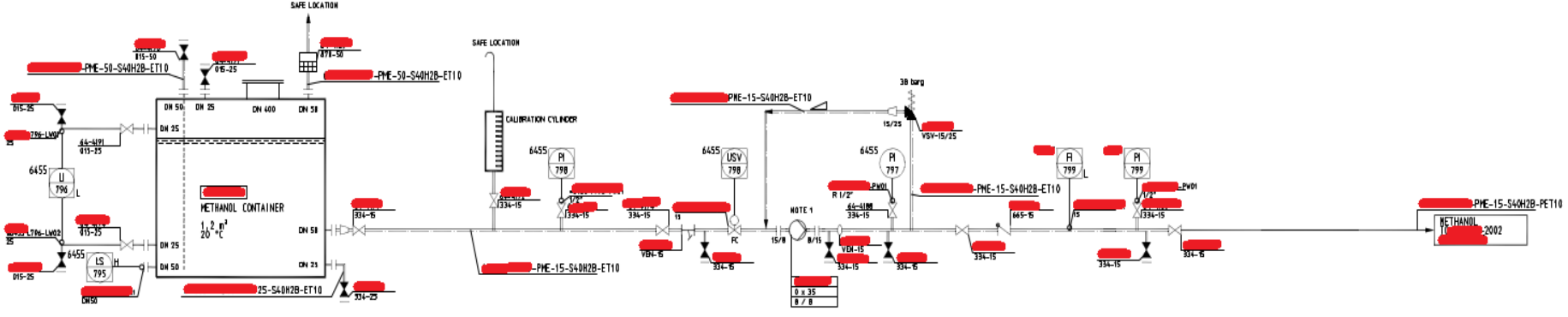
What To Do in a Biorefinery Project?

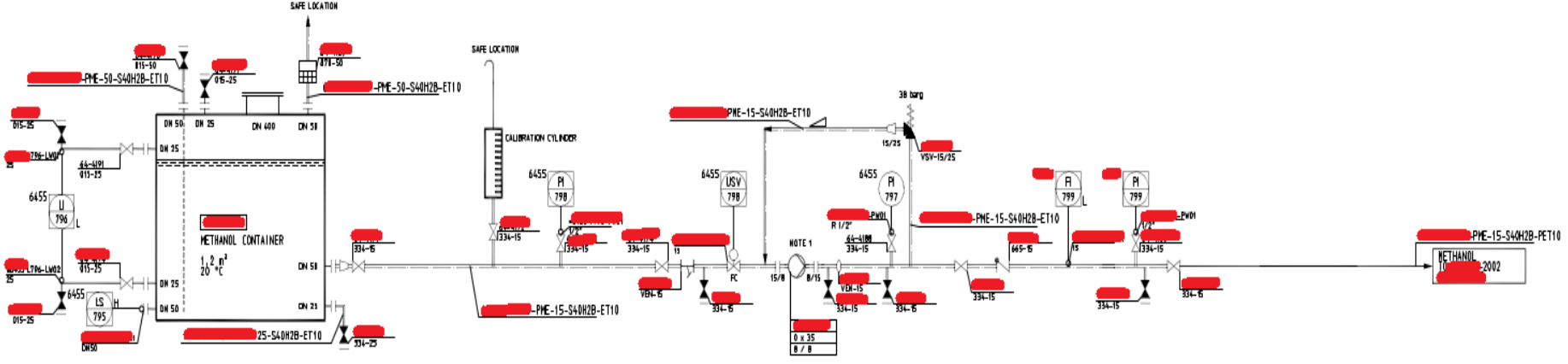
- **Project located in Finland.**
- **Methanol container (1m^3) is added to the site in detail design phase.**
- **You have to take care of MOC (Management Of Change).**

Process engineer gives you the next initial data:



Questions from Process Engineer:

- **Is ATEX regulations applied?**
- **Where to find information?**



From Material Safety Data Sheet and…

- Can be found from google, BUT!
- **Should be asked from project, because for example the content or concentration can vary.**

Initial data from project:

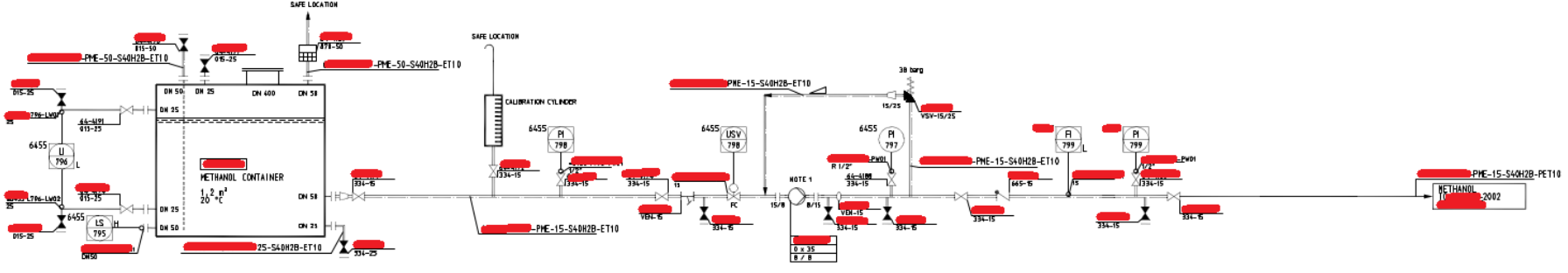
Chemical	Abbreviation	Amount	Used at	Flash point	Auto ignition temperature	Explosive limits:	Gas relative density:
Methanol	PME	1 m^3	Plant	11 °C	385°C	5,5 – 36,5 til-%	1,1

- **What else do we need?**

From SFS-59 Handbook

Chemical explosion and temperature groups

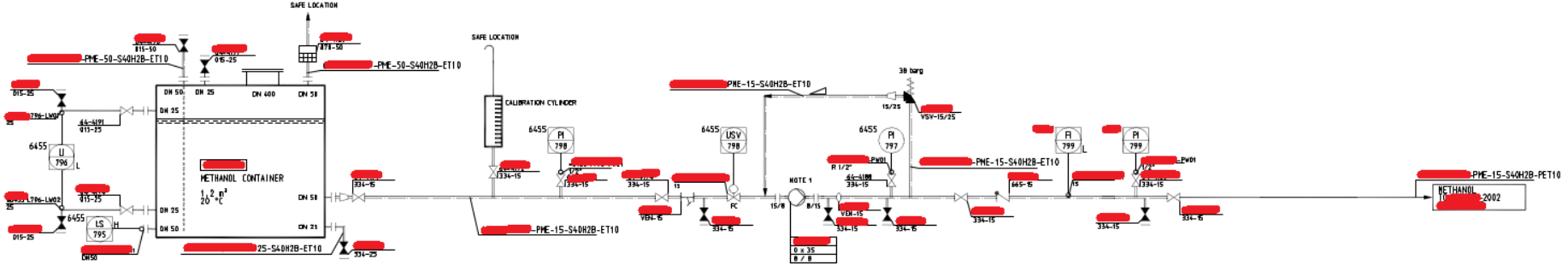
Nimi	Luokitus		Kemiallinen kaava	Leimah-dus-piste (°C)	Itsesyt-tymis-lämpö-tila (°C)	Syttymisrajat		Nesteen tiheys (vesi=1)	Höyryn tiheys (ilma=1)	Kiehu-mis-piste (°C)	Veteen-liukoi-suus	Reak-tio-alttius	Sytty-mis-ryhmä	Räjäh-dys-ryhmä
	Palavuus	Muu ominai-suus				Alempi (til.-%) [g/m³]	Ylempi (til.-%) [g/m³]							
Metylaali dimetoksimetaani	F	*)	$CH_3OCH_2OCH_3$	(-18)	247			0,9	2,6	44	Kyllä	2	T3	IIB
Metyleenioksidi kts. formaldehydi	F+	T												
Metyyliakrylaatti	F	*)	$CH_2=CHCOOCH_3$ Huom! Polymeroituu	-3	415	2,8 [100]	25 [895]	1,0-	3,0	80	Ositt.	2	T2	IIB
Metyylialkoholi metanoli	F	T	CH_3OH	11	386	5,5	36	0,8	1,1	65	Kyllä	0	T2	IIA



Chemical	Abbreviation	Amount	Used at	Flash point	Auto ignition temperature	Explosive limits:	Gas relative density:
Methanol	PME	1 m³	Plant	11 °C	385°C	5,5 – 36,5 til-%	1,1

Questions from Process Engineer:

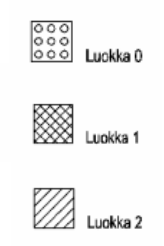
Where are the ATEX areas then?

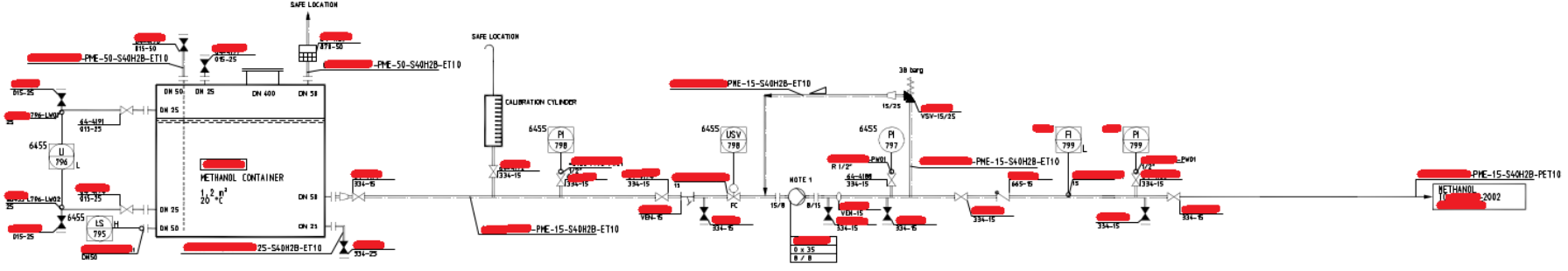


From SFS-59 Handbook

ATEX area classification according to SFS-59, 5.1

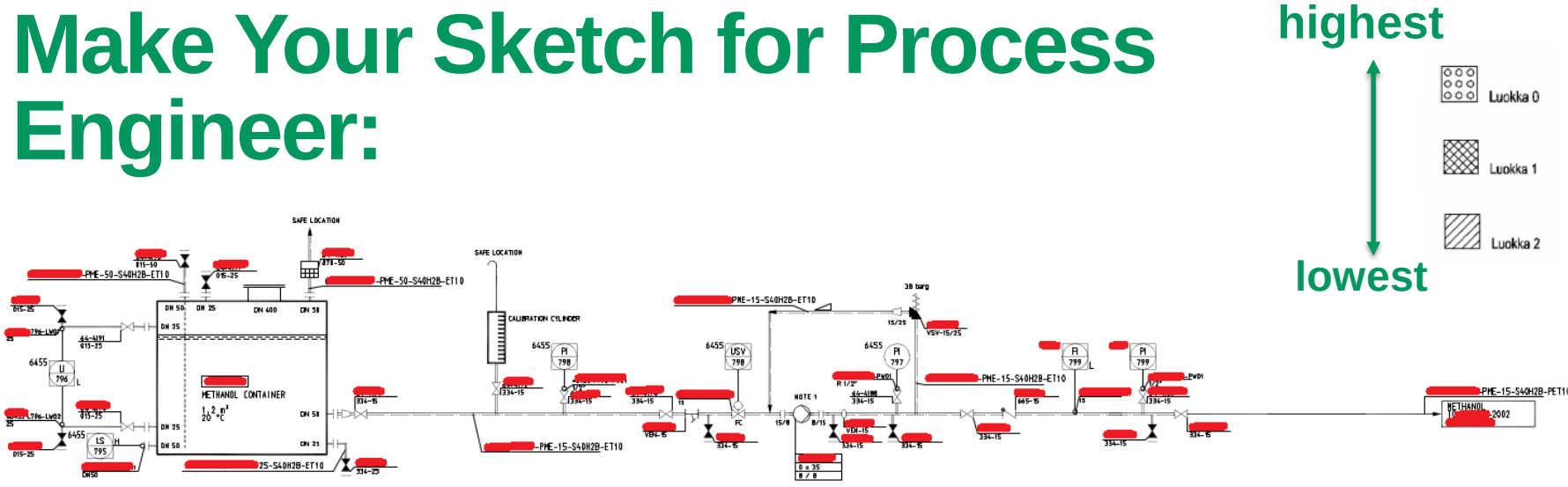
- *ATEX Area 0: inside the structures and in closures marked with*
- *ATEX Area 1: around safety valves or rupture disks marked with*
- *ATEX Area 2: around possible leakage points marked with*





Chemical	Abbreviation	Amount	Used at	Flash point	Auto ignition temperature	Explosive limits:	Gas relative density:
Methanol	PME	1 m³	Plant	11 °C	385°C	5,5 – 36,5 til-%	1,1

Make Your Sketch for Process Engineer:



Around leakage points:

- *ATEX Area 0: inside the structures and in closures*
- *ATEX Area 1: 4.5 m from safety valves or rupture disks*
- *ATEX Area 2: 1 m outdoors, 1.5 m indoors around possible leakage points*

Example of the presentation of ATEX zones