Republic of Serbia
Ministry of Environmental Protection
Department for Major Chemical Accident Protection

Methodology of the Safety Report development with a special focus on risk assessment methodology that is applied in Serbia

UNECE Seminar on Risk Assessment Methodologies
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Legal requirements for Safety Report development

- As proscribed by Law on Environmental Protection, all upper tier complexes are required to draft a Safety Report and submit it to CA for evaluation.
- Threshold values for dangerous substances defining upper tier complexes are transposed from Annex I of EU Seveso III directive.

- Data from Safety Report is a base for determining Domino zones and possible transboundary effects.
- Main focus of CA evaluation process is risk.
- CA evaluation process has only two outputs:
  1. Decision on compliance, with or without additional measures, or
  2. Decision on non-compliance, with ban of operation for complex or part of complex.

Structure of Safety Report

- Introduction
- Major accident prevention policy
- Safety management system
- Description of complex and its environment
- Hazards identification
- Scenarios
- Consequence Analysis
- Prevention measures

- Structure is similar to Annex II of Seveso III directive, but not fully aligned with it.
- Procedure for identification and assessment of risk, a part of SMS, is crucial for further risk analyses.
- With this procedure operators determine what method will be used for identification of critical points on complex.
- Description of complex and its environment gives foundation data for any further analyses.
- Assessment of risk is guided by Rulebook.

Hazards identification

Hazards identification

Procedure for identification and assessment of risk

Description of complex and its environment

Implies analysis of:

1. Technical specifics and deficiencies in production, transport and storage
2. Specificity of physical-chemical properties of dangerous substances
3. Possible failures of components and materials due to deterioration of equipment and interruption of supply of energy products
4. External sources of danger (extreme temperatures, wind, precipitation and floods, fires, earthquakes and landslides)
5. Activities of the neighbouring operators
6. Analysis of previous accidents

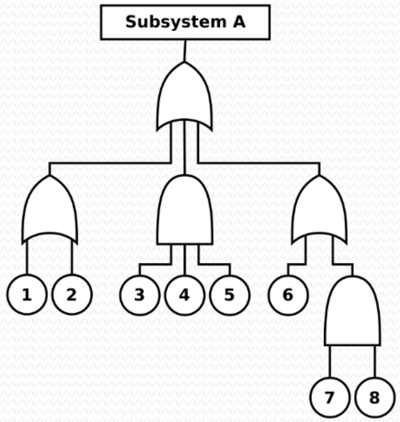
- Hazard identification implies the identification of critical points.
- The human factor as a possible cause of the accident is analysed in particular.
- Operators can decide which method for identification of critical points to use.
- Most often where ARAMIS and simple “What – if” method, and only in few cases HAZOP was used.
- Some modification of ARAMIS where made to align with GHS labelling system.

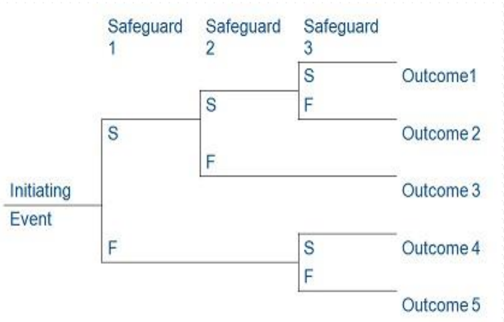
Scenarios

- Scenarios should be chosen on the basis of identified critical points and characteristics of dangerous substances, as well as effects that may arise (explosion, fire, release and expansion of gases, vapours, liquids, aerosols and dust, models of penetration and dispersion of dangerous substances into the soil, surface water and groundwater).
- Similar scenarios are not repeated.
- Operators must draw up the worst case scenario, the one with the greatest consequences for people and the environment.
- When drawing up the worst case scenario, all preventive measures are set as "failed".
- If a complex may have various types of effects (physical, toxic, environmental), worst case scenario is drawn up for every type of effects.
- There is no limit set on number of scenarios to draw up, but later in process operator analyses and determines for which ones he must model the effects.

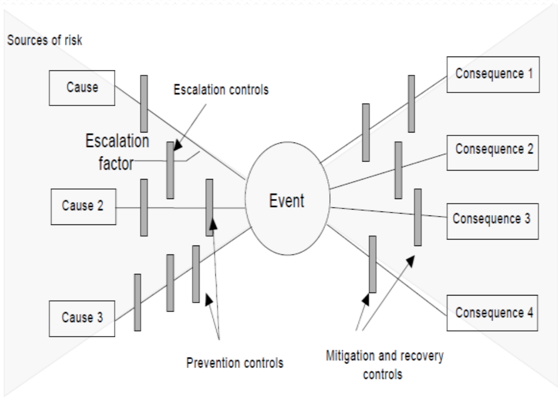
Scenarios

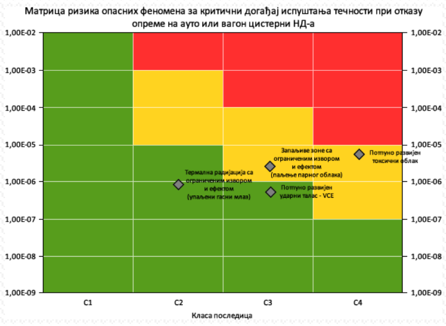
- For presenting scenarios operators can use, but not limited to:





1. Fault tree
2. Event tree
3. Combination of two previous (Bow – tie)





- Bow – tie type of presentation of scenarios is most often used.

Consequence Analysis

- The consequence analysis includes modelling the effects of accident, vulnerability analysis and determining the possible level of accident, followed by risk assessment.
- This process is guided by Rulebook.
- According to the defined scenarios, the effects of accidents are modelled and vulnerability zones are determined.
- In the vulnerability analysis, it is necessary to identify and report all endangered objects in the vicinity of complex and within the vulnerable zones.
- The possible level of the accident is determined according to the width of the vulnerable zones and the vulnerability analysis, and is expressed as I, II, III, IV or V level of accident.
- Risk assessment includes the assessment of the likelihood of the occurrence of the accident, the assessment of possible consequences and the determination of the acceptability of the risk.

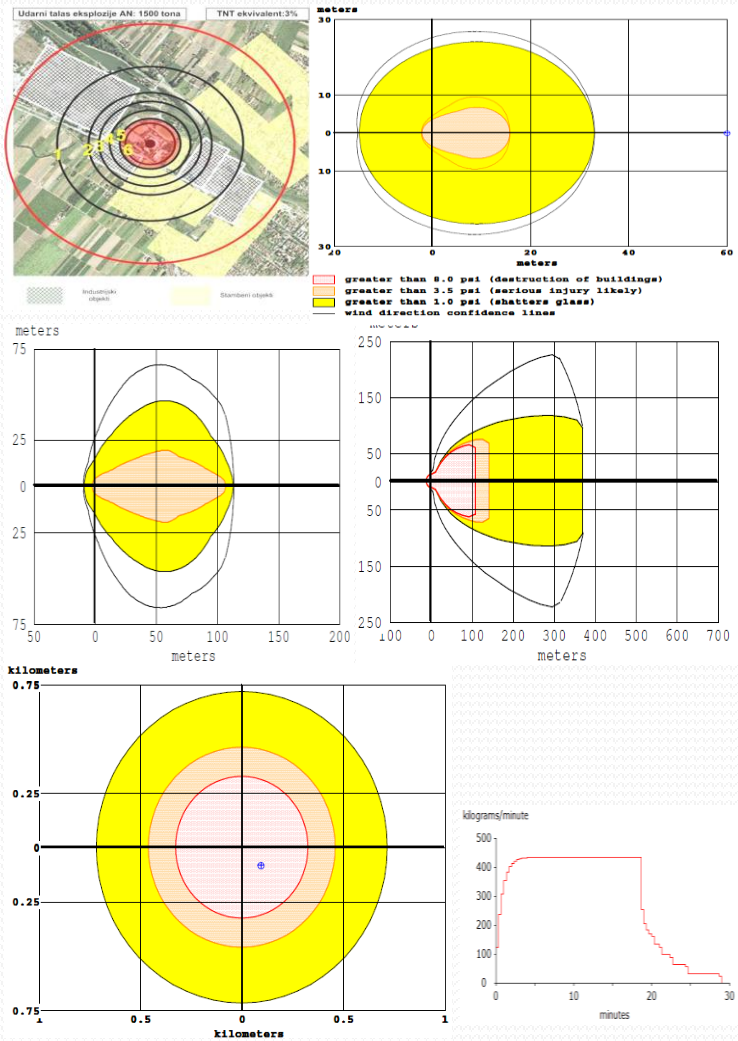
Modelling the effects of accident

- The following data and parameters are required for model design:

1. Quantities of dangerous substances and their properties (from safety data sheets);
2. Possible effects that each substance can have in case of accident (explosion and fire; expansion and discharge of gases, vapours, liquids and aerosols; distribution and penetration of liquids in soil, surface and underground water);
3. Information abut the area in which accident will occur (indoor or open space, characteristics of the terrain, inhabited or not);
4. Meteorological conditions:
   - Wind speed and atmospheric stability (WCS – wind 1.5 m/s and atmospheric stability of "F" class, all other – wind 2-3 m/s and atmospheric stability of “D" class, but for locations where there are statistical data that the prevailing condition of the atmosphere is silence and/or inversion, they should be taken for modelling the effects);
   - Outside temperature and humidity (If the WCS does not require the highest daily temperature, the temperature that determines maximum effects of the given scenario should be used. For other cases, data for medium annual temperatures should be used.)

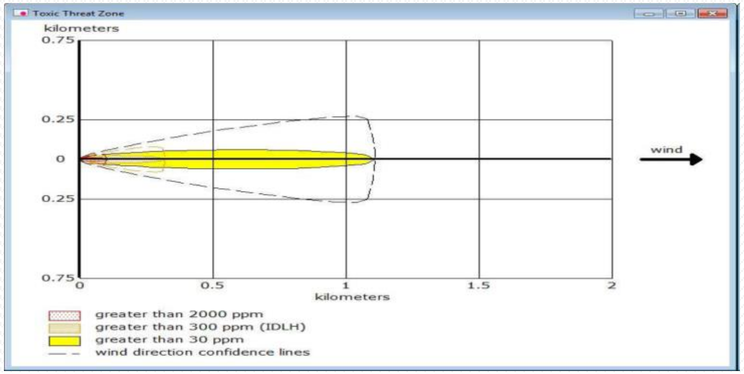
Explosion and fire

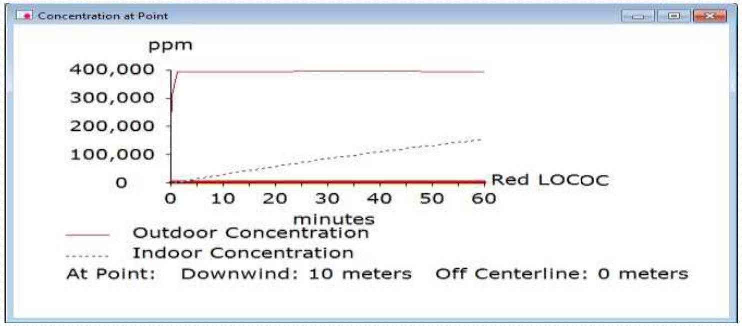
- Detonation (overpressure zones for 50% deaths, 50% lung damage, 50% and 1% eardrum rupture, total, severe, moderate and light destruction of objects);
- VCE - Vapour Cloud Explosion (domino/escalation zone, overpressure zones for total and partial destruction of objects, thermal zones for 50% death, 1% death, I degree burns, safety zones);
- Flash fire (vapour propagation zones, domino/escalation zone, thermal zones for 50% death, 1% death, I degree burns and safety zones);
- BLEVE - Boiling Liquid Expanding Vapour Explosion (characteristics of fire ball, thermal zones for 50% death, 1% death, I degree burns, safety zones);
- Pool Fire and Jet fire - (characteristics of flame, domino/escalation zone, thermal zones for 50% death, 1% death, I degree burns, safety zones).

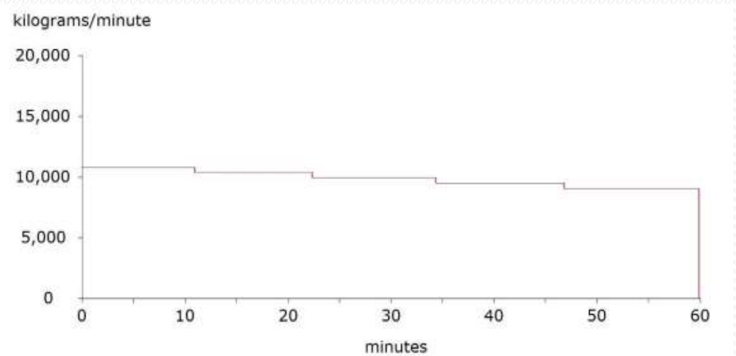


Release and expansion of gases, vapours, liquids, aerosols

- Releases of liquids, gases and vapours are modelled as: ideal models (not two faze and no friction); real models (with friction); two faze models (include the quality and the specific volume of the mixture of vapour and liquid); instantaneous release models.
- Evaporations of easily volatile liquids are modelled as models of evaporation from land or water surface.
- Dispersions of gases, vapours, aerosols and solid particles are modelled as: current point or linear sources, continual point or linear sources, continual surface sources and combined sources (LD50, LC 50, IDLH, 0,1IDLH or LEL/UEL or MDK or GVE or SPEGL or AEGL…).

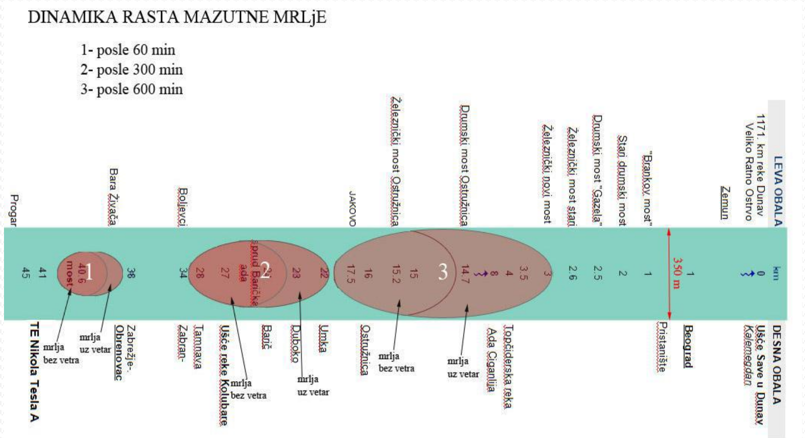


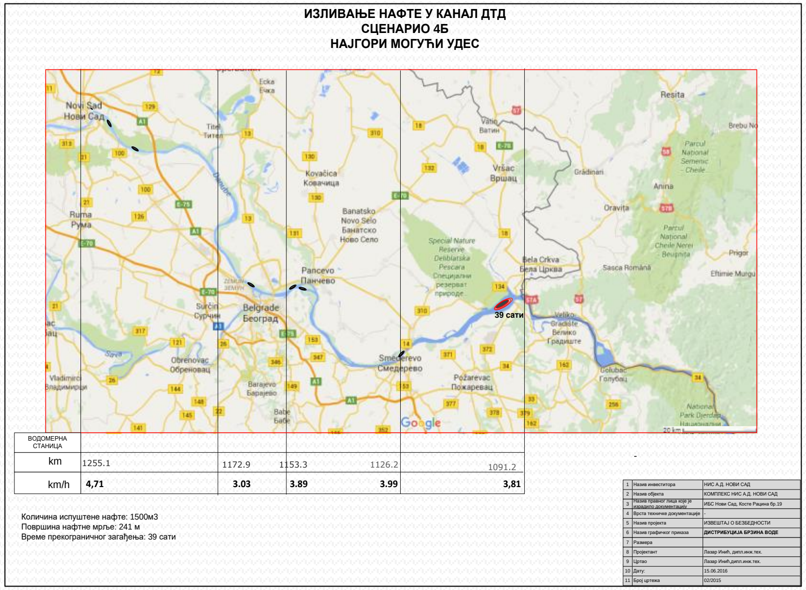




Dispersion and penetration of liquids into the soil, surface water and underground water

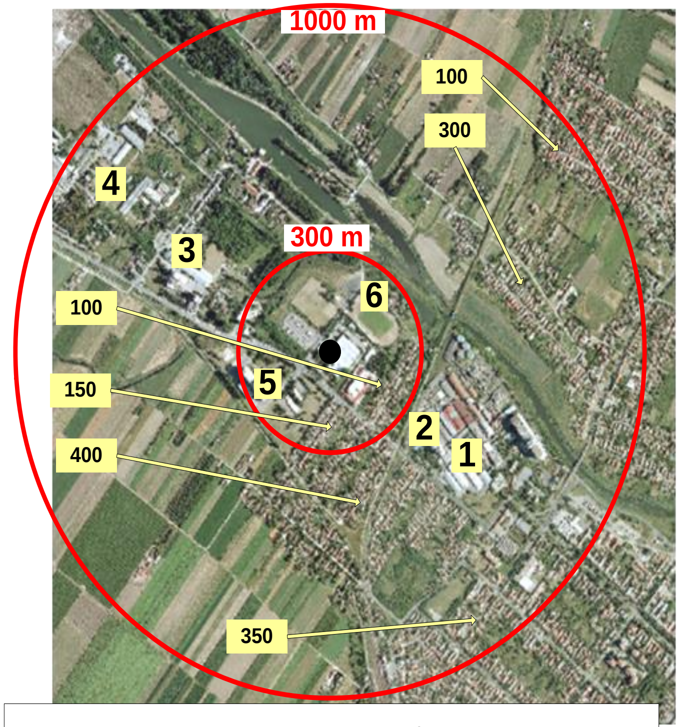
- For dispersion and penetration into surface and underground waters models define speed, diffusion, biodegradation, etc., and additionally for underground water sorption must be defined.
- For dispersion and penetration into soil, models must define hydrogeological - hydrodynamic parameters in static and dynamic conditions for penetration of hazardous substances from the soil surface to the level of groundwater, as well as distribution of hazardous substances in aquifers.
- Also, for surface and underground waters numerically two-dimensional and three-dimensional models for a homogeneous and/or heterogeneous environment are used.





Vulnerability analysis

- In the vulnerability analysis, it is necessary to identify all harmful objects in the complex vicinity within the vulnerable zones.
- The operator must determine the places and the number of workers and other personal who are in vulnerable zones.
- The operator must determine the number of people outside the complex that can be exposed to the effects of accident.
- It is also necessary to identify objects that have increased presence of people in certain parts of the day such as: business buildings, shopping malls, recreational areas and other facilities.
- Identification of vulnerable objects includes also the display of buildings, natural and cultural assets that suffer consequences due to fire, demolition and contamination, on and off the complex (housing, infrastructure and other facilities, neighbouring industry, objects of agriculture, flora and fauna, protected cultural goods, protected natural assets, surface and groundwater, objects that are important for the domino effect etc.).



1. Industrija ulja Vital: 350 radnika, 2. Fabrika stočne hrane Carnex: 50 radnika, 3. Trivit Vrbas: 120 radnika, 4. Karnex industrija mesa 1000 radnika, 5. Silosi Karnex: 10 radnika, 6. Fudbalski stadion 10000 mesta (u računu 200 gledalaca)

Determining the level of accident

- The possible level of the accident is determined based on the width of the vulnerable zone and the vulnerability analysis, and is expressed as:
  1. Level I accident – consequences of the accident are limited to part of the installation or the whole installation, at the same time has no consequences for the whole complex;
  2. Level II accident – consequences of the accident are limited to part of the complex or whole complex, at the same time has no consequences outside of complex;
  3. Level III accident – municipality level, where the consequences of the accident are extended beyond the boundaries of the complex, at municipality;
  4. Level IV accident – regional level, where the consequences of the accident have been extended to the territory of several municipalities or cities or region;
  5. Level V accident – international level, where the consequences of the accident are extended beyond the borders of the Republic Serbia.

Risk assessment

- Risk assessment is conducted via Accident probability assessment, Potential consequences assessment and Chemical accident risk determination.
- Accident probability assessment is performed in one of the following ways:
  1. based on statistic data – historical approach (source of data must be stated);
  2. based on hazard identification – analytical approach;
  3. by combining historical and analytical approach.
- The probability is numerically or descriptively expressed as low, medium and high.
- The following table may be used if no other data is available:

Criteria for accident probability assessment

High probability (10^0 - 10^{-1} frequency of the occurrence/yr)	Medium probability (10^{-1} - 10^{-2} frequency of the occurrence/yr)	Low probability ($<10^{-2}$ frequency of the occurrence/yr)
• leakage of hazardous substances at pipe joints, valves, etc. • spillage in liquids decanting and dispersal of solid substances in manipulation • damages made to unit packaging and spillage of contents • leakage of liquids and dispersal of solid substances in internal transport • leakage of gases under pressure from pipelines and other pressurised systems • created conditions for fire of explosion in Hazard ZONE 2 • initial fire in plants	• liquid substances pipeline breakage • pressurised gas pipeline breakage • spillage of the whole contents from the tank storing liquids • spillage from vehicle and train tanks in the establishment after breakdowns • created conditions for fire of explosion in Hazard ZONE 1 • fire and explosion in a part of the establishment • two and more accidents of high probability in one location at the same time	• crack of transport vessels • crack of storage vessels • fire in the whole establishment • fire in the whole establishment • explosion of the whole establishment • explosion of the whole storage • created conditions for fire of explosion in Hazard ZONE 0 • two and more accidents of medium probability in one location at the same time

Risk assessment

- Potential consequences assessment of chemical accident are expressed as: consequences of no significance, significant, serious, sever and catastrophic consequences, on the basis of number of casualties with lethal outcome and with injuries, intoxicated persons, number of dead animals, area of contaminated soil and waterways and the amount of material damage.
- Possible consequences to human life and health and environment are estimated on the basis of data obtained in vulnerability analysis.
- Criteria for potential consequences assessment are provided for in the following table:

Consequence indicators	Consequences				
	Low significance	Significant	Serious	Severe	Catastrophic
Number of casualties with lethal outcome	no	no	1-2	3-5	more than 5
Seriously injured Seriously intoxicated	no	1-2	3-6	7-10	more than 10
Slightly injured Slightly intoxicated	no	1-5	6-15	16-30	more than 30
Dead animals	≤0,5 t	0,5-5 t	5-10 t	10-30 t	more than 30 t
Contaminated soil	≤0,1 ha	0,1-1 ha	1-10 ha	10-30 ha	more than 30 ha
Materialistic damages in thousands RSD	≤100	100 – 1,000	1,000 – 10,000	10,000 – 100,000	higher than 100,000

Risk assessment

- Chemical accident risk is assessed on the basis of accident probability and potential consequences.
- Chemical accident risk is expressed as: negligible, low, medium, high and very high,
- The risk is acceptable if it has been assessed as: negligible, low, medium and high risk. The risk is not acceptable if it has been assessed as very high risk.
- If the risk is not acceptable, complex working with such a level of risk is not acceptable, and the complex operator must introduce additional technical and other protective measures, as well as through organisation of safety and operation systems, in order to reduce such risk to the acceptable level.
- Risk criteria based on the accident probability and possible consequences is shown in the following table:

Accident probability	Consequences				
	low significance	significant	serious	severe	catastrophic
low	negligible risk	low risk	medium risk	high risk	very high risk*
medium	low risk	medium risk	high risk	very high risk*	very high risk*
high	medium risk	high risk	very high risk*	very high risk*	very high risk*

THANK YOU FOR YOUR ATTENTION!

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