IDENTIFICATION AND ACCIDENTAL RISKS ANALYSIS

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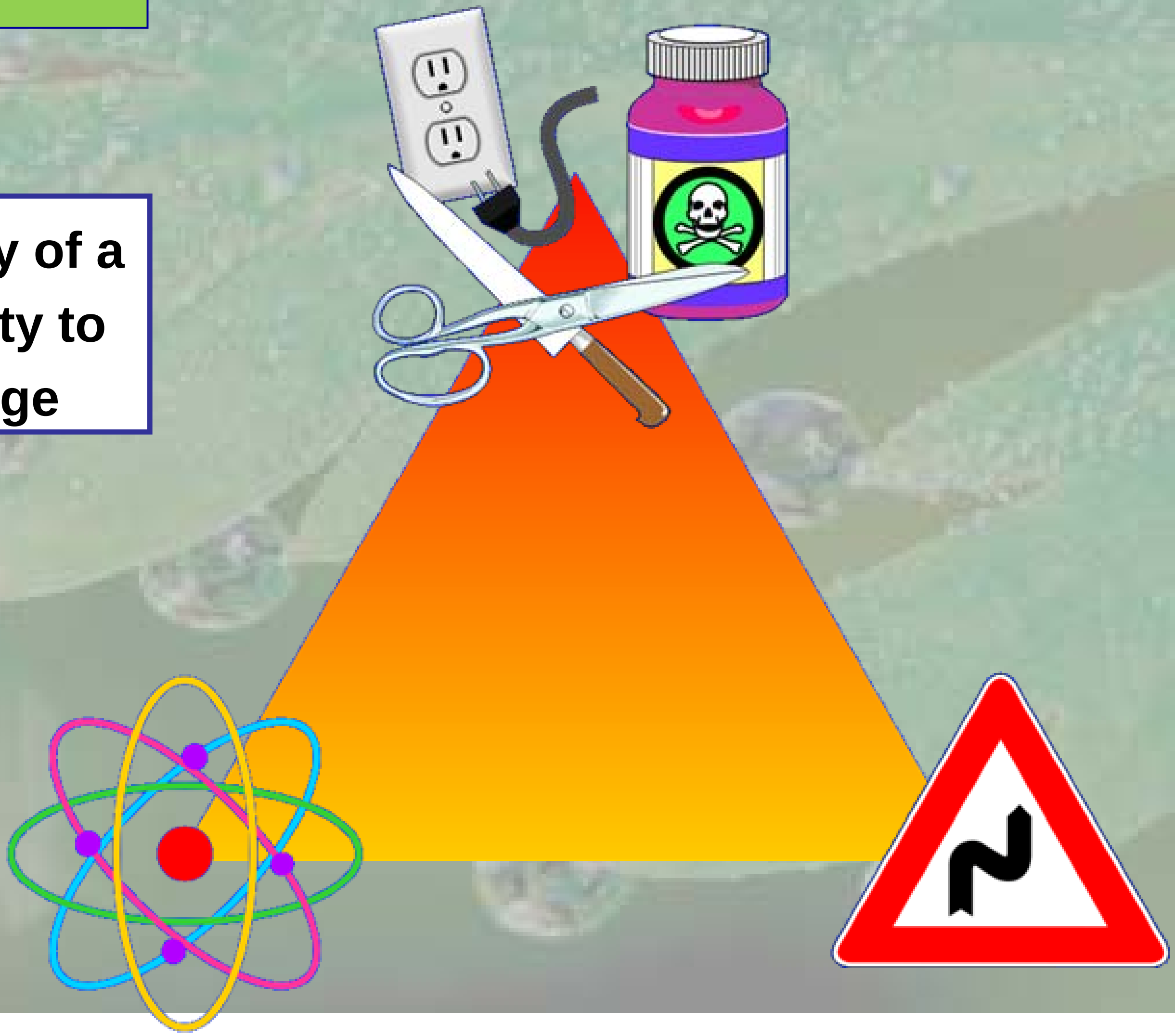
Convention on the Transboundary Effects of Industrial Accidents
Assistance Programme for Eastern Europe, Caucasus and Central Asia (EECCA) and South-Eastern Europe (SEE)

HAZARD

Intrinsic property of a determined entity to cause a damage

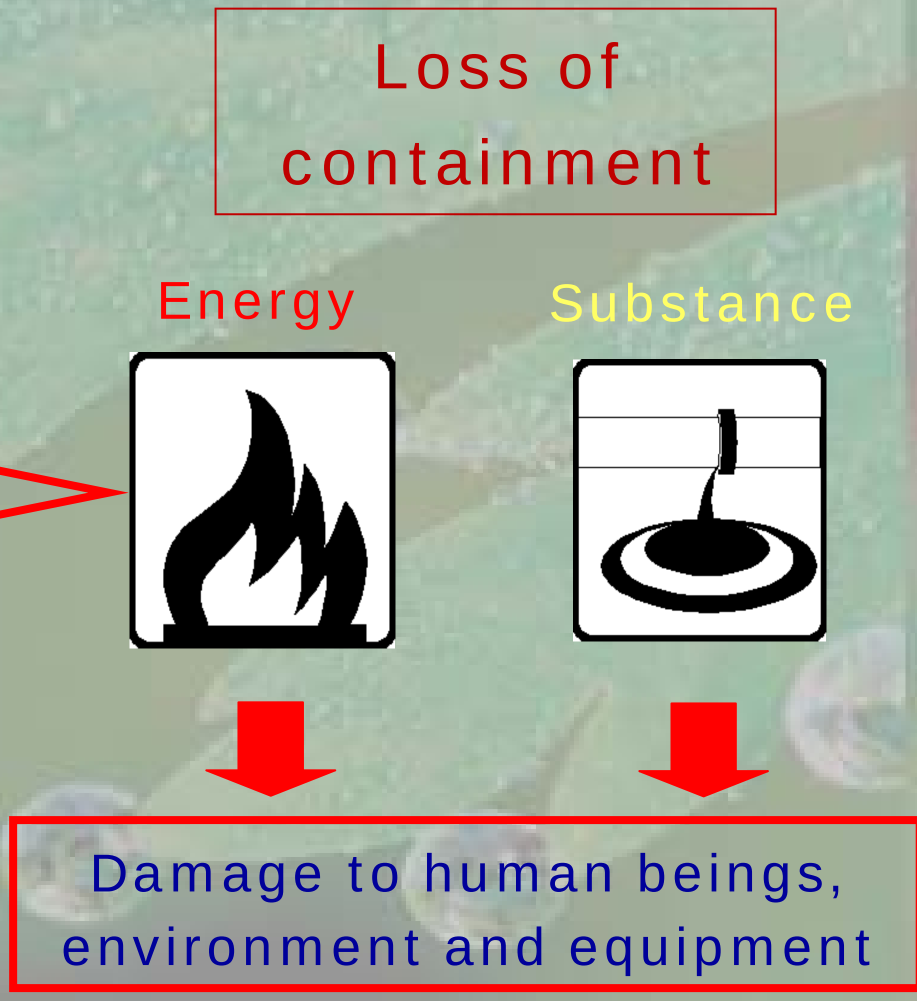


RISK

Combination of the FREQUENCY with which an hazardous event may occur and the MAGNITUDE of relevant consequences.

Why a chemical plant is risky ?

- It handles hazardous substances (toxic, flammable, etc.)
- Substances might be stored and processed at high pressure and/or high temperature
- Substances are subjected to reactions, change of phases, heating and cooling



Refineries – Petrochemical Plants

Toxic substances

Flammable substances

Dangerous for the environment

Identification and analysis of major accidents

Main elements of risk analysis are following:

1. hazard identification
2. accident scenario selection
3. scenarios' likelihood assessment
4. scenarios' consequence assessment
5. risk ranking
6. reliability and availability of safety systems

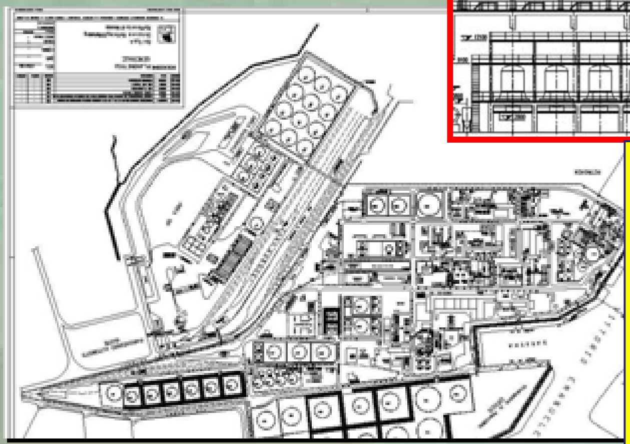
"Guidance on preparation of safety report to meet the requirements of Directive 96/82/CE as emended by Directive 2003/105/CE" (JRC – 2005)

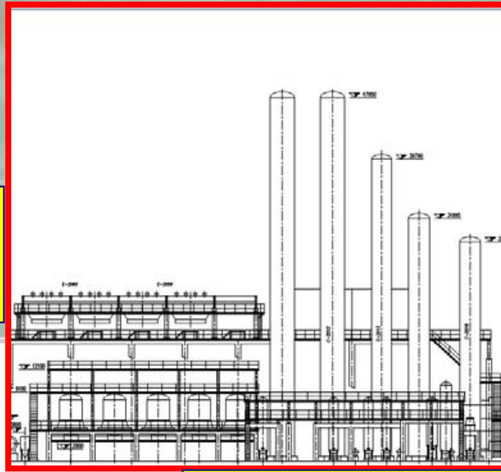
Hazard Identification

Historical analysis

- Real case scenarios;
- Analysis of causes and consequences;
- Lessons learnt.

Detailed techniques





- HAZOP
- FMEA
- What if?
- Index method

- Analysis of the lay out, flow schemes, processes;
- Identification and classification of the hazard.

Hazard Identification

Historical analysis

MARS

(MAJOR ACCIDENTS RECORDING SYSTEM)

Content :

It contains occurred industrial accidents in plants of the EU countries according to Seveso II provisions.

Sources :

Notifications from competent authorities of the single countries that must be provided at the senses of the article 11 of the Directive.

Ref.: http://mahbsrv.jrc.it/mars

Historical analysis

MHIDAS

(MAJOR HAZARDS INCIDENT DATA SYSTEM)

Content :

More than 8,000 industrial occurred accidents in around 90 countries with particular reference to USA, United Kingdom, Canada, Germany, France, India, Italy).

Sources :

Technical and scientific magazines, newspaper and industries of several countries.

Ref.: http://www.hse.gov.uk/infoserv/mhidas.htm

Hazard Identification

Historical analysis

Advantages

- **Based on real accidents.**
- **Possibility to analyse similar accidents in terms of dangerous substances or chemical process.**
- **Possibility to apply the lessons learnt technique.**

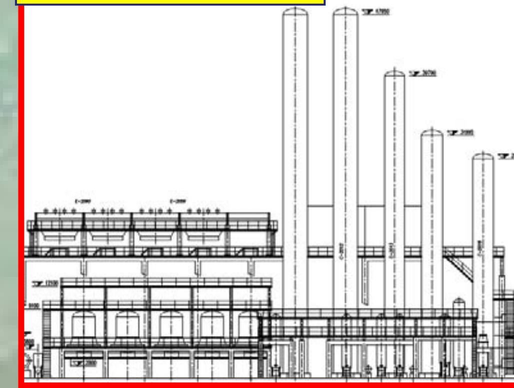
Weak points

- **Limited reliability and homogeneity of the sources;**
- **Limited information regarding root causes and first phases of the development of the scenarios;**
- **Difficulties in the elaboration of the information at statistical level.**

Useful tool, to be integrated with a more systematic technique

Hazard Identification

HAZOP



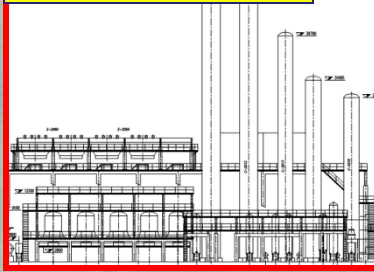
HAZOP (HAZard and Operability analysis):

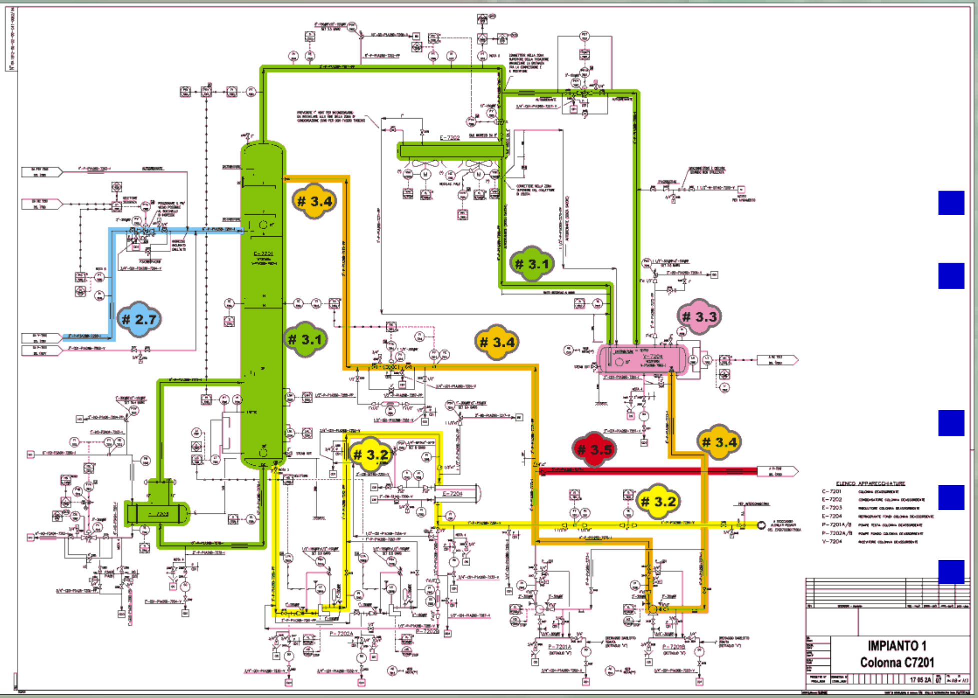
- **Structured hazard identification tool using a multi-disciplined team.**

- **'The application of a formal systematic examination to the process and engineering intentions of new or existing facilities, to assess the potential of malfunction of individual items of equipment and their consequential effects on the facility as a whole.**

Hazard Identification

HAZOP



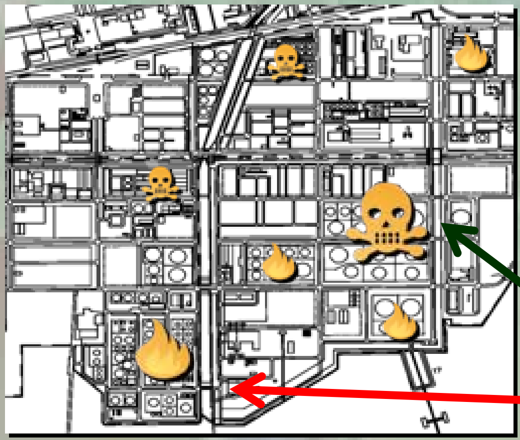


- Subdivision of the plant in Nodes.
- Hypothesis for every single possible deviation;
- Identification of causes;
- Identification of consequences;
- Definition of critical scenarios (Top Events);
- Identification of possible actions for risk reduction.

Powerful tool, but time consuming due to details of the analysis

Accident scenario selection

Specific criteria to qualify the major accidents among all the possible events



Substance criteria

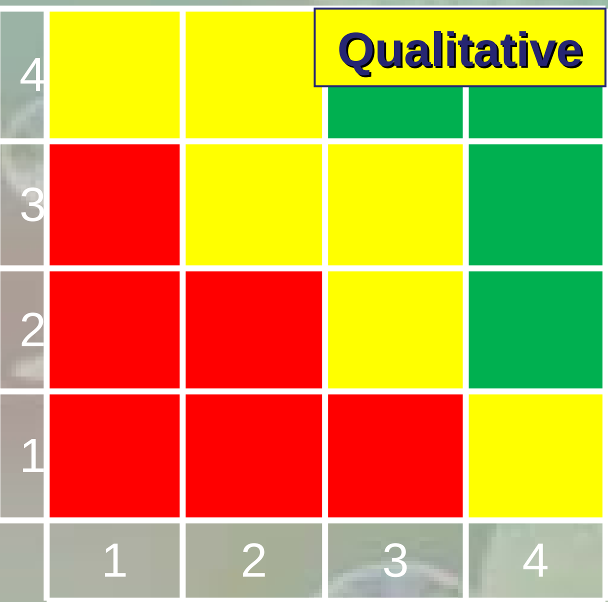
- **Selection of high amount of dangerous substances**
- **Selection for different typology of substances**

Frequqncy criteria

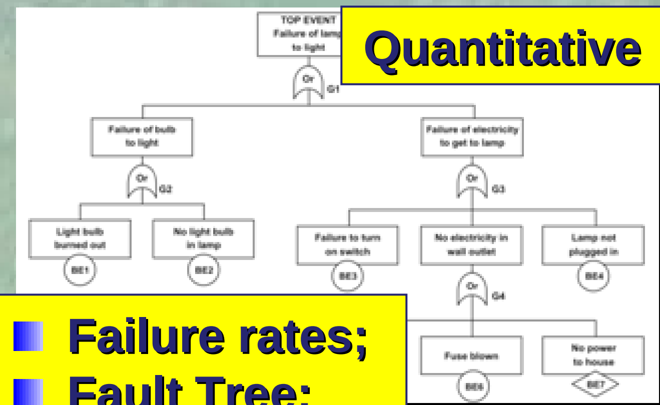
Event classification	(events/year)
PROBABLE	$> 10^{-1}$
FAIRLY PROBABLE	$10^{-2} \div 10^{-1}$
SOMEWHAT UNLIKELY	$10^{-3} \div 10^{-2}$
QUITE UNLIKELY	$10^{-4} \div 10^{-3}$
UNLIKELY	$10^{-5} \div 10^{-4}$
VERY UNLIKELY	$10^{-6} \div 10^{-5}$
EXTREMELY UNLIKELY	$< 10^{-6}$

Elimination of extremely unlikely events

Scenarios' likelihood assessment



Qualitative



Quantitative

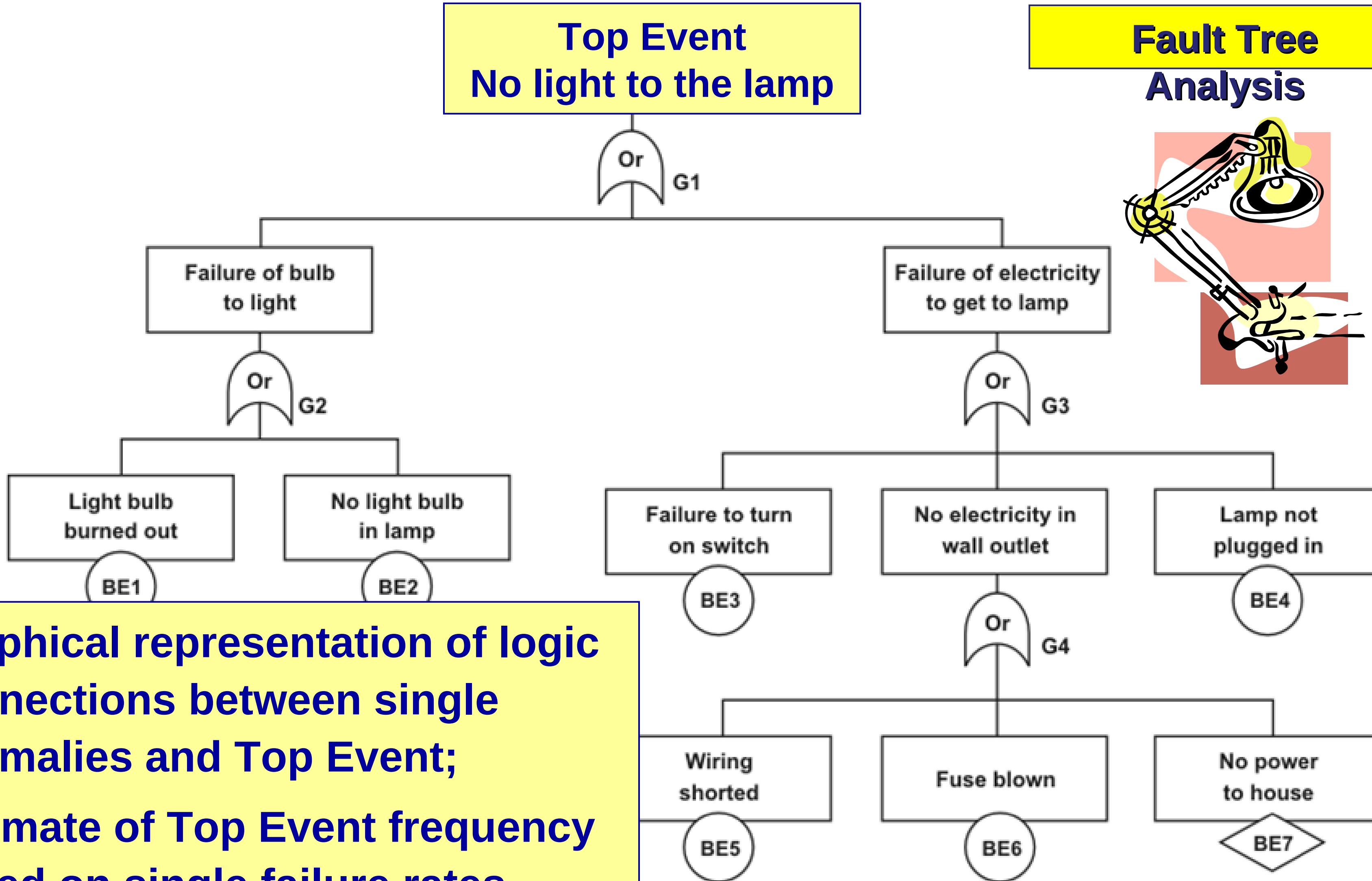
- **Failure rates;**
- **Fault Tree;**
- **Event Tree.**

- **Use of generic data (e.g. from historical analysis)**
- **Estimate of category of likelihood (frequent, occasional, rare).**

- **Use of structured techniques based on numerical evaluation;**
- **Identification of number of frequency associated to the Top Event.**

Scenarios’ likelihood assessment

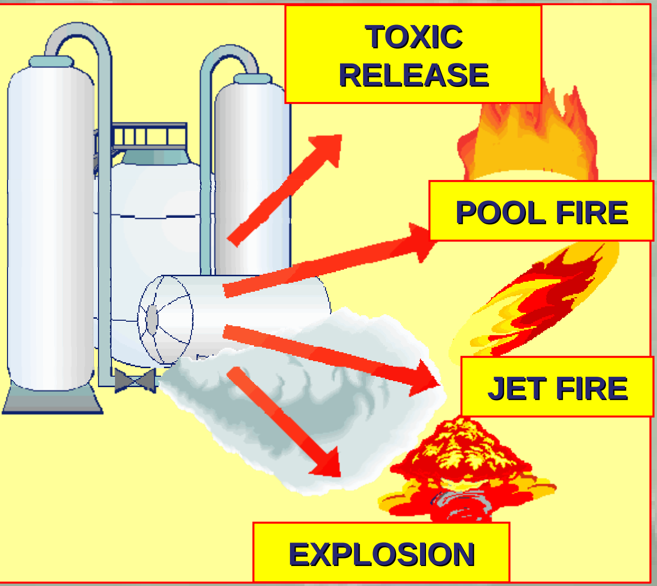
Fault Tree Analysis

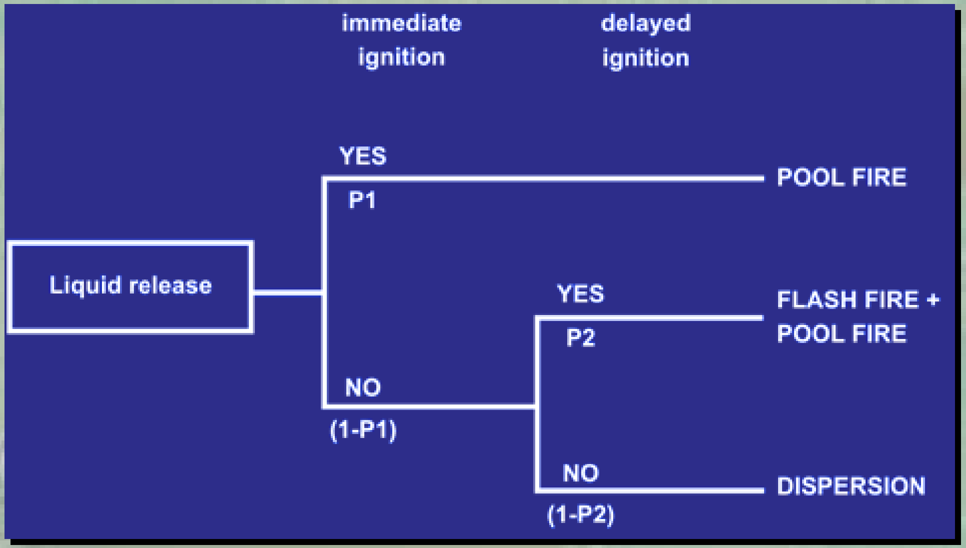


- Graphical representation of logic connections between single anomalies and Top Event;
- Estimate of Top Event frequency based on single failure rates.

Scenarios' likelihood assessment

Event Tree Analysis



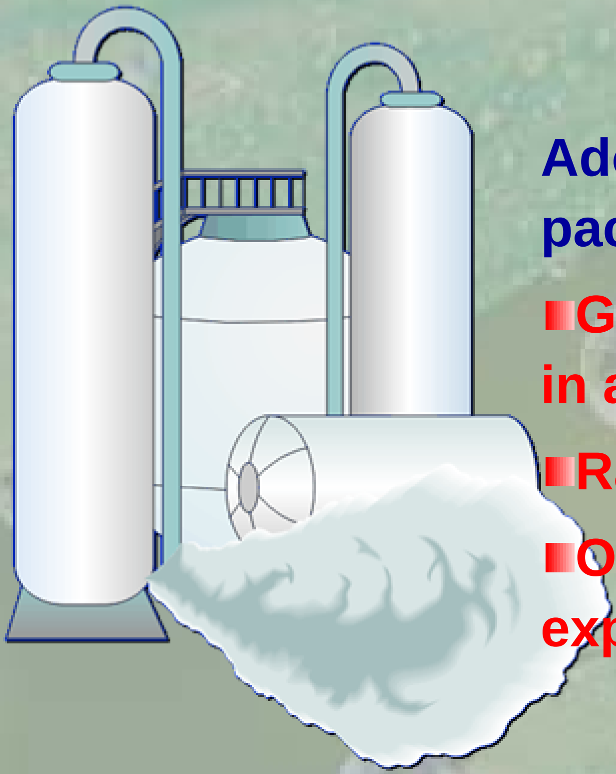


- **Graphical representation of possible development of the event after the initial release;**
- **Estimate of likelihood of each scenario based on probabilistic analysis.**

Scenarios' consequences assessment

Source terms

- Dimension of the loss of containment
- Operating conditions of dangerous substances.



Consequences modelling

Adoption of software packages for evaluation of:

- Gas/vapours dispersion in atmosphere;
- Radiation of fires;
- Overpressure due to explosions.

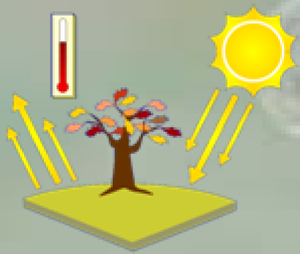
Consequence modelling is generally a quantitative approach

Scenarios’ consequences assessment

Consequences modelling – weaher conditions

Parameters that increase turbulence and reduce the concentration of the cloud

- High wind speed (in windy regions damage distances are generally lower).



- Low atmospheric stability (during sunny day damage distances are generally lower).

- High surface roughness (in regions with high mean obstacles, damage distances are generally lower).

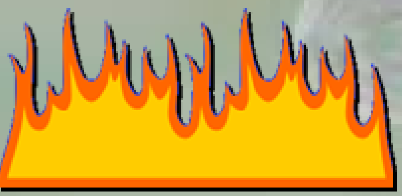
Scenarios' consequences assessment

Consequences modelling – effects on population

Dangerous effects for the exposed people

- **High concentration of toxic substances**

  Various effects to organs (respiratory, circulatory, digestion)



- **Radiation due to fire**

  Burns due to heat.

- **Overpressure due to explosion.**

  Burns due to heat, collapse of building

Scenarios' consequences assessment

Consequences modelling – effects on population

Definition of dangerous effects (Italian legislation)

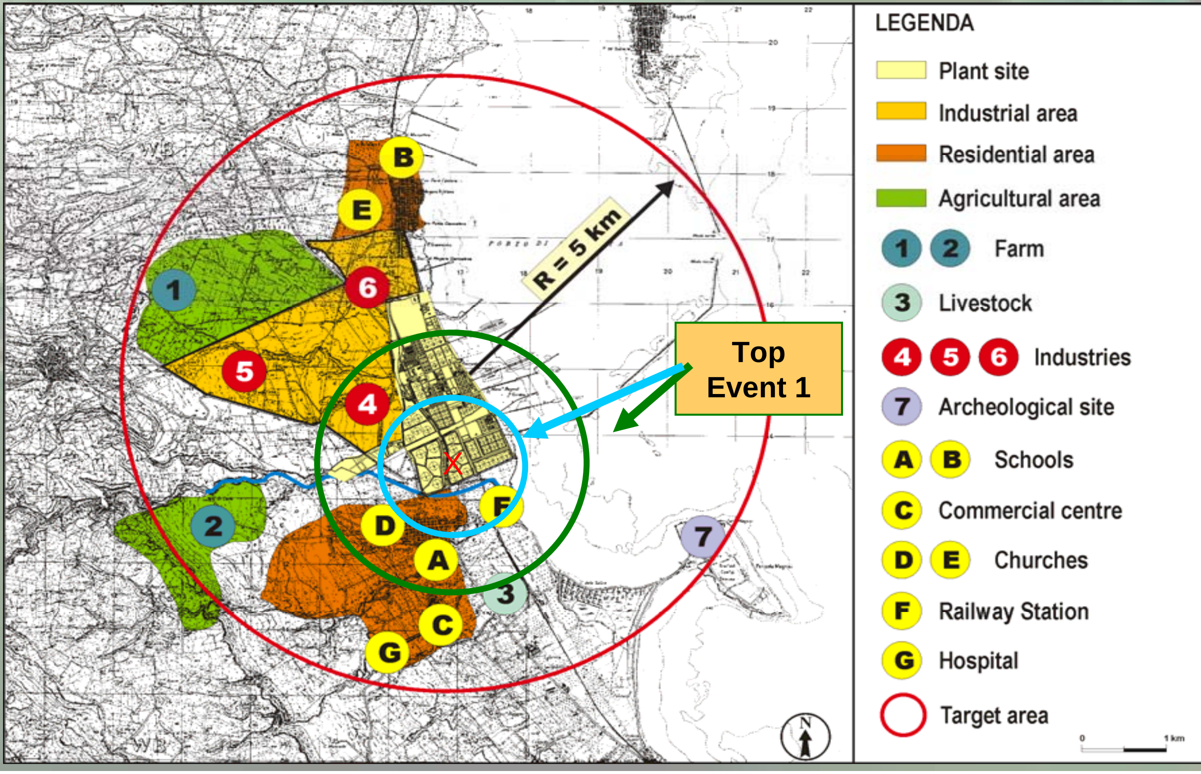
SCENARIO	HIGH LETHALITY	POSSIBLE LETHALITY	IRREVERSIBLE EFFECTS	REVERSIBLE EFFECTS	DAMAGE TO STRUCTURE
FIRE (RADIATION)	12,5 kW/m^2	7 kW/m^2	5 kW/m^2	3 kW/m^2	12,5 kW/m^2
UVCE (OVERPRESSURE)	0,3 bar	0,14 bar	0,07 bar	0,03 bar	0,3 bar
TOXIC DISPERSION	LC50 (30 min)	---	IDLH	---	---

Scenarios' consequences assessment

Consequences modelling – effects on population

Maps of consequences

- **Maps with identification of damage distances in the territory**
- **Identification of potential vulnerable targets in the effects zones.**



Scenarios' consequences assessment

Consequences modelling – effects on population

Simplified approach

UNEP/ WHO/ IAEA/ UNIDO - Method for classification and prioritisation of risk due to major accidents in process and related industries. IAEA, November 1996

- **Selection of type of substance (toxic, flammable, etc.)**
- **Selection of class of equipment (storage, process, etc.)**
- **Selection of maximum releasable amount (entire volume)**

→ **Definition of basic damage distances**

Useful tool for first selection of representative major accidents

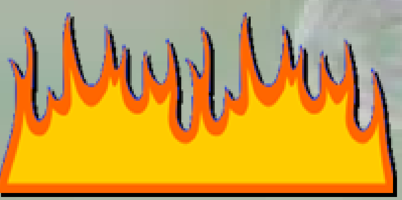
Scenarios' consequences assessment

Consequences modelling – effects on environment

Environmental fate of dangerous substances

- **Toxicity**

  Toxic effects to animal life (especially aquatic organisms)



- **Persistence**

  Reactivity with water, air, soil, air.

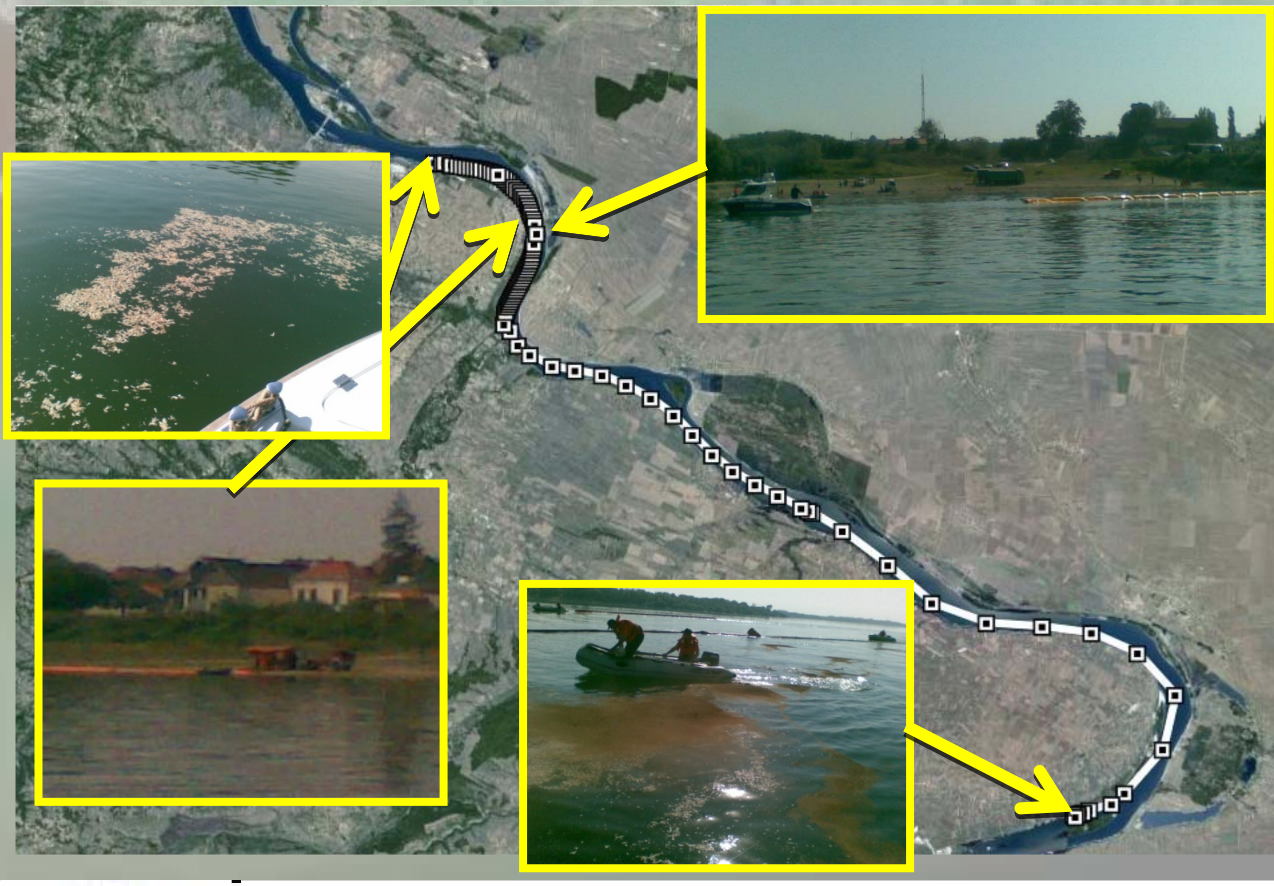
- **Bio-accumulation.**

  Capacity to be assumed by the animal organisms

Scenarios' consequences assessment

Consequences modelling – effects on environment

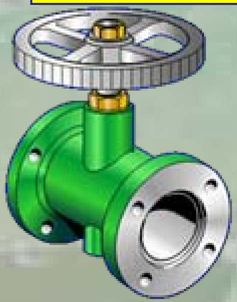
Environmental fate of dangerous substances



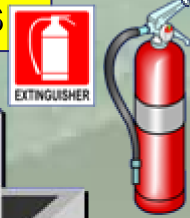
- Water bodies are the most sensible targets (rivers, seas, groundwater);
- Fundamental parameters are density, solubility, reactivity with water.

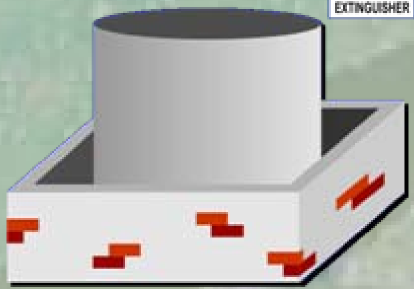
Safety measures

Preventive measures



Mitigating measures





- Redundancy in control and alarm systems;
- Automatic action to shut down the unit;
- Preventive maintenance and inspections.

- Containment systems to reduce the spill.
- Fire alarms;
- Fire brigade for rapid intervention in case of emergency

Risk presentation

FREQUENCY					
Probable	4				
Improbable	3				
Highly improbable	2				
Extremely improbabile	1				
		1	2	3	4
		Slight	**Local**	**Major**	**Extensive**
		CONSEQUENCES			

Acteptable

ALARP

Not Acceptable

Combination of frequency and consequences (qualitative of quantitative in order to establish is the combined level of risk is acceptable for the people and for the environment

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