Cefic Guidance on Safety Risk Assessment for Chemical Transport Operations JC Hermand

Transport Risk Assessment

Background

- **As part of its commitment to Responsible Care, the chemical industry strives to continuously improve its safety performance through learning from shared experience and implementing best practices.**

- **Increasing urbanization and higher risk aversion of society result in more and more restrictions on the transport of dangerous goods (e.g. 'Basisnet' in the Netherlands).**

- **Risk assessment is an important tool in risk management**

In 2012 the Cefic SIG Logistics decided to create a new Issue Team to review current transport risk assessment practices and to develop Cefic guidance on transport risks assessment

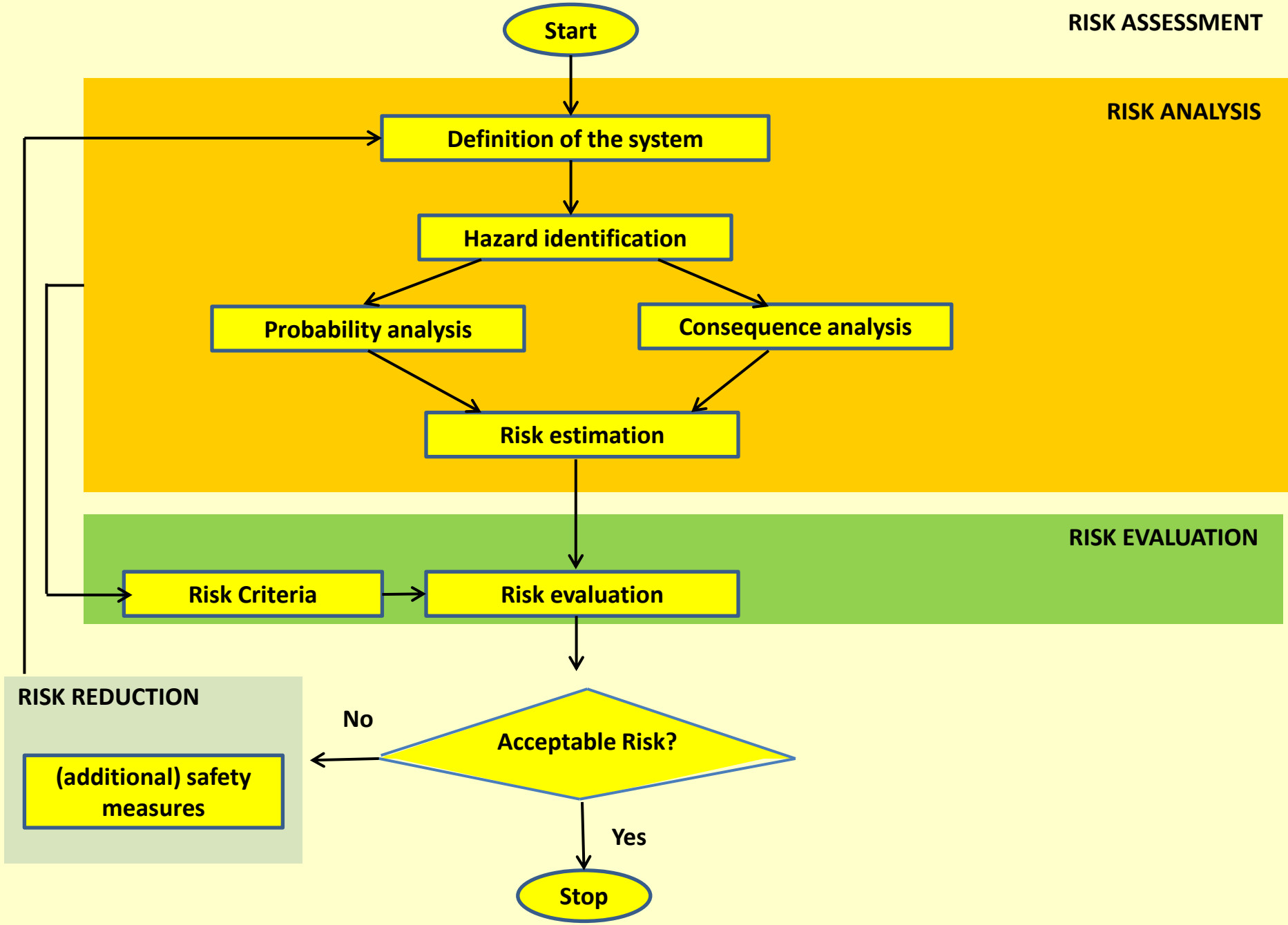
Transport Risk Assessment

- Qualitative
- Quantitative

Qualitative transport risk assessment

- First step in overall risk assessment process
- Results in relative ranking
- Identification of higher risk operations/scenarios
- No use of precise numeric values (probability)
- No detailed calculations of risks

Same assumptions to be used thoughout whole process in order to maintain consistency in the approach


RISK ASSESSMENT
Start
RISK ANALYSIS
Definition of the system
Hazard identification
Probability analysis
Consequence analysis
Risk estimation
RISK EVALUATION
Risk Criteria
Risk evaluation
RISK REDUCTION
(additional) safety measures
No
Acceptable Risk?
Yes
Stop

Qualitative transport risk analysis

Different steps

- Definition of transport operation to be analysed
- Identification of all relevant hazards
- Consequence analysis
- Probability analysis
- Risk estimation (matrix)

Qualitative transport risk assessment

Consequence analysis = investigation of potential consequences of a transport accident taking into account the intrinsic hazards of the product (hazard severity analysis) and the potential exposure to these hazards (hazard exposure analysis)

Hazard severity ranking

Hazard severity (potential impact)	*Criteria*	*Score (A)*
Low potential impact	**PG III in bulk**	**1**
Intermediate potential impact	**PG II in bulk**	**2**
High potential impact	**PG I in bulk**	**3**
Very high potential impact	**-Toxic by inhalation in any quantity** **- Flammable gases in bulk** **- Toxic gases in bulk** **- Highly flammable liquids in bulk** **- Highly toxic liquids in bulk**	**4**

Hazard exposure ranking

Population density along the transport route	*Proximity of environmentally sensitive areas **	*Score (B)*
Low	**Very distant**	**1**
Intermediate	**Distant**	**2**
High	**Close**	**3**
Very high	**Very close**	**4**

Total consequence ranking

Hazard Severity Ranking Score (A)	*Hazard Exposure Ranking Score (B)*			
	4	*3*	*2*	*1*
4	16 (IV)	12 (IV)	8 (III)	4 (III)
3	12 (IV)	9 (III)	6 (III)	3 (II)
2	8 (III)	6 (III)	4 (III)	2 (II)
1	4 (III)	3 (II)	2 (II)	1(I)

Total Consequence Ranking	*Total score*
Very high consequence (IV)	16/12
High consequence (III)	9/8/6/4
Moderate consequence (II)	3/2
Low consequence (I)	1

Probability analysis

Probability of occurrence of a transport hazard determined by

- **accident frequencies for the transport mode being assessed**
- **transport volumes and distances**

Data on transport accident frequencies are not readily available, in particular data on frequencies of accidents with loss of containment

Transport accident frequencies are normally expressed as number of accidents per distance driven by the transport vehicle (truck, train, barge).

Probability analysis

Overview of accident frequencies based on accident data of 1994-1996 *

(see Guidelines for quantitative risk assessment. “Purple Book”. Report CPR 18E.)

* ***More country/product/mode specific accident frequencies can be found in literature.***

ROAD **Average**	**1.8×10^{-7}/truck.km**
RAIL **Average** **Speed >40 km/h** **Speed <40 km/h**	 **3.6×10^{-8}/car.km** **4.5×10^{-8}/car.km** **2.2×10^{-8}/car.km**
BARGE **Navigability Class (CEMT) 4** **Navigability Class (CEMT) 5** **Navigability Class (CEMT) 6**	 **6.7×10^{-7}/vessel.km** **7.5×10^{-7}/vessel.km** **1.4×10^{-6}/vessel.km**

Example of a risk matrix

Total consequence Ranking Hazard x Exposure	Probability			
	Very unlikely	Not likely	Likely	Frequent
Very high consequences (IV)				
High consequences (III)				
Moderate consequences (II)				
Low consequences (I)				

Risk Category

4	Very high risk
3	High risk
2	Moderate risk
1	Low risk

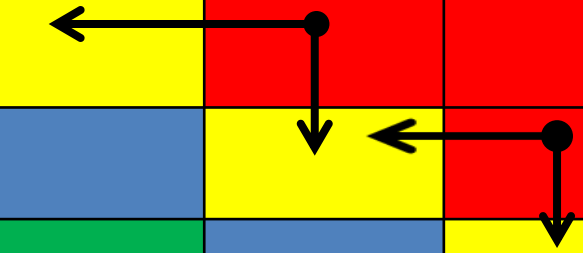
Quantitative transport risk assessment

Based on many assumptions: uncertainty of available accident frequency data

- **To be used primarily for transport operations with very high consequence ranking**
- **Only to be used for relative ranking of different transport options**
- **Calculation of absolute risk levels often not meaningful**

Risk mitigation

Total consequence Ranking *Hazard x Exposure*	Probability Very unlikely	Not likely	Likely	Frequent
Very high consequences (IV)				
High consequences (III)				
Moderate consequences (II)				
Low consequences (I)				



- Reduction of probability of accidents
- Reduction of probability of leakage in case of an accident
- Reduction of potential consequences

Risk mitigation measures

Reduce the probability of an accident by

- reducing the total volume of transported product
- reducing the distance
- selection of the mode of transport
- selection of the route of transport
- selection of the carrier (using SQAS etc)
- training of all people involved in the transportation process (drivers, managers, planners,…)
- maintenance and inspection of the transport equipment
- systems increasing the stability of the vehicle
- taking into account weather conditions
- taking measures to improve security

Risk mitigation measures

Reduce the probability of leakage in case of an accident by

- **Reducing the speed of the vehicle**
- **Improving the quality of the containment (e.g. shell thickness of tanks, double shell, …)**
- **Installing crash-buffers (on rail tank cars)**

Risk mitigation measures

Reduction of potential consequences

Hazard severity

Since in most cases the hazards are intrinsic to the product to be transported, there is little opportunity to reduce these (change concentration / phase)

Reduction of the size of the containment (packed instead of bulk, compartimentization of tank)

Hazard exposure

Reduce potential exposure along the transport route by changing the

- **transport mode**
- **transport route (e.g. rail route, motorways vs secundary roads; roads avoiding densely populated urban areas)**
- **time of transport (day vs night).**

Viarregio – LPG rail accident

	VIARREGIO LPG
Hazard Classification HIN	UN 1075 Class 2/ flammable gas HIN 23
Containment	Bulk
Hazard severity ranking Fig 2	Very high potential risk A = 4
Hazard exposure ranking Fig 3	Population density : high/very high B = 3/4
Total consequence ranking Fig 4	A x B = 12-16 (IV) Very high consequence
Probability	4.5 x very unlikely
Risk category	Yellow (3) High risk

Risk matrix Viarregio

Total consequence Ranking Hazard x Exposure	Probability			
	Very unlikely	Not likely	Likely	Frequent
Very high consequences (IV)	Viarregio			
High consequences (III)				
Moderate consequences (II)				
Low consequences (I)				

Waldhof - barge sulphuric acid

	WALDHOF Sulphuric Acid
Hazard Class HIN	UN 1830 Class 8 /Corrosive liquid – PG II HIN 80
Containment	Bulk
Hazard severity ranking Fig 2	Intermediate potential risk A = 2
Hazard exposure ranking Fig 3	Proximity of water course: very close B = 4
Total consequence ranking Fig 4	A x B = 8 (III) High consequence
Probability	1.4 x 10^{-6} (not likely)
Risk category	Yellow (3) High risk

Risk matrix Waldhof

Total consequence Ranking Hazard x Exposure	Probability Very unlikely	Not likely	Likely	Frequent
Very high consequences (IV)				
High consequences (III)		Waldhof		
Moderate consequences (II)				
Low consequences (I)				

Risk Category

4	Very high risk
3	High risk
2	Moderate risk
1	Low risk

Antwerp – road bromine accident

	ANTWERP bromine
Hazard Class HIN	UN1744 Class 8/Corrosive liquid, toxic – PG I HIN 886
Containment	Bulk
Hazard severity ranking Fig 2	Very high potential risk A = 4
Hazard exposure ranking Fig 3	Population density: high B = 3
Total consequence ranking Fig 4	A x B = 12 (IV) Very high consequence
Probability	1.8 x 10^{-7} (not likely)
Risk category	Red (4) Very high risk

Risk matrix bromine

Total consequence Ranking Hazard x Exposure	Probability Very unlikely	Not likely	Likely	Frequent
Very high consequences (IV)		Antwerp Bromine		
High consequences (III)				
Moderate consequences (II)				
Low consequences (I)				

Potential risk reduction measures

Risk Reduction Measures	**Rail** **VIARREGIO** **LPG**	**Barge** **WALDHOF** **Sulphuric acid**	**Road** **ANTWERP** **Bromine**
Reduce hazard exposure level	- Change rail route to avoid populated areas - Change transport mode to avoid populated areas (to barge/road/ pipeline) ???	- Change transport mode (to road or rail)???	- Change route in port of Antwerp ? - Change transport mode ???
Reduce probability of occurrence	- Better inspection & maintenance of equipment - Lower speed of train - Remove sharp objects along the rail track - Install crash buffers - Use tank cars with higher shell thickness - DDD	- Increase stability of ship - Better management of ballast water - Improve training of ship crew - Improve ship vetting system	- Increase stability of truck by lowering chassis and gravity point - Improve selection of transport company (dedicated haulier) - Improve experience and training of drivers (awareness of high density of product)

Accident scenarios with potential high consequences

- **UVCE (Unconfined Vapor Cloud Explosion)**
- **Hot BLEVE (Boiling Liquid Expanding Vapour Explosion)**
- **Toxic vapor cloud release**
- **Pool fire**
- **Jet fire**
- **Spillage of substances harmful for the environment**