Safety Risk Assessment for Chemical Transport Operations

Semi-quantitative Approach

CEFIC Workshop

Safe and Sustainable Chemical Transport and Logistics

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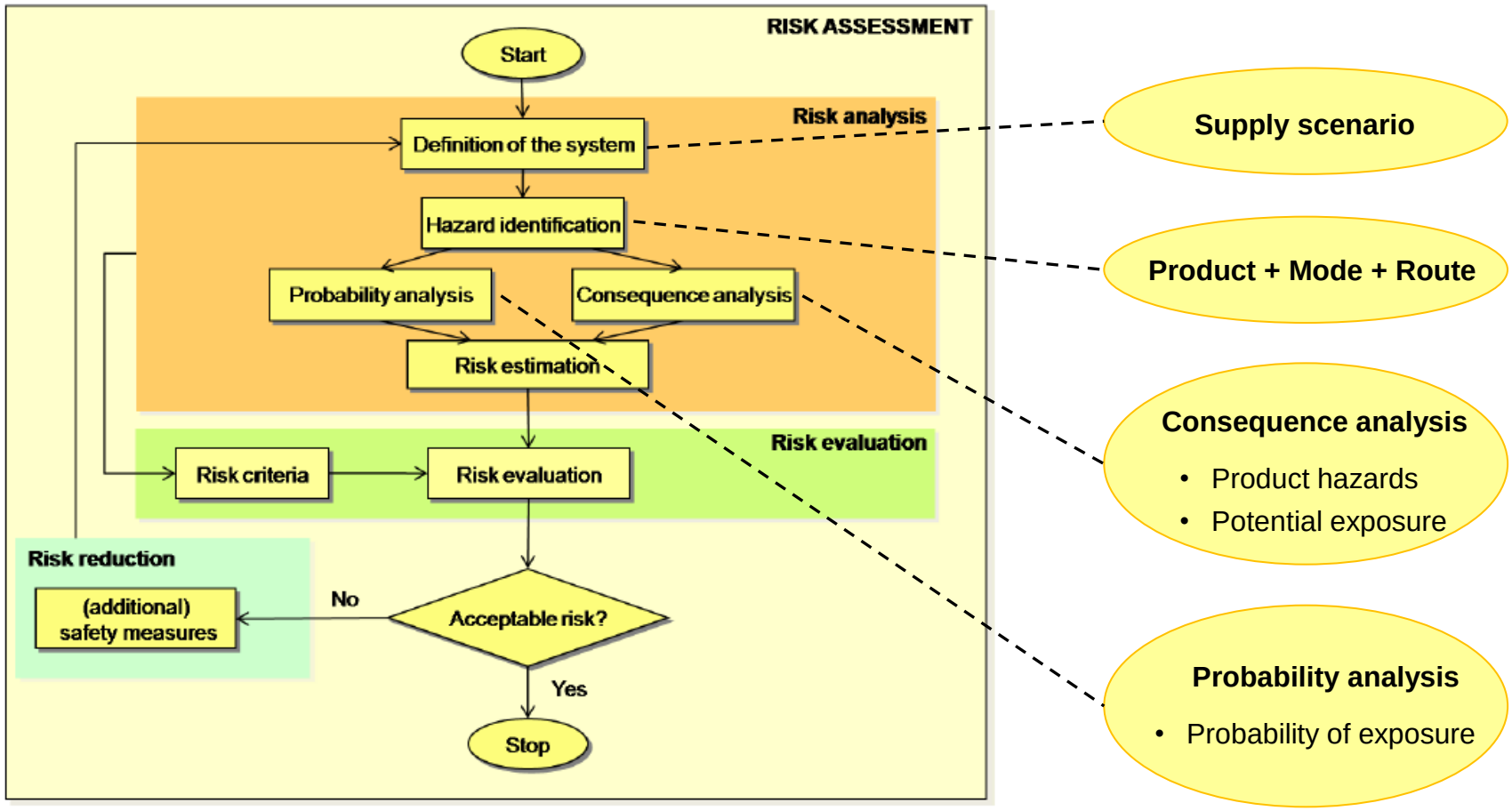
Safety Risk Assessment for Chemical Transport Operations

General approach



Adopted from.: PIARC Technical Committee C.4 Road Tunnel Operation: Technical Report “Risk Evaluation”, Draft Version 5.0_2010

Safety Risk Assessment for Chemical Transport Operations

Semi-quantitative risk analysis

Definition of the system / Hazard identification

- Focusing on specific transport operations with a very high consequence ranking (Cefic Guidance, Score III/IV)
  - Dangerous goods with very high potential impact (Cefic Guidance, Score 4)

Dangerous goods with very high potential impact (acc. Cefic Guidance)**:**

- Goods that are toxic by inhalation (TIH), transported in any quantity
- Goods transported in bulk with one of the following hazard identification numbers (HIN):
  - Flammable gases — HIN 23, 263, 238, 239
  - Toxic gases — HIN 26, 265, 268
  - Highly flammable liquids — HIN 33, 333, 336, 338, 339, X323, X333, X338
  - Highly toxic liquids — HIN 66, 663, 664, 665, 668, 669, 886, X88, X668

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Semi-quantitative risk analysis

Definition of the system / Hazard identification

- Focusing on specific transport operations with a very high consequence ranking (Cefic Guidance, Score III/IV)
  - Dangerous goods with very high potential impact (Cefic Guidance, Score 4)
  - Significant shipping volumes and/or number of shipments per year
  - Modes and/or routes critical with respect to hazard exposure

Consequence analysis

- Consequences of an accident are considered to depend on
  - the properties of the dangerous good and
  - to be of similar extent for different modes (“Iceberg”-Theory; worst case approach)

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Semi-quantitative risk analysis

Probability analysis

Identification of the probability of occurrence of a transport hazard

- Transport accident frequencies, normally expressed as number of accidents per distance driven by the transport vehicle (truck, train, barge)
- Basic information provided by
  - company internal records
  - statistical surveys published by national/regional authorities
  - statistical investigations prepared by engineering consultants
- Detailed data on transport accident frequencies partly difficult to find, i.e. mode specific accident frequencies for transportation of chemicals, drilled down to
  - incidents with loss of containment
  - specific information related to the route
- Alternatively, average accident frequencies for general freight transportation in the country or region, at least specific for the different modes have to be used

Example

Freight Transportation in China

Accident statistics

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KPI, 2010	Road (20 t per truck)	Rail (1,100 t per train)
Shipping Volume [t/a] a)	2.45×10^{10}	3.64×10^{9}
Hauling capacity [t.km] a)	4.34×10^{12}	2.76×10^{12}
Average mileage [km] a)	177	759
Shipments	1.22×10^{9}	3.31×10^{6}
Accidents	757,791 b)	21,211 c)
Accident frequency rate per t.km	1.75×10^{-7}	7.67×10^{-9} c)
Accident frequency rate per shipment	6.19×10^{-4}	6.41×10^{-3} c)
Accident frequency rate per transport kilometer	3.49×10^{-6}	8.44×10^{-6} c)

a) National Bureau of Statistics of China: Database 2010 (Status 07/2012)

b) Ministry of Transportation P. R. China: China 2010 Traffic Accident Report

c) PLANCO / BAGK: Verkehrswirtschaftlicher und ökologischer Vergleich der Verkehrsträger Straße, Schiene und Wasserstraße (November 2007; WSD Ost, Hrsg.)

- Number of truck accidents b) derived from the total number of traffic accidents of 3,906,137 applying the share of overall fatal accidents affected by vehicles carrying fright of ~ 19.4 %
- Accident statistics for rail operations in China c) publicly not available; data used for the present report adopted from statistics of “Deutsche Bahn Cargo” (Germany, 2005), which proved to reflect the performance of rail operations in Germany, Europe, USA and Mexico quite reliable; number of rail accidents projected accordingly

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Semi-quantitative risk analysis

Risk estimation

- Definition of supply scenarios by mode, route, distance and number of shipments per year
- Calculation of the number of expected accidents related to each supply scenario
- *Risk Points* are determined by the ratio of the expected number of accidents with respect to the level defined by the BASF benchmark (BM)
  - One risk point is representative for a rail supply scenario of EO, daily operated by a unit train, over a distance of 500 km (BASF benchmark, BM)
  - Relative ranking of different / alternative supply scenarios (mode, distance, number of shipments)

Example

Benzene Supply, China

Risk estimation

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	Supply route	Railway lines		Mileage [km]	Shipping volume [t/a]	Shipments per year	Expected number of accidents	(Risk points)
Rail	S1 – BASF Site	Line A – B – C	CN1	1,456	250,000	227	1.2	(1.8)
		Line D – E	CN2	1,226	250,000	227	1.0	(1.5)
	S2 – BASF Site	Line F – G	CN3	550	250,000	227	0.4	(0.7)
		Line F – H – I	CN4	363	250,000	227	0.3	(0.5)
	BASF-Benchmark	DB Germany [1)]	BM	500	400,000	365	0.7	(1.0)
Road	S2 – BASF Site		CN5	390	250,000	12,500	17.0	(26.5)
			CN6	390	125,000	6,250	8.5	(13.2)
			CN7	390	100,000	5,000	6.8	(10.6)
			CN8	390	50,000	2,500	3.4	(5.3)
			CN9	390	25,000	1,250	1.7	(2.6)

1) BM: Unit train with direct connection, daily operated by DB Schenker; Database “Deutsche Bahn Cargo”, Germany 2005 (for reference)

- Rail supply operated by unit trains (~ 1,100 t) presuming sufficient storage capacity on site; unit trains are not subject to shunting operations, thus facing only ~ 42 % of possible train accidents (derived from statistical data of the DOT, USA)
- Risk points are determined by the ratio of the expected number of accidents with respect to the level defined by the BASF benchmark BM (severity of accidents assumed to be of comparable extent for all routes)

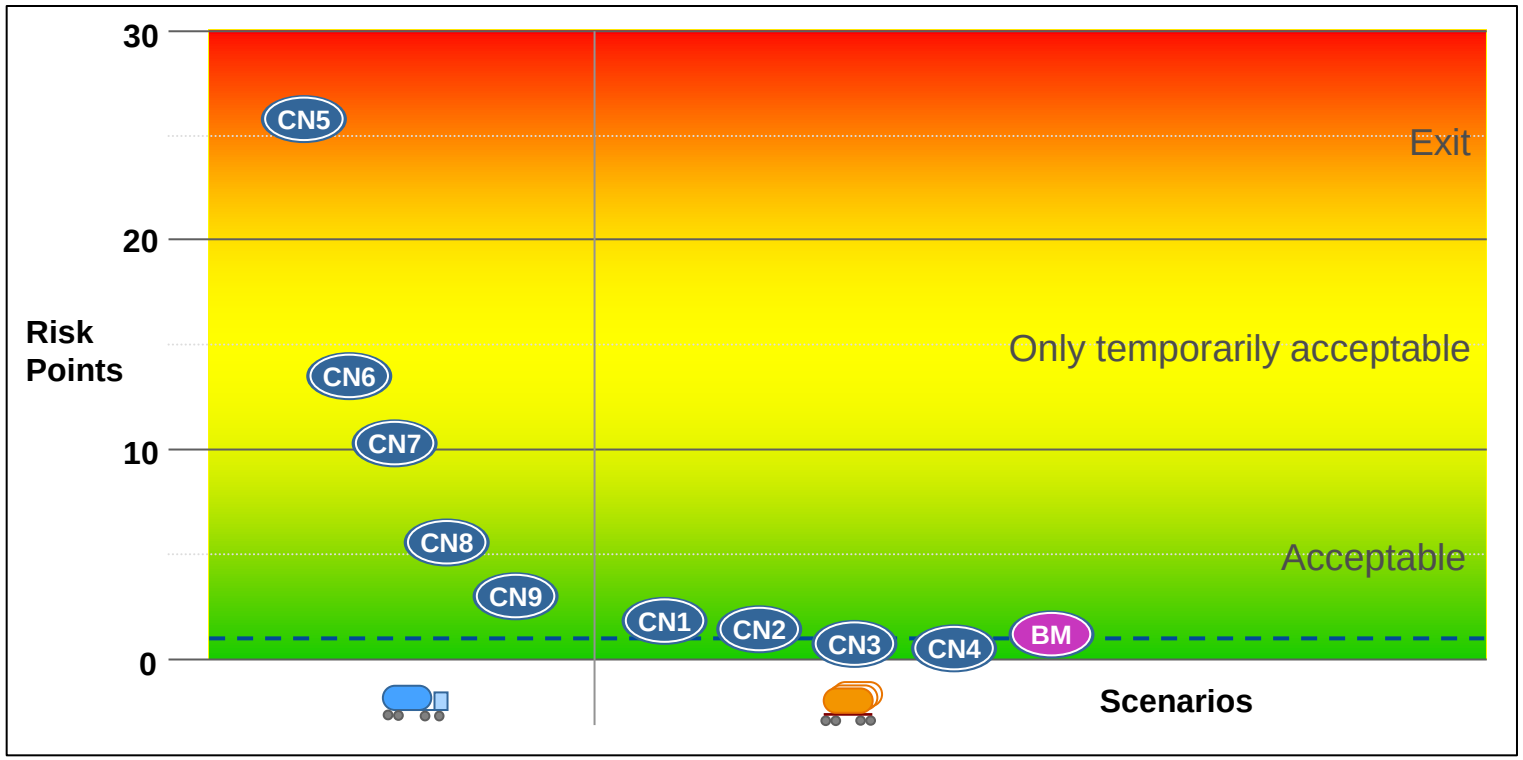
Risk evaluation

- Results of the risk estimation in terms of risk points are displayed in a standardized *Risk Plot* to compare the different supply scenarios
  - The corridor of accepted risks in transportation is defined by 10 risk points (one order of magnitude)
  - Scenarios rated beyond 10 risk points are only temporarily accepted or subject to phase-out

Example

Benzene Supply, China

Risk Plot



Risk mitigation

- The risk of a transport operation can be reduced by taking measures that either
  - reduce the frequency (probability) of accidents or
  - reduce the potential consequences of an accident
  - Redesign of the supply scenario, e.g. mode, route, limitation of shipping volumes, selection of equipment and service providers, etc.
- Local specifics of the routes deviating from the standards and average conditions covered by the accident statistics require a *Field Survey*
  - Identification of topographic situation, climatic conditions, crossings, bridges, tunnels, vicinity of sensitive installations, etc.
  - Basis for conclusions and recommendations on individual measures of risk mitigation (e.g. convoying, pilot vehicles, time schedules, etc.)

Example

Benzene Supply, China

Field Survey

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Risk based analysis of the Field Survey

- Yearly demand ~ 250,000 tons of Benzene
- Transportation by rail preferred option for both supply sources, S1 and S2

- Transportation by road from S1
  - Due to the rural road conditions in a mountainous area and the overall distance of more than 1000 km, use of this route not recommended

- Transportation by road from S2
  - Route is acceptable based on the technical standard and short distance of about 390 km
  - Quantity transported by road is recommended to be limited to 40,000 – 35,000 t/a in order to stay within the acceptance corridor

Thank you for your attention!

Questions?