Methodology for Rapid Risk Ranking of H_2 Refuelling Station concepts

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By Norsk Hydro ASA and DNV
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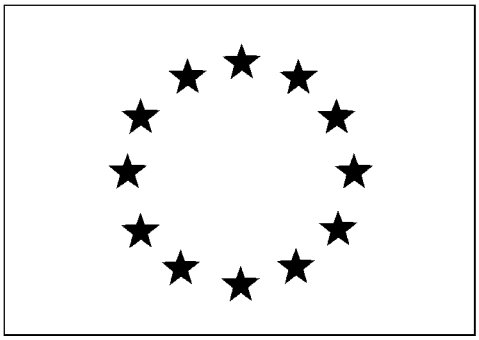

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Methodology for Rapid Risk Ranking of H_2 Refuelling Station concepts

1 INTRODUCTION

In WP5 Rapid Risk Ranking (RRR) analyses of the different refuelling station concepts will be performed. This report describes the methodology and basis for this work.

RRR is a simpler approach than a full quantitative risk analysis (QRA). The reason for using RRR is that the information available at this stage is not detailed enough for a full QRA. Rapid Risk Ranking (RRR) with the use of risk matrixes will yield the desired results for evaluation of the different concepts.

By using the proposed methodology the relevant hazards for persons operating, refuelling and in the vicinity of the station will be identified and risk ranked. The risk ranking is based on qualitative estimates of the probability for and the consequences of the identified hazards.

RRR is suitable when an overview of risks in a system or object is required, and will often be the very first analysis method used when evaluating risks.

2 RRR METHODOLOGY

Figure 1 describes the different steps of RRR assessment.

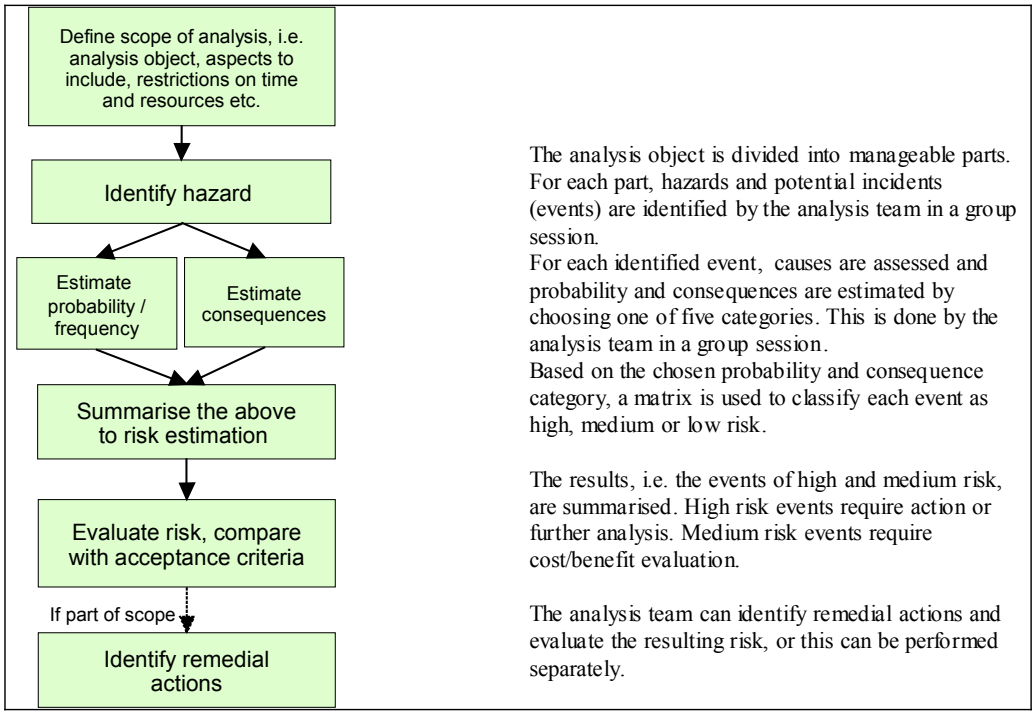

Figure 1 The different steps in the RRR methodology

The hazard identification and the risk estimation is done as a group session. On beforehand the RRR facilitator and concept "owner" has defined the analysis scope and broken the process down into manageable parts.

2.1 System breakdown

To be able to identify all hazards and events, it may be necessary to split them into manageable parts, especially when the object is big or complex. In RRR this splitting up is normally geographical or related to process sections. An example of splitting for a hydrogen filling station based on pressurised hydrogen, where production of hydrogen also is included, can be as follows:

Process units

- Storage of raw materials such as methanol, ammonia etc.
- Hydrogen production unit, e.g. container
- Drying/purification
- Compression unit
- Storage of hydrogen
- Dispenser unit

Activities

- Filling of buses/cars
- operation, maintenance, transport etc.

Exposed to risk

- Operators
- Control rooms
- Cafeterias/kiosks
- Persons working in cafeterias/kiosks
- Persons refuelling
- Residential areas
- etc.

Figure 2 illustrates how a H_2 refuelling station may be divided into segments or sub systems.

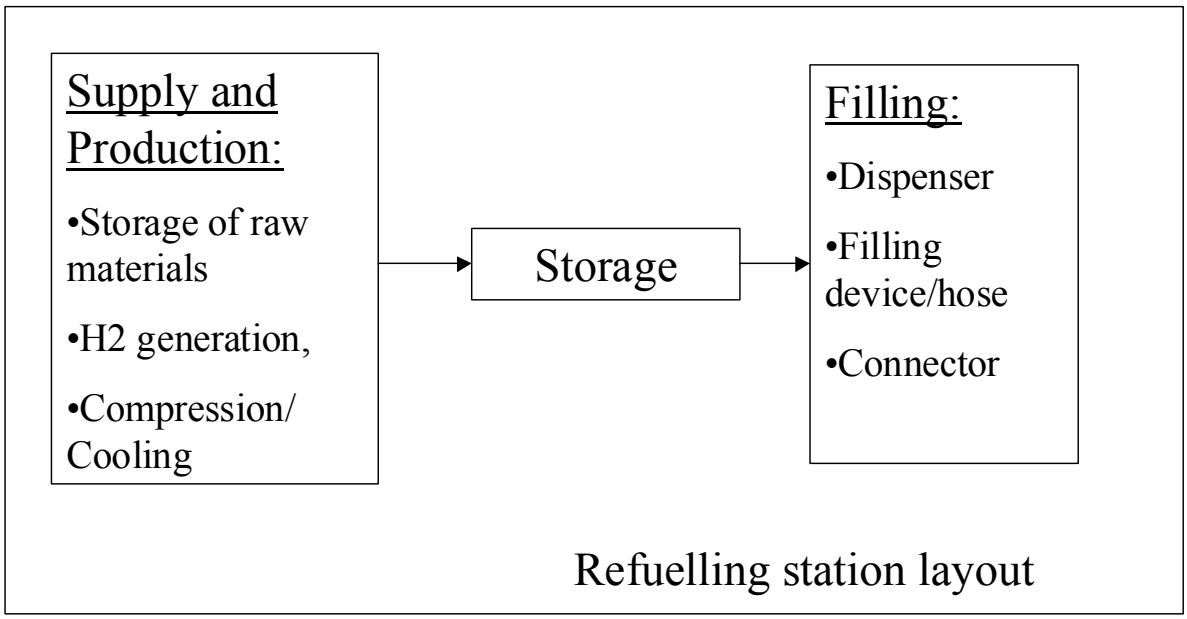

Figure 2 Segmentation of H_2 refuelling station

2.2 Group session

The risk analyses will be performed as a group session with experts and "owners" of the respective concepts who can provide the necessary knowledge and experience on the object being analysed. The goal is to identify and risk rank relevant hazards.

The team will normally consist of

- a facilitator (team leader) with competence and experience in the method to be used will lead the analysis
- a recorder will report the results.
- team members (2-4 persons) who can provide necessary knowledge and experience on the object being analysed

The composition of the analysis team is very important. The results of the analysis are dependent on the team being positive and open-minded, and on their knowledge, competence and experience.

The group will go through the following tasks:

- concept presentation
- hazard identification (HAZID)
- consequence and frequency estimation
- risk ranking

2.2.1 Concept presentation

The *concept presentation* should give the team members an overview of the concept and its process. The information given in the concept presentation should include:

- Process flow diagrams or other simplified block diagrams showing the principles of the filling station, including process conditions such as pressure, temperature, amount of hazardous materials
- Layout drawings
- Description of systems for detection and control of hazards/unwanted incidents

- Description of emergency systems and mitigation of hazards.

2.2.2 Identification of hazards and potential incidents (HAZID)

After the concept presentation the group will do a *HAZID* to identify relevant hazards and accident scenarios. It is important to go through all parts of the process, operational modes, maintenance operations, safety systems etc. All hazards and possible accidental events in the analysis object must be identified. All findings will be recorded.

The analysis team's experience and imagination as well as accident reports and statistics etc. may be used. No hazards are too insignificant to be documented. "Murphy's law" must also be borne in mind, i.e. if something can go wrong, sooner or later it will.

There are different sources of hazards:

- Mechanical
- Electrical
- Thermal
- Noise and vibration
- Material and substance (chemicals incl.)
- Ergonomics

A checklist is shown in appendix A. This gives an overview of all types of hazards and will be of some assistance.

For the RRR analysis of a hydrogen filling station, the main focus will be hazards to people.

The results of the group sessions will be reported. A suggested report form is shown in appendix Appendix B. For each identified hazard in different areas/systems, its cause, possible mitigation measures, consequence, probability and risk must be recorded. Comments may also be added.

2.2.3 Risk ranking

The risk is established as a combination of probability of a given consequence and a grading of the severity of the same consequence.

For each identified hazard, the group will assess the **probability of the hazard** occurring and the **severity of the related consequences**. This will enable a ranking of the hazards in a **risk matrix.** These results will later be used to compare the different concepts and evaluate them against relevant acceptance criteria.

2.2.4 Consequence severity

The consequence is graded according to the assumed severity as presented in Table 1.

Table 1 Consequence severity

Level	Description	Definition		
		People	**Environment**	**Material**
1	CATASTROPHIC	Several fatalities	Time for restitution of ecological resource such as recreation areas, ground water >5 years	Total loss of station and major structural damages outside station area
2	SEVERE LOSS	One fatality	Time for restitution of ecological resource 2 - 5 years	Loss of main part of station. Production interrupted for months.
3	MAJOR DAMAGE	Permanent disability Prolonged hospital treatment	Time for restitution of ecological resource < 2 years	Considerable structural damage Production interrupted for weeks
4	DAMAGE	Medical treatment Lost time injury	Local environmental damage of short duration < 1 month??	Minor structural damage Minor production influence
5	MINOR DAMAGE	Minor injury Annoyance Disturbance	Minor environmental damage	Minor

The stated category of consequence must correspond to the stated probability or frequency for the specific analysed undesired incident or hazard. Normally the most likely consequences are used, and the worst case does not happen every time. This means that a given incident or hazard may well have two or more risk estimations (frequency and consequence), for example one that is likely to happen and one or more unlikely. An example of this is fall accidents. Most falls are from low heights and cause minor injuries. Falls from high heights that cause fatalities are more seldom. A low frequency should be used for the accidents with fatalities, while a higher frequency is used for accidents with minor consequences.

2.2.5 Probability levels

The probability levels are defined as shown in Table 2.

Table 2 Probability levels

Level	Description	Definition	Frequency
A	IMPROBABLE	Possible, but may not be heard of, or maybe experienced world wide.	About 1 per 1000 years or less
B	REMOTE	Unlikely to occur during lifetime/operation of one filling station	About 1 per 100 years
C	OCCASIONAL	Likely to occur during lifetime/operation of one filling station	About 1 per 10 years
D	PROBABLY	May occur several times at the filling station	About 1 per year
E	FREQUENT	Will occur frequently at the filling station	About 10 per year or more.

2.2.6 Acceptance level

The risk is a combination of the severity and the probability. In order to evaluate if it is acceptable or not one can use a risk matrix as shown below as a guide. The combination of probability and severity for each hazard is plotted in the risk matrix.

Table 3 Risk Matrix

		PROBABILITY (per year)				
		A (<0.001)	B (0.01-0.001)	C (0.1-0.01)	D (1-0.1)	E (10-1)
SEVERITY	1 (Catastrophic)	H	H	H	H	H
	2(Severe loss)	M	H	H	H	H
	3 (Major damage)	M	M	H	H	H
	4 (Damage)	L	L	M	M	H
	5 (Minor damage)	L	L	L	L	M

In the table above there are three risk levels and the following acceptance criterion is proposed (Table 4):

Table 4 Risk levels

Level	Level name	Description
H	High	High risk, not acceptable. Further analysis should be performed to give a better estimate of the risk. If this analysis still shows unacceptable or medium risk redesign or other changes should be introduced to reduce the criticality.
M	Medium	The risk may be acceptable but redesign or other changes should be considered if reasonably practical. Further analysis should be performed to give a better estimate of the risk. When assessing the need of remedial actions, the number of events of this risk level should be taken into consideration.
L	Low	The risk is low and further risk reducing measures are not necessary

APPENDIX A
HAZARD CHECKLIST

Table 1: **Hazardous events (only acute hazards included)**

Hazards to people	Hazards to environment	Hazards to material values
Collision	Release of environmentally dangerous chemicals	Collision
Falling on the same level	Flooding	Falling on the same level
Falling to a lower level	Release of oil	Falling to a lower level
Stumbling	Release of dust	Hitting against something
Hitting against something	Landslide, snowslide	Impact from moving object
Squeezing, pinching		Flying objects, fragments
Impact from moving object		Contact with corrosive chemicals
Flying objects, fragments		Fire, explosion
Contact with sharp object		Stop, loss of production
Contact with electric conductor		Off spec quality
Contact with hot or cold surface/fluid		Late delivery
Contact with dangerous chemicals (fluids)		Flooding, dependent on location
Exposure to dangerous gases, smoke		Collapsing
Exposure to steam		Landslide, snowslide
Exposure to dust		
Exposure to dangerous light		
Choking, reduced oxygen content		
Drowning		
Fire, explosion		
Radiation		
Crime		
Biological threats		

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APPENDIX B
REPORTING FORM

Area/ID	Hazard	Cause	Mitigating measures	Consequence			Prob-ability	Risk			Comment
				People	Environment	MV		People	Environment	MV	

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