Quantitative Risk Assessment (QRA) – Its role in Safety Cases

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Agenda

- What is risk and what is QRA?
- Why conduct a QRA and what does it do?
- What a QRA does and doesn’t do in a safety case
- Is a QRA required?
- Qualitative and semi-quantitative risk assessments
- Which method is the right method?
- Conclusion

Safety Case

- A Safety Case is a document that contains:
  - The hazards and risks that may lead to a major accident at a Major Hazard Installation; and
  - The technical, managerial and operational measures in place to manage or control those hazards.
- A Singapore compliant Safety Case requires identification of all possible Major Hazard Scenarios using one or more risk studies such as:
  - **QRA**
  - PHA Studies (e.g. HAZOP, FMEA, PHR)
  - Safety reviews and studies of causes of past major accidents/incidents
  - Industry standards or checklists
  - Job safety analysis (e.g. task analysis)
  - Human failure identification method

What is Risk and what is QRA?

- Risk is a combination of the consequences and likelihood of ‘bad stuff’ happening
- QRA is a technique used to systematically calculate and analyse the risks from hazardous events
- QRA is the expression of risk in a numerical measure – the risk of fatality to an operator is 1 in 10,000 years
- Quantifies a range of potential MAHs and their consequences, such as fire events (pool, jet, flash, explosions, fireballs) and toxic dispersions from hydrocarbons. Can include a large number of hazard sources and events in a single study.
- Used particularly in ‘major hazard’ types of industry where there are many hazard sources on individual sites. For example:
  - Chemical and Petrochemical sites;
  - Onshore and Offshore oil and gas sites;
  - Nuclear industry.

Why Conduct QRA?

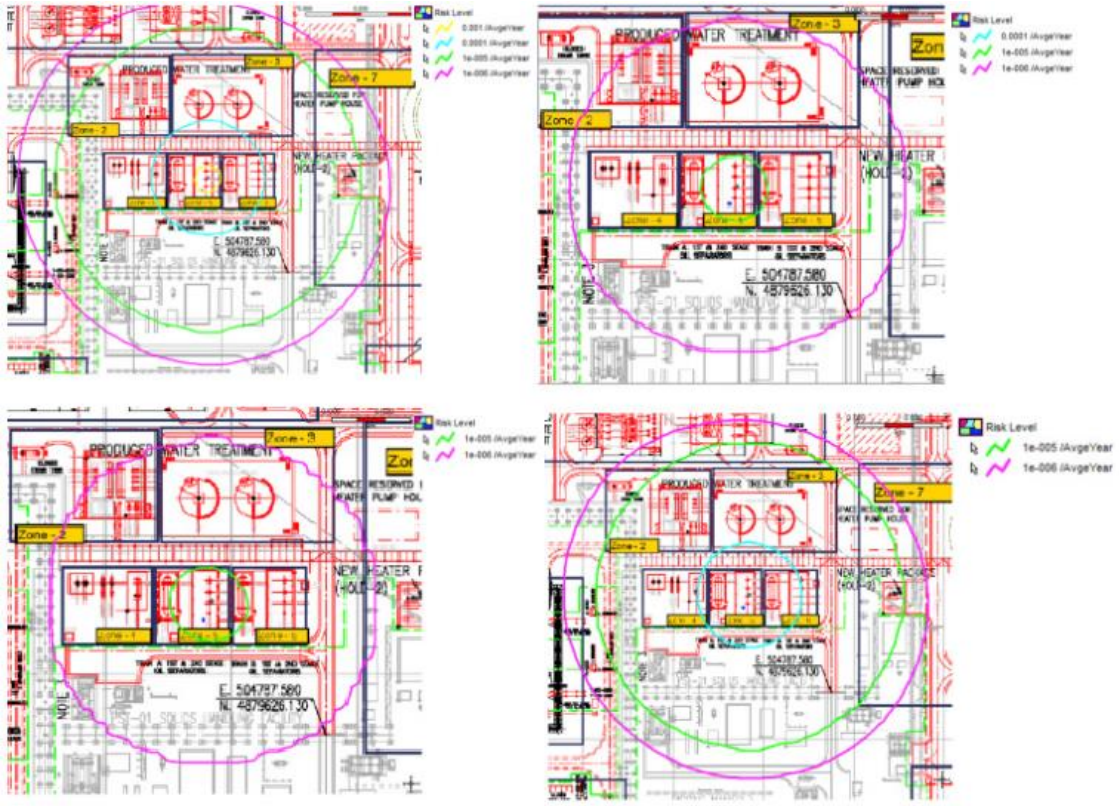
- Regulatory requirement? Often stipulated as the way for facilities to show regulators what risks are
- Considered good practice by some
- If you have high perceived risks
- If something is new, complicated or unusual
- Where there are multiple sites with overlapping risk profiles
- To provide information to local stakeholders about offsite risks
- To identify likely scenarios for emergency planning

What Does a QRA Do?

- QRA attempts to answer the following:
  - What can go wrong? – by identifying the hazards with major accident potential
  - What are the consequences? – by consequence analysis
  - How likely is this to happen? – by frequency analysis
  - What is the risk? – risk = consequence x frequency – QRA integrates the risk from many hazards
  - Is the risk acceptable? – risk evaluation by comparing to country/industry/company risk criteria
- Identify the major contributors to risk to show where more attention is needed in terms of safety management
- Building risk assessment – identify risks to manned / critical buildings for protection or location
- QRA allows for a much better appreciation of low frequency, high consequence events
- Caution – not an exact science. Lots of uncertainty, particularly with the input data so results are not absolute

QRA During Design?

- Used during design of new facilities but also in the design of upgrades or modifications to existing facilities
- Show the differences in risk levels between different design options and plant layouts
- Show the changes to risk levels from different risk reduction measures
- Can show the risk from operating facilities to workers during the construction phase of projects (SIMOPS)



What a QRA Does do in a Safety Case

- Safety Case Regulations, including the Singapore regulations, all require risks to be assessed
- QRA is a systematic approach so it is well suited to the large complex systems included in Safety Case Regulations
- Well known and widely used methodology so allows for robust arguments to regulators
- Software based on scientific principles and results from experimental data. Also uses results of investigations from real incidents.
- Provides information in numerical and graphical formats which are easy to understand and can be compared to relevant risk acceptance criteria
- The results feed directly to ALARP assessments

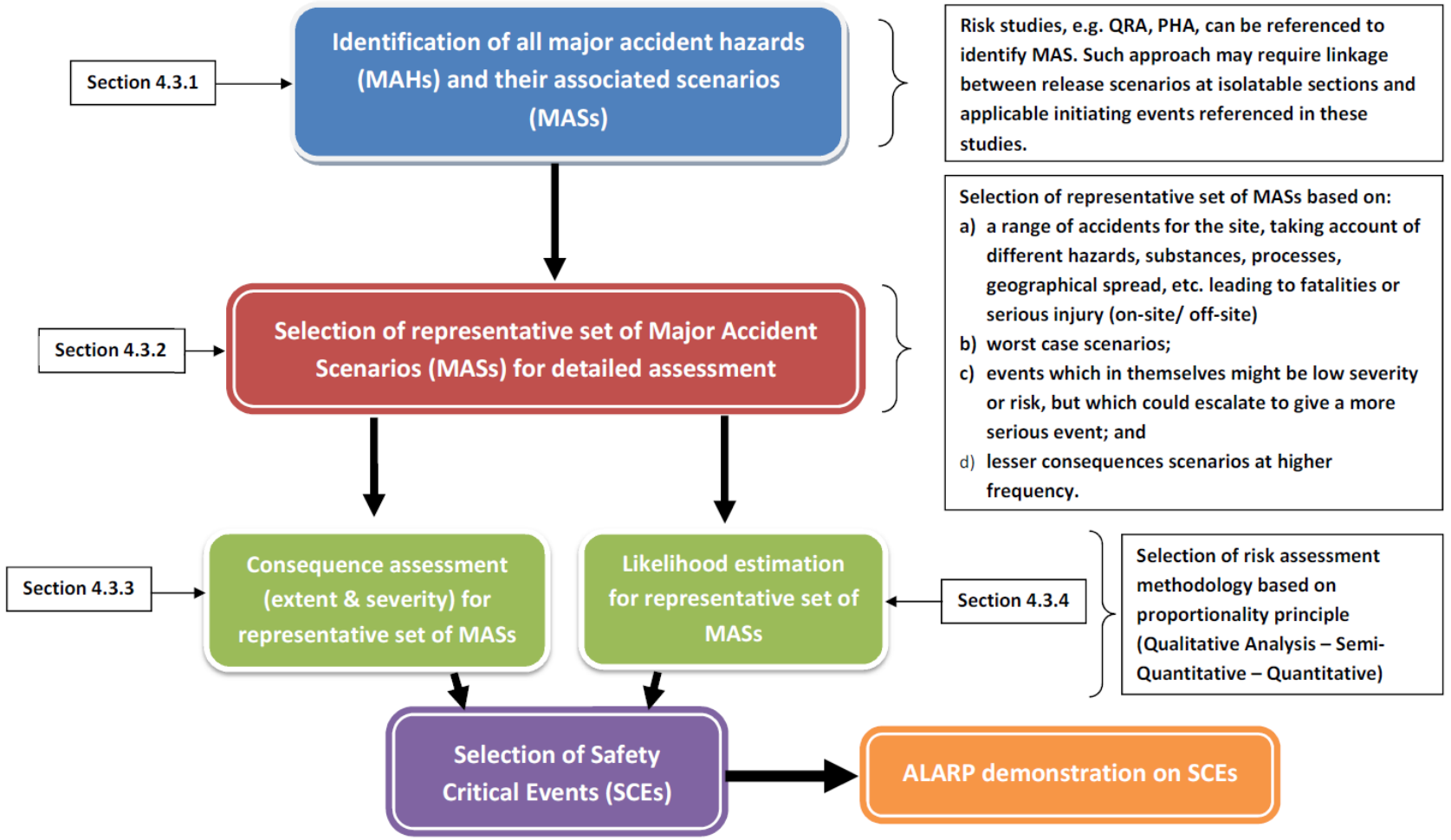
What a QRA Doesn't Do in a Safety Case

- Does not tell you everything – the results of the QRA are only one part of the discussion on risk (need to include issues such as asset integrity, emergency response, extreme weather, aging facilities, etc.)
- Can not be used to justify not implementing risk reduction measures because the risk is already in the ALARP region
- Does not replace the need to follow codes and standards. Even if the QRA shows a low risk, the minimum requirements of the relevant codes and standards still have to be met
- Can't be used to justify decisions after they have been made or after money has been spent
- The QRA for a similar facility does not show the risk is acceptable at another one

Is QRA Required?

- QRA as described is very useful for large facilities with high hazard potential and major risks.
- However, not all sites which fall under Safety Case regulations are process facilities such as refineries and petrochemical plants.
- Sites such as warehouses, storage and distribution facilities which store major hazard materials are also required to develop Safety Cases.
- Large, complicated and expensive QRA models are not always justified.

Risk Assessment is Necessary



Singapore Safety Case Technical Guide, October 2016

Type of Risk Assessment

- The Singapore guidelines allow the operator to determine the best methodology as appropriate to the facility.
- They suggest:
  - QRA
  - PHA Studies (e.g. HAZOP, FMEA, PHR)
  - Safety reviews and studies of causes of past major accidents/incidents
  - Industry standards or checklists
  - Job safety analysis (e.g. task analysis)
  - Human failure identification method
- Other methods may be more appropriate

Qualitative Risk Assessment

- Identifies risks generally based on a high / medium / low concept.
- Can be used to look at project risks away from safety such as budget, schedule, project impact and reputation – can identify opportunities as well as threats.
- Can involve brainstorming, checklists, mind-maps, questionnaires, expert judgement, etc. to identify hazards and consequences
- Will often use a Risk Assessment Matrix (RAM) which defines risk level based on general statements of consequence severity and the probability of those consequences.

Severity of Consequence		Likelihood				
		A	B	C	D	E
		Very Low	Low	Medium	High	Very High
1	Very Low	LOW RISK	LOW RISK	LOW RISK	MEDIUM RISK	MEDIUM RISK
2	Low	LOW RISK	MEDIUM RISK	MEDIUM RISK	MEDIUM RISK	MEDIUM RISK
3	Medium	MEDIUM RISK	MEDIUM RISK	MEDIUM RISK	MEDIUM RISK	HIGH RISK
4	High	MEDIUM RISK	MEDIUM RISK	HIGH RISK	HIGH RISK	HIGH RISK
5	Very High	MEDIUM RISK	HIGH RISK	HIGH RISK	HIGH RISK	HIGH RISK

Qualitative Risk Assessment

- Risks can be grouped through ‘Risk Categorisation’ – risks with similar attributes (hazards, initiating events, consequences, etc.) can be grouped to show where extra effort can be applied
- Whichever study is used, there will need to be identification of the systems, processes and procedures in place to manage the risk. These may concentrate on preventing the hazard being realised or on mitigating the severity of the consequences (including recovery and emergency response)
- A fundamental part of any risk assessment is to identify where gaps exist in risk management and developing (and implementing) risk reduction measures

Semi–Quantitative Risk Assessment

- Builds on the theme of qualitative but provides additional information on certain aspects to give more definitive information to base the assessment on
- For example, if we consider a fire:
  - In a qualitative assessment, we may say there will be a medium sized fire and it will happen at a low frequency (low risk)
  - In a semi-quantitative assessment we would do some calculations to see how big the fire might be and we can be more confident in saying that a 400m fire may cause multiple fatalities and has happened once in the company (high risk)

Severity of Consequence		Likelihood				
		A	B	C	D	E
		Never heard of in industry worldwide	Has occurred in industry but not in Company	Has occurred in Company at least once	Occurs in Company several times a year	Occurs in Company several times a year in a specific location under assessment
1	Slight Injury (First Aid Case)	LOW RISK	LOW RISK	LOW RISK	MEDIUM RISK	MEDIUM RISK
2	Minor Injury (Restricted Work Case	LOW RISK	MEDIUM RISK	MEDIUM RISK	MEDIUM RISK	MEDIUM RISK
3	Major Injury (Partial Disability and/or Lost Time Injury)	MEDIUM RISK	MEDIUM RISK	MEDIUM RISK	MEDIUM RISK	HIGH RISK
4	Permanent Total Disability and/or a Single Fatality	MEDIUM RISK	MEDIUM RISK	HIGH RISK	HIGH RISK	HIGH RISK
5	Multiple Fatalities	MEDIUM RISK	HIGH RISK	HIGH RISK	HIGH RISK	HIGH RISK

Which Method is the Right Method

- There is no definitive answer
- All methods used must be proportional to the site and to the hazards identified
- Must also be appropriate to the business (i.e. can't be too time-consuming or too expensive)
- Smaller sites may have the same products as larger, more complex facilities but they will likely be finalised product and in much smaller quantities
- The consequence of release may be very different
- The ways that the hazard is realised is likely to be very different (more related to peoples actions, rather than process upsets)
- Need to be mindful of the frequency of an initiating event, and the mechanisms that makes the scenario become a major accident

Example – Chemical Warehouse

- Perform a HAZID assessment to identify the high risks (flammable, toxic, explosive substances, transportation?)
- Identify how those hazards can be realised – forklift accidents, racking problems, etc.
- Identify the controls in place to prevent or mitigate the release
- Determine the size of the hazard – 1 container or multiple containers? Size of container?
- Determine the size of the consequence – possibly with some consequence modelling.
- Identify how often the consequence will occur (frequency).
- This gives the risk but if the assessment is done with enough granularity, we can identify the risk to workers, other businesses, local residents, etc.
- Identify improvements that can be made?
- Do we consider our risks to be ALARP?

Conclusion

- QRA very useful for large complex facilities with many hazard sources.
- Provides numerical values of risk which can be compared to risk acceptance criteria.
- Graphical representation of risk is easy to understand by non-technical people
- Useful in design stages to optimise processes and facility layout.
- Useful in operational phase to show high risk areas where additional controls may be required
- QRA is not a one-stop-shop – doesn't give all the answers. Other risk assessment options available for less complex facilities
- All risk assessments are only as good as the people doing them. Ensure the method used is appropriate for the facility and that people are competent in that methodology

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