

DEMONSTRATION OF ALARP WITHIN COMAH SAFETY REPORTS

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The implementation of the SEVESO II Directive (COMAH Regulations as it is implemented in the UK) requires operators to demonstrate that major accident risks are as low as is reasonably practicable (ALARP). Meeting this requirement entails carrying out some form of risk assessment and then assessing whether further controls are required. Guidance produced by the UK Chemical Industries Association [1] addresses risk assessment and demonstration of ALARP in relation to on-site occupied buildings but does not address hazards which are difficult to quantify in terms of numerical risk, involve process operators, pose off-site risks or threaten the environment. A more generalised approach to risk assessment/demonstration of ALARP is required to address the variety of hazards associated with chemical sites. This paper will provide examples that demonstrate how such approaches can be successfully applied to COMAH safety reports. An important component of the ALARP demonstration is identifying the range of possible risk reduction measures and then choosing the right one. Ranking of risk reduction options and selection of the optimum solution is discussed for practical situations.

Key words: As Low As Reasonably Practicable (ALARP), Quantified Risk Assessment (QRA), Risk Reduction Measures, Control of Major Accident Hazards (COMAH)

BACKGROUND TO SAFETY REPORT REQUIREMENTS

The COMAH Safety Report Assessment Manual [2] states that operators are required to demonstrate that major accident hazards have been identified and the necessary measures taken to prevent such accidents and limit their consequences to persons and the environment. Decisions about the acceptability of existing risks and the requirement for additional safeguards generally require some form of risk assessment.

The risk assessment approach used to identify and evaluate the risks can be undertaken in a number of ways such as quantitative, semi-quantitative, qualitative or a combination of these. The most suitable approach for a particular hazardous site will be dependent upon the consequences of the event and the magnitude of the risk for example, whether the consequences are confined on-site or extend off-site to significant populations or environmental features will be important factors.

INTRODUCTION

This paper will provide a demonstration of the application of semi-quantitative risk assessment in decision making by means of a case study involving a UK major hazard installation. The purpose of the case study was to undertake a risk assessment for the site in order to identify and evaluate the major accident hazards, assess the acceptability of the risk and make decisions on any required additional risk reduction measures in accordance with the ALARP principle. The basis for the identification of major accident hazards has been structured around brainstorming sessions involving application of a set of guidewords to the various site operations. The assessment of risk has been carried out using a semi-quantitative risk assessment approach in which a relative rank or weight is assigned to each consequence and its likelihood and then an overall risk value assigned on the basis of an agreed risk matrix. Risks have been assigned as high, medium or low and rules applied governing application of risk reduction measures to each risk category.

RISK ASSESSMENT METHODOLOGY

The identification of hazards (including major accident hazards) has been undertaken by means of brainstorming sessions involving application of a set of standard guidewords to a list of the various facilities and a description of the activities undertaken in each facility. The list of assessed facilities included all significant inventories of dangerous substances as defined under COMAH (toxic, flammable, ecotoxic etc.). The list of guidewords adopted for the study was as follows:

- Mechanical failure (corrosion etc)
- Natural external events (extreme weather)
- Man - made external events (fire/explosion etc)
- Impact (vehicles, cranes etc)
- Operator error (incorrect procedure etc)
- Maintenance error (equipment fitted incorrectly etc)
- Equipment failure (stirrers etc)
- Extreme internal conditions (temperature/ pressure/ level/ flow etc)

The brainstorming sessions assigned a relative rank or weight to each accident consequence and its likelihood (Table 1 and Table 2) in order to determine an overall risk ranking in accordance with an agreed risk matrix (Table 3). The definitions in the Tables were based on internal company risk procedures, these definitions will differ from company to company, but the basic concepts remain the same.

Hazard scenarios for this case study were rated using scales of 1 – 4 for consequence and likelihood with level 4 representing the highest loss and frequency.

Consequence categories are assigned on a worst case basis, assuming that only passive safeguards are in operation (i.e. those that require no human intervention). If credit is to be given to passive safeguards then these will need to be fit for purpose and well-maintained e.g. a bund should be in a good state with no leakage.

The approach for assigning likelihood ratings starts with the plant operating experience using the above table. If the event has happened once or more in the past five years on the plant or a similar one then the frequency is assigned a likelihood rating of 4. If an accident has occurred once or more on a longer timescale then the likelihood rating is 3. If no accidents with similar consequences have occurred then the maximum likelihood rating would be once in 100 years or a level 3. The next step is to look at the safeguards in place. If there are effective passive and/or active safeguards in place then the likelihood rating can be reduced to level 2. This is a subjective judgement, which is made by group consensus and is influenced by the generic failure rates of those safeguards. If a high level of protection, including passive engineered safeguards and administrative controls, is in place then a level 1 can be assigned. Level 1 probabilities are intended to be used sparingly and only after considerable thought.

Table 1: Consequence Ratings

Consequence Level	Consequence Definition	Example of Losses On-Site	Examples of Losses Off-Site
4	Off-Site Hazard	• Multiple Severe Injuries • Large Spills and Releases • Property Damage • Business Interruption	• Large Scale Evacuation • Major Property Damage • Major Environmental Impact
3	On-Site Hazard	• 1 Fatality or Severe Injury • Significant Spills and Releases • Property Damage • Business Interruption	• 1 or 2 LTA Injuries • Evacuation; Shelter-in-Place • Significant Property Damage • Environmental Impact
2	In Building Hazard	• Medical Treatment Cases • Multiple First Aid Cases • Medium Spills and Releases • Property Damage	• Nuisance Impact (odours, noise, traffic etc.)
1	Hazard Confined to Local Work Area	• 1 – 2 First Aid Cases • Small Spill or Release that is contained	• No discernible Impact

Table 2: Likelihood Ratings

Likelihood Level	Likelihood Definition	Frequency Range
4	Frequent Occurrence	> Once every 5 years
3	Occasional Occurrence	> Once every 100 years
2	Unlikely Occurrence	Between 100 years to 10,000 years
1	Very Unlikely	< Once every 10,000 years

Each combination of consequence and likelihood is assigned a risk ranking. These risk rankings are allocated as high, medium or low risk in accordance with the following risk matrix (Table 3).

Table 3: Risk Matrix

Consequence		Likelihood			
		1	*2*	*3*	*4*
	1	1	2	3	4
	2	2	4	6	8
	3	3	6	9	12
	4	4	8	12	16

Where:

Risk Level	Risk Definition
1 –3	Low Risk
4 – 9	Medium Risk
9 – 16	High Risk

Once risk rankings have been calculated for each identified hazard, the following rules are applied for dealing with each risk category. Those scenarios identified as high risk should have additional safeguards applied to them to reduce the risk rating to a lower level. As general guidance, the implementation of one additional robust safeguard would reduce the likelihood by one level and two additional robust safeguards would reduce the likelihood by two levels. Those scenarios identified as medium risk should have additional safeguards considered and if reasonably practicable, then these should be implemented. Low risk scenarios are considered to be adequately controlled. However, if there are simple additional safeguards which can be applied, then these should be implemented.

CASE STUDY EXAMPLE: TANKER UNLOADING OPERATION AT A UK HAZARDOUS INSTALLATION

The following case study provides an example of the application of the risk assessment methodology as described above. The extracted example is for the road tanker unloading operation for the site. Solvent contained within road tankers is being unloaded into bulk storage tanks for use on-site.

RESULTS OF ASSESSMENT

The results of the risk assessment involving the road tank unloading operation are detailed in Annex 1. The table also includes a listing of the existing safeguards under the headings: prevention, control and mitigation.

ACCEPTABILITY OF RISKS

The risk assessment for the road tanker unloading operation (Annex 1) indicates that for the identified scenarios the risks fall within the high and medium classification of risk. There are no low risk scenarios. In accordance with the above methodology, the site is required to identify and implement a safeguard or safeguards to reduce high risks to a lower risk category and in the case of medium risks to implement a further safeguard or safeguards where reasonably practicable in terms of cost-benefit.

The high-risk scenario (i.e. Operator error leading to incorrect connection) was reviewed by the site management in terms of the adequacy of the existing safeguards. The selected action was to carry out a more detailed risk evaluation study to verify the high-risk status and; if necessary, identify additional safeguard(s) that will reduce the risk to ALARP levels.

In the case of the medium risk scenarios, the actions identified by the site management were as shown in Table 4.

Table 4: Identified Medium Risk Scenarios

Hazardous Scenarios	Location/ effected area	Site Response
Tanker drive away resulting in loss of containment	Tanker Unloading Area/ On-Site effects	• Consider the use of wheel chocks during unloading operations • Consider automatic shut-off on detection of fault condition and audible alarm • Consider de-coupling the Tanker from the truck when the tanker is positioned within the unloading bay area
Vehicle impact onto road tanker resulting in fire and loss of containment	Tanker Unloading Area/ On-Site effects	• Consider placing warning barriers, moveable barriers or closure of unloading area by gates when tankers are in position
Flame impingement onto road tanker resulting in fire	Tanker Unloading Area/ On-Site effects	• Safeguards have been assessed to be appropriate and no further measures are required
Mechanical failure of unloading hoses resulting in loss of containment	Tanker Unloading Area/ On-Site effects	• Consider automatic shut-off on detection of fault condition and audible alarm

USE OF STANDARDS, BEST PRACTICE ETC. IN SELECTION OF SAFGUARDS

The demonstration of ALARP requires arguments to be presented which demonstrate the adequacy of the safeguards in place. For hazards that are essentially confined on-site and where the risk is not considered high, this demonstration can generally be restricted to showing that the safeguards in place plus proposed measures will ensure compliance with legislation, codes of practice, appropriate standards and any other simple improvements. In other cases, for example where hazards extend off-site and/or risks are high, then safeguards in addition to those required above may be required. Appropriate selection of such safeguards is likely to require consideration of how the proposed safeguards would contribute to the prevention, control and mitigation of major accident hazards.

HIERARCHIAL APPROACH TO SELECTION OF SAFEGUARDS

The use of a hierarchical approach to the selection of control measures will help to ensure that priority is given to those safeguards that eliminate or minimise major accident hazards by "inherently safe" design and prevention measures rather than place over reliance on control and mitigation measures. The design stage represents the best opportunity to put such considerations into effect; however they may also be applied to modifications and installation of additional safeguards in existing plant. Another aspect of the hierarchical approach to the selection of control measures is that preference should be given to engineered safeguards rather than managerial controls. This is a reflection of the fact that human error is a major factor in many accidents.

The detailed implementation of such a hierarchical approach to the selection of safeguards will vary from site to site, however, this approach can be used to determine practical options for the management of hazards and risk and in turn provide justification that risks are ALARP.

Annex 1: Extract from the site risk assessment. Road Tank Unloading Operation

Item No.	Major Accident Hazard including description of consequence of hazard	Consequence	Safeguards			Frequency	Risk
			Preventive measures	Control measures	Mitigation measures		
1	Mechanical failure of unloading hoses e.g. corrosion etc resulting in loss of containment	1	• Hoses fit for purpose, designed to appropriate standards • Visual inspection of hoses prior to use • Hoses are pressure tested at lease once a year	• All transfer operations are supervised by competent persons • Isolation valve on tanker outlet	• Spillage procedure • Operator training for Spills • Site drainage system contained	4	4 M
2	Flame impingement onto road ranker resulting in fire/ explosion	3	• Permit to Work system for hot working in the area • Housekeeping procedure • Earthing of tankers, hoses and equipment while unloading	• Hazardous area zoned • Unloading procedure • No smoking policy	• Operator supervision • Fire extinguishers • Fire sprinkler system • Emergency plan	2	6 M
3	Vehicle impact onto road tanker whilst unloading resulting in loss of containment	3	• Designated unloading areas • Site speed limit of 5 mph		• Operator supervision • Forklift driver training • Site drainage system Contained	2	6 M
4	Operator error (incorrect connections) resulting in loss of containment	3			• Manual isolation valves On tanker and tanks • Operator training • Emergency stop buttons For pumps located in the unloading area	4	12 H
5	Tanker drive away resulting in loss of containment	3	• Road tanker air brake System	• Manual isolation valves	• Spillage procedure • Operator supervision • Spillage kits • Site drainage system contained	2	6 M

CONCLUSIONS

This paper provides an example of the application of semi-quantitative risk assessment in decision making by means of a case study involving a UK major hazard installation.

The aim of the study was to identify the major accident hazards for the site and determine whether existing risks were ALARP. For the high-risk scenario identified in the study, further quantitative assessment was identified as necessary in order to verify the classification of the high-risk scenario and if necessary identify further safeguards which will reduce the risk to ALARP levels using a method of cost-benefit analysis. For the identified medium risk scenarios, practical options were identified after consideration of their effectiveness in terms of prevention, control and mitigation and what is required to meet industry best practice. Demonstration of ALARP also requires appropriate evidence that the identified measures will be implemented. To meet this requirement, the identified actions were incorporated into a site action plan.

REFERENCES

[1] Guidance for the Location and Design of Occupied Buildings on Chemical Manufacturing Sites, Chemical Industries Association, February 1998.
[2] COMAH Safety Report Assessment Manual, Predictive Aspects, Part 2 Chapter 3, Health and Safety Executive.