Guidelines for Quantitative Risk Assessment (QRA)

Process Plants
1.0 Purpose & Objective

a) QRA study is intended to identify and quantify all potential failure modes that may lead to hazardous consequences from the process plants and its associated facilities.

b) Identify hazards including full bore/catastrophic ruptures/failures.

c) Estimate potential consequences of such an event and subsequent effects of fire, explosion, toxicity etc., whichever and wherever is applicable.

d) Estimate the risks to individuals, group of individuals and property wherever these are affected.

e) Recommend suitable risk reduction measures to mitigate the risks and hazards.

2.0 Applicability

This document is applicable for Process Plants of GAIL.

3.0 Cross References

PNGRB (Codes for Practice for Emergency Response & Disaster Management Plan (ERDMP) Regulations 2010, European Gas Incident Data Group, UK HSE Risk Criteria & IS 15656

4.0 QRA Approach

a) Collection of data
b) Hazard Identification
c) Identify potential failures including frequency
d) Calculate the quantity of material that may be released in each failure, estimate the probability of such occurrences
e) Evaluate the consequences of such occurrences based on scenarios such as most probable and worst case events that may be confined within the premised or may spill off site triggering cascading effects
f) Consequences of an incident are fire, explosion, deflagration, blast waves, fast spreading flames, BLEVE, UVCE, Toxicity etc. resulting in direct effects like damage to buildings/property, burns, fatalities etc.
g) Combination of consequences and probability to ranking of hazards
h) Risk Calculation & Risk Presentation
i) Recommendation for Risk Reduction and mitigation of consequences to ensure ALARP Performance in the operation

5.0 Methodology

5.1 Various process installations should be divided into isolatable sections i.e. sub -installations to identify the hazards, loss of containment (LOC) and incident scenarios for consequence analysis and risk calculation. The following loss of containment (LOC) scenarios based on their applicability in each case

- Generic LOC: To consider all the cases of failures not explicitly covered like corrosion, construction errors, welding failures, blocking of tank vents etc.
• External impact LOC: To consider for tankers/wagons movement inside the loading Gantry.

• Loading/unloading LOC: For the case of trans-shipment from the transport unit to the stationary installations.

• Specific LOCS: Like run away reactions and domino effects.

5.2 The frequency for occurrence of each event leading to loss of containment should be taken from reliable and credible database internationally/ nationally acceptable and applicable to Oil & Gas industries or may be calculated using standard latest software.

5.3 For each loss of containment event, its outflow and dispersion in the environment should be calculated to get LFL distance or toxicity limit such as LC 50 Value & other value as per IS 15656. Various types of models which may be used as follows:

- Outflow and Spray release
- Spreading liquid
- Sharp Orifice
- Pool Evaporation
- Vapor Cloud Dispersion
  a) Jets and Plumes
  b) Dense Gas dispersion
  c) Passive Dispersion
- Vapor Cloud Explosion
- Heat flux from Fires
- Rupture of Vessels

The above models are for illustration purpose and do not represent the comprehensive list. The models as specified in the standard guidelines should be used and which may be built with the standard software (Names and detail features of the software to be mentioned).

5.4 The release duration for a loss of containment event will be taken as 30 minutes or as considered appropriate by the agency & GAIL on mutual agreement based on the condition and type of installation.

5.5 The risk should be calculated in terms of probability of death of an individual or fraction of population expected to die due to the exposure effects such as toxicity, heat radiation and overpressure etc.

5.6 The consequence analysis and risk calculation should be made for cases of direct ignition, delayed ignitions based on the suitability to the installation considering the probability for the same and accordingly the effect of consequences such as jet fire, pool fire, flash fire, explosion, unconfined vapor cloud explosion (UCVE) should be evaluated.

5.7 The QRA study should also take into account the domino effect i.e the hazards posed by an installation which can lead to further escalation on account of its proximity/Vicinity to other installation.

5.8 Both the individual and societal risks (if applicable due to presence of population within a distance of 5 Kms in the effect zone) for each consequence shall be calculated and presented in the form of risk contours & FN curves respectively.
5.9 Internationally acceptable (latest version) software shall be used for QRA study purpose and its validity to be ensured.

6.0 Risk Calculation & Risk Presentation.

- Based on the results of the consequence analysis, both individual risk and the societal group risk of each incident will be estimated.
- The individual risk will be estimated taking into consideration the detailed weather conditions, probable ignition sources identified and the details of population and other facilities in the near vicinity of the pipeline facilities.
- The individual risk computed would be presented in the form of Risk Contours, which represents the chance of an individual fatality.
- To calculate societal group risk, the total number of people killed for each release case, event tree outcome, weather type and wind direction must be calculated. The frequencies of all those combinations contributing to the same number of fatalities must be summed.
- These results to be presented in the form of an FN societal group risk curve. An FN curve is a graph, which plots the frequency of N or more fatalities per year (F) against the number of fatalities (N).
- The risk should be ranked according to and considering their intolerability and for each risk measures should be suggested to mitigate and reduce those risks

7.0 Acceptable Risk

The estimated risk levels will be compared with acceptable individual risk acceptance criteria (Fatality Per Annum) in line with ERDMP. Based on the findings of the risk analyses, conclusions shall be made and suitable recommendation shall be suggested for risk reduction and mitigation of consequences to ensure ALARP performance in the operation.

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Individual Risk Per Annum (IRPA)</th>
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<tbody>
<tr>
<td>Unacceptable Risk</td>
<td>&gt; 1.0 x 10⁻³</td>
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<tr>
<td>Tolerable Risk (Subject to the implementation of mitigation measures to reduce risk to As Low As Reasonably Practicable (ALARP).)</td>
<td>&gt; 1.0 x 10⁻⁵ and &lt;1.0 x 10⁻³</td>
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<tr>
<td>Broadly Acceptable Region</td>
<td>&gt; 1.0 x 10⁻⁵</td>
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8.0 Report Structure.

8.1 A typical QRA report shall include the following
- Introduction
- Scope of work
- Facilities description
- Study methodology
- Detail Study inputs
- Study results
- Conclusion & recommendations

8.2 Study result shall include
- Individual risk – contour
- Individual Risk at reference points
- Societal risk- FN curves
- Major risk contributors to societal risk
- Risk Ranking
- Mitigation measures
- Consequence analysis [dispersion, heat radiation & overpressure contours for minor, major and FB leakage]

9.0 Competency

9.1 For process plants the agency must have executed at least single work order of QRA in hydrocarbon process industry i.e. Petrochemicals, Refinery & Fertilizers in last 5 years.

9.2 Agency should be able to deploy personnel with BE/B. Tech (Chem./Mech/Elec./Inst./ Env.) qualification & minimum experience of 10 years for team leader & 5 years for others.