Guidelines for Quantitative Risk Assessment (QRA)

*Pipeline & its installations*
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 pipelines 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 Pipeline Installations 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 In order to undertake QRA, first the information is required about the pipeline network and the facilities (valve stations, compressor stations etc.) as below:

- Relevant data regarding plant, process, pipeline etc. of GAIL installation
- Preparation of suitable data base from Generic failure rate data from past incidents, UKOPA, European pipeline failure data, US gas transmission data etc.
• Adjusting the failure data to reflect actual pipeline mechanical and process conditions, e.g. pipeline diameter, thickness, pressure and temperature, coating, line passing through urban area or rural area and so on.

• Estimating population data on 200 meter either side of center of pipeline route. Meteorological data required to perform QRA from meteorological departments.

• Ignition source data during site visit for point source, line source (Roads, Railway Line, and Electrical transmission line) and area source.

5.2 The next step is hazard identification and consequence estimation as below:

• After collection of all data and information, a list of failure scenarios shall be made and all the major hazards/ hazardous zones that can arise from the pipeline facilities and which could affect the integrity of the facilities shall be identified.

• The study shall cover fire, explosion hazards and also toxic/health hazards.

• Hazards to the installation shall on various failure mode causes by Man-Made, Natural Calamities & Extraneous.

• The potential impact on downwind air quality or downstream water quality from an incidental release and possible danger to human, Flora and Fauna and animal health shall be identified.

• In general, the following typical types of failures with or without fire/explosions associated with underground pipeline shall be considered:
  
  a. Full Bore Rupture  
  b. Hole (20 mm – Diameter of Pipeline)  
  c. Pin Hole/Crack (5 mm – 20 mm)

For above ground pipelines following additional failures with or without fire shall be considered

  d. Depressurization of Pipeline  
  e. Flange Gasket Failure  
  f. Instrument Tubing Failure

• The effects of these scenarios on the adjoining facilities, if any shall also be studied.

• For the selected failure cases under the failure case list, the hazard distances (Vertical jet, Impingement etc) shall be calculated with respect to Lower Flammability Limit (LFL) of the material, Thermal radiation effects, Blast over Pressure effects for the predominant weather condition prevailing including wind velocity, stability class, temperature etc. at the site. The consequence results will be reported in terms of LFL distance, thermal radiation distances, and blast overpressure distances.

5.3 Estimation of failure frequencies for the selected failure cases shall be done from in-house available data and/or literature and/or internationally acceptable data bank and applicable to Oil
& Gas industries or may be calculated using standard latest software.

5.4 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>
</tr>
<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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</tbody>
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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 Pipeline installations the agency must have executed at least single work order of QRA in Cross Country Hydrocarbon pipelines along with its associated facilities in the 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.