Quantitative Risk Assessment

18th November 2014

OISD–API seminar on

“Enhancing Process Safety in O&G Installations”
Overview

• Introduction
• Process Safety & QRA
• Statues & standards that recommend QRA
• QRA Methodology
• QRA for Hydrocarbon Transportation - case study
• Applications & limitations of QRA
• QRA Study in India – challenges faced
Quantitative Risk Assessment (QRA) - a decision making tool

Risk analysis provides answers for the following questions -
- What can go wrong?
- How likely is it?
- What are the impacts?

Risk assessment
- evaluate the results of risk analysis to indicate whether risks are tolerable
- assist in achieving risk reduction to ALARP level
- assist in selection of option especially during project phase

Assist in communicating with the workforce and third parties regarding their impact on risk and their exposure to risk

Demonstrate compliance with legislation & organization policy
• Major disasters of the 1970s and 1980s
  ▪ Flixborough (UK)
  ▪ Bhopal (India)

• Process safety recognized as critical – “must never happen again”

• 1980s/90s - Emphasis on personal safety

• Late 1990s – Focus on product safety

• Early 2000s – Warning signs that the likelihood of major process incidents are increasing
Statues & standards that recommend QRA

- MSIHC Rules
- P& NG (Safety in Offshore Operations) Rules, 2008
- PNGRB (Technical Standards & Specifications including Safety Standards for Natural Gas Pipelines) Regulations, 2009
- IS-15656 Code of practice on Hazard Identification & Risk Assessment
- OISD-227 - Emergency Response Preparedness in E&P industry
- OISD-232 - Identification of Hazards and Control Measures in E&P
- CPCB publication on “Risk assessment in Oil refinery & petrochemical complex”
QRA Methodology

1. Hazard Identification (IHAZID process)
2. Scenario Development
3. Frequency Analysis
4. Consequence Analysis
5. Risk Assessment
6. Risk Tolerance Criteria
7. Investigate Further Risk Reduction Measures
8. Event Trees which take consideration of:
   - Weather conditions
   - Population distributions
   - Plant layout
   - Fatality models
   - Protective equipment
   - Emergency response
9. Are risks reduced to a level that is as low as is reasonable?
   - Yes: Document Plan to Implement agreed risk reduction measures
   - No:
10. Release modeling
11. Dispersion modeling
12. Explosion models
13. Fire models
14. Walkthrough PFDs
15. Process descriptions
16. FN Curve (Societal Risk)
17. Individual Risk Contours
18. Good Practice
19. Codes & Standards
Pipelines are a safe and efficient means of transporting large quantities of hydrocarbons

- Require significantly less energy to operate
- A much lower carbon footprint
Massive explosion in Natural Gas pipeline in Andhra Pradesh kills 21 & left several injured – 27th June 2014
Taiwan Propylene pipeline blasts kill 25 - July 31st 2014
Description of the facility -

• 7.8 Km long crude oil pipeline from tank farm to refinery is considered for the study
• Pipelines are mostly underground, but exposed to atmosphere only at valve stations
• Some pipelines have pigging facility
QRA Case study – Consequence Analysis

- LOC scenarios identified
- Potential for damage or injury from specific incidents determined
- Single incident (e.g. Leak/Rupture of crude oil pipeline) can have many distinct incident outcomes e.g.
  - Fire
    - Jet fire
    - Pool fire
    - Flash fire
  - Explosion
    - Vapor Cloud Explosion (VCE)
  - Un-ignited Gas dispersion (Toxic)
QRA Case study – Consequence Analysis

Liquid/Multiphase flow

Release orientation

Weather conditions
  Surface roughness

Hole size

Buried pipelines

Mass flow rates

Consequence analysis

- Failure frequency calculation
- Risk estimation
- Risk presentation
- ALARP demonstration
QRA Case study – Consequence Analysis

Results of consequence analysis

Jet & Pool Fire (1.5F & 5D)
1. 6 kW/m²
2. 12.5 kW/m²
3. 37.5 kW/m²

Exp. of 20 sec to 37.5 kW/m² - 100% fatality

Flash Fire (1.5F & 5D)
1. 0.5LFL
2. LFL
3. UFL

Inside LFL - 100% fatality

VCE (1.5F & 5D)
1. 0.1 bar
2. 0.3 bar
3. 0.5 bar

>500mbar - 100% fatality

Toxic dispersion (1.5F & 5D)
• IDLH

Consequence analysis

Failure frequency calculation
Risk estimation
Risk presentation
ALARP demonstration
QRA Case study – Frequency calculation

• Parts count
• Release duration
• Ignition probabilities
• Interaction length for pipelines
• Failure frequency from database
• Event tree analysis

Consequence analysis

Risk estimation

Risk presentation

ALARP demonstration
QRA Case study – Risk estimation

Risk = Likelihood * Severity

Risk depends on:
- Consequence results
- Base event frequency
- Ignition probability
- Weather conditions
- Population density in the area etc.,
**QRA Case study – Risk presentation**

**Individual risk** –
directly related to the proportion of time individuals spend at a particular location

**Societal risk** -
relationship between frequency and the number of people suffering from a specified level of harm in a given population from the realization of specified hazards.

**Location Specific Individual Risk** -
measure of the inherent hazard associated with different geographic locations within a plant or facility.

**Potential Loss of life** -
product of the workgroup IR and the number of members of the workgroup.
QRA Case study – Risk presentation
QRA Case study – ALARP demonstration

Risks associated with the pipeline is compared with Risk Tolerability Criteria to evaluate the tolerability.
QRA Case study – Risk reduction

The various risk mitigation measures considered at specific sections of the pipeline are:

- Increase in depth of cover
- Provision of concrete slab covers & sleeve
- Increase in pipe wall thickness
- Provision of cathodic protection
- Periodical patrolling, inspection & testing
- Reduction in the distance (inventory) between sectionalizing valves
- Increase in the separation distance between proposed redevelopment and pipeline manifold
Modeling implies a series of uncertainties

Sensitivity analysis is required to be carried out to provide an indication of the criticality of the input data

Sensitivity analysis is carried out for

- Failure frequencies
- Release orientation (vertical, downward and angled)
- Impact distance for 0.5LFL
- Isolation probability
- Ignition probability
Applications of QRA

- Design Evaluation
- Fire Risk Assessment
- Facility Siting
- Fire & Gas detection
- Public liability
- Emergency planning
Limitations of QRA

Methodology

Scenario selection

Environmental conditions

Software models

Frequency database
**QRA Study - Overseas vs India**

- Rule sets available
- Leak size specified & parts count done
- Failure frequency database specified
- Risk Acceptance criteria available
- Sensitivity Analysis done

- Rule sets are not available
- Leak Size not specified & parts count not done
- Failure frequency database not specified
- Risk Acceptance criteria of other countries adopted
- Sensitivity Analysis not done
QRA Study in India – challenges faced

- Consistency in QRA methodology, Assumptions & rule sets
- Regulatory requirements, in particular on risk tolerability criteria
- Uncertainties in data and in modeling
- Approved consequence and risk models, validation, etc.
- Sensitivity of results to input data
- Presentation of results
- Input into other critical processes
- Integration of risk from multiple areas/activities
- Timely implementation of QRA recommendations