Brief Overview Quantitative Risk Assessment (QRA) Life-Cycle and Methodology

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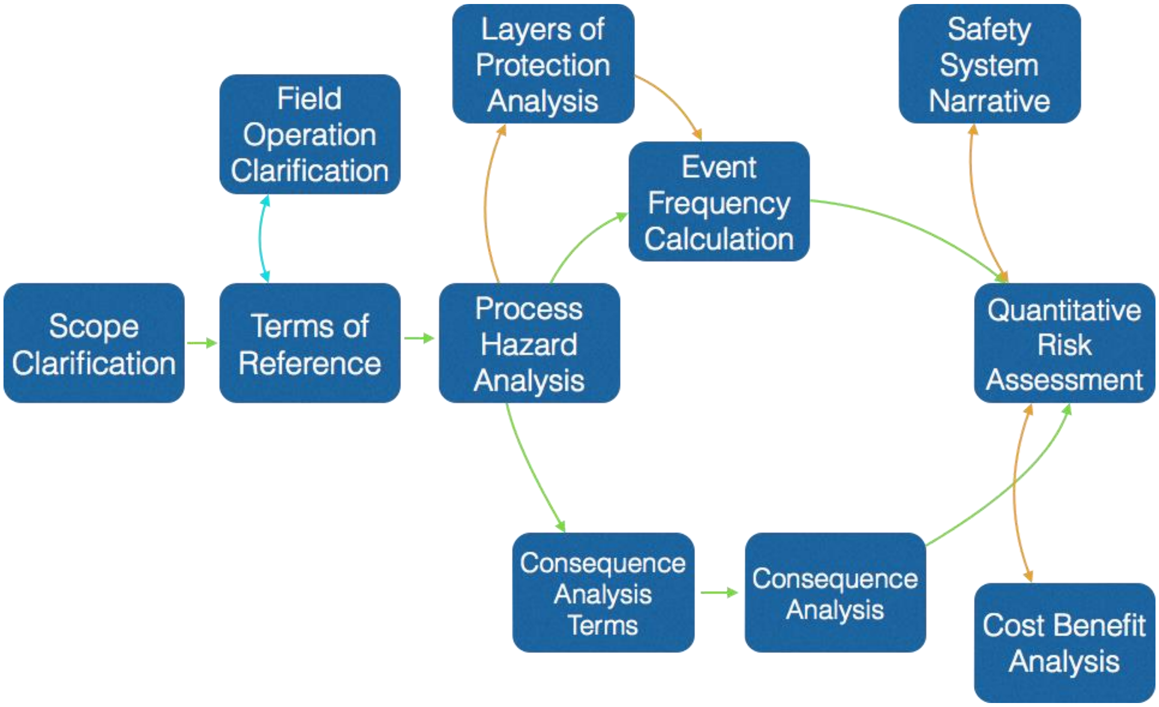
INTRODUCTION

Quantitative Risk Assessment (QRA) tools are used to determine, evaluate and manage high risk complex processes. Often a generic approach is taken to provision of a QRA, although this may result in streamlining the process it lacks the much needed custom approach necessary to address the complexity of the assessment. The proposed life cycle however, provides a unique approach where a QRA life-cycle is adopted and a breakdown of key phases allows for customisation of the study. Guidance is provided on potential challenges in delivering the required activities for each phase and the importance of a QRA Terms of Reference.

QRA METHODOLOGY OVERVIEW

The QRA methodology encompasses an array of studies, which allow the overall risk for to be acquired. Figure 1 provides an overview of the QRA Life Cycle.

Figure 1. QRA Life Cycle



It should be noted that a detailed QRA study entails qualitative and semi-quantitative risk assessment techniques as part of the input in to the quantification of risk.

1.1 Hazard Types

Consideration should be made to all process hazards however the following are often typical:

- Process hazards.

- Overpressure scenarios where process can exceed Maximum Allowable Operating Pressure.
- Loss of containment due to leaks from Flanges, Valves, Instrumentation and Fittings.
- Corrosion and erosion.
- External impacts

1.2 QRA Life Cycle Technical Steps

Scope Clarification
It is essential to get full clarity on the scope of the assessment and facilities prior to starting collation of data and information. This is of particular importance where perhaps offshore and onshore portion of particular facilities are to be assessed at difference times.

Terms of Reference
Having clarified the scope, the first step is to develop a Terms of Reference (ToR). The ToR will capture all the necessary information to initiate a QRA and will continue as a live document throughout the QRA project.

Field Operations Identification
Complex facilities which have difference modes of operations shall be evaluated and identified. It should be noted that modes of operation may have difference hazards associated with them and thus contribute differently to the total calculated risk.

Hazard Identification
The next step is Process Hazard Identification (PHA) which pinpoints the major causes of hazards for the facility and identifies their broad consequences. This step provides the foundations for the study as is a key input for the following steps and is often conducted as a Hazard Identification (HAZID)

The HAZID is conducted to identify hazardous scenarios that could lead to significant adverse consequences. The HAZID process and brainstorming workshops qualitatively identified the potential causes, which could lead to the hazardous events. The consequence of these hazardous releases are also discussed, however detailed quantitative approach such as a Frequency Analysis is needed to calculate the frequencies and a detailed consequence analysis modelling is required in order to better ascertain the consequence of the identified hazardous events.

Frequency Analysis

Frequency analysis is carried out in two stages. Initially it is semi-quantitatively through the Layers of Protection Analysis (LOPA) methodology as a part of the PHA study, which determines the most significant causes of overpressure as well as protection layers which may mitigate those scenarios. Following this Fault Tree Analysis (FTA) is employed to build a more complete picture of potential overpressure cases. The preliminary LOPA allows for indication of any Safety Integrity Level (SIL) rated Safety Instrumented Functions existing or proposed.

Consequence Analysis

The consequences of a potential hazards are fully modelled and analysed using technical tools such as DNV PHAST and Shell FRED. This can consider flammable effects such as jet and pool fires, Vapour Cloud Explosions (VCEs) and Boiling Liquid Expanding Vapour Explosions (BLEVEs) as well as toxic effects if a sour field is being studied.

Event Tree Analysis

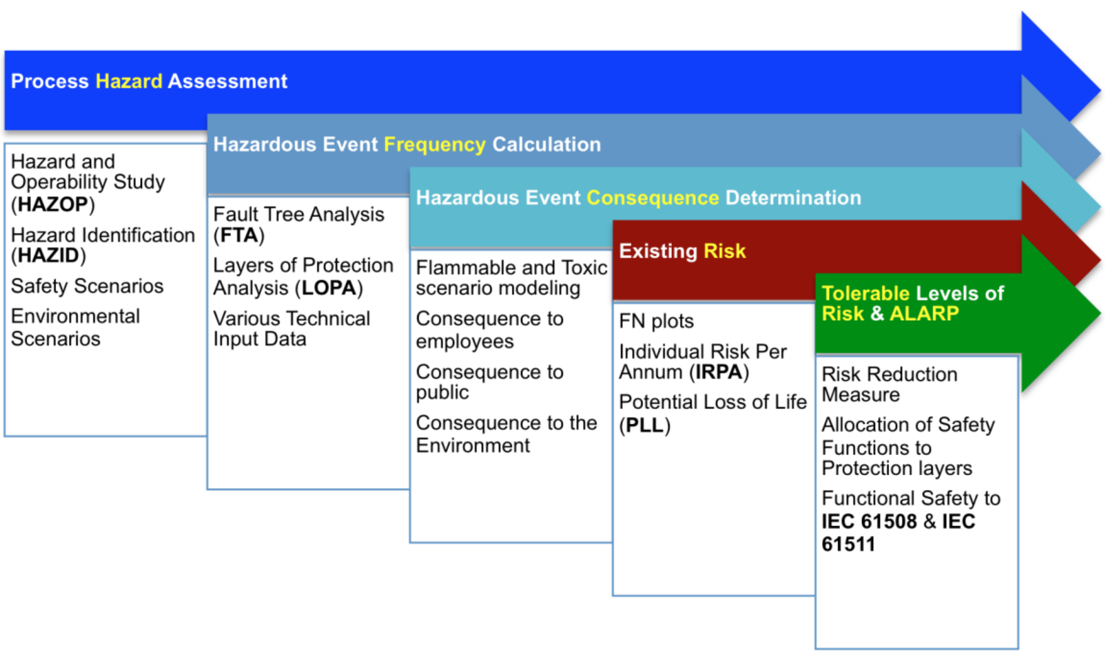
Event trees are ‘bottom-up’ analytical tree diagrams that determine the overall likelihood of a consequence. The event trees start with an initial hazard frequency, after which conditional modifiers such as ignition, etc. are applied and an overall frequency is calculated.

Results from the consequence modelling are used as part of the analysis to determine the number of potential fatalities from a particular hazardous event (e.g. flash fire).

Risk Assessment

These consequences are combined with the frequencies determined from FTA in the final risk assessment stage which considers factors such as probability of ignition, occupancy and leak frequencies to calculate an overall Individual Risk per Annum, which is compared with corporate risk criteria. Additional deliverables may include System Narrative documents for implementing SIFs and Lifecycle Cost (LCC) studies to compare the financial costs of several methods of risk reduction.

Figure 2. Technical Delivery



1.3 Risk Assessment

The risk calculations are carried out using the intermediate event frequencies from the Event Tree Analysis, results from the consequence modelling and the probability of fatality as a result of the hazardous release and effect. The following sub-sections summarise the methodology and calculations that have been carried out.

Potential Loss of Life

PLL is defined as the level of risk (potential fatality) experienced by a group of people exposed to a hazard during a given year of plant operation. PLL is dependent on the number of people present in each group.

The ETA gives the frequencies for a list (n) of potential fatal accidents (Fi), and the consequence analysis calculates the number of fatalities for each of the fatal accidents (Ni). The PLL for each location is calculated by using the following equation:

$$PLL = \sum_{i=1}^{n} F_i \times N_i$$

In the above calculation Fi is taken as the impact frequencies determined from the ETA and other conditional modifiers, including occupancy percentage, weather category percentage, wind direction factor and fraction of pipe that can potentially cause risk. Ni is determined on the basis of consequence results, maximum number of personnel on site, site area and probability of fatality.

Individual Risk per Annum

IRPA is the risk experienced by a single individual in a year. For offshore facilities that are generally unmanned, the IRPA and PLL has the following relationship:

$$PLL = IRPA \times P_N$$

Where; PN is the maximum number of people may be present at a given location.

F-N Plots

F-N curves, i.e. curves relating the cumulative probability per year of causing N or more fatalities (F) to N, are plotted for overpressure scenarios, leaks and a combination of both in order to assess the risk and compare it with client's corporate risk criteria, in particular the maximum tolerable risk target.