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# Quantitative Risk Assessment For Industrial Safety

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## ABSTRACT

Risk assessment (RA) is a means of making a systematic analysis of the risks from hazardous activities, and forming a rational evaluation of their significance, in order to provide input to a decision-making process.

RA is sometimes called 'probabilistic risk assessment' or 'probabilistic safety analysis'; terms originally used in the nuclear industry. The term 'quantified risk assessment' is synonymous with QRA as used here. The term 'quantitative risk analysis' is widely used, but strictly this refers to the purely numerical analysis of risks without any evaluation of their significance [5].

RA is probably the most sophisticated technique available to engineers to predict the risks of accidents and give guidance on appropriate means of minimising them. Nevertheless, while it uses scientific methods and verifiable data, RA is a rather immature and highly judgemental technique, and its results have a large degree of uncertainty. Despite this, many branches of engineering have found that RA can give useful guidance. However, RA should not be the only input to decision-making about safety, as other techniques based on experience and judgement may be appropriate as well.

Keywords: QRA, Risk Assessment, Safety Analysis

## I. INTRODUCTION

### WHY DO WE DO QRA?

- Legal requirement
- To understand risks and manage them effectively
- To support a land-use planning decision
- When a major change (with risk implications) is planned
- To calculate risk exposure and insurance requirements
- Decision support:
  - Selection between costly options (concept/location/layout)
  - To reduce risks (maximise safety) cost-effectively

## WHY RISK, NOT JUST CONSEQUENCES?

- Consequences alone tell only part of the story
  - High-consequence events are also (usually) extremely rare
  - Likelihood is also important
- Worst cases rarely dominate risk
- Moderate-consequence, moderate frequency events often do
- Total risk exposure is the sum of risks from the full range of events
  - Therefore, look at range of events to get total risk exposure
- Mitigation focused on worst cases may incur heavy expenditure
  - The expenditure may not be justified if the worst cases are rare
  - The expenditure may not address the risk drivers
  - The mitigation may not be cost effective

## ADVANTAGES OF QRA

- Considers thousands of scenarios that involve multiple failures, thus providing an in depth understanding of system failure modes. Such an enormous number of possible accident scenarios cannot be investigated by traditional methods. The completeness of the analysis is significantly enhanced by the RA investigation
- Increases the probability that complex interactions between events/systems/operators will be identified
- Provides a common understanding of the problem, thus facilitating communication between various stakeholder groups
- Facilitates risk management by identifying the dominant accident scenarios so that resources are not wasted on items which are insignificant contributors of risk.

## *KEY COMPONENTS IN RA*

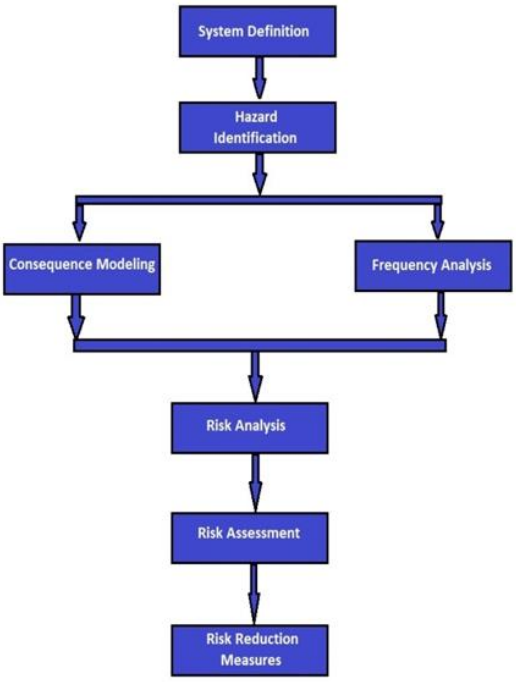

Figure 5.1: RA Methodology Flowchart

The study is based on the premises of a traditional Risk Assessment. The key components of a RA are explained belowand illustrated in figure below.

## SYSTEM DEFINITION

System definition is the first step prior to conducting the assessment which involves definition of facilities and personnel to include in the analysis, identification of the scope of work for the QRA, selecting the suitable methodology, criteria and assumptions that form the basis of the study. This is to define goal of the study, boundaries for the study, identifying which activities are to be included and which are to be excluded.

Studying project drawings (PFD, P&IDs, and Layouts), process description, process condition, and process parameters plays major roles in system definition.

In a QRA, hazard identification uses similar techniques, but has a more precise purpose – defining the boundaries of a study in terms of materials to be modelled, release conditions to be modelled, isolatable sections within the process, impact criteria to be used and identifying and selecting a list of failure cases that will fully capture the hazard potential of the facilities to be studied.

Failure cases are usually derived by breaking the process system down into a larger number of sub- systems, where failure of any component in the sub-system would cause similar consequences. In pipeline case, this can be performed by breaking the line into sections depending on availability of isolation valves along the line.

## CONSEQUENCE MODELLING

Consequence modelling evaluates the resulting effects if the accidents occur, and their impact on people, equipment and structures, the environment or business, depending on the defined scope of the RA study. Consequence modelling will be conducted to evaluate the effect distances of the identified LOC scenarios and their impact on people and nearby structure this comprises evaluating physical effects modelling to determine the size of the hazard that is associated with the released fluid (for example heat radiation, flammable gas dispersion, toxic gas dispersion and explosion overpressure as applicable) and comparison of the physical effects model with the impact criteria. Estimation of the consequences of each possible event often requires some form of computer modelling like ALOHA, PHAST etc.

## FREQUENCY ANALYSIS

The frequency analysis estimates how likely it is for the accidents to occur, based on the type and number of equipment components included in the defined failure cases. The component failure frequencies to be used are usually derived from an analysis of historical accident experience, or by internationally accepted failure frequency available databases like OGP, UK-HSE etc.

The base failure frequencies are often converted into actual frequencies depending upon type of facility by mathematical formulas and part count methodology. This numerical analysis gives a clear idea to distinguish between frequent and rare scenarios i.e. their chances of occurrence.

### *RELEASE SIZES CONSIDERED*

As per QRA best practices and OGP (2019 edition) guidelines, below table present the representative release sizes, which shall be used for the Process Area, Pressurized Storage Vessel and Storage Tanks.

Table 5.1: Representative Release Size for Process Area

| Release Category | Hole Diameter (mm) | | | |
|---|---|---|---|---|
| | Range (mm) | Nominal (mm) (for pipeline size ≤ 150) | Nominal (mm) (for pipeline size > 150) | Nominal (mm) (for Vessel) |
| Pinhole | 1-10 | 5 | 5 | 5 |
| Medium Leak | 10-50 | 25 | 25 | 25 |
| Rupture | >150 | Full Bore | Full Bore | Catastrophic |

### *RELEASE DURATION*

The release duration may also influence the consequence modelling. In this study, as per QRA guideline "Guideline for quantitative risk assessment – Purple Book (TNO) CPR 18E" the maximum release duration is assumed as 30 minutes (1800 seconds). The inventory released shall primarily be governed by the dynamic inventory based on the isolation time philosophy and release rate

### RISK ANALYSIS

After the frequencies and consequences of each modelled scenario (combination of initiating event, cause, and consequence) were estimated, they were combined to produce quantified risk results. The risk was calculated for each frequency-consequence pair, and then summed for each area of interest to yield a total risk for the area. Risk quantification results are typically presented in several different ways to provide a complete picture. The quantified risk results can be grouped into two general groups – Individual and Societal Risk.

Individual Risk (IR) – IR is a measure of the risk at a location, regardless of whether a person might be present or not.

Societal (Group) Risk - Societal Risk (SR) is typically presented as an FN curve plotted on a log-log scale. SR is a measure of the relationship between the cumulative frequency (F) and number of fatalities (N). It is defined as the risk experienced by a group of people (including workers and the public) exposed to the hazard.

### RISK ASSESSMENT

Up to previous step, the process has been purely technical, and is known as risk analysis. The next stage is to introduce criteria, which are yardsticks to indicate whether the risks are acceptable, or to make some other judgement about their significance. Risk assessment is the process of comparing the level of risk against a set of criteria (from governmental regulatory requirements, recommended guidelines, or corporate guidelines)to indicate whether the risks are tolerable or to make some other judgment about their significance as well as the identification of major risk contributors. The purpose of risk assessment is to develop mitigation measures for unacceptable generators of risk, as well as to reduce the overall level of risk to As Low as Reasonably Practicable (ALARP).

## *ISOLATION TIME*

As per TNO Purple book CPR 18 (E) guideline, below table represents the isolation time philosophy of the various process systems:

Table 5.2: Isolation Time

| Process System | Isolation Time (min) |
|---|---|
| Fully automatic blocking system (including automatic detection and closure of block valves) | 2 |
| For remote operated blocking systems (detection is automatic, but control room operator must validate alarm signal and close block valve remotely) | 10 |
| For hand-operated blocking systems (detection is automatic, but control room operator must validate alarm, go to field, and manually close block valve) | 30 |

The process area of the plant is having remote operated blocking system. Gas detectors, pressure, temperature, and flow transmitters are available in the process area for detection of any irregularities/leak. These irregularities/leak will alarm the concerned personnel in the Control room/ substation to take necessary action. Therefore, 2 minutes, 10 minutes and 30 minutes of isolation time and dynamic inventory calculation has been considered as per scenarios for this QRA study.

## RISK REDUCING MEASURES

Risk Reducing Measures (RRM) process starts by identification of the Major Risk Contributors to given worker group or at a location. These major risk contributors are further drilled down to determine the top contributors to risk. Risk reduction measures are identified against these contributors to reduce the risk. While identifying these risk reduction measures hierarchy of controls shall be maintained. Once these major risk contributors are identified and risk reduction measures are highlighted, an ALARP workshop shall be conducted to discuss and brainstorm these risk reduction measures or any additional risk reduction measures. In order to help assess the viability of, the economic costs of the measures can be compared with their risk benefits using Cost Benefit Analysis (CBA).

## IGNITION PROBABILITIES

The ignition sources observed, and their probability of ignition considered for this QRA study is tabulated below:

Table 5.3: Ignition Probabilities

| Source | Ignition Probability | Time period (minute) |
|---|---|---|
| **Point Source** | | |
| Workshop | 0.3 | 1 |
| Fabrication/Switch Yard | 0.5 | 1 |
| Canteen | 0.6 | 1 |
| **Line Source** | | |
| Road (motor vehicle without spark arrestor) | 0.4 | 1 |

## RISK MODELLING WITH PHAST AND SAFETI VS8.4

Phast& Safeti has become an internationally recognized package for RAs for onshore facilities. The study utilized the Phast & Safeti software package throughout the modelling process.

The software is used by governments and regulatory authorities and is in use on over 30 sites worldwide. Regular User Group meetings are organized to identify further needs for improvement. This allows for software upgrades incorporating industry experience and expertise, as well as for capturing advances in consequence modelling and risk analysis technology. The basis for this risk study is Phast & Safeti Vs 8.4.

Phast & Safeti automates the risk assessment of chemical and petrochemical facilities where toxic and flammable materials are manufactured, stored, and transported. As a major decision-support tool, Phast & Safeti can be used during strategic planning, facility sitting andlayout, and for detailed riskand safety assessments. Phast & Safeti combines a complete library of rigorous mathematical models which, either singly or in combination, are used to calculate the risk associated with a hazardous facility or activity. The consequence models include detailed modelling of the impact of the following event outcomes: dispersing toxic gas cloud, explosion, fireball, BLEVE, flash fire, jet fire, and pool fire.

Phast & Safeti has different built-in event trees that are automatically selected based on type of material and release conditions. These event trees determine which alternate consequences may be associated with each release, and their fractional probability. Event-trees assign the “split” between alternate consequence outcomes (e.g. fireball, jet fires and explosions, no hazard), based on immediate ignition, delayed ignition and no ignition probabilities.

Risk contours, societal FN curves, and rankings of risk contributors are the main output parameters. With this information, the safety of an installation against any risk criteria can be assessed and guidance obtained concerning possible mitigation measures such as changes in design, operation, response or land use planning. Risk results are available graphically and may be overlaid on digitized maps, satellite photos and plant layouts.

Phast & Safeti is a consequence modelling package that can be used to assess situations which present potential hazards to life, property and the environment and to quantify their severity.

Phast & Safeti examines the progress of a potential incident from the initial release to far-field dispersion including modelling of pool spreading and evaporation, and flammable and toxic effects. The results from the analysis can be displayed in tabular & graphical form, so the extent of the impact can be seen, and the effect of the release on the population and/or workforce and environment can be assessed.

## *DISPERSION & STABILITY CLASS*

The factors that affect dispersion are wind velocity, stability class, temperature as well as surface roughness Atmospheric stability is an important criterion for dispersion, which depends on the difference between surface and air temperatures. It is a measure of the atmospheric turbulence caused by thermal gradients. It is generally a function of vertical temperature profile of the atmosphere. The stability factor directly influences the ability of the atmosphere to disperse pollutant emitted into it from sources in the plant. In most dispersion problems relevant atmospheric layer is that nearest to the ground. The turbulence induced by buoyancy forces in the atmosphere is closely related to vertical temperature profile.

Temperature of atmospheric air normally decreases with increase in height. The rate of decrease of temperature with height is known as the lapse rate. It varies with time to time & place to place. Pasquill has defined stability classes.

Table 5.4: Pasquill Stability Classes Derivations (As per PHAST Software)

| | |
|---|---|
| A | Very unstable – Sunny, Light Winds |
| A/B | Unstable – As with A only Less Sunny or More Windy |
| B | Unstable – As with A/B only Less Sunny or More Windy |
| B/C | Moderately Unstable – Moderate Sun and Moderate Wind |
| C | Moderately Unstable – Very Windy / Sunny or Overcast / Light Wind |
| C/D | Moderately Unstable – Moderate Sun and High Wind |
| D | Neutral – Little Sun and High Wind or Overcast / Windy Night |
| E | Moderately Stable – Less Overcast and Less Windy Night than D |
| F | Stable – Night with Moderate Clouds and Light / Moderate Wind |
| G | Very Stable – Possibly Fog |

Validation of software is important to obtain reliable results, and Phast & Safeti is amongst the world’s most validated consequence modelling software packages, using comparisons with observations during both experiments and real-life incidents.

## *MAJOR GENERAL HAZARDS*

This chapter describes details of consequence modelling and damage criteria applied for the study.A brief description of the following general possible hazards envisaged for project facility is given in this section.

a) Flash Fire
b) Jet Fire
c) Pool Fire
d) Vapour Cloud Explosion (Overpressure)
e) Fireball/ BLEVE

### FLASH FIRE

A Flash Fire is low-intensity combustion without explosion, whose effect zone is up to the LFL region of the cloud. A flash fire may occur if the gas cloud reaches a source of ignition and rapidly burns back to the source of release. Due to the short duration of a flash fire, only people within the fire path will be affected.

In case of flammable material, the cloud dispersion simulation provides the distance (from the source/ leak) at which the concentration of flammable material reaches its Lower Flammability Limit (LFL) value.

The effect of flash fire on people is evaluated in terms of flammable gas envelope. The impact distance for flash fire is considered up to lower flammability limit (LFL) from release source. LFL & 0.5 LFL criterion will be studied in this report.

### JET FIRE

Release of a flammable material at high pressure due to hardware failure (leak) may lead to formation of jet, which may cause jet fire on immediate availability of ignition. The jet flame direction & tilt depend on prevailing wind direction & velocity.

The Jet Fire could damage the neighbouring vessels / tanks by direct flame impingement. The thermal radiations may as well affect surrounding population.

A jet or spray fire is a turbulent diffusion flame resulting from the combustion of a fuel continuously released with some significant momentum in a particular direction or directions. Jet fires can arise from releases of gaseous, flashing liquid (two phase) and pure liquid inventories.

Jet fires represent a significant element of the risk associated with major accidents on onshore/offshore installations. The high heat fluxes to impinged or engulfed objects can lead to structural failure or vessel/pipework failure and possible further escalation. The rapid development of a jet fire has important consequences for control and isolation strategies.

The properties of jet fires depend on the fuel composition, release conditions, release rate, release geometry, direction and ambient wind conditions. Low velocity two-phase releases of condensate material can produce lazy, wind affected buoyant, sooty and highly radiative flames similar to Pool Fires.

### POOL FIRE

A Pool Fire is a turbulent diffusion fire burning above a horizontal pool of vaporising fuel where the fuel has zero or low initial momentum. Fires in the open will be well ventilated (fuel-controlled), but fires within enclosures may become under-ventilated (ventilation-controlled). Pool Fires may be static (e.g. where the pool is contained) or 'running' fires.

Pool Fires represent a significant element of the risk associated with major accidents on offshore installations, particularly for Northern North Sea (NNS) installations that may have large liquid inventories.

### VAPOR CLOUD EXPLOSION (OVERPRESSURE)

Explosion is a sudden and violent release of energy, which may be in the form of physical energy or chemical energy. Continuous release of flammable material over a period may lead to formation of vapour cloud on unavailability of immediate ignition. This may lead to **V**apour **C**loud **E**xplosion (**VCE**), if this cloud gets ignition before it is diluted to the concentration below the Lower Explosive Limit (LEL) in air.

The explosion will cause overpressure resulting into damage to the surrounding buildings and equipment. The overpressure effect of explosion has been evaluated by baker Strehlow Model.

### BLEVE

Boiling Liquid Expanding Vapour Explosion (BLEVE) is an explosion caused by the rupture of a vessel containing a pressurized liquid that has reached temperatures above its boiling point. Because the boiling point of a liquid rises with pressure, the contents of the pressurized vessel can remain liquid so long as the vessel is intact. If the vessel's integrity is compromised, the loss of pressure and dropping boiling point can cause the liquid to rapidly convert to gas and expand extremely rapidly. If the gas is combustible as well, further damage can be caused by an ensuing fire.

There are three key elements causing a BLEVE:

i. A substance in liquid form at a temperature above its normal atmospheric pressure boiling point.
ii. A containment vessel maintaining the pressure that keeps the substance in liquid form.
iii. A sudden loss of containment that rapidly drops the pressure.

Typically, a BLEVE starts with a container of liquid, which is held above its normal, atmospheric pressure boiling temperature. Many substances normally stored as liquids, such as ethane, propane, butane and other similar industrial gases have boiling temperatures, at atmospheric pressure, far below room temperature. If the pressurized vessel, containing liquid at high temperature (which may be room temperature, depending on the substance) ruptures, the pressure which prevents the liquid from boiling is lost. If the rupture is catastrophic, where the vessel is immediately incapable of holding any pressure at all, then there suddenly exists a large mass of liquid which is at very high temperature and very low pressure. This causes a portion of the liquid to "instantaneously" boil, which in turn causes an extremely rapid expansion.

Depending on temperatures, pressures and the substance involved, that expansion may be so rapid that it can be classified as an explosion, fully capable of inflicting severe damage on its surroundings.

## *DAMAGE CRITERIA*

Taking into consideration the published literature on the subject, damage estimates due to thermal radiation and overpressure has been arrived. The consequences can then be visualized by superimposing the damage effects zones on the proposed site plan and identifying the elements within the project site as well as in the neighboring environment, which might be adversely affected, should one or more hazards materialize in real life.

The effect of thermal radiation on people is mainly a function of intensity of radiation (heat flux) and exposure time. The effect is expressed in terms of the probability of death and different degrees of burn. The following table gives the effect of various levels of heat flux:

Table 5.5:Practical Significance of Radiation Intensity

| **Heat Radiation ($kW/m^2$)** | **Damage to Equipment** | **Damage to People** |
|---|---|---|
| 4.73 | --- | Accepted value to represent injury – 2 degree burns after 2 mins |
| 12.5 | Minimum energy to ignite wood with a flame, Melts plastic tubing. | First degree burns in ten seconds. |
| | | 1% Fatality in 20 sec, |
| | | 30% Fatality in 30 seconds. |
| 37.5 | Severe damage to plant | 100 % Fatality |

The human species, if suitably clothed, is capable of living within a wide range of ambient temperature. However, human body itself can only function within a relatively narrow temperature range & therefore for some climate conditions clothing is needed.

Determining the severity of a burn includes establishing how deep the damage goes into or through the skin. Burn thickness in most burn units is classified by degree -- the higher the number, the worse the burn.

First-Degree Burns

This means a superficial burn. The surface of the skin is damaged, but the epidermis (the outermost layer of skin) is still intact, and therefore able to perform its functions (control temperature and protect from infection or injury). When determining severity, care providers ignore first-degree burns.

Second-Degree Burns

This means damage that has extended through the epidermis and into the dermis (the second layer of skin). Second-degree burns also are known as partial-thickness burns. In determining the severity of burns, the presence of second-degree burns indicates a loss of skin function. Blisters are the first sign of a second-degree burn.

### Third-Degree Burns

This indicates the burn has destroyed both the epidermis and dermis. The victim has the same trouble with fluid loss, heat loss, and infection that come with second-degree burns. Full thickness burns also cause nerve death, so the victim may not be able to feel anything in the area of the burn.

## EXPLOSION OVERPRESSURE DAMAGE

Blast injury to people may comprise either direct effects (e.g. ear drum rupture) or indirect effects (injury due to flying debris). Blast damage to equipment of structures can result from either loading (applicable to large objects, e.g. walls) or drag loading (applicable to objects of narrow cross-section, e.g. pipework or primary steelwork) or a combination of the two. The extent of damage is dependent not only on the peak overpressure, but also the blast wave duration, impulse and rise time.

People outside of building or structures are susceptible to

1. Directly blast injury (blast overpressure)
2. Indirect blast injury (missile or whole-body translation)

Table 5.6 : Damage Produced by Blast

| **Overpressure Ranges (bar)** | **Mechanical Damage to Equipment** | **Damage to People** |
|---|---|---|
| 0.206-0.551 (3-8psi) | Heavy damage to plant & structure | Fatality probability = 1 for humans indoor as well as outdoor |
| | | > 50% eardrum damage |
| | | > 50% serious wounds from flying objects |
| 0.14-0.206(2-3psi) | Repairable damage | 1% death |
| | | > 1% eardrum damage |
| | | > 1% serious wounds from flying objects |
| 0.0206-0.14(0.3-2psi) | Major glass damage/10% glass damage | Slight injury from flying glass |

A hazard is a state or condition having the potential to cause a deviation from uniform or intended behaviour which, in turn, may result in damage to property, people or environment. The objective of the hazard identification technique is to identify all the possible hazards in Petroleum Refining Unit.

Most of the accidents start with loss of containment of the hazardous material. The nature of release depends on the substances. In case of a flammable substance, if ignited, fire or explosion may result causing injuries, fatalities and structural damage. Delayed ignition of the flammable vapour cloud will lead to a vapour cloud explosion. Un-ignited released substance and toxic substance however will begin to disperse in the atmosphere.

## *MAXIMUM CREDIBLE LOSS SCENARIOS*

The potential hazards in the facility are associated with the loss of containment of flammable chemicals from the equipment considered. This can happen as a result of failure of pipeline, seal leak, flange leak, blast, full bore rupture etc.

MCLS assumes maximum inventory of hazardous chemicals and worst weather conditions prevailing at the time of failure. No credit is given to the safety features provided in the plant to determine maximum possible damage from the scenario selected. In reality, leakage of hazardous chemicals will be smaller in magnitude.

## *CASCADING EFFECT*

Often, an incident which starts in one item may affect nearby items (e.g., vessels contain hazardous material) by thermal, blast, or fragment impacts. Domino analysis is also used to evaluate equipment separation to minimize the potential for incident propagation.

Domino Effects may be analysed by increase the consequences of a given incident at fixed frequency, to allow for larger consequences due to domino effects (modify the outcome in an event tree context).For the project facility, large consequences have been estimated by considering worst case scenarios.

## LOCATION SPECIFIC INDIVIDUAL RISK (LSIR)

LSIR assumes that the individual is at a location 24 hours and 365 days a year. Practically, this cannot be used for risk-based decisions on-site as it does not take into account the manning distribution around the site. However, LSIR can be used as an initial guideline to highlight which process block/unit has the highest risk level. In addition, LSIR is used to calculate the IRPA values from the manning distribution and it can be used as an input for land use planning decisions. Overall LSIR Contours generated at project site.

## INDIVIDUAL RISK PER ANNUM (IRPA)

IRPA is the probability of fatality for an individual in any one calendar year by a particular set of hazards. The individual risk calculation takes account of the fact that people move from one place to another. The value is derived by taking into account LSIR values and the time spent by individuals on-site per year. IRPA is required for risk tolerability assessment and quantitative ALARP demonstration.

The PNGRB and HSE UK Individual Risk Criteria was considered to assess the risk for this study. Individual risk above $10^{-3}$ per annum for any person shall be considered intolerable and fundamental risk reduction improvements are required

PNGRB Risk criteria for Individual Risk are explained in following figure:

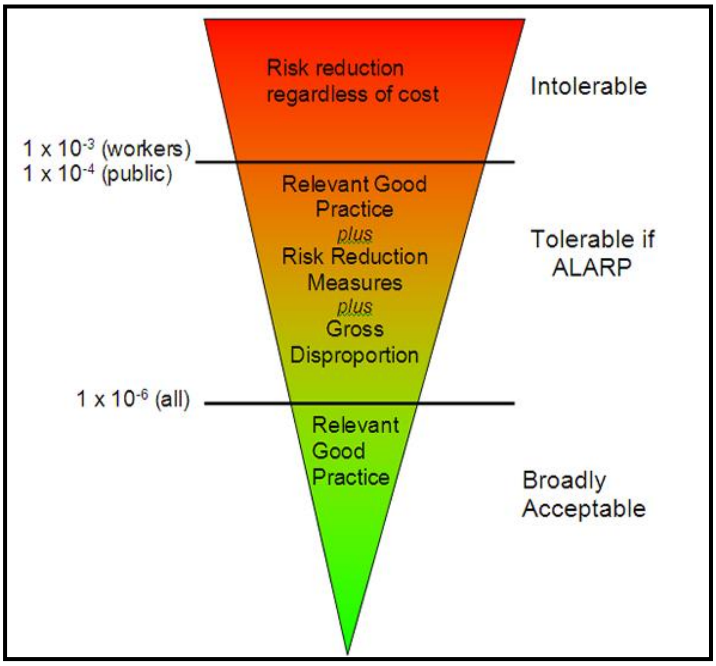

Figure 5.2: ALARP Principle

## SOCIETAL RISK (F-N CURVE)

The "societal risk" is a measure of the risk that the events pose to the society (nearby population). The societal risk is expressed in terms of the likelihood of event outcomes that affect a given number of people in a single incident (e.g. the likelihood of event outcomes that affect up to 10 people, or the likelihood of event outcomes that affect up to 20 people).

The risk results are presented in the form of FN Curve, which shows the frequency (F) of outcomes which cause N or more fatalities. In addition, the PLL (Potential Loss of Life) and contribution of each failure case to the societal risk are calculated.

Due to non-availability of any national risk acceptance criteria for societal risk HSE UK guideline on the same is proposed. UK-HSE proposes maximum and minimum criterion line which is clearly shown in the figure below. The below figure can be interpreted as Risk level above the maximum criterion line 1 x $10^{-2}$ per year will be unacceptable/intolerable to society, area covered between risk levels 1 x $10^{-2}$ and 1 x $10^{-4}$ per year will be considered as low as reasonably practicable (ALARP) region and Risk level below the minimum criterion line 1 x $10^{-4}$ per year will be broadly acceptable to society as per HSE UK criteria. The same is represented in the figure below:

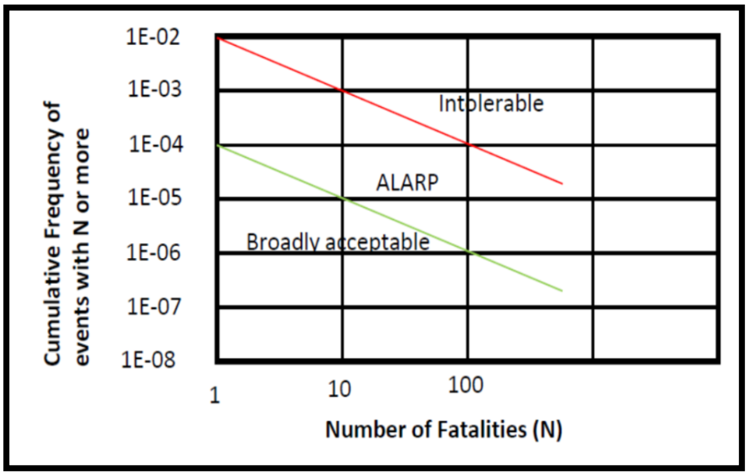

Figure 5.3: Societal Risk Criteria (UK HSE)

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