ADWEA HSE PROCEDURE MANUAL

RISK MANAGEMENT GUIDELINES

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AMENDMENTS SHEET

VERSION	PAGE NUMBER	DESCRIPTION OF CHANGE	APPROVED BY	EFFECTIVE DATE
		All changes and midification done as per ISO14001:2004 and OHSAS18001:2007		
1	1	HSAE Advisor changed to HSE Specialist		
1	4	Section 2 " Risk Mnagement Methodology " added new.		
1	5 & 6	Section 5 " Definitions & Abbreviations" modified and new difinitions added		
1	7	Section 6 , clause 6.1		
1	11	Section 6 , clause 6.3		

1. INTRODUCTION

The assessment and control of risk are essential requirements for proactive HSE management. In order to make a value judgement and to decide on what risks are acceptable, an easy understood criteria should be in place and followed. Risk criteria are required to promote consistency in evaluating the results of relevant studies which will help in being proactive interms of incident prevention.

2. *RISK MANAGEMENT METHODOLOGY*

The risk management methodologe must be undertaken to identify and manage all hazards and associated risks to ensure risks are reduced to as low as reasonably practicable.

The process of identifying , assessing and controlling risks is undertaken by :

- *Ide ntifying potential hazards;*
- *Assessing risks associated with hazard;*
- *Managing risks by controlling and/or reducing risk to as low as reasonably practicable,*
- *Monitoring risk management strategy*

3. PURPOSE OF THIS DOCUMENT

This document describes the risk management concepts, principles and processes which are recommended for use, as well as risk tolerability criteria which shall be utilized as guidance within the ADWEA Group of Companies.

These guidelines specifically aims to:

- Introduce risk management in order to assist the Group Companies towards having a common and consistant approach to risk management.
- Introduce common risk terminology as a basis for sharing principles, training methods and ideas.
- Highlight some of the techniques used to arrive at the qualitative and quantitative assessments.
- Set the basis for risk acceptance criteria and to set specific and consistent tolerability criteria for qualitative and quantitative assessment of risk levels which are applicable through out ADWEA and the Group Companies.

The guidelines do not aim to provide detailed guidance on specific hazard identification (e.g. HAZOP, HAZAN, HAZID) or risk assessment techniques (e.g. QRA).

4. RESPONSIBILITIES

Ultimate responsibilty for effective management of HSE rests with the General Management of the Company.

General Management should:

- Ensure that the organization has access to sufficient knowledge, skills & experience and resources to manage the HSE risks in a responsible manner and in accordance with legislation.
- Alocate HSE responsibilities and accountabilities, including risk management.

5. DEFINITIONS & ABBREVIATIONS

Definitions

ALARP: Means to reduce a risk to a level which is "as low as reasonably practicable" and involves balancing reduction in risk against the time, trouble, difficulty and cost of achieving it.

Consequence (or severity): is the loss that can be inflicted if the hazard event occures.

Frequency: is the number of occurences of an event per unit time.

Hazard, *Source, situation, or act with a potential for harm in terms of human injury or* ***ill health****, or a combination of these.*

Hazard Management: is the systematic process to:

- Identifying potential hazardous events and their potential consequences (hazard analysis).
- Evaluating the risk potential of the hazardous event occuring (risk analysis).
- Managing the risk at an ALARP risk level, which may be achieved by reducing the probability of a hazardous event occuring or mitigating its potential consequences.
- Reviewing the hazards and risks on a periodic basis.

Individual Risk: Individual Risk "IR" is defined as the combined fatal risks to a "named individual". IR would include such factors as:

- Total Risk, the sum of contributions from all hazards exposed to.
- Occupancy, the proportion of time exposed to work hazards.
- Vulnerability, the probability that exposure to the hazard will result in fatality

IR = Σ Frequency **x** Occupancy **x** Vulnerability

Public: anybody not directly employed by the company or contractors (including sub-contractors) working for the company.

Public Risk: identical to Individual Risk but relates to the public rather than the "named individual" who is usually employed by the company or contractor (including sub-contractors) working for the company.

ill health : *Identifiable, adverse physical or mental condition arising from and/or made worse by a work activity and/or work-related situation.*

Risk: *is a combination of the likelihood of an occurrence of a hazardous event or exposure(s) and the severity of injury or ill health that can be caused by the event or exposure(s)* upon:

- People – injury or harm to physical or psychological health
- Assets (or revenue) – damage to property (assets) or loss of production.
- Environment – water, air, soil, animals, plants and social.
- Reputation – employees and third parties. This includes the liabilities arising from injuries and property damage to third parties.

Risk = Frequency x Consequences

Social Risk (SR): Social Risk is generally used to describe multiple injury accidents/fatalities, or to describe risks to "unnamed" individuals, which could include the public and is usually described by F-N curves (frequency vs. deaths listed in increasing order of magnitude, 10, 100, 1000 etc.). Social Risk may also be calculated as a single value known as "Expectation Value" (EV) or "Potential Loss of Life" (PLL), which is given by the expression:

SR = Σ Frequency **x** Proportion of time person(s) are exposed **x** number of people exposed **x** Vulnerability

Vulnerability: is the probability that exposure will result in death

Worker: anybody who is directly employed by ADWEA or the Group Companies or contractors (including sub-contractors) working for ADWEA or the Group Companies.

Abbreviations

EV: Expectation Value
FAC: First Aid Case
FMEA: Failure Mode and Effect Analysis
HAZAN: Hazard Analysis
HAZOP: Hazard and Operability Study
HSEIA: Health, Safety and Environment Impact Assessment
LTI: Lost Time Incident
MTC: Medical Treatment Case
RWC: Restricted Work Case
PHSER: Project Health, Safety and Environment Review
P&IDs: Process & Instrumentation Diagram
PLL: Potential Loss of Life
QRA: Qualitative Risk Assessment

6. HAZARD IDENTIFICATION & ASSESSMENT

6.1 Identification of Hazard

Examples of hazard identification techniques include HSE audits, HSE inspections, task analysis, HAZOPs, HSEIAs, PHSERs, FMEAs, model reviews, P&IDs reviews, accident/incident & near miss reporting etc. Failures of software and hardware systems *as well as hazards orginating outside workplace and incidents of human error should be considered in the hazards identification*.

6.2 Evaluation(Analysis & Assessment) of Hazards

All identified hazards should be evaluated for risk potential. This means analysing the hazard for its probability to actually progress to a loss event, as well as the likely consequences of this event. There are 3 risk assessment methods widely used in the industry:

- Quantitative Risk Assessment (QRA)
- Semi-quantitative
- Qualitative

Quantitative Risk Assess (QRA)

QRA uses historical/statistical and failure data along with computer generated consequence modelling to generate “people” risk data. From QRAs one will get individual risk (IR), public risk and/or social risk (SR).

Semi-quantitative Risk Assessment

The semi-quantitative approach depends on a selected team of experienced personnel who have access to accident, historical and failure data to make probability decisions. Semi-quantitative assessments might determine consequences based upon in-house modelling or use of hazard impact tables such as depicted in Figure 1 (Risk Potential Matrix). The probability categories relate to the theoretically calculated chance of major incidents happening. They do not relate to actual events as experienced on specific plants, locations or companies.

A detailed explanation of the criteria used to rate the potential cosequences of a hazard event can be found in attachment-1.

Figure 1 – Risk Potential Matrix – Semi-quantitative

					Probability				
					A	B	C	D	E
Sevirity	People	Assets	Envir-onment	Reput-ation	Improbable 1 in 100,000 years	Remote 1 in 10,000 years	Occasional 1 in 1000 years	Probable 1 in 100 years	Frequent 1 in 10 years
5. Catast-rophic	Multiple fatalities or permanent total disabilitis	Exten-sive damage	Massie effects	Interna-tional impact			HIGH	RISK	
4. Severe	Single fatality or perma-nent total disability	Major damage	Major effect	National impact					
3. Critical	Major injury or health effects	Local damage	Localied effect	Consie-rable impact		MED.	RISK		
2. Marginal	Minor injury or health effects	Minor damage	Minor effect	Minor impact					
1. Negligibe	Slight injury or health effects	Slight damage	Slight effect	Slight impact	LOW	RISK			

The risk matrix is divided into three risk categories as defined below :

High Risk (Unacceptably high)

This level of risk exposes the Company to intolerable losses to people, assets, environment or reputation. The hazard should be eliminated or its risk reduced to tolerable levels immediately. **Action must be taken immediately to lower the risk.**

Medium Risk (Acceptable but must be managed at ALARP)

The hazards must be managed to reduce the frequency and/or the severity of the hazardous events to ALARP. **Risk reduction measures must be planned and documented.**

Low Risk (Acceptable without required further action)

Corrections may be applied as resources allow.

Qualitative Risk Assessment

The qualitative approach also uses a risk potential matrix as a guide in determining risk potential. The matrix as depicted in Figure 2 facilitates quick reference and assignment of risk levels for each of the risk categories (High, Medium, Low). Thus hazards identified during audits, inspections, reviews, accident/incident investigation, qualitative risk assessment etc. may be assessed using this matrix.

A detailed explanation of the criteria used to rate the potential cosequences of a hazard event can be found in attachment-1.

Figure 2- Risk Potential Matrix – Qualitative

					Probability				
					A	B	C	D	E
Sevirity	**People**	**Assets**	**Envir-onment**	**Reput-ation**	**Has occurred in world wide industry but not in ADWEA Group Companies**	**Has occurred in other ADWEA Group Companies**	**Has occurred specific-ally in the concerned Company**	**Happens several times per year in this specific Company**	**Happens several times per year in same location in this specific Company**
5. Catast-rophic	Multiple fatalities or permanet total disabilities	Exten-Sive damage	Massive effects	Interna-tional impact			HIGH	RISK	
4. Severe	Singlefatal ity or perma-nent total disability	Major damage	Major effect	National impact					
3. Critical	Major injury or health effects	Local damage	Localised effect	Conside -rable impact		MED.	RISK		
2. Marginal	Minor injury or health effects	Minor damage	Minor effect	Minor impact					
1. Negligible	Slight injury or health effects	Slight damage	Slight effect	Slight impact	LOW	RISK			

When assessing risks associated with the consequences of an "incident" such as a fire, explosion, acute illnesses or fatality then the risk is "acute" or "incidental". Plotting

these risks on the matrix is relatively simple. There are also risks of a long term nature relating to environmental discharges and emissions or exposure to health hazards.

These "chronic" or "routine" risks are the ones where the pre-defined limits are exceeded over time, and can also be plotted on the matrix . The matrix may also be used on a scenario by scenario basis to prioritise risk reduction efforts. It is adaptable to varying levels of information and depths of evaluation.

6.3 Manage the Risk to Acceptable Level

After the risk has been identified and analysed as per above, corrective action is necessary to manage the hazard at an acceptable and ALARP risk level. Depending on the nature of the specific hazard, this may require different steps to:

The following hierarchy of control will be considered to manage the risks:

- ***Elimination.***

  Eliminate the risk by removing the hazard.

- ***Substitution:***

  Substitute less hazardous materials, equipment, process or substances

- ***Engineering controls isolation :***

  Make structural changes to the work environment, work system, tools or equipment. Use mechanical aids or manual handling devices. Enclose or isolate the hazard through the use of guards or remote handling techniques. provide local or general exhaust ventilation.

- ***Administrative controls :***

  appropriate administrative procedures such as polices, guideline, standard operating procedures(SOPs), registries, work permit, safety signage, job rotation , job timing, routine maintenance and housekeeping. provide training on hazards and correct work procedures.

- ***Personal protective equipment* (PPE) :**

  Provide correctly fitted and properly maintained personal protective equipment (PPE), and/or protective clothing and training in its use.

If the risk is low, no action may be required. Medium and high risks require that management formulate a corrective action plan, which should include:

Agreed actions, responsible person(s), and completion dates. In formulating these plans, it is important to realise that risk management measures include organisational and system measures, such as:

- Personnel training and qualification procedures
- Change control and documentation procedures
- Quality assurance, maintenance and inspection procedures
- Periodic personnel medical check-ups and prophylactic medical treatments such as vaccination/immunisation.
- *Personnel behaviour*

Follow up that includes regular updates for progress to ensure actions are closed per the the plan.

6.3.1 Demonstrating ALARP

In all cases cosideration should be given to reducing risk to a level deemed ALARP reflecting among other factors local conditions and circumstances, the balance of cost

and benefits and the current state of scientific and technical knowledge. To reduce a risk to an ALARP level involves balancing reduction in risk to a level where the trouble, difficulty and cost of further reduction measures becomes unreasonably disproportional to the additional risk reduction obtained, as illustrated in figure 3.

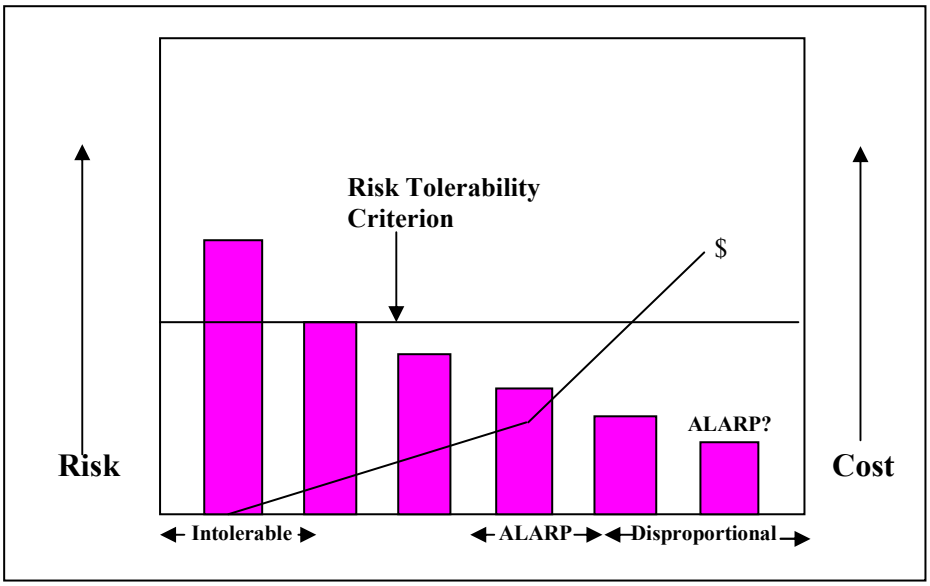

Figure 3 – Demonstrating ALARP

Demonstrating ALARP requires consideration of all the hard and soft issues related to a range of options. It requires a judgement decision at the right level in the organisation with the full knowledge of all options, associated risks and costs.

Specifically in the context of project engineering, ALARP is not just a demonstration that risks of the preffered or selected option are acceptable and/or comparable to other similar developments. Demonstrating ALARP requires consideration of fundamentally different options to provide assurance that the company gets best value for money over lifetime of a facility or operation.

In defining ALARP risk reduction measures, the potential for changes in risk tolerability criteria with time should be borne in mind for those projects or operations with a considerable life span. Rather than applying fit-for-purpose now, the contingency should be built-in which allows for seamless ALARP upgrade without

costly retrofits. What is considered ALARP today may be no longer be acceptable in the future, for example:

- The applicable legislation may change,
- Public awareness may increase and/or tolerance may decrease,
- The company's own HSE objectives may become more stringent.

Determining the exact level of ALARP is difficult and depends on many factors such as internal/external influences and the nature of the hazards and associated risks.

One may arrive at different ALARP definitions for identical hazards/risks which occur at different locations. As such it is critically important to fully understand the effects of risk reduction measures, specifically for those risks which require multiple measures to achieve ALARP. The effects of the individual measures should be fully explored with a view to avoiding potential clashes and/or overlaps.

Every effort should be made to "design out" rather than add on mitigation ontrols/ measures. In the various attempts to achieve ALARP one should be cautious and not over-complicate:

- Equipment and process control/shutdown system designs,
- Procedures for systems and processes, and
- Personnel training and qualification criteria.

Speciffically for projects, ALARP should be pursued with risk reduction measures that have obvious, clear and measurable effects on the estimated risk level.

Where quantitative risk assessment is used, then the costs of the various options can be compared with the respective risks and ALARP illustrated in a graph similar to figure 3 above. In qualitative analysis, ALARP is established using standards, legislative requirements and judgement based on experience. Regardless of the risk assessment methodology used, it still needs to be demonstrated, at a reasonable cost, that risks are ALARP from all points of view.

6.3.2 Review/Verify the Risks

Depending on the magnitude of risks and the potential consequences of hazards, these should be periodically reviewed by competent staff. The reviews should involve those parts of the organisation which are involved in day-to-day management of these hazards i.e. the operations and maintenance functions.

As a typical issue for these reviews one should verify if the base assumptions have changed since the original design was implemented or since the risks were reviewed previously e.g.:

- Has the plant/equipment performance lived up to the expectations of the original design in terms of accidents, incidents and equipment uptime?

- Has the product (water & electricity) or equipment price changed significantly i.e. what is the current cost of production loss and/or equipment replacement?

- Have there been significant and unexpected changes in age and/or technical integrity of equipment e.g. excessive corrosion, wear/tear?
- Have there been significant hardware changes and if so, have the risk associated been adequately reviewed in the context of previously defined risk levels?
- Is the average experience level of plant/facility operators and maintainers still the same?
- Can new technology provide lower and possibly cheaper ALARP levels?
- Have legislation and/or public perceptions changed regarding what is now considered acceptable/unacceptable?
- Have there been changes outside company influence which could affect overall risk levels e.g. population build-up around facilities in previously isolated areas, increased road traffic, security aspects, etc.?

Speciffically for those issues which are managed at ALARP risk level but still remain toward the upper end of the ALARP region, management should insist on a minimum review frequency (e.g. annually) to be conducted by appropriate and expert personnel. The documented results of these reviews should be fully auditable.

7 CRITERIA FOR RISK TOLERABILITY

7.1 The Framework for Risk Criteria

The two diagrams below are intended to guide ADWEA and the Group Companies in decision making in response to recommendations and feed-back from QRA and HSEIA reports.

7.1.1 Individual Risk Criteria (IR)

Idealy, there is a need to determine the limits for IR, based on numeric values (based on QRA studies and HSEIAs) which would be regarded as intolerable. Figure 4 shows the principle of this frame work.

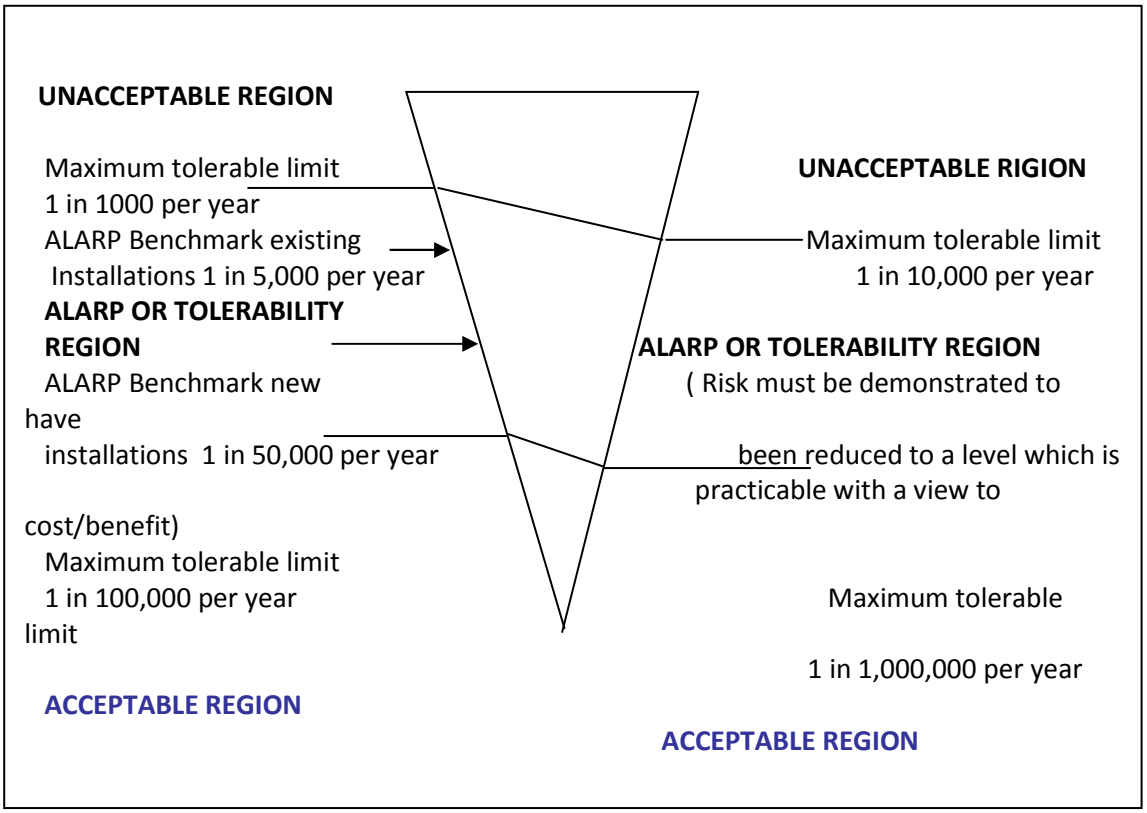

Figure 4 – Risk Acceptance framework for Individual Risk to Worker or Public

The ALARP principle which underlines the regulation of risk depicts three particular regions viz.: the unacceptable region, the ALARP region and the broadly acceptable region.

At the top of the triangle is the unacceptable level, on or above which the risk is so great or the outcome so unacceptable that it must be refused altogether. At the other extreme is the broadly acceptable region, where there is no requirement to undertake additional HSE measures. In between lies a wide range of risk levels to which the ALARP principle applies, i.e. the risk must be reduced to the lowest level practicable, bearing in mind the benefits flowing from its acceptance and taking account of the costs of any further reduction. Thus for the risks which fall within the ALARP region, some weighing of costs and benefits is necessary to detrmine compliance with the ALARP principle.

7.1.2 Social Risk Criteria

The ALARP principle applies in the same way for social risk as for Individual Risk (figure 4). Societal risk tolerability would be utilised in reporting QRA results.

Societal risk should not be confused as being the risk to society or the risk as being perceived by society. The word "societal" is merely used to indicate a group of people and societal risk refers to the frequency of multiple fatality incidents, which includes workers and the public. Societal risk is usually represented by F-N (fatality-frequency) curve such as Figure-5 below. The F-N curve represents societal risk for a single fixed installation only, like a refinery, a power plant.

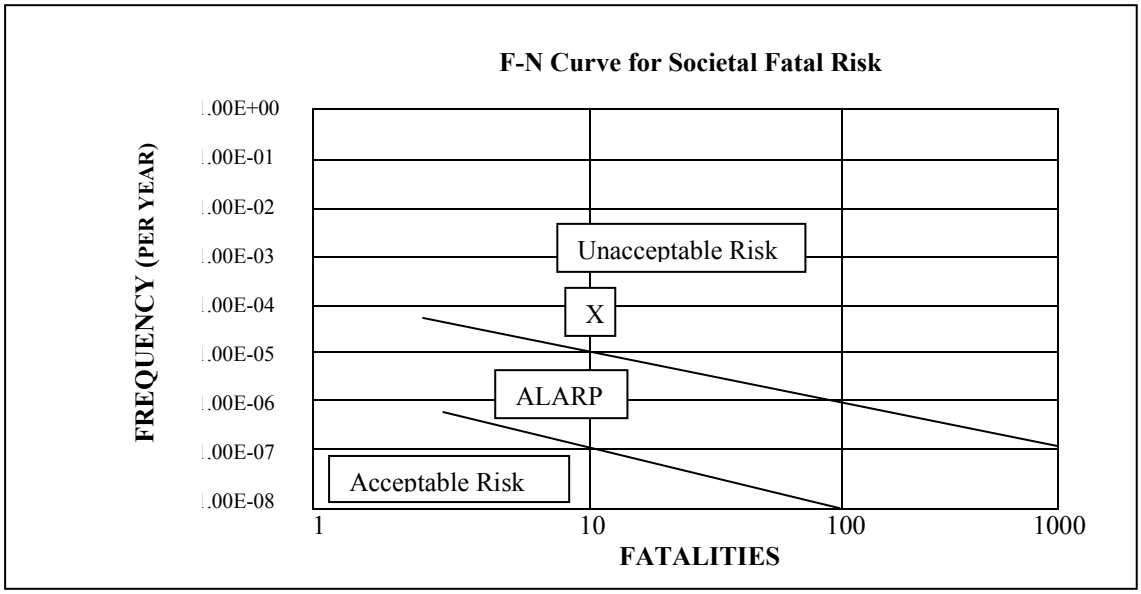

Figure-5 F-N Curve: Societal Fatal Risk Tolerability, Single Plant/Facility

To illustrate an example of societal risk, note the'X' in the upper portion of the graph which is marked "unacceptable Risk". The 'X' is located at the axis of the lines "1.00E-04" (1 in 10,000 years) and 10 fatalities. The 'X' thus represents an event which would kill 10 people at a frequency of once in 10,000 years. This is unacceptable. This principle of societal risk indicates that society's tolerance for risk decreases as fatalities increase.

7.2 Factors affecting the Risk Criteria

The risk criteria for numerical risk levels is generally based on risk comparisons. However, there are some factors which need to be considered in order to ensure that the proposed risk criteria reflects adequately the nature and risk levels for activities/processes used at ADWEA and Group Companies. These factors include the following:

- Risks which may be tolerable for workers in a hazardous industry are not necessarily tolerable for a member of the public who may be exposed to the work activity hazards.
- Risk criteria selected by different industries are not necessarily the same. Risk criteria adopted by different countries may also not be the same.
- The concept of ALARP is based on cost – benefit assessment and requires explicit valuation of a life. Refer to section 7.
- The QRA criteria for risk relates to Individual Risks to workers (and the public) as well as to societal risks as a result of fatal accidents. Injuries and/or ill health are not included in this method of risk assessment.
- Multiple fatality accidents require use of F-N Curves for risk tolerability. See figure 5.

7.3 ADWEA Target Individual Risk Criteria

	ADWEA Maximum Individual Risk Criteria		
	Workers		Public
	Existing Installations	New Installations	All Installations
Benchmark	IR = 1 in 5,000 or below (IR < 2×10^{-4}	IR = 1 in 50,000 or below (IR < 2×10^{-5})	IR = 1 in 100,000 or below (IR < 10^{-5})
Unacceptable	IR = 1 in 1,000 or above (IR > 10^{-3})	IR = 1 in 1,000 or above (IR > 10^{-3})	IR = 1 in 10,000 or above (IR > 10^{-4})
Acceptable	IR = 1 in 100,000 or below (IR < 10^{-5})	IR = 1 in 100,000 or below (IR < 10^{-5})	IR = 1 in 1,000,000 or below (IR < 10^{-6})
Where IR = Individual Risk (fatality per person per year)			

Table 1: ADWEA quantitative risk tolerability criteria

The tolerable risk level lies between the acceptable and unacceptable levels in which ALARP must be demonstrated. Once a specific hazard is demonstrated by analysis to result in acceptable risk there is no requirement, other than the HSEMS continuous improvement principles, to further reduce risk under the ADWEA ALARP criteria.

Workers would include ADWEA and Group Company employees and contractors. The public includes the general public, visitors and any other third party who is not directly involved in the ADWEA and/or Group Company work activities.

The tolerability criteria above should not be misinterpreted as the number of fatalities that ADWEA is prepared to accept in conducting operations. They must be used only in QRA context as statistical probability that equipment, systems and procedures fail and result in fatalities.

The “IR benchmark” for new installations is the overall IR level which project teams should aim for when designing new facilities.
The design of existing installations is set which leaves less flexibility in reducing absolute risk levels than for new design. As such, the benchmark IR target for existing installations is set one order of magnitude higher than for new installations. This benchmark should be used when designing major alterations/modifications to existing facilities.

8. THE COST BENEFIT ANALYSIS APPROACH

The cost benefit analysis (CBA) approach is an effective risk management tool as it aids consistency in the decisions for HSE resource allocation. The CBA approach requires monetary evaluation of risks or the monetary evaluation of the loss. Some typical examples are:

- loss of plant, assets (e.g. rebuild cost)
- loss of product and/or revenue
- loss of life
- loss of or damage to a natural resource

The evaluation of measures to avert loss of life requires "valuation of life" for which different fiquers have been used by various industries and countries.

ATTACHMENT-1

Detailed breakdown of consequences for the four Risk Management Categories

1. People

Severity	Description
5	Multiple fatalities – from an accident or occupational illness e.g. poisoning
4	Single fatality or permanent total disability – from an accident or occupational illness e.g. poisoning
3	Major injury or health effects (including permanent disability) – affecting work performance in the longer term, e.g. prolonged absence from work. Irreversible health damage without loss of life, e.g. noise induced hearing loss, chronic back injuries.
2	Minor injury or health effects – affecting work performance, e.g. restriction to activities (restricted work case – RWC) or need to take a time off work to recover (lost time incident – LTI). Limited, reversible health effects, e.g. skin irritation, food poisoning.
1	Slight injury or health effects (including first aid case – FAC and medical treatment case – MTC). Not affecting work performance or causing disability.

2. Assets

Severity	Description
5	Extensive damage – substantial or total loss of operation (costs in excess of US$ 10,000,000)*
4	Major – partial operation loss (2 weeks shutdown, costs up to US$10,000,000)*
3	Local damage – partial shutdown (can be restarted but costs up to US$ 500,000)*
2	Minor damage – brief disruption (costs less than US$ 100,000)*
1	Slight damage – No disruption to operation (costs less than US$100,000)*

* These losses in US$ are meant as guidance only. Individual Group Companies may use more appropriate figures provided they are within the above quoted limits.

3. Environment

Severity	Description
5	Massive effect – persistent severe environmental damage or severe nuisance extending over a large area. In terms of commercial or recreational use or nature conservation, a major economic loss for the company. Constant, high exceedance of statutory or prescribed limits.
4	Major effect – severe environmental damage. The company is required to take extensive measures to restore polluted or damaged environment to its original state. Extended exceedance of statutory or prescribed limits.
3	Localised effect – limited loss of discharges of known toxicity. Repeated exceedance of statutory or prescribed limits. Affecting neighbourhood. Spontaneous recovery of limited damage within one year.
2	Minor effect – contamination. Damage sufficiently large to attack the environment. Single exceedance of statutory or prescribed limits. Single complaint. No permanent effect on the environment.
1	Slight effect – local environmental damage. Within the fence and within systems. Negligible financial consequences.

4. Reputation

Severity	Description
5	International Impact – International public attention. Extensive adverse attention in international media. National/international policies with potentiallly severe impact on access to new areas, grants of licenses.
4	National impact – national public concern. Extensive adverse attention in the national media. Regional/national policies with potentially restrictive measures and/or impact on grant of licenses.
3	Considerable impact – regional public concern. Extensive adverse attention in local media. Slight national media and/or local/regional political attention. Adverse stance of local government and/or action groups.
2	Limited impact – some local public concern. Some local media and/or political attention with potentially adverse aspects for company operations.
1	Slight impact – public awareness may exist, but there is no public concern.