4.1.1 Relationship of Risk Management Terms - ISO

Organizations may describe the above key risk management concepts in different terms even though the same relationships and definitions still apply.

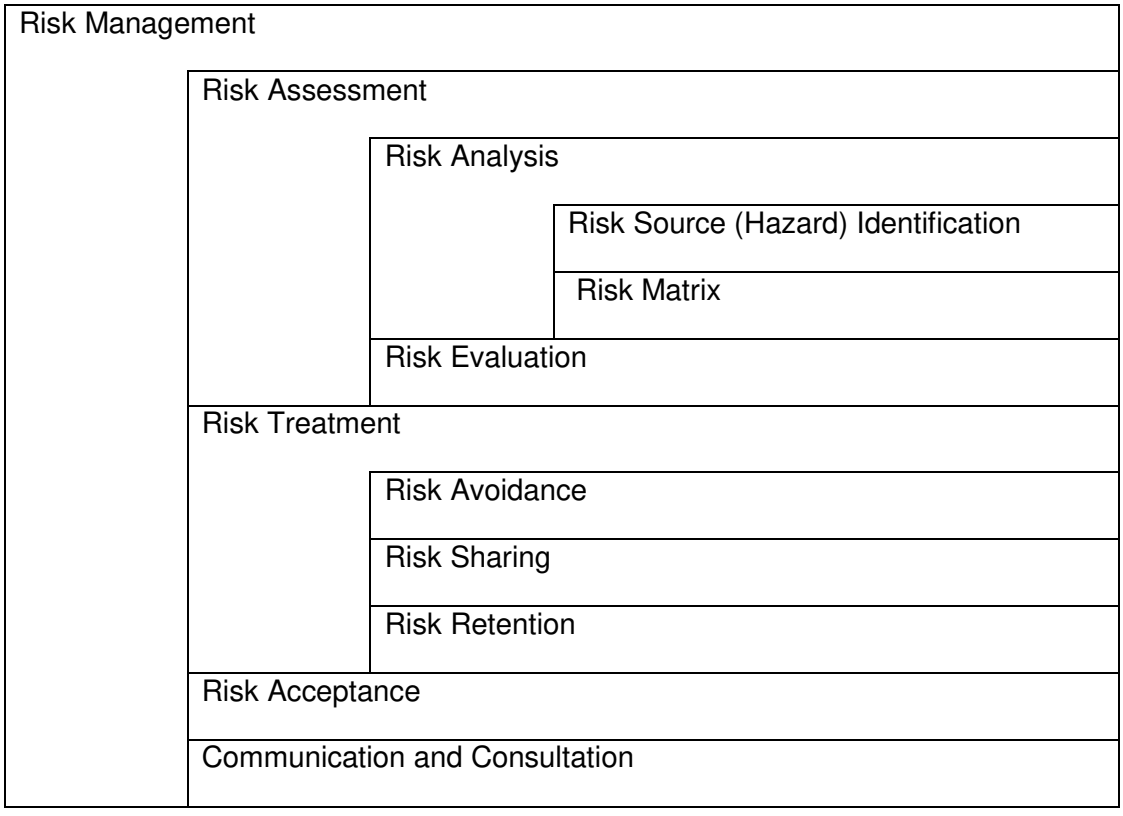

Table 4.1.1.1, Relationship of Risk Management Terms – ISO

4.1.2 Risk Management Process – ISO 17776

Ensuring appropriate competence is available to apply the risk management process is essential in the preparation of an HSE Case. Figure 4.1.2.1, Risk Management Process – ISO 17776, models the essential steps related to the application of an effective risk management process:

- Step 1 - Identification of the hazards (including risk sources and environmental aspects, if applicable).
- Step 2 - Assessment of risks arising from hazards, and consideration of risk tolerability.
- Step 3 - Elimination or reduction of the risk.

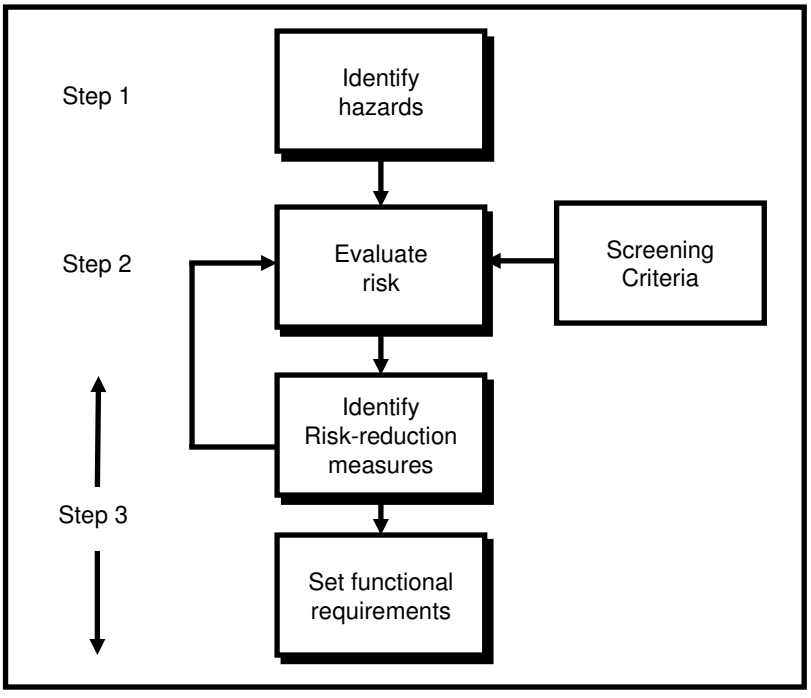

Figure 4.1.2.1, Risk Management Process – ISO 17776

There are internal and external business aspects a Drilling Contractor must consider when applying a risk management process. These specific business aspects take into account differences in geographical location, the suitability of the MODU for the operating environment, the client(s) and third parties under their control, the regulatory environment, and the supplier/sub-contractor support infrastructure (onshore/offshore) available.

Effective application of a risk management process requires sound judgments and appropriate decisions to be made, such as: identifying appropriate screening criteria; defining effective and achievable risk management barriers; and determining when levels of risk are tolerable.

It is necessary to verify that the people participating in the risk management process have sufficient understanding with these internal and external business aspects, as well as HSE management and risk management processes.

4.1.3 Structured Hazard Identification and Control (SHIDAC) Process

The Risk Management Process recommended to be applied in the development of an HSE Case is named: Structured Hazard Identification and Control (SHIDAC) Process.

SHIDAC is based on Figure 4.1.2.1, Risk Management Process – ISO 17776, but with additional sub-steps included to provide a more appropriate description of the practical requirements for Drilling Contractors for each of the three key risk management steps:

- Step 1 - Identify Hazards
- Step 2 - Evaluate Risk
- Step 3 - Identify Risk Reduction Measures (control, defence, and recovery measures) and Set Functional (Performance) Requirements

SHIDAC is a process incorporating the basics of fault-tree and event-tree analyses, and includes implementation of measures to control major and other workplace hazards and to recover in the event of a hazard release. A key deliverable of this process is the

determination of major hazards, other workplace hazards, and the critical activities/tasks to implement, monitor and maintain barriers related to a Drilling Contractor's scope of operations.

The SHIDAC process is an iterative process, potentially requiring multiple passes of each step to effectively complete the risk management process related to specific hazards. Drilling contractors may find it appropriate to use a "Bow-Tie" diagram to assist them in identifying the various causes and consequences of a particular hazard scenario. Such diagrams also simplify the identification of control, defence and recovery barriers. Reference numbers can be assigned to each barrier to facilitate capturing which barriers are common to several causes for a particular scenario, and those which are common to several scenarios. A typical Bow-Tie diagram (ISO 17776) is shown in figure 4.1.2.2. Bow-Tie diagrams can:

- identify and document the "lines of defence" or "HSE barriers" which are in place;
- facilitate a qualitative assessment of any gaps; and
- help inform an assessment of event likelihood.

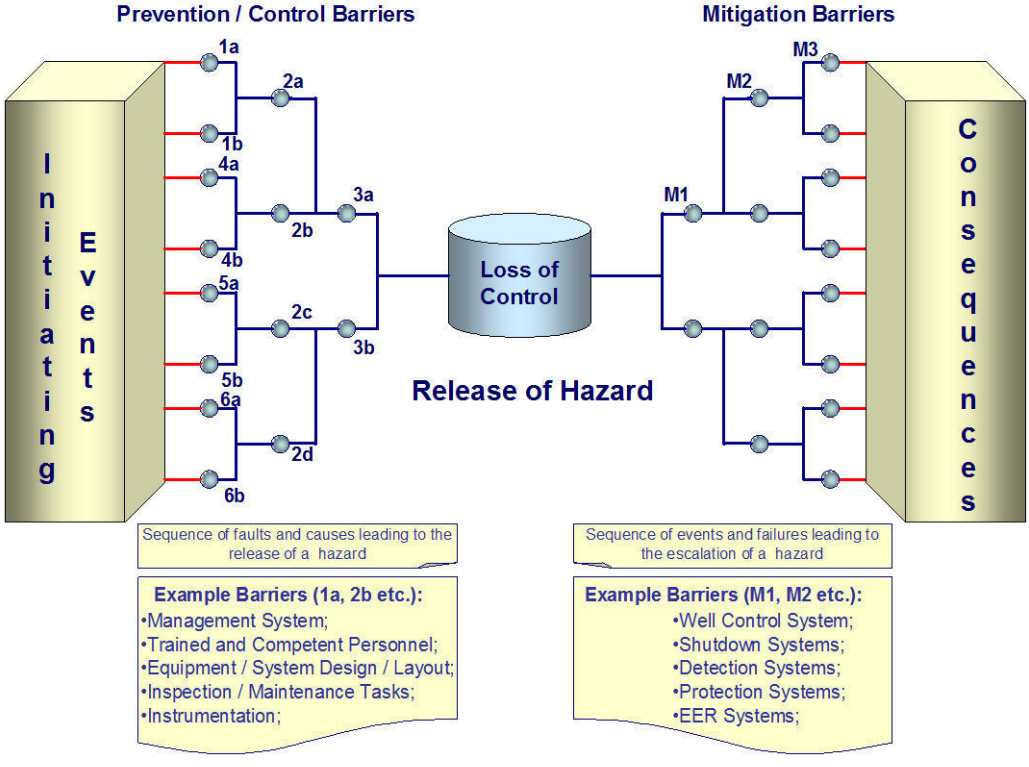

Figure 4.1.2.2, Diagrammatic Representation of a Hazard Scenario (ISO-17776)

4.2 STRUCTURED HAZARD IDENTIFICATION AND CONTROL (SHIDAC) PROCESS

4.2.1 SHIDAC Step 1 – Identify Hazards *(See also Part 4.3 of this document)*

- Select team members with the appropriate competency to participate in the process, including:
  - team members with the appropriate operational and business competence. (Workforce involvement); and
  - team members with the appropriate risk management process competence. (Specialist involvement).

- Define the scope for applying SHIDAC (e.g., what location/installation is involved, suitability of equipment, what operations are involved, what interfaces will be included, etc.)

- Identify the major and other workplace hazards related to the Drilling Contractor's scope of operations and their potential consequences.

    - Drilling contractor to include all identified potential major and other workplace hazards in the Drilling Contractor's Hazard/Risk Register. (See Table 4.3.1.)

- Identify the risk sources, as related to the location or specific operation, which can release or introduce one or more major hazards or other workplace hazards. Sources can be hazardous operations (e.g., simultaneous/combined operations), necessary equipment, necessary materials, environmental conditions, etc.

    - For each hazard in the Drilling Contractor's Hazard/Risk Register, include all of the identified risk sources. (See Table 4.3.1.)

- Identify which specific parts (causes) of the operation can release each hazard (e.g., incorrect mud weight can release the hazard of "Hydrocarbons in the formation").

4.2.2 SHIDAC Step 2 – Evaluate Risk *(See also Parts 4.4 and 4.5)*

- Apply appropriate screening criteria to evaluate and estimate the risk of all the identified hazards (both major and other workplace hazards) included in the Drilling Contractor's Hazard/Risk Register. Determine the potential consequences (severity) of the release of the hazards by applying credible scenarios (including those causes identified in SHIDAC Step 1E). Determine the probability (likelihood) of the total scenario (not just the probability of the consequences if the hazard is released).

    - Drilling contractor to determine which operations are hazardous operations based on the potential to release one or more major hazards. This can be recorded in the Drilling Contractor's Hazard/Risk Register. (See Table 4.3.1.)

- Drilling contractor to apply risk assessment matrix (RAM) to rank risks into categories (High, Medium, or Low Risk), to ensure people's efforts to manage risk will be proportional to the anticipated level of potential risk. Screening criteria developed by the Drilling Contractor is represented in the RAM to judge the tolerability of an identified hazard and consequence. (See also Part 4.4.2 - Screening Criteria of this Chapter.)

4.2.3 SHIDAC Step 3 – Identify Risk Reduction Measures and Set Functional/Performance Requirements (*See also Part 4.6*).

- For other workplace hazards that have been assessed to be **low risk**, and have potential consequences resulting in a minor incident, apply risk reducing controls available within the general workplace practices and procedures, represented in the Drilling Contractor's management system.

- For other workplace hazards that have been assessed to be **medium risk**, and have potential consequences resulting in a **moderate incident**, conduct a hazard analysis onsite at the workplace based on people's experience and judgment by applying barriers or controls contained within the general procedures of the Drilling Contractor's management system to prevent the release of hazards and to mitigate and recover from the consequences. Additional specific controls identified in documented job hazards analyses and workplace hazard assessments should be included.

- For major hazards that represent high risk, and other workplace hazards that have been assessed to be high risk, the risk treatment to be applied includes the following steps:

- For each cause (potential to release hazards), identify the barriers expected to prevent the release of the hazard.
- For every potential release of a hazard, identify the barriers to reduce the consequences, or assist in the recovery from the consequences.
- For each barrier identified:
  - identify the **critical task/activities** required to ensure barriers are in-place, working effectively and their integrity is maintained;
  - identify the resources and competencies required for the barrier to be implemented and effective;
  - identify where the barrier is referenced in the Drilling Contractor's management system;
  - identify any factors that prevent such barriers from being defeated, removed from service or any reduction or elimination of their effectiveness; and
  - identify any compensatory barriers and the associated activities, resources, competencies, and Drilling Contractor's management system references to address such barrier defeating factors.

Note: Drilling contractor to summarize the factors that defeat a barrier, either singly or in combination, which results in the potential to exceed the Drilling Contractor's tolerability limits of safe operations. This summary of defeating factors will allow the Drilling Contractor to establish the Summary of Operation Boundaries (SOOB) for the location. (See also Part 4.6.3 - Summary of Operational Boundaries).

4.3 IDENTIFICATION OF HAZARDS AND RISK SOURCES

Objective

To identify and describe all the HSE Hazards and Risk sources associated with a MODU and its operations.

Discussion

The first step in managing the risks associated with a Drilling Contractor's Scope of Operations is to systematically identify all the Hazards and Sources that may affect, or arise from, the operations the MODU undertakes.

In these guidelines, a Hazard is defined as an intrinsic property of anything with the potential to cause harm. Harm includes ill-health and injury, damage to property, plant, products or the environment, process losses, or increased liabilities. (Note that this definition of Hazard is more specific than some other common uses of the word such as 'danger', 'chance' or even 'risk'.)

A Hazard Source is defined as:

- anything with the potential to release a hazard; or
- a condition that can defeat a barrier leading to an increase in the realisation of a hazard being released. (Barriers are explained in detail later.)

Hazardous sources can be operations (e.g., running casing), simultaneous/combined operations, (e.g. running casing while offloading supply vessel), necessary equipment (e.g., pressure vessel, energized (live) electrical panel, etc.), necessary materials (e.g., hazardous chemicals), environmental aspects and conditions, as well as acute and chronic health aspects and conditions, etc.

Each Drilling Contractor's organization must identify the hazardous sources for major and other workplace hazards as relate to their scope of operations.

The identified hazards to health, safety and environment and their sources should be entered into the Drilling Contractor's Hazard/Risk Register. A Hazard/Risk Register is a brief, but complete, summary that demonstrates that hazards have been identified and assessed and that barriers (both controls and defences) are in place. The HSE Case should only include references to the Drilling Contractor's management system for each barrier, not the full details of each barrier.

(1) ***Hazard***	***(2)*** ***Sources***	***(3)*** ***Consequences***	***(4)*** ***MH*** ***(Y/N)***	***(5)*** ***OWH*** ***(Y/N)***	***(6)*** ***Risk Rank*** ***P/E/A/R***	***(7)*** ***Control Barriers*** ***(MS Reference)***	***(8)*** ***Defence Barriers*** ***(MS Reference)***
Hazard 1	***Source 1.1*** ***Source 1.2*** ***Source 1.3***	***Consequence 1.1*** ***Consequence 1.2*** ***Consequence 1.3*** ***Consequence 1.4***	***Y***	***N***	***3D / 1A / 1A / 3A***	***Control 1.1*** ***Control 1.2*** ***Control 1.3***	***Defence 1.1*** ***Defence 1.2*** ***Defence 1.3*** ***Defence 1.4***
Hazard 2	***Source 2.1*** ***Source 2.2*** ***Source 2.3*** ***Source 2.4***	***Consequence 2.1*** ***Consequence 2.2*** ***Consequence 2.3***	***N***	***Y***	***3A / 3E / 2B / 2B***	***Control 2.1*** ***Control 2.2*** ***Control 2.3*** ***Control 2.4*** ***Control 2.5***	***Defence 2.1*** ***Defence 2.2*** ***Defence 2.3***

Table 4.3.1 - Example Drilling Contractor's Hazard/Risk Register

Abbreviations used in Table 4.3.1. (See also Figure 4.4.1.1)

P/E/A/R *People/Environment/Asset/Reputation*
MS *Management System*
MH *Major Hazard*
OWH *Other Workplace Hazard*

4.3.1 Acute and Chronic Hazards

Due to the integrated approach to managing HSE risks, it is necessary to identify and take into consideration two distinct types of hazards - acute and chronic.

Acute hazards are those with the potential to cause impairment (harm) and or fatalities as a result of more or less instantaneous events or incidents.

Chronic hazards are those with the potential to cause harm arising from non-instantaneous exposures such as repeated emissions or discharges, continuous emissions or discharges, and/or occupational exposures.

In order to estimate the level of harm from such hazards, it is necessary to provide a means by which such exposures/risks are quantified in terms of the intensity, duration of exposure and consequences of effect. Two basic criteria must feature in the determination process, namely:

- the threshold of harm above which an individual requires protection to prevent impairment of his capacity to escape or to avoid becoming a fatality (i.e. survivability); and
- a means for the estimation of fatality probability should dose levels exceed the harm threshold and adequate protection is not present.

The concept that chronic hazards are often known and accepted or normalized into the operation is central to environmental and occupational health assessments. Control of chronic hazards is often achieved by setting risk tolerance limits (in case of health hazards) or discharge/emission limits (in case of environmental aspects). Exceeding these limits can be treated as the release of the hazard (aspect), similar to the treatment of the release of acute hazards.

4.3.2 Environmental Aspects and Occupational Health Hazards

When the Drilling Contractor includes environment and health into their HSE Case, the same process applied to safety hazards should be applied to environmental aspects and to health hazards. In such cases the Drilling Contractor's Hazard/Risk Register should also include health hazards and environmental aspects, where included in the HSE Case, to provide a composite overview of the hazards to persons on the MODU and also to the environment. Thereby providing each Drilling Contractor with a complete overview of risk causation, hazard effect, control and defence barriers in place, and actions required. See Table 4.3.2.1 for some common environmental activity and aspects categories. See Table 4.3.2.2 for an overview of Occupation Health related hazards and Table 4.3.2.3 for some common Occupational Health risk reduction methods.

Activities	Aspects
Energy Usage	Raw Material Usage
Water Usage	Packaging
Material Usage	Product Usage
Material Storage	Disposal
Emissions (air, water, waste, heat)	Energy Usage

Table 4.3.2.1 – Common Environmental Activity and Aspect Categories

How can this be achieved?

- By incorporating Occupational Health and Environmental hazards into the Drilling Contractor's Hazard/Risk Register to ensure all hazards and sources are addressed in the HSE Case.
- By systematically identifying if, where and when each possible hazard is encountered on the MODU (e.g., area layout, fixed equipment, etc.) and during which operations.
- Risks can be related to the circumstances present in an area or related to a certain activity; applying both of these approaches provides a complete hazard overview.
- By systematically identifying credible sources that could release each identified hazard; the sources can be categorized into the following groups:
    - exposures related to systems (e.g., Mud systems, electrical installations, flaring system, etc.);
    - equipment exposures (e.g. Iron roughneck, airpowered tools, etc.); and
    - chemical and substance exposures (e.g., burns or fumes, etc)
- By identifying the credible consequences that could result if control of the hazard was lost (i.e., if the hazard was released).
- By identifying the measures of control of each of the Hazards.

What should be (referenced) in the HSE Case?

- The identification method used to make the inventory of Hazards.
- Listings of hazards, equipment, areas, chemicals and substances, responsibilities, tasks and measures of control to limit the exposure from such hazards.
- Through a baseline survey, exposure levels, as appropriate, should be assessed against a relevant standard to determine if they are tolerable and safe.
- Identification of Company exposure/risk tolerance level standards.
- How and at what exposure/risk level actions are taken and where improvement is necessary.

The following is a set of typical examples of exposures to hazards which can occur from equipment and systems, with an indicative rating representing an action level.

This list may not be exhaustive and the Drilling Contractor may need to vary the list depending on its Scope of Operations and the operating area(s).

OCCUPATIONAL HEALTH RELATED HAZARDS	
Noise	Vibration
Abrasive Wheels / Grinders	Electro-Magnetic Radiation
Ionising Radiation	Thermal Radiation
Chemical Vapours	Chemical Particles
Chemical Gases	Ergonomics
High Surface Temperature *(equipment)*	Low Surface Temperature *(equipment)*
Transport Safety *(portable equipment)*	Structural Safety (Hit by - Caught by - Cut by)
Stress	

Table 4.3.2.2 – Overview of Occupational Health related Hazards

For those exposures/risks identified as unacceptable, the method of mitigation should be identified.

Drilling Contractors may find it appropriate to identify and document a specific item(s) of PPE for each level of hazard exposure.

Elimination	Eliminate the risk (i.e., engineer out)
Substitution	Substitute method and materials to reduce the risk
Modification	Modify methods and materials to reduce the risk
Containment	Contain materials to reduce the risk
Isolation	Isolate people from processes and materials to reduce risk
Procedures	Implement and monitor performance standards.
Training	Increase people's skill and abilities to reduce the risk
Personal Protective Equipment (PPE)	Protect people from health hazards to reduce risk

Table 4.3.2.3 – Common HSE Risk Reduction Hierarchy

4.3.3 Hazard and Source Identification Techniques

For each Hazard, the Drilling Contractor should identify the reasonable, worst-case potential consequences, or effects of that hazard being realized. This will determine the hazard's relative degree of significance. The objective is to systematically identify the most severe but credible consequence to people (P), assets (A), the environment (E) or company reputation (R) that could result from each Hazard (or Source). Only a reasonable estimate of what could happen if control of the hazard was lost is required. Therefore the experience and judgment of the people assigned to participate in this identification step is very important.

There are many techniques that can be used to help identify hazards, sources and consequences. Some of these can be applied to focus on individual Health, Safety or Environmental Aspects. Some of the more common techniques for Hazard and Source information are listed below - Drilling Contractors should choose those that are appropriate for their organizations and management systems.

Relevant legislation/regulatory documents	Existing environmental management practices and procedures
Incident, Audit and Inspection reports	Environmental discharge and emission records
Hazard identification (HAZID)	'What-If?'
Preliminary hazard analysis (PHA)	Gross Hazard Assessment (GHA)
Job hazard analysis (JHA) – Individual, Verbal, and Written	Task Risk Assessment (TRA)
Fault tree analysis (FTA)	Event tree analysis (ETA)
Hazard and operability analysis (HAZOP)	Driller's Hazard and Operability Study (HAZOP)
Health risk assessment (HRA)	Environmental impact assessment (EIA)
Failure modes and effects analysis (FMEA)	Failure modes and effects criticality analysis (FMECA)
Failure modes and impacts criticality analysis (FMICA)	Hardware in loop (HIL) simulation
Emergency response plan scenarios	Quantitative Risk Assessment (QRA)
Cost Benefit Analysis (CBA)	Physical-effects modelling (PEM)
Fire and Explosion Studies	Emergency Escape and Rescue Analysis (EERA)
Hazard Analysis (HAZAN)	

Table 4.3.3.1, Hazard and Source Identification Techniques

Information on the identified Hazards and the potential consequences associated with each is recorded in the Drilling Contractor's Hazard/Risk Register which will be regularly updated and forms an important part of the HSE Case. (See Table 4.3.1.)

How can this be achieved?

- By developing a Drilling Contractor's Hazard/Risk Register to ensure all hazards and sources (including Environmental Aspects and Health Hazards, when applicable) are addressed in the HSE Case.
- By systematically identifying if, where and when each possible hazard is encountered on the MODU (e.g., area layout, fixed equipment, etc.) and during which operations.
- By systematically identifying credible sources that could release each identified hazard.
- By systematically identifying the credible consequences that could result if control of the hazard was lost (i.e., if the hazard was released).
- By recording the above information in the Drilling Contractor's Hazard/Risk Register.

What should be (referenced) in the HSE Case?

- A description of the hazard identification process that has been applied.
- A list of the team members involved in the process with descriptions of their knowledge, competence, and understanding of the Drilling Contractor's management system.
- The Drilling Contractor's Hazard/Risk Register showing that all relevant hazards have been addressed.

4.4 RISK ESTIMATION

Objective

To determine HSE levels of risk by assigning values to the severity of each potential consequence and to the probability of the consequence occurring.

Discussion

An important activity in risk management, Risk Estimation is the process of ranking identified hazards with respect to their significance to people, assets, the environment or any other area of concern such as company reputation.

Risk Analysis is the combined activities of Hazard Identification and Risk Estimation.

4.4.1 Risk Assessment Matrix (RAM)

In order to provide a consistent and systematic estimation of risk, the recommended approach is to apply a Risk Assessment Matrix (RAM) in a qualitative manner. A RAM provides a convenient structure to apply the Drilling Contractor's screening criteria (values, targets or performance standards) to evaluate or compare the significance of an identified hazard, event or associated risk to determine the tolerability.

Risk is defined as the combination of the probability of occurrence of a consequence (including the probability of the release of the hazard) and the severity of that consequence. Therefore a matrix should be developed with consequence severity on the Y-axis and probability of occurrence on the X-axis. The level of risk can then be determined qualitatively at the intersection of the relevant row and column for a given scenario. Examples of how to use the RAM are provided after Figure 4.4.1.1.

These Guidelines do not prescribe using a particular matrix. Also, different Drilling Contractor organizations may have different matrices. However, when applied effectively for risk estimation, a RAM is fundamental to the risk management process described in these guidelines.

The example RAM shown in Figure 4.4.1.1 below is derived from the matrix described in ISO standard 17776. This example RAM is also referred to for several risk management purposes throughout these Guidelines and is equally applicable to health, safety, environment, and business risk assessments. Note that the example RAM is shown with a gradient across the levels of risk. In practice, there are divisions between the levels of risk so that each cell contains only one level or risk (high, medium, or low). These divisions are to be determined by the Drilling Contractor.