Health and Safety Executive

HSE Information sheet

Guidance on Risk Assessment for Offshore Installations

Offshore Information Sheet No. 3/2006

This information sheet provides guidance for Asset Managers, Safety Managers and Safety Engineers in the offshore industry on suitable and sufficient risk assessment, particularly in the context of the Offshore Installations (Safety Case) Regulations 2005 (SCR05)[1].

Legal Background

SCR05 r.12 requires, among other matters, a demonstration by duty holders that:

- all hazards with the potential to cause a major accident have been identified;
- all major accident risks have been evaluated; and,
- measures have been, or will be, taken to control the major accident risks to ensure compliance with the relevant statutory provisions (i.e. a "compliance" demonstration[2]).

A safety case 'compliance demonstration' has to show how a duty holder meets, or will meet, the requirements of the relevant statutory provisions [i.e. Health and Safety at Work etc. Act 1974 (HSWA), Offshore Installations (Prevention of Fire and Explosion, and Emergency Response) Regulations 1995 (PFEER), Offshore Installations and Wells (Design and Construction, etc) Regulations 1996 (DCR) and other provisions relevant to the control of major accident risks]. Many of the requirements within the relevant statutory provisions are qualified by phrases such as so far as it is reasonably practicable (SFAIRP), as low as reasonably practical (ALARP) or even, "appropriate with a view to". Where legal duties use these qualifying phrases, they call for similar tests to be applied. Wherever such wording is used this means a duty holder has to show, through reasoned and supported arguments, that there is nothing else that could reasonably be done to reduce risks further.

The compliance demonstration should be proportionate to the magnitude of risk; this guidance examines the role of different approaches to risk assessment from qualitative to quantified risk assessment (QRA). The primary objectives of risk assessment in this context are to identify and rank the risks so that they can be adequately managed and to examine associated risk reduction measures to determine those most suitable for implementation.

SCR92 tended to focus the attention of a duty holder on the extensive use of detailed QRA, frequently prepared by a specialist contractor on their behalf. This approach has been useful for advancing the understanding of risk on offshore installations, or from activities in connection with them. However, now that this understanding is more mature, it is suggested that risk assessment should now become increasingly focused on where it can add value (e.g. in evaluation of risk reduction options) rather than provided as "off-the-shelf" assessment. Thus any risk assessment should answer the fundamental question of whether there is anything more that can be done to reduce the risk, while adding value. There is also a shift in focus from contractor-owned risk assessment back to management ownership.

Previously, the first edition guidance guidance to SCR92 set a quantitative criterion for Temporary Refuge Impairment Frequency (TRIF) and this implied the need for QRA. This has now been better aligned with HSE thinking on risk tolerability and the more focused criterion of Temporary Refuge Integrity (TRI) has been established.

TRI is a determination of the survivability of the TR in terms of its ability to protect the occupants for a specific time period in such a way that they will remain unimpaired until such a time that they determine a need to evacuate the installation or recover following a hazardous event.

Guidance on what constitutes a suitable and sufficient risk assessment, for the purposes of a safety case demonstration, is provided here. The scope is aimed at fire and explosion risk assessment but the general principles may also be applicable to the assessment of risk from other sources. It is complementary to HSE's Topic Guidance[3] on fire, explosion and risk assessment.

Approaches to Risk Assessment

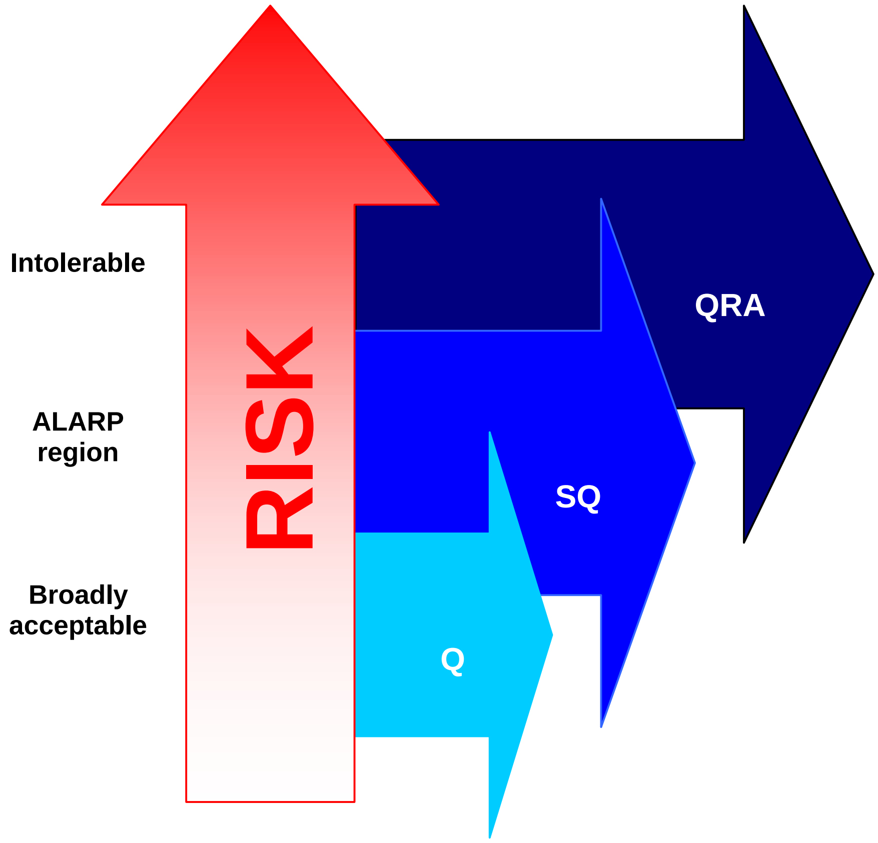
The risk assessment methodology applied should be efficient (cost-effective) and of sufficient detail to enable the ranking of risks in order, for subsequent consideration of risk reduction. The rigour of assessment should be proportionate to the complexity of the problem and the magnitude of risk. It is expected that assessment would progress through the following stages to provide an appropriate demonstration:

- **Qualitative** (Q), in which frequency and severity are determined purely qualitatively.
- **Semi-quantitative** (SQ), in which frequency and severity are approximately quantified within ranges.
- **Quantified risk assessment** (QRA), in which full quantification occurs.

These approaches to risk assessment reflect a range of detail of assessment from Q (lowest) to full QRA (highest). The choice of approach should take into account the following dimensions:

- The level of estimated risk (and its proximity to the limits of tolerability).
- The complexity of the problem and/or difficulty in answering the question of whether more needs to be done to reduce the risk.

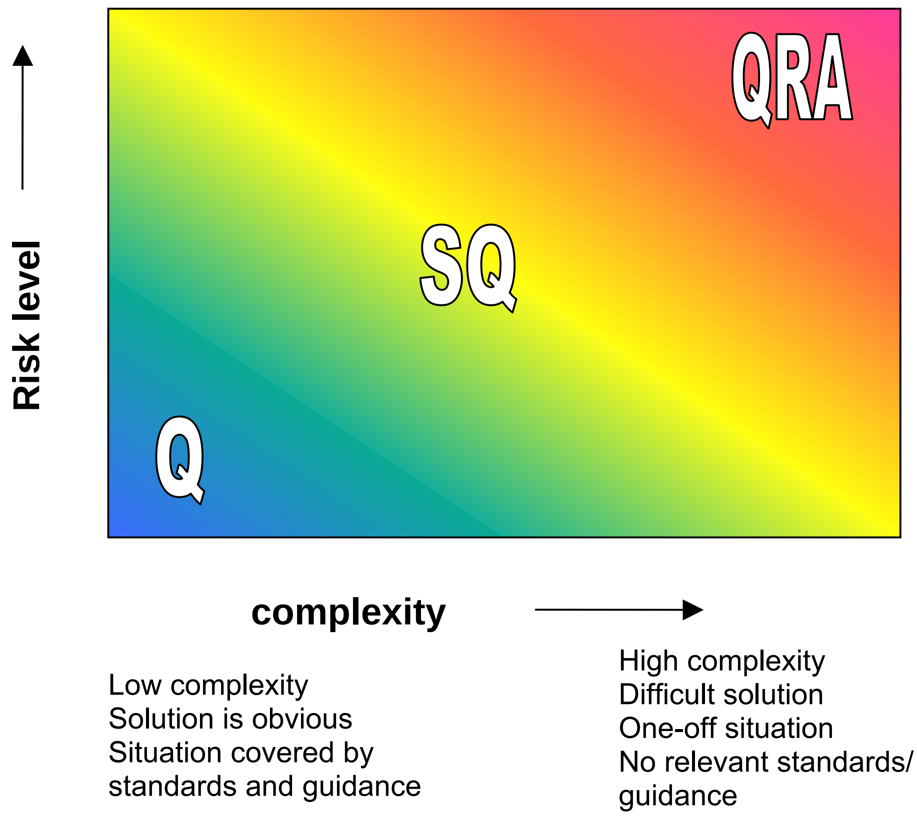
Figure 1: Proportionate risk assessment



In the risk dimension, the level of risk assessment used should be proportionate to the magnitude of risk, as shown in Figure 1 above. However, this may be modified according to the complexity of the decision that risk assessment is being used to inform. For example, it may occasionally be possible to use qualitative risk assessment in extremely high risk situations, where it is obvious that the risk is so high that risk reduction is essential. Great care must also be taken when attempting to justify something that is a significant deviation from existing codes, standards or good practice.

Figure 2: Alternative description of the approach to risk assessment as a function of risk level and complexity

complexity



Most importantly, risk assessment should be used to provide an input in to the decision making process and those responsible for such decision making should be suitably qualified, experienced and of sufficient seniority to be competent and accountable for their actions.

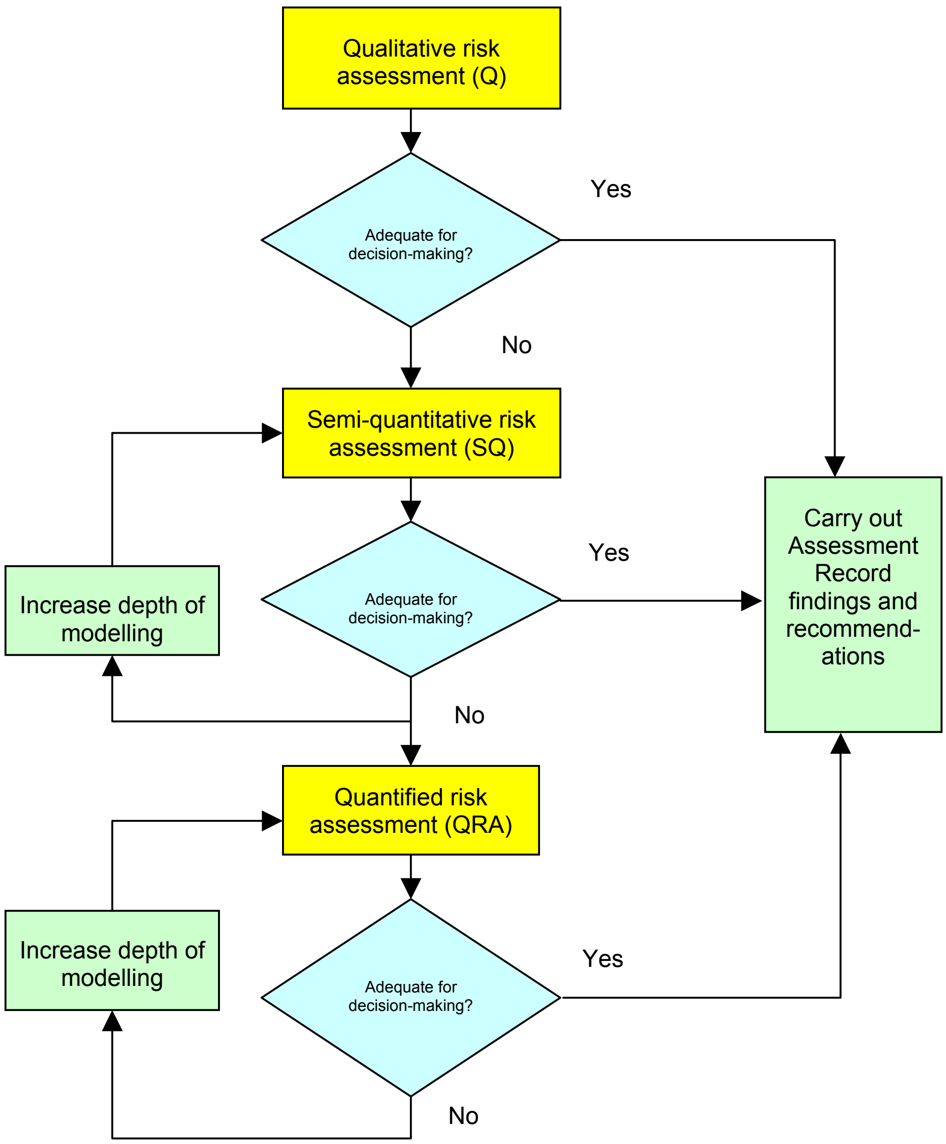
The lower levels of assessment (Q and SQ) are considered most appropriate for screening for hazards and events that need to be analysed in greater detail, e.g. to assist in determining the events to be included in the representative set for more detailed assessment. One approach to deciding the appropriate level of detail would be to start with a qualitative approach and to elect for more detail whenever it becomes apparent that the current level is unable to offer:

- The required understanding of the risks;
- Discrimination between the risks of different events; or
- Assistance in deciding whether more needs to be done (making compliance judgements).

This is illustrated by the flowchart in Figure 3 below.

However, to avoid unnecessary iteration a competent assessor may decide to start the process with SQ or QRA to make the process more efficient. This is a matter of judgement and experience and some further guidance is given in Appendix A.

Figure 3: Screening to determine appropriate risk assessment level



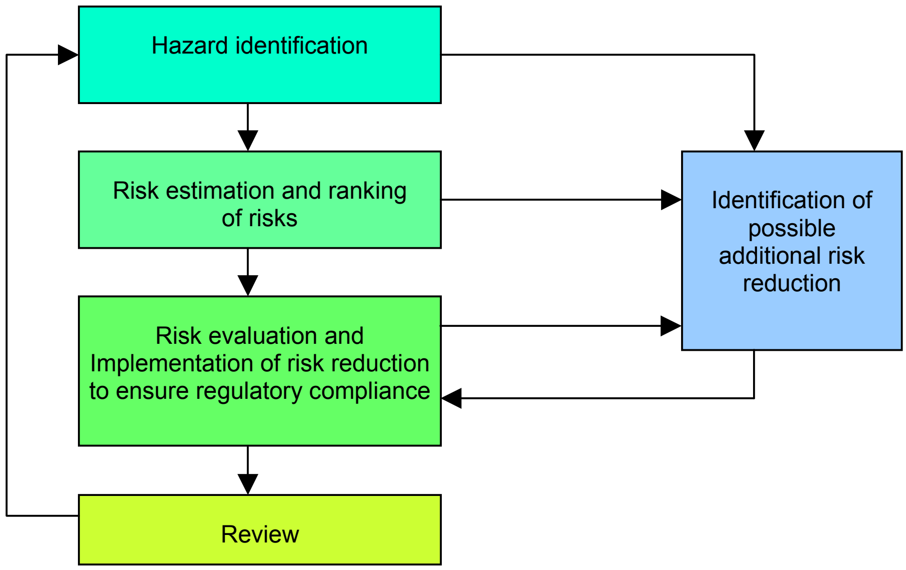
The Risk Assessment Process

Figure 4 below summarises the main stages in the process of risk assessment and achievement of a compliance demonstration. The main purpose of risk assessment is to identify and rank the risks so that they can be adequately managed. Each stage in the process can be seen as an opportunity to identify potential risk reduction options.

Hazard identification

Hazard identification needs to be comprehensive whatever the approach to risk assessment used.

Figure 4: Main stages in the risk assessment process



Risk estimation and ranking of risks

Risk estimation entails assessing both the severity (consequence) and frequency (likelihood) of hazardous events. The amount of detail and effort required increases from qualitative (Q) to semi-quantitative (SQ) to quantified risk assessment (QRA). For the Q or SQ approaches, a risk matrix is a convenient method of ranking and presenting the results. It is important that the risk matrix used should be capable of discriminating between the risks of the different hazardous events for the installation. A 5 x 5 matrix will give greater opportunity for such discrimination than a 3 x 3. Further information about the different approaches to risk assessment and the available guidance is given in Appendix B.

Figure 5: Example risk matrix

Frequency per year	Severity				
	A	**B**	**C**	**D**	**E** (highest)
I (highest)					
II					
III					
IV					
V (lowest)					

Identification of potential risk reduction

The main purpose of risk assessment is to decide if more needs to be done. An important aspect of this overall process is therefore the identification of existing and potential risk reduction measures. This process will typically parallel the risk assessment, informing it and being informed by it.

Identification of hazards may often spark ideas about potential risk reduction and these should be captured. Similarly, the risk estimation can help identify possible additional risk measures because it entails a thought process about the way in which the hazard scenarios would unfold, and about the interaction with the physical layout etc. of the installation. It can be particularly helpful to consider which stage(s) of the scenario dominates its risk, e.g. whether fatalities would be immediate, due to escalation or during escape, evacuation and rescue (EER).

The ranking of risks prioritises them for systematic consideration. A risk reduction measures study is best carried out by a multi-disciplinary brainstorming team with adequate experience, knowledge and qualifications. It will take each risk in turn and identify potential risk reduction measures, including any identified during the risk assessment but also seeking to extend this by further brainstorming. Ideally, this should be done by personnel from the duty holder who have extensive knowledge of the installation and its operation. It may be informed by a bow-tie diagram or similar presentation (see Appendix C), relevant to the risk being considered and by any relevant guidance, standards or industry best practice.

A hierarchical approach to risk reduction should be taken, e.g. as required by PFEER [4]:

- Elimination and minimisation of hazards by design (inherently safer design);
- Prevention (reduction of likelihood);
- Detection (transmission of information to control point);
- Control (limitation of scale, intensity and duration);
- Mitigation of consequences (protection from effects); and
- EER.

Risk evaluation

The output of the risk estimation should be a list of risks in ranked order for consideration. The process of risk evaluation starts with the highest risk and proceeds down the list of identified potential risk reduction measures until it is evident that no further risk reduction measures can be justified. The process then continues through the remaining risks until all have been evaluated. A duty holder must demonstrate that risks are controlled to ensure compliance with the relevant statutory provisions, and not intolerable.

Intolerability

Any risk identified as intolerable must be reduced until tolerable, before further considering additional reduction to ensure those risks are controlled in compliance with the relevant statutory provisions. It is for the duty holder to set their tolerability criteria. An individual risk of death of 10^{-3} per year has typically been used within the offshore industry as the maximum tolerable risk. Such quantitative criteria can be used directly if the level of risk assessment performed was QRA.

SQ or Q analysis should be used only where the risks are low enough that the risk is not expected to be intolerable. Experience of QRA results for similar (or higher risk) installations, for which the risk was not intolerable, could be used to assess this. This might be the case for, for example, drilling installations where the design and controls follow standardised solutions.

Temporary refuge impairment frequency (TRIF) has been used as a surrogate tolerability criterion for group risk. However, experience of risk assessments and evaluations within safety cases has led to the conclusion that use of such a criterion adds little value. In particular, it should not be considered necessary to undertake a QRA solely to demonstrate compliance with a TRIF criterion if experience from previous QRAs on similar installations indicates that the installation is likely to comply. Instead, the TR should be specified so far as reasonably practicable such that impairment will not occur, moving the focus from TRIF to temporary refuge integrity (TRI). The risk assessment (particularly the consequence modelling) is best used to define the necessary time for which TRI would be required in the relevant accident scenarios and the levels of explosion overpressure, thermal radiation, smoke, toxic gas etc. to which it would be exposed. This identifies the key protective systems required for the TR and thus enables the appropriate performance standards to be set and evaluated against compliance criteria.

ALARP

Guidance on demonstrating compliance with the relevant statutory provisions is given in Offshore Information Sheet No 2/2006[4]. Potential risk reduction measures can be evaluated by a mixture of qualitative and quantitative considerations, as appropriate. It may be that more than one such measure requires to be implemented to achieve compliance with the relevant statutory provisions.

All such evaluations should include qualitative screening, which may take into account factors which cannot easily be included in a cost benefit analysis (CBA), such as practicability and uncertainty. When deciding whether a particular risk reduction measure is viable, account must be taken of whether it would prevent or control more than one hazardous event. The use of bow-tie diagrams (Appendix C) can be helpful in analysis of the system to determine this.

In cases where it is difficult to determine whether the cost is justified, and where the level of risk assessment has been appropriate, CBA may be a useful aid to decision-making. In exceptional cases, it may be necessary to refine the level of risk assessment in order to determine whether or not a particular risk reduction measure should be implemented. Alternatively those making decisions on the basis of CBA must use cautious risk estimates, taking full account of the uncertainty (see Appendix D). Where significant uncertainty exists, CBA may be deemed inappropriate. Sensitivity analysis on the effects of certain input parameters may be particularly useful in exploring the influence of uncertainty on decisions about risk reduction.

Decisions on the requirement for additional risk reduction should be made by appropriately qualified and experienced technical personnel. Decisions should be made on the basis of whether risks are controlled to ensure legal compliance rather than affordability (e.g. availability of money within budgets). The output from the risk reduction measures study should be a list of the risk reduction measures considered for each prioritised risk, with a conclusion as to whether it is to be implemented or not. If it is to be implemented, it should form part of an improvement plan, including responsibilities, accountabilities and timescale; if not, the reasons should be documented and justified on the basis of reasoned argument.

Review

The risk assessment should be reviewed periodically and whenever there are significant changes that affect the risks.

Any remedial measures that are adopted will change the position of the relevant risk(s) within the ranking. Use of the process periodically will therefore promote continuous reduction in risk, irrespective of the approach to risk assessment that has been employed.

Documentation

The risk assessment should be documented in the case for safety in such a way as to explain the process, highlight the key assumptions and justify the decisions made including the approach to risk assessment, choice of representative hazard set etc. The inputs to the risk assessment should be justified with links to performance standards and physical conditions such that they can be verified by audit or inspection, if required. The main outputs should be described including justification that the risks are not intolerable and the list of risks, ranked in order for consideration of risk reduction. Some of the details of the risk assessment, such as hazard identification meeting records, full QRA inputs and output, will be best documented separately but referenced.

Duty holder relationship with third parties employed to carry out risk assessment

The duty holder has ultimate responsibility for any risk study carried out on their undertaking.

There is little or no value in commissioning a risk assessment from a contractor, only to file away the results. Nor is there value in carrying out, or having carried out, a generic "handle-turning" risk assessment that does not fully address issues pertinent to the installation. Equally, it is better to spend money on appropriate remedial measures rather than on extensive and detailed quantified risk assessment. Fit-for-purpose risk assessment is essential to ensuring that money is well spent and effective. Therefore a proportionate balance needs to be struck in deciding the approach to risk assessment required.

The duty holder is responsible for:

- Initiating the process of risk assessment;
- Scoping the risk assessment (given the knowledge of the installation, stage in the lifecycle etc.). This should typically include:
    - the context and purpose of the work;
    - the process(es) and parts of the installation to be included, with a full list of supporting information resources;
    - the approach or depth of risk assessment to be employed;
    - the format of the report.
- Sub-contracting appropriate aspects, e.g. leadership of hazard identification, quantification, to specialist contractors, if appropriate;
- Providing the necessary inputs and members of brainstorming teams to the sub-contractors;
- Providing all necessary resources and support;
- Reviewing the outputs so as to ensure that details of the installation and its operation are appropriate, and to obtain an understanding of the hazards, potential consequences and risks;
- Making use of the results of the risk assessment as part of the continuous improvement of safety, e.g. by using it to identify and evaluate possible remedial measures;
- Reviewing the risk assessment periodically and updating it as required.

The ownership of the risk assessment needs to be retained by the duty holder. The duty holder will therefore need to carefully consider how to supply the data input required by the contractor, including details of the installation and its operation. In all cases, personnel carrying out the risk assessment should have a knowledge of the:

- Equipment, process and/or activity to be assessed;
- Hazards present;
- Probability/likelihood of the failure scenarios realising a hazard;
- Consequences of exposure to the hazards present or produced.

The duty holder is responsible for producing a risk assessment that is fully appropriate for the installation and purpose, rather than a generic risk assessment for the type of installation, (unless it can be demonstrated that the generic study is adequate and conservative and does not fail to address significant issues which are specific to the installation).

Where consultants or contractors are employed to carry out the risk assessment, their scope of work would be expected to include the making of recommendations about the potential for further risk reduction. The duty holder is responsible for evaluation of these recommendations.

It should be recognised by the duty holder that all risk assessment is subject to uncertainty (see Appendix D). However, even fairly approximate risk assessment (in terms of the accuracy of any quantification) may often still be useful for decision-making, providing the assessors have a suitable knowledge base and experience. There should be feedback from the evaluation of possible remedial measures to the risk assessment so that the effects of uncertainties, and any conservative assumptions used to overcome uncertainty, can be fully understood. Opportunity should be taken whenever possible to provide a "reality check" on the risk assessment, e.g. by means of comparison with incident and maintenance statistics, so as to increase the level of confidence in it.

The relationship of risk assessment with the duty holder's safety management system (SMS) is discussed in Appendix E.

References

1. The Offshore Installations (Safety Case) Regulations 2005, Statutory Instrument 2005 No. 3117, http://www.opsi.gov.uk/si/si2005/20053117.htm

2. Offshore Information Sheet No 2/2006; Offshore Installations (Safety Case) Regulations 2005, regulation 12 - Demonstrating Compliance with Relevant Statutory Provisions

3. Fire, Explosion and Risk Assessment Topic Guidance, HID Offshore Division, June 2003, http://www.hse.gov.uk/offshore/fireexp/index.htm

4. Offshore Installations (Prevention of Fire and Explosion, and Emergency Response) Regulations, 1995 (PFEER), Approved Code of Practice and Guidance, L65, HSE Books 1997, ISBN 0 7176 1386 0

Further Information

Any queries relating to this notice should be addressed to:

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This information sheet contains notes on good practice which are not compulsory but which you may find helpful in considering what you need to do.

Appendix A

FURTHER GUIDANCE ON CHOICE OF RISK ASSESSMENT APPROACH

Starting point for risk assessment approach

It may be efficient to make an initial assessment of the likely minimum approach to risk assessment, rather than following the iterative screening approach described above. This initial assessment defines the starting point approach and it may still be necessary to upgrade the approach if it proves not to be detailed enough.

Some examples of likely starting points are:

- Large integrated platforms in the northern North Sea or large nodal platforms in the southern North Sea are likely to have a combination of complexity and risk level requiring QRA;
- For installations with less complexity and fewer personnel, e.g. drilling installations, normally unattended installations (NUIs), SQ may often be adequate. However, it will then be necessary to rely on good practice procedures to control risks such as the transport (helicopter or equivalent) of personnel between installations;
- In cases where there are clear standards and benchmarks for design and risk reduction, Q may sometimes be sufficient;
- For some stages of the lifecycle, where hazard identification can lead directly into specification of good practice risk reduction measures, e.g. combined operations and decommissioning, Q or SQ may often be sufficient.

Some of the factors that should be taken into account when deciding the initial approach to risk assessment are shown in the following Table.

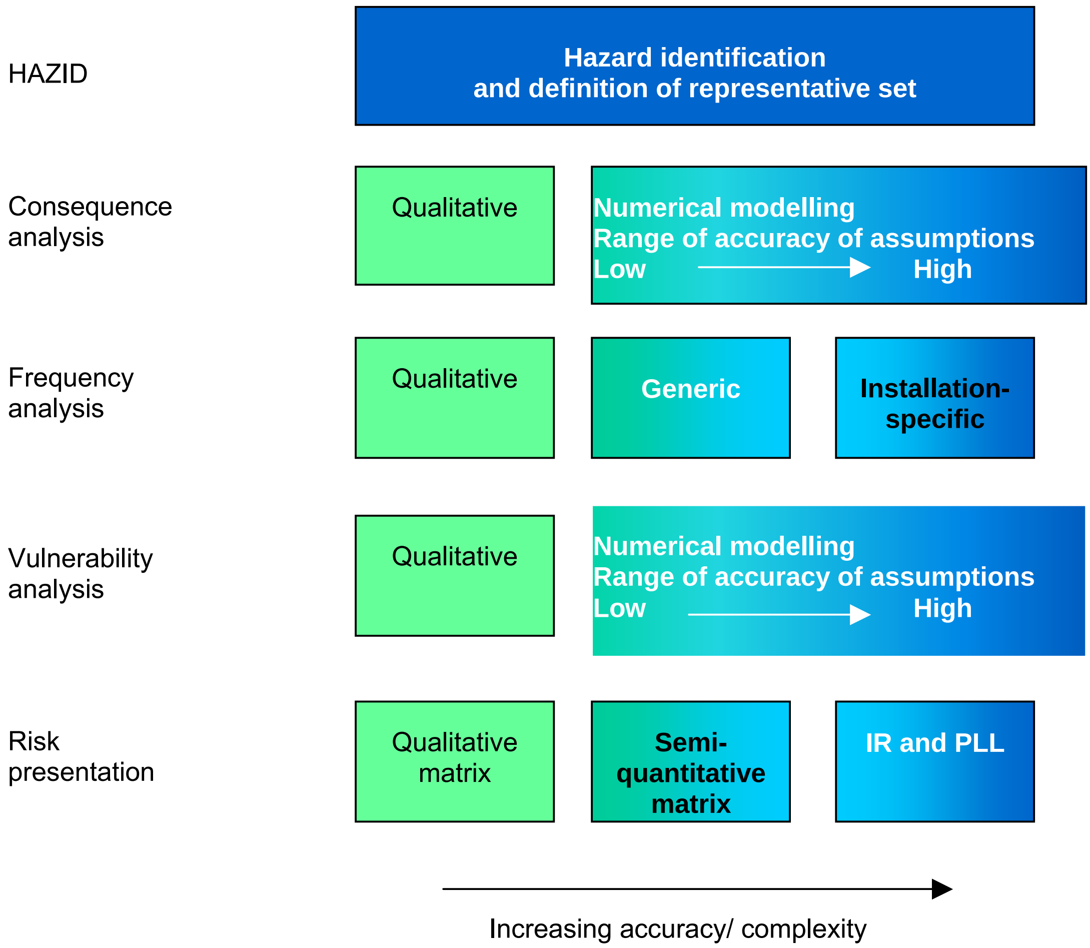
Factors in deciding initial risk assessment approach

Issue	Factors tending towards more detailed risk assessment approach	Factors tending towards less detailed approaches
Stage in life-cycle	• Design • Initial operation • Significant modifications	• Combined operations • Abandonment/ decommissioning • Minor modifications
Process conditions	• High inventory/ throughput • High pressure/ temperature • Well fluids containing gas/ condensate	• Low inventory/ throughput • Low pressure/ temperature • Well fluid is oil/ water with no gas or condensate
Degree of standardisation	• Novel concepts and designs • High complexity	• Standardised designs and controls available
Complexity	• Integrated platforms • Processing of well fluids	• Drilling • Export of well fluids only • Storage • Accommodation
Persons on Board (POB)	• High POB • Permanent presence	• Low POB • Occasional manning

Risk assessment approach as a function of stage in the risk assessment process

The different approaches to risk assessment imply different levels of detail and complexity at each stage in the risk assessment process, except that hazard identification needs to be comprehensive whatever the approach used. The amount of detail and effort required at each stage increases from qualitative (Q) to semi-quantitative (SQ) to quantified risk assessment (QRA). The three approaches form a continuum in terms of level of detail and rigour, rather than discrete steps. See the diagrams in Figures 5 and 6 below.

Figure 5: Detail and effort at each stage in a risk assessment



Appendix B

GUIDANCE ON RISK ASSESSMENT

QRA

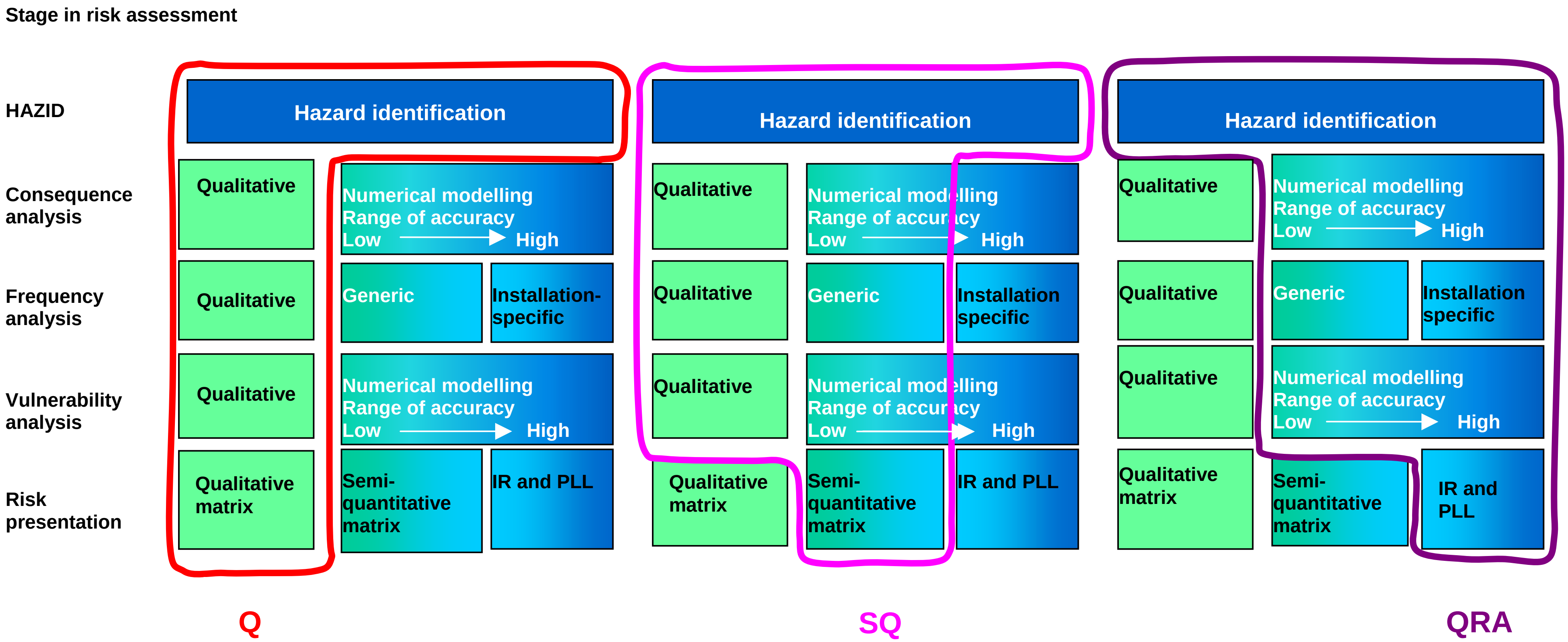
Considerable guidance on the detailed methodologies involved in QRA for offshore installations already exists and includes standards, industry guidance and internal guidance produced by operators. Some useful references are given in the Appendix F. HSE's Topic Guidance for fire and explosion risk may also be helpful.

Q and SQ

It is important that the risk matrix used should be capable of discriminating between different risks. This requires careful selection of the severity and frequency categories. The severity categories should cover the full range of interest, for example:

- Serious harm;
- Single fatality
- Multiple fatalities
- Loss of installation;
- Loss of complex;
- Loss of field with several installations

Figure 6: Approaches to risk assessment



The frequency categories should be chosen so as to cover the range relevant to the severity categories. The aim of the matrix is to rank risks for further consideration. This implies ranking them in terms of their closeness to the ‘high risk’ corner of the matrix.

The risk matrix should be used as a guide to ranking. Expert judgement is to be encouraged to take account of qualitative factors such as the uncertainty and/or degree of conservatism in the risk estimates. Where several events fall within the same cell, expert judgement can be used to rank these events. This may be informed by the “raw” severity and frequency scores, which may indicate which event has the higher risk.

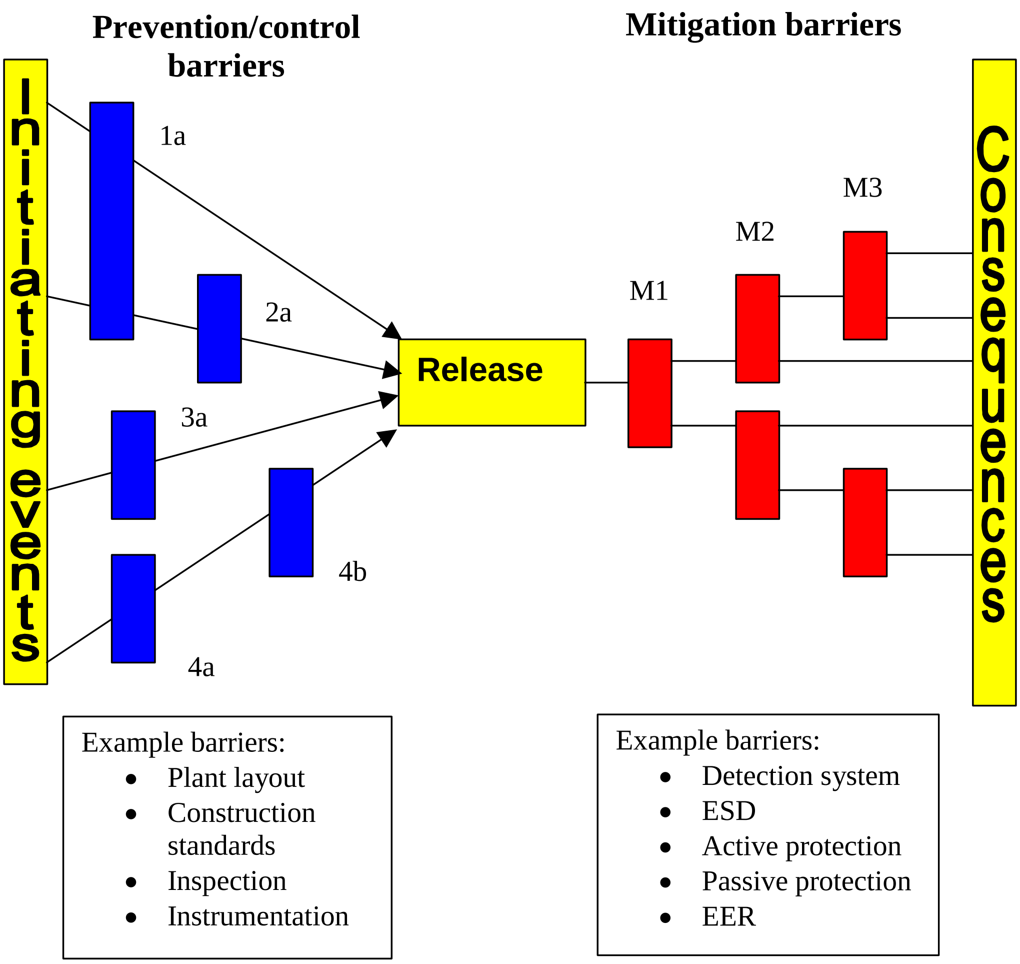
Some guidance has been produced for HSE in both offshore and onshore context, covering the use of risk matrices to determine the most significant risks. References are given in the Appendix F. The significant risk events should include all the very high severity events, and the highest frequency events in each severity category.

Appendix C

BOW-TIE DIAGRAMS

A bow-tie diagram is a representation of all the initiators and consequences of a particular scenario, together with the safety barriers that are in place to prevent, control or mitigate the event. Such barriers are usually referred to as lines of defence (LOD) or layers of protection (LOP). Reference numbers can be assigned to each barrier to facilitate capturing which barriers are common to several initiators for a particular scenario (see for example barrier 1a in Figure 7 below) and those which are common to several scenarios.

Figure 7: Example of a bow-tie diagram



Bow-tie diagrams can:

- Identify and document the "lines of defence" or "safety barriers" which are in place;
- Facilitate a qualitative assessment of any gaps;
- Help inform an assessment of event likelihood for semi-quantitative analysis.

Sources of further guidance on the use of bow-tie diagrams can be found in the Bibliography in Appendix F.

Appendix D

UNCERTAINTY

Some of the many sources of uncertainty in any risk assessment for fire and explosion hazards are shown in Figure 8 below.

The biggest inaccuracy/uncertainty in any risk assessment is usually associated with whether any hazards have been missed during hazard identification and therefore not included in the scope. The aim is to identify all the relevant hazards and it is only once these have been identified that a fully informed view can be taken on the depth of analysis required. All types of installation require comprehensive hazard identification. This should lead to the definition of a representative set for consequence analysis.

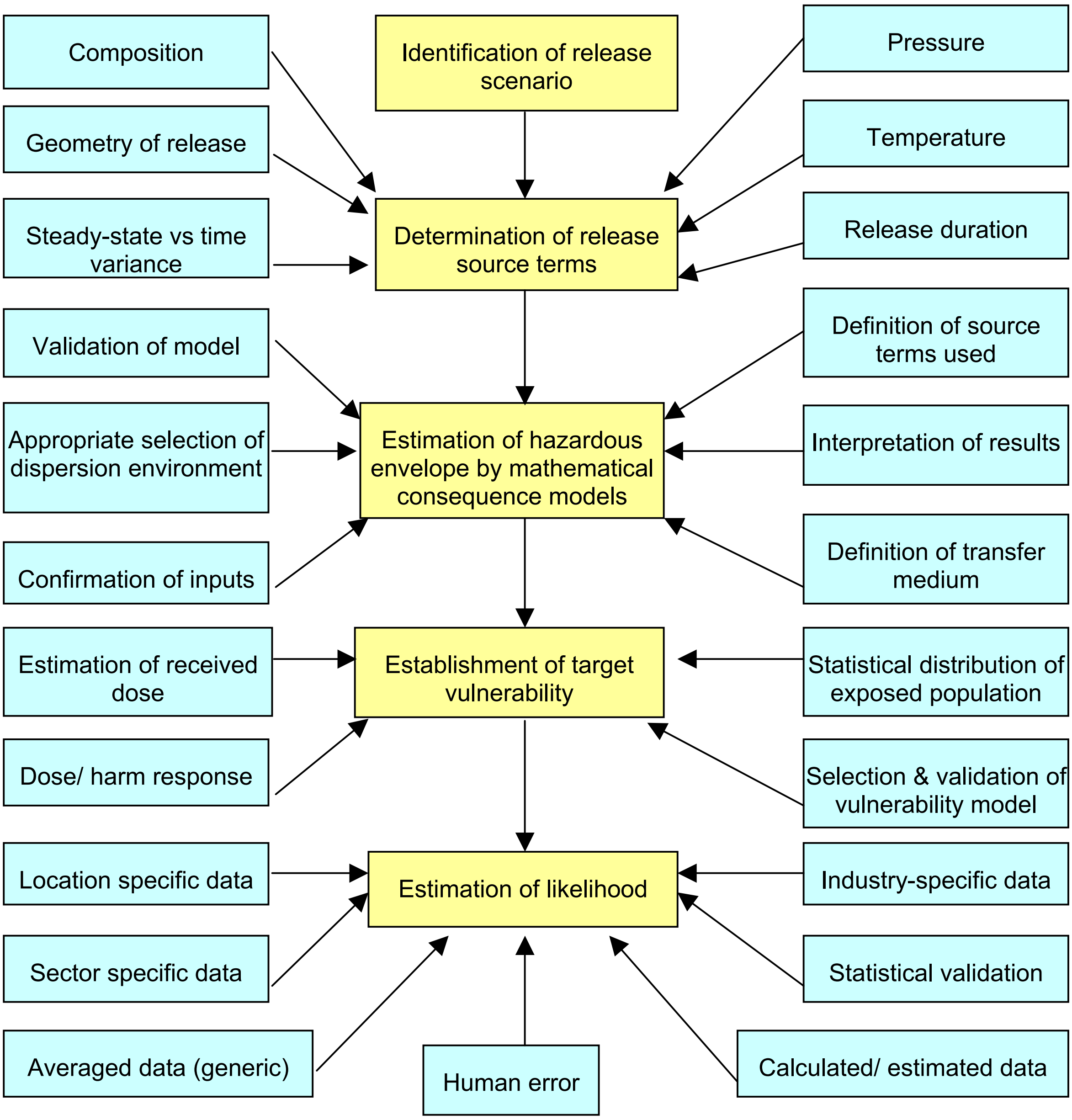
A main objective of the risk assessment is to rank risks for consideration of further risk reduction. A key issue for the integrity of the risk assessment is therefore whether any events, which would have come high in the risk ranking, have been missed from the scope. It is therefore good practice to review the selection of the representative set to increase assurance that no such significant events have been missed.

It is usual to reduce all the hazardous events into a set of representative release scenarios. Typically, release rate and duration enable estimation of an averaged scenario deemed to be representative of a range of events. The range is chosen on the basis that there is little variation in the consequence estimates produced. Care must be taken to avoid an excessive range in each representative scenario. It is more pertinent to range release rate than to use a range of average hole diameters. Since release rate varies with area, the use of an average diameter will underestimate the average release rate.

Modelling of consequences and vulnerabilities should be "fit-for-purpose" in terms of achieving a sufficient level of rigour to allow decisions to be reached about the ranking of the risk against other risks; and about whether further risk reduction measures are required to control the risk to ensure compliance with the relevant statutory provisions. In general higher rigour (use of less or better simplifying assumptions) correlates with higher resources and cost for the assessment. Reduced modelling rigour can be compensated by applying conservatism when making simplifying assumptions. A satisfactory balance needs to be struck between this conservatism and the cost of the study.

A way of dealing with uncertainties in event frequencies is to use standardised numbers, usually based on generic data. Some sources of such data are included in the Appendix F. Any uncertainty in the inputs to the frequency analysis can be addressed by conservative assumptions. It would be expected that, for the Q and SQ approaches to risk assessment, there should be significant conservatism. For QRA, the analysis may be pitched within a range of rigour versus conservatism. If it becomes apparent from the results that the level of conservatism may be too great to support decision-making, then it may be necessary to refine the analysis in order to remove conservatism. Such refinements will require detailed justification and be capable of withstanding detailed scrutiny.

Figure 8: Some sources of risk assessment uncertainty



Sensitivity analysis is an appropriate technique for assessing the magnitude of effect of uncertainty in input data in cases where it may affect the results in terms of the final risk ranking. In most cases, a limited number of carefully chosen sensitivity studies will be sufficient, rather than a more costly Monte Carlo analysis.

When QRA has been employed, both Individual Risk (IR) and Potential loss of life (PLL) should be broken down in a number of ways, including by groups of exposed workers, scenario, location and/or the stage of the incident in which the fatality would occur (immediate, escalation, EER etc.). It is particularly important that IR and PLL be provided for the group(s) of workers at most risk. Averaging over the whole population of the installation adds little understanding and has the potential to distort the risk picture by diluting high risks (hot spots) in particular worker groups. Care should be given to defining the worker groupings to be used. Ranked lists of risks should be informed by all this information, with the final decisions taken by expert judgement, taking into account any relevant qualitative factors and uncertainties.

Appendix E

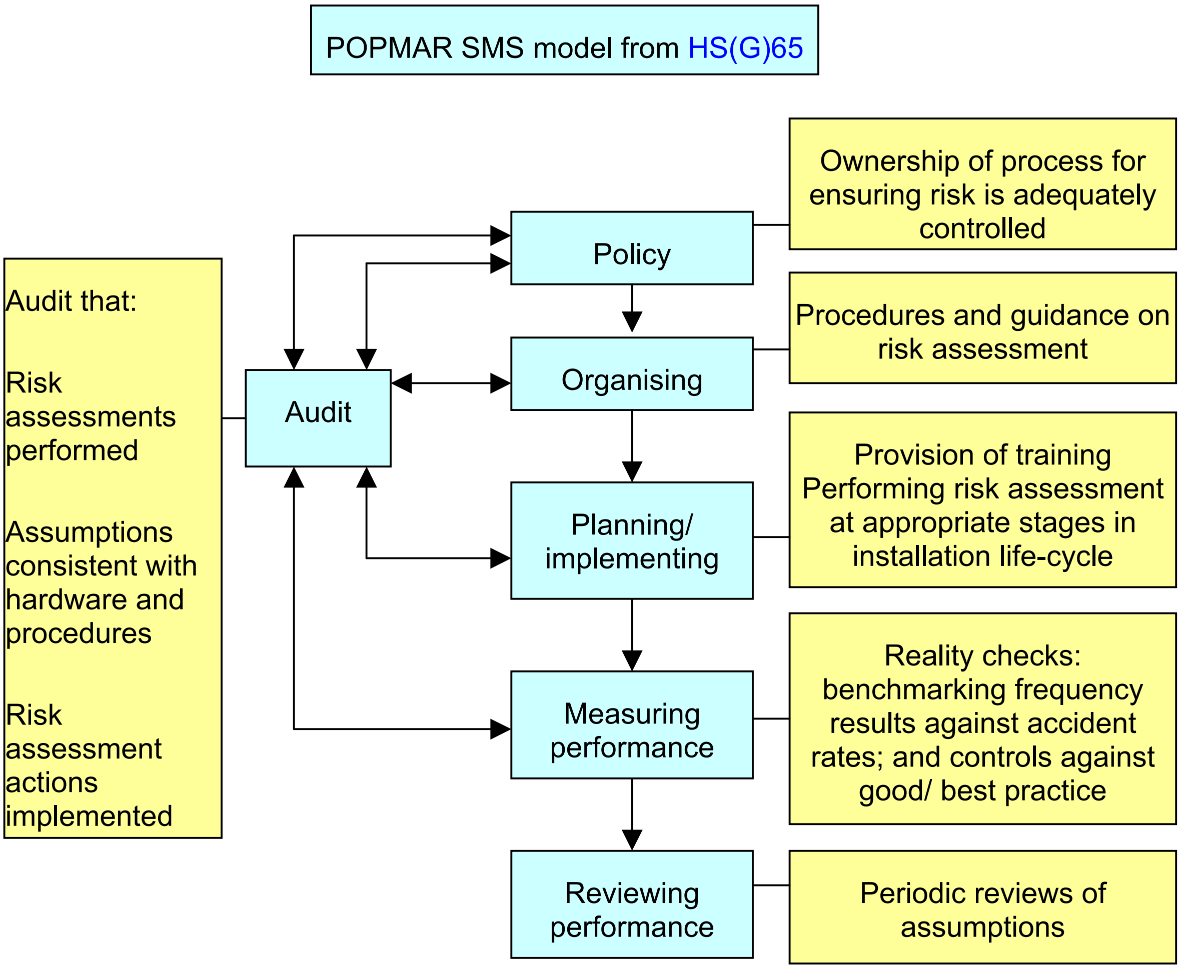
RELATIONSHIP OF RISK ASSESSMENT WITH SMS

Risk assessment alone does little or nothing to reduce risks, particularly if risk assessment is seen as an end in it self. Rather, risks are reduced by employing the risk assessment process in an active and intelligent way, as a tool to help focus the process of continual improvement within the safety management system (SMS).

Active engagement in the process of risk assessment, with a view to gaining an understanding of the risks and their relative priorities, is to be encouraged at all levels of the workforce. Risk assessment is an essential part of any SMS including that for fire and explosion risks. The purpose is to identify and rank risks so that they can be adequately managed. It is part of the process of deciding whether or not additional controls are required or justified and hence to providing assurance to management that both safety and business risks are adequately managed and controlled.

The diagram below shows the way in which the risk assessment itself fits within the HS(G)65 SMS model.

Figure 9: Risk assessment as part of safety management



Appendix F

BIBLIOGRAPHY

QRA

CMPT (1999), A Guide to Quantitative Risk Assessment for Offshore Installations, Centre for Marine and Petroleum Technology, Publication 99/100, J Sponge (Ed.)

BS EN ISO 17776:2002, Petroleum and natural gas industries — Offshore production installations — Guidelines on tools and techniques for hazard identification and risk assessment

HSE (2003), Offshore Division Fire, Explosion and Risk Assessment Topic Guidance, June 2003, DNV (2001), Marine risk assessment, Offshore Technology Report 2001/063, HSE Books, ISBN 0 7176 2231 2, http://www.hse.gov.uk/research/otohtm/2001/oto01063.htm

NORSOK (2001), Standard Z-013, Risk and Emergency Preparedness Analysis, Rev 2, 2001, Norway, http://www.standard.no/pronorm-3/data/f/0/01/50/3_10704_0/Z-013.pdf

WorkSafe MHD (2002), Major Hazard Facilities Regulations Guidance Note, Safety Assessment under the Occupational Health and Safety (Major Hazard Facilities) Regulations, MHD GN – 14, Rev 0, January 2002, Australia,

http://www.workcover.vic.gov.au/vwa/home.nsf/pages/so_majhaz_guidance/

Frequency data

Offshore Hydrocarbon Releases Statistics and Analysis, 2002, HSE, February 2003,

http://www.hse.gov.uk/offshore/statistics/hsr2002/hsr2002.pdf

CMPT (1999), A Guide to Quantitative Risk Assessment for Offshore Installations, Centre for Marine and Petroleum Technology, Publication 99/100, J Sponge (Ed.)

Q and SQ

DNV (2001), Marine risk assessment, Offshore Technology Report 2001/063, HSE Books, ISBN 0 7176 2231 2, http://www.hse.gov.uk/research/otohtm/2001/oto01063.htm

M Middleton & A Franks (2001), "Using Risk Matrices", The Chemical Engineer, September 2001, pp 34 - 37

BS EN ISO 17776:2002, Petroleum and natural gas industries — Offshore production installations — Guidelines on tools and techniques for hazard identification and risk assessment

Layer of protection analysis and bow-tie diagrams

CCPS, (2001). 'Layer of Protection Analysis – Simplified Process Risk Assessment'. American Institute of Chemical Engineers, New York.

Amey VECTRA (2002), 'Lines of Defence/Layers of Protection Analysis in the COMAH Context', www.hse.gov.uk/research/misc/vectra300-2017-r02.pdf.

Safety management

Successful Health and Safety Management, HSG65, HSE Books, 1997, ISBN 0 7176 1276 7.