HHRM

HELLENIC HYDROCARBON RESOURCES MANAGEMENT

ALARP GUIDANCE

UNDER L4409/2016

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1 INTRODUCTION

Law N. 4409/2016 (the Law) makes Hellenic Hydrocarbon Resources Management S.A. (HHRM S.A.) the Competent Authority for the major hazard regulation of offshore oil and gas operations within licensed areas in Greece. Within this, clauses 1 and 4 of Chapter 2, Article 3 of the Law state:

> *1. Operators shall ensure that all suitable measures are taken to prevent major accidents in offshore hydrocarbons operations.*
>
> *4. Operators shall ensure that offshore hydrocarbons operations are carried out on the basis of systematic risk management so that the residual risks of major accidents to persons, the environment and offshore installations are tolerable.*

This is a requirement for Operators and Owners to reduce all major accident risks to a level that is Tolerable meaning that all Suitable risk measures are implemented. It is based on the principle that those who create and have control over risks have responsibility for their management and must assess them to ensure sufficient risk reduction measures are implemented until the risk is 'Tolerable'.

Internationally, this is known as the ALARP concept, where with regards to the terminology used in the Law, 'Suitable' has the same meaning as 'Reasonably Practicable' and 'Tolerable ('acceptable')' has the same meaning as 'As Low As Reasonably Practicable (ALARP)'. The ALARP demonstration forms a central part of a Report on Major Hazards (RoMH) submitted under the Law (see Annex 1 2(5), 3(5)). The RoMH Guidance details how the ALARP Assessment should be documented in the RoMH and it should follow the guidance given here.

The ALARP principle states that all risk reduction measures must reduce risk to levels that are "As low as reasonably practicable". The reduction must thus be made in such a way that the sacrifice of time, effort and money is not grossly disproportionate to the benefit arising from the risk reduction measure. The decision is weighted in favour of health and safety because the presumption is that the operator should implement the risk reduction measure. To avoid having to make this sacrifice, the operator must be able to show that it would be grossly disproportionate to the benefits of risk reduction that would be achieved. Thus, the process is not one of balancing the costs and benefits of measures but, rather, of adopting measures except where they are ruled out because they involve grossly disproportionate sacrifices. What is reasonably practicable in any given situation will be determined by the facts of the case.

This *ALARP Guidance* document provides detailed guidance on HHRM's requirements for an ALARP assessment to demonstrate that the Major Hazards risk is ALARP. It is a requirement of the HHRM that the ALARP assessment process set-out in this document, or a process that achieves the same objectives, is followed and detailed in the RoMH. Although the principles outlined here are still applicable, guidance on the assessment of the safety risks from non-Major Hazards and environmental consequences of Major Hazards is outside the scope of this document.

This document draws on guidance issued by statutory bodies regulating safety in the oil and gas industry in the UK, Ireland and Australia and industry bodies in the UK.

2 ALARP ASSESSMENT

2.1 Overview of the ALARP Principle

The ALARP principle is illustrated in Figure 1. The triangle represents an increasing level of overall risk (all risks, or the total risk, that a person, or population are exposed to) from a low risk, represented by green at the base of the triangle, to a high risk, represented by red at the top of the triangle.

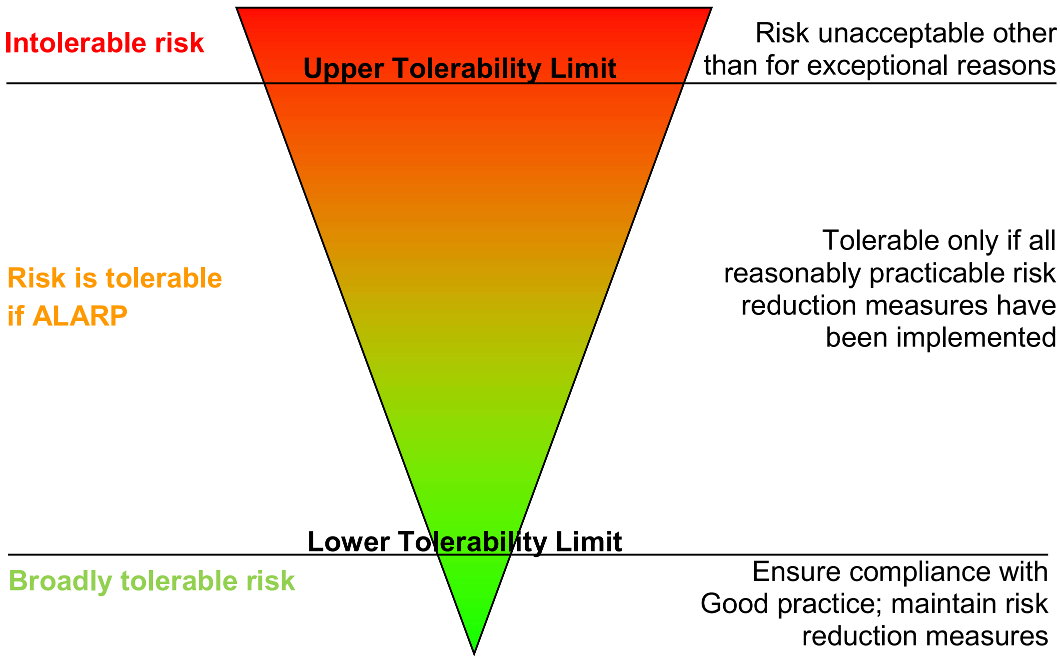

Figure 1: Schematic diagram illustrating the ALARP principle

Figure 1 shows the Upper Tolerability Limit, above which the risk is intolerable and will only be permitted for exceptional reasons.

Below the Upper Tolerability Limit, the risk is only tolerable if it is ALARP. This means that all practicable risk reduction measures must be identified and those that are reasonably practicable implemented. The term reasonably practicable indicates a narrower range than all physically possible risk reduction measures. If the cost of a risk reduction measure, whether in terms of money, time or trouble, can be demonstrated to be grossly disproportionate to the risk reduction gained from the measure, taking account of the likelihood and degree of harm presented by the hazard, then implementation of the measure may not be required. Where the risk(s) in question are between the Upper Tolerability Limit and the Lower Tolerability Limit, an ALARP Assessment will be required.

Figure 1 also shows the Lower Tolerability Limit below which the risks are broadly tolerable to society and comparable to everyday risks faced by the general public. If the overall risk is below the Lower Tolerability Limit, the ALARP Assessment is likely to be straightforward and limited to ensuring compliance with Good Practice. Below the Lower Tolerability Limit, the principal risk management concern is the maintenance of existing risk reduction measures to avoid degradation. Values for the Risk Tolerability Limits and further guidance on them are given in Section 2.5.

2.2 Risk Management Process

In carrying out an ALARP Assessment, a risk management process (also termed hazard management process) must be followed that incorporates the ALARP principle. This section describes the expectations of such a process and it, or a process that achieves the same objectives, must be followed. The steps in the process illustrated in Figure 2 are:

1. A comprehensive identification of all Major Hazards associated with the operation (Section 2.3);
2. Where Good Practice exists, this or its equivalent must be implemented (Section 2.4);
3. For the Major Hazards associated with the operation:
   a) A quantitative assessment of the total safety risk must be carried out:
      - In circumstances where the risk of an identified Major Hazard cannot be assessed with sufficient certainty to be reliably compared with the Risk Tolerability Limits, recourse must be made to the precautionary principle (Section 3.4.3).

   b) Compare the total risk from Major Hazards to the Tolerability Limits (Section 2.5):
      - If the total risk is above the Upper Tolerability Limit (i.e. is intolerable), the operation is not permitted except for exceptional reasons, which would need to be justified to and agreed with the HHRM. Otherwise, if the operation is to proceed, risk reduction measures must be implemented regardless of whether they are reasonably practicable, until the risk is below the Upper Tolerability Limit. Once this has been achieved, the assessment carries on as for risks that are initially below the Upper Tolerability Limit (step 3(c)); and
      - If the total risk is below the Lower Tolerability Limit, following on from step 2, demonstrate that relevant Good Practice has been identified and implemented.
      - If the total risk is between the Upper and Lower Tolerability Limits, identify all physically possible risk reduction measures (Section 3.5):
        - Implement each risk reduction measure unless it is demonstrated and documented that it is not reasonably practicable to do so (Section 3); and
        - If the safety benefit of a risk reduction measure cannot be assessed with sufficient certainty to determine if it is reasonably practicable, recourse must be made to the precautionary principle (Section 3.4.3).
4. Ensure that all risks continue to be ALARP throughout the lifecycle of the infrastructure or operation (Section 3.6) by periodic review following this process.

The process is summarised in Annex 1 2(5), 3(5) of the Law, which states in relation to a RoMH:

> *(5) demonstration that all the major hazards have been identified, their likelihood and consequences assessed … and that their control measures including associated safety and environmental critical elements are suitable so as to reduce the risk of a major accident to an acceptable level ...;*

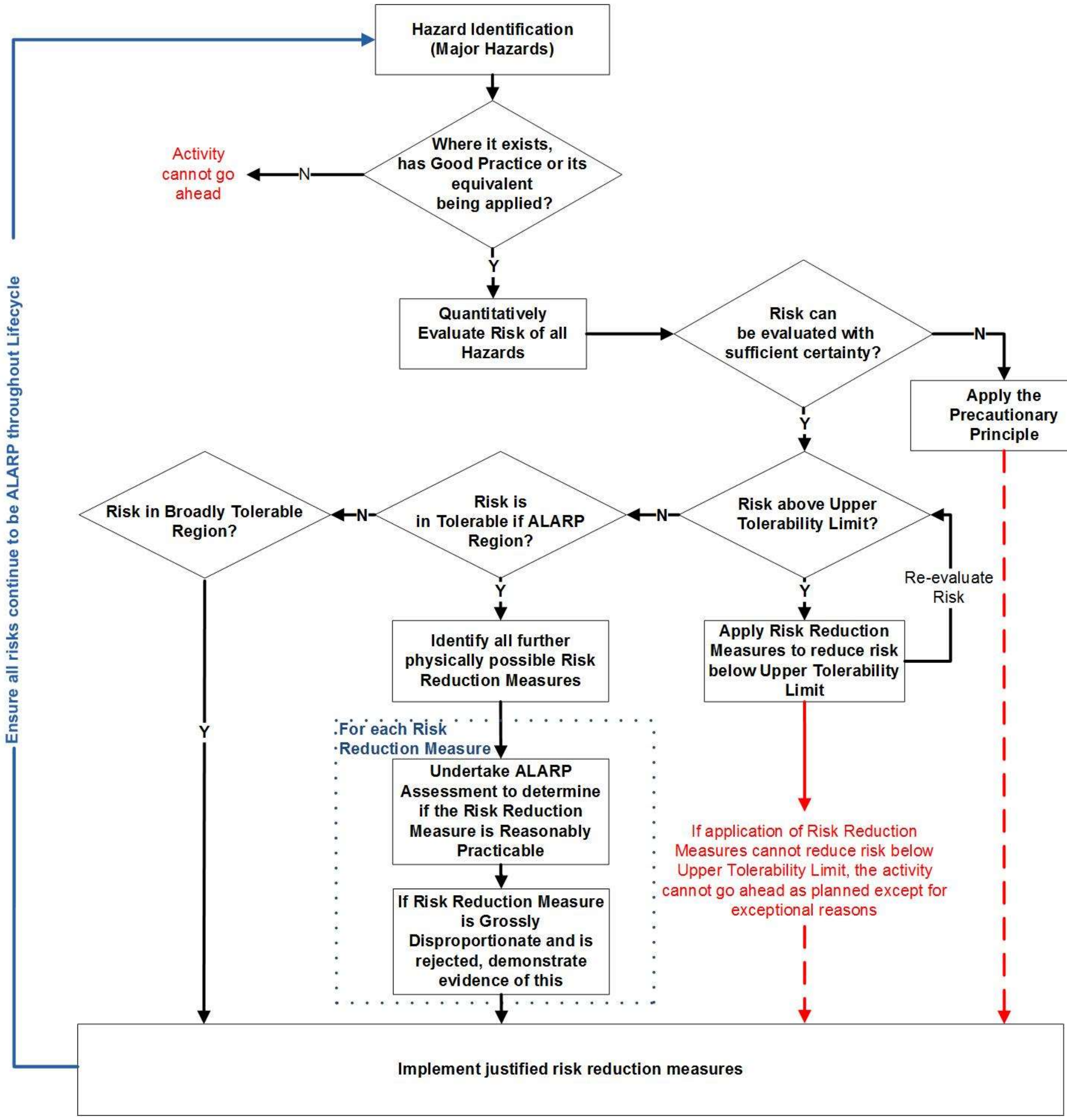

Figure 2: Risk Management Process

A key part of the documentation of an ALARP demonstration is that it must describe those measures that have not been implemented and the reasons for this. This is especially important where circumstances or hazards change, as previously discarded measures might need to be implemented to maintain the risk ALARP. Also, in many cases a risk reduction measure may simply be provision of 'more' of a particular safety measure (e.g. more passive fire protection) and in this case the reason why it is not reasonably practicable to provide 'more' of the safety measure needs to be included in the ALARP demonstration. The RoMH Guidelines describe how the ALARP assessment must be documented in a RoMH.

2.3 Major Hazard and Risk Reduction Identification

As described in Annex 1 2(5), 3(5) of the Law, the first stage in the risk management process is the comprehensive identification of Major Hazards that could have a safety impact. As illustrated in Figure 3, these hazards have a low frequency, but high consequence, and because of this and their typical complexity, they are more difficult to manage than simpler, high frequency low consequence occupational non-Major Hazards. For this reason, Major Hazards are the focus of the Law.

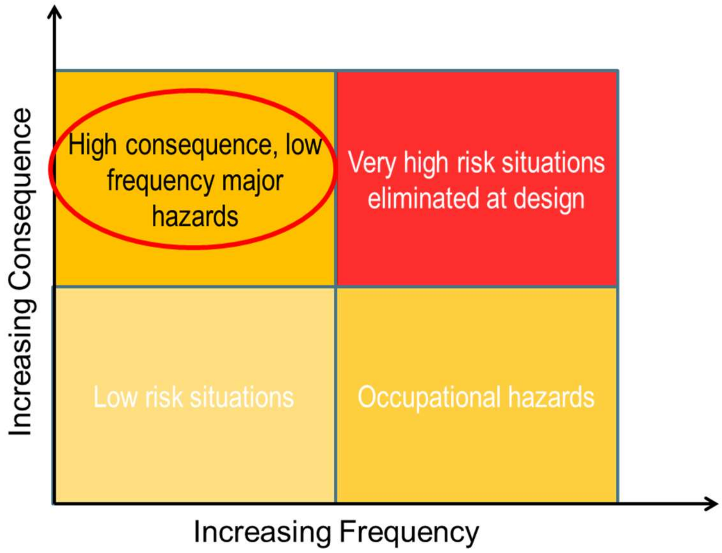

Figure 3: Comparative frequency and consequence of major accident hazards

Hazard identification usually involves a workshop carried with a group of competent persons knowledgeable in the particular offshore installation, project, operation and its hazards. A team approach is preferable since an individual generally cannot have the depth of experience and expertise on all these aspects, and group interactions are more likely to stimulate consideration of hazards that even well-informed individuals might overlook. Operational staff who will be exposed to the hazards can make a valuable contribution to hazard identification.

Hazard identification requires careful consideration of the ways in which an operation or equipment could fail and create a Major Hazard, which may include:

- Persons: Accidental or intended human intervention with unintended consequences;
- Procedures: Incorrect procedures leading to an error; or
- Plant: Mechanical failure due to factors such as corrosion.

Hazard identification becomes more critical as the complexity of the operation increases. For well understood activities with little complexity, the hazards have often already been identified and the risk reduction measures needed to manage them will be detailed in suitable codes and standards (i.e. in Good Practice). A more complex operation will require the hazards associated with all component parts of the operation and, for example, interactions between different equipment items, to be identified.

Hazard identification must be managed in a formal process with accurate recording of the scope and the outcome. Defining of the scope is important as it must be clear that it covers the totality of the operation being considered, otherwise the full range of hazards associated with it may not be identified. In addition, the information that is provided to the hazard identification team must be accurate and up-to-date.

As part of the hazard identification process, risk reduction measures already implemented must be identified so that the residual risk can be assessed. Then, all physically possible additional risk reduction measures need to be identified, so that those deemed reasonably practicable can be implemented.

Identification of risk reduction measures is often best carried out under the same process during the hazard identification workshop. Identified risk reduction measures should include those that are new, or are improvements to existing measures already implemented, e.g. in terms of equipment, improved maintenance, or operations. Risk reduction measures can either lower the possibility (frequency) of the hazard occurring or reduce its consequences, or both.

2.4 Good Practice

The adoption of current Good Practice, or its equivalent, is the first requirement in the risk management process and so the first step of an ALARP assessment is to determine whether this requirement is met. Good Practice is defined to be:

> *The recognised risk management practices and measures that are used by competent organisations to manage well-understood hazards arising from their activities.*

These practices and measures are found in a variety of forms including:

- Guidance or codes of practice from national regulators;
- Standards from standards-making organisations;
- Guidance produced by a body such as a professional institution or trade federation representing an industrial or occupational sector; and
- Lessons learned from previous accidents, not yet incorporated into standards.

The inclusion of the equivalent of Good Practice allows a different approach that achieves as good an outcome as Good Practice to be adopted. It does not permit a lesser solution that may equate to an erosion in standards.

In applying Good Practice:

1. It should be considered in the risk management hierarchy as follows, with the concept being that it is inherently safer to eliminate a hazard than to reduce its frequency or manage its consequences:
    - **Elimination:** Complete removal of a hazard;
    - **Substitution:** Replacement of one part of an operation, process or design by another that is inherently less hazardous;
    - **Prevention:** measures to reduce the frequency of a hazard;
    - **Control:** measures to reduce the consequences of a hazard;
    - **Mitigation:** measures to protect personnel from the consequences of a hazard; and
    - **Emergency Response:** measures to protect personnel during the response to an emergency, including by removal of persons from the place of danger.
2. Good Practice evolves as knowledge and experience improves over time, and it is current Good Practice that forms the basis of an ALARP assessment, which means that:

    a) The most recent version of codes and standards should be used;

b) If there is a choice of codes, a justification is needed as to why the selected code is the most appropriate; and

c) If a code or standard is updated such that are potentially significant safety shortcomings compared to the new code, there is a need to assess whether it is reasonably practicable to make changes to meet the new code. It is recognised that the cost of modifying an existing design to retrospectively address these deficiencies and comply with the new standard may be grossly disproportionate to the benefit gained and so a reasonable practicability assessment is necessary.

3. In assessing compliance with Good Practice, it is important to consider whether all aspects of an operation or design are covered by the Good Practice. It may be possible for each individual aspect to be covered by a prescriptive code that defines Good Practice, but no guidance be given for the sum of all of them. In this case, an ALARP assessment must be carried out for the totality of the activities. For example, there is Good Practice on the required type(s) of gas detector, but further ALARP assessment is need to determine how many are required and where they should be located.

4. If Good Practice is defined, it should be implemented, or alternative measures should be implemented that are demonstrated to reduce the risks to at least the same degree. However, deviation from Good Practice will require more onerous justification.

5. Some codes and standards are risk-based themselves (e.g. IEC 61511).

6. Some Good Practice exceeds the standard that can be justified through cost benefit analysis (e.g. the provision of liferafts on an offshore installation). Despite this, relevant Good Practice must be adopted if risks are to be reduced to ALARP (except as mentioned in 2(c) above regarding retrospective application of updated standards).

RoMHs that do not follow Good Practice, or an equivalent, will not be accepted by the HHRM.

2.5 Comparison of Risks Against Risk Tolerability Limits

The calculated risk must be compared with the Risk Tolerability Limits, which are numerical expressions of the risk of fatality from all hazards, and so quantitative risk assessment (QRA) must be undertaken to determine the overall risk from all hazards i.e. Major Hazards plus any additional occupational risks (non-Major Hazards) in these terms. Less rigour is expected however, in the assessment of non-Major Hazard risks compared to those from Major Hazards and the use of generic historical fatality data is usual for non-Major Hazards if it is certain that the data is representative, or conservative. The detail required in the QRA must be such that the risk is calculated with sufficient certainty to make this comparison, otherwise recourse should be made to the precautionary principle (see Section 3.4.3).

The ALARP principle requires that Risk Tolerability Limits are defined in terms of individual risk to a single person and these are given in Table 1. The Risk Tolerability Limits are consistent with current practices internationally (UK, Ireland [2], Norway [3], Australia [9]).

Table 1: Individual Risk Tolerability Limits for workers

Tolerability Limit (Risk of fatality per year)	
Upper	10^{-3}
Lower	10^{-6}

The individual risk can account for a normal work pattern, although a risk that is below the Upper Tolerability Limit solely because of a particular work pattern compared to a different, commonly used pattern, will not be accepted.

3 DETERMINING WHAT IS REASONABLY PRACTICABLE

3.1 Introduction

The following sections provide guidance on how to assess and demonstrate whether it is reasonably practicable to implement a risk reduction measure. The technique required for this assessment will vary according to the hazard, risk and risk reduction measure being considered. It is always the responsibility of the Operator and/or Owner to determine the correct technique to use.

An ALARP Assessment process is set-out in the remainder of Section 3 to enable the appropriate technique to be selected and justified, so that business, technical and other factors can be considered in fit-for-purpose assessments. The approach is adapted from that published by the Irish and Australian offshore oil and gas regulators (CRU [2], NOPSEMA [9]) and Oil and Gas UK [7].

3.2 Uncertainty

Within the risk management process, and key to the ALARP assessment, is a requirement that any assessment of reasonable practicability must be made with sufficient certainty. This is particularly relevant where a clearly safer option is not chosen, or there is sufficient uncertainty in the analysis to allow for the possibility that the selected option does not meet the Risk Tolerability Limits. In establishing that risks are tolerable, the margin between assessed risk levels and tolerability limits must be shown to exceed any uncertainty in the risk assessment.

The more uncertainty (or complexity) associated with a decision, the more likely it is that more complex decision techniques will need to be deployed to minimise the uncertainty.

In determining the risk, the impact of realistic changes to inputs to the assessment and the assessment techniques themselves must be determined, if there is a possibility that they would change the result of the assessment. This does not mean that all parameters in the assessment need to be varied as some may have only a small effect on the final risk figure. Additionally, if there are potentially severe consequences, the risk assessment should be conservative, making it unlikely that uncertainties in the parameters result in a less-safe outcome being chosen.

3.3 Decision Context

The first step in the ALARP assessment is to determine the decision context, i.e. the combination of circumstances, knowledge and events within which the decision is to be made. Many factors and constraints will be important in determining the decision context. Those considered key are:

- The novelty and type of the proposed operations, technology, approach or methods; and
- The risks associated with the decision and the certainty with which these can be assessed.

Guidance is given below on how the above factors may affect the decision context and thereafter on selection of the method(s) most appropriate to assess reasonable practicability.

3.3.1 Type of Activity

The type of activity to be undertaken, and the novelty of the operations, technology, approach and methods involved, will affect the decision context. The risk associated with common, well-understood situations is more likely to be controlled by the application of Good Practice, while less common situations will need risk assessment. For novel operations or technology, the approach is more likely to adopt the precautionary principle as described in Section 3.4.3.

3.3.2 Risk and Uncertainty

Factors that affect the certainty of the risk assessment process and results (e.g. novel technology) affect the decision context. Decisions made by reference only to Good Practice require a high degree of certainty. Increasing uncertainty implies a need to consider other assessment techniques.

3.3.3 Stakeholder Interest

Under the Law, Operators and/or Owners are responsible for ensuring and demonstrating that safety risks have been reduced to ALARP. ALARP assessments may however also be of interest to other stakeholders and Operators and/or Owners may wish to take account of stakeholder views. While this is not a regulatory requirement, the guidance in Section 3.4 does provide a means to do this. It is important to recognise however, that stakeholder interest will always move the decision context such that the decision is made by a process that is either more rigorous, or more conservative, i.e. towards a higher level of safety risk management, in excess of regulatory requirements.

3.4 Decision Methods

For different decision contexts, Figure 4 suggests the decision methods or techniques that allow a decision on reasonable practicability of a risk reduction measure to be made with sufficient certainty. Three decision contexts (A, B and C) are shown for simplicity of presentation and a series of guide phrases, based on the factors above, aid in assigning the context to a given decision. However, in reality there is a continuum of context (illustrated by the graded colours) ranging from more mundane decisions to the most complex. The chevrons in Figure 4 indicate the technique(s) likely to be needed to make a decision. Whatever the context, Good Practice must be met and the risk must not to be intolerable.

- For a context **A decision**, where the risk is relatively well understood, in general the decision will be determined by the application of recognised Good Practice. In cases where Good Practice may not be sufficiently well-defined, an engineering assessment may be required to guide the decision.
- For a context **B decision**, involving greater uncertainty or complexity, the decision will not be made entirely by established Good Practice. Thus, while any applicable Good Practice must be met, there will also be a need for an engineering assessment to make the decision.
- A context **C decision** will typically involve sufficient complexity and/or uncertainty to require the precautionary principle to be adopted. In this case, relevant Good Practice will still have to be met and detailed engineering risk assessment will be used to inform this approach.

Once the decision context has been determined, the assessment techniques on which the reasonable practicability decision is likely to be based are illustrated in Figure 4. The following sections describe each of these techniques.

3.4.1 Good Practice

Where Good Practice exists, or a measure that gives an equal or better outcome, it must be followed – it is always reasonably practicable to implement a measure required to meet Good Practice. Further to this, if a number of risk reduction options are being considered only those that meet or exceed relevant Good Practice should be taken forward. The options should be considered against relevant codes, standards and guidance in the hierarchy as detailed in Section 2.4.

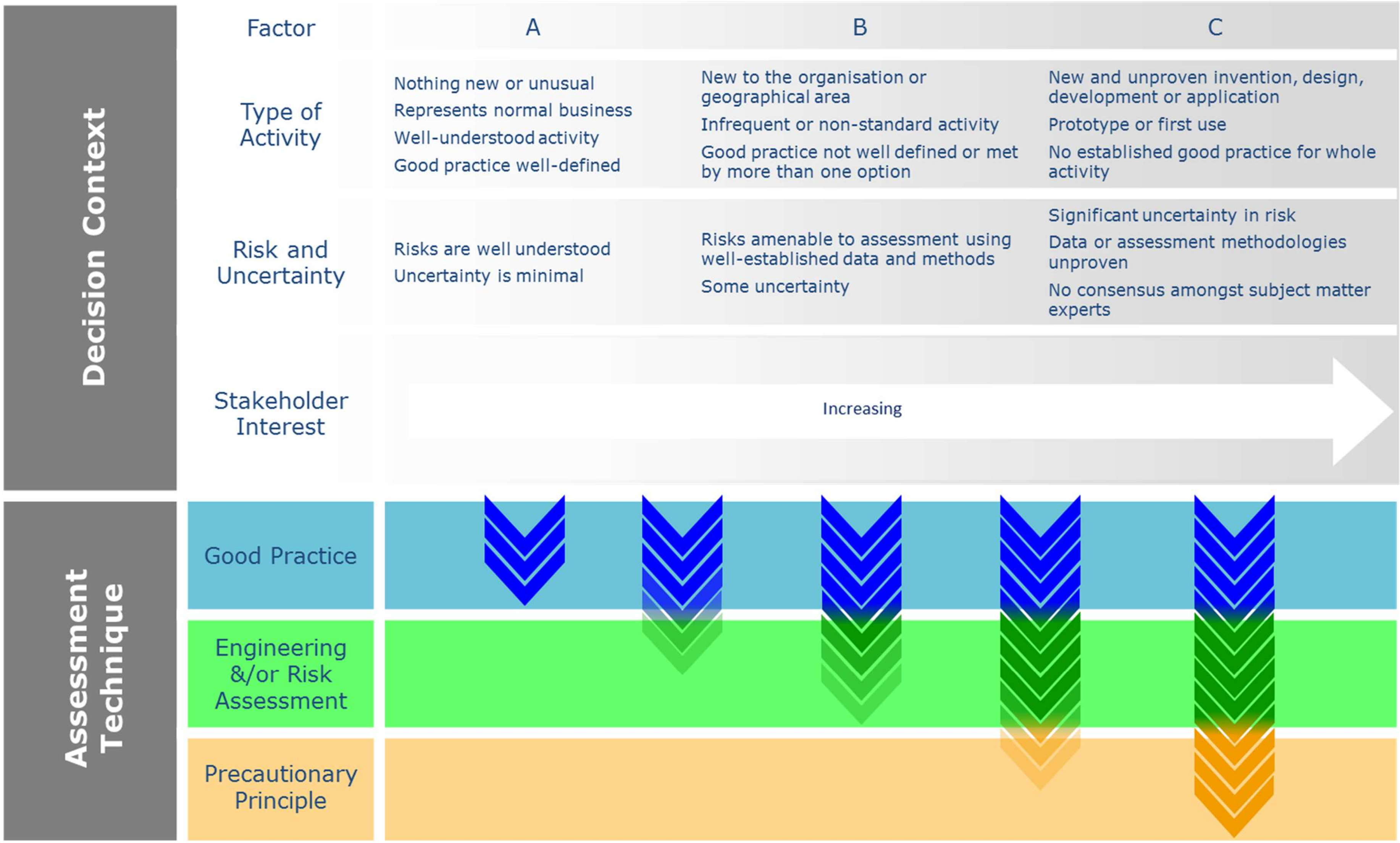

Figure 4: Techniques to determine reasonable practicability

3.4.2 Engineering and/or Risk Assessment

Where Good Practice is not well-defined or where the particular circumstances of the decision are not fully within its scope, an engineering, or risk assessment is required that takes account of the specific circumstances. Such an assessment may involve the use of a range of techniques and will require an understanding and application of sound engineering and scientific principles and methods, such as:

- Engineering analysis (e.g. structural, fatigue, mooring, process simulation); and
- Consequence and/or risk modelling (e.g. fire, explosion, ship collision, dropped object).

If a decision can be made based on consequence assessment alone, there may be no need to reference the frequency of an event. For example, if a facility can be designed to withstand the maximum possible explosion overpressure, there is no need to determine the frequency with which this might occur. This is the preferred approach since it eliminates any reliance on the (low) likelihood of a hazard being realised.

Should it not be possible to eliminate the hazard, a risk assessment needs to be carried out to ensure that the remaining risk is ALARP. Key in the selection of the risk assessment technique for an ALARP assessment is that it should be able, with confidence, to differentiate between the risk with and without the risk reduction measure being considered in place. Thus, for example, a risk matrix is a good tool for making decisions in relation to occupational risks, but is, for example, an inappropriate tool to justify a decision not to install a pipeline subsea isolation valve (SSIV).

Once a risk assessment has been undertaken, a safety measure is reasonable practicability to implement unless gross disproportion is demonstrated between the risk benefit and the cost [8]; this is shown by:

1. Calculating the Implied Cost of Averting a Fatality (ICAF) for the risk reduction measure, which is its cost divided by the risk reduction (potential loss of life reduction) achieved over its lifetime;
2. Calculating the ratio between the Calculated ICAF and a Defined ICAF criterion; and
3. If this ratio is greater than a pre-defined Gross Disproportion Factor (GDF), gross disproportion is shown.

Defined ICAFs are typically in the range of €1.5-2.5M Euros (UK, Ireland [2], Norway [3]) and a robust justification is required for any GDF less than 10.

Care must be taken when evaluating risk in a qualitative or semi-quantitative way and using the analysis to show that the residual risk is ALARP as these techniques usually do not give a direct measurement of risk to which the cost of a risk reduction measure can be compared.

In any assessment where more than one technique is used, if different techniques give different results, the results should not be combined by assigning weightings to results in order to arrive at a final decision. If different outcomes arise from different techniques, this indicates that the assumptions and data used in the assessments should be re-examined, or the use of the techniques themselves questioned. In general, more sophisticated (quantitative) techniques give more certain results. Expert knowledge of the different assessment techniques is therefore required and if significant uncertainties remain, then the precautionary principle needs to be invoked.

3.4.3 Precautionary Principle

If the assessment, taking account of all available engineering and scientific evidence, is inconclusive or uncertain, then the precautionary principle should be adopted. This means that uncertain analysis is replaced by conservative assumptions, which will increase the likelihood of a risk reduction measure being implemented. The degree to which this principle is adopted should be commensurate with the level of uncertainty in the assessment and the level of danger (hazard consequences) believed to be possible.

Under the precautionary principle, the hazards that are assessed should at least include the worst-case outcome that can be realised, but should not include hypothetical hazards where there is no evidence that they may occur. While the approach adopted is expected to be proportionate and consistent, under the precautionary principle, safety should take precedence over economic considerations, meaning that a safety measure is more likely to be implemented.

Adoption of the precautionary principle may result in the implementation of risk reduction measures for which the cost may appear to be grossly disproportionate to the safety benefit gained. However, in these circumstances, the uncertainty associated with the risk assessment means that the risk associated with non-implementation cannot be shown to be ALARP with sufficient certainty.

3.5 General Issues Relating to Reasonable Practicability

3.5.1 Ranking of Risk Reduction Measures

Risk reduction measures being considered for implementation can be ranked at the start of an ALARP assessment so that, combined with costing information, the most effective risk reduction measures can be identified, or further analysed. This ranking can use any technique so long as the ranking is sufficiently robust such that any decisions dependent on it are made with sufficient certainty. The technique used must allow any 'cut-off point' below which measures are not implemented to be well-defined such that there is a robust justification for all measures not implemented.

Where suitable data is available, the ranking of risk reduction options can be done through cost benefit analysis, based on quantified risk assessment. Less sophisticated techniques can only be used if the differences in cost or risk are so large as to make the comparison certain.

3.5.2 Range of Consequences to be Considered

If a hazard is realised, the consequences that develop will vary depending on at least environmental conditions and the reaction of persons and safety systems. Due to the large number of possible outcomes, it is appropriate to model a reduced range of consequences in the ALARP assessment that are representative of the range of potential outcomes (e.g. flammable gas dispersion scenarios for wind speeds in the range 4–6 m/s will be similar and may be represented by a single scenario with a 5m/s wind). Consequences that at least cover the worst-case credible and most likely events need to be modelled. In modelling the range of potential outcomes, it must be ensured that the total frequency of the hazardous event is accounted for and all scenarios allocated to a representative outcome.

Alternatively, just the worst-case credible outcome could be modelled assuming that every time the hazard is realised it leads to this worst-case. Being a conservative assessment, this approach will be more likely to lead to the conclusion that a risk reduction measure should be implemented.

3.5.3 Cost of the Risk Reduction Measure

The cost of the measure, against which the safety benefit is being compared, should be restricted to those costs that are solely required for the measure. Realistic costs should be used so that, for example, the measure is not over engineered to derive a large cost, distorting the comparison to conclude that it would be grossly disproportionate to implement.

If the cost of implementing a risk reduction measure is primarily lost or deferred production, the ALARP assessment should be undertaken for the two cases where this cost is and is not accounted for. If the decision not to implement a risk reduction measure depends on this additional cost, a robust argument as to why the measure could not be installed while losing less production (e.g. during an installation or pipeline shutdown) will be required. If the lost production is actually deferred production, then the lost production should only take account of lost monetary interest on it plus an allowance for operational costs during the implementation time, or potential increase in decommissioning or dismantling costs.

If shortly after a design is frozen, or constructed, a risk reduction measure is identified that normally would have been implemented as part of a good design process, but has not been, it would normally be expected that the measure, or one that provides a similar safety benefit, is implemented. An argument of grossly disproportionate correction costs cannot be used to justify an incorrect design.

3.5.4 Remaining Lifetime

In determining whether it is reasonably practicable to implement a risk reduction measure, the remaining lifetime of the infrastructure is relevant in the analysis. This is immediately apparent in a cost benefit analysis if the cost of the risk reduction measure is mainly a capital cost since the cumulative safety benefit will rise as the remaining lifetime increases whilst the costs remain roughly constant. Thus, a risk reduction measure will increase in reasonable practicability as the infrastructure lifetime increases.

If, because of a short remaining lifetime, the cost of a risk reduction measure is assessed to be in gross disproportion to the safety benefit and it is not implemented, supporting analysis should be carried out for a number of different remaining lifetimes due to the inherent uncertainty in such a figure. The justification for a non-implementation decision that is dependent on a short lifetime assumption needs to be robust. This is also true for non-permanent operations where the lifetime is, by definition, short.

3.5.5 Avoidance of Reverse ALARP

An argument could be constructed that, for a reason such as short remaining lifetime, the re-instatement cost of a previously functioning risk reduction measure is grossly disproportionate to its safety benefit. This is commonly called reverse ALARP. In this case the test of Good Practice must still be met and, since the risk reduction measure was initially installed, it is Good Practice to reinstall or repair it. Reverse ALARP arguments will not be accepted in an ALARP assessment.

This does not prevent a suitably justified decision not to re-instate a risk reduction measure if either:

- The original reason for installing it changes due to, for example, elimination of a hazard;
- The additional risks to those carrying out the re-instatement work exceed the risk benefit gained by restoring the measure to be fully functional (see Section 3.5.7 on risk transfer); or
- An alternative or better risk reduction measure has been implemented in place of the original.

3.5.6 Representing the Real Risk

All risk assessment methodologies rely on input data. Whilst the use of generic data may be appropriate in the design stage or as a starting point for operating assets, it is important that the reality of the condition of any operating asset is taken into account. This is particularly important with ageing assets, or where adequate inspection data is not available.

3.5.7 Risk Transfer

In assessing a risk reduction option, care should be taken to ensure that all of the risks to people are taken into account. A narrow view of the people affected can result in an option being selected that appears to give the best solution, but actually transfers risks to another group not considered within the assessment. For example, the retrospective installation of an SSIV on a stabilised crude oil line might slightly reduce risks to personnel on the platform, but will introduce risk to the divers installing it.

3.6 Risk Reduction Measures and the Lifecycle

The need to ensure that the risk is ALARP must be considered at the beginning of the design process. This requirement is important because, early in the design process, decisions can fundamentally influence the risks. The concept and design stages offer an opportunity to eliminate hazards and to make the design inherently safer. It is therefore important that the requirement for the risk to be ALARP is considered at the concept stage and throughout design and operations.

Figure 5 illustrates the impact that different risk reduction approaches can have at different stages of the lifecycle. The diagram shows the risk management hierarchy, overlaid with shading that represents by width their importance in the concept, design and operational phases of the lifecycle.

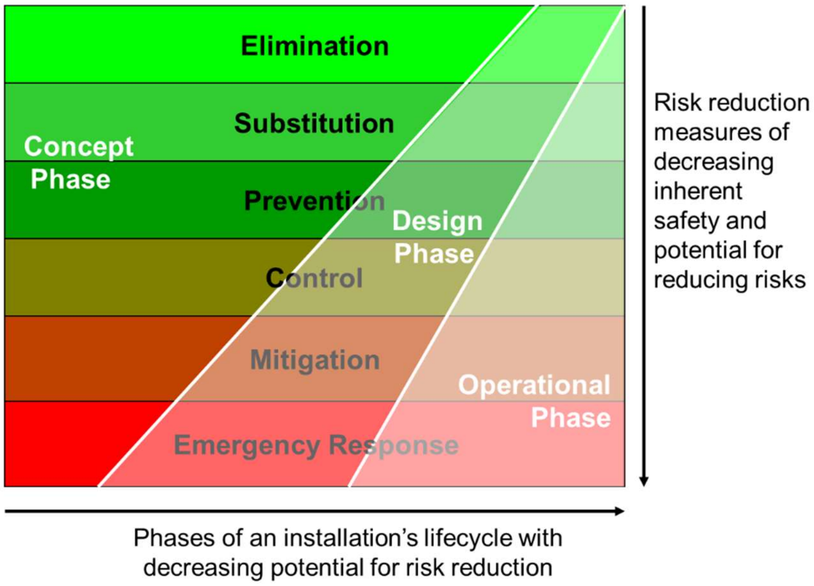

Figure 5: Risk reduction measures at different stages of the lifecycle.

The concept phase overlay shows that elimination, substitution and prevention are the most important risk reduction measures at that phase and that they apply more to this phase of the lifecycle than any other. Eliminating hazards and ensuring inherent safety principles are applied is vital during the concept and design phases. During the operational phase, the emphasis on further risk reduction measures is towards control, mitigation and emergency response measures, as the fundamentals of the design cannot usually be changed meaning that hazards cannot usually be eliminated.

As an operation progresses, there is no guarantee that the risks will remain ALARP due to:

- Changes in Codes and Standards;
- Changes to an operation that may make it more hazardous;
- Changes in technology that allow for improved risk assessment or risk reduction measures;
- Learnings from mistakes or incidents and from other operations.

Reducing risks to ALARP must be considered and re-considered throughout the lifecycle from early in the design phase through to the operational phase and beyond to decommissioning. It is incumbent on Operators and Owners to continually review whether all the risks to safety remain ALARP.

4 REFERENCES

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