

ALARP

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Core concepts

- One of the main objectives of the Commonwealth *Offshore Petroleum and Greenhouse Gas Storage (Safety) Regulations 2009* [OPGG(S)] is to ensure that the risks to health and safety of people at offshore facilities are reduced to a level that is as low as reasonably practicable (ALARP).
- A safety case has to show how an operator meets, or will meet, the requirements of the regulatory provisions relevant to the control of major accident event risks and the risks to health and safety of people at the operator's facility. Many of the requirements are qualified by the phrase "reduce the risks to a level that is ALARP". This means that the operator has to show, through reasoned and supported arguments, that there are no other practical measures that could reasonably be taken to reduce risks further.
- The adopted control measures for any particular identified major accident event must be shown to collectively eliminate, or reduce to a level that is ALARP, the risk to health and safety.
- The approach employed in providing the required evidence of ALARP within a safety case is at the discretion of the operator. In practice a combination of approaches is likely to be necessary.
- Only by inclusion of a sufficient level of detail of information will NOPSEMA be able to make a judgement on the appropriateness of the safety case in accordance with OPGGS(S) Regulation 2.26 (for new safety cases) or Regulation 2.34 (for revised safety cases).
- This guidance note addresses how the ALARP concept can be addressed in the context of a safety case.

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Abbreviations/acronyms

ALARP	As Low As Reasonably Practicable
CBA	Cost Benefit Analysis
EERA	Evacuation, Escape and Rescue Analysis
FERA	Fire and Explosion Risk Analysis
FPSO	Floating, Production, Storage and Offloading
FSA	Formal Safety Assessment
HSC	Health and Safety Commission
HSE	United Kingdom Health and Safety Executive
ICAF	Implied Cost of Averting a statistical Fatality
IMO	International Maritime Organisation
IRPA	Individual Risk Per Annum
LSA	Life Saving Appliances
MAE	Major Accident Event
MODU	Mobile Offshore Drilling Unit
NOPSEMA	National Offshore Petroleum Safety and Environmental Management Authority
OPGGs Act	Offshore Petroleum and Greenhouse Gas Storage Act 2006
OPGGs(S) Regulations	Offshore Petroleum and Greenhouse Gas Storage (Safety) Regulations 2009
QRA	Quantitative Risk Assessment
SMS	Safety Management System

Key definitions for this guidance note

The following are some useful definitions for terms used in this guidance note and are a suggested starting point only.

Risk Assessment - Risk assessment is the process of estimating the likelihood of an occurrence of specific consequences (undesirable events) of a given severity.

ALARP - This term refers to reducing risk to a level that is As Low As Reasonably Practicable. In practice, this means that the operator has to show through reasoned and supported arguments that there are no other practicable options that could reasonably be adopted to reduce risks further.

Reasonably Practicable - The legal definition on this was set out in England by Lord Justice Asquith in *Edwards vs. National Coal Board* [1949] who said:

‘Reasonably practicable’ is a narrower term than ‘physically possible’ and seems to me to imply that a computation must be made by the owner, in which the quantum of risk is placed on one scale and the sacrifice involved in the measures necessary for averting the risk (whether in money, time or trouble) is placed in the other; and that if it be shown that there is a gross disproportion between them — the risk being insignificant in relation to the sacrifice — the defendants discharge the onus on them. Moreover, this computation falls to be made by the owner at a point of time anterior to the accident.

This English decision has since been confirmed by the Australian High Court.¹

1. Introduction

1.1. Intent and purpose of this guidance note

This document is part of a suite of documents (see Figure 1 below) that provide guidance on the preparation of safety cases for Australia's offshore facilities, as required under the Commonwealth Offshore Petroleum and Greenhouse Gas Storage (Safety) Regulations 2009 [the Safety Regulations] and the corresponding laws of each State and of the Northern Territory where powers have been conferred on NOPSEMA.

This guidance note in particular, 'ALARP', provides direction on the descriptions that could be included in a safety case submission as a means of addressing the requirements of the Safety Regulations in providing evidence that risks are reduced to a level that is ALARP. The guidance will be of use to those with responsibility for health and safety at offshore petroleum facilities, and particularly those developing the facility safety case.



Figure 1 – Safety case guidance note map

¹ Slivak v Lurgi (Australia) Pty Ltd (2001) 205 CLR 304 cited in Bluff & Johnstone (2004) The relationship between Reasonably Practicable and Risk Management (WP 27 ANU National Research Centre for OHS Regulation)

The purpose of the guidance is to explain the objectives of the Safety Regulations, to identify the general issues that should be considered, and to provide practical examples to illustrate the concepts and potential approaches that can be taken in the preparation of safety cases. It is not the intention of the guidance to provide detailed approaches or detailed regulatory assessment criteria.

Guidance notes indicate what is explicitly required by the regulations, discuss good practice and suggest possible approaches. An explicit regulatory requirement is indicated by the word **must**, while other cases are indicated by the words **should**, **may**, etc. NOPSEMA acknowledges that what is good practice, and what approaches are valid and viable, will vary according to the nature of different offshore petroleum facilities and their hazards. This guidance note is not a substitute for detailed advice on the Safety Regulations or the Act under which the Safety Regulations have been made.

1.2. Summary of the legislative requirements

Summary tables of the legislative requirements with respect to providing evidence that the risks to health and safety of persons at the facilities are reduced to a level that is ALARP are included as a quick reference throughout this document. **However, the reader is encouraged to work directly from the regulations.**

2. Application of the ALARP principle

OPGGS(S) Regulation – Objects

Reg 1.4(3) An object of these regulations is to ensure that the risks to the health and safety of persons at offshore petroleum facilities are reduced to a level that is as low as reasonably practicable.

A safety case has to show how an operator meets, or will meet, the requirements of the regulatory provisions relevant to the control of major accident event risks and the risks to health and safety of people at the operator's facility. Many of the requirements are qualified by the phrase "reduce the risks to a level that is as low as reasonably practicable". This means that the operator has to show, through reasoned and supported arguments, that there are no other practical measures that could reasonably be taken to reduce risks further.

The concept of 'reasonably practicable' is central to the safety case regime. It allows operators to set goals for their own safety performance rather than following prescriptive requirements. It also allows NOPSEMA to accept or reject the operator's arrangements under the safety case. This flexibility is a great advantage but it can be challenging because it requires people to exercise judgement with respect to how they are going to manage their risks. In the great majority of cases, a decision can be made by referring to existing 'good practice' that has been established. However, for complex situations it may be difficult to reach a decision on the basis of 'good practice' alone. There may be some situations, for example in the case of new technology, where there is no relevant 'good practice' that can be followed. In these situations other decision-making techniques need to be applied to inform our judgment.

Other regulators such as the United Kingdom's Health and Safety Executive (HSE) and the Norwegian Petroleum Directorate have been successfully administering safety case regimes for many years. The HSE, in particular, has developed constructive guidance on the topic of the application of ALARP (available on the HSE website www.hse.gov.uk) and readers are encouraged to make reference to it. However, it is essential to bear in mind that while there are parallels in the regulatory approach, there are also important variations in the safety case legislation between the UK and Australia, and as such the HSE guidance should only be referenced to for concepts and principles.

Key aspects of the HSE guidance are distilled in this guidance note with respect to how to go about constructing an ALARP argument.



Further information is available in the NOPSEMA policy:

“Safety Case Assessment”

3. Key principles

It is important to understand the key principles underpinning the ALARP principle. The following descriptions have been adapted from HSE information sheet no. 2/2006 and the Oil & Gas UK Guidance on risk decision making, Issue 2 July 2014.

Reasonable practicability - determining whether risks have been reduced as low as is reasonably practicable involves an assessment of the risk to be avoided, and an assessment of the sacrifice (in money, time and effort) involved in taking measures to avoid that risk, and a comparison of the two. A risk may sit on a spectrum from very low (where it is very unlikely that it would be possible to reduce the risk further) through to levels of risk that are very high. The greater the initial level of risk under consideration, the greater the effort likely to be required to demonstrate that risks have been reduced to a level that is as low as reasonably practicable, however, just because the initial level of risk may be low doesn't mean it may not be reasonably practicable to reduce it further. The basis on which the comparison is made involves the test of 'gross disproportion'.

Gross disproportion - if a measure is practicable and it cannot be shown that the cost of the measure is grossly disproportionate to the benefit gained; then the measure is considered reasonably practicable and should be implemented. The criterion is reasonably practicable not reasonably affordable: justifiable cost and effort is not determined by the budget constraints/viability of a project.

Inherently safer design - it is good practice to apply the principles of prevention as a hierarchy.

- Elimination of risk by removing the hazard
- Substitution of a hazard with a less hazardous one
- Prevention of potential events
- Separation of people from the consequences of potential events
- Control of the magnitude and frequency of an event
- Mitigation of the impact of an event on people
- Emergency response and contingency planning.

Operators are entitled to apply these general principles as they see fit. However, NOPSEMA promotes the incorporation of inherently safer design features, where appropriate.

Choosing between options - for new facilities or brown-field redevelopment projects, a selection among options may be needed at any stage in any project, not least at the design stage, which will involve making a choice between differing design concepts for the project as a whole. In making choices operators should consider the risks involved over the whole life cycle of a project. However, it is expected that a new installation would not give rise to a residual level of risk greater than that achieved by the best examples of existing good practice for comparable functions. The reasonable practicability of any further risk reduction

should be measured against this baseline. Safety cases should show that the lowest risk option has been selected in all cases, or why the selected higher risk option is ALARP.

Good practice - within the HSE and their ALARP guidance documentation, good practice is the term used for those standards for controlling risk which have been judged and recognised by the HSC (Health and Safety Commission) as satisfying the law when applied to a particular relevant case in an appropriate manner. This is not the case in Australia. NOPSEMA has not endorsed any 'approved codes of practice' or standards to allow them a special legal status. The term 'good practice' in NOPSEMA guidance documentation therefore is taken to refer to any well-defined and established standard or codes of practice adopted by an industrial/occupational sector, including 'learnings' from incidents that may yet to be incorporated into standards. Good practice generally represents a preferred approach; however it is not the only approach that may be taken. While good practice informs, it neither constrains, nor substitutes for, the need for professional judgement. Good practice may change over time because of technical innovation, or because of increased knowledge and understanding.

Reverse ALARP - operators have from time to time tried to show through quantitative risk assessment (QRA) and cost benefit analysis (CBA) that moving to a less protected situation will meet the legal requirement to reduce risks to a level that is ALARP, sometimes arguing that the increase in risk is more than balanced by gains in reduced operational costs or increased operating profit – a "reverse ALARP" argument. The legal requirement to reduce risks as low as reasonably practicable would rule out NOPSEMA accepting a less protected but significantly cheaper approach to the control of risks.

Changed circumstances - operators may wish to introduce new processes, new technology or alter the conditions in which equipment is operated in response to changed circumstances. Such changes may result in a change to the risk profile - some risks may increase. This may be permissible provided control measures are taken to ensure that the risks are reduced as low as reasonably practicable for the new situation.

Risk uncertainty - it is expected that risk related decision making should be made with sufficient certainty and understanding of the both the likelihood and consequence of an event occurring. Where this is not the case a precautionary approach to demonstrate risks are ALARP should be taken.

Precautionary approach - where the lack of certainty is not used as reason for not implementing effective safety control measures. Uncertainties in risk are replaced by conservative (worst case) assumptions resulting in safety controls being more likely implemented. Operators should use a precautionary approach where there are greater levels of uncertainty in the determined consequence or likelihood, for example, from the use of new technology, disagreement in opinions or limited relevant industry standards. In cases where uncertainties are present safety controls should take more precedence over the economic considerations by operators.

4. What ALARP descriptions are required in the safety case?

4.1. FSA ALARP descriptions

OPGGS(S) Regulation - FSA Description

- Reg 2.5(2) **The safety case for the facility must also contain a detailed description** of the formal safety assessment for the facility, being an assessment, or series of assessments, conducted by the operator that:
- (a) identifies all hazards having the potential to cause a major accident event; and

- (b) is a detailed and systematic assessment of the risk associated with each of those hazards, including the likelihood and consequences of each potential major accident event; and
- (c) identifies the technical and other control measures that are necessary to reduce that risk to a level that is as low as reasonably practicable.

As part of the formal safety assessment (FSA) the Safety case must contain a detailed description that demonstrates that all hazards that have the potential to cause an MAE have been assessed and controls identified that are necessary to reduce risks to ALARP. In respect of this requirement, the Safety Regulations also explicitly require two studies in particular to be carried out as part of the FSA:

an evacuation, escape and rescue analysis (EERA) that identifies control measures necessary to reduce the risks associated with emergencies to a level that is ALARP [OPGGS(S) subregulation 2.16(2)(h)];and

a fire and explosion risk analysis (FERA) that identifies control measures necessary to reduce the risks associated with fires and explosions to a level that is ALARP [OPGGS(S) subregulation 2.17(2)(g)].

Operators should note that the regulations require the consideration of a range of control measures in each instance, including different procedures, a range of amenities and/or equipment, alternative measures, etc. [OPGGS(S) subregulation 2.16(2) and subregulation 2.17(2)]. Consequently, information presented in the safety case should not simply focus on promoting or 'selling' the chosen design option but rather a discussion on the merits of different options and a justification that the chosen option is indeed the one that reduces risk to a level that is ALARP.

Example of FSA ALARP description content requirement

A recently constructed facility has chosen a CO₂ fire suppression system for their engine room compartments as a mitigation control. Given that the introduction of a CO₂ fire suppression system on a facility introduces an asphyxiation hazard, it is expected that an assessment would have been completed with consideration of other alternatives that may eliminate or reduce the risk of asphyxiation. For example, a high pressure water mist system may have been considered. The Formal Safety Assessment would need to clearly describe the reasons for the CO₂ system being chosen instead of other alternative systems and provide adequate demonstration that risks are ALARP for both engine room fires and asphyxiation from suppression system release.

For existing facilities, operators should not merely concentrate on providing 'information' on design features of control measures, but should also put effort into providing 'knowledge' acquired from operating the facility, such as adequacy assurance gained from control measure performance data over time. 'Design ALARP' should be taken as a starting point only.

4.2. SMS ALARP description

OPGGS(S) Regulation – SMS Description

- Reg 2.5(3) **The safety case for the facility must contain a detailed description** of the safety management system that:
- (a) is comprehensive and integrated
 - (d) provides for the continual and systematic identification of hazards to health and safety of persons at or near the facility

- (e) provides for the reduction to a level that is as low as reasonably practicable of risks to health and safety of persons at or near the facility including, but not limited to:
- (i) risks arising during evacuation, escape and rescue in case of emergency; and
 - (ii) risks arising from equipment and hardware.

The FSA is focused on MAE's and demonstration that their risk is ALARP.. Unlike the FSA, the SMS must provide for **all** health and safety risks (not just MAE's) and ensure systems are in place that manage these risks to a level that is ALARP. What this means is that, unlike the FSA that must identify all MAE's and demonstrate their risk is ALARP, the SMS does not need to identify all health and safety risks. Instead there is a requirement for the SMS to contain policies, procedures, and processes that provide for the continual and systematic identification, assessment and reduction to ALARP of all health and safety risks. The operators SMS should provide ongoing identification and management of risks to ALARP for all activities and operations over the life of the facility. The detailed description of the SMS in the SC should describe how this is achieved, maintained and the way deviations are managed to ensure they achieve a risk profile that is ALARP.

Example of SMS description content requirement

A provisions crane on a facility is out of service due to major maintenance. An impact of this is an increased risk of injury to persons from manual handling due to food containers requirement transfer from another cranes location. The SMS description should not contain the individual controls to manage this unique manual handling risk. The safety case SMS detailed description should however contain a description of the processes that allow for the identification and management of the hazard to ensure risks are ALARP when conducting the activity. A description of the operator's deviation process may provide the necessary information to demonstrate compliance.

OPGGS(S) Regulation – SMS Description

- Reg 2.5(3) **The safety case for the facility must contain a detailed description** of the safety management system that:
- (i) specifies the performance standards that apply.

In order to maintain risks at a level that is ALARP it is essential that control measures remain effective. The information provided in the safety case in support of the ALARP argument should cover the following aspects as a minimum:

- Performance standards have been established
- Performance is measured against set performance standards within inspection, maintenance and safety management systems
- There is periodic review of the process by which performance standards are established and maintained, including checks that the right things are being measured.



Further guidance is available in the NOPSEMA guidance note:

“Control measures and performance standards”

4.3. What are the fundamental approaches to consider for ALARP demonstration?

There is no prescribed methodology for demonstrating that the necessary control measures have been and will continue to be identified to reduce risks to ALARP. However, there are several basic approaches which may be used to support an operator's provision of evidence and justification within the safety case. Operators could consider using one or more of these approaches, but should also be prepared to consider developing specific approaches appropriate to their facilities. In practice, it is likely that most facilities will require a combination of approaches.

In setting out to provide evidence that the risks are reduced to a level that is ALARP, it is a fundamental requirement to demonstrate, in the first instance, that the hazard identification and risk assessments carried out have been systematic and detailed, as they provide the foundation on which to base the control measure selection. The following approaches may be considered:

Hazard/risk criteria approach – define criteria that is considered to correspond to ‘reducing risk to a level that is as low as is reasonably practicable’, assess performance quantitatively or qualitatively (using matrices for example) and compare against the criteria.

Comparative assessment of risks, costs and benefits – evaluate risk and associated costs for a range of control measure options for the facility and compare the relative merits of the different options, selecting the options which are practicable.

Cost benefit analysis [CBA] – the numerical assessment of the costs of implementing a design change or modification and the likely reduction in fatalities that this would be expected to achieve. The quality of the modelling and the data will affect the robustness of the numerical estimate and the uncertainties in it must always be borne in mind when using the estimate in risk management decisions. In making this assessment there is a need to set criteria on the value of a life or implied cost of averting a statistical fatality (ICAF). In reality of course there is no simple cut-off and a whole range of factors, including uncertainty need to be taken into account in the decision-making process.

Comparison with codes and standards – compare design, the management system framework and operational procedures against recognised national, international or industry standards, codes of practice, guides etc.

Audit against good practice – audit the basis and implementation of the management system, including operations and maintenance systems, against good practice for offshore facilities, vessels, or relevant similar industries onshore.

Technical analysis – evaluate control measures in technical terms; assess strengths and weaknesses, e.g. effectiveness, functionality, availability, reliability, technical feasibility, compatibility, survivability, correspondence of control measures to hazards and risks, appropriateness of performance standards, etc.

Performance data – evaluate MAE safety-related performance data as evidence of adequacy or satisfactory levels of performance, e.g. data on the operational effectiveness or reliability of a control measure may support the demonstration of its appropriateness for that service.

Improvement approach – demonstrate the extent of relative improvements in performance for the facility based on past, present and planned modifications and enhancements.

Judgement approach – present considered judgements as to the suitability of control measures and the management systems, or the perceptions of a cross-section of various stakeholders, e.g. key members of the workforce, senior management, plus independent observers.

Practical tests - demonstrate that the management system and/or control measures function effectively, using major accident event simulations, management system tests, equipment breakdown and recovery tests, etc. For example, it may be possible to conduct fire impingement tests to show that fire rating of the material being used is appropriate.

For safety case acceptance purposes, NOPSEMA will evaluate the operator's approach in terms of its robustness, transparency and appropriateness to the facility. The operator should therefore define the underlying rationale, criteria and decision-making basis for the case.

The description must be convincing; this means that the rationale for deciding the completeness of the hazard identification and the adequacy of the measures employed should be supported and accompanied by all assumptions made and conclusions drawn. Where appropriate, it should present/summarise the results of supporting studies that have been performed.

The description should demonstrate that the process was systematic which means that it followed a fixed and pre-established scope. Finally, the degree of analysis in support of the demonstration should be proportionate to the risk and to the complexity of the facility, hazards and the control measures.

Example – application of a model using a combination of approaches

Note: The following model is an example of using a combination of approaches. It is included as an illustration only and is not required to be prescriptively followed. It should be noted that following such a model does not necessarily lead to reducing the risks to a level that is ALARP.

The UK offshore oil and gas industry has developed a framework to assist risk-related decision making ("Oil & Gas UK", formerly UKOOA, 2014), which helps decision-makers choose an appropriate basis for their decisions. A summary of the framework is shown in Figure 2 below.

The framework takes the form of three different decision context (A, B & C). Initially the decision context needs to be determined. Guidance is provided on the factors that may affect the decision context. Consideration for factors including activity type, risk & uncertainty and stakeholder influence is made in determining the decision context. The assessment techniques used will depend on the selected decision context. The chevrons in the diagram show the assessment techniques likely to be needed to make an ALARP decision.

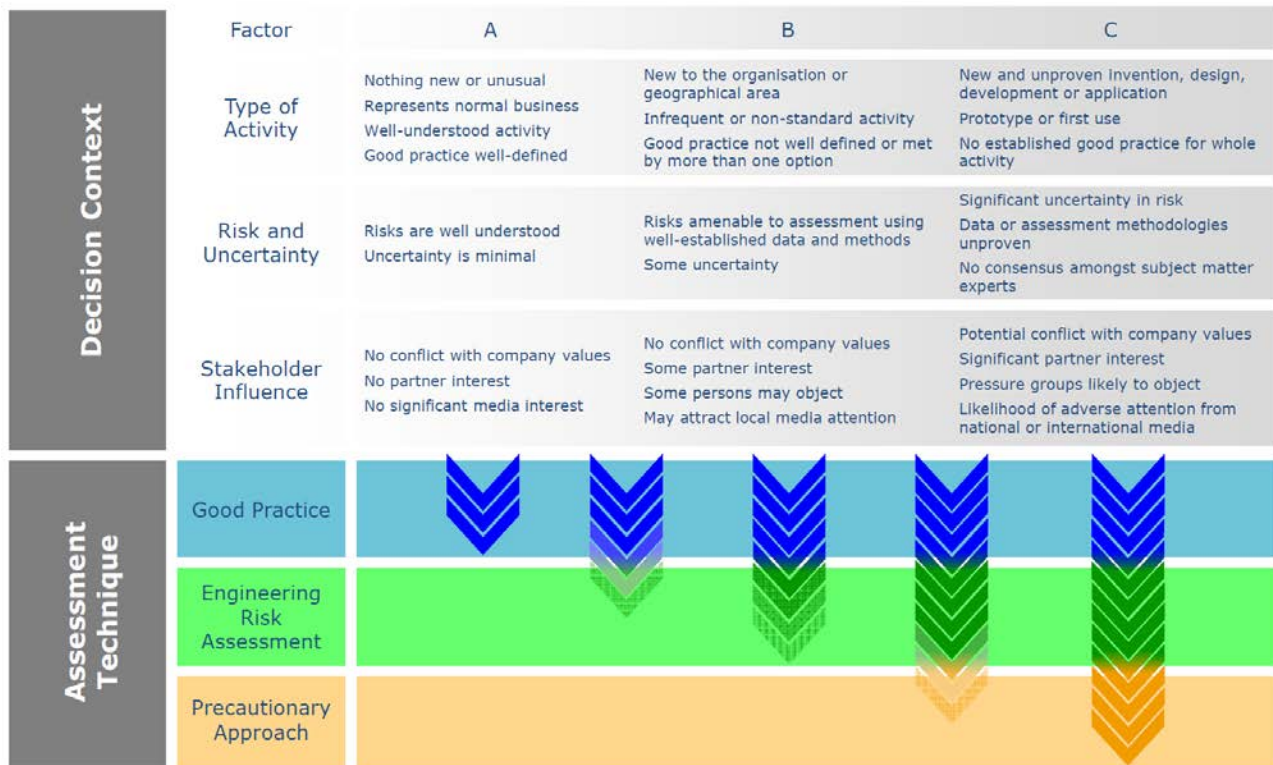


Figure 1 – Risk related decision support framework (Oil & Gas UK, 2014)

This approach shows that good practice would predominantly influence Type A decisions. Engineering risk assessments and good practice would have major input to Type B decisions involving infrequent non-standard activities, deviation from standard practice, some risk uncertainty, etc. Type C decision context identify the need for a precautionary approach in the decision making based on significant uncertainty in risk, unproven or novel design, conflict of values, etc.

It is advisable to make reference to the Oil & Gas UK guidelines themselves for detail on the use of the framework as the diagram is complex and its interpretation can be very subjective.

As an additional caution, operators who are making Type A decisions that rely predominantly on codes and standards as a decision basis should ensure they truly understand how the codes and standards act to minimise risks. Without this knowledge it is difficult to identify when change (planned or otherwise) will undermine the effectiveness of that standard or code as a control measure.

The following example gives an application of the framework for illustration purposes: three facilities, three different outcomes.

Table 1 – Example of applying the risk related decision support framework

	Facility 1	Facility 2	Facility 3
Scenario	Standard temperature / pressure pipeline in a mature oil and gas development area with no known unique environmental concerns and much existing similar infrastructure.	Normally attended facility which has some hydrocarbon processing equipment on board. There is nothing new or unusual about the equipment or process but this is the first time a facility of this type has been installed and operated by this operator.	Normally attended facility with novel technologies and complex hydrocarbon processing equipment that requires frequent monitoring during the initial start-up phase of operations. The facility has a large number of personnel on board and is located a long way from the mainland.
Decision type	Nothing new or unusual, company and external codes cover this application extensively, the best design, installation and maintenance approaches are known and well established over many years. The decision type is A.	Hydrocarbon processing facilities are not novel but they are new to the operator and thus deviate from established company practice. Qualified engineering judgement and some risk based assessment will be required to determine that the design is ALARP. The decision type is B.	Some new and novel technologies are utilised and the number of potentially exposed personnel is high. The impacts from any loss of containment are potentially very high. A precautionary approach to decision making is required. The decision is type C.
Risk reduction measures	Good Practice standard control measures specified in design codes and adopted on the existing infrastructure are put in place.	Good practice standard control measures put in place for processing facilities and decisions made regarding increased monitoring and inspection.	The decision type means that much more effort is expended on examining risk reduction options and proving the design is ALARP. Although costly, a standby vessel is incorporated into the design and operation philosophy for the facility.

5. Suitability of control measures for MAEs

The basic requirement for control measures for MAEs is that they must collectively reduce the risk to the health and safety of people to a level this is ALARP. Risk assessment provides information necessary to test this requirement, and it is this information that must be included in the safety case. Reduction of risk to ALARP is dependent on identification of hazards having the potential to cause MAEs and proper selection of the necessary control measures for each of them. This has several aspects, all of which will in general apply to each facility:

- The knock-on effects of hazards must be considered, i.e. any chain of events, causes and contributing factors leading to MAEs

- For any MAE there may be several independent hazards or combinations of hazards, each of which could lead to that event, and several control measures which may be particularly important because they may impact on one or more of those hazards
- The potential for escalation of major accident events needs to be considered, i.e. the cumulative consequences of apparently separate events that may be triggered by each other
- In cases where a large number of different hazards and potential incidents exist, the cumulative risk may be significant even if the risk arising from each is low. For example, the cumulative effects of many sources of risk in an offshore accommodation area may identify an unacceptable risk even if each source is low risk.

Consequently the demonstration that risks from MAEs are eliminated or reduced to ALARP may need to be made for hazards individually, in groups, and as a whole.

As stated earlier, there is no single correct way to “demonstrate” ALARP. However, it is expected that for each MAE identified for the facility, the demonstration would contain elements of the following process:

- Identification and consideration of a range of potential measures for risk reduction (both those adopted and those rejected);
- Systematic analysis of each of the identified measures and a view formed on the safety benefit associated with each of them;
- Evaluation of the reasonable practicability of the identified measures and the adoption or rejection of each; and
- Recording of the process and results, to be summarised in the safety case.

Clearly, the balance between benefits in terms of reduced risk and the costs of control measures will play a part in achieving and justifying ALARP. For example, if a control measure has a benefit that greatly outweighs the cost, this control measure would almost always have to be implemented, or very good reasons provided for not doing so. In contrast, if the cost greatly outweighs the benefit, demonstrating that the control measure is not appropriate is straightforward, as other options will almost certainly exist that are able to achieve a similar level of risk reduction at lower cost. If benefits and costs are both high, or are both low, more careful consideration may be required before selecting or rejecting control measures.

The operator may be able to rank available control measure options according to their benefits and costs in qualitative or quantitative terms. This will enable the operator to show that the appropriate balance has been achieved, where further steps to reduce risk would incur unreasonably high cost with little gain.

For existing facilities, in undertaking risk assessment and providing justification, operators should also consider if newly adopted control measures could pose additional hazards or contribute to incident scenarios, e.g. during installation or commissioning of new control equipment, or arising from ‘spurious’ operation of control measures.

Implementation arrangements should be included for any risk control measures that are planned but not yet in place, i.e. scheduled implementation. Specific and explicit commitments should be included that demonstrate the operator’s intention not to operate their facilities at an increased level of risk, in that activities will not be carried out until such time as the corresponding control measures have been fully implemented.

While there is no explicit requirement within the Safety Regulations to record in the safety case the range of control measures that has been considered, the content and level of detail needs to be sufficient to gain an appreciation of the scope and process for undertaking the consideration including sources of data and rationale for excluding or discounting items from consideration. It is difficult to see how an operator could show that risks are ALARP without making reference to other, discarded risk control measures.

Given all of the issues that may need consideration in demonstrating that the necessary control measures have been identified, it is appropriate to develop an approach that is logical, structured and efficient. For example, it would be inefficient to assess the effect of a control measure in detail if it was not practicable from a cost perspective. Equally, if there are control measures that can eliminate hazards, there may be little purpose in devoting significant effort to the assessment of measures for reduction or mitigation of the identified associated MAE.

Performance standards should be set for MAE control measures, and the safety case will need to include a convincing argument that these standards are appropriate. This is required to provide evidence to enable NOPSEMA to make a decision on whether the safety case is appropriate to the facility in accordance with OPGGS(S) subregulation 2.5(2)(c). These factors are discussed in greater detail in NOPSEMA Guidance Note – Control Measures and Performance Standards.



Further guidance is available in the NOPSEMA guidance note:

“Control measures and performance standards”

Example for a new build FPSO

An example of adopting a risk management strategy incorporating a “hierarchy of controls” and inherently safe design principles is encompassed in the case of reducing risks associated with conventional FPSO cargo pumps (located in a pump room) by using motor driven submersible pumps located on deck.

The safety issues associated with a conventional pump room versus deep well pumps located in each crude oil tank were evaluated. The review concludes there are advantages and disadvantages to both options, however the pump room option does not satisfy established isolation protocol as the pump seals are prone to leak thus posing significant fire and gas risk in the enclosed pump room space. Based on this evaluation, the deep well pump option was selected.

A further review was then carried out to examine the safety issues associated with hydraulic versus electric driven deep well pumps. Overall, it was concluded that the electric pump option is safer, primarily because the lower personnel exposure more than offsets the higher ignition potential. For this reason, the electric pump option was chosen for the design. Once the decision was made, the design and provision was finalised, incorporating inputs from ergonomic, material handling and human factor interface reviews.

6. Summary of factors in selecting or rejecting control measures

Methodology for understanding controls	Points to consider
Control Measure Hierarchy <ul style="list-style-type: none"> • Elimination • Prevention • Reduction • Mitigation 	Is there a control higher up the hierarchy that would more effectively manage the hazard? Where appropriate, is there a spread of controls across the hierarchy?
Types of Control Measure <ul style="list-style-type: none"> • Technical (Hardware/software) • Other (SMS/Procedural) 	Is there an appropriate spread of technical and other controls?
Common Mode Failures	Have failure modes been identified for each control measure and then compared to identify common mode failures?
Layers of Protection <ul style="list-style-type: none"> • Design Standards • Control Systems • Operating Procedures • Safety Devices • Emergency Systems 	Are the layers of protection provided adequate for the level of risk posed by the hazard?
Operating Circumstances <ul style="list-style-type: none"> • Environment • Operating conditions • Activities being carried out 	Have the controls been assessed for effectiveness over the range of different operating circumstances they may have to operate in?
Focus of Control Measure	Does the relative importance or vulnerability of the control measure justify a higher depth of scrutiny than others
Effective <ul style="list-style-type: none"> • Functionality • Availability • Reliability • Survivability 	Has the functionality, availability, reliability and survivability, been established for each control measure? Have means of improving these aspects been considered?
ALARP	Has each control measure been assessed for practicability, and those found practicable been implemented while those found to be not practicable noted as such with sufficient justification?

7. Risk assessment and providing evidence

Operators of offshore facilities must adopt a comprehensive and systematic method for assessing the risks of major accident events at their facilities. Some operators may choose to adopt quantitative methods, particularly if this is common practice in their company, whereas others may choose to adopt qualitative methods. The results of such assessments should be used to support the evidence that necessary control measures have been identified, and to show that risks are eliminated or reduced to a level that is ALARP. NOPSEMA expects the operator to justify the adopted risk assessment methodology and associated risk acceptance criteria as being suitable and appropriate to the specific facility.

7.1. Risk assessment tools

Approaches to formal safety assessment are discussed in numerous publications, and in NOPSEMA Guidance Note: "Risk Assessment", so only limited details of risk assessment methods are provided in this guidance note. ISO 17776, in relation to offshore production facilities, may provide further guidance on tools and techniques for hazard identification and risk assessment. The requirement is for the operator to select an approach which supports decision-making on control measures. Risk assessment will be an important part of this process, by showing that risks are reduced to a level that is ALARP and by showing that decision-making relates to the level of risk.



Further guidance is available in the NOPSEMA guidance note:

"Risk assessment"

7.2. Risk criteria

Many operators of offshore facilities may elect to assess and evaluate risks in a quantitative or semi-quantitative manner, and to develop criteria against which to compare the estimated risk levels. It must be noted, however, that all risk assessment is subject to uncertainty. For this reason, most approaches evaluate risk based on broad ranges of risk, rather than on specific criteria.

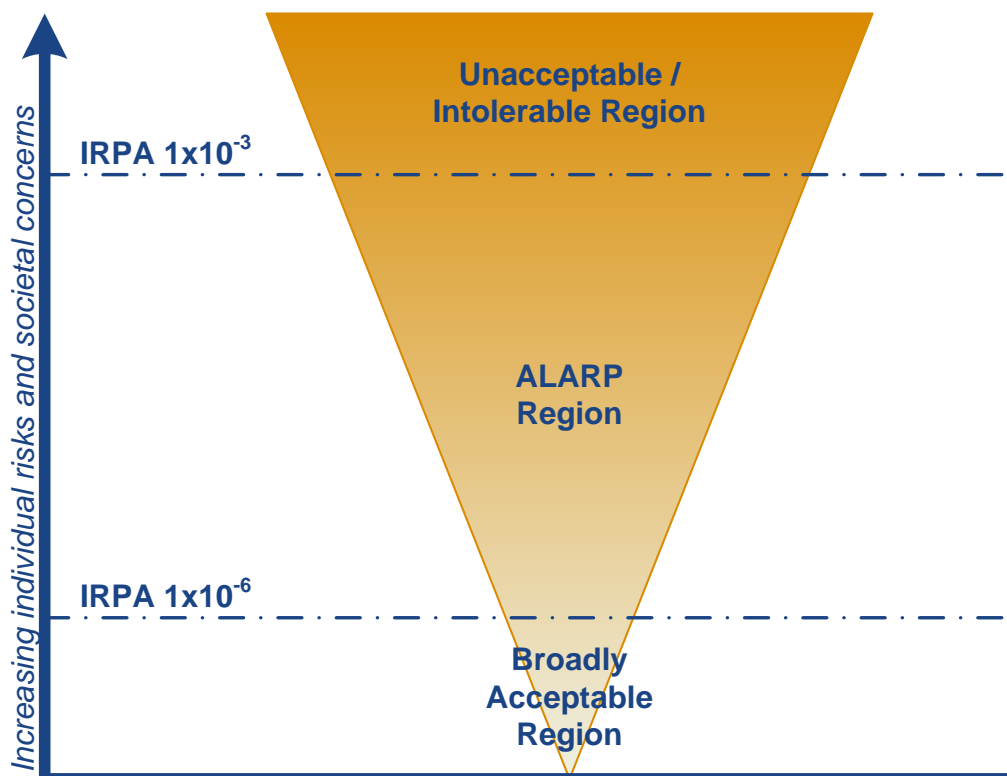


Figure 3 - Example of an ALARP triangle

Risk is most commonly represented on an inverted triangle (such as Figure above) as increasing from a 'broadly acceptable' risk region, through a 'tolerable' region only if shown to be ALARP, to an 'intolerable' region, in which the risk cannot be justified on any grounds. Such diagrams also typically introduce

numerical thresholds between the risk bands, often in terms of the Individual Risk Per Annum (IRPA) of a fatality. Operators may find it helpful to think of risk in terms of the inverted ALARP risk triangle; however it is important to be aware that the overall provisions the operator has to make through the safety case need to consider hazards and risks in all regions of the triangle.

As shown in Figure 4 below, a more accurate representation of an ALARP triangle in the context of the Safety Regulations is simpler, but more challenging, with the sole requirement being the reduction in risk to ALARP. It is notable that in order to keep risk at a level that is ALARP requires ongoing action to ensure the integrity of the control measures is maintained.

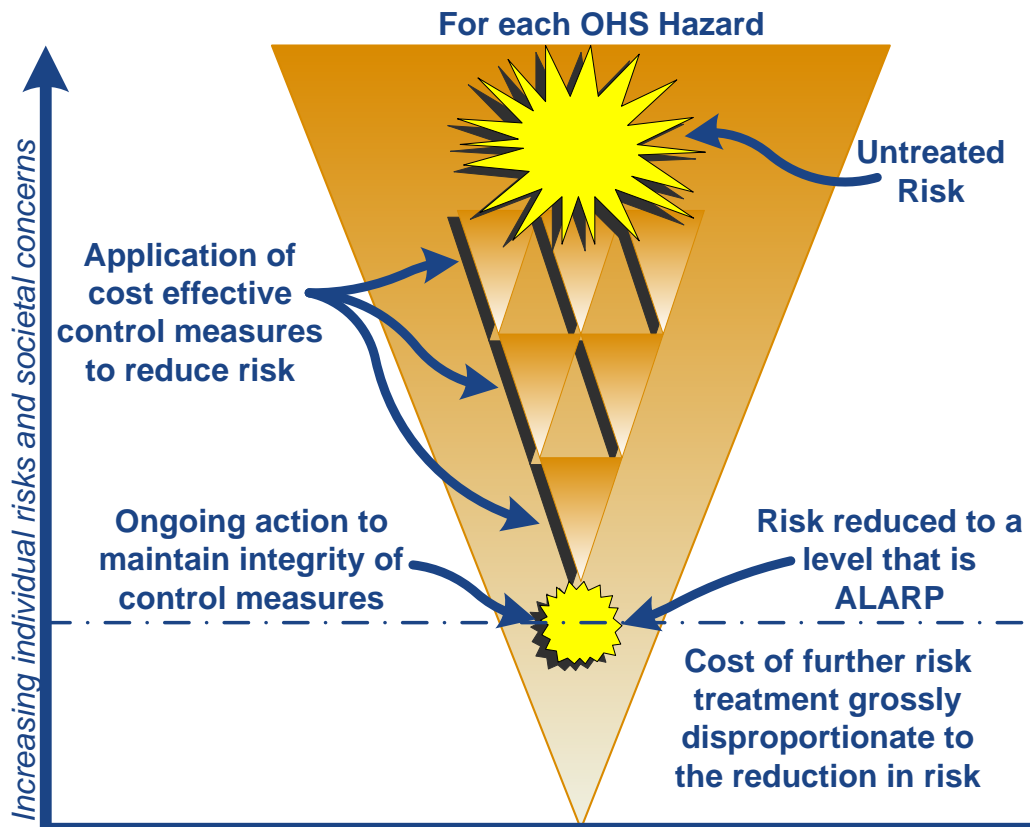


Figure 4 – OPGGS(S) ALARP triangle diagram

Although the Australian safety case regime may appear broadly compatible with that applied internationally, it is important to stress that the requirements contained within the Safety Regulations incorporate continuous improvement aspects. This means that at the lowest risk band, it may be reasonably practicable to further reduce the risk, and the regulations also require that this is considered. The safety case will have to show that:

- all hazards with the potential to lead to a major accident event have had all reasonably practicable risk reduction measures applied;
- any hazards or risks that may arise in the future will be effectively dealt with; and
- there are suitable and reliable processes for continuing to manage hazards and risks at all levels, and for achieving continuous improvement

It is appropriate to apply concepts of 'proportionality' to treating risks, and to concentrate effort on high risk areas. Numerical categorisation of risk may provide a "yardstick" to assist understanding and prioritizing risk reduction measures, however it should not be used as a single acceptance criterion.

7.3. Continuous improvement

While the safety case may place emphasis on reducing the risk to a level that is ALARP, it should not detract from the need for continuous improvement. Reducing risks to a level that is ALARP and continual improvement are both key objectives of the regulations, and relate both to what is done currently and to what is planned for the future.

If carried out properly, the process of developing the safety case will improve safety of offshore activities by ensuring a systematic review of the hazards, their associated risks and the control measures that are applied at the facility to either eliminate the hazards or otherwise reduce the risks. Progress, in terms of risk reduction, is achieved by applying the process both during initial development of the safety case and subsequently in the course of continuous improvement (see Figure 5 below).

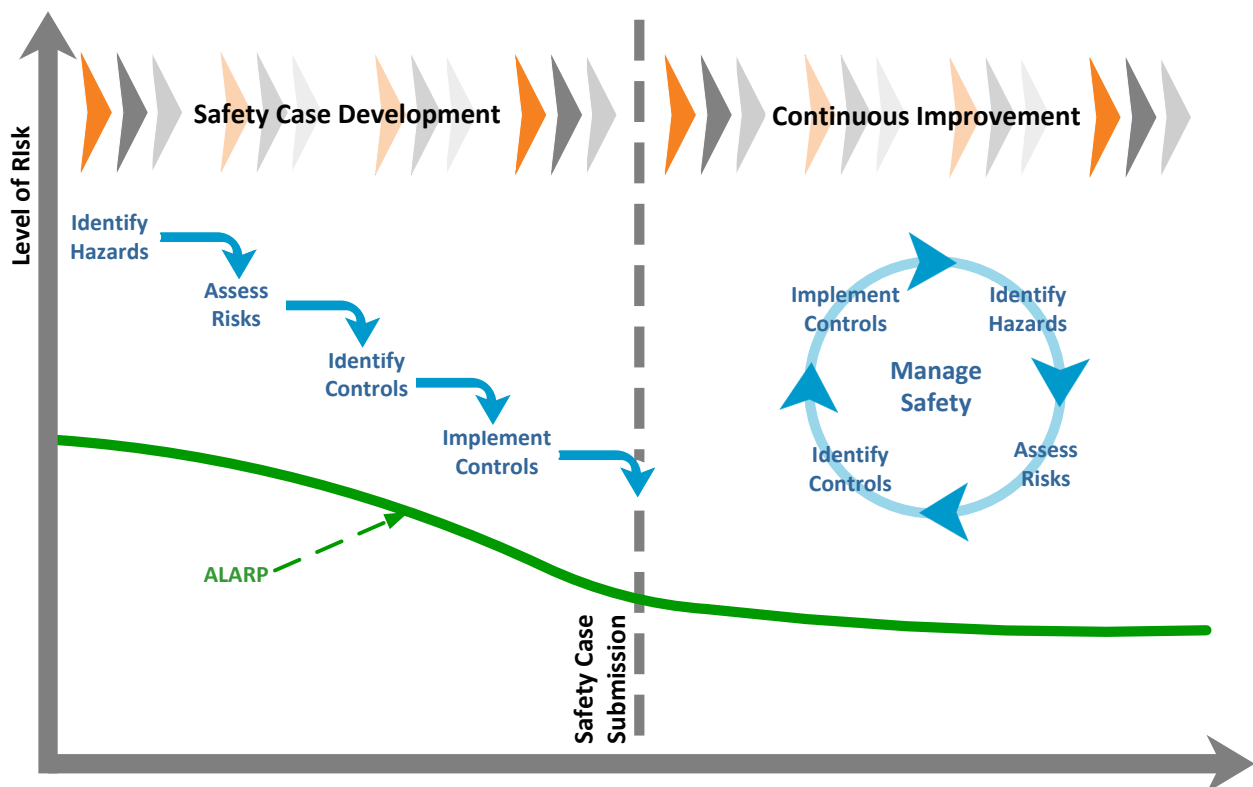


Figure 5 - Continuous improvement in safety through implementation of the safety case

It is expected that over the life of a facility an operator's risk management processes will identify opportunities to enhance the effectiveness of existing control measures or implement additional control measures and that a proportion of these will be reasonably practical to implement. This expectation is based on both ongoing developments in the state of knowledge concerning hazards and risks and the associated control measures and the over-arching duty of an operator to take all reasonably practicable steps to ensure that the facility and activities carried out at the facility are safe and without risk to the health and safety of any person at or near the facility.

8. Use of industry codes and standards

For most facilities, compliance with industry standards, codes or practices may play an important role in providing evidence that necessary and appropriate control measures have been identified and adopted. In principle, such standards may be Australian Standards, equivalents from overseas organisations such as ISO standards, international industry practices such as those from the American Petroleum Institute, or company-specific standards. However, the existence of a published standard does not imply that it is always useful or correct. Whichever standards are being used, these standards, and the control measures that they apply, should all be shown to be suitable and appropriate to the specific facility, taking account of its type, scale, activities, location, etc. Operators have the responsibility to consider the available standards, specify the correct one, enforce compliance, and use the system or equipment correctly. Validation of suitability of standards for safety-critical equipment is also necessary.



Further guidance is available in the NOPSEMA guidance note:

“Control measures and performance standards”

Technical standards issued by classification societies, IMO, national authorities and industry bodies underpin the design of many aspects of most offshore installations. For example, ISO 13702 (Control and mitigation of fires and explosions on offshore production installations), ISO 15544 (Requirements and guidelines for emergency response) and ISO 10418 (Basic surface process safety systems) provide guidance in relation to offshore production facilities. These standards have been developed using the expertise of the industry, responding to previous accident and incident experience and, in general, prescribe specific design solutions. The aim of technical standards is to ensure that, provided the installation is used for a standard application under good safety management, the risks will be reduced. However, it is an established part of good safety management to make use of risk assessment to identify hazards and minimise risks. Compliance with technical standards provides a sound design basis for standard offshore installations, but does not replace risk assessment altogether.

Example: Option selection

Standards, for the most part, allow for multiple solutions to a design. For example, in a project design process a decision would be made on, for instance, a type of compression to be adopted on the facility and then the appropriate standards are applied to the type of compression selected. Standards compliance on its own does little to demonstrate an ALARP decision process, since one type of compression may be of inherently lower risk than the other. The real ALARP decision process centres on the option choice whereas the standards argument is merely demonstrating that the chosen option meets appropriate standards for the option selected.

In some cases there may be a single over-arching standard that appears to apply. An example is the International Maritime Organisation Code for the Construction and Equipment of Mobile Offshore Drilling Units, (MODU Code) for most of the marine standards for an offshore drilling unit. For simple facilities, it may be possible to present evidence that risk related to design aspects are ALARP based largely on such standards, however the overall requirement for evidence of ALARP applies equally to construction, operation, ongoing maintenance and decommissioning phases (depending on the stage(s) in the life of the facility addressed in the safety case) as well as the facility design. In addition, a significant component of the ALARP requirements of the Safety Regulations relates to the safety management system [OPGGS(S)

subregulation 2.5(3)(e)] and therefore it is not normally possible to base an ALARP demonstration on standards alone.

For particularly large or complex facilities, it may be necessary to go beyond the established standards in order to demonstrate that risks related to facility design are ALARP. For example:

- The standards may not address the types of incident that are of prime concern to the facility;
- There may be gaps in the standards, such that the particular standard does not govern all aspects of hazards and risks at a facility; and
- The standard has fallen behind current good practice, or the facility has fallen behind the standard as that has been further developed.

Example: Lifeboat capacity

An operator may decide to comply with the Life Saving Appliances (LSA) IMO code for all lifeboats on a specific facility, since LSA is an internationally recognised standard for lifeboats on vessels. The operator should recognise according to the LSA code, lifeboat capacity is based on a person having an average mass of 82.5kg. If the average weight for the personnel on the operators' facility is typically 90kg then the operator should identify the limitation of the LSA code and ensure their lifeboat capacities are reclassified accordingly.

Example: Hazardous area zoning

An operator suspected that hazardous area classification zones described in a standard used by their organisation might not accurately reflect what was occurring in practice. As a result, a gas monitoring system was set up that identified the hazardous area zones needed to be increased due to the specific site circumstances. Under a goal-setting regime, it is also possible for operators to make such zones smaller if they can demonstrate it is reasonable to do so.

In the petroleum and chemical processing industries, there are no single over-arching standards for all aspects of facility design and operation. Rather, there are detailed standards in specific areas of design such as pressure vessels, hazardous area classification, fire-protection, and so on, plus general standards related to safety management. Standards are good at a system or equipment level but not necessarily suitable at a holistic level; they cannot be relied upon to give an indication of the adequacy of risk management of a combination of unique hazards on a specific facility. In this situation, it is common for an operator to adopt a suite of standards, perhaps taken from a number of different organisations. In such cases, significant effort may be necessary to show that this overall suite of standards is suitable and appropriate, as well as the individual parts.

Particular issues that will need additional consideration, which may not be covered by the individual standards, include plant layout, routing of escape-routes and protection of manned areas. In such cases there will be particular benefit in the operator developing a "basis for safety" for the specific facility.

Whatever standard or set of standards is used, the operator should take care to justify applicability and recognise limitations of those standards.

There may be cases where the current most relevant standard is not complied with in certain respects. An example may be a complex or novel facility where there are no applicable standards; another may be an ageing facility designed and constructed to standards now superseded. In such cases, the operator should show that additional measures have been introduced to compensate (i.e. to show that equivalent safety has been achieved), or that additional measures are not reasonably practicable. Examples of measures that may achieve equivalent safety are re-rating of equipment and introduction of more frequent testing or inspection. Where weaknesses are known or suspected to exist, for example if there is a gap in overall control measures, or a measure has been compromised by age, this must be explicitly identified. Solutions for addressing these weaknesses must be explored, and the chosen solution incorporated.

OPGGS(S) Regulation – Objects

- Reg 1.4(2) An object of these regulations is to ensure that safety cases for offshore petroleum facilities make provision for the following matters in relation to the health and safety of persons at or near the facilities:
- (a) the identification of hazards
 - (b) the implementation of measures to eliminate the hazards or otherwise control the risks;
 - (c) a comprehensive and integrated system for management of the hazards and risks;
 - (d) monitoring, audit, review and continuous improvement.

With respect to OPGGS(S) subregulation 1.4(2)(d) the review of facility hazards and risks should be a periodic process whereby the applied standards on a facility are reviewed against new and updated standards. If new standards or requirements are introduced they cannot be dismissed because the plant or facility was built prior to them; neither should they be automatically adopted: the risk assessment process must be undertaken. The task would be to understand the intent of the new standard and the change that it evokes from the current/existing operating situation. Once the assessment has taken place then decisions can be made about implications for a new understanding of risk on the facility and the steps that need to be taken.

Example: MODU code

A number of MODUs operating in Australian waters are only classed to the 1979 MODU Code (rather than the 1989 Code or 2001 amendment). One area of significant difference with later versions of this code is considerations for ballast control following the Ocean Ranger incident in which a MODU and all on board were lost. Any ALARP argument for the management of ballasting related MAEs should explicitly consider the limitations of the older code and implementation of the current code or equivalent control measures unless it can be demonstrated not to be reasonably practicable to do so.

It is also an option for an operator to use earlier versions of a code or standard if it can be shown that by doing so the risks are reduced to a level that is ALARP. In taking such an approach an operator would also need to be mindful of the basis for the change to the code or standard noting that such changes are generally improvements in response to an identified failure or weakness of the code or standard.

Example: Electrical colour coding

An operator may in the past have complied with Electrical Installation Standard AS 3000 which was revised in 2007 with respect to selection of cables for size and colour. The operator may assess that there is a risk arising from the use of two different cable colour schemes in the same system. NOPSEMA would expect under such circumstances that older conductors would be thoroughly tested to ensure that their physical condition is acceptable and that existing cables do actually meet the standard the operator has quoted in terms of adequate cross-sectional area, voltage drop levels, cable grouping etc.

9. Good practice and reasonable practicability

In determining what is reasonably practicable (or not), the courts usually do so in the context of an incident and therefore take an 'event focus' - they consider in hindsight an alleged breach associated with a particular incident, and each incident is judged on a case by case basis. Due to the event focus of prosecutions, courts traditionally have not been concerned with what proactive steps might need to be taken by an operator to address risk across a facility. In contrast, risk management provisions in the Safety Regulations are framed as a proactive and holistic process, to prevent or control risks before incidents occur rather than simply reacting to them when they do.

In the decision by Lord Asquith, the computation associated with reasonably practicable "falls to be made by the owner at a point of time anterior to the accident". Furthermore, in regard to what is 'practicable', the test of gross disproportion applies: if a measure is practicable and it cannot be shown that the cost of the measure is grossly disproportionate to the benefit gained, then the measure is considered reasonably practicable and must be implemented. This reinforces a precautionary approach by requiring the requisite control measures to be implemented unless there is an obvious imbalance between the sacrifice (cost) and the risk and further that as risk levels rise so too does the sacrifice (cost) that could reasonably be considered as being grossly disproportionate.

When reviewing health or safety control measures for an existing facility, plant, installation or for a particular situation (such as when considering retrofitting, safety reviews or upgrades), operators should compare existing measures against current good practice. The good practice measures should be adopted so far as is reasonably practicable. It might not be reasonably practicable to apply retrospectively to existing plant, for example, all the good practice expected for new plant. However, there may still be ways to reduce the risk e.g. by partial solutions, alternative measures, etc.

In determining what is reasonably practicable, the starting point for the risk/sacrifice computation should be the current situation. Operators should also consider the adequacy of the relevant good practice. An operators SMS should incorporate processes to monitor changes to applicable codes and standards. When a code or standard is updated to a higher standard, the facility, plant, installation or situation should be examined to see if it can be brought up to the new standard. Any such upgrades must be undertaken if it is reasonably practicable to do so.

New plant, installations or situations should conform to current good practice, as a starting point. Other potential options should be considered to determine whether further risk reduction measures are reasonably practicable. As a guide, designers can aim and compare against levels of safety that are known to have been achieved in other 'good practice' designs.

The use of good practice at the design stage is essential to demonstrating achievement of ALARP. Therefore, it is important that the operator capture all of the relevant information about risk-reduction decisions made during the early design stages. This should include use of sound design principles (e.g. inherent safety) as well as codes, standards and guidance. The earlier an operator undertakes an ALARP evaluation, the greater the ability to reduce risks to a level that is ALARP. Practicability is reduced as the project progresses and inherent safety opportunities are often lost beyond the concept selection stage. As previously mentioned, the criterion is reasonably practicable, not reasonably affordable: justifiable cost and effort is not determined by the budget constraints/viability of the project.

10. Critical factors for success

NOPSEMA expects the operator to address at least the following specific factors in their consideration of ALARP in the safety case submission:

- Timeliness - the earlier an operator undertakes an ALARP evaluation, the greater the ability to reduce risks to a level that is ALARP
- Safety case content that is consistent with the requirements specified in the Safety Regulations
- Involvement of people who know the facility or a very similar operation
- Access to a wide range of reference material such as standards, safety alerts, etc
- Description with an sufficient level of detail that explains the means by which the operator ensures suitability of the design, construction, installation, operation, maintenance or modification that is appropriate to the facility
- A transparent and robust presentation of evidence showing that the adopted control measures reduce risk to ALARP
- A transparent and robust presentation of evidence that the SMS provides for and will continue to provide for reduction of risk to ALARP, and that the SMS is comprehensive and integrated.

11. References, acknowledgements and notes

Offshore Petroleum and Greenhouse Gas Storage Act 2006

Offshore Petroleum and Greenhouse Gas Storage (Safety) Regulations 2009 (the Safety Regulations)

HSE Offshore Information Sheet 2/2006 *The Role of Offshore Installations (Safety Case) Regulations 2005 regulation 12* – <http://www.hse.gov.uk/offshore/sheet22006.pdf>

ISO 10418 Petroleum and natural gas industries -- Offshore production platforms - Basic surface process safety systems

ISO 13702 Petroleum and natural gas industries -- Control and mitigation of fires and explosions on offshore production installations -- Requirements and guidelines

ISO 15544 Petroleum and natural gas industries -- Offshore production installations -- Requirements and guidelines for emergency response

ISO 17776 Petroleum and natural gas industries -- Offshore production installations -- Guidelines on tools and techniques for hazard identification and risk assessment

National Research Centre for Occupational Health and Safety Regulation, *The Relationship Between 'Reasonably Practicable' and Risk Management Regulation, Bluff and Johnstone, 2004*

UK HSE *Assessment Principles for Offshore Safety Cases 2005*

UK HSE *Assessing compliance with the law in individual cases and the use of good practice*

UK HSE *Principles and Guidelines to assist HSE in its judgements that duty holders have reduced risk as low as reasonably practicable*

UK HSE *Policy and guidance on reducing risks as low as reasonably practicable in Design*

The UK offshore oil and gas industry *guidance on risk-related decision making* (Oil & Gas UK, formerly UKOOA, 2014)

Note: All regulatory references contained within this Guidance Note are from the Commonwealth *Offshore Petroleum and Greenhouse Gas Storage Act 2006* and the associated Commonwealth Offshore Petroleum and Greenhouse Gas Storage (Safety) Regulations 2009. For facilities located in Victorian designated coastal waters, please refer to the Victorian *Offshore Petroleum and Greenhouse Gas Storage Act 2010* and the associated Offshore Petroleum and Greenhouse Gas Storage Regulations 2011. For facilities located in other designated coastal waters, please refer to the relevant State or Northern Territory legislation.

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