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Offshore Wind and Marine Energy Health and Safety Guidelines

2014: Issue 2

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ACKNOWLEDGEMENTS

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This document was prepared for RenewableUK by SgurrEnergy Ltd.

STATUS OF THIS DOCUMENT

RenewableUK Health and Safety Guidelines are intended to provide information on a particular technical, legal or policy issue relevant to the core membership base of RenewableUK. Their objective is to provide industry-specific advice or guidance for example where current information could be considered absent or incomplete. Health and safety guidelines are likely to be subject to review and updating and so the latest version of the guidelines must be referred to. Attention is also drawn to the disclaimer below.

DISCLAIMER

The contents of these guidelines are intended for information and general guidance only, do not constitute advice, are not exhaustive and do not indicate any specific course of action. Detailed professional advice should be obtained before taking or refraining from action in relation to any of the contents of this guide, or the relevance or applicability of the information herein.

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LINKS AND UPDATES

All reasonable care has been taken to ensure that the references and links included in the guidance are accurate and effective at the date of publication. However should you identify any references or links that appear to be out of date or compromised, RenewableUK would welcome these being brought to our attention. Please e-mail any comments or concerns to:

healthandsafety@RenewableUK.com.

VERSION

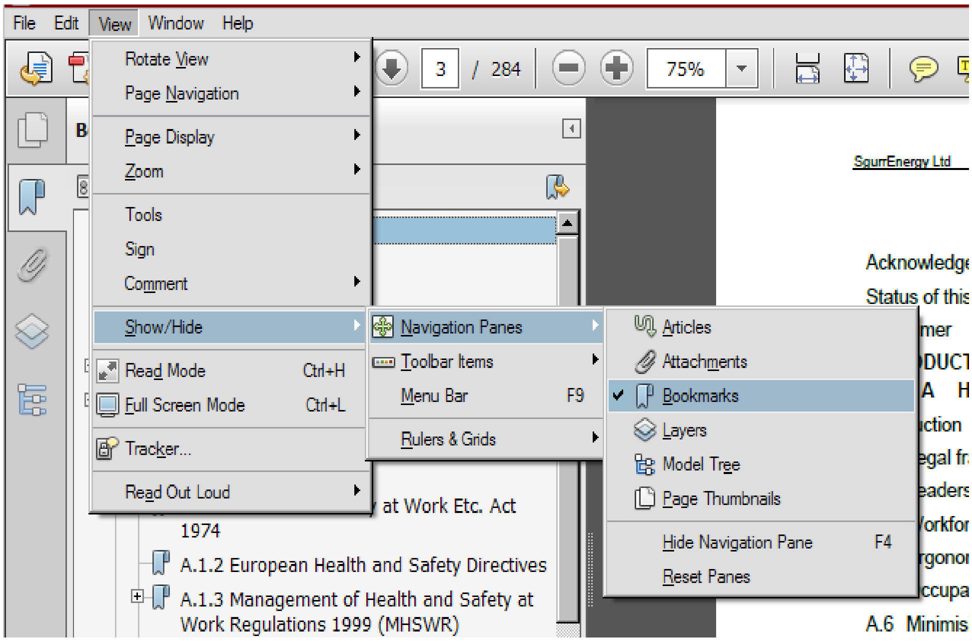
2014: Issue 2

Contents

MAIN CHANGES FROM ISSUE 1 OF THE GUIDELINES:

Section	**Change and Reason**
A.1.9, A.1.10	Amended to take account of MCA feedback
A.6	Comprehensive revision to take account of withdrawal of MHWSR ACOP and new version of HSG65, including the adoption of the "Plan – Do – Check – Act" approach
A.16	First Aid: • Section moved from C.8 in Issue 1, to reflect its position as part of the health and safety arrangements, rather than an activity or hazard, and to connect it with Emergency Response (A.15); • Title of section amended to "First Aid and Emergency Medical Response" to reflect current offshore practice; • Content of section aligned with revised HSE guidance.
C.8 to C.24	Renumbered as a consequence of First Aid section being moved.
Hyperlinks	Updated to reflect new publications, and changes in website addresses. Links to DNV publications now go to category webpage, rather than individual documents.

Note: This document is recommended to be viewed as a pdf; this enables all headings to be used as bookmarks for ease of navigation:



INTRODUCTION

The publication of the Offshore Wind and Marine Energy Health and Safety Guidelines is an important milestone for the renewable energy sector, and offshore wind and marine energy projects in particular. They support the strategic vision of RenewableUK:

> "*to be a leading enabler in the delivery of an expanding UK wind, wave and tidal sector free of fatalities, injuries and work related ill-health."*

The guidelines support our commitment to championing health and safety for the benefit of everyone in the wind, wave & tidal industry, thereby:

- Continuing to make the UK a leader as a safe and responsible jurisdiction in which to do business; and
- Ensuring that health and safety remains a top priority throughout the wind, wave and tidal industry.

SCOPE AND STATUS OF THE GUIDELINES

The guidelines do not define or mandate any new industry standards or requirements. They have been developed by taking account of existing and emerging industry good practice within the framework of UK health and safety legislation. Specifically, the guidelines consider the occupational health and safety of employees and others who may be exposed to risks as set out under the Health and Safety at Work etc. Act 1974 and the applicable subordinate regulations. While marine legislation is referenced, the health and safety requirements for seafarers are **not** considered in detail within the scope of the guidelines.

The guidelines do not aim to influence or direct any specific risk management, operational, technical or other solution. Duty holders throughout the life cycle of an offshore wind or marine energy project continue to be responsible for ensuring compliance with regulatory and contractual obligations, and so must make their own assessment of the relevance and suitability of any guidance provided. However, while no new standards are set out, the guidelines collectively are likely to be regarded as representing the current industry state of knowledge for the issues addressed.

TARGET AUDIENCE OF THE GUIDELINES

The guidelines are primarily written from the perspective of the developer or client in relation to projects designed, constructed, operated and maintained in the United Kingdom. However, they are likely to also provide a useful reference source for:

- Designers and Manufacturers – of wind turbine generators (WTGs) and wave or tidal devices, balance of plant and associated project infrastructure;
- Contractors – including Principal Contractors and other contracting and supply chain parties; and
- Professional advisers – including nominated health and safety competent persons, CDM Co-ordinators, inspection and certification companies and other occupational health and safety advisers.

SCOPE AND CONTENT OF THE GUIDELINES

The guidelines aim to consider occupational health and safety risks in relation to offshore wind and marine (wave and tidal) energy projects[1] with the territorial waters and Renewable Energy Zone (REZ)[2] of the United Kingdom.

For the purpose of this guidance:

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[1] Offshore Renewable Energy Installations (OREI's) including the associated balance of plant and project infrastructure.

[2] A REZ is an area, outside the territorial sea, designated by order under section 84(4) of the Energy Act 2004 which may be exploited for the production of energy from water or wind.

- Offshore wind projects are considered to relate to WTGs as defined by EN 61400-3 (BS EN 61400-3:2009 - Wind turbines. Design requirements for offshore wind turbines) including the associated balance of plant and project infrastructure; and

- Marine energy projects[3] are considered to relate to Tidal Energy Converters (TEC)[4] and Wave Energy Converters (WEC),[5] including the associated balance of plant and project infrastructure.

Either of these may constitute an Offshore Renewable Energy Installation (OREI), so this term is used throughout the guidelines, unless referring to a specific element of an OREI.

The guidelines acknowledge a collective responsibility for health and safety in the industry, and so support a strategic objective to enhance the overall improvement in the health and safety performance of the sector.

However, the guidelines cannot cover every relevant issue or every possible risk associated with the lifecycle of offshore wind and marine projects. For example, the guidelines do not address the relationship between health and safety law and employment law, which can sometimes be at odds, nor do they address onshore activities that occur as a precursor to offshore projects.

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[3] Terms used from DD IEC/TS 62600-1:2011 - Marine energy — Wave, tidal and other water current converters. Part 1: Terminology.

[4] Device which captures energy from tidal currents and converts it into another form.

[5] Device which captures energy from surface waves and converts it into another form.

STRATEGIC HEALTH AND SAFETY CONTEXT

The strategic importance and business benefits[6] of good health and safety management are recognised by all responsible organisations. Good practice in health and safety makes sound business sense and can help to:

- Protect people from the suffering caused by accidents and ill health;
- Reduce absences and sick leave;
- Retain staff;
- Maintain an organisation's reputation;
- Improve productivity and profits; and
- Reduce insurance premiums and legal costs.

While these broad outcomes are all relevant to the sector, good health and safety management can also offer specific benefits, including:

- Supporting and enhancing the overall improvement in health and safety performance for OREI projects;
- Adding value and reducing costs and uncertainty, by supporting the timely, effective, safe and sustainable delivery and operation of assets throughout their life cycle;
- Contributing to the reduction of both direct and indirect health and safety related risks within the sector;
- Addressing complex or contentious issues that are unique or have a particular sector-specific dimension; and
- Protecting and enhancing the reputation of the UK renewable energy industry.

These are reflected in the RenewableUK Offshore Wind and Marine Energy Health and Safety Accord, which enables organisations to show their commitment to:

- Clear and visible leadership on health and safety;
- Being part of a responsible industry that is fully engaged in self-regulation, by confronting its key health and safety challenges; and
- Taking a proactive stance on health and safety, to eliminate hazards and reduce risks.

Examples of how companies can take account of this in the strategic goals and priorities of their business include:

- Recognising that good health and safety is an integral part of the safe delivery and operation of OREI projects;
- Adopting lifecycle thinking, and a lifecycle approach to managing health and safety risks, with particular emphasis on health and safety considerations influencing the project concept and design;
- Ensuring direct and indirect health and safety and commercial benefits, through the development of effective partnerships and alliances when managing health and safety risks;
- Applying an iterative risk management approach that takes account of the rapidly changing state of knowledge within the sector;
- A commitment to monitoring performance and sharing good practice, to enable lessons to be learnt, and good industry practice to be widely communicated;
- Ensuring effective co-operation and co-ordination of all contracting parties, including setting out clearly defined roles and responsibilities; and

[6] http://www.hse.gov.uk/business/business-benefits.htm

- Recognising the need to develop and maintain individual and organisational health and safety competencies relevant to the risks concerned.

STRUCTURE OF THE GUIDELINES

Although the guidelines are published as a single document they are designed to be accessed and used as an initial reference source on a wide range of topics, providing clear signposting of key supporting health and safety information on the topic concerned. Where possible, references are provided as links to other related sections of the guidelines, or external reference sources. For these reasons, while the document can be printed, it will be most effective if used as an electronic document, using bookmarks to section headings within the document, and hyperlinks to access supporting guidance on the internet.

The guidelines are structured as follows:

Part A: Health and Safety Offshore;

Part B: The Offshore Project Lifecycle;

Part C: Offshore Hazards and Activities; and

Part D: References and Glossary.

Part A sets the context for offshore health and safety management in OREI development. It considers:

- The **legal frameworks** that apply to activities offshore;
- The importance of **leadership** and the establishment of a positive health and **safety culture** including effective **workforce engagement**, **human factors** and **occupational health,** and the minimisation of collective risk through the development of **shared value;**
- Health and safety **management systems** and **risk management** including their role in developing **competence** and **safe systems of work;**
- The significance of **stakeholder engagement** and **supply chain management**, including the **management of change**, **SIMOPS** and **strategic planning**; and
- Offshore-specific approaches for **emergency response and preparedness**.

Part B sets out a generic lifecycle framework in order to identify, assess and manage the main health and safety hazards and risks that could reasonably arise in OREI development. It also aims to put in context the potential critical timelines and decision points to enable suitable and effective health and safety precautions to be identified and put into effect. It considers:

- The relevance and importance of a **life cycle approach** to the management of health and safety;
- The **project definition** and **project design** phases, and how they will affect subsequent life cycle phases;
- The significant phases creating a direct occupational health & safety risk exposure including **construction & commissioning, operations & maintenance** and **decommissioning;** and
- Major supporting activities that span the above phases, including **survey & geophysical, logistics & mobilisation** and **modifications & upgrades.**

Part C aims to consider the most significant health and safety hazards and activities relevant to offshore wind and marine projects. It considers:

- Access, transport and logistics issues including **access and egress** by vessel or helicopter, **aviation** and **ports and mobilisation**;
- Construction and infrastructure risks including **piling and grouting**, **cable laying and entry** and **geological unknowns**;
- Safety risks including **confined spaces**, **electricity** and **fire** as well as **remote working** and **working at height**;

- Health and related risks including **hazardous substances**, **noise**, **vibration, ergonomics** and **welfare** including **first aid** as well as the health and safety issues in **waste and spillage** management; and
- Marine and vessel management including **subsea operations**, **unexploded ordnance (UXO)**, **vessel selection**, **marine co-ordination**, **metocean** and **navigational** risks.

Within Part C, these topics are arranged in the alphabetical order of their titles.

Part D includes a consolidated list of references and a glossary of terms and abbreviations used in the guidelines.

PART A HEALTH AND SAFETY OFFSHORE

INTRODUCTION

This part of the guidance sets the context for offshore health and safety management in OREI development, and considers:

- The role of leaders, and the establishment of a positive health and safety culture;
- The regulatory frameworks that apply to activities offshore;
    - The focus is on the frameworks relating to occupational health and safety risk arising over the lifecycle of an OREI; maritime regulation is relevant to this, but not addressed in detail;
    - Regulatory requirements in relation to specific activities and hazards are covered in Part C;
- Health and safety management arrangements in relation to:
    - The organisation itself, including the management of risk, the health of the workforce, and the operation of safe systems of work; and
- Offshore-specific and applied techniques for managing planned and emergency situations.

This guidance provides an overview in each of these areas, with links to more detailed guidance documents, which can help in addressing specific issues.

The interactions between health and safety issues, over the different phases in the whole lifecycle of an OREI, are addressed in Part B.

A.1 LEGAL FRAMEWORK

The Health and Safety at Work etc. Act 1974 (HSWA) modernised the legal framework for health and safety in the UK, replacing numerous industry-specific regulations with non-prescriptive general duties under the Act, more prescriptive regulations are made to address specific activities and hazards, rather than industrial sectors. The effect of this approach is that, even though there are no regulations that specifically address renewable energy, the relevant activities and hazards are already subject to existing regulations and the general duties under the HSWA.

OREI development is also subject to maritime regulation, which applies to all vessels engaged in activities at any stage of the lifecycle. In many cases, health and safety regulations made under the HSWA and under the Merchant Shipping Act 1995 impose near-identical duties, so common standards of health and safety can be expected. The regulations and regulators have clearly-defined interfaces, with the aim of avoiding gaps or duplication in application or enforcement.

This section outlines the principal acts and regulations that address the overall framework for health and safety management in OREI projects; regulations pertaining to specific activities and hazards are covered in the relevant sections of Part C.

A.1.1 HEALTH AND SAFETY AT WORK ETC. ACT 1974

The HSWA imposes general duties upon:

- Employers, employees and the self-employed;
- Those who have control of workplaces; and
- Designers, manufacturers, importers and suppliers of articles and substances for use at work;

to ensure, so far as is reasonably practicable, the health and safety of those who may be affected by their actions or omissions, whether they be employees, users of equipment or premises, or members of the public; employers have an additional duty to ensure the welfare of their employees at work.

A fundamental principle of the Act is to make those who create risks, in the course of work activity, responsible for protecting workers and the public from the consequences of their activities. The HSE requires duty-holders to address "*hazards which are a reasonably foreseeable cause of harm, taking account of reasonably foreseeable events and behaviour*".[7]

The Act also establishes:

- The Health and Safety Executive (HSE) as the regulator;
- A framework for regulations to be made under the Act, which also provides a means for EU directives to be adopted as UK regulations;
- The legal status of Approved Codes of Practice (ACOPs) published by the HSE;
- The system of enforcement of regulations, including the powers of inspectors, and the issue of improvement and prohibition notices;
- The arrangements for prosecution of offences, which allow for directors or other company officers to be prosecuted where they are responsible for an offence by a corporate body.

The Act and subsidiary regulations generally adopt a "goal-setting" approach, in that they set objectives, with broad applicability, and leave duty holders to determine the best way of achieving these objectives, rather than imposing particular approaches, standards or technical solutions. However, it must be noted that in some cases, regulations impose absolute duties, which are not qualified in any way and must be complied with.

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[7] From HSE – *Reducing Risks, Protecting People*.

A.1.1.1 REASONABLY PRACTICABLE

In essence, health and safety law in the UK seeks to ensure duty holders reduce all material risks, "so far as is reasonably practicable" (SFAIRP), also expressed as "as low as reasonably practicable" (ALARP). Material risks are those that are more than fanciful, and are real. SFAIRP and ALARP are central to the general duties under the Act and its subsidiary regulations. There are very few cases in which regulations define an exact technical specification; in most cases, the duty holder will have to identify a specification or practice that will reduce risk to ALARP.

When determining whether a risk has been reduced ALARP, both cost and risk reduction are considered; however, the decision is weighted in favour of health and safety: further risk reduction measures should be implemented unless the cost or effort of doing so would be grossly disproportionate to the resulting risk reduction. In the event of legal proceedings relating to this duty, it is for the duty-holder to demonstrate that they had reduced risk ALARP, rather than for the prosecution to show that they had failed to do so; this reverses the normal burden of proof.

When considering if a risk has been reduced ALARP, control measures can be compared against recognised and relevant good practices, including HSE ACOPs and Guidance; if these do not cover the full scope of activities, then recognised good practices should be followed as far as possible, and an assessment made of whether more can be done to reduce the risk. Note that the fact that a practice is universal in an industry does not necessarily mean that it is a good practice; established practices should be reviewed against current legislation, available technology, and relevant good practices that have been demonstrated elsewhere.

Note that it is neither possible, nor a regulatory requirement, to eliminate all risks; rather, the actions taken to reduce risk should be proportionate to the risk involved, noting that in many cases, the offshore environment will increase risk, when compared to undertaking the same activity onshore.

A.1.1.2 LEGAL STATUS OF ACOPS AND GUIDANCE

Regulations are Statutory Instruments, made by government, and must be complied with. As legal documents, they define duties precisely, but more practical explanation is helpful in understanding their application, so the HSE publishes ACOPs and / or Guidance on regulations and other specific topics to assist in this. These are generally published in the same document, with formatting to ensure that the distinction between them is clear, given their different legal statuses.

ACOPs provide practical guidance on how to comply with the law, and have a special legal status:

- If a duty-holder follows the advice in the ACOP, then they will be deemed to be complying with those legal duties that it covers;
- If a duty-holder is prosecuted for a breach of health and safety law (i.e. the Act or a regulation), and it is shown that they did not follow the advice in the ACOP, then they will need to show that they have satisfied the legal duty in some other way, otherwise they will be found to be non-compliant.

Guidance also provides practical means of complying with the law, but does not have the same legal status; while it is seen as best practice, and following it will normally ensure compliance with relevant legal duties, duty-holders are free to take other action.

A.1.1.3 HSWA APPLICATION OUTSIDE GREAT BRITAIN ORDERS

There are no specific acts or regulations relating to the health and safety of offshore renewable energy activities; the regulatory approach has been to extend many of the provisions of the HSWA, and subsidiary regulations, to cover these activities, therefore the regulatory regime is largely the same as onshore.

The HSWA was extended, in the HSWA Application Outside Great Britain Order (AOGBO) 2001, to cover renewable energy activities within the Territorial Sea, which extends to 12NM from the shore or baseline. A Variation Order in 2009 (renewed in 2011) further extended its geographical coverage to the Renewable Energy Zone (REZ), as defined in the Energy Act, thereby covering the entire area within which leases can be granted by the Crown Estate. The 2013 Order consolidated the provisions of the 2001 Order and 2011 Variation Order, and superseded them; unlike the Variation Orders, it has no “sunsetting provision”, so will remain in force.

The AOGBO applies specific articles of the HSWA to the activities that are likely to take place over the full lifecycle of an OREI, including preparatory work, construction, O&M, decommissioning, personnel transfers from vessels or aircraft (including helicopters), diving and cable works. Regulations made under the HSWA only apply offshore if they contain a clause that explicitly states so, in which case they will also specify the extent of their application, by reference to relevant articles of the Order. This means that although statutory protection under the HSWA applies to the whole REZ, some regulations only apply within the territorial sea, and certain articles within regulations may not apply offshore.

However, even where an article or regulation has not been extended outside Great Britain, it could still be taken as setting expectations of good practice, and established approaches to compliance could satisfy the requirement under HSWA to reduce risk ALARP. A responsible duty-holder should not aim to work to a lower standard of safety than the standard that they would achieve in a location where the regulations apply explicitly.

A.1.1.4 Health and Safety Executive for Northern Ireland (HSENI)

The Health and Safety at Work (Northern Ireland) Order 1978 establishes the HSENI, and provides for the making and enforcement of regulations in a similar manner to the arrangements in Great Britain; further details are available from the HSENI website. There is no equivalent in Northern Ireland (NI) to the AOGBO; the HSENI inserts offshore provisions, as necessary, into individual sets of NI health and safety regulations.

A.1.1.5 Interface between HSWA and Merchant Shipping Regulations

In most cases, regulations made under the HSWA “*do not apply to the master or crew of a seagoing ship or to the employer of such persons in respect of the normal ship-board activities carried out solely by a ship’s crew under the direction of the master*”, as these will be covered under Merchant Shipping regulations.

Regulations relating to the use of work equipment and lifting equipment take a slightly different approach, recognising that situations may arise where:

- The ship’s equipment is used by workers who are not part of the ship’s crew; or
- Use of the ship’s equipment, by the ship’s crew, could put others at risk.

These regulations include specific provisions to manage such situations. The interface arrangements are explained in more detail in the relevant ACOPs. In many cases, regulations made under the HSWA, and Merchant Shipping regulations, are implementing EU Directives, so a similar level of safety can be expected.

A.1.1.5.1 Offshore Installations

Where health and safety regulations refer to “Offshore Installations”, this means offshore oil and gas installations; the AOGBO refers to “energy structures”, meaning WTGs or wave / tidal devices, and “related structures”, such as offshore substations.

OREIs are therefore not subject to the Safety Case regime that applies to Offshore Installations; conversely Offshore Installations are not subject to CDM, so people moving between industries will need to become familiar with the relevant regulations.

A.1.1.6 References

A complete list of the regulations enforced by the HSE is available on the Statutory Instruments page of the HSE website.

HSE Offshore Information Sheet 1/2013 - Application of health and safety law offshore provides guidance on the HSWA AOGBO 2013.

A.1.2 European Health and Safety Directives

Many aspects of health and safety are subject to EU directives, the requirements of which are generally transposed into UK legislation in the form of Statutory Instruments (regulations) made and enforced under the HSWA or the Merchant Shipping Act 1995. The EU Framework Directive on Safety and Health at Work, adopted in 1989, set out to guarantee minimum health and safety standards throughout Europe, while still allowing member states to maintain or establish more stringent conditions. Key EU health and safety directives, and the associated regulations, are listed in Table 10 in the Appendix; note that only the most relevant regulations are listed, as each directive may affect multiple sets of regulations.

As EU directives are implemented in this manner, the general duties under the HSWA still apply, in particular the ALARP principle. There may also be substantive differences in requirements or application between the EU directive and the related UK regulations. These differences may mean that contractors and suppliers from other member states are used to different requirements and approaches, despite the regulations being of common origin.

An exception to this approach is the Supply of Machinery (Safety) Regulations, which are made under the European Communities Act 1972, rather than the HSWA, but enforced by the HSE.

A.1.3 Management of Health and Safety at Work Regulations 1999 (MHSWR)

The MHSWR, also known as the Management regulations, are aimed mainly at improving health and safety management, by promoting a systematic approach. The regulations require employers, amongst other duties, to:

- Establish a health and safety policy
- Assess the risks to the health and safety of their employees and others who may be affected by their work activity;
- Make arrangements for putting into practice the health and safety measures that the risk assessment shows to be necessary; these arrangements should cover planning, organisation, control, monitoring and review;
- Establish plans for the response to emergencies, considering both internal response and the involvement of emergency services;
- Ensure co-operation on health and safety measures between contractors and subcontractors;
- Ensure that they have access to competent health and safety advice;
- Providing suitable supervision; and
- Consult with employees regarding workplace risks and preventive and protective measures.

In organisations with five or more employees, the health and safety policy and risk assessments must be recorded.

Specific risk assessments that may be required under other regulations, such as COSHH or Manual Handling regulations, will partially fulfil the duty to carry out assessments under the MHSWR, and therefore do not need to be repeated or supplemented, provided that they remain valid and cover all significant risks.

The MHSWR further expand the general duties under the HSWA by requiring employers to take account of their employees' capabilities, in relation to their health and safety, when giving them tasks to do; this could include the employee's previous training, knowledge and experience. The employee's competence will affect the level of supervision that is required in order for them to work in a safe manner.

A.1.3.1 References

HSE HSG65 - *Managing for health and safety*.

A.1.4 Construction (Design and Management) Regulations 2007 (CDM)

The CDM Regulations provide a framework for the management of construction projects. The key aims of CDM are to:

> "*integrate health and safety into the management of the project and to encourage everyone involved to work together to:*

a) improve the planning and management of projects from the very start;

b) identify hazards early on, so that they can be eliminated or reduced at the design or planning stage, and the remaining risks can be properly managed;

c) target effort where it can do the most good in terms of health and safety; and

d) discourage unnecessary bureaucracy"[8].

Managing a project in accordance with CDM will involve the production of certain documents, namely Pre-Construction Information, a Construction Phase Health and Safety Plan, and a Project Health and Safety File, however these documents only exist as a means to support effective communication and the safe management of a project, and are not of themselves the purpose of CDM.

A.1.4.1 RELEVANT ACTIVITIES

The regulations apply to construction work, the definition of which is given in CDM Regulation 2, and includes a wide range of activities, such as:

- Construction, on-site assembly / dismantling, fitting out, installation of services, commissioning, and decommissioning;
- Preparation of a site, including site investigation (intrusive investigations), but excluding non-intrusive survey activities; and
- Demolition and removal from site;

Certain other activities are specifically excluded from the definition of construction:

- General maintenance of fixed plant, unless it involves substantial dismantling or alteration of structures; and
- Off-site manufacture of items that will later be installed on site.

The ACOP illustrates these exclusions with examples. In relation to OREIs, this would mean that, for example, the manufacture of a WTG foundation would not be subject to CDM regulations, however:

- The designer of the foundation would have duties in respect of the risks that their design presents throughout its lifecycle; and
- The manufacturer of the foundation would have health and safety duties under the relevant regulations at the location of their facility.

Certain projects are notifiable to the HSE, in which case additional duties apply; notifiable projects are those that are expected to involve more than:

- 30 days on which any construction work takes place on the site; or
- 500 person days of construction work, over any period of time.

It is anticipated that the majority of the works relating to OREI development will be notifiable, and therefore require the formal assessment and appointment of CDM Co-ordinator (CDMC) and Principal Contractor.

A.1.4.2 APPLICATION OFFSHORE

CDM applies onshore, and offshore under Article 8 of the 2001 AOGBO, which extends it to the whole of the UK Territorial Sea.

The subsequent AOGBO Variation Orders, and the 2013 AOGBO, which extend the HSWA to the entire UK Renewable Energy Zone, do not extend the application of CDM. As the general duty to reduce risk ALARP applies throughout the REZ, if it were proposed to adopt an alternative approach that differed from CDM, then it would be necessary to be able to demonstrate that the alternative approach would provide an equivalent level of safety.

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[8] HSE L144 - *Managing health and safety in construction - Construction (Design and Management) Regulations 2007 Approved Code of Practice*.

A.1.4.3 Roles and Duties under CDM

CDM defines a number of key duty holders within a project:

- Client;
- CDM Co-ordinator;
- Designer(s);
- Principal Contractor;
- Contractors.

Note that although the CDM regulations are the means by which the UK has implemented the EU Temporary and Mobile Construction Sites Directive, the approach taken in the UK to fulfilling the duties of Designer, CDM Co-ordinator and Principal Contractor differs from that of most other member states.

The duties held by each of these roles are summarised in Table 1 on page 19; additional explanation of key points is given in the sections below.

A.1.4.4 The Client

A Client is an organisation or individual for whom a construction project is carried out. The Client can be considered to be the entity to which the final project will be delivered; their actions will have a significant influence on the safety of the project, such as:

- Appointing key members of the project team;
- Determining the time and resources available to the project team;
- Establishing the culture and arrangements for co-operation and co-ordination of the activities of team members; and
- Providing Pre-Construction Information to the team.

The Pre-Construction Information package should concentrate on any significant project-related hazards that competent designers and contractors could not reasonably be expected to anticipate or identify; Appendix 2 of the ACOP provides a list of potential hazards, although these are not specific to offshore activities.

In the case of a Joint Venture (JV), the steering committee must determine how the role of Client is to be fulfilled; either:

- An individual organisation within the JV formally accepts the role of Client, with the full written agreement of all of the other parties in the JV to entrust this one organisation with the full responsibilities and authority of the Client; or
- The steering committee of the JV undertakes the role of Client themselves.

Notwithstanding the above, the legal structures applied to JVs, can differ from one project to another. Some JVs may be separate legal entities in their own right, others may be unincorporated associations between various companies. To ensure all parties to a JV know exactly what their legal duties are with regard to health and safety, specialist advice should be taken.

A.1.4.5 The CDM Co-ordinator (CDMC)

The CDMC advises the Client on the management of health and safety risks in construction work, including:

- Assisting the Client to appoint competent contractors;
- Assessing the adequacy of health and safety management arrangements;
- Ensuring that health and safety aspects are properly co-ordinated in the design process;
- Facilitating communication and co-operation amongst project team members, for example between Designers and Contractors; and

- Preparing the project Health and Safety File, which hands over relevant information from the construction phase to assist health and safety management in subsequent lifecycle phases.

In order for the CDMC to fulfil these duties, they should be appointed before any significant design decisions are made on the project, and ideally have continuity throughout the project.

The CDMC should have sufficient independence from the Client to ensure that they can provide impartial advice with respect to health and safety throughout the project. This does not mean that the CDMC cannot be an employee of the Client organisation, but if so, the CDMC should be able to demonstrate true impartiality.

The CDMC is appointed by the Client, based on a robust assessment of their competence in relation to the nature of the project; guidance on assessing the competence of a CDMC is given in Appendix 5 of the CDM ACOP.

A prospective CDMC should be offered the role by the Client in writing and shall give a written acceptance of this. Included in this written acceptance is the confirmation that the CDMC considers that they are competent to fulfil the role for the specific project being undertaken.

In complex developments, the CDMC may also have an important role in interfacing with adjacent construction projects or operational sites.

A.1.4.6 THE DESIGNER(S)

Anyone who takes a design decision relating to a construction project is a Designer under CDM, and should be aware of their responsibilities as such, which are to:

- Eliminate hazards and reduce risks in the design;
    - This will require a suitable risk assessment process to be applied as the design is developed; and
- Provide information about remaining risks;
    - The emphasis should be on risks that are unusual in some way, or not obvious to a competent contractor or another designer;
        - The ACOP specifically cautions against producing lengthy lists of standard risks, which can obscure the most important and relevant risks;
    - If the safety of construction could be affected by the adoption of a particular sequence or method, then this information should also be provided;
        - Providing this information is not the same as instructing a contractor to adopt a particular approach.

This broad definition of a Designer can include many different parties on a project, such as:

- The project developer – who may also be the Client;
- External project development consultants (or companies);
- The Marine Warranty Surveyor, who will provide co-ordination between equipment design, installation techniques and vessel capabilities; and
- Geotechnical, environmental or resource assessment consultants.

The manufacturer of a standard product, such as a WTG that can be used in any project, is not a Designer under CDM, although under the Supply of Machinery (Safety) Regulations they have similar duties to eliminate hazards and reduce risks over the whole lifecycle of the product, and to provide information to users. Exactly who would be held to be a Designer under CDM is not always obvious, and specialist advice should be sought. For example, it is arguable that the person who selects the WTG for a particular project could be held as a Designer under CDM. It is also arguable that where a bespoke product is designed for a project, then both the specifier of the product, and the manufacturer that develops the detailed design, are Designers. Much of course would depend upon the nature of the project, the specific circumstances in consideration and the extent of knowledge of the relevant person involved in the actual design.

The Designer(s) is/are appointed by the Client. Early in the development lifecycle, the Designer may be an individual within a team that is developing the concept for the project, and will also be key to ensuring that the appropriate risk assessments are performed on the design as it evolves. As the project progresses, other Designers may be appointed, often with respect to a particular discipline or work package. Their appointment and design packages should be co-ordinated by a lead designer and/or the CDMC as appropriate; the CDMC has a specific duty to co-ordinate health and safety aspects of design work. The lead designer and CDMC should support the Client in assessing the competence and resources of all additional design contractors prior to appointing them to the project.

In cases where a design is prepared or modified outside Great Britain for use in construction work, then the Designer's duties will apply to:

- The person who commissions the design (if they are established within Great Britain); or
- If that person is not established within Great Britain, the Designer's duties revert to the Client.

Clients should be aware of this when placing contracts for work packages that include design work.

A.1.4.7 THE PRINCIPAL CONTRACTOR (PC) AND CONTRACTORS

The PC plans, manages and monitors the construction phase. Prior to the start of construction work, the PC will prepare the Construction Phase Plan, which will form the basis for the safe management of construction work. The PC also has responsibilities relating to the provision of welfare facilities, undertaking site inductions, assessing the competence of appointees and liaison with Designers. In offshore construction, the PC is likely to have responsibility for the Marine Co-ordination function.

The CDMC should support the Client to assess the competence and suitability of a potential PC, using Appendix 4 of the CDM ACOP as a guide. The PC can either be a suitable external construction organisation, or, if the Client is taking a multi-contractor approach to development, with the result that there will not be a main or managing contractor for the duration of the works, and if the Client has the necessary competence, then it may be appropriate for the Client to take on the duties of the PC. Clients should always take care when taking on the role of PC.

Contractors, who may include the PC, subcontractors, and sometimes also Client personnel, are required to:

- Manage their own work;
- Ensure the competence of their own personnel and any subcontractors that they appoint; and
- Co-operate and co-ordinate with the PC and other contractors in order to support safe management of the work.

There can only be one PC for a project at any given time, however an OREI development may include several projects running in parallel, such as offshore installation, onshore substation and onshore O&M base, each with a separate PC. In situations where preliminary works such as geotechnical investigations are carried out in advance of the main construction package, it may be appropriate for a change of PC to occur between these phases. Any such change should be clearly recorded and communicated to all involved, particularly where it results in a change of safety management arrangements.

A.1.4.8 REFERENCES

EU Council Directive 92/57/EEC– *Temporary and Mobile Construction Sites*.

HSE L144 - *Managing health and safety in construction - Construction (Design and Management) Regulations 2007 Approved Code of Practice*.

Table 1: CDM Roles and Duties.

	All construction projects (Part 2 of the Regulations)	Additional duties for notifiable projects (Part 3 of the Regulations)
Clients (excluding domestic clients)	• Check competence and resources of all appointees • Ensure there are suitable management arrangements for the project welfare facilities • Allow sufficient time and resources for all stages • Provide pre-construction information to designers and contractors	• Appoint CDM co-ordinator* • Appoint principal contractor* • Make sure that the construction phase does not start unless there are suitable welfare facilities and a construction phase plan is in place. • Provide information relating to the health and safety file to the CDM co-ordinator • Retain and provide access to the health and safety file • **(* There must be a CDM co-ordinator and principal contractor until the end of the construction phase)**
CDM co-ordinators		• Advise and assist the client with his/her duties • Notify HSE • co-ordinate health and safety aspects of design work and co-operate with others involved with the project • Facilitate good communication between client, designers and contractors • Liaise with principal contractor regarding ongoing design • Identify, collect and pass on pre-construction information • Prepare/update health and safety file
Designers	• Eliminate hazards and reduce risks during design • Provide information about remaining risks	• Check client is aware of duties and CDM co-ordinator has been appointed • Provide any information needed for the health and safety file
Principal contractors		• Plan, manage and monitor construction phase in liaison with contractor • Prepare, develop and implement a written plan and site rules (Initial plan completed before the construction phase begins) • Give contractors relevant parts of the plan • Make sure suitable welfare facilities are provided from the start and maintained throughout the construction phase • Check competence of all appointees • Ensure all workers have site inductions and any further information and training needed for the work • Consult with the workers • Liaise with CDM co-ordinator regarding ongoing design • Secure the site
Contractors	• Plan, manage and monitor own work and that of workers • Check competence of all their appointees and workers • Train own employees • Provide information to their workers • Comply with the specific requirements in Part 4 of the Regulations • Ensure there are adequate welfare facilities for their workers	• Check client is aware of duties and a CDM co-ordinator has been appointed and HSE notified before starting work • Co-operate with principal contractor in planning and managing work, including reasonable directions and site rules • Provide details to the principal contractor of any contractor whom he engages in connection with carrying out the work • Provide any information needed for the health and safety file • Inform principal contractor of problems with the plan • Inform principal contractor of reportable accidents, diseases and dangerous occurrences
Workers/ everyone	• Check own competence • Co-operate with others and co-ordinate work so as to ensure the health and safety of construction workers and others who may be affected by the work • Report obvious risks	

A.1.5 Reporting of Industrial Diseases and Dangerous Occurrences Regulations 2013 (RIDDOR)

RIDDOR places a duty on employers, the self-employed and those in control of premises, to report certain serious accidents, occupational diseases and dangerous occurrences, that "arise out of or in connection with work", whether they affect employees or others, such as members of the public. The purposes of reporting are to:

- Enable the HSE to respond rapidly and investigate serious incidents;
- Provide intelligence that allows the HSE to target its interventions;
- Provide data to enable trends and progress to be tracked at a national level; the reports generated from this data can assist businesses in targeting their health and safety management efforts.

The categories of incident that must be reported include:

- Deaths;
- Major injuries;
- Injuries that cause a person to be incapacitated for routine work for more than seven consecutive days;
    - Even though the *reporting* requirement applies after seven days, any injuries incapacitating a person from routine work for more than three days must still be *recorded* by the employer.
- Occurrences of specified occupational diseases; and
- Specified dangerous occurrences.

The HSE provide clear guidance on which incidents should be reported, and the regulations specify the time limits for reporting different categories.

A.1.5.1 References

HSE INDG453 - *Reporting accidents and incidents at work - A brief guide to the Reporting of Injuries, Diseases and Dangerous Occurrences Regulations 2013 (RIDDOR)* provides a clear overview of reporting requirements under RIDDOR.

A.1.6 Supply of Machinery (Safety) Regulations and Harmonised Standards

The first EU Machinery Directive was adopted in 1989, and the current Directive (2006) has been adopted into UK law by means of the Supply of Machinery (Safety) Regulations 2008. The Directive aims to improve the safety of machinery, by adopting inherently safe designs that fulfil the Essential Health and Safety Requirements (EHSRs) of the Directive, and thereby enable the free movement of machinery in the course of trade within the EU. In order to achieve this, the Directive is supported by harmonised standards, and processes for conformity assessment and type examination, which together give the assurance that a satisfactory standard of safety has been achieved.

A.1.6.1 General Principles

The EHSRs are to be applied in accordance with General Principles, defined in the directive and regulations, which can be summarised as:

- The responsible person (who will usually be the manufacturer, or their authorised representative) must ensure that a risk assessment is carried out; this should identify the hazards presented by the machinery, and thereby determine which EHSRs apply:
    - The design and construction of the machinery must address the outcomes of the risk assessment;

   - The responsible person must determine the limits of the machinery, considering both its intended use and any reasonably foreseeable misuse;
     - This considers situations such as mistakes being made by operators or technicians, or short cuts being taken in the execution of tasks;
     - Machinery is to be designed and constructed in such a way as to prevent abnormal use, if such use would give rise to a risk;
- The responsible person must apply an iterative process of risk assessment and risk reduction, according to the Principles of Safety Integration specified in the regulations, which define the hierarchy of risk reduction as:
   - *"eliminate or reduce risks as far as possible (inherently safe machinery design and construction);*
   - *take the necessary protective measures in relation to risks that cannot be eliminated;*" and then
   - "*inform users of the residual risks due to any shortcomings of the protective measures adopted, indicate whether any particular training is required and specify any need to provide personal protective equipment."*[9]

Annex 1 of the Directive (incorporated into Schedule 2 of the regulations) details the EHSRs, which are therefore mandatory. The only qualification to this is that if, considering the "state of the art", it is not possible to satisfy the requirements in full, then the machinery must, as far as possible, approach the requirements. The state of the art can be summarised as the most effective technical means that is generally available on the market, at a reasonable cost, considering the type of machinery involved, and the risk reduction that is required.

The state of the art therefore evolves over time, so as improved solutions become available, manufacturers should review older designs that are still in production; users or owners of machinery are not required to upgrade existing machines to the state of the art.

If, however, an owner were to undertake major modifications part way through the life of a machine, then they would be expected to consider if the design could be modified to approach the state of the art; further, if a risk assessment relating to the use of a machine identified hazards, then the owner would have a duty to take steps to reduce risk ALARP.

A.1.6.2 THE ESSENTIAL HEALTH AND SAFETY REQUIREMENTS

The EHSRs, which are applicable to all machinery, address a wide range of issues, and apply to all phases from installation to decommissioning and disposal; some of the most relevant requirements are listed below:

- General requirements:
   - The materials of construction, and products (such as fluids and gases) used, including any filling / exchange operations required, must not endanger persons' health and safety;
   - Lighting must be provided within machinery, in situations where ambient light alone will not be sufficient for the required tasks during operation and maintenance activities;
   - Machinery and components must be designed to facilitate handling, whether by hand or by means of lifting equipment;
   - The design must minimise ergonomic risks to operators / maintainers of machinery; this includes ensuring that there is enough space for movements of the parts of the person's body;
- Control systems:

[9] From: European Commission – Enterprise and Industry - *Guide to application of the Machinery Directive 2006/42/EC*.

    - Control systems must be designed and constructed in such a way as to prevent hazardous situations from arising, taking account of the operating conditions, and including ensuring that a fault in the hardware, software or logic of the control system, or reasonably foreseeable human error, does not lead to a hazardous situation;
    - There must be safe arrangements for stopping and starting machinery, including in situations where the machine can be controlled from more than one location, or where specific sequences must be followed;
    - The design must ensure that safety is maintained at all times, even where different control and operating modes can be selected; this includes features such as maintenance modes, or enabling operation with a protective device in a disabled state, which may affect the normal function of safety systems;
    - The machinery must remain safe in the event of an interruption to the power supply; in the case of OREIs, this would include behaviour relating to interruptions to the grid or electricity export systems;
- The design and construction of the machinery must protect against mechanical hazards including:
    - Loss of stability, such as overturning, falling or uncontrolled movements during transportation, assembly, dismantling and any other action involving the machinery;
    - Break-up of components during operation, including failure of rigid or flexible high pressure pipework, and taking account of failure modes such as fatigue and ageing;
    - Falling objects;
    - Sharp edges, surfaces or angles;
    - Moving parts;
    - Uncontrolled movements;

  Where protection against mechanical hazards is to be by means of guards, the regulations specify detailed requirements.
- The design and construction of the machinery must provide safety from a range of other hazards including:
    - Electricity, including both electrical systems and static electricity;
    - Other sources of energy;
    - Errors of fitting;
    - Extreme temperatures, which could harm people in contact;
    - Fire or overheating;
    - Noise and vibration;
    - Slipping, tripping or falling from locations where people may stand or move around;
    - Lightning;
- The design must consider maintenance requirements, including providing:
    - Safe access to adjustment and maintenance points, and the ability to carry out all necessary adjustments and maintenance while the machinery is stopped or otherwise made safe;
    - Suitable isolations from all energy sources;
- The responsible person must also provide information including:
    - Information or warning pictograms and devices;

- Information devices such as SCADA screens; and
- Operating and maintenance instructions.

Machinery that satisfies all of the relevant EHSRs is in conformity with the Directive, and is therefore permitted to carry the CE mark; it is an offence to place any machinery on the market in the EU without this.

A.1.6.3 HARMONISED STANDARDS

Harmonised (EN) standards provide methods and specifications to assist machinery manufacturers in achieving compliance with the EHSRs. Unlike the EHSRs themselves, the specifications laid down in harmonised standards are voluntary:

- Harmonised standards provide an indication of the state of the art at the time when they were adopted (or revised), and therefore provide a benchmark of the level of safety that was generally being achieved at that point in time;
- If a manufacturer chooses to adopt an alternative solution to those specified in the standards, then they must be able to demonstrate that their solution is in conformity to the EHSRs, taking account of the current state of the art, thereby achieving a level of safety that is at least equivalent to that which would be achieved by adopting the specifications of the relevant harmonised standard.

There are three types of harmonised standard under the Machinery Directive; when an article is stated as being in conformity with a standard, it is important to understand the nature of that standard, as this determines the extent of conformity.

Table 2: Types of harmonised standard under the Machinery Directive.

Type	Content	Application	Effect
A	Basic concepts; Terminology; Design Principles	All categories of machinery	Essential framework for correct application of Machinery Directive; Not sufficient to ensure full conformity with relevant EHSRs.
B	Specific aspects of machinery safety; or Specific types of safeguard	Wide range of categories of machinery	Presumption of conformity with those EHSRs that the standard covers, if a C-type standard or the manufacturer's risk assessment shows that the technical solution specified by the B-type standard is adequate.
C	Specifications	Specific category of machinery	Presumption of conformity with the EHSRs that the standard covers, when applied on the basis of the manufacturer's risk assessment; May refer to A or B-type standards, but the requirements of the C-type standard take precedence.

A.1.6.4 REFERENCES

HSE INDG 270 - *Supplying New Machinery*.

HSE INDG271 - *Buying new machinery*.

European Commission – Enterprise and Industry - *Guide to application of the Machinery Directive 2006/42/EC*.

The Supply of Machinery (Safety) Regulations 2008.

The European Commission Enterprise and Industry website contains a *complete list of harmonised standards*, by category.

EN ISO 12100:2010: *Safety of machinery: General principles for design. - Risk assessment and risk reduction.*

A.1.7 PROVISION AND USE OF WORK EQUIPMENT REGULATIONS 1998 (PUWER)

The aim of PUWER is to minimise the health and safety risk that work equipment of any kind, provided under any contractual arrangement, presents to users. There are two main ways in which the regulations seek to achieve this aim:

- Management arrangements, relating to the selection of work equipment, its ongoing inspection and maintenance, control of specific hazards, and provision of suitable information, instruction and training to users;
- Physical requirements, relating to the design of work equipment, such as suitable guarding of dangerous parts, appropriate control and stopping systems, stability, lighting and warnings to users.

PUWER applies to all work equipment, ranging from simple hand tools such as a spanner, powered tools such as grinders, portable generators and permanently-installed hoists. PUWER sets the framework for the provision and use of work equipment; other more specific regulations apply to particular categories or components within work equipment, such as:

- Lifting equipment, where the more specific requirements of the Lifting Operations and Lifting Equipment Regulations (LOLER) also apply;
- Machines, the supply of which is subject to the Supply of Machinery (Safety) Regulations, which will help to fulfil many of the physical requirements of PUWER;
    - Note that PUWER applies to all work equipment, at the point of provision and use, irrespective of when it was placed on the market, or its ownership.

As the MHSWR require the risks involved in any work activity to be assessed, this risk assessment should take account of the risks presented by work equipment; the requirements of PUWER should inform this risk assessment, particularly with respect to the management and physical measures to reduce risk to users of work equipment, but a separate risk assessment is not required to fulfil duties under PUWER.

During activities involved in OREI construction and O&M, it is likely that employees of one employer will make use of work equipment owned by another organisation; in this situation, each employer retains the duty to ensure that any work equipment that their employees use conforms to, and is used in accordance with, the requirements of PUWER. Where work is undertaken under CDM, the construction phase plan should address the arrangements for sharing equipment, so that there are clear responsibilities for co-ordination of equipment and reporting requirements, and that users understand relevant safe methods and limitations of use.

A.1.7.1 REFERENCES

HSE L22 - *Safe use of work equipment - Provision and use of Work Equipment Regulations 1998 Approved Code of Practice and guidance*.

A.1.8 PERSONAL PROTECTIVE EQUIPMENT REGULATIONS 2002

The PPE regulations impose a range of duties on employers:

- Suitable PPE must be provided, without charge, to employees. The suitability of PPE should be assessed in relation to the task(s) for which it will be used, the conditions in the working environment, and the characteristics of the user;
    - While the employer is the duty-holder, a meaningful assessment of the suitability of PPE will generally need the involvement of the end user, possibly also involving field trials to assess the practical performance of items before widespread adoption;
    - Many tasks will require the use of more than one item of PPE, in which case the employer must ensure that the different items are compatible. For example, the harnesses, lifejackets and immersion suits used for transfer must all be compatible with each other;

- PPE must be maintained and replaced as necessary, to ensure that it functions efficiently. Suitable storage facilities are also required, and will assist in keeping the PPE in good condition; and
- Information, instruction and training must be provided to users; the extent of this should reflect the complexity of the equipment involved, and will be particularly rigorous for items such as specialised PPE for work at height.

Other duties apply both to employers and employees:

- The employer has duty to ensure that the PPE is properly used, usually by means of training, supervision and auditing of use, while employees have a duty to use PPE in accordance with the instructions and training that they have received;
    - Use of procedures such as "buddy checks" of each other's PPE prior to commencement of a task can help to fulfil this duty;
- The employer must make arrangements to enable employees to report any defects in PPE, and for it to be repaired or replaced as required, while employees have a duty to take reasonable care of PPE provided, and to report any loss or obvious defects.

A.1.8.1 CE Marking

PPE should always carry a CE mark, with the declaration of conformity confirming that the CE mark relates to the requirements of the PPE Directive and relevant harmonised standards. However, certain items of safety-related equipment, such as rescue lifting devices to EN 1496:2006, are not classified as PPE, and are outside the scope of other product supply directives. In these cases, there is no harmonised standard, and no directive under which a CE mark could be obtained, so while such items may conform to the relevant product standard, and be safe to use, they cannot carry the CE mark.

A.1.8.2 Avoidance of Counterfeit PPE

People can be put at risk by counterfeit PPE, some of which carries the CE mark, despite not conforming to the relevant standards, and which may also be accompanied by fraudulent declarations of conformity. While some counterfeit products are easily spotted, others appear almost identical to the genuine articles, but do not provide the same level of protection; the British Safety Industry Federation has introduced the Registered Safety Supplier Scheme to provide audited assurance that suppliers in this scheme are sourcing genuine PPE.

A.1.8.3 References

HSE L25 - *Personal protective equipment at work (second edition) - Personal Protective Equipment at Work Regulations 1992 (as amended) - Guidance on Regulations*.

British Safety Industry Federation – *PPE Checklist* provides guidance on checks that may help to spot counterfeit PPE. The BSIF also provides a useful list of *Safety Product Standards*.

A list of harmonised EN standards for PPE is available on the European Commission website.

A.1.9 Maritime Regulation

A.1.9.1 UK Merchant Shipping Regulation

The Merchant Shipping Act 1995 and the Merchant Shipping and Maritime Security Act 1997 form the basis for maritime regulation for the whole of the United Kingdom of Great Britain and Northern Ireland, establishing the Maritime and Coastguard Agency (MCA), and with specific regulations being made under those acts and / or the European Communities Act.

The MCA is responsible for implementing the UK Government's maritime safety policy and exists to:

- Promote high standards of safety at sea;
- Minimise loss of life amongst seafarers and coastal users;
- Respond to maritime emergencies 24/7; and
- Protect the environment by minimising pollution from ships.

Through the Acts and / or other powers delegated by the Secretary of State for Transport, the Agency is responsible for, but not limited to:

- Inspection and survey of ships for compliance with UK and international rules;
- Monitoring the performance of organisations delegated to carry out statutory functions (e.g. Surveys) on the behalf of the UK and MCA (e.g. Certifying authorities, Recognised Organisations – classification societies) – a function shared with EU institutions ;
- Approval of training and certification of seafarers;
- Vessel and seafarer registration;
- Receipt of distress, alerts and information sent by ships and other States in compliance with statutory and international requirements; and
- Provision of 24h maritime search and rescue services (SAR).

For the UK, the MCA fulfils EU Directive and other requirements as a member of the Paris Memorandum on Port State Control.

The Acts also establish the Marine Accident Investigation Branch (see Section A.1.10.3), thereby providing a body that is dedicated to accident investigation, and separate from the regulator.

The content, application and enforcement of maritime regulations are based on:

- Obligations under international maritime Conventions, protocols, other treaties and customary international law of the sea:
- Domestic requirements (e.g. codes of practice - Brown Code) including ships on domestic voyages, usually reflecting Convention requirements and principles, where they are below the size, or by other reasons excluded from Convention application; and
- A range of EU requirements affecting ships, including also health and safety directives with duties similar to regulations made under the HSWA.

Other UK port and navigational authorities exist, with specific technical and geographical areas of responsibility, and statutory powers for monitoring, management and control of relevant activities.

A.1.9.2 INTERNATIONAL CONVENTIONS AND RELATED TECHNICAL INSTRUMENTS

The International Maritime Organisation (IMO) is a UN agency, part of whose purpose is to develop and maintain the international regulatory framework for shipping and seafarers; one of the ways in which this is achieved is through Conventions, which include technical requirements and other details. Key Conventions include:

- The International Convention for the Safety of Life at Sea 1974 (SOLAS), which defines requirements for the safety of shipping and maritime security, including for example:
    - Technical provisions for the construction, stability, equipment and operation of ships, including requirements for life-saving, navigation and communication equipment;
    - Responsibilities for governments to certify that ships under their flag comply with the requirements of the Convention;
    - Powers for governments to inspect ships in their territorial waters, and detain those that are substantially non-compliant (known as or Port State Control);
    - Mandatory codes such as the International Safety Management (ISM) Code, International Maritime Dangerous Goods Code and High Speed Craft (HSC) Code(s);
- The International Load Line Convention 1966, establishing uniform principles and rules on the limits to which ships may be loaded;
- The Convention on the International Regulations for Preventing Collisions at Sea (COLREGS), defines actions to be taken to avoid collision; as well as the lights, shapes and signals to be displayed or sounded under various conditions;

- International Convention on Standards of Training, Certification and Watchkeeping for Seafarers, Manila 2010 (STCW) sets international minimum standards for each of those areas, with respect to various aspects of responsibility in vessel operation; and
- The International Convention for the Prevention of Pollution from Ships 1973 (MARPOL) regulates matters such as the transport of oil as fuel or as cargo, transport of chemicals and the disposal of garbage and sewage.

Several safety standards have been developed and published under the IMO to facilitate specialised ship operations and designs in the offshore sector, which are considered by interpretation or equivalency as satisfying Convention requirements, for example the Special Purpose Ships Code 2008, the Code for the Construction and Equipment of Mobile Offshore Drilling Units (MODU Code) 2008 and Guidelines for the Design and Construction of Offshore Supply vessels 2006. Implementation is left to the discretion of individual flag states.

In addition to IMO Conventions, the International Labour Organisation (ILO) has introduced the Maritime Labour Convention 2006 (MLC), bringing together a range of mostly existing provisions relating to the employment, welfare and living conditions of seafarers.

As a contracting State to the Conventions, the UK transposes their requirements into domestic regulations. The precise requirements that are applicable generally depend on a vessel's construction, who and what she carries, how and where she operates; these can be indicated by the class 'notation'.

A.1.9.3 MARITIME REGULATORY PUBLICATIONS

In order to assist compliance with the law, the MCA publishes:

- Merchant Shipping Notices (MSNs), often containing the fine technical detail of UK law, and legally enforceable when referred to by regulations;
- Marine Guidance Notes (MGNs), giving guidance and recommendations about best practice on interpretation of law and general safety advice, although any advice that they give on the law is not definitive;
- Marine Information Notes (MINs) are intended for a limited audience, for example training establishments or equipment manufacturers; or contain information which will only be of use for a short period of time, such as timetables for MCA examinations, and have a cancellation date of no more than twelve months after publication; and
- Codes of practice, key examples in use offshore, providing technical standards that are statutory for vessels of less than 24 metres load line length.

As well as charts and other publications required for safe navigation, Admiralty Notices to Mariners (ANtoM) are issued by the UK Hydrographic Office (UKHO), providing mainly navigational information such as chart updates, changes to Aids to Navigation, and the location of permanent or temporary hazards and offshore operations that affect safety. ANtoMs are issued weekly; with more urgent information transmitted using Radio Navigation Warnings which are broadcast every 12h, and Navigational Telex (NAVTEX) which is transmitted every 4h. Notices to Mariners (NtoM) serve a similar purpose, and are issued by a variety of bodies such as Port authorities, General Lighthouse Authorities and OREI project duty holders.

Publications of particular relevance to OREIs are:

- MGN 371: Offshore Renewable Energy Installations (OREIs) - Guidance on UK Navigational Practice, Safety and Emergency Response Issues, including:
    - Considerations on site position, structures and safety zones;
    - Navigation, collision avoidance and communications;
    - MCA shipping template, used in assessing wind farm boundary distances from shipping routes;
    - Safety and mitigation measures recommended for OREI during construction, operation and decommissioning; and

- Standards and procedures for generator shutdown and other operational requirements in the event of a search and rescue, counter pollution or salvage incident in or around an OREI;

- MGN 372: Offshore Renewable Energy Installations (OREIs): Guidance to Mariners Operating in the Vicinity of UK OREIs, provides information and advice relating to:
  - Visibility of structures, aids to navigation and charting;
  - Effect on routeing, systems for communication and navigation; and
  - Exclusion or safety zones.

A.1.9.4 REFERENCES

MGN20 - Merchant Shipping and Fishing Vessels (Health and Safety at Work) Regulations1997 defines the requirements for management of health and safety on vessels.

MSN1781 - The Merchant Shipping (Distress Signals and Prevention of Collisions) Regulations 1996 known as the COLREGS.

MGN371 - Offshore Renewable Energy Installations (OREIs) - Guidance on UK Navigational Practice, Safety and Emergency Response Issues.

MGN372 - Offshore Renewable Energy Installations (OREIs): Guidance to Mariners Operating in the Vicinity of UK OREIs.

MSN1769 - International Labour Organization Convention (ILO) 178 and Recommendation 185 – Concerning the Inspection of Seafarers' Working and Living Conditions describes the scope and applicable standards in to be applied in the periodic inspection of vessels exceeding 500 Gross Tonnage.

MSN1731 – the Merchant Shipping and Fishing Vessels Personal Protective Equipment Regulations 1999.

MGN390 - Construction Standards for Offshore Support Vessels and Other Special Ship Types – Under revision in late 2013.

MGN471 - Maritime Labour Convention, 2006: Definitions.

MGN490 - Maritime Labour Convention: Application to small vessels of less than 200GT that are ordinarily engaged in commercial activities.

MGN491 - Maritime Labour Convention: Application to workboats of 200GT to less than 500GT

A.1.10 REGULATORS, INVESTIGATION AND ENFORCING AUTHORITIES

The law relating to Health and Safety in the UK, essentially consists of statutory duties set out in legislation, either Acts of Parliament or subordinate regulations, and duties created by judicial precedent over many years (often referred to as common law). There is both State enforcement of the duties, through the criminal courts and other enforcement methods available to State regulators, and private enforcement by way of private civil actions. Both systems exist side by side, and the common law and legislative duties often overlap.

The different regulatory and enforcing authorities, their responsibilities and jurisdictions are listed in Table 3 below.

Table 3: Summary of Regulatory and Investigative Authorities

Activity	Lead Regulator / Investigator
Regulation of work under the HSWA and subsidiary regulations	HSE (Great Britain, its Territorial Sea and UK Renewable Energy Zone (REZ)) HSENI (Northern Ireland)
Investigation of accidents during activities regulated under the HSWA	HSE (Great Britain, its Territorial Sea and UK REZ) HSENI (Northern Ireland)
Prosecution of offences under the HSWA	HSE (England and Wales, their Territorial Seas and their part of the UK REZ) Procurator Fiscal (Scotland, its Territorial Sea and its part of the UK REZ) HSENI (Northern Ireland)
Merchant shipping regulation	MCA
Merchant shipping accident investigation	Marine Accident Investigation Branch (Part of the Department for Transport)
Investigation of fatality or life-threatening injury	Police have jurisdiction, in addition to the above regulators
Aviation regulation	Civil Aviation Authority
Aviation accident investigation	Air Accidents Investigation Branch (Part of the Department for Transport)
Aids to Navigation	General Lighthouse Authorities (GLAs): • Trinity House, responsible for English, Welsh and Channel Islands waters; • The Northern Lighthouse Board, responsible for Scottish and Manx waters; and • The Commissioners of Irish Lights, responsible for waters around Ireland (both the Republic of Ireland and Northern Ireland)

The sea areas listed in this table are shown on the UK Hydrographic Office chart of the Territorial Seas and the REZ.

A.1.10.1 HSE

The HSE's functions include the development of regulations and standards, carrying out research, providing information and advice, and enforcing health and safety law. The jurisdiction of the HSE covers Great Britain, and offshore activities specified in the AOGBO, taking place within the Territorial Sea and the UK Renewable Energy Zone. The Health and Safety Executive for Northern Ireland (HSENI) covers Northern Ireland.

The HSE's Field Operations Directorate:

- Provides advice and guidance on how to comply with the law;
- Inspects workplaces, installations and facilities;
- Investigates accidents and complaints; and
- Takes enforcement action where necessary.

HSE inspections can be carried out without prior notice, to audit compliance of operations at sites, or to examine corporate systems at company offices; for offshore inspections, transport shall be provided if requested by inspectors. In the event of deficiencies being found, the HSE's response aims to be proportionate to the severity of the problems, and ranges from:

- Verbal or written guidance on necessary improvements;
- A written Notification of Contravention;
- Issue of an Improvement Notice, specifying the required improvements to be completed within a certain timescale;
- A Prohibition Notice suspending work at an unsatisfactory site; to
- Prosecution of the most serious cases, where:
  - A specific requirement in a regulation made under the HSWA has not been complied with; and / or
  - A general duty defined in the HSWA has not been satisfied; and
  - It is judged that, given the nature of the offence, prosecution would be in the public interest, and there is sufficient evidence to give a realistic prospect of conviction.

If a Notification of Contravention, or an Improvement or Prohibition notice is issued, this indicates that the HSE takes the view that a material breach of health and safety law has occurred. In such cases, under the Fee for Intervention system, the HSE will recover, from the duty-holder, the costs that were incurred in addressing the material breach. These costs cover the time spent by the HSE in identifying the material breach, assisting the duty-holder with resolving the issue, and any other investigation and enforcement action relating to the breach.

In the event of a criminal prosecution under the HSWA and or subordinate regulations, most offences can be tried and or sentenced in either the lower courts (e.g. Magistrates' Court) or the higher courts (e.g. Crown Court). The more serious and or complex cases are tried and or sentenced by the higher courts, where there are greater, tougher sentencing powers available. The penalties available in the event of a corporate entity or individual being convicted; depending upon the severity of the offence(s), can include imprisonment for up to 2 years, disqualification from acting as a director for up to 15 years, and unlimited fines. If the breaches of duty result in a death, then the Corporate Manslaughter and Corporate Homicide Act 2007, and common law offence of gross negligence manslaughter may apply.

A.1.10.1.1 References

HSE - HSE41 - *Enforcement Policy Statement*.

HSE – *Enforcement Management Model*.

HSE HSE48 – Fee for intervention

A.1.10.2 ***MARITIME AND COASTGUARD AGENCY (MCA)***

The MCA inspects vessels in order to ensure compliance with international conventions and UK legislation; inspections cover both the physical state of a vessel and its management arrangements, thereby auditing operations undertaken at sea. Survey and certification records will be checked to ensure that they are valid, and that other ways a vessel's condition, personnel and equipment substantially correspond with what is required (they are not surveys). In the event deficiencies being identified, corrective actions can be specified and recorded. In severe cases where health, safety or the environment is being put at risk, vessels may be detained in port. Action may also be taken against offenders through the courts, which is more common where operational incidents have occurred.

Depending upon their size, type and area of operation, ships are required to carry valid statutory certificates issued by or on behalf of their flag State to demonstrate compliance with relevant regulations (which may be international regulations, such as in IMO Conventions) if they are to trade freely. Port States where ships call have a right to inspection to ensure they meet appropriate standards.

The frequency and scope of periodic Port State Control inspections are based on international risk criteria, considering both the physical characteristics of the vessel and the past history of previous inspections and others managed by the same company. Periodic inspections are co-ordinated with other port States in order to avoid unnecessary repeated inspection of the same vessel, or other vessels being missed; additional inspections may be carried out where there is cause for concern about safety.

In addition to inspections, the MCA will consider any reports of significant breaches of maritime legislation; and will investigate and take action as appropriate.

While there are no restrictions applied to commercial operation of vessels in the UK on the basis of flag, non-UK vessels may be required to demonstrate compliance with UK and international requirements, or of their equivalency on the basis of *no more favourable treatment*.

With respect to OREIs, the MCA is a statutory consultee in the consenting process; if a developer has not followed MCA guidance, then this may lead to delays or objections to consent.

The quality and outcomes of Navigational Safety Risk Assessments are subject to MCA approval, while Emergency Response Co-operation Plans (ERCoPs) are required to be agreed between the developer and the MCA.

A.1.10.3 MARINE ACCIDENT INVESTIGATION BRANCH (MAIB)

The MAIB investigates marine accidents, and publishes the outcome of its investigations in order to assist in the prevention of future accidents. The MAIB does not apportion blame or liability, is not a regulator or prosecuting authority, and has no enforcement powers.

It is responsible for the investigation of accidents involving:

- Any vessel in UK territorial waters; and
- UK registered vessels, anywhere in the world.

The decision as to whether or not to conduct an investigation, and the extent of any such investigation, depends on:

- The seriousness of the accident;
- The type of vessel and / or cargo involved; and
- The potential for the findings of a safety investigation to lead to the prevention of future accidents.

In certain cases, the Secretary of State for Transport may determine that the MAIB should investigate an accident involving a non-UK registered vessel, outside UK waters.

The MAIB's authority to conduct investigations comes from the Merchant Shipping Act 1995, and the investigations are carried out in accordance with the Merchant Shipping (Accident Reporting and Investigation) Regulations 2012, which reflect the requirements of EU Directive 2009/18/EC, establishing the fundamental principles governing the investigation of accidents in the maritime transport sector, and thereby ensuring common standards for marine accident investigation throughout the European Economic Area.

A.1.10.4 INTERFACES BETWEEN REGULATORS

The HSE, MCA and MAIB signed a memorandum of understanding in 2005 to enable efficient and effective regulation of offshore health and safety, with the specific objectives to:

- Allow the regulators to co-ordinate their work of regulatory enforcement and incident investigation in areas where their duties could overlap, thereby avoiding duplication of effort or gaps in regulation;
- Avoid conflicting duties being placed on persons operating at the interfaces between the regulatory regimes; and
- Maintain consistent standards of protection for all personnel involved in, or affected by, offshore work, irrespective of their normal working location and employment arrangements.

The responsibilities of the different bodies can be summarised as:

- The MCA enforces merchant shipping regulations, which cover all aspects of vessel safety;
- The HSE enforces the HSWA and subsidiary regulations, and has enforcement responsibility for construction work, including when this is carried out on or from a ship; and
- The MAIB investigates accidents involving ships and their crews, while the HSE investigates land-based and offshore accidents.

The memorandum also defines arrangements for one of the regulators to lead, with support from others, in cases where there is overlapping legislation, and makes it clear that if there is any remaining uncertainty over the allocation of responsibilities, the different regulators will co-operate as required on a case by case basis. As the MoU was signed in 2005, it pre-dates the 2009 AOGBO which extended the HSE's regulatory powers to cover OREI activities in the Renewable Energy Zone, but similar co-operation is to be expected.

In the case of enforcement action that may result in prosecution, the HSE and MCA are both parties to the Prosecutors' Convention 2009, which sets out the arrangements in cases where more than one prosecuting body or investigating authority has the power to take some action.

A.1.10.4.1 Reference

Memorandum of Understanding between the Health and Safety Executive, the Maritime and Coastguard Agency and the Marine Accident Investigation Branch for health and safety enforcement activities etc. at the water margin and offshore.

A.1.10.5 Police Jurisdiction

The police have criminal jurisdiction, under the Criminal Jurisdiction (Application to Offshore Renewable Energy Installations etc.) Order 2009, for OREIs within the UK territorial sea and the Renewable Energy Zone. While recognising the primacy of HM Coastguard in relation to any search and rescue operation, it is likely that the Police would become involved at some point in the response to an incident involving a fatality or a person sustaining life-threatening injuries.

A.1.10.6 Other Bodies with Regulatory Powers

A.1.10.6.1 General Lighthouse Authorities (GLAs)

Under the Merchant Shipping Act 1995, the responsibility for superintendence of all Aids to Navigation (AtoN) in UK waters lies with the General Lighthouse Authority for the relevant area of sea, irrespective of who owns or maintains the AtoN. The geographical areas of responsibility for each of the UK GLAs is shown in Table 3 on page 29. An AtoN may only be established, altered or removed with the consent of the GLA, which will also audit its performance.

The technical body for AtoN is the International Association of Marine Aids to Navigation and Lighthouse Authorities (IALA-AISM), which aims to harmonise AtoN worldwide; IALA-AISM is not a regulator.

A.1.10.6.2 The Civil Aviation Authority (CAA)

The CAA is the aviation regulator for the UK. In relation to OREIs, the CAA defines the requirements for obstruction marking, and for any aviation operations associated with the development, including aerial surveys and helicopter access.

A.1.11 Interface with Grid, OFTOs etc.

National Grid Electricity Transmission (NGET) is the System Operator for all high voltage electricity systems in Great Britain, including offshore networks operating at 132kV or above.

Under the current regulatory regime, all offshore transmission assets, which will include cables and substations, will be owned and maintained by Offshore Transmission Owners (OFTOs), selected through a tendering process managed by the regulator, Ofgem. Note that Ofgem regulates the gas and electricity markets, and is not a health and safety regulator.

This ownership model ensures that separate entities own and operate generation, transmission and distribution assets, but creates operational interfaces that require careful management to ensure safety. The interfaces first arise during the development phase, where the OREI operator has to provide information to the OFTO, to allow them to prepare for construction or transfer, depending on the development approach being taken.

Initial EIA and consent planning is undertaken by the OREI developer; thereafter design, consenting and construction of these assets will either be undertaken:

- By the OFTO; or
- By the OREI developer, and then transferred to the OFTO once constructed.

The offshore transmission infrastructure may be built as an individual connection to a single OREI, or shared between a number of developments, and may also have to accommodate a phased approach to OREI development.

The interfaces during the operational phase are summarised in Table 4 below. The offshore transmission system may either connect to the onshore distribution or transmission networks; this will determine which party is involved with the onshore network.

Table 4: Offshore Transmission Interfaces

	Onshore Network	Offshore Transmission	Offshore Generation
Owner / maintainer	Transmission: NGET (England & Wales); SPT or SHETL (Scotland) Distribution: DNO	OFTO	OREI owner
System Operator	NGET or DNO	NGET	OREI owner

The responsibilities of the different parties are set out in the:

- Connection and Use of System Code (CUSC), which sets out the contractual framework for grid connection;
- Grid Code, which specifies day-to-day procedures for both planning and operational purposes and covers both normal and exceptional circumstances;
- System Operator – Transmission Owner Code (STC), which defines:
    - Arrangements for agreeing capacity and performance requirements of a transmission asset, and for managing outages;
    - Procedures and responsibilities for managing operational switching in a variety of situations, including in emergencies, and switching which is required in order to implement safety precautions;
    - Arrangements for communication with others who may be affected by switching operation, including the “Affected Users”, i.e. the OREI; and
    - Procedures for co-ordination between different parties, where work is to be carried out on equipment, and which requires another party to implement safety precautions in order to allow safe completion of the work.

The Codes and procedures are available from the National Grid website.

OFTOs and OREI owners will develop site-specific procedures, based on these standard processes, together with suitable bridging documents for their safety management systems. In many cases, OFTOs will subcontract the O&M of their assets, so at a practical level, the interface is between the OREI maintenance team and the OFTO’s subcontractor (although in some cases the OFTO may subcontract the work to the OREI owner).

A.2 LEADERSHIP & SAFETY CULTURE

A.2.1 LEADERSHIP

High standards of health and safety performance depend on the commitment and leadership of senior management. Health and safety must be regarded as a key risk-management issue, to be driven from the highest levels of an organisation; failure to do so can put employees and members of the public at risk and expose the organisation, its directors, senior managers and employees to serious legal, contractual and financial consequences. In OREI development, a failure to manage health and safety effectively can also lead to serious commercial impacts, as it may jeopardise the ability to construct a project to time and budget.

Board members have both collective and individual responsibility for health and safety. Directors and boards need to examine their own behaviour, particularly in relation to the priorities that they set, and the standards that they accept. If they see that their actions fall short of the standards required, then they should take action to change what they do, in order to become more effective leaders in health and safety.

Why directors and board members need to act:

- Protecting the health, safety and welfare of employees, and members of the public who may be affected by their activities, is an essential part of risk management and must be led by the board;
- Failure to recognise health and safety as a key business risk in board decisions can have serious results. Investigations into serious accidents and incidents have often identified failure of leadership as being amongst the root causes; and
- Health and safety law places duties on organisations and employers, and directors can be personally liable when these duties are breached.

The leadership of an organisation is responsible in law for that organisation's health and safety performance; beyond this strict legal responsibility, leaders have a moral responsibility, as well as the opportunity to ensure that effective management of health and safety contributes to the reduction of risk to the business as a whole.

The Corporate Manslaughter and Corporate Homicide Act 2007 enables corporate bodies to be prosecuted in cases where serious failures in the management of health and safety result in a fatality. The provisions of this act do not change the liability of directors, board members or other individuals under health and safety or general criminal law, so such persons can still be prosecuted for separate health and safety offences.

The HSE has, together with the Institute of Directors, identified essential principles of health and safety leadership as:

- "*Strong and active leadership from the top:*
    - *visible, active commitment from the board;*
    - *establishing effective 'downward communication systems and management structures;*
    - *integration of good health and safety management with business decisions.*
- *Worker involvement:*
    - *engaging the workforce in the promotion and achievement of safe and healthy conditions;*
    - *effective 'upward' communication;*
    - *providing high quality training.*
- *Assessment and review:*
    - *identifying and managing health and safety risks;*

- *accessing (and following) competent advice;*
- *monitoring, reporting and reviewing performance.*"[10]

The leadership define the structures and behaviours that will determine the safety culture of an organisation, and ultimately determine the safety of all those affected by the organisation's activities.

A.2.1.1 Reference

HSE INDG417 – *Leading Health and Safety at Work* – joint publication with Institute of Directors, which puts forward the principles listed above, and provides guidance for leaders on how to fulfil their responsibilities for health and safety, both in terms of a standard to meet, and practical steps to take.

A.2.2 Safety Culture

Safety culture is defined in HSE guidance as:

> "*the product of individual and group values, attitudes, perceptions, competencies, and patterns of behaviour that determine the commitment to, and the style and proficiency of, an organisation's health and safety management.*
>
> *Organisations with a positive safety culture are characterised by communications founded on mutual trust, by shared perceptions of the importance of safety and by confidence in the efficacy of preventive measures*."[11]

In a weak safety culture, typical behaviours include:

- Routinely ignoring safety procedures, which may also be out of date or incorrect;
- Management decisions prioritising schedule over safety; and
- Failing to report or investigate incidents adequately, for a variety of reasons including a blame culture, covering up issues, or a lack of belief that any meaningful improvements will follow from reporting.

A strong safety culture is characterised by:

- Real and visible management commitment to safety, prioritising safe working above other goals, and ensuring that effective safety management systems are in operation;
- Genuine consultation, encouraging workforce participation in setting targets and developing solutions to problems, and ensuring that the organisation is open to continuous learning and improvement;
- High level of trust between workforce and management, where all employees and contractors (not just supervisors and health and safety specialists) are genuinely empowered to raise concerns about safety issues;
- Effective two-way communications, providing clear and relevant information at the appropriate time, and listening and receiving feedback so that responsibilities and critical tasks are clearly understood; and
- People being competent for the roles that they are fulfilling in all parts of the organisation, with effective processes to develop competence.

It must be noted that safety culture involves every level of the organisation: it is not just about increased workforce compliance, or hoping that a good workforce safety culture will compensate for weak systems or unrealistic targets:

- To be safe an organisation has to learn, particularly from errors and near misses, which need to be reported and investigated, with effective preventative actions being followed through.

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[10] HSE INDG417 – *Leading Health and Safety at Work*.

[11] HSE Human Factors Common Topic 4: *Safety Culture*.

- To report, staff need to know that they will not be blamed and punished for genuine human errors or "honest mistakes" and that their reports will be used for organisational learning and safety improvement.

However, everyone should remain accountable for their actions, and the line between acceptable behaviour, where honest mistakes are tolerated, and unacceptable behaviour (such as serious deliberate violations) needs to be defined clearly, and understood by all, in order to establish a "just" safety culture.

Establishing a culture can be more difficult in a situation with a transient workforce, as will often be the case in OREI development, however the increasing scale of developments is increasing the opportunity for this, which can be further supported through appropriate contractor selection, clear and consistent definition of expectations, and implementation of suitable management arrangements. In the O&M phase, the core workforce is likely to be more stable; the safety culture that is established will affect the long term safety and wellbeing of the workforce who are involved in the longest phase of the life of the OREI.

A.2.2.1 References

HSE Human Factors Common Topic 4: *Safety Culture* provides practical guidance on how to assess safety culture; it is aimed at HSE inspectors, but is also useful for any situation where the safety culture of an organisation needs to be assessed and improved.

HSE OTO00049 - *Safety Culture Maturity Model* provides the basis for a deeper assessment of safety culture, outlining a five stage model from "emerging" to "continuous improvement".

HSE RR942 - *Safety Culture on the Olympic Park* describes the practical steps that were taken to create a safety culture that delivered an outstanding safety performance on a complex multi-contractor project.

HSE *Leadership and worker involvement toolkit* provides practical diagnostic and improvement tools to help contractors and managers to make health and safety improvements in their businesses.

A.3 WORKFORCE ENGAGEMENT

Employers have a legal duty to consult with employees in matters relating to their health and safety; in addition to this, successful health and safety management needs the shared commitment of all personnel involved.

A.3.1 LEGAL DUTIES

There are two sets of regulations that impose specific duties in relation to employee consultation, depending on whether or not employees are represented by safety representatives appointed by recognised trade unions:

- The Safety Representatives and Safety Committees Regulations (1977), made under the HSWA, apply in relation to workers who are represented by a trade union safety representative; and
- The Health and Safety (Consultation with Employees) Regulations 1996, which implement requirements of the EU Framework directive on safety and health at work, apply to other workers.

Both sets of regulations impose duties on employers to consult with the workforce in relation to changes that may affect their health and safety, including matters such as provision of information, competent people for safety-related roles, and allowing employees who are serving as safety representatives to have sufficient time during their contracted working time, and use of facilities, in order to undertake their duties or necessary training. If the workforce in a workplace is a mixture of union and non-union staff, then both sets of regulations will apply; formation of a joint committee for health and safety can ensure that both groups of employees are consulted in a consistent manner.

Trade union safety representatives have a wider range of rights under the regulations than other workforce representatives; these include:

- The investigation of potential hazards, dangerous occurrences, and concerns raised by other employees;
- Carrying out workplace inspections; and
- Representing the relevant group of employees in consultations with the HSE or other enforcing authorities.

These functions can both support and audit the employer’s safety management system.

The regulations also provide for the establishment of a Health and Safety Committee, which is required if requested by a trade union safety representative, and recommended in HSE guidance in other cases.

A.3.2 GOOD PRACTICES

While the regulations impose legal duties on consultation with employees, which must be complied with, businesses may benefit from doing more than the legal minima, and creating a genuine partnership with the workforce to manage health and safety risks. This involves creating a culture in which safety concerns and suggestions are shared freely and addressed effectively, and where the whole workforce participates in improving the health and safety standards in their workplace.

While this guidance refers to employers and employees, a similar approach could be adopted amongst clients and contractors; in the construction phase this will help to fulfil the general duty under CDM to co-operate and co-ordinate in matters relating to health and safety.

Effective employee involvement in health and safety can lead to a range of benefits, including:

- Lower accident rates, which are supported by better control of common workplace risks;
- Creation of a positive health and safety climate, where employees are encouraged to raise concerns; and

- Ensuring that decisions related to health and safety are informed by the workforce's practical experience and understanding of issues, allowing the development of joint solutions to problems, and encouraging workforce acceptance.

Effective employee involvement is most likely to be achieved in an environment where:

- Senior managers show personal and long-term commitment to health and safety;
- The views of employees are valued, as shown by the response when health and safety concerns or suggestions which are raised;
- People throughout the organisation are clear on their safety-related roles and responsibilities; and
- There is a good level of trust between management and employees, which is reinforced by actions being consistent with policy statements.

These characteristics are part of the safety culture of an organisation.

Workforce consultation should be based on a clear understanding of:

- The methods of consultation that will be most appropriate in a given setting, taking account of the nature of the business, workplace and workforce;
- The topics for consultation; some of these are determined by regulations, but it will be beneficial to consult on others such as incident and accident reports, and occupational health issues; and
- When to consult, both in terms of establishing regular consultation processes, and recognising specific issues that may require additional attention.

A.3.3 Codes of Practice and Guidance

HSE L146: *Consulting workers on health and safety - Safety Representatives and Safety Committees Regulations 1977 (as amended) and Health and Safety (Consultation with Employees) Regulations 1996 (as amended) Approved Codes of Practice and guidance*.

HSE HSG263: *Involving your workforce in health and safety - Good practice for all workplaces* provides extensive practical guidance on good practices for workforce involvement, together with case studies describing initiatives taken in a range of workplaces.

HSE *Leadership and worker involvement toolkit* provides practical diagnostic and improvement tools to help contractors and managers to make health and safety improvements in their businesses.

A.4 ERGONOMICS, HUMAN FACTORS AND BEHAVIOURAL SAFETY

Direct ergonomic risks to people in the course of their work are discussed in Section C.6; this section focuses on the contribution of ergonomic and human factors to initiating and escalating incidents, and how design and behavioural safety approaches can be used to reduce the risks that human errors introduce.

A.4.1 HUMAN FACTORS

The HSE definition is: '*Human factors refer to environmental, organisational and job factors, and human and individual characteristics which influence behaviour at work in a way which can affect health and safety'*.[12]

Within the different categories in this definition, there is a wide range of contributory factors such as:

- Environmental:
  - Noisy, unpleasant or poorly-maintained workplace;
  - Extremes of temperature;
  - Quality of lighting;
- Organisational:
  - Health and safety culture;
  - Quality of training and supervision;
  - Effectiveness of communications, including at shift changeovers;
- Job:
  - Design of equipment and control / warning systems;
  - Workload / time pressure;
  - Interruptions during complex multi-stage tasks;
    - These could be momentary interruptions, affecting concentration, or longer interruptions such as operations being suspended due to weather;
  - Physical and mental match between the job and the individual;
- Human and individual characteristics:
  - Competence;
  - State of health and fatigue;
  - Boredom;
  - Habits, which can either have positive or negative effects; and
  - Personality and attitudes.

A.4.1.1 TYPES OF ERROR

There are many different forms of human error, with different underlying reasons:

- Deliberate deviation from procedures, which may be:
  - Routine, for a variety of reasons such as:
    - Procedures are incorrect or impractical; or
    - Taking short cuts makes it easier to accomplish the task, and the resulting risk may or may not be recognised by the person involved; and

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[12] HSE Website: *Introduction to Human Factors*.

        - People do not expect to get caught taking the short cut;
    - Situational, often arising from:
        - Attempting to meet conflicting or unrealistic demands; or
        - Trying to get the job done without having all of the necessary tools available;
    - Exceptional, where a person's response to abnormal circumstances is to take actions that deviate from the established procedures with which they would normally comply;
- Errors of action, which may either be:
    - Lapses or omissions, such as forgetting to attach oneself to a fall arrest system before descending a ladder;
        - A simple, momentary lapse such as this can have fatal consequences;
    - Slips, where a simple and routine action is performed incorrectly, such as pressing the wrong button on a hoist control pendant;
- Errors of thinking, such as:
    - Correctly following the wrong procedure for the prevailing circumstances; or
    - Having inadequate knowledge of what to do in an unfamiliar situation, so working out a course of action, based on limited knowledge, that turns out to be wrong.

The consequences of errors can affect both operations and safety, and can range widely in severity.

A.4.1.1.1 Latent Errors

While some errors and their consequences are immediately obvious, known as "active failures", people may also be put at risk by "latent failures", where the error has occurred, but the consequences are not experienced until later; these could include:

- Design and calculation errors, leading to dangerous failures of equipment;
- Ineffective training and communication; or
- Errors in procedures, either relating to the steps to be followed, or a lack of clarity on safety-related responsibilities.

When the risk of such errors is recognised, mitigation can be applied, such as incorporating suitable checks into the design process, improving communications protocols, and undertaking practical reviews of procedures including emergency drills. In high risk situations, formal Human Reliability Assessment should be undertaken, with competent specialist support.

A.4.1.2 RELEVANCE TO LIFECYCLE STAGES

Human factors should be considered throughout the lifecycle:

- During risk assessments relating to equipment design, procurement, control of change and operating procedures:
    - If safety depends on human actions, then the risk from errors should be assessed:
        - Everyone makes mistakes; good design of equipment and procedures can minimise the probability and severity of mistakes;
- During investigation of health and safety incidents:
    - If the incident appears to have been caused by human error, then seek to understand why the error occurred:
        - Unless the causes of the error are understood and addressed, it is likely that similar errors will occur again in future; or

        - If the error cannot be eliminated, can the error-tolerance of the system be increased, to minimise the consequences?

- In routine operational management, including ensuring that effective physical and procedural precautions are maintained in the workplace.

A.4.2 STRATEGIES FOR REDUCING RISK FROM HUMAN ERRORS

Risk reduction can be approached in two complementary ways:

- Taking account of human factors in the design process, to identify ways to reduce the probability of errors occurring, and their safety implications; and
- Using behavioural safety approaches to improve human reliability.

A.4.2.1 REDUCING HUMAN ERRORS BY DESIGN

There are various ways in which design can take account of human factors, such as:

- Where correct assembly of components is critical to their function, the design should minimise the potential for latent errors to occur;
- The potential for operational errors can be reduced by making the layout of controls and operation of equipment as intuitive as possible;
- Local control panels and indicators should give clear and consistent indications of status;
- Design of SCADA, alarms and other control room systems should:
    - Provide clear information, and avoid overloading operators with large quantities of trivial or repeated information that can mask critical alarms;
    - Enable efficient use of multiple systems, including SCADA, communications, vessel and personnel locations; this allows more effective co-ordination in emergency situations;
        - The effectiveness of control room systems should be assessed during emergency exercises, and any necessary improvements implemented;
    - Ensure that monitoring systems do not rely on people sustaining their concentration; and
- Procedures should ensure that the sequence of assembly and installation operations minimises the risk to the safety of the people involved.

A.4.2.2 REDUCING HUMAN ERRORS THROUGH BEHAVIOURAL SAFETY

Safe behaviour has an important place within the overall management of health and safety: any risk control measures that rely on procedures being followed, or PPE being used, will only be fully effective if they are understood and complied with by all of the people involved. It should be noted that procedural measures and PPE are at the lower levels of the hierarchy of risk reduction, so while safe behaviour increases the effectiveness of these measures, it is not a substitute for the adoption of measures that are higher on the hierarchy, particularly where a human error could have serious consequences.

Figures are often quoted indicating that human behaviour is a contributory factor in 70-80% of accidents, however, this does not mean that behaviour is the only reason for the accident, or that only the behaviour of front-line personnel should be considered. Any programmes to improve safety by means of behaviour modification should form part of a range of measures to address human factors and the safety culture of an organisation.

Behavioural safety programmes typically involve workplace observation of unsafe acts or conditions, supported by follow-up work to resolve identified issues, and a reporting system, in order to address the different types of human failure. Programmes should also involve observation of, and positive feedback on, safe practices in order to identify and be able to disseminate and reinforce safe behaviour. The success of such a programme will be strongly influenced by an organisation’s culture: where a programme involves observing and giving feedback, the willingness to do so will depend on safety improvement being a shared objective that transcends hierarchical and workgroup boundaries.

Both deliberate deviations and errors can be reduced by identifying and addressing underlying causes, variously referred to as “Performance Influencing Factors” or “antecedents” of behaviour, together with increasing the awareness of the consequences of deviations and errors. Performance Influencing Factors are wide ranging, and can include organisational and management arrangements, contractual incentives, and the working environment:

- Errors are particularly likely if the design of operations leads to high levels of distraction, for example, if the person supervising a task is also operating complex equipment that is critical to the safe execution of the task;
- Deviations are most likely in cases where the design of the equipment and task make it inconvenient to operate in the correct way, for example, if a point of isolation is not readily accessible, then this can introduce the temptation to use other, less reliable, means of stopping equipment.

Behavioural safety programmes can be effective in reducing the frequency of low-severity personal injuries, but with less impact on reducing incidents that result from technical failures or inadequacies in procedures, which can lead to accidents with high potential severity. The precursors of high severity accidents may differ from those of more minor incidents, hence different management approaches are required.

Prior to embarking on a behavioural safety improvement programme, an organisation should ensure that:

- Risk assessments have been undertaken, in order to:
    - Identify hazards;
    - Apply the hierarchy of controls to reduce risk; and
    - Identify where the control of residual risks relies on correct behaviours being adopted;
- Suitable and effective operating procedures are in place, including those for response to abnormal / emergency situations;
    - This will be supported by establishing a culture where, if an employee judges a procedure to be incorrect, they are required to stop the task, and seek clarification / revision, rather than ignoring / deviating from the procedure; and
    - Implementation of the procedures will need a combination of training and supervision in order to develop competence;
- There is adequate resourcing to:
    - Respond to safety concerns identified by the workforce;
    - Implement lessons learned from site / corporate / industry experience; and
    - Keep safety management systems and risk control measures relevant and up to date.

These preparatory measures help to ensure that the behavioural safety programme can focus on true behavioural issues, and is not attempting to compensate for systemic weaknesses in the organisation’s safety culture and risk management.

A.4.3 References

A wide range of literature is available, from introductory overviews to detailed guidance on specific aspects.

HSE Website - *Human factors and ergonomics*.

BS EN ISO 6385:2004 - Ergonomic principles in the design of work systems.

HSE HSG48 – *Reducing Error and Influencing Behaviour* provides detailed coverage of human factors issues in general, including a wide range of case studies.

HSE - *Performance Influencing Factors (PIFs)* provides a useful one page checklist.

HSE Inspectors Toolkit - *Human factors in the management of major accident hazards - Introduction to human factors* provides guidance on understanding and addressing the different categories of human failures.

HSE Human Factors Briefing Note No. 3 - *Humans and Risk* provides concise and practical guidance on how to address human factors in risk assessment and incident investigation.

HSE Human Factors Briefing Note No 6 - *Maintenance Error* addresses the hazards that errors during maintenance work can introduce into a system, and gives practical guidance on ways to reduce or eliminate such errors, benefiting both safety and reliability.

HSE RR001 - *Human factors integration: Implementation in the onshore and offshore industries* provides detailed guidance on the integration of human factors considerations throughout the development lifecycle.

HSE - *Improving maintenance - a guide to reducing human error* provides very detailed guidance on how to manage maintenance so as to reduce the risk from human errors.

International Association of Oil and Gas Producers, Report No. 454 – *Human Factors Engineering in Projects* – aimed at engineering contractors working on the design and execution of major capital projects, from screening to operational feedback; especially Appendix 3 (Human factors screening tool) and Appendices 8,9 (Human factors consideration during HazOp).

HSE Offshore Technology Report 2000/048 - *Behaviour modification programmes - establishing best practice*.

HSE – *Behavioural safety and Major Accident Hazards – magic bullet or shot in the dark* discusses the usefulness of behaviour modification techniques, and gives practical guidance based on experience of regulating major hazard sites.

HSE – *Human Failure Types* – chart and descriptions, categorising and explain the main types of human failure in the workplace.

HSE Contract Research Report 430/2002 - *Strategies to promote safe behaviour as part of a health and safety management system* discusses how behavioural safety measures can be integrated with an organisation's safety management system, and used to promote wider risk-control behaviours, rather than being addressed in isolation.

MCA - The Human Element: a guide to human behaviour in the shipping industry provides a detailed insight into important aspects human behaviour, and how related risks can be minimised.

A.4.3.1 ELSEWHERE IN THIS GUIDANCE

Safety Culture

Incident Investigation, Nonconformity, Corrective and Preventive Actions

Ergonomics

A.5 OCCUPATIONAL HEALTH AND MEDICAL FITNESS TO WORK

The health of the workforce can be:

- Affected by the hazards that they are exposed to, and the activities that they undertake while at work; and
- A risk to their safety when undertaking work activities.

For these reasons employers need to identify and assess workplace hazards to health, and monitor and review the health of the workforce.

While accidents and injuries are readily identified, and can have immediate and severe impacts on those involved, health risks can also have life-changing adverse impacts on people, and identical legal duties apply, including adopting the same hierarchy of risk reduction. However, work-related ill health may not become fully apparent until some time after exposure to hazards, and it can be more difficult to assess the risk that a level of exposure to a hazard represents to the people involved.

The consequence of these challenges is that additional effort and specialist assistance may be needed in order to understand and manage the potential health impacts that proposed activities represent. Occupational health therefore needs to be integrated into health and safety management strategies, so that employers have a clear understanding of the state of health of their workforce, in terms of short and long term physical health and wellbeing.

A.5.1 DEFINITIONS

Health surveillance is a system of health checks, undertaken either as an outcome of a risk assessment, or when required by law. Its purposes include:

- Early detection of health problems, so that improved controls can be introduced to prevent worsening;
- Provision of data to enable health risks to be evaluated, and the effectiveness of control measures to be assessed; and
- Enabling employees to highlight concerns about health effects of their work, and reinforcing training and education on health-related hazards and protective measures.

Certain regulations require health surveillance to be undertaken by an HSE-appointed doctor; this is known as **statutory medical surveillance**.

Fitness for work assessments are specific checks to assess whether an individual is fit to undertake the work they will be doing without unacceptable risk to themselves or to others."

The HSE define **Occupational Health** as being "*about protecting the physical and mental health of workers and ensuring their welfare in the workplace. This includes a wide range of activities, but the key priority is to prevent ill health arising out of conditions at work by identifying, assessing and controlling health risks".* [13]

The occupational health function may also provide support in:

- Ensuring initial and continued fitness to perform a job safely;
- Advising on the provision of first aid and emergency medical services;
- Health education and promotion; and
- Rehabilitation after illness or injury.

This broad definition of occupational health includes the **occupational hygiene** function, which is focused on prevention of work-related ill health, by anticipating, recognising, evaluating and controlling the risks that people may be exposed to as a consequence of work activities, and the working environment.

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[13] HSE Website: *Occupational health risks offshore*

A.5.2 Risk Control

OREI construction and maintenance activities present a new combination of hazards to the health of people involved, however the individual hazards have already been encountered in other sectors, so the lessons learned can be applied to OREIs.

As the full effects of hazards to health are often delayed, the risks can be difficult to assess, particularly in cases where the relationship between a level of exposure to a hazard, and the subsequent health impact, is not widely understood. In order for a risk assessment to be suitable and sufficient, suitable competent advice should be obtained. This is where occupational hygienists can provide support, by helping to anticipate, recognise, evaluate and control risks to health. This support can include:

- Assisting designers (both machinery manufacturers, and Designers under CDM) to identify and eliminate risks to health;
- Assisting CDM Co-ordinators, Principal Contractors and Contractors to ensure that suitable and sufficient assessments of risks to health are undertaken, and appropriate methods of work are devised; and
- Carrying out workplace assessments and robust measurement of exposure to hazards, to ensure that control measures are effective and appropriate.

Adopting this approach ensures that the full hierarchy of risk control can be applied; as well as minimising the risk to workers, this can reduce or simplify PPE requirements, thereby minimising inconvenience to workers and enhancing productivity.

A.5.3 Medical Fitness to Work

Safe working requires that a person’s capability is well matched to the tasks that they will be undertaking as part of their job. While the risks to people can be minimised through the ergonomic design of equipment and operating methods, together with training and supervision in the use of safe methods of work, functional assessment of people may be necessary in order to determine their fitness to undertake the work that a role requires.

While good ergonomic design principles should be applied in all situations, the need for, and scope of, medical assessment of people, should be based on the outcomes of risk assessments.

Medical fitness is relevant to all stages of the lifecycle that involve on-site work. The challenges will vary between phases; for example the construction and commissioning phase is likely to involve large numbers of people working on a project for short periods of time, whereas the O&M phase is likely to have a core staff who may work on the OREI for many years. This will affect the nature of the assessment that is needed, in terms of initial fitness, and ongoing monitoring to identify any effects that the work is having on the workforce.

A.5.3.1 Potential Hazards and Risks

If a person is not medically fit to undertake the tasks which a job involves, then this can lead to a range of adverse outcomes:

- The person may be unable to perform their job effectively, for example, if a cardiovascular condition impedes climbing;
- Pre-existing medical conditions may be worsened by the demands of the job, for example, symptoms of cardiac conditions can be worsened by strenuous activity;
- It may be unsafe for a person to undertake certain tasks, for example if they suffer from blackouts, then this could lead to falls or harness suspension if working at height; and
- If a person becomes ill as a consequence of a pre-existing medical condition, even if this is not aggravated by their work, and requires emergency evacuation while working offshore, then the remoteness from medical facilities and the difficulties of evacuation increase the risk that this presents.

Employers should therefore ensure that fitness for work assessments are specific to the tasks that the person will be undertaking, in order to ensure that the person is fit for the demands of the job, and in order to monitor the effects of the work that they are doing. Imposing a single standard across a project is unlikely to reflect the diversity of tasks that will be involved and could be contrary to the requirements of applicable equality legislation.

A.5.3.2 APPROACHES TO RISK ASSESSMENT

Fitness for the demands of a particular role may be assessed as part of pre-employment medical check. Any such check should reflect the requirements of the role, thereby ensuring that people are not unnecessarily excluded from roles that they would be capable of fulfilling, and that potential risks are not overlooked. OREIs represent an area of employment without a long history, but which places clearly recognisable demands on the workforce, such as:

- Ergonomic risks, such as restricted working positions and climbing;
- Transfer by vessels, introducing the risk of seasickness and whole body vibration; or
- Extremes of heat and cold in the working environment.

Areas to consider include aspects of physical fitness such as:

- Eyesight and hearing;
- Cardiovascular and respiratory function;
- Musculoskeletal fitness;
- Chronic conditions such as diabetes and epilepsy;
- Effect of drugs (including prescription and over-the-counter medication) and alcohol;
- Skin conditions;
- Peripheral circulation.

While these conditions, and the effectiveness of any ongoing measures being taken to control symptoms, may determine the fundamental capability to complete tasks, a more holistic view of fitness to work in a role will include consideration of:

- Mental / psychological health:
    - Conditions related to stress and depression;
    - Tolerance of lone working etc.; and
- Social factors:
    - Effects of remote and lone working, including separation from family; and
    - Needs for access to medical provision.

Taking a holistic view of the demands that a job places on people allows for better identification of risks, and definition of suitable fitness assessments.

Both an individual’s health, and the demands of their role, may change over time, so on-going fitness assessment may be appropriate; employers should establish policies for this, which may include:

- Repeating the fitness to work assessment at fixed intervals, or after events such as illness or incidents, where these may affect fitness;
- Random or with-cause testing for drugs or alcohol; and
- Pre-work fitness check by supervisors, to gain awareness of any relevant changes in the individual’s health.

A.5.3.3 ASSESSMENT STANDARDS

Seafarers are subject to statutory medicals, known as either ENG1 or ML5, depending on the class of the vessel and intended area of operation; the MCA maintains a list of acceptable equivalent medical certificates for non-UK seafarers.

The offshore oil and gas industry uses the Oil and Gas UK (OGUK) Offshore Medical as a standard, as do some employers in offshore wind. It gives particular attention to underlying medical conditions that could cause problems offshore.

Neither the seafarer nor the OGUK medical certifications is designed to reflect the specific risks that will be encountered in work on OREIs. For this reason, RenewableUK has developed medical fitness to work guidelines, which outline the nature and scope of assessments provided to wind turbine technicians and other personnel who may need to work on, access and climb a medium or large wind turbine. The guidelines are intended for onshore and near-offshore application, but could form a starting point for assessments for working further offshore, which would have to give increased attention to the implications of potential underlying medical conditions in workers, combined with increased remoteness from medical support.

The requirements for medical examinations and assessment of divers are set out under the Diving at Work Regulations 1997 and the relevant approved code of practice requirements

A.5.4 Health Surveillance

The primary aim of health surveillance is to ensure that the control measures in place to protect an individual from an identified health risk are suitable and adequate.

Under the MHSWR, employers are required to provide health surveillance to employees in certain circumstances, in order to detect damage to health at an early stage, and enable further harm to be prevented. Provision of health surveillance should be determined on the basis of a risk assessment, which should consider whether:

- The work activity and conditions carry a recognisable health risk;
- Valid techniques exist to detect indications of the disease or health condition; and
- Health surveillance is likely to enhance the protection of the health of the employees.

The existence of a valid technique is important, as health surveillance is only worthwhile where it can reliably show that damage to health is starting to happen or becoming likely. A technique is only useful if it provides accurate results, and is safe and practical. Undertaking health surveillance can reveal the accuracy of the initial risk assessment, and the effectiveness of control measures, and also help to identify and protect those individuals whose work puts them at increased risk.

A.5.4.1 Specific Regulatory Requirements for Health Surveillance

Certain regulations specify health surveillance requirements, for example:

- The Control of Noise at Work Regulations 2005, and the Control of Vibration at Work Regulations 2005, impose duties on employers to ensure that workers exposed to health risks, due to noise or vibration, are placed under health surveillance; and
- The COSHH Regulations specify conditions under which users of certain hazardous substances are to be placed under health surveillance.

The regulations specify whether health surveillance by a competent person is sufficient, or if statutory medical surveillance is required.

A.5.5 Further Guidance

HSE Health surveillance webpages provide an overview and detailed information on health surveillance.

RenewableUK *Medical Fitness to Work - Guidelines for near offshore and land based renewable energy projects* provides more detailed guidance, although the precise content may not be sufficient for far-offshore developments.

International Association of Oil and Gas Producers Report No. 470 - *Fitness to Work - Guidance for company and contractor health, HSE and HR professionals*.

HSE WEB02 *Working together to prevent sickness absence becoming job loss - Practical advice for safety and other trade union representatives* is aimed at workforce representatives, and suggests ways in which they can work in partnership with employers and the workers whom they represent to help prevent illness, injury and disability leading to prolonged sickness absence and job loss.

HSE Webpage: Divers medical requirements - sets out details and requirements for all those who dive at work in the UK to have a valid certificate of medical fitness

MCA *Medical Fitness Requirements for those working on domestic vessels and small commercial vessels* explains the different seafarer medicals.

IMCA Medical Guidelines for Non-Marine Crew Working in the Offshore Environment provides guidance for examining physicians who are assessing personnel who will be working offshore, but who are not subject to seafarer medicals.

A.6 MANAGEMENT SYSTEMS

The MHSWR impose a duty on employers to assess the health and safety risks presented by the activities of their organisation, and to have appropriate arrangements "*for the effective planning, organisation, control, monitoring and review of the preventive and protective measures*" identified in the risk assessment. This duty can be fulfilled in a systematic way by means of a suitable health and safety management system, which provides a framework and tools to enable the organisation to achieve the aims of its health and safety policy.

Management systems commonly use the "Plan – Do – Check – Act" approach, which is outlined in current HSE guidance and in BS OHSAS 18001; this approach supports integration of health and safety management with quality, environmental and other management systems. The standard can both be used to support internal development and assessment, and as the basis of certification of the management system by an external auditor. While the standard provides a common approach, it does not specify performance levels, so assessment of an organisation's performance is still necessary.

The key activities in the Plan – Do – Check – Act process are:

- "Plan": set objectives, and identify the processes that will be needed;
- "Do": implement the processes that are needed;
- "Check": assess and report on the performance of processes against health and safety policies, objectives, legal and other requirements; and
- "Act": periodic management review of the health and safety management system to assess its continued effectiveness, suitability and adequacy for the organisation's activities.

These activities should be viewed as parts of a continuous improvement cycle, rather than as one-off actions.

OREI development generally involves multiple organisations, from a range of backgrounds, working together; given that each organisation will have its own health and safety policy and management systems, effective bridging processes will be needed at interfaces.

A.6.1 HEALTH AND SAFETY POLICY

An organisation's health and safety policy records management commitment to:

- The prevention of injury and ill health;
- Achieving continuous improvement in health and safety management arrangements and performance; and
- Fulfilling relevant legal duties, and other requirements (for example, from contracts or industry guidelines) that may apply to the health and safety hazards in the organisation's activities;

The policy provides a framework for setting and reviewing health and safety objectives, and should be formally documented, implemented (by means of the health and safety management system), and reviewed and maintained as necessary to ensure that it remains appropriate, with particular respect to changes in legal duties, performance standards and the activities of the organisation. The policy should be communicated to all personnel (including both employees and contractors) working under the control of the organisation, in order to ensure that they are aware of their responsibilities; it should also be made available to others as required.

The policy should influence all of the organisation's activities, including the selection and development of people, the planning and execution of tasks, and the procurement, design and provision of goods, services, equipment and materials.

The policy needs to recognise that organisational failings often contribute to causing accidents, or increasing their severity; integrating health and safety into the business strategy should ensure that staff who are responsible for implementing company policies can do so on the basis of clear and consistent guidance, and are not left to reconcile conflicts between corporate objectives and health and safety requirements.

A.6.2 "PLAN"

The Planning stage starts with identification of hazards that are presented by the organisation's activities, and then defines the arrangements for the control of the associated risks, throughout the organisation and in accordance with regulatory duties.

A.6.2.1 HAZARD IDENTIFICATION AND RISK ASSESSMENT

The MHSWR imposes a duty on employers to make a suitable and sufficient assessment of the risks to the health, safety and welfare of their employees whilst they are at work, and to the health and safety of others who may be affected by the work that they undertake. Further, in the context of the general duty to reduce risk ALARP, robust risk reduction can only take place when risks have been adequately identified and assessed.

A specific assessment of risk is also required under of several sets of regulations, including Control of Substances Hazardous to Health (COSHH) and Manual Handling.

Risk assessments should address all health and safety risks, during every phase of the life cycle of an OREI, and include risk to members of the public, as well as personnel working on site. Risk assessment techniques should be selected according to the hazards being considered, and the phase of the OREI lifecycle. The health and safety management system should provide a structure for the risk assessment process, including the risk assessment techniques to be used, and competence requirements for those performing or reviewing risk assessments.

The findings of all risk assessments should be recorded and reviewed at regular intervals to ensure that they remain up to date, and they should also be reviewed as part of the management of change process, or when there is new learning from incidents or safety observations. More detail on risk management is given in Section A.7.

The identified risks should be prioritised, considering the severity and probability of the risks and the effectiveness of the controls in place at the time of the assessment.

A.6.2.2 DETERMINING RISK CONTROLS

Risk controls should be determined in accordance a hierarchy such as the General Principles of Prevention given in the MHSWR, or as given in BS OHSAS 18001:

1. Elimination;
2. Substitution;
3. Engineering controls;
4. Signage / warnings and / or administrative controls;
5. PPE

The design phase offers the greatest opportunity to eliminate risks, or reduce them ALARP. Designers have similar duties under CDM and the Supply of Machinery (Safety) regulations to identify and eliminate hazards, and reduce risks at every stage of the design process, and to provide information with the design or product regarding any significant residual risks. Clients can help to ensure that Designers fulfil these duties.

Some findings of a risk assessment may be in the form of controls to be applied to the workplace to reduce exposure to the identified risks. Both the identified risks, and the control measures selected to prevent the realisation of those risks, must be communicated to those carrying out the work, prior to work commencing. Records of all information, instruction and training should be retained as evidence that they were provided.

A.6.2.3 REGULATORY REQUIREMENTS

As the health and safety management system supports the organisation in fulfilling its legal duties, the organisation needs to have a procedure for ensuring that relevant legal requirements are identified, and that the management system will fulfil them. This compliance needs to be maintained, taking account of regulatory changes, and changes in the organisation's activities. Relevant information on legal requirements should be communicated to personnel working under the control of the organisation, and to others who may have an interest.

A.6.2.4 OBJECTIVES AND PROGRAMME

Health and safety objectives for relevant functions and levels of the organisation should be cascaded through the organisation from the policy, in order to ensure that they are consistent with it, and contribute to its delivery.

In order to manage progress towards the objectives, a programme should be established, identifying the responsibilities, authority, method and timescale for actions to be carried out.

A.6.3 "Do"

This stage is focused on the actions that are necessary for the implementation and operation of the health and safety management system.

An effective health and safety management system will be capable of controlling risks, adapting to changing demands, and promoting a positive health and safety culture; such a system must be implemented effectively. Doing so will help to prevent accidents, ill health and losses by systematically identifying, eliminating and controlling hazards and risks, across the whole scope of an organisation's activities.

Key components of the system to be implemented include:

- Workplace precautions, which address the hazards and risks of all work activities undertaken within the organisation, through a combination of physical protection, information, training, competence, supervision and the operation of safe systems of work;
- Risk Control Systems (RCSs), which ensure that adequate workplace precautions are established and maintained, with respect to the inputs, internal processes and outputs of the organisation;
- Management arrangements, which provide for the establishment and operation of the RCSs, including auditing their effectiveness.

A.6.3.1 RESOURCES, ROLES, RESPONSIBILITY, ACCOUNTABILITY AND AUTHORITY

The ultimate responsibility for health and safety lies with the board of directors, or other top management of the organisation, who should ensure that:

- The necessary resources are made available to establish, implement, maintain and improve the health and safety management system; and
- The roles, responsibilities, accountability and authority for health and safety management are defined, documented and communicated throughout the organisation.

As the board is normally in overall control of the organisation, it has a duty under the MHSWR to obtain the advice and assistance of 'Competent Persons' on health and safety matters. These Competent Persons can be in-house advisers or a team of safety professionals, or the advice may be obtained from external consultants.

Although health and safety is the responsibility of everyone in an organisation, specific responsibilities may be delegated by the board to individuals involved in the management of health and safety. These responsibilities need to be appropriate for each level of the organisation, and the relationships between those individuals may be set out along normal reporting lines. The aims of the organisation should be to:

- Establish and maintain management control of health and safety throughout the organisation;
- Promote co-operation throughout the organisation, in order to ensure that the management of health and safety is a collaborative and consistent effort;
- Ensure communication of relevant information throughout the organisation, and where it interfaces with external stakeholders; and
- Secure and enhance the competence of employees, including arrangements relating to recruitment, training, supervision and competence assessment.

While Competent Persons may be providing advice to the company, safety management should be the first priority of all line managers, and should be integrated into design and project development processes, rather than leaving a separate part of the organisation to “police” work activities. Elimination of hazards at the earliest stages can avoid incurring the costs associated with having to make late changes to improve safety, or having to maintain precautions to mitigate residual risks.

A.6.3.2 COMPETENCE

The organisation should ensure that all personnel under its control, both direct employees and contractors, have the necessary competence to undertake their tasks without adverse effects on the health and safety of themselves or others. Such competence may be gained through a combination of training and experience, with formal competence assessment where necessary.

In order to develop competence, training requirements should be identified, based on the risks identified in the risk assessment, and the requirements of the health and safety management system. The need for competence applies to all levels and functions of an organisation, and is not limited to those who may be directly exposed to hazards, such as technicians and construction personnel. Other relevant groups, whose competence could affect health and safety, include people in management and supervisory positions, those undertaking risk assessments, audits, monitoring activities on a site and investigating incidents.

In addition to competence, people should have sufficient awareness of health and safety aspects of their work, including site-specific information such as emergency procedures, as well as an understanding of the potential health and safety consequences of their actions, behaviour and any deviations from policies and procedures.

Further details on training and competence are given in Section A.8.

A.6.3.3 COMMUNICATION, PARTICIPATION AND CONSULTATION

Effective communication and consultation can increase the understanding of health and safety issues, encourage participation in the development and use of the health and safety management system, and the adoption of good practices. Communication processes should enable the flow of information between different levels and sections of an organisation, and should work in both directions.

Participation in activities such as hazard identification, risk assessment, incident investigation and development of risk controls helps to ensure that these are based on relevant experience, and increases ownership of the outcomes. In addition to fulfilling the legal duty under the HSWA to consult with employees in matters affecting their health and safety, effective consultation arrangements can help to ensure that risks are adequately controlled, and that systems work well in practice.

A.6.3.4 DOCUMENTATION AND DOCUMENT CONTROL

The MHSWR imposes a duty that, where there are five or more employees, risk assessments and health and safety arrangements shall be recorded. As well as documenting the health and safety management system itself, its operation will involve the creation of documents and records; these should be properly controlled, in terms of approval, issue, review, updating, distribution and ensuring that obsolete documents are not unintentionally used

Documentation will be most effective if it is kept to the minimum that is required for effective operation of the health and safety management system; it should be proportionate to the complexity of the activity, and the hazards and risks involved. Effective document control ensures that information is available where and when it is needed, both in normal operation and emergency situations. This may affect the format in which documents are kept; for example, emergency information may be more effectively provided through signs and laminated cards, rather than solely in an electronic format.

A.6.3.5 OPERATIONAL CONTROL

Operational controls are the means by which the risks associated with the identified hazards are controlled. They include:

- General measures, such as those addressing risks arising from workplace conditions, work activities and behaviour;

- Specific control measures, such as procedures for hazardous activities, procurement of goods and services, and contractor management.

The level of detail in the operational controls should be proportionate to the hazards that they address; in many cases, detailed operating criteria, which specify approved equipment and methods, will be defined. Operational controls should be maintained to ensure that they remain effective, both as part of a management of change process and through periodic reviews, so that the controls are updated when operating activities or equipment are to be changed.

A.6.3.6 EMERGENCY PREPAREDNESS AND RESPONSE

Organisations have a duty under the MHSWR to have suitable procedures in place to deal with situations involving "serious or imminent danger", and for contacts with external emergency services. This duty can be fulfilled by implementing an emergency response procedure, which identifies potential emergency situations, and then defines the methods and equipment that should be used in the response, in the context of the wider Emergency Response co-operation Plan (ERCoP) for an OREI. The procedure should also identify requirements for training, periodic practice drills and review processes. See section A.15 for further details.

A.6.4 "CHECK"

A.6.4.1 PERFORMANCE MEASUREMENT AND MONITORING

In order to check that the health and safety standards are actually being achieved in practice, performance needs to be measured against a range of active and reactive indicators, and any necessary improvements implemented.

A.6.4.1.1 Active / Pro-active Monitoring Systems

Active monitoring systems measure the extent to which plans are being implemented, and policies complied with. They typically use leading indicators from sources such as:

- Monitoring of performance against health and safety objectives;
- Systematic inspection of premises, plant and equipment by supervisors, maintenance staff, management and safety representatives, or other employees to ensure the continued effectiveness of workplace precautions;
- Environmental monitoring and health surveillance to check on the effectiveness of health protection measures and to detect early signs of harm to health; and
- Direct observation of work and behaviour by first line supervisors and co-workers to assess compliance with procedures, rules and risk control.

A.6.4.1.2 Reactive monitoring systems

These measures consider where health and safety standards are not being met, and report and analyse failures – for example, accidents, cases of ill health or damage to property.

When reporting and response systems are put in place, the information from monitoring activities should be evaluated by people who are competent to recognise situations in which there is an immediate risk to health or safety, as well as longer-term trends. They must have sufficient authority to ensure that appropriate remedial action is taken.

Performance data is often summarised as statistics; for these to be useful and meaningful, particularly if data is to be used for benchmarking, or for monitoring trends over time, it is important that the measurement systems are carefully defined, including:

- Use of standard categories of incident / injury; and
- Expressing data as frequency rates (for example, per million hours worked) rather than as simple totals of occurrences, ensures that the data allows for changes in the level of activity.

A.6.4.1.3 Combining Active and Reactive Monitoring

Reactive monitoring efforts will provide lagging indicators, such as accident data, which record the performance that has been achieved. Active monitoring provides leading indicators that can be used to measure the inputs to the health and safety performance, such as the number of inspections undertaken, safety observations identified, or relevant safety training undertaken. Appropriate leading indicators take account of the safety culture maturity of an organisation, and should be directly relevant to the risks to which the workforce is exposed. The combination of leading and lagging indicators, and trends over time, can show if workplace precautions and RCSs are:

- Receiving minimal effort, but despite this the organisation has been lucky, and has had few incidents;
- Receiving minimal effort, with a correspondingly high level of incidents;
- Receiving a high level of effort, but the efforts that are being measured have yet to reduce a high level of incidents, or are not focused on the risks that are giving rise to the incidents; or
- Receiving a high level of effort, with a low level of incidents occurring, which suggests that the risk control effort has been well targeted up to the point in time at which performance was measured.

This approach gives a deeper understanding of an organisation's performance, and the reasons behind it, than would be the case if only reactive monitoring were undertaken, and can therefore allow improvement efforts to be targeted more effectively.

A.6.4.1.4 Further Guidance on Performance Measurement

HSE – *A Guide to Measuring Health & Safety Performance*.

Step Change in Safety - *Leading Performance Indicators - Guidance for Effective Use* considers how to identify suitable leading performance indicators for an organisation, and then combine these with lagging indicators to prioritise improvement actions.

A.6.4.2 EVALUATION OF COMPLIANCE

Part of the purpose of the health and safety management system is to ensure compliance with legal requirements, and other requirements from industry codes or contracts; therefore this compliance should be evaluated periodically. This evaluation should consider both external factors, such as a review of current legal requirements, and internal factors such as audit reports, reviews of documents, activities and projects, workplace inspections and interviews.

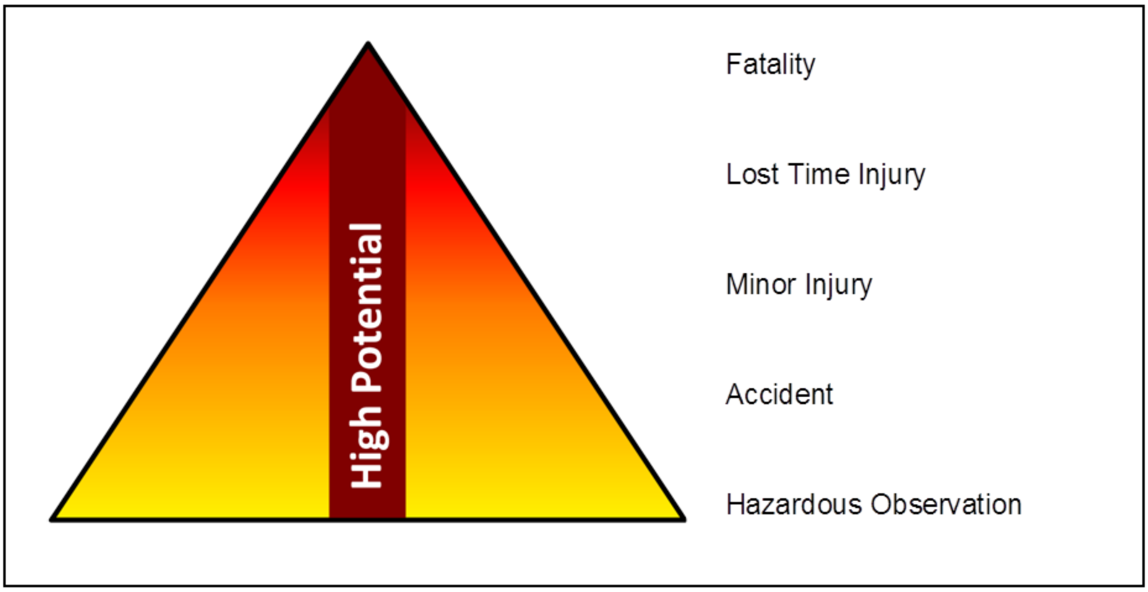
A.6.4.3 INCIDENT INVESTIGATION, NONCONFORMITY, CORRECTIVE AND PREVENTIVE ACTIONS

A.6.4.3.1 Incident Investigation

When an incident occurs, it is vital that it is properly investigated, and that steps are taken to prevent a recurrence. A procedure should be established for the investigation of incidents, with the aim of identifying underlying causes, opportunities for collective and preventive actions and improvements, and communicating the outcomes.

The first step in this lies in the immediate response to the incident: all necessary actions to protect people and prevent escalation of the incident should be carried out, but nothing else should be done that could hamper investigation of the incident, such as removing equipment or debris, or resetting controls. Thereafter, the effort expended on investigation and follow-up activities should be proportionate to the risk that the incident represents, in terms of its potential consequences and probability of recurrence, and not just the severity of the outcome on the particular occasion being investigated. This is illustrated in Figure 1 below.

Figure 1: Event triangle, illustrating a typical ratio of events of different actual severity, but with the high potential events highlighted. These events demand the greatest attention in incident investigation and follow-up.



In the event of any significant incident, and in particular where this has resulted in a fatality or major injury, appropriate legal and professional advice should be considered. There are also certain statutory reporting requirements, and in some cases, more than one report will be necessary:

- In the event of a fatality or life-threatening injury, the police should be informed immediately;
- Certain categories of incident and dangerous occurrence are reportable to the HSE (see section A.1.5);
- If death or serious injury occurs as a result of, or in connection with, the operation of a vessel, then this should be reported to the MAIB; and
- Leases and contracts may specify further reporting requirements.

When selecting actions to prevent recurrence of an incident, the hierarchy of protective measures should be applied, with hazards being eliminated where reasonably practicable; note however that it will be more difficult to eliminate hazards in equipment that has already been built, than it would have been at the design stage.

The outcomes of the investigation need to reach management with sufficient authority to initiate remedial action, including organisational and policy changes. The actions identified in the investigation should be recorded, and their completion monitored across all relevant parts of the organisation, to ensure that an incident is not repeated as a consequence of identified actions not being completed.

A.6.4.3.2 Levels of Causation

When investigating an incident, several different levels of causation need to be considered, which can be categorised as:

- Immediate cause: the most obvious reason why an event occurs;
- Underlying cause: less obvious factors that contributed to the event occurring, often related to failings in systems or organisations;
- Root cause: the initiating event or failure, without which the incident would not have occurred.

Getting to the root cause offers the best prospect of preventing a recurrence of the event. The example given in Table 5 below illustrates the different levels of causation of an incident, showing how these will lead to different follow-up actions, and protect different groups of people.

Table 5: Getting to the root cause of an incident

Incident: Worker fell through open hatch during maintenance task					
Level	**Question**	**Potential answer**	**Type of cause**	**Possible follow-up action**	**Whose safety is improved?**
1	**Why** did the worker fall through the hatch?	Hatch had been left open	Procedural violation	Warning / disciplinary action	Individual worker
		Worker forgot / did not notice that it was open	Lapse / Error	Toolbox talk	Work group
2	**Why** was the hatch open?	Letting light in to area below	Design	Improve lighting	All workers
		Frequent access required during task	Procedure	Improve planning of task	All workers
3	**Why** didn't the worker see that it was open?	Lighting conditions	Design	Improve lighting	All workers
		Stepping backwards while undertaking adjacent task	Procedure	Improve planning of work	All workers
4	**Why** was it possible to fall through the hatch?	Lack of edge protection when hatch open	Design	Retrofit edge protection at similar locations	All workers
5	**Why** was a hatch without edge protection accepted at the design stage?	Inadequate design review / prototype acceptance	Procedure	Update specifications and checklists	Future workers

The above table only provides a simplified summary of how the root cause of an incident could be identified, and seeks to demonstrate the importance of going deeper than the immediate cause of an incident. In practice it is invariably more complex and more sophisticated techniques and models (including proprietary systems) can provide deeper insight and evaluation.

A.6.4.3.3 Further Guidance on Incident Investigation

HSE HSG245 - *Investigating accidents and incidents* provides detailed guidance, and tools for undertaking investigations.

Energy Institute – *Guidance on investigating and analysing human and organisational factors aspects of incidents and accidents*.

IOSH - *Learning the Lessons: How to Respond to Deaths at Work and Other Serious Incidents*

A.6.4.3.4 Nonconformity, Corrective and Preventive Actions

In order to ensure the continuing effectiveness of the management system, the organisation needs to have a procedure for identifying and responding to actual or potential nonconformities. A nonconformity is defined as the non-fulfilment of a requirement, which may either be a requirement of the health and safety management system, such as failing to carry out specified actions, or a failure to achieve specified health and safety performance. Nonconformities should be addressed by corrective actions, and potential nonconformities by preventive actions. For example:

- If an item of lifting equipment was damaged due to being overloaded during lifting, then this would be an incident;
- If a load was about to be lifted, but the requirement in the lifting procedure to provide information on the weight of the load had not been fulfilled, then this would be a nonconformity, and a corrective action could be to weigh the load;
- Having identified the existence of the non-conformity, there may be potential nonconformities, such as similar deviations from procedure occurring on other lifts, so preventive actions could be to increase awareness of the requirements with other workgroups, and increase monitoring of similar activities.

A.6.4.4 CONTROL OF RECORDS

Records should be kept to demonstrate conformance to the requirements of the health and safety management system and applicable regulations, and as evidence of how risks are being managed. A wide range of different records may be created, such as risk assessments, incident reports, inspection reports, training records and records of legal compliance checks. The procedure for control of records should specify the retention requirements for different types of record, and also maintain confidentiality of personal data held in the records, such as health surveillance reports.

A.6.4.5 INTERNAL AUDIT

The health and safety management system should be subject to periodic internal audits, to determine if the system is operating as intended, and to assess its effectiveness in meeting the requirements of the organisation's health and safety policy and objectives. Auditing helps to ensure that all components of the health and safety management system remain fit for their purpose, and that they are not allowed to deteriorate, or become obsolete as a consequence of changes in the organisation or its activities. Audits will be most meaningful if the audit schedule takes account of risk factors, such as:

- Areas where changes have occurred, such as new activities, hazards or personnel; and
- Areas of concern identified in previous audits, or incident and nonconformity reports.

Auditors need to have sufficient understanding of the hazards that are present in the activities covered by the processes being audited, in order to be able to make a valid assessment of the effectiveness of the risk controls. Audits generally begin with an initial review of relevant documentation and previous audit reports, followed by discussions with the person or group being audited, collection and evaluation of information and records, and preparation of a report.

The audit findings may identify the need for corrective or preventive actions to be taken, and it is important that completion of these actions is monitored.

A.6.5 "ACT"

Organisations need to review their health and safety performance and management systems, and take action on the basis of any lessons learned.

A.6.5.1 MANAGEMENT REVIEW

The health and safety management system should be subject to periodic management review, in order to assess its performance, in terms of its:

- Suitability for the organisation, considering factors such as its current size, activities and related risks;
- Adequacy, in terms of giving complete coverage of the organisation's health and safety policy and objectives; and
- Effectiveness, which will be demonstrated by the health and safety performance being achieved.

The management review should draw on data and reports on the performance of the system (which will come from the steps in the "Check" stage above), with additional reports if greater understanding of specific areas is needed. The review may also look ahead, to anticipate potential changes arising from foreseeable changes in activities, strategy, legislation and technology. The review may identify the need for actions to be taken to improve aspects of the health and safety management system.

A.6.6 CODES OF PRACTICE AND GUIDANCE

HSE HSG65 – *Managing for health and safety (2013 Edition)* describes the Plan – Do – Check – Act approach, identifies key actions for different groups of personnel within an organisation, and provides useful descriptions of "what to look for" when assessing the effectiveness of different aspects of a management system.

A.6.6.1 REGULATIONS AND STANDARDS

BS OHSAS 18001:2007 *Occupational health and safety management systems. Requirements*

BS OHSAS 18002:2007 *Occupational health and safety management systems. Guidelines for the implementation of OHSAS 18001:2007* provides more detailed guidance on the components and operation of such a system.

A.7 RISK MANAGEMENT

Effective management of risk is vital to the safe development and operation of complex projects; OREI development involves undertaking major projects in a hostile environment, often including the use of new technologies and methods, and therefore requires particularly thorough risk management.

Such projects may involve a large number of different parties, at different stages and in different roles within the supply chain; the collective risk burden will be minimised where it is recognised that responsibility for the health and safety performance of the project extends right through the supply chain. Each party should therefore manage both the direct risks that are present in their own activities, and the risks to and from the activities of other parties.

A.7.1 PRINCIPLES AND PRACTICE

The hierarchy of risk management prioritises the actions to take:

1. Eliminate hazards where possible, for example by design changes, elimination of a hazardous operation, or selection of a different method;
2. Reduce the potential of those hazards that cannot be eliminated;
3. Reduce the exposure of people to hazards, by means of collective protection measures such as fixed guards;
4. Where fixed guards or similar are not possible, protective systems such as interlocks may be used; these should be designed such that if they fail, the machine will default to a safe state; and then
5. Mitigate residual risks by systems of work and use of PPE.

A.7.1.1 DEFINITIONS: HAZARD AND RISK

A hazard is anything with the potential to cause harm, such as articles, substances, plant or machines, work equipment, work activities, the working environment and the way in which work is organised.

Risk considers both the probability of harm occurring, and the potential severity of that harm.

A.7.1.2 SUITABLE AND SUFFICIENT RISK ASSESSMENT

The MHSWR impose a legal duty to undertake a suitable and sufficient risk assessment; “suitable and sufficient” is not defined in the regulations, although guidance is given in HSG65. Given the level of risk in many OREI operations, an effective risk assessment process will typically need to:

- Take account of risks arising from or in connection with an activity, with the thoroughness of the assessment being proportionate to the risk;
- Make use of specialist knowledge where necessary for particularly complex operations or techniques;
- Consider all who may be affected by the activity;
- Involve workers or their representatives in the process;
- Make use of available information when identifying risks; this may include sources outside the organisation, such as regulations, vendor information, industry reports and publications, or competent advisers; and
- Ensure that precautions are reasonable, and the residual risk is low.

As many designs and tasks related to OREI development are novel, there is less historical data on which to base judgements, so other approaches will be needed in order to provide evidence of the level of risk presented. The added complexity of marine operations also increases the risk, compared to equivalent operations onshore.

The overriding aim is to ensure that all reasonably foreseeable risks are adequately assessed.

A complex project will require many risk assessments to be carried out; it is important that the scopes of individual risk assessments, how they relate to each other, and Designer / Contractor / Client responsibilities, are managed as part of a coherent process, to avoid risks at interfaces or from interactions being overlooked.

A.7.2 LIFECYCLE APPROACH

Risk management is best viewed as an ongoing process throughout the project lifecycle, both to assess and inform decisions. As a project is developed from concept through to commissioning and operation, the ability to make fundamental changes reduces, while the detailed understanding of specific risks increases. This change in data availability will also affect the appropriateness of different risk assessment techniques.

The concept phase offers the greatest opportunity to eliminate risks, by substituting hazardous equipment, substances or activities by less hazardous alternatives.

As design activities progress, risks may be combated by engineered protective measures, such as:

- Designing equipment so that it separates people from hazards, by measures such as guarding and interlocks;
- Minimising inventories of hazardous substances,
- Provision of remote diagnostic systems to minimise offshore intervention requirements, and optimise planning of maintenance activities;
- Provision of isolation systems to ease implementation of safe systems of work for maintenance activities.

Once the design has largely been frozen, the residual risks can be minimised by:

- Designing suitable systems of working;
- Using personal protective clothing and equipment, although this should not be used as the primary means of protection.

If the risk assessments at this late stage identify risks that cannot be mitigated to an acceptable level by the above means, then modifications may be required, almost certainly resulting in a far greater impact on cost and schedule than if the risks had been identified earlier.

A.7.3 OVERVIEW OF RISK ASSESSMENT TECHNIQUES

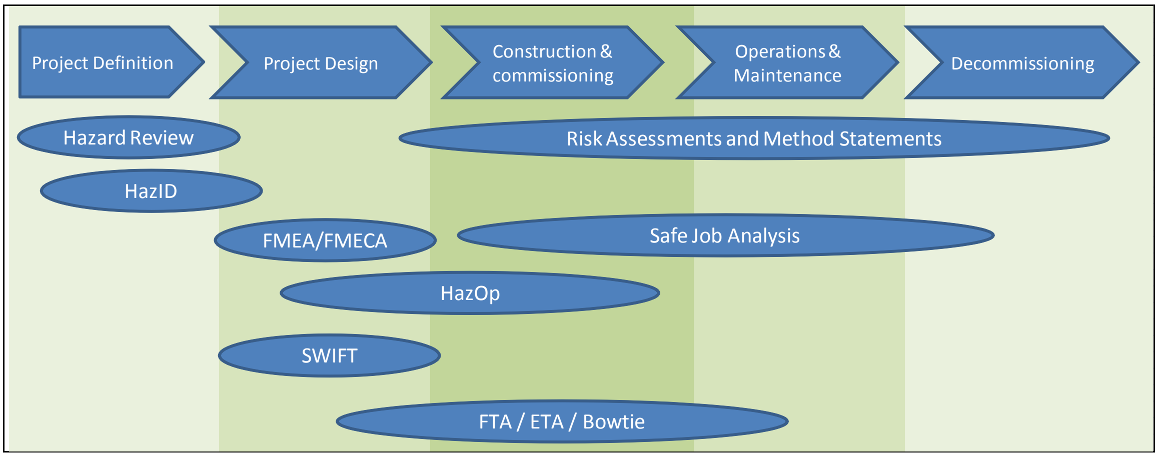
A wide range of risk assessment techniques is available; appropriate selection is important in order to fulfil the duty to undertake suitable and sufficient risk assessment. Some of the factors to consider in selecting an approach are described in Table 6 below.

Table 6: Factors affecting choice of risk assessment technique

Factor	Effect on choice of technique
Lifecycle stage	Availability of design details and project-specific data is limited in early stages, encouraging use of qualitative approaches or external data sources to learn from relevant experience elsewhere; the output of early stage risk assessment should guide later detail design work. This is illustrated in Figure 2.
Hazard potential	More significant hazards may need quantitative methods to demonstrate acceptable risk levels, whereas qualitative approaches or engineering judgement may be appropriate for lower hazards.
Context	Assessment of established practices and standard designs may be supported by historical data and published design codes, whereas novel proposals may require more detailed individual analysis.
Enterprise risk	Where the outcome of a risk assessment may affect the viability of a development, additional rigour in assessment, and senior management support, may be required.

Specific risk assessment approaches are required for certain aspects of offshore development, for example, the DTI has published a methodology for assessing the Marine Navigational Safety Risks of Offshore Wind farms.

Figure 2: Example of how different risk assessment approaches may be used over a project lifecycle.



The techniques listed in Figure 2 are briefly summarised in the sections below; more details are given in the HSE and DNV guidance on marine risk assessment.

For all of these techniques, it is vital to ensure that the right people are involved; with a study leader who is trained and experienced in the risk assessment process, supported by a team with sufficient experience of the subject of the study, and the process being used, to be able to give suitable consideration to all relevant risks. It is important to recognise that risks may arise from both technical and human factors, so both of these areas require sufficient consideration.

As the risk assessment process needs to continue throughout the project lifecycle, it is important to ensure that the outcomes of each stage of the process are retained, and made available to subsequent stages, perhaps including a formal handover from one stage to the next. This ensures that the investment in risk assessment is not wasted through duplication or loss of information, and that assumptions are not made about the level of risk assessment that has already been undertaken.

A.7.3.1 HAZARD IDENTIFICATION

A range of techniques exists, with their suitability depending on the stage in project development, and the resulting level of project-specific detail. In the earliest stages of project development, experience on other projects should be used to inform the design of the project under consideration, while in later stages, the project itself can be assessed in increasing detail. Available techniques include:

- Hazard Review:
    - A qualitative review, based on previous experience of similar developments, industry guidelines and codes of practice;
    - Useful in concept design, to ensure that prior learning is utilised, but the ability to do this is reduced for novel situations;
- Hazard Checklists, Structured What-If checklist Technique (SWIFT):
    - Standard checklists, based on previous experience, are used to prompt consideration of hazards which may be present;
    - "What-if" questions are used to prompt consideration of novel failure modes, and human factors;
- Hazard Study / HazOp (Hazard and Operability Study):
    - Each step of a process is reviewed, by a study team, against foreseeable deviations from the design intent;
    - Considers physical properties such as speed and temperature as well as operating sequences and procedures;
- Failure Modes, Effects (and Criticality) Analysis (FMEA / FMECA):
    - Identifies failure modes at the individual component level of a system, and assesses the effect of such failures on the performance of the system as a whole, taking account of the ease with which they can be detected;
    - Requires a detailed system structure to have been defined;
- Safe Job Analysis (SJA):
    - Used to identify hazards and mitigation measures for a particular discrete task or activity;
    - Particularly relevant for activities that are not part of routine operating procedures, as it can be carried out by the actual personnel involved in the tasks or activity, although for this reason, clear thresholds must to be set for the level of hazard that can be addressed in this manner.

A.7.3.2 QUALITATIVE RISK ASSESSMENT

Having identified the hazards, an assessment can be made of their:

- Probability, which may range from "frequent" to "improbable" or "incredible"; and
- Severity, which may range from "catastrophic" to "not credible".

These categories must be carefully defined, and understood by the team members, as the study relies on their assessment of the probability and severity of each hazard. For this reason, although this approach can give numerical outputs, it is still a qualitative approach. It is also important be clear on exactly which event and outcome is being assessed:

- Does the probability relate to an event involving, for example:
    - A single device in a discrete stage of its lifecycle, or a single occurrence of an operation; or
    - An entire development over its whole lifecycle, or an operation that is to be repeated regularly?
- Does the severity relate to, for example:

    - The most likely severity; or
    - The most severe foreseeable outcome?

For a novel development, there may be very limited evidence to support these judgements.

The outputs may be in the form of a:

- Risk Priority Number, which is generally the product or sum of numerical values assigned to probability and severity;
    - This approach does not distinguish between “high probability, low severity” and “high severity, low probability” events; these require different management approaches;
- Risk Matrix, with probability and severity on its axes.
    - This ensures that high severity risks are clearly identified, regardless of their probability; this is particularly important where there is uncertainty in the probability.

A.7.3.3 SEMI-QUANTITATIVE AND QUANTITATIVE RISK ASSESSMENT

The most common techniques in these categories are Fault Tree Analysis (FTA), Event Tree Analysis (ETA), and Bow Tie diagrams; the ability to quantify risk will depend on the quality and availability of failure and event data.

Fault Tree Analysis generally starts with the potential “Top Event”, in which the hazardous situation occurs, and works down through logic gates to identify the combinations of basic (initiating) events which could cause the top event, and safeguards or protective systems which could prevent it.

Probabilities may be assigned to events and safeguards, based on failure rate data. FTA can consider combinations of technical and human factors. As it breaks complex systems down into discrete functions, it may be possible to model novel systems, where they are composed of established components or practices, provided that suitable allowance is made for effects of the new operating context.

Event Tree Analysis starts with an initiating event, such as a component failure, and then models the potential outcomes, taking account of actions or systems that could mitigate the consequences, and their probabilities of success. It may also include environmental factors such as sea state or wind direction, where these can affect the outcome, although the method is clearest when these can be captured in a binary state, such as wind towards / away from structure.

A Bow Tie diagram effectively combines FTA and ETA; for a given Top Event, the FTA works back to the initiating events, while the ETA works forward to the consequences. This captures the full range of initiating events and safeguards on a single diagram, and can also consider the effect of elements of a Safety Management System. While Bow Ties are most commonly used in a semi-quantitative manner, software can be used to assist in calculating probabilities.

A.7.4 RISK CONTROL

Risk control systems (RCSs) are the basis for ensuring that adequate precautions are provided and maintained, to minimise the identified risks. The different areas to be subject to RCSs may be classified as:

- **Input:** minimising hazards and risks entering the organisation:
    - This includes areas such as the selection of contractors, personnel, and equipment, management of the supply chain and outsourced design activities;
- **Process:** minimising risks to those within the organisation:
    - This includes risks arising from carrying out the organisation’s activities, including its premises, plant, substances, procedures and people; and
    - The controls should address all foreseeable operating states such as normal operation, maintenance and emergency situations;

- **Output:** minimising risks from the organisation's activities to others outside the organisation:
    - This includes operational effects on other sea users, customers and clients; and
    - Physical outputs such as the organisation's products, services, installations, disposal of materials and provision of information.

The classification of an activity will depend on the organisation's place in a supply chain.

Organisations need RCSs that are appropriate to the hazards arising from their activities and sufficient to cover all hazards. The design, reliability and complexity of each RCS needs to be proportionate to the particular hazards and risks.

A.7.4.1 METHOD STATEMENTS

Project and task-specific risk assessments may be used to devise methods of work (sometimes referred to as 'method statements'). These method statements should not be prepared entirely as generic 'process' documents unless the process is unlikely to change. If there is a possibility that these method statements will be revised (for example, if a different vessel is to be used for the task), then the method statements should be under the control of a person with sufficient competence, authority, time and resources to be able to review the effectiveness of the method, or to suspend the task pending revision of the method.

Sufficiently robust work instructions should be given to personnel involved, to ensure that work is stopped and delayed if necessary. In addition, there should be suitable contractual arrangements for delay caused as a result of safety precautions; this will also encourage thorough preparation, to minimise the risk of such delay occurring.

If the method of work is not capable of change without reference to a manufacturer or designer then these people should be available to assist with revision of the method statement as needed. Contractual requirements in procurement may assist with securing this responsiveness.

A.7.5 CODES OF PRACTICE AND GUIDANCE

A.7.5.1 REGULATIONS AND STANDARDS

BS ISO 31000-2009: *Risk management – Principles and guidelines* provides a comprehensive framework for risk management, and is applicable to health and safety and other categories of risk.

A.7.5.2 OTHER RELEVANT GUIDANCE

HSE HSG65 - *Managing for Health and Safety*

DNV RP-H101: *Risk Management in Marine and Subsea Operations*, obtainable from DNV Recommended Practices webpage provides detailed guidance on risk management and assessment processes and methods.

HSE Offshore Technology Report 2001/063 - *Marine Risk Assessment* - while some of the content is specific to certain oil and gas operations, this document gives a comprehensive overview of different risk assessment techniques, and their strengths and weaknesses.

HSE INDG163 - *Five Steps to Risk Assessment* provides an overview of basic risk assessment; not sufficient for complex operations or projects.

DTI / DfT / MCA *Methodology for Assessing the Marine Navigational Safety Risks of Offshore Wind Farms* defines the process to be used in preparing navigational risk assessments.

HSE RR637 – *Optimising hazard management by workforce engagement and supervision* provides detailed examples of Bow Tie usage in Appendix B, mainly focused on barrier decay issues.

HM Treasury - *The Orange Book - Management of Risk - Principles and Concepts* provides detailed guidance on risk management across an enterprise, and considers both the organisation's strategy and management approaches, in relation to external and internal sources of risk.

HSE Website – *Risk Management* pages provides guidance and tools to help businesses understand what they need to do to assess and control risks in the workplace and comply with health and safety law. Although written with small businesses in mind, the site is relevant to all businesses.

A.8 TRAINING AND COMPETENCE

Under the HSWA, once an employer has fulfilled their duty to eliminate risks so far as is reasonably practicable, they are required to provide such information, instruction, training and supervision as is necessary to address the residual risks.

A person can be considered competent if they have:

- Sufficient understanding of the risks and safe systems of work that are relevant to the location where they are working;
- Sufficient knowledge of the specific tasks to be undertaken, and the risks that they entail; and
- Sufficient training, experience and ability to undertake their assigned duties, and sufficient understanding to recognise their own limitations.

Being competent means that a person has the ability to undertake the work that a role entails, safely and to the required standard; the level of competence that a person needs is determined by:

- The level of risk that a task presents; and
- The level of supervision under which the task will be performed; for example, an apprentice technician, working under the direct personal supervision of another technician who is both competent in the task, and in the supervision of an apprentice, could safely undertake tasks that they would not be competent to undertake on their own.

Different levels of training are necessary in order to develop competence:

- Entry level: health and safety training for any person newly exposed to a relevant health and safety risk;
    - This is typically required for new employees, newly appointed contractors and service providers, and visitors;
    - It primarily addresses company, contractual and project-specific requirements; and
    - It is typically carried out as part of a company and / or site induction programme;
- Basic Level: specific health and safety training for any employee undertaking a defined role or task on a project, in any life cycle phase;
    - Its scope and application primarily addresses the specific risks that the individual is exposed to, in addition to any company or project requirements; and
- Advanced or specialist training, which may relate to technical operations such as installation of a particular equipment item, or a role within a safe system of work, such as Authorised Technician.

A.8.1 REGULATORY REQUIREMENTS

In addition to the general duties under the HSWA, mentioned above, many other regulations impose specific duties. These include:

- The MHSWR require employers to take account of employees' capabilities in relation to health and safety, and to provide adequate health and safety training; this:
    - Should be provided when employees are initially recruited; and thereafter when they are exposed to new or increased risks, which may arise from changes in their role, or in the work equipment, technologies or systems in use; and
    - Should be repeated periodically where appropriate;
        - This is particularly relevant to skills that may only occasionally be used; for example, in an emergency, it is vital that every employee is competent to fulfil their responsibilities, even though such situations should not be frequent occurrences;

- Under CDM, Clients, CDM Co-ordinators and others in control of work are required to assess the competence of organisations and individuals who will be involved in projects, and the ACOP provides detailed guidance on competence assessment; and
- PUWER requires that users of work equipment have received adequate training in its use, the risks that this entails, and the precautions to be taken.

These regulations have broad application, and affect almost every work activity; regulations relating to other specific activities and hazards also address training requirements, including those for lifting, work in confined spaces, working with electricity, work at height, manual handling, fire and first aid.

The requirements for training and competence of seafarers are set out in maritime regulations, which specify the required standards according to types of vessel and area of operations. Given the specialised nature of vessel operations in support of OREIs, evidence of relevant experience and competence should also be sought; this may be supported by using competence assessment schemes operated by trade bodies such as the International Marine Contractors' Association (IMCA) and the International Jack-up Barge Owners' Association (IJUBOA).

A.8.2 RISK ASSESSMENT AND ANALYSIS OF TRAINING REQUIREMENTS

In order for an employer to fulfil their legal duty, suitable and sufficient risk assessments and analysis of training requirements should be undertaken. This typically requires an employer to:

- Assess the training requirements, taking account the findings of relevant risk assessments, current levels of competence, and lessons learned from accident and incident data;
- Prioritise the delivery of training, taking account of legal duties and in particular identifying situations where a lack of information and / or training might result in serious harm;
- Deliver the training, by selecting and using the most effective approaches, ensuring that information provided is easy to understand and delivered by competent trainers; and
- Review the training, including assessing its effectiveness in terms of ensuring that employees understand the training provided, and apply it in their safety behaviours in the workplace.

Suitable advice should be taken from the nominated competent persons for health and safety, and consultation with employee representatives.

A.8.3 INDICATIVE TRAINING FRAMEWORK

While there are challenges in identifying and agreeing training standards, there is a developing consensus that it should endeavour to:

- Be risk based and take account of the particular roles and responsibilities of the individual;
- Be supported by a suitable workplace assessment process, to verify the scope and suitability of any training identified;
- Be delivered in a structured manner to enable additional training to be added if new or additional risks arise as part of the role or activity;
- Take account of relevant training standards, where they exist, to minimise duplication of training, while retaining the integrity of the approach to address regulatory or contractual requirements; and
- Be flexible, to take account of the developing state of knowledge and emerging industry good practice.

In taking these into account, the following are considered to be an industry good practice framework against which duty holders can benchmark their training and competence arrangements. They are not an official or agreed industry standard, but do nonetheless consider the most relevant entry and basic level health and safety training that is likely to be suitable in order to address the most significant risks associated with OREI projects in the UK.

These are:

- Entry level training; a typical scope may include:
  - Company inductions covering general health and safety policies and arrangements;
  - General overview of health and safety risks in the sector, with a focus on key risks; and
  - Project / site inductions covering specific health and safety policies and arrangements;
- Basic level training – identified by the risk assessment and taking account of any role, task or contractual requirements. Such training is likely to include some or all of the following areas:
  - First aid (basic awareness and / or statutory);
  - Work at height and rescue;
  - Relevant hazards such as manual handling, fire, lifting, work in confined spaces, or hazardous substances;
  - Safety rules and safe systems of work in use on the site;
  - Any additional training to address specified risks;
  - Marine safety, for those working on vessels;
  - Personnel transfer, between vessels or helicopters and offshore structures, or other vessels; and
- Any advanced or specialist training, which relates to an individual's role in normal operations and emergency situations.

A.8.4 STANDARDS AND ACCREDITATION SCHEMES

There are no mandatory training schemes or standards that specifically apply to OREIs. Each duty holder is responsible for identifying their own training requirements, and determining whether any particular training standards or schemes can fulfil these needs. However, standards and schemes that have been developed and supported through industry consensus (such as RenewableUK standards) are likely to be regarded as a benchmark of good practice. This is relevant in the event of enforcement or intervention action by regulators, as it may show evidence that recognised good practices have been adopted. It is recommended that where they are suitable for the risk profile and job role performed, preference should be given to the "standards" below in the following order of priority.

- Benchmark standards:
  - These standards have been developed by the industry to address significant risks that are specific or particular to the sector, and are supported by suitable third party accreditation systems. Relevant examples include:
    - RenewableUK Training Standards; and
    - Global Wind Organisation – Basic Safety Training;
- External standards:
  - These standards may address specific risk areas but either do not include adequate OREI-specific content and / or include elements that are unnecessary, or even potentially conflicting with OREI-specific approaches. There are numerous potential examples, with the most relevant likely to be those used in:
    - Oil and Gas, such as OPITO;
    - Marine contracting, such as IMCA; or

        - Marine operations, such as Certificates of Competency under STCW.
- Internal standards:
    - These will consider the specific requirements of the duty holder arising out of risk assessments and training needs analysis;
        - Scope and content may vary considerably and will not typically be subject to third party accreditation. However these can still play a key role in providing additional and / or complementary training to supplement any benchmark or external training provided.

A.8.5 Contractual Arrangements

The variety of training standards and accreditation schemes introduces risks when entering into contracts:

- If clients demand specific qualifications or courses, and will not consider equivalents, then this can result in contractor personnel who work on multiple projects having to undertake multiple similar training courses; or
- If there is inadequate scrutiny of training records and standards, then gaps in competence may later be revealed.

Either of these outcomes can affect safety, quality and cost for all parties concerned.

It is therefore highly recommended that the agreed training and competence standards are clearly set out in company policies and contractual documentation, and properly communicated to all concerned in a timely manner. While recognising the benefits of referencing benchmark standards where they exist, some degree of flexibility and recognition of equivalent content of external training standards may be appropriate, in order to avoid unnecessary duplication of training. This would still need to be subject to an appropriate risk assessment process.

A.8.6 Codes of Practice and Guidance

A.8.6.1 Regulations and Standards

HSE L144 - *Managing health and safety in construction - Construction (Design and Management) Regulations 2007 Approved Code of Practice* – especially appendices 4-6, competence development and assessment.

A.8.6.2 Other Relevant Guidance

HSE INDG345 Health and Safety Training – A brief guide explains what employers may need to do to ensure that employees receive appropriate health and safety training.

RenewableUK - *Health & Safety Training: Entry- and Basic-Level Health & Safety Training and Competence Standards: Scope and Application to Large Wind Projects* provides an overview of the different areas and levels of training for work on onshore and offshore projects.

IJUBOA has defined competence standards for barge masters, as well as training for crew members and those involved in the management or procurement of jack-up barge services.

IMCA provides detailed competence assurance and assessment checklists for a wide range of positions and levels such as vessel masters, crane operators, riggers, technicians, and in relation to different activities such as survey work, diving and general vessel operations.

RenewableUK standards for Working at Height and Rescue and Marine Safety Training – Vessel Transit and Transfer, both of which incorporate Global Wind Organisation requirements.

A.9 SAFE SYSTEMS OF WORK

Employers have a general duty under the HSWA to establish and maintain systems of work that are, so far as is reasonably practicable, safe and without risks to health; this includes systems for:

- The control of work activities, including both normal operation and maintenance activities, and managing the interaction between different activities; and
- Means of keeping people safe from the inherent hazards that plant presents, where they could be exposed to these in the course of work.

These functions are generally fulfilled through a combination of supervision and control of operations, supported by management systems:

- Normal (or Routine) Operating Procedures define tasks that are:
    - Part of normal operation, and
    - Where operation of the equipment does not expose the people undertaking the task to health and safety risks;
- A Permit to Work (PTW) system covers all other activities. Over the lifecycle of an OREI, various different PTW systems are likely to be operated:
    - During the construction phase, the Principal Contractor will generally operate a PTW system, as part of their safety management plan;
        - Part of the function of a PTW system is to manage potential interactions between tasks, therefore only one PTW system should be in operation at a location at any time;
        - The PTW system should make provision for circumstances where work being carried out under a PTW could have effects on systems or personnel beyond the boundaries of the system; such effects could potentially occur, for example where power or communications systems are being tested;
- Once a WTG is in operation, plant investigation and maintenance activities are likely to be undertaken under:
    - The Wind Turbine Safety Rules (WTSR) on mechanical and LV electrical systems; or
    - HV safety rules, on HV systems (defined as 1000V AC or 1500V DC and higher). These rules may also include LV rules and also extend to plant other than just the WTG.

During commissioning, there is likely to be a phased handover process, with the construction PTW system, HV Safety Rules and the WTSR being in simultaneous operation on different parts of the project. In order for this to be done safely, the plan, boundaries, completion requirements and responsibilities for this transition must be absolutely clear, and must also correspond to the handover arrangements in the construction, commissioning and operations contracts for the project.

While this section refers to the WTSR and WTGs, a similar approach could be adopted for any wave or tidal devices that are to be maintained in-situ.

A.9.1 PERMIT TO WORK SYSTEMS

A PTW system operates on the basis of defined roles, standard procedures and forms. It must be noted that there are a wide variety of roles, definitions and titles used in association with permit to work systems. The most common are set out by the HSE Guidance on Permit to Work System (HSG 250). In every case it is essential that all parties involved fully understand what terms and definitions will be used for the specific situation concerned.

A typical PTW process would normally consist of the following steps:

- The need for a task to be undertaken is identified, and a permit is requested;

- Prior to the commencement of a task, the person responsible for issuing the permit will:
    - Review the scope of a task;
    - Identify hazards and precautions associated with a task (often making use of risk assessments and method statements that have been prepared for the task);
        - Depending on the hazards and precautions identified, additional supporting assessments and documents may be required, for example to cover work involving sources of ignition, or in confined spaces;
    - Check for conflicts with other work activities;
    - Notify personnel as required;
    - Ensure that all necessary isolations have been securely implemented, for example by ensuring the keys to the points of isolation remain in safe custody;
    - Confirm the conditions at the work location before the task commences;
    - Issue the permit to the person accepting the permit on behalf of the permit user(s) and record it in a register;
- The person accepting the permit along with any others operating under the permit then undertake the task in accordance with the requirements of the PTW;
    - The PTW system may require the person accepting the permit to apply their own lock to isolations, as a safeguard against unintentional de-isolation. (In some systems the person accepting the permit and the person responsible for issuing the permit may have joint custody);
    - The person accepting the permit should retain the safety documentation in safe custody after briefing his working party;
    - If unforeseen circumstances require any change in the work (e.g. a change of intent, scope, method or sequence) from that which was recorded in the PTW, then the person accepting the permit will raise this with the person responsible for issuing the permit. Permits should never normally be altered and any additional work would only be accepted by the person responsible for issuing the permit if the changes form part of the agreed scope of work and the points of isolation are adequate;
    - The PTW system should include arrangements to enable permits to be transferred, extended or cancelled as necessary;
- On completion or abandonment of the task, the permit should be returned to the person responsible for issuing the permit, and the status of the work site and equipment communicated.

Awareness of the need for PTWs would typically be covered in a site safety induction, while further training and competence assessment would be required for people carrying out work under the system.

Given that a PTW can be used to manage both the safety of discrete tasks, as well as their potential interactions, employers may determine that all work on a site shall be carried out under the PTW system, even where there are no task-specific risks to control.

The above summarises the general scope and approach for PTW systems and some variation to the above may apply in practice. However in the context of safe systems of work and PTW systems operated in an offshore wind or marine environment, attention needs to be given to the particular risks and operational circumstances to ensure such systems are properly implemented and communicated to all parties concerned. This should take into account:

- The importance that the task and its nature in the context of particular situation is identified by an authorised and competent person familiar both with the applicable systems and rules relevant to site and turbine specific arrangements;
- The need for documentation to be correctly approved to ensure that controls have been properly applied to achieve safety from the system; and

- The importance of having in place a robust process to ensure that the issue and handover of all documentation to nominated and competent persons is properly communicated and understood by all individuals concerned including specifying any limitations to the work activity.

These core aims are embedded into the Wind Turbine Safety Rules (WTSR) which are summarised below.

A.9.2 THE WIND TURBINE SAFETY RULES

The WTSR have been developed by wind farm owners and operators for the purpose of formalising a safe system of work for operational wind turbines (onshore and offshore), and are widely used at wind farms throughout the UK and Ireland. The WTSR perform the functions of a PTW system, but with modifications that take account of the differences between wind farms and conventional industrial situations, in particular the fact that there is unlikely to be a person responsible for issuing the permit at the location of the task, thereby requiring the person accepting the permit (e.g. Authorised Technician) to have greater involvement in the management of isolations.

Adoption of the WTSR is not a legal requirement, and the WTSR do not impose any duties that exceed legal requirements, however the WTSR, when implemented correctly and appropriately should:

- Represent industry good practice for safeguarding employees from the inherent dangers that exist from installed electrical and mechanical equipment in wind turbines;
- Assist in the development and application of safe systems of work in a consistent manner; and
- Provide a robust approach to demonstrating legal compliance with relevant health and safety regulations.

In order to assist in the adoption of the WTSR, detailed guidance and model procedures are provided on the RenewableUK website; that duty holders should fully familiarise themselves with. A brief summary of the WTSR is provided in the following sections.

A.9.2.1 SCOPE AND EXCLUSIONS

The type of work that can be carried out under the WTSR must be clearly defined, to ensure that the appropriate safe system of work is used for any given task. In addition, it is important to establish clear boundaries between the WTSR and other Safety Rules systems and that these are effectively communicated across the site (e.g. It is good practice to display a single line diagram in appropriate areas defining the boundary points that have been agreed to by the owners of the different safety rule sets.)

The WTSR can be applied to all mechanical and LV electrical systems on an OREI:

- The WTSR do not apply to HV electrical systems; these are subject to HV safety rules.
- In cases where making LV equipment safe to work on requires actions to be implemented on HV systems, or vice versa, then both sets of rules will have to be used, and steps taken to co-ordinate the actions of the different persons involved.

Certain tasks may be carried out by a Competent Technician under Routine Operating Procedures where an AWP is not required; these may include tasks such as cleaning of work areas (e.g. floors) or visual inspections (without removal of any guards). For these tasks, the safety of the technician is assured through a combination of the wind turbine being safe in normal operation, and the scope of the procedure ensuring that it does not interfere with normal operation.

The interfaces between HV safety rules, the WTSR, and Routine Operating Procedures (the last part of which are part of the WTSR) must be clearly defined; based on this, for every procedure in the manufacturer's service manual, a decision can be made as to which set of rules applies. Note that for WTGs having the transformer in the nacelle, the boundary between HV and LV will extend right up the tower and into the nacelle. Any tasks being carried out in these areas under the WTSR need to be carefully assessed to ensure that they do not interfere with HV systems.

A.9.2.2 ASSURANCE OF SAFETY

The WTSR consider both:

- General Safety, which includes ensuring that:
    - A safe means of access and egress is available at all times;
    - The place of work is safe for the work or testing to progress;
    - Appropriate tools and equipment are available;
    - Any necessary PPE is available;
    - A safe method of work is available; and
- Safety from the System ("Condition which safeguards persons working on or testing Plant and/or LV Apparatus from the Dangers that are inherent in the System") which refers to safety from the mechanical and LV electrical hazards that would put people at risk if they were to work on equipment that had not been isolated / blocked / deenergised.

A.9.2.3 KEY ELEMENTS OF THE WTSR

Effective operation of the WTSR is achieved by a combination of:

- Appropriately trained and authorised persons, fulfilling the defined roles of:
    - Authorising Engineer;
    - Authorised Technician;
    - Competent Technician;
    - Operational Controller; and
    - Selected Person.
- A clear set of procedures for defined activities:
    - Routine Operating Procedures;
    - Transfer of Control; and
    - Approved Written Procedure (AWP).

These persons and procedures are explained in more detail in the following sections. Arrangements for appointment of persons, and preparation of procedures, need to be defined in the company's own Management Instructions. (Note: All aspects of the implementation of the WTSR need to be reviewed and adapted where appropriate by duty holders.).

A.9.2.3.1 Persons

The main duties of named Persons under the WTSR are summarised in this section; these descriptions are not exhaustive, and full definitions are given in Part D of the WTSR, together with guidance on processes and criteria for determining the competence of these appointees. A clear understanding of each person's role, responsibilities and limitations of authority is vital to the safe operation of the WTSR.

- Authorising Engineer:
    - Determines when work can be carried out under a Routine Operating Procedure (ROP);
    - Is responsible for the approval of AWPs for packages of work, ensuring that they:
        - Include all necessary safety precautions, points of isolation, and signature check points;
        - Provide clear instruction as to how Safety from the System will be maintained at all stages of the procedure, including stages where isolations are to be removed; and

        - Identify where additional assessments are required from Selected Persons;

- Authorised Technician:
    - Undertakes Transfer of Control from / to the Operational Controller;
    - Establishes General Safety prior to commencement of work, and suspends work if General Safety cannot be maintained;
    - Ensures that the necessary precautions to provide Safety from the System (such as isolations) are in place during the work, in accordance with the AWP;
    - Sets working parties to work, providing supervision as required in the AWP; and
    - Administers the use of the AWP, including transfer, clearance and cancellation as appropriate, and records these steps on the AWP;
- Competent Technician:
    - Obtains consent from the Operational Controller before undertaking work under a ROP and informs them on completion / suspension of the work;
    - Establishes General Safety prior to commencement of work, and suspends work if General Safety cannot be maintained;
    - Performs work in accordance with Routine Operating Procedures; and
    - Sets working parties to work, provides personal supervision to the working party;
- Operational Controller*:*
    - Undertakes Transfer of Control to / from Authorised Technicians with respect to work to be carried out under an AWP, and contributes to provision of Safety from the System;
    - Gives consent for work to be carried out under Routine Operating Procedures; and
    - Co-ordinates activities on the OREI to ensure that different work packages do not give rise to unsafe interference;
- Selected Person:
    - Provides additional competence where special precautions are required in order to safeguard persons; for example, if the work to be carried out under an AWP involves specific hazards such as entry into a confined space, then the Authorising Engineer should ensure that the Selected Person is satisfied with the precautions to enable this work to proceed; these might include carrying out on-site testing and examination, and preparation of task-specific rescue plans prior to commencement of work.

A.9.2.3.2 Routine Operating Procedures

These procedures define work that can safely be carried out during normal operation of the wind turbine whilst under the supervision of a Competent Technician. No isolations are required for this work, as it does not expose the technician to any hazards relating to the operation of the equipment; clearly, this limits the scope of work to tasks such as inspection, cleaning and diagnostic activities, where the design of the equipment allows safe access during normal operation.

A.9.2.3.3 Transfer of Control

This is a formal process in which control of equipment is released from the Operational Controller to the Authorised Technician, and later returned, either on completion / termination of the task, or the end of the working period. The Authorised Technician records the Operational Controller's name on the AWP, together with the time and date of the transfer.

The WTG will not be switched to Local control until this process is complete.

A.9.2.3.4 Approved Written Procedures

All work carried out under the Rules must be performed in accordance with an AWP or a Routine Operating Procedure where applicable:

- The procedure is created by someone with sufficient knowledge of the Rules, the equipment and the work to be carried out; it is then checked and approved by the Authorising Engineer, thereby becoming an AWP;
- AWPs will include clear and unambiguous cross-references to the maintenance procedure or work instruction, (contained within the Manufacturer's Service Manual), to which it applies; there will normally be no need to duplicate the details contained in the maintenance procedure or work instruction but the AWP must contain details of all the safety precautions necessary to achieve and maintain Safety From The System;
- The AWP provides part of a system of work and can refer to other relevant documents ("Associated Documents") such as method statements, risk assessments, maintenance manuals etc. Each AWP is uniquely identified (usually by a serial number), and relates to a single package of work;
- Each AWP requires signature by the Authorised Technician at various points over the course of the work package, so is most likely to be created as a paper document. This does not preclude the use of an electronic system, provided that an equal level of control, traceability and retention is achieved;
- The AWP can refer to "Associated Documents", which may include method statements, specialised risk assessments etc.;
- It is essential that the AWP identifies all the hazards that may arise from the task, and the precautions to be taken, which may include measures such as isolations, instructions, PPE and / or ventilation;
- If necessary, the AWP will specify how Safety from the System is to be maintained during any periods when isolations are to be removed (for example, for testing or repositioning of components), as this may give rise to additional hazards;
  - As it is safer to work with all sources of motive power fully isolated, wherever possible tasks and equipment should be designed to avoid the need to restore motive power at any intermediate step.

Under the WTSR when an AWP is in force for work or testing on any items of Plant/LV apparatus then no other AWP shall be implemented on those same items of Plant/LV apparatus at the same time. However if there is a need for more than one AWP to be in operation at any one time on a single WTG, then the Authorising Engineer has to assess the potential for the two work packages to interact, before permitting this situation to occur. If there are more than one AWP to be worked on at the same time on the same turbine then the Authorising Engineer must authorise this and there should only be one Authorised Technician that holds both (or more) AWP's on that turbine. The Authorised Technician must control both work activities so they do not have any conflict with each other. The points of isolation will be separate for each of the AWP's and isolation keys are to be segregated. If the same points of isolation are required then a suitable device/system should be used that allows more than one padlock to be applied at the same point.

A.9.3 HV SAFETY RULES

A.9.3.1 INTRODUCTION

All work on HV systems must be undertaken in accordance with HV Safety Rules (HVSRs). These detail both general and specific requirements for work on HV apparatus. They are specific and prescriptive, providing sufficient detail to be clear and unambiguous.

A.9.3.2 GENERAL REQUIREMENTS

The general requirements of the HV Safety Rules are that no person shall undertake any repairs, maintenance, cleaning, alteration, testing or similar work on any part of an HV system unless those parts of the system are:

- Released from Operational Control;
- Isolated, including LV supplies, voltage and auxiliary transformers and other sources from which the equipment could become live, and a Caution notice attached;
- Tested dead;
- Protected by a connection to earth, applied by a switch or another approved means;
- Identified at the point of work; and
- Released for work by the execution of an appropriate Safety Document.

A.9.3.3 Duties of Persons

Note: Different HV Safety Rules may have different persons named and defined within their systems for example in some HV Safety Rules an AP does not exist.

The basic duty as a Competent person is to receive a safety document, and then:

- Be conversant with, and understand the nature and extent of the work to carried out, and not exceed this;
- Ensure that all persons under their control also understand the extent of the work; and
- Provide supervision to the working party.

The duties of an Authorised person are, in addition to those of the Competent person, to carry out operations on the system such as switching, isolations and earthing.

The duties of a Senior Authorised Person (SAP) are typically to issue and cancel safety documents.

A.9.3.4 Authorisations

Typical authorisations are Competent, Authorised (to various levels) and Senior Authorised.

Competent persons must have sufficient technical knowledge or experience to avoid danger.

Authorised persons are Competent persons, adequately trained, possessing technical knowledge, and appointed in writing to carry out specific operations. They would be likely to possess an electrical qualification, and have suitable and sufficient experience, including:

- Adequate knowledge of electricity;
- Adequate experience of electrical work;
- Adequate understanding of the system to be worked on and practical experience of that class of system;
- Understanding of the hazards that may arise during the work and the precautions that need to be taken; and
- Ability to recognise at all times whether it is safe for work to continue.

Any person that has been nominated or authorised under a set of safety rules has to be deemed competent by that company. This will normally take into account evidence such as recognised electrical qualifications and relevant experience in relation to the role and tasks to be performed. It is the responsibility of duty holders to clearly define and justify what and how competency will be defined taking into account the safety rules applied and the system it applies to. It is also vital that evidence to support these competency assessment decisions is properly documented and where necessary shared with relevant contracting parties. In view of the potential complexity of the issues involved professional advice may need to be taken.

A.9.3.5 Operations and Switching

Where practicable the use of remote live switching should be seen as the preferred option. Even if this can be achieved, the operation of the HV system must be managed by the person who has responsibility for the system to ensure personnel and system safety. Often specific procedures allow delegation of this control at a specific location to a SAP who may be a representative of the

DNO / OFTO, a specialised subcontractor or the OREI maintenance contractor. In all cases a form of HV Safety Rules will apply to the control of the HV network.

There is also likely to be HV system management performed within the boundaries of the OREI's plant (for example HV switching of the WTG switchgear to undertake turbine transformer inspections). The OREI operator must ensure that appropriate HV Safety Rules are in place to cover these activities.

A.9.3.6 Safety Documents

The Rules typically define three types of safety document:

- Limitation of Access, for work in proximity to the HV system;
- Permit to Work, for work on the HV system; and
- Sanction for Test, for testing on HV system, where the removal of earths is permitted.

A.9.3.7 Interfaces with WTSR

The most common interface point between the WTSR and the HV Safety Rules is the LV circuit breaker connected to the transformer LV side. This circuit breaker can be used as:

- A point of isolation for work on the generator LV system under the WTSR; and
- A point of isolation for work on the transformer under the HV safety Rules. (LV circuit breakers can be used as a point of isolation as long as they have been designed for that function by the manufacturer and in accordance with applicable technical standards e.g. IEC BS EN 60947.)

Work on any equipment/apparatus (including for example the LV circuit breaker itself) must be carried out under the safety rules that apply to that system within its set boundary.

If the LV isolator is being used to permit safe work on HV systems, then this isolation would have to be made by an Authorised Technician under the WTSR, with a second lock or other means of preventing de-isolation applied by the HV Authorised Person; persons must not work outside the boundaries of their authorisations.

In such situations a specific cross boundary AWP will need to be in place to ensure cross boundary precautions are implemented as agreed to by the Authorising Engineer and the HV contractors' representative. Further information is set out in the guidance issued to support the WTSR.

A.9.4 Design of Machinery to Support Safe Systems of Work

The Essential Health and Safety Requirements in Annex 1 of the Machinery Directive include:

> "*Machinery must be fitted with means to isolate it from all energy sources. Such isolators must be clearly identified. They must be capable of being locked if reconnection could endanger persons. Isolators must also be capable of being locked where an operator is unable, from any of the points to which he has access, to check that the energy is still cut off…*
>
> *… After the energy is cut off, it must be possible to dissipate normally any energy remaining or stored in the circuits of the machinery without risk to persons.*
>
> *As an exception to the requirement laid down in the previous paragraphs, certain circuits may remain connected to their energy sources in order, for example, to hold parts, to protect information, to light interiors, etc. In this case, special steps must be taken to ensure operator safety."*[14]

Machinery that complies with these requirements will readily enable operation under a safe system of work; conversely if the need for isolation has not been given due consideration at the

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[14] European Commission – Enterprise and Industry - *Guide to application of the Machinery Directive 2006/42/EC*

design stage, with respect to foreseeable tasks, then it will be much more difficult to provide essential isolations.

A.9.5 REFERENCES

HSE HSG250 - *Guidance on permit-to-work systems* provides detailed guidance on the essential requirements of a PTW system.

HSE HSG85 – Electricity at Work: Safe working practices provides guidance on the key elements that need to be considered when devising safe working practices for people who carry out work on or near electrical equipment.

HSE HSG253 -The safe isolation of plant and equipment provides guidance for the on/offshore oil or gas industry, chemical manufacturing and associated industries to enable duty holders to develop, review and enhance isolation standards and procedures.

RenewableUK website: *Health and Safety – the Wind Turbine Safety Rules*

A.10 SIMULTANEOUS MARINE OPERATIONS (SIMOPS)

OREI development typically involves the construction and subsequent maintenance of large numbers of similar offshore structures, which is in direct contrast to more traditional offshore operations in the oil and gas industry, involving a smaller number of larger structures. The large number of simultaneous operations in support of this pattern of development increases the risk of interference between different operations; where such interference could lead to adverse effects such as unsafe situations or asset damage occurring, a SIMOPS process should be used to manage the operations.

The SIMOPS process, which will generally be led by the Marine Co-ordination function, and involve relevant package managers and contractors, can be summarised as:

- Identification of the SIMOP, which may arise due to causes such as:
    - More than one operation being scheduled for the same time and location;
        - This may either be a consequence of intentional scheduling, or a result of factors such as task durations differing from the original plan. For example, a delay in the completion of foundation piling could lead to clashes between the programmes for transition piece installation and array cable laying;
    - Physical interference between vessels and other operations that are spread over a wide area, such as cabling works or the anchor patterns of moored barges, affecting transit routes between the port and the development site;
- Planning phase, typically consisting of:
    - Kick-off meeting, involving all parties to the operation, in order to:
        - Define the scope of the SIMOP; and
        - Identify and assess risks and mitigation measures.
    - Preparation of work-package information by each of the SIMOPS participants, including:
        - Procedures;
        - Drawings;
        - Vessel information;
        - Organisation chart;
        - Principal hazards and mitigation measures;
        - Management of change procedure;
        - Identification of escape routes;
        - Metocean limitations for operations;
        - Routine and emergency communications arrangements; and
        - Contingency plans;
    - Joint review of work-package information to ensure compatibility, assess risks, and agree risk control measures;
        - The outcome of this review will inform the development of an interface plan, detailing the agreed arrangements for managing the SIMOP;
- Execution phase, including:
    - Initial briefing of all parties;
    - Ongoing communications for the duration of the SIMOP; and
    - Monitoring of operations against the plan, and ensuring effective control of change;

- Close-out review to identify any learning for future operations.

The level of effort in this management process will be determined by the level of risk which the SIMOP presents, and whether similar operations have previously been undertaken. Over the lifecycle of an OREI, it is likely that there will be many situations where similar operations are repeated at different locations, sometimes with different vessels and crews involved; effective management of these changes will be key to the safe and efficient management of the SIMOPS.

A.10.1 References

IMCA M203 – *Guidance on Simultaneous Operations (SIMOPS)* provides detailed guidance and explanation of the SIMOPS process described above.

A.11 STAKEHOLDER ENGAGEMENT

The consenting process for OREIs takes account of the views of statutory consultees, including:

- Regulators such as the MCA, CAA, and the Environment Agency;
- Conservation bodies, such as the Joint Nature Conservation Committee (JNCC);
- The relevant General Lighthouse Authority (GLA); and
- Local councils.

Beyond the statutory consultees, there should be appropriate engagement with a wide range of other stakeholders such as:

- Other sea users – including merchant shipping, fishing, recreational interests, and the RNLI;
- Local resilience fora (England & Wales) or Scottish Government; and
- Host communities, whose views will be considered by councils and consenting authorities.

Some of these stakeholders will be directly concerned with health and safety; in other cases, the stakeholders' areas of concern may introduce additional challenges to the safe execution of the project, for example if planning conditions that aim to avoid disturbance to protected species of wildlife require works to be undertaken during seasons that do not offer ideal conditions.

Engagement with stakeholders can take several forms, with the appropriateness of the approach depending on how best to address their needs and expectations relating to the issue; these forms of engagement include:

- One-way provision of information;
    - In simple, non-controversial cases, this may be all that is required to address potential or actual concerns, particularly if it is provided in a clear, timely and willing manner;
- Two-way consultation, and deeper involvement and participation in a collaborative process:
    - These approaches can help to identify issues, provide information and develop solutions;
    - They provide an opportunity to learn from internal and external experience.

The appropriateness of each of these approaches depends on the issue being considered, in terms of:

- The level of concern about the issue; and
- The level of discontent with how the issue is being addressed.

An effective stakeholder engagement process will:

- Be supported by the provision of suitable information, in a format that is useful to the participants, and with an appropriate level of detail;
- Be transparent, with a clear process that demonstrates how the outcomes relate to the inputs;
- Be targeted at the issues that are most relevant to the stakeholders involved; and
- Have demonstrable support from senior levels of the organisation, so that it is clear that the engagement is a real part of the decision-making process.

Similar processes can also be applied to engagement with internal stakeholders, such as employees, in the development of safety management arrangements:

- Where employees are involved in the development of procedures, possibly including testing or trialling novel approaches, not only is it likely to result in more effective procedures, but it will also increase ownership and support for their adoption;

- In some cases, the engagement process is fully empowered to make decisions, rather than just advising a separate decision-maker.

The effectiveness of internal stakeholder engagement approaches is strongly connected to an organisation's safety culture, and also reinforces it.

A.11.1 REFERENCES

Rail Safety & Standards Board - *Engaging Stakeholders in Safety Decision Making*: while some of the comment is specific to the rail industry, Section 3 reviews the approaches used in a range of industries, and Section 4 outlines a framework for determining appropriate approaches to engagement, together with assessment of the strengths and weaknesses of different approaches.

A.12 SUPPLY CHAIN MANAGEMENT

The development and maintenance of an OREI rely on procurement of services and goods from a wide range of contractors and suppliers, so the overall health and safety performance of a development will largely depend on how well these entities fulfil their duties.

A.12.1 CONTRACTED SERVICES

The majority of OREI survey, design, construction, installation and commissioning is generally undertaken by contractors; successful management of project safety therefore depends on:

- Appointment of suitable Competent Persons for key safety-related roles;
- Appropriate contractor selection, considering their safety culture, and ensuring that a contractor's investment in developing competent people and safe methods brings a competitive advantage, rather than just considering the initial cost;
- Effective communication of safety information to the relevant personnel, including between contractors and phases of a project;
- Agreement of suitable contractual arrangements, that promote safe working and define relevant KPIs; and
- Effective monitoring of contractor performance according to KPIs and compliance with method statements.

During the O&M phase, work is typically carried out by a combination of the owner's employees and contractors, some of whom will be based at the site on a long-term basis, with others undertaking specific tasks as required. This change in the balance of contracted and in-house work, together with an increased proportion of the work being on longer-term contracts, changes the emphasis of safety management effort; the site will have an established safety culture and management systems, with which contractors can be expected to integrate.

A.12.1.1 COMPETENCE AND CONTRACTOR SELECTION

The CDM regulations, which apply to all construction projects in Great Britain and its Territorial Sea, impose duties on all parties involved in construction work to ensure their own competence, and the competence of those whom they appoint, to undertake the tasks for which they are appointed; the appendices to the CDM ACOP describe processes for assessing the competence of CDM Co-ordinators and Contractors. The level of effort in assessing competence should be proportionate to the risk that the work in question represents.

Prior to appointment of contractors, clients typically use pre-qualification processes to carry out initial screening of potential contractors. Repeated pre-qualification for multiple potential customers can impose a significant administrative burden on contractors, which can be mitigated in various ways, such as using:

- Intermediary organisations that pre-qualify suppliers on behalf of a large number of potential customers; or
- Standard formats such as BSI PAS 91 Construction related procurement – Prequalification questionnaires.

Such approaches can be used where appropriate to the nature of the work, and supplemented as necessary by project-specific assessment.

While the CDM regulations only apply to construction work and enabling activities, the approach that they adopt to verifying Contractor competence could be applied to selection of contractors in other situations. However, CDM defines clear roles and responsibilities, such as Client and Principal Contractor; when work is undertaken that does not come under CDM, then there is an increased need for the client to work with the contractor to agree how health and safety will be managed, such as:

- Whether the work is to be undertaken by the contractor operating under:
    - The client's health and safety management system (SMS); or

- Their own SMS, with bridging documents to manage the interface with the client SMS, and an agreed level of audit by, and reporting to, the client;

- Allocation of responsibilities for instruction and supervision of the works;
- Arrangements for verifying the competence of key contractor personnel, including any requirements for the client to review CVs, or even interview potential appointees; and
- Arrangements for managing safety-related interfaces. For example, for offshore work, the owner is likely to appoint contractors to transport people (both contractors and direct employees) and equipment to and from the work location. This introduces a number of interfaces, needing clear management arrangements.

The suitability of any given approach to these issues will depend on the nature of the work, and the capabilities of the parties involved.

A.12.1.2 Contractual Arrangements

Conditions set out in contracts should be aligned with health and safety objectives – indeed, this should be clear from the start of the tendering process. The contract schedule should ensure that realistic durations are allowed for preparatory work as well as offshore activities, and that any incentives or penalties in the contract promote safe and efficient execution of the work.

Weather conditions will affect offshore work, and contracts need to provide for this; appropriate sharing of risk will encourage the selection of vessels and methods that minimise weather downtime. Contracts should avoid creating a situation where weather delays can expose a contractor to a loss that they cannot sustain, as this may encourage risk-taking. Individual employees may also have contractual incentives for offshore work; these need to be appropriate, and support safe working.

Where contracts are let on a one-time basis, there may be less opportunity for the mutual influencing of contractor performance and client demands than in cases where a longer-term alliance is formed.

Contracts will also need to define the arrangements for performance monitoring, incident investigation and reporting, to ensure that there is visibility of suitable leading and lagging indicators, and appropriate follow-up of incidents. On a multi-contractor project, common arrangements will be needed for all contractors, to ensure consistency. Recognising that contractors work on multiple sites, increasing commonality in reporting requirements across the industry can reduce the administrative burden and improve the quality of reporting.

A.12.1.3 End of Contract Review

On completion of the contract, both the client and contractor can benefit from undertaking a joint review to consider areas of learning, such as:

- Outputs of active and reactive monitoring of health and safety, to understand how effectively safety management systems operated, and provide feedback on incidents;
- Adequacy of pre-contract information;
- Any late changes to the planned works; and
- Suitability and performance of equipment, techniques and vessels used.

The outcomes of the review should be shared as appropriate within the organisations involved, and through industry reporting schemes, in order to avoid the same issues being repeated elsewhere.

A.12.2 Supply of Plant, Equipment and Structures

Development of an OREI involves the procurement of a very wide range of physical goods, ranging from sophisticated mechanical and electrical systems, to rock for scour protection. Procurement decisions affect the project risk profile in several ways:

- The degree to which health and safety is considered in the design and quality of products will affect the risk to people, both immediately, and in the course of O&M

activities during the operating life and ultimate decommissioning / disposal of the product;

- The robustness of QA arrangements will affect the level of risk that may arise from a product not performing as specified; for example, poor preparation of surfaces prior to painting may lead to accelerated deterioration and additional offshore maintenance / repair work; and
- The management of health and safety in the facilities where the products are manufactured will affect the risk to the people involved;
  - This is an important Corporate Social Responsibility issue, recognising that OREIs include numerous heavy fabricated structures, which may pose high risks to those involved in their production unless suitable safety management processes are in place throughout the global supply chain.

The scale of proposed OREIs allows for effective engagement with suppliers in each of these areas. This can be particularly effective at the prototype stage of development, as this provides an opportunity for hands-on assessment, and feedback based on operational experience.

For simple purchases of standard items, which do not affect the project risk profile, streamlined approaches such as electronic auctions may be appropriate, particularly in cases where the required characteristics of the product can readily be quantified.

A.12.2.1 REFERENCES

HSE L144 - *Managing health and safety in construction - Construction (Design and Management) Regulations 2007 Approved Code of Practice* – especially Appendices 4,5, which relate to competence assessment.

BSI PAS 91-2010: *Construction-Related Procurement* details a standard prequalification process and questionnaire, and can be downloaded free of charge from the BSI website (registration required).

The documents listed below may be useful guidance, but are based on oil and gas industry practices, and therefore do not refer to CDM requirements:

- International Association of Oil & Gas Producers Report No. 423: *HSE Management – Guidelines for Working Together in a Contract Environment* describes a process, and issues to consider, for health and safety management of a contracted work package from planning through to final review.
- NORSOK Standard S-006 - *HSE Evaluation of contractors*: Appendix A gives suggested contractual requirements relating to health, safety and environmental protection, while Appendix B suggests indicates how the relevance of different considerations may vary according to the nature of the contract.

A.13 MANAGEMENT OF CHANGE

An effective design process will minimise the need to make changes later in the project lifecycle, however several different types of change are inevitable over the lifecycle of an OREI; these may be:

- Technical, relating to the design or specification of equipment and materials;
    - These can be highly visible, such as exchange of hardware, or invisible but still very important, such as changes to software;
- Organisational, relating to staff, contractors or systems;
- Permanent or temporary, such as an operational restriction on an item of equipment until checks or repairs have been undertaken.

Unexpected or unforeseen events or situations may arise at any stage throughout the OREI lifecycle. These may require changes to be implemented quickly, which if not managed effectively, may significantly increase health and safety risks. Other changes may arise as a consequence of the project progressing, with different management arrangements being required in construction and O&M phases; while these are foreseeable, care is still required in their management.

A.13.1.1 OVERVIEW OF CHANGE MANAGEMENT

Whether changes are planned or unplanned, their potential impact on health and safety must be properly assessed, so that hazards or risks associated with technical or procedural changes and their implementation are identified and managed effectively. An effective Management of Change process should be implemented across all phases of the OREI lifecycle, so that changes can be introduced effectively into the workplace. This process should consider:

- The need for the change;
- How the change will affect the health and safety risk presented by the OREI;
    - In general, modifications should reduce risks; if the assessment indicates increased risk, then the design should be reconsidered;
- The risks that will occur during the installation and commissioning of the modification, including any additional equipment or materials that will be used;
- Requirements for follow-up activities, such as:
    - Provision of training and information those who will be affected, updating of drawings, and changes to spares inventory;
    - Review, and where necessary, revision of existing risk assessments, safe systems of work, method statements and work instructions;
    - Any additional control measures – organisational, procedural, engineering controls and / or PPE;
    - Issuing modified information and instructions to relevant people, and the withdrawal of information and instructions that are superseded;
- The allocation of sufficient time and resources to implement the change.

Given the wide range of implications that a technical change can have, effective communication is key to minimising risk.

In many cases, given the number of individual devices within a large OREI, changes will be phased in over an extended period of time, leading to the parallel operation of modified and unmodified equipment. This will require the operation of very effective management systems in order to minimise the risk of this temporary inconsistency causing confusion, such as provision of incorrect spare parts, or use of inappropriate procedures.

The change management process should involve people with direct experience of the equipment and activities involved, in order to have the clearest understanding of potential effects and any previous attempts to address the issue to which the modification relates.

A.13.1.2 Implementation of Major Modifications

Where modification programmes involve major changes, such as structural alterations to equipment on an OREI, or where the implementation of the modifications will involve "*substantial dismantling or alteration of fixed plant which is large enough to be a structure in its own right*", then such work falls within the definition of construction, under the CDM regulations, and should be managed in accordance with the duties defined in the regulations.

Depending on the scope of construction work, the project may also be notifiable to the HSE, and also require the appointment of a CDM Co-ordinator and a Principal Contractor (PC). This introduces an interface between other parts of the OREI that are in normal operation, under the control of the Operational Controller, and those that become a construction site, under the control of the PC; this is similar to the situation that occurs in a phased handover from construction to operation, and requires both the owner and the PC to take account of this in their safety management systems.

A.13.1.3 Control of Software Change

While some modifications will be obvious to any technician approaching an item of equipment, software modifications can introduce fundamental changes to the operation of equipment, without of themselves being visible. Software changes should be managed with the same rigour as physical changes, with additional attention being paid to ensuring that:

- Unintended effects and interactions are avoided, by undertaking suitable validation of code, and functional testing of the device after the modification has been implemented;
- Backups are made before the changes are implemented, in order to provide a path for reversal of the change;
- Any parameters that may have been set during initial commissioning are retained in the correct state when the upgrade is applied, and not reset to default values; and
- The software archive is updated on completion, to ensure that any future developments are based on the most recent version of the programme, so that modifications are not accidentally lost in future.

The level of effort to be applied to managing a software modification should reflect the level of risk that the software can give rise to, with particular care being taken where software can affect the safety of people, or the protection of equipment. In cases where software updates can be implemented from remote locations, close co-operation is needed between the software engineering function and the operator in order to maintain satisfactory control of such changes.

A.13.2 Personnel changes

In addition to technical changes, personnel changes require careful management. These can be very obvious, such as a change of contractor, or more subtle, such as:

- Introduction of new people to established work groups; or
- Loss of experienced people to other duties or employers.

Thorough induction processes should be in place, supported by formal systems to provide increased supervision and support for new employees, ideally differentiating between those who are new to a site, and those who are new to the industry; the "Green Hat" system used in offshore oil and gas has proved an effective approach. These processes address the fact that a person who is working in an unfamiliar environment is at increased risk of making mistakes that affect the safety of themselves and others around them.

A.13.3 References

IMCA SEL-001 – *The Management of Change in the Offshore Environment*.

Step Change in Safety publishes *New Starts – Green Hats – Keeping Them Safe* which describes the approach for identifying those who are new to offshore, and new to a location.

A.13.3.1 ELSEWHERE IN THIS GUIDANCE

Modifications & upgrades considers where changes will occur in the OREI lifecycle, and the management of major organisational change.

A.14 STRATEGIC PLANNING

The management systems described in Section A.6 provide the framework for the control of risk in day to day operations, as well as short-term forward planning and reviewing past performance. However, the management systems must be suitable for the nature of an organisation's activities at a given point in time, taking account of the state of development of the industry, and should therefore be driven by a strategic planning process. This is similar to the approach by which successful organisations determine their wider business strategy; the strategic planning of health and safety can follow on from this, in order to identify how the objectives determined by the business strategy can be achieved safely. Taking such an approach is particularly important in organisations, or industries, that are changing rapidly.

Strategic planning is a formal, periodic process by which an organisation looks ahead, typically over the next 3-5 years. Various tools are used, with SWOT analysis being one of the most common approaches; in the context of health and safety, this could consider:

- Strengths and Weaknesses: these are internal factors, describing the current state of the organisation, such as:
    - Comparing the experience gained on past projects with the scale and nature of planned future projects;
    - Resources available;
- Opportunities and Threats: these are external factors, likely to shape the future operating environment for the organisation; these may include aspects such as changes in:
    - Market conditions, such as the balance of supply and demand for equipment and services;
    - Technology, ranging from entirely new energy conversion devices to new access or remote diagnostic methods; or
    - Regulation and licensing, such as leasing rounds opening up in new areas, or amendments to EU Directives.

The outcomes of this analysis are then considered in the context of the organisation's fundamental purpose (its mission), informed by the organisation's vision of how it will operate in future, and its values, which set the priorities. These combine to define the strategy for how the organisation is to move from its present state to the desired future state.

In organisations that are growing rapidly, or moving from one phase of the project lifecycle to another (for example, from design to construction of an offshore wind farm), this type of process should be used to guide the development of health and safety management competence. Even for an organisation that is apparently operating in a steady state, periodically undertaking such a review could reveal needs such as succession planning, or changes in the market or regulatory regime that will require adjustments to the organisation's strategy.

A.14.1 PREDICTING AND ADAPTING TO NEW AND EVOLVING SITUATIONS

Part of the function of the strategic planning exercise is to gain some foresight of developments that may cause shifts in the future risk profile, so that the organisation is prepared for them in advance. Present examples of emerging risks include:

- Increasing use of "flotel" or mothership concepts:
    - Strategic concerns would include identifying conceptual requirements for such vessels and understanding the regulatory / vessel classification regime;
    - Specific issues such as vessel selection, emergency response and operating procedures relating to transfers and weather limits would be considered as part of the health and safety management systems;
- Increasing remoteness of developments from shore:
    - Strategic considerations would include the adoption of different access and support strategies;

- Management arrangements would then need to be implemented to support the new strategy.

Strategic planning should also consider emerging opportunities: for example the increasing scale of the industry, particularly in areas where several developments are to be located close to each other, may create opportunities to share support services between developments. While some opportunities, such as shared metocean data collection and forecasting, have little direct impact on an organisation's risk exposure, others such as shared monitoring and emergency response facilities would need a degree of alignment between different organisations' health and safety strategies, as well as clear management arrangements.

The organisation can also use this foresight to ensure that suitable contingency plans are in place prior to emergency situations arising; while the detailed management arrangements for responding to marine emergencies will be defined in the Emergency Response Co-operation Plan, the organisation also needs to have arrangements in place for broader operational risks, to ensure appropriate and effective responses and continuity of operations.

A.14.2 REFERENCES

HM Treasury - *The Orange Book - Management of Risk - Principles and Concepts* provides detailed guidance on risk management across an enterprise, and considers both the organisation's strategy and management approaches, in relation to external and internal sources of risk. The PESTLE approach (which considers Political, Economic, Socio-cultural, Technological, Legal / regulatory and Environmental risks) is particularly relevant to strategic planning.

A.15 EMERGENCY RESPONSE & PREPAREDNESS

A.15.1 SCOPE AND RELEVANCE

In the event of an emergency occurring at any stage of the OREI lifecycle, the operator of the development is responsible for leading the initial response, including care and evacuation of any casualties; this reflects the fact that the operator will have people and vessels on site, and is therefore able to provide the most immediate response. Alternatively, during the construction phase, the developer and Principal Contractor may agree that the Principal Contractor will lead the emergency response.

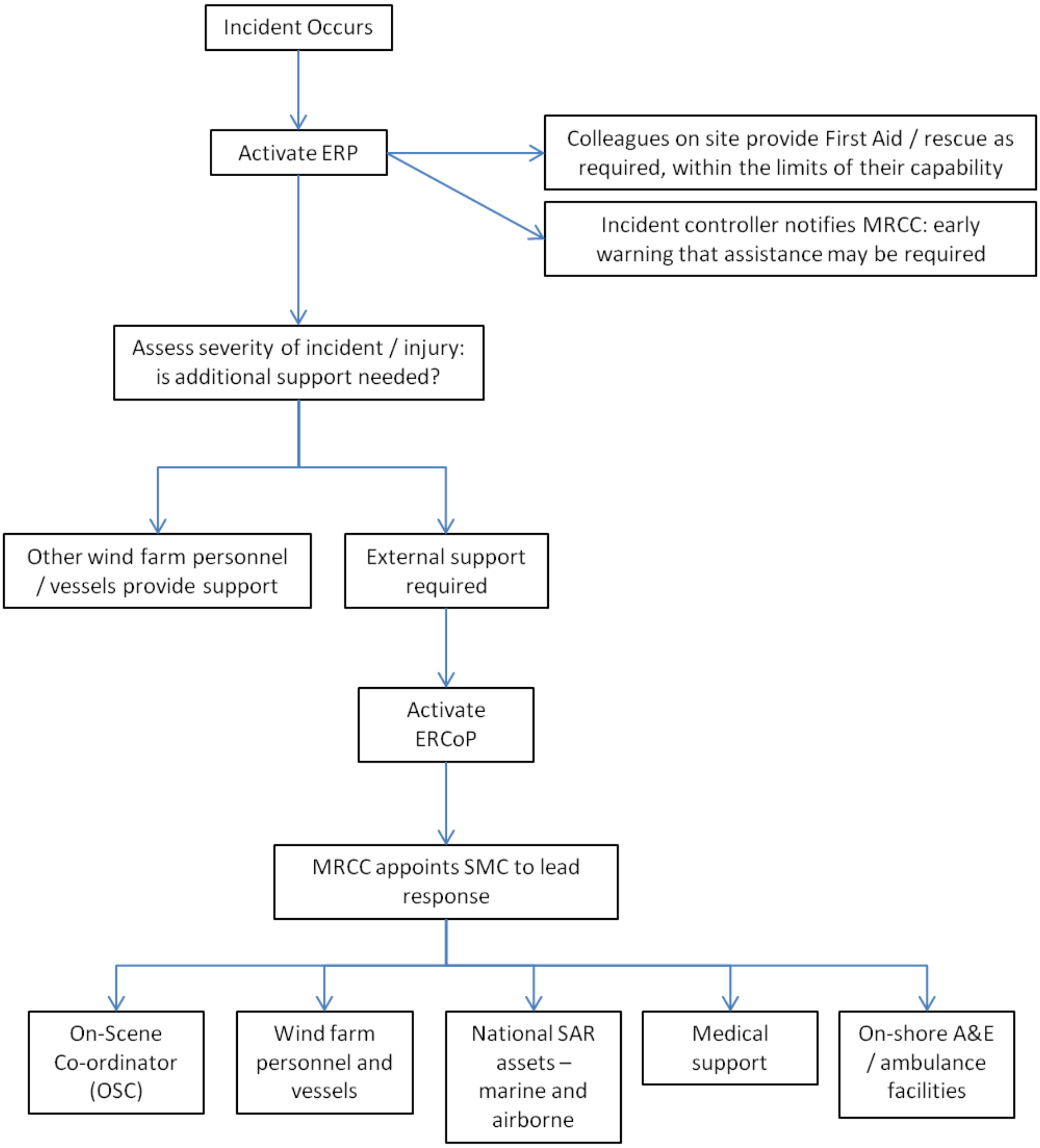
This response will normally follow their predetermined procedures detailed within the OREI's Emergency Response Plan (ERP). If the incident is deemed within the capability of the OREI operator and does not have a critical impact on the health of the individual, then the operator will be responsible for the safe conclusion of the incident. If there is any doubt, or if specific assistance may be required, e.g. the transfer of a casualty from a work boat to an ambulance, then assistance should be sought through the MCA's Marine Rescue Co-ordination Centre (MRCC) with responsibility for the sea area where the development is located.

Should the scale or severity of the incident exceed the operator's capability to respond, and in any case where a casualty's life is endangered, then assistance should be obtained from national marine rescue resources, by escalating the incident according to the procedures defined in the Emergency Response Co-operation Plan (ERCoP). The ERCoP is required to be in place prior to commencement of offshore work, so that roles, responsibilities and resources are all clearly defined in advance of an incident occurring. The ERCoP will be a joint agreement between the operator and the relevant MRCC.

A Search And Rescue (SAR) Mission Co-ordinator (SMC) will be allocated by the MRCC for each incident and will lead subsequent stages of the incident response. Should there be any doubt as to the severity of a casualty's injuries, then a doctor's advice will be sought through the MCA's (MRCC) on-call medical advice providers - either Aberdeen Royal Infirmary (ARI) or Queen Alexandra Hospital, Portsmouth (QAH). The SMC will decide on the proposed SAR plan, taking into account all relevant issues and following detailed discussions with the OREI operator. Should a helicopter rescue be contemplated, then the MRCC will request an aviation asset through the UK's National Aeronautical Rescue Co-ordination Centre (ARCC).

The sequence of steps in the response to an incident is shown in Figure 3 below.

Figure 3: Incident Response flowchart



A.15.2 Application and Examples Offshore

The OREI operator is responsible for the initial stabilisation of the casualty, and providing care up to the point where they have been handed over to external medical teams; depending on the situation, this could be at a local hospital, an ambulance on the quayside, or a helicopter / lifeboat medic.

External assistance could on rare occasions take a considerable time to arrive, therefore the level of medical / rescue provision by the operator should be proportional to the hazard exposure and time for external response; the required level of provision at any point in time therefore depends on:

- The operations being undertaken;
- The location; and

- Any other factors (such as metocean conditions) that could affect external response times.

First aid provision should consider:

- The level of training of technicians;
- Availability of others with additional skills within the OREI site;
- Equipment to be provided; and
- The locations where equipment should be stored, such as in the nacelle, tower, or on a vessel.

OREIs are inherently safe locations and abandonment should only be considered as a last resort.

A.15.2.1 LIMITATIONS AND INTERFACES

The UK SAR service comprises a mixture of dedicated assets, including government bodies such as the MCA and MOD, and volunteer organizations such as the Royal National Lifeboat Institution (RNLI). The UK's Renewable Energy Zones are largely contained within the UK Search and Rescue, although they are not mirror images.

The ERCoP will address interfaces for a given site in detail; in general, key interface points with emergency services are:

- National SAR helicopter assets will only recover a casualty from the WTG nacelle or from a vessel that is clear of wind farm obstructions:
  - The WTG will have to be prepared for helicopter transfer in accordance with MGN371 and the MCA / OREI ERCoP;
  - Helicopter crew members will enter the nacelle but are not trained to undertake technical rescues from within the WTG structures;
    - Should specialist help be required then the SAR helicopter could transfer Turbine Rescue Teams (i.e. specialist wind farm staff) to the incident turbine to assist in the relocation of the casualty to a transfer position;
- Lifeboat crews may assist with marine emergencies, but are not trained in climbing WTG towers;
- Ambulances may transport casualties from quayside to hospital, but are not necessarily trained or equipped to transfer a casualty from a vessel, so arrangements need to be in place to bring the casualty to the agreed handover point;
- In the event of any incident involving a fatality or life-threatening injury, the police should be informed without delay.

The ERCoP should also address emergencies that can occur in ports, in which case additional interfaces and resources need to be considered.

A.15.3 RISK ASSESSMENT AND RISK MANAGEMENT

The OREI operator is responsible for completing hazard identification for all aspects of the OREI and ensuring that proportionate barriers and mitigation measures are put in place. Such measures should form the basis for the OREI ERP, which needs to provide procedures to follow in the event of emergency situations such as:

- Injury or illness requiring rescue and evacuation of a casualty from a WTG;
- Marine accident involving vessel(s) that are supporting the OREI, including person overboard;
- Marine emergency involving vessels unrelated to the OREI, but occurring in its vicinity, such as a drifting vessel.

While the primary responsibility rests with the OREI operator, some foreseeable situations may be beyond their capability to respond. Such contingencies will influence the creation of the OREI ERCoP. Emergency response procedures should take into account nearby offshore energy installations and should declare what assistance could be made available to assist nearby SAR incidents, unrelated to the OREI.

The MCA provide a detailed template for ERCoPs on their website, covering both construction and operations phases. The ERCoP includes information about:

- The company that is developing / operating the OREI, including contact and communication arrangements;
- The OREI, including its location, layout, heights and arrangements for shutdown;
    - During the construction phase, regular updates on activities are required;
    - Vessel information is also required, as the OREI's own access vessels are the primary means of rescue and emergency response;
- The MRCC, including communications systems, and arrangements for the appointment of an On-Scene Co-ordinator (OSC) from amongst the OREI staff to support the SMC in managing the incident;
    - The OSC is a key role, so it is important that sufficient personnel on site at any given time have the training and capability to fulfil this role in an emergency situation;
- The responsibilities and primacy of the different parties involved;
- SAR facilities, including surface craft and helicopters;
- Search planning, including the effects of local currents / wind on a drifting casualty;
- Arrangements for medical support;
- Arrangements for support with firefighting or release of trapped personnel;
- Shore reception arrangements, including transfer and subsequent care, to ensure that interfaces with on-shore support are clearly defined in advance;
- Procedures for informing and supporting next of kin;
- Procedure for standing down SAR participation;
- Procedures for notifying authorities of any criminal activities suspected within or around the site;
- Procedures for handling media relations.

Where the involvement of local emergency services such as coastguard, fire, and medical services is envisaged, preparation of the ERCoP provides an opportunity to determine whether or not these services have sufficient capacity or specialist capability to cope with the potential new demands. Early dialogue between developers and local emergency services will develop a clear mutual understanding of capabilities and operational activities.

A.15.3.1 RESPONSE PRIORITIES

It is essential that the ERP and supporting systems and arrangements set out clear priorities for the incident response team, to enable them to manage an incident effectively. PEAR(LS) is a commonly accepted response hierarchy used offshore. It sets out the priorities of the incident response team as follows:

- People – saving and safeguarding life;
- Environment – protection and mitigation;
- Asset – protection of plant and property;
- Reputation – protection of company image;
- Liabilities – commercial and contractual commitments; and

- Sustainability – on-going business continuity.

A.15.4 MONITORING / REVIEW AND CHANGE MANAGEMENT

The ERP and ERCoP should be tested and reviewed regularly, and revised as necessary. A formal review should be conducted in consultation with the MCA to capture lessons learned after the activation of either the ERP or ERCoP.

Individual elements of the plan, such as man overboard drills, communications equipment and rescue arrangements should be tested regularly, together with desktop exercises and full scale exercises in the field, involving both OREI personnel and local emergency services where it is safe and practicable to do so.

A.15.5 RELEVANT GOOD PRACTICE

In the event of an emergency, it is essential that all personnel involved are fully familiar with their roles and responsibilities, which may vary depending on the nature of the emergency and their location at the time. For this reason, thorough training in the ERP and ERCoP is required before each phase of the development lifecycle, or when the plans are updated, together with regular exercises to ensure preparedness. Competence is required in a range of areas, including:

- Casualty rescue and evacuation;
- First aid;
- Incident control;
- Emergency co-ordination;
- Media liaison;
- Communication with relatives
- Regulatory liaison; and
- Firefighting.

Emergency information should be displayed at suitable locations within the OREI, so that it is available to personnel when required.

During the construction phase, the Principal Contractor (PC) may take the lead responsibility, rather than the OREI operator; any such transfers of responsibility must be managed with absolute clarity, both within the project team and externally, particularly if handover from the PC to the operator is phased to match the development of different geographical areas of a project.

Emergency management teams may need to hire in additional resources, such as vessels, at short notice; this will be more easily achieved if suitable arrangements have been made in advance.

While emergency services may be stood down once the casualty has been evacuated to a place of safety, the employer still needs to ensure that the casualty receives all necessary support; this includes practical arrangements, recognising that the casualty may now be in a location that is remote from their home – possibly even in a different country, with no keys, money or change of clothing, and even if they are fit to drive, they are unlikely to have access to a vehicle.

A.15.5.1 ADDITIONAL CONSIDERATIONS

While the ERCoP defines formal processes for issuing press releases, in conjunction with the MRCC, operators need to be aware of the likelihood of information becoming available by other routes, including social media, and also recognise that marine VHF radio communications can be heard by any receiver within range.

In the event of an incident occurring on any OREI in an area, a high volume of media enquiries may also be received by adjacent operators, even if there is no incident on their own OREI; operators may need to be prepared for this situation arising, both in terms of readiness to handle enquiries, and co-operation with neighbouring sites.

A.15.6 Legislation & Standards

HSE HSG65 - *Managing for health and safety (2013)* provides guidance on the arrangements that are needed for emergency preparedness.

MCA MGN 371 - *Offshore Renewable Energy Installations - Guidance on UK Navigational Practice, Safety and Emergency Response Issues*: Annex 5 details design and operational requirements for offshore wind turbines in relation to emergency situations, including helicopter rescues.

The MCA Website provides a template for ERCoPs.

The HSE provides a checklist of considerations for assessing preparedness for emergencies; it is not aimed at renewables, but has a focus on human factors.

Search and Rescue (SAR) Framework Document for the United Kingdom of Great Britain and Northern Ireland details the UK's comprehensive SAR service for those reported in trouble either on land, on water or in the air and for those reported missing.

The *IMO SAR Convention (1979)* aims to ensure that no matter where an incident occurs, the rescue of persons in distress will be co-ordinated by a SAR organization, or by co-operation between neighbouring SAR organisations; this is relevant where developments take place close to international borders, and hence cross-border co-operation may be required in an emergency.

International Air and Maritime Search and Rescue (IAMSAR) publications provide detailed practical guidance on SAR marine and aviation procedures.

OPITO Approved Standard - *OIM Controlling Emergencies*, provides an example of the approach used in the oil and gas industry to defining and managing the competence of personnel in safety-critical roles; while the content is industry-specific, the approach may be of value.

The Cabinet Office website *Risk Assessment* pages give information on national and local emergency management and resilience arrangements, while the *Civil Contingencies* pages set out the regulations and statutory guidance for Emergency Preparedness including establishing a clear set of roles and responsibilities for those involved in emergency preparation and response at the local level. Note that Category 2 responders potentially include utility companies.

RenewableUK - *Incident Response: Offshore Wind and Marine Projects* sets out a reminder and simplified protocol for managing the immediate stages following an actual or potential major incident where third party assistance may be required.

BSI PAS 200:2011 - *Crisis management – Guidance and good practice* is designed to help organisations to take practical steps to improve their ability to deal with crises; it recognises that crises are distinct from operational incidents, and therefore require different management approaches.

A.16 FIRST AID AND EMERGENCY MEDICAL RESPONSE

A.16.1 OVERVIEW

While the main objective of health and safety management is to reduce the risk of people suffering injury or illness at work, the risk cannot be entirely eliminated. Suitable arrangements should therefore be put in place, in order to minimise the severity of the effects on a person who is ill or injured; these arrangements aim to:

- Preserve life, by the application of first aid techniques;
- Prevent further harm, by taking steps to reduce the risk of the condition worsening; and
- Promote recovery, by enabling the start of the recovery process from the illness or injury.

The definition of first aid in the Health and Safety (First-Aid) Regulations 1981 includes "*in cases where a person will need help from a medical practitioner or nurse, treatment for the purpose of preserving life and minimising the consequences of injury and illness until such help is obtained*", as well as the treatment of minor injuries where no medical support is necessary. This definition is clearly focused on preserving life and minimising consequences; achieving this may go beyond the scope of traditional first aid provision, so first aid and emergency medical response capability should be considered together.

First aid provision should be integrated with the Emergency Response Plan for the OREI, and is likely to comprise successive levels of support, for example:

- The immediate response is likely to be provided by the casualty's colleagues in the working party who will raise the alarm, and where it is safe to do so, rescue the casualty from immediate danger and provide initial first aid within the remit of their training;
- Other personnel within the OREI may provide further assistance in the care of the casualty, particularly where they have more advanced first aid or medical training and may also assist with evacuation to a support vessel or helicopter; and
- Support vessels within the OREI may be needed both to transport assistance to the casualty, and evacuate the casualty, and may also provide access to further equipment and supplies.

Each level of support must be capable of taking care of the casualty until the next level of support is available, until the casualty is handed over to full medical care, in a place of safety such as a hospital or ambulance.

A.16.1.1 POTENTIAL HAZARDS AND RISKS

A.16.1.1.1 Direct Health and Safety Risks

Work on OREIs presents a number of hazards that the first aid provision has to address:

- There is the potential for complex and difficult injuries to occur, such as suspension syncope, electric shock, major trauma, crushing / entrapment, hypothermia, and heat stress;
- Injuries may occur in locations that are difficult to access, or in restricted working positions such as work at height or in confined spaces;
- Underlying medical conditions may give rise to acute illness;
- OREIs are located beyond the reach of land-based emergency services, while offshore emergency service personnel (such as Search and Rescue (SAR) and RNLI) will not have the necessary training to enter OREI structures; and
- Metocean conditions may contribute to the risk of incidents occurring, and impede the subsequent response and evacuation.

It should be noted that, in general, the emergency services will only become involved in evacuation if there is a danger to life; in less critical cases, the resources of the OREI should be capable of providing all necessary care and evacuation; the detailed interfaces will be defined in the ERCoP.

A.16.1.2 RELEVANCE TO KEY LIFECYCLE PHASES

The risks to people, and the number of people exposed, will both vary over the lifecycle, as will the level of support available within the OREI; a typical pattern could be:

- During construction:
  - Large numbers of people will be undertaking high-hazard activities;
  - The workforce will be provided by multiple contractors, often from a number of different countries; and
  - There will be numerous vessels on site, possibly including large construction vessels with comprehensive medical facilities and helipads;
- During commissioning:
  - Most heavy lifting and assembly work will have ceased; electrical systems will be energised, and moving machinery will be present;
  - The workforce will be smaller, provided by a reduced number of employers; and
  - There will still be numerous vessels on site, but these are more likely to be crew transfer vessels or workboats, with more limited first aid provision;
- During Operations and Maintenance:
  - The work will be very varied, ranging from low-hazard inspection activities to repair or replacement of major components;
  - The core workforce is likely to be permanently assigned to the OREI, with specialist contractors coming to site as required; and
  - Vessel provision will be reduced, and will mainly consist of crew transfer vessels.

A.16.2 REGULATORY REQUIREMENTS

The Health and Safety (First-Aid) Regulations 1981 require employers to provide "*adequate and appropriate*" equipment, facilities and personnel to ensure that their employees receive immediate assistance if they are injured or taken ill at work; the regulations do not prevent personnel with appropriate training from taking action beyond initial casualty management. In summary, the regulations require duty holders to:

- Assess the first aid needs of a workplace, to determine what will constitute adequate and appropriate provision, based on the circumstances of a particular workplace;
- Based on the assessment of needs, provide:
  - A suitable number of persons, with an appropriate level of training, for rendering first-aid to employees; and
  - The necessary first aid materials, facilities and equipment;
- Ensure that persons who provide first aid are competent and trained to an appropriate level; fulfilling this duty may involve:
  - Assessing the suitability of available first aid qualifications, and the competence of training providers, and
  - Providing additional training, if standard qualifications do not give sufficient preparation for the situations that may occur in the workplace; and
- Inform employees of the arrangements that have been made for first aid provision.

During the construction phase, the Principal Contractor has a duty to define the arrangements for provision of first aid, as part of the construction phase plan, and to inform personnel of the arrangements as part of their site induction. On a multi-occupied site, the different employers should co-operate to ensure that their combined or shared first aid provision is adequate, with respect to the hazards and risks on the site, and that employees are kept informed of arrangements.

The HSE provides guidance on the syllabus of standard Emergency First Aid at Work and First Aid at Work courses, however the duty to provide additional training where necessary is particularly relevant to OREIs. The HSE no longer approves any first aid training courses or qualifications; it is the employer's duty to select a competent training provider. This duty can be fulfilled through a various different approaches, including:

- Voluntary approval schemes, with third party accreditation against an industry standard;
    - This allows for the development of first aid training that is targeted at the specific needs of an industry, such as the RenewableUK (GWO) first aid standard;
- Approval by a qualification regulator, such as Ofqual, Scottish Qualifications Authority or the Welsh Government;
- Operation within the assurance systems of a Voluntary Aid Society; or
- Direct provision of evidence to the employer;
    - This may be particularly relevant for specialist training that goes beyond the scope of industry standards.

Irrespective of the approach taken to approval, the training should be in accordance with current Resuscitation Council (UK) guidelines, and the first aid manual of the Voluntary Aid Societies, or with other published guidelines that are consistent with these or supported by a responsible body of medical opinion.

Requirements for first aid training of crew members, and provision of medical supplies on vessels, are defined in maritime legislation; while these regulations do not apply to personnel carried as passengers on vessels supporting OREIs, vessel crew may have a role in the care of a casualty during evacuation from the offshore location, so their capabilities will form part of the overall provision of offshore first aid.

Where subsea operations involving divers are undertaken, the Diving at Work regulations impose a duty on the Diving Contractor to ensure that suitable emergency response and first aid provision is in place, to cope with foreseeable emergencies on the project. The regulations also specify the first aid training requirements for divers, and the provision of diver medics in each dive team.

There is also a duty to report certain accidents and incidents at work under RIDDOR (Reporting of Injuries, Diseases and Dangerous Occurrences Regulations 2013).

A.16.3 MANAGING THE RISKS

A.16.3.1 APPROACHES TO RISK ASSESSMENT

The factors that determine the suitability of first aid provision can be grouped together as:

- The risk to people, arising from factors such as the:
    - Nature of the work to be carried out;
    - The severity of potential injuries or illnesses that may occur;
    - Number of people exposed, their distribution and working patterns;
    - Location (including remoteness) of the workplace;
    - Previous accident history, within the organisation and the industry; and
    - Scale and complexity of the activities being undertaken;
- The response time, which comprises the time taken to:
    - Raise the alarm;
    - Rescue the casualty from immediate danger;
    - Get first aiders and further support to the casualty; and
    - Evacuate the casualty to a place of safety.

The level of provision should be directly related to the foreseeable risks and response times for a particular OREI and task.

A.16.3.2 Risk Mitigation Measures

First aid provision should consider the:

- Level of training of technicians who will provide the immediate response;
- Availability of others with additional skills within the OREI site;
- Equipment and supplies to be provided; and
- Locations where equipment and supplies should be stored, such as in the nacelle, tower, or on a vessel.

On-site personnel who are responding to emergencies may benefit from being able to consult offsite specialists if advice is required on managing serious or complex injuries. In some cases, the needs assessment may show that offshore medical support, that goes well beyond the remit of a first aider, is necessary.

HSE guidance provides suggested contents for first aid kits, but these lists are not mandatory; the actual contents should be determined by the first aid needs assessment.

A.16.3.3 Monitoring, Review and Change Management

Given that the factors affecting risk and response will vary, both between project phases and arising from changes in daily operations, first aid provision should be considered in the planning of offshore work. Employers should also undertake periodic formal reviews, as well as after any significant operating changes. The review would consider:

- Facilities and equipment: should any changes be made, in order to manage the identified risks of injury and illness?
- Training: Should any changes be made to the first aid and associated training that is provided?
- Procedures: Do any procedures need to be revised or developed, and communicated, to ensure that the first aid response is suitable and effective?

Given the close relationship between first aid provision and the site ERCoP, neither should be changed in isolation from the other.

Where first aid equipment and supplies are provided at various locations within OREIs, suitable arrangements need to be in place to ensure that these provisions are replenished after use, and before expiry of perishable items.

Where accidents or illnesses have occurred and first aid has been required, the first aid response should be reviewed as part of the incident investigation, to identify any learning that could improve the response in future. Employers should also ensure that employees who have been involved in emergency response, particularly where it was concerned with the serious injury or illness of a colleague, are suitably debriefed and supported afterwards.

A.16.4 Codes of Practice and Guidance

A.16.4.1 Regulations and Standards

HSE L74 - First aid at work - The Health and Safety (First-Aid) Regulations 1981 - Guidance on Regulations.

A.16.4.2 Other Relevant Guidance

RenewableUK – *First Aid Needs Assessment: Guidance for Renewable Energy Projects*.

HSE GEIS3 - *Selecting a first-aid training provider - A guide for employers*

RenewableUK - *Health & Safety Training: Entry- and Basic-Level Health & Safety Training and Competence Standards: Scope and Application to Large Wind Projects* identifies how first aid training fits in with other basic training requirements.

Global Wind Organisation (GWO) *Basic Safety Training (BST) (Onshore / Offshore)* includes a first aid module, which is intended to provide a common standard for the basic training of all personnel on wind energy sites.

HSE RR708 - *Evidence-based review of the current guidance on first aid measures for suspension trauma*.

MCA MGN 147 (M+F) - *Training in First Aid and Medical Care for Fishing Vessel Personnel, Boatmaster's Licence Holders and Small Commercial Vessel Personnel (Not covered by the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers as amended in 1995 (STCW95))* provides details of the different levels of first aid training that seafarers may have.

RenewableUK - *Incident Response: Offshore Wind and Marine Projects*.

A.16.4.3 ELSEWHERE IN THIS GUIDANCE

Emergency response & preparedness

Medical Fitness to Work

Reporting of Industrial Diseases and Dangerous Occurrences Regulations 2013 (RIDDOR)

PART B THE OFFSHORE LIFECYCLE

INTRODUCTION

This part of the guidance considers how health and safety management can be addressed over the lifecycle of an OREI. Using a simplified model of the OREI lifecycle, the key activities in each phase are addressed, in relation to:

- Future risks, that will be determined by decisions made during the phase, and which will affect health and safety in later phases of the OREI lifecycle; and
- Risks arising out of activities undertaken within the phase.

The regulatory framework, and health and safety management arrangements within which all activities are to be undertaken, are described in Part A of this guidance, while the risks and regulations that relate to specific activities and hazards are described in the relevant sections of Part C.

LIFECYCLE APPROACH

The development of any OREI will consist of a number of phases; decisions taken in one phase will affect health and safety performance in subsequent lifecycle phases. The exact lifecycle terminology will vary, depending on the nature of the project and the contracting strategy being employed, although the typical phases that can be expected are outlined in Figure 4, with the main activities in each phase summarised in Table 7 below. This diagram also highlights the major supporting activities that can span multiple project phases. In reality, project development is not a simple linear flow, and would typically involve a degree of iteration, with different parts of the development progressing through the phases at different rates.

As each phase of a project is completed, the opportunity to eliminate or reduce risks through the design and selection of equipment is reduced, and once contracts are agreed for the supply of goods or services, methods may largely be defined. If changes that will be essential for health and safety are identified late in the lifecycle, the cost and schedule implications of their adoption will be greatly increased.

It is therefore critical that decisions made during all project phases, including the definition and design phases, are based on an appropriate level of risk assessment, and that the information from this is passed on effectively to subsequent activities. Each of the phases, and the project itself, should be subject to appropriate audit and review, with the learning being used to update processes and inform future projects.

Figure 4: Lifecycle phases and key supporting activities

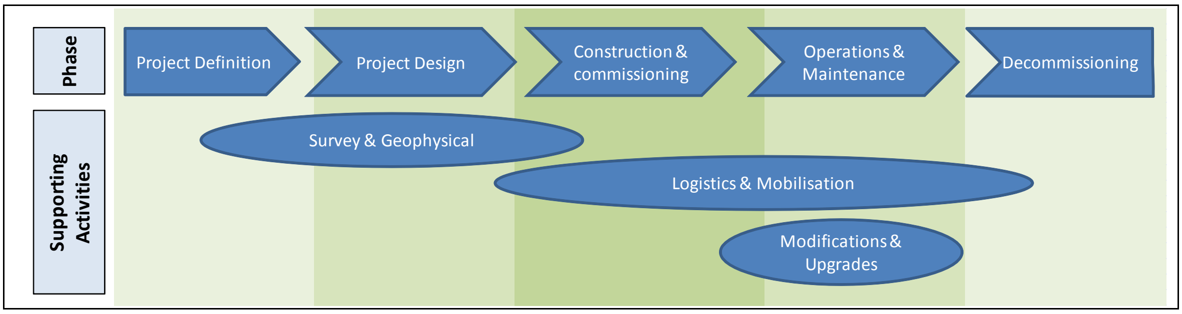


Table 7: Typical activities within lifecycle phases

Project Definition	Project Design	Construction & Commissioning	Operations & Maintenance	Decommissioning
Project concept Contracting strategy Resource assessment Site survey Concept studies Consenting Device specification Device certification	Detail design and integration Design for maintenance Installation strategy Detailed planning for construction Commissioning strategy Vessel and access system selection Contractor selection Contract negotiation Project certification Port infrastructure	Support sites Emergency preparedness Port operations and Logistics Installation of foundations / moorings Device installation Offshore substation installation Cable installation Commissioning and handover	Maintenance strategies – planned / reactive / scheduled / condition-based Monitoring Statutory inspections Safe systems of work Operational Control End of warranty	Removal / dismantling Recycling / disposal Re-powering and reconsenting

B.1 PROJECT DEFINITION

At the start of this phase, the proposed OREI is likely to be a business objective, but with limited certainty as to its size, location or technologies. During this phase, the concept is developed, and the initial project team is formed, so that at the end of the phase, the concept of the proposed development and the organisational arrangements to take it forward are clear, and more detailed design activities can commence. If the development is to be "safe by design", then that approach needs to be adopted from the beginning of project definition.

The project team is likely to be at its smallest in this phase, possibly with limited resources. As the project does not yet exist in a physical form, the ability to make significant changes without incurring excessive cost is at its greatest in this phase, and so too is the effect of the decisions taken, on the safety and economic viability of the development over its entire lifecycle. Where these decisions depend on data, the quality of this data is a key input that will determine the quality of decisions, the ability to implement them, and hence to minimise the need for enforced changes in later phases of the lifecycle.

The main activities during project definition can be grouped as those relating to:

- The project concept:
  - Location, scale of development, technologies to be employed;
  - Access and O&M arrangements;
- Understanding the site:
  - Energy resources, including deployment of instruments;
  - Seabed properties and metocean conditions;
  - Essential support for the development, such as ports, grid connection, vessels, skills and training;
- The energy converter (offshore WTG or wave / tidal device, hereafter referred to simply as the device) and balance of plant such as substations and cabling, including preliminary consideration of:
  - Device specification and design; and
  - Conformity to standards / certification requirements;
- Leasing and consenting:
  - Agreement of seabed lease and grid connection;
  - Consenting requirements, including Environmental Impact Assessment (EIA) and Navigational Safety Risk Assessment and supporting surveys;
  - Consultation with external stakeholders, including local communities and other sea users who may be affected by the proposal;
- Management arrangements and key appointments for the phase:
  - Project information management;
  - CDM Appointments and Duties;
  - Management of subcontracted consultants / designers; and
  - Contracting strategy for subsequent phases.

The financial and technical resources available in this phase of the development can present a further challenge to developers:

- As the development will not have obtained consent until late in this phase, there is a risk that if the development does not receive consent, or later does not progress beyond financial close, there will be no return on the investment that is involved up to that point, which may be several years after the project was initiated;
- Where contractor resources are needed in order to progress tasks in this phase, the contracts will be of shorter duration and lower value than in later phases; this may limit

the ability to obtain preferred vessels and equipment, and to build a shared safety culture.

While these challenges are acknowledged, it is important that health and safety standards are not compromised.

B.1.1 Relevance and Impact on Subsequent Phases of Lifecycle

The project definition phase will determine the overall envelope within which the OREI is to be developed; these will then form constraints for all future design and operational decisions, so it is essential that a safe and viable development can be constructed and operated within these parameters.

The core project team will also be formed in this phase; this will affect the health and safety culture of all subsequent activities. The processes for project and risk management that are established will also determine how effectively the project objectives are achieved.

B.1.2 Key Health and Safety Risks to be Considered

B.1.2.1 Project Concept

The location of the development is likely to be determined by a combination of feasibility studies and the outcome of leasing processes; key considerations include:

- The energy resource at candidate sites and the estimated energy yield that candidate devices would deliver;
- The ability to construct the development, taking account of:
  - Site conditions, including seabed properties;
  - Foundation / mooring technologies; and
  - Foreseeable installation vessels;
- The ability to operate and maintain the development, taking account of:
  - Expected maintenance requirements of the candidate devices;
  - Site metocean conditions;
  - Potential service strategies and bases; and
  - Foreseeable access methods;
- The ability to export energy, in terms of the:
  - Availability of a grid connection; and
  - Identification of potential cable routes;
- External constraints, that can affect the ability to construct, operate and maintain the development, and which will be addressed as part of the consenting process; these include:
  - Existing and historical sea uses, which should be considered in a Navigational Safety Risk Assessment; and
  - Environmental / habitat protection requirements.

Such studies are likely to take an iterative approach, starting with a “screening” stage that considers limited detail over a wide range of options, and leading to more detailed study of the most likely options. As the detail increases, these studies start to need an increased level of project-specific information, which will need to be obtained through on-site measurement and survey work. The technical and economic evaluation of proposed concepts should run in parallel with hazard identification and risk assessment processes, which will also increase in detail as the concept develops.

B.1.2.2 UNDERSTANDING THE SITE

B.1.2.2.1 Resources and Supporting Infrastructure

At the start of this phase, resource information is likely to consist of modelled data, validated against limited physical measurements, which may have been obtained at locations remote from the candidate sites, or from short-term measurement campaigns at candidate sites. Such data may support initial site selection, but is likely to introduce high levels of uncertainty to estimates, and be unsuitable for use as an input to the design process, so site-specific data collection becomes a priority. The required spatial resolution of the data is likely to be particularly high for wave and tidal energy developments, as these can be directly affected by site bathymetry.

In addition to energy resources, consideration should be given to the availability of essential supporting services and infrastructure for the development, such as ports, grid connection, vessels, a workforce with suitable skills, and training facilities to help develop the future workforce.

B.1.2.2.2 Seabed Properties

The nature of the seabed will affect the design of the OREI, as it will influence the design decisions to be made in relation to foundations / moorings and cable routes, and will also affect the use of jack-up vessels. Understanding the seabed is an iterative process, and the specification of investigations and surveys needs to reflect the purpose for which the resulting data will be used. Similarly, the outcome of such studies must be understood in the context of their purpose: for example, a seabed survey that is entirely suitable for identification of potential cable routes is likely to involve low spatial resolution over a wide area; its outputs may form a useful starting point for later consideration of installation methods, but will not provide sufficient resolution or detail to enable the installation process and precise route to be fully defined.

B.1.2.2.3 On-site Survey and Measurement Activities

These activities are likely to give rise to the first point in the development lifecycle at which people are exposed to the risks of working on the project site, during aerial or marine survey work, or the installation of measuring equipment. While some equipment, such as subsea or surface devices for wave and current measurement, is relatively straightforward to deploy, offshore meteorological mast installation represents a significant construction project. The developer therefore needs to have suitable contractor selection, procurement and health and safety management processes in operation at this stage, even though the main work on the site may not start until several years later.

At this early stage in the development, the project team's knowledge of the site will be at its most limited; the risks that this brings can be mitigated by:

- Adopting a conservative approach to specifying equipment and planning operations, so that if conditions are found to be more challenging than expected, the safety of people and the success of the operation are not put at risk;
- Selecting contractors with suitable experience of the operations to be undertaken;
- Engaging competent advisors on specialist technical and safety aspects; and
- Utilising existing knowledge about the site and its approach routes, for example local seafarers may have particular understanding of the area.

Offshore work will depend on making use of available vessels; this may require some flexibility in the type of vessel to be used, and the scheduling of activities. The risks that this introduces can be mitigated by:

- Robust vessel selection and audit processes, in order to be able to determine whether a specific vessel is fit for a given purpose; and
- Designing deployments so that they can be carried out safely by a wide range of vessels that will potentially be available, and trying to minimise the weather-sensitivity of tasks.

B.1.2.3 CONSENTING

Prior to a project receiving consent, an EIA will, in most cases, be required. The EIA enables risks to be identified at an early stage and thus presents the opportunity to design them out, thereby ensuring that risks are minimised throughout the project. The EIA process is informed by an understanding of both the project, and the characteristics of its location, and therefore makes use of design information about the development, as well as survey data on the site. Depending on the environmental risks identified, survey data may be typically required for periods of two years, or longer; this will be in addition to the time needed for consultation with stakeholders.

In the project definition phase, the device selection needs to provide the EIA process with sufficient clarity as to the type, location and number of devices to enable a meaningful assessment to proceed, in order to develop the Environmental Statement that is required as part of the consenting process. This can make use of the "Rochdale Envelope"[15] approach, that enables the maximum adverse case scenario to be assessed, without requiring every detail of a development to be tightly defined. Subsequent phases of more detailed design and device selection activities will then aim to work within these constraints, and take account of any mitigation actions that are identified as being necessary during the EIA process, or conditions imposed upon the project as part of the consent.

While this approach maintains some flexibility, the envelope that is defined for the development needs to be sufficiently well founded to ensure that it will be possible to construct and operate the development within these parameters; gaining certainty on this depends on having sufficient understanding of site characteristics and the practicalities of the construction operations involved. This will be best achieved if there is effective co-operation between engineering and environmental specialists within the project team. If it were later found not to be practicable to construct and operate the development within the consent conditions, then further assessment could be required to support any application for the consent to be varied.

B.1.2.4 DEVICE AND BALANCE OF PLANT

Device selection will be a key process in the definition of most developments, other than those that are technology-led, where a developer has decided on the device that they intend to deploy, and then sets about finding a suitable location.

In addition to technical performance and economic considerations, it is important that health and safety aspects are given sufficient attention in specification and subsequent tendering activities, otherwise the rest of the project lifecycle may involve applying mitigation efforts to hazards that could otherwise have been eliminated. This applies both to the device and the balance of plant, such as foundation structures, offshore substations and cabling. The level of design-related health and safety risk will be affected by the degree of novelty in the device design and the site characteristics.

As an absolute minimum, all devices must comply with the Essential Health and Safety Requirements set out in the Machinery Directive, as this is a legal requirement; while in most cases the manufacturer or supplier of the machinery is the duty-holder under the regulations, OREI developers should assure themselves that the duties are being fulfilled. Industry-specific approaches such as the certification of devices, site-specific structural designs and overall project designs minimise the risk of technical failures; this brings a significant indirect health and safety benefit by reducing the risk exposure that recovery from failures would entail.

Specific health and safety considerations in the definition of requirements for device and balance of plant design include:

- Implications of the proposed design for construction, O&M and decommissioning activities;
- Philosophy for survival of extreme metocean conditions, in particular, whether survival is entirely passive, or the extent to which it depends on control and communication systems and actuators being functional in order to prepare the device for the expected conditions;
- Means of access, including vessel and helicopter operability constraints;
- Provision of lifts for people, and lifting equipment for components;

[15] See Infrastructure Planning Commission Advice Note Nine: "*Using the 'Rochdale Envelope*'

- Facilities for operation within safe systems of work such as the Wind Turbine Safety Rules (WTSR), including the provision of isolators in suitable locations.
- Facilities for communication with vessels, shore-based control centres and emergency services;
- Aids to navigation;
- Arrangements for emergency egress and evacuation, whether by vessel or helicopter;
- Welfare facilities, including accommodation and facilities in the event of stranding;
- Fire detection, protection and refuge; and
- Lightning protection and refuge.

Some of these requirements could be used as assessment criteria when selecting devices from amongst a range of standard designs; others will form part of the specification for site-specific design work.

As the design is developed and defined in increasing detail, risk assessments should be carried out or updated at each stage of the design process, with the findings being used as inputs for the next phase.

B.1.2.4.1 Standards and Certification

The IEC 61400 series of standards addresses many aspects of the WTG lifecycle, including:

- Part 1 specifies minimum design requirements, with a focus on structural integrity, as well as measures to ensure the safety of people, and the reliable operation and survival of the WTG, with respect to the operating conditions for a particular class of site;
    - While this part pertains to onshore WTGs, the Rotor – Nacelle Assembly (RNA) of an offshore WTG will generally conform to it;
- Part 3 specifies additional design requirements for offshore WTGs, including taking account of metocean effects in normal operation and fault conditions;
    - Its scope concentrates on structural integrity, but also considers mechanical, electrical and control systems, and safety procedures applied over the lifecycle of the WTG;
- Part 22 describes the type and project certification processes, which provide assurance of conformity and quality for a wide range of aspects of a WTG. Type certification of a RNA addresses:
    - The design basis;
    - An assessment of the design against standards, including those relating to protection and control systems;
    - Testing requirements for components; and
    - Quality systems in manufacturing.
- Type certification does not take account of project-specific conditions or designs; these are addressed in project certification, which provides:
    - Independent verification that a type-certified RNA, together with the design of its support structure and foundations, conforms with site-specific requirements and conditions.
    - Surveillance of processes from manufacturing, through installation to commissioning, operations and maintenance, in order to ensure that the design intent is achieved in practice.

In addition to the explicit consideration of conformity with safety standards, the certification process should help to ensure reliable operation, thereby minimising the risk exposure that remedial work could involve over the lifecycle of a development.

IEC standards have not yet been finalised for wave and tidal energy converters, although draft standards are available.

B.1.3 HEALTH AND SAFETY CRITICAL INTERFACES AND COMMUNICATIONS

The project definition phase involves both on-site and desktop activities, combining to produce a clear specification for the proposed project:

- As understanding of the project location increases, there may be interactions between different aspects of the project definition; for example, increased knowledge of seabed conditions may affect the array layout or foundation types being considered, so it is important to co-ordinate the different work packages in order to ensure that they are working from a common and up to date data set;
- Concept studies carried out during project definition will determine the future design of the OREI, so must be based on sufficient and accurate understanding of the site;
- Where on-site survey and measurement activities are carried out, there may be interactions with other sea users and stakeholder groups, so suitable liaison and formal notification processes should be used; and
- Much of the work in the phase will be carried out by contractors; the developer will need to ensure that the interfaces between work packages are effectively managed, and that all necessary information can be shared in order to support good decision-making and minimise duplication of activities.

B.1.4 MANAGEMENT AND OPERATIONAL CONTROLS

Project definition will often involve the formation of new teams, or new tasks being taken on by an existing or growing team; the composition of teams should ensure that there is sufficient competence to undertake the tasks involved in developing the project. Employers have a duty under the MHSWR to ensure that they have access to competent advice on health and safety matters; such advice will be particularly important when undertaking new activities, and may be provided by a combination of internal and external expertise.

Ensuring full conformity with applicable standards and regulations from the definition and specification activities onwards will help to ensure that the designs and approaches adopted later in the project satisfy legal duties.

Project definition should also make use of learning from incidents that have occurred in the renewable energy industry and other relevant sectors, in order to ensure that the potential for similar incidents to occur in future is reduced. This sharing of learning can help to accelerate the safe development of the industry as a whole, and minimise the risk to people.

B.1.4.1 PROJECT INFORMATION MANAGEMENT

The key deliverable from the definition phase is information, in a variety of forms, that will be used in consenting, for subsequent phases of the project, or even transferred to another entity if the project is sold on at a later stage. Effective systems for managing this information are vital to the safe and efficient development of the project:

- The definition phase is likely to involve significant work being undertaken by subcontracted consultants and designers, who will need to be working from a common project dataset that is kept up to date as the design is developed;
  - The project data should be in a form that allows it to be used effectively in subsequent phases;
- Risk assessment should be viewed as a process that operates over the project lifecycle, with information from one stage of risk assessment informing the next; for example, a risk assessment that compares different installation concepts will inform future design and contracting decisions, but will be no more than an initial input to the risk assessment of detailed installation plans; and
- The interfaces between organisations and work packages must be clearly defined and actively managed.

Efficient processes for maintaining project registers of risks, interfaces and decisions will assist the smooth running of the project, as well as helping to demonstrate that legal duties to minimise risk are being fulfilled.

B.1.4.2 APPOINTMENTS AND DUTIES UNDER CDM

Project definition involves taking some fundamental design decisions, and is therefore a phase where the Client will often be a Designer under CDM, and must be able to fulfil their duties in this respect. The CDM regulations require the Client to:

- Appoint a suitable CDM Co-ordinator as soon as practicable after initial design work has begun;
- Provide Pre-Construction Information to Contractors and Designers who may be appointed to the project; this gives potential appointees the project-specific health and safety information that they will need in order to assess their own competence, and identify hazards and risks related to the proposed design and construction work; and
- Appoint a Principal Contractor (PC) before any construction work takes place; note that this includes geotechnical survey work (although not geophysical survey work, as this is non-intrusive). The PC who is appointed in relation to these early geotechnical survey activities will not necessarily be the PC in later phases of the project.

The requirements for Pre-Construction Information are described in detail in Appendix 2 of the CDM ACOP, with the key principle being the provision of "*the right information for the right people at the right time*"; an information package that is overloaded with generic information, and which does not make the key project-specific information sufficiently clear, is little better than an information package that omits key information.

Appointments should follow from a robust process of assessing the competence of potential contractors, in accordance with the guidance given in Appendices 4,5 of the CDM ACOP.

CDM imposes a legal duty on the Client to ensure sufficient time and resources for all stages of a project; this is also consistent with good project management practice. In the early stages of a project, business pressures can conflict with this, for example:

- Financial constraints before the project is consented can encourage resource levels to be constrained, for example by minimising survey work or giving undue weighting to price when selecting contractors;
- If early work packages overrun, it can be tempting to compress the schedule for later tasks in order to maintain target dates, but this should only be done if such acceleration is based on genuine changes in approach, or evidence that less time will be required, rather than on optimistic scheduling; and
- Capital or revenue support schemes for renewable energy generation may have fixed qualifying dates which, if not met, could jeopardise the economics of the development.

Making sufficient investment in the early stages of a project minimises the risk of changes being required at later stages, which would be likely to lead to far greater costs and delays.

B.1.4.3 CONTRACTING STRATEGY

The contracting strategy to be used for subsequent phases of the development will usually be defined during this phase. A variety of approaches exists, with the selection being influenced by characteristics of:

- The developer and potential contractors, such as:
    - Their capabilities to undertake the range of activities involved in the scope of the project, considering areas such as design, project management, procurement, installation and commissioning;
    - Their appetites for exposure to, and capacities to absorb, financial risk;
    - The level of involvement that they wish to have in later stages, such as the provision of O&M services; and

    - Whether they are seeking to establish a strategic partnership to undertake a series of developments, or are approaching the development as a one-off contract;

- The development:
    - Whether it is similar to other projects that have already been undertaken elsewhere, or represents a novel development, as this affects the ability to establish a clear definition of works and estimate costs accurately.

In broad terms, the commonest contracting strategies include:

- Multi-contract, where the client manages the project and its interfaces, and employs contractors to undertake individual work packages against detailed designs and specifications that combine to deliver the project:
    - The Client will be fulfilling the roles of a Designer and PC under CDM, and may also provide the CDM Co-ordinator and even be a Contractor for certain activities;
    - This needs a high level of client competence, and requires the client to carry greater financial risk, but can offer the greatest flexibility on projects where high levels of novelty mean that a degree of development work is being undertaken as part of the project implementation;
- Engineering, Procurement and Construction (EPC) contracting, which is the opposite extreme, where a single contracting entity (which may be a joint venture, possibly established specifically for a particular project) delivers a "turnkey" project to the client:
    - The client needs to provide a clear specification of what they want; the EPC contractor then has a high degree of autonomy as to the detailed design and delivery of the specified works;
    - The EPC contractor will generally be appointed as PC and Designer, and will appoint Contractors;
    - This approach minimises the client's involvement in the management of the project, and therefore minimises their need for such competencies;
    - The contractor carries greater financial risk for the project, and therefore needs to have the financial strength to cover this, and will include a risk premium in their contract price;
    - The scope of the EPC contractor's work may be further increased by contracting for the provision of O&M services for a certain time period after commissioning;
- EPCM (Engineering, Procurement and Construction Management), which can be seen as a hybrid approach, where:
    - A Construction Management (CM) contractor manages the project on behalf of the client, and may also be the PC and lead Designer, thereby providing the competence or capacity that the client may not have available;
        - The CM contractor will therefore be responsible for the preparation of the Construction Phase Plan and managing safety on site;
    - The client contracts with the individual contractors, and carries the financial risk for the execution of the project as a whole; note that in the event of problems, the pursuit of claims can become very complex.

The decisions made in this phase, in relation to contracting strategy, will therefore determine the responsibilities, resource levels and competence requirements for both the Client and contractors in subsequent project phases.

Offshore contracts must make adequate provision for weather delay, and any contracting strategy should ensure that it incentivises the delivery of the client's most important outcomes, in terms of safety, quality and balance of initial / whole lifecycle cost.

B.1.5 PROJECT DEFINITION PHASE DELIVERABLES

The key deliverables from the project definition phase can be summarised as:

- Design-related aspects:
  - Sufficient site information to enable design and on-site activities to proceed in subsequent phases;
  - Evaluation of a range of concepts for the project, including:
    - Physical characteristics: location, scale, layout, candidate devices, substations and cabling, foundations / substructures / moorings, construction methods, O&M, access;
    - Support strategies, including the use of onshore / offshore bases, vessel requirements and maintenance strategies;
  - Understanding of the resource and supporting infrastructure requirements and availability; and
  - Conceptual specification for the device and balance of plant;
- Project management and related aspects:
  - Established information and risk management processes;
  - Initial appointments made of CDM Co-ordinator, Principal Contractor and Designer(s);
  - Definition of contracting strategies for construction and subsequent phases, and preparation for contractor selection, including provision of Pre-Construction Information;
  - Completion of Environmental Impact Assessment, and obtaining consent for the development to proceed within an agreed envelope, which will determine the constraints on subsequent design activities; and
  - Preparation of Pre-Construction information that will be provided to potential contractors, to be used in tendering, competence assessment and as a starting point for development of methods and safety management arrangements.

These combine to define both the project that is to be developed, and the approach that will be taken to achieving this.

B.1.6 LEGISLATION, STANDARDS AND GUIDANCE

BS EN 61400-1:2005: *Wind turbines – Design requirements* specifies design requirements applicable to all WTGs.

BS EN 61400-3:2009: *Wind turbines: Design requirements for offshore wind turbines* addresses the principal systems and structures of an offshore WTG, considering the conditions at the site where it is to be installed, over the lifecycle, including assembly, installation, commissioning, operation and maintenance.

BS EN 61400-22:2011 *Wind turbines: Conformity testing and certification* specifies the process and requirements for WTG type and project certification.

DNV-OS-J101: *Design of Offshore Wind Turbine Structures* obtainable from DNV Offshore Standards webpage.

DNV-OSS-312: *Certification of Tidal and Wave Energy Converters* obtainable from DNV Offshore Service Specifications webpage.

Draft standards for marine energy devices and projects

Further details and links to relevant regulatory guidance are given in the following sections of this guidance:

Construction (Design and Management) Regulations 2007 (CDM)
Supply of Machinery (Safety) Regulations and Harmonised Standards

Leadership & Safety Culture
Management Systems
Risk Management
Supply chain management
Access and Egress
Geological Unknowns
Metocean
Navigation
Vessel Selection

B.2 PROJECT DESIGN

This phase takes the deliverables from the Project Definition phase, and works within the consented project envelope to produce a finalised design for the project, and a detailed plan for its implementation, addressing health and safety, technical and organisational aspects. A key milestone within this phase is Financial Close, which enables the signing of contracts, thereby releasing the necessary funding so that detailed project-specific work can be undertaken, and reservations made for the use of production facilities and installation resources. Major activities include:

- Selection of:
  - Device;
  - Installation strategy;
  - Vessels and access systems; and
  - Maintenance strategy;
- Front End Engineering Design (FEED), followed by detailed design of project-specific structures and components, taking account of:
  - Site conditions;
  - Constructability; and
  - Maintenance requirements;
- Selection of contractors within the defined contracting strategy;
- Preparation of the Construction Phase Plan;
- Preparation of detailed plans for construction, commissioning and handover to operations;
- Device and project certifications;
- Preparation of Emergency Response Co-operation Plan (ERCoP) for the construction phase; and
- Preparation of Decommissioning plan.

Many of these activities will span Financial Close, with a step change in the level of detail and extent of preparation after this point.

Fundamentally, this phase delivers a package that defines exactly what is to be constructed and maintained, how this is to be done, and by whom.

B.2.1 RELEVANCE AND IMPACT ON SUBSEQUENT PHASES OF LIFECYCLE

During this phase, the detailed design of the project will largely be completed and frozen, so the residual risk after this phase will affect all future operations. As well as addressing technical risks, this phase integrates the different parties into the project team, so effective management of organisational and interface risks is important.

The decisions made in this phase will determine:

- The tasks that will be required in installation, commissioning, O&M and decommissioning;
- Who will carry out these activities;
- The resources available;
- The safety management arrangements during construction; and hence
- The level of risk presented by these activities.

B.2.2 Key Health and Safety Risks to be Considered

B.2.2.1 Site-Specific Design and Specification

The selection process needs to consider the health and safety risks that different candidate designs of devices and foundations / moorings may present. In addition to assessing performance against the health and safety requirements of the device specification, other areas to consider include:

- Devices need to be matched to the resource characteristics of the development site;
- Foundations and moorings need to be matched to the loads imposed by the device and the metocean conditions at the site, as well as seabed conditions and geotechnical characteristics, so will require site-specific design and individual detailing, possibly with more than one type being used on a site with wide variations in conditions, thereby increasing the complexity of installation and O&M activities; and
- Device and / or substructure design for access.

The selection of WTGs, and site-specific conditions and designs, can be subjected to a project certification process, in order to provide independent verification of conformity to standards – see Section B.1.2.4.1.

B.2.2.2 Design and Strategy for Maintenance

Decisions taken in this phase will determine the level of risk to which people are exposed during O&M activities. Where possible, hazards should be eliminated at the design stage; not only does this reduce risk to people, but it will often enable more efficient working, reducing downtime and maintenance costs. A good design also reduces the probability of errors occurring during maintenance, again protecting both people and equipment. Specific areas to consider include:

- Support requirements to maintain the device in good condition in the absence of the grid or substation connection; these include the potential consequences of an interruption of a given duration, and the ease with which temporary supplies can be provided;
- Maintenance requirements, and the challenges that these may present in the offshore environment, and which may be mitigated by selection and design of the device, the provision of lifting equipment, good access and space to store components safely during maintenance operations;
    - As a general aim, the maintenance strategy should seek to avoid high-risk activities, and minimise the need for offshore work. This aim can be supported by maximising the ability to diagnose / reset faults remotely, and thereby to complete repairs in a single visit;
    - The strategy should consider different options for carrying out repair work, as the practicality of these options will be influenced by the device design; options include:
        - Carrying out repairs at the offshore location;
        - Exchanging major components offshore; or
        - Exchanging entire devices, for working replacements, with repairs being conducted at an onshore or port base;
    - Maintenance should be considered together with the ability to access a failed device when necessary; where devices are to be installed in locations with limited accessibility, then this may justify investment in redundant systems to enable the device to continue generating, perhaps at reduced output, until repairs can be carried out. In other cases, it may be more appropriate to enhance the access systems, where this can be achieved safely;
- Design for safety during maintenance, including consideration of isolation strategies, the status of control, communications and protective systems, and provision of essential services during maintenance activities;

- Design to consider corrosion prevention through the specification of component details, coating systems and their application, and ensuring that surfaces can be maintained later in the life of the OREI. The requirements will vary between different parts of offshore structures; and
- Condition Monitoring and Predictive Maintenance systems may be used to minimise offshore interventions, and allow optimal use of weather windows, to minimise the pressure that unplanned downtime and restricted access imposes.

Addressing these areas not only minimises health and safety risks, but also reduces downtime risks.

The long-term maintenance strategy should also be considered; for example, if it is the intention that the owner's personnel should assume responsibility for maintenance after the warranty period, then contracts should include requirements for training of such personnel while the device manufacturer is undertaking maintenance during the warranty period.

B.2.2.3 INSTALLATION STRATEGY

Installation strategy must take account of device and site characteristics, such as device size and weight, prevailing sea conditions, water depth and distance to port. A wide range of jack-up, leg-stabilised and floating installation vessel designs exists, together with support options such as the use of feeder vessels and offshore accommodation modules. A variety of installation approaches may be used:

- For offshore WTGs, these range from lifting separate sections and assembling on site, to a single lift of fully-assembled tower, nacelle and rotor; while
- For wave and tidal devices, options include towing to site and mooring / ballasting into position, or the installation of piled foundations;
    - As wave and tidal development is not at the same scale as offshore wind, adoption of installation methods that can be undertaken safely by commonly-available vessel types can minimise the risk of delay or cost escalation due to vessel availability.

Each of these options presents different benefits and risks, and requires thorough assessment, in the context of the metocean and seabed characteristics of a development site, and the technology to be deployed. Designs that minimise offshore, and especially subsea work during installation and commissioning, reduce exposure to the hazards that are inherent in these activities.

B.2.2.4 COMMISSIONING STRATEGY

Increasing the extent of commissioning work that is carried out before delivery or offshore installation can reduce the need for later offshore work, thereby reducing risk exposure for people. The ability to achieve this depends on both the device design and the provision of suitable testing facilities; if individual devices have completed a full range of functional tests prior to installation, then this should minimise faults and spurious trips in sensors and control systems, and give the assurance that the devices were fully functional. If problems are subsequently experienced after installation, the potential causes are more limited, which should reduce the potential scope of work to resolve the problems. While carrying out full-load testing of mechanical and electrical systems increases time and cost during manufacture, it can pay back by allowing more repeatable testing and analysis, enabling swifter rectification of any problems, avoiding the secondary damage that could result from defects, and reducing the risk of delays in offshore commissioning being completed. Given that metocean conditions are the energy source for OREIs, there may be a considerable delay between installation and operation at full load, therefore undertaking such testing also reduces uncertainty in early performance.

Such tests may be particularly challenging to undertake for small numbers of devices, as may be the case for early wave or tidal arrays, however the benefits may be even greater where devices are being assembled on a project basis, rather than being manufactured in series production.

Design of substations and array cabling should also consider the potential for a phased handover from construction to operation, and provide the necessary segregation of systems if this approach is to be adopted. Construction contracts and project interface management arrangements should ensure that the approach to be taken, and the responsibilities of the different parties involved, at the handover from construction to commissioning and operation are clearly defined from the start.

B.2.2.5 VESSEL AND ACCESS SYSTEM SELECTION

A wide range of vessels and access systems is available; for offshore WTGs this ranges from the established practice of using an access workboat with step-over at the bow onto the transition piece ladder, to large Dynamically-Positioned vessels with heave-compensated walkways. The access system needs to be considered during foundation design, to ensure that the access point(s) are compatible with the potential access systems, and aligned with respect to the prevailing metocean conditions.

For wave and tidal developments, due to the diversity of the devices being developed, there is little convergence on access solutions. This increases the challenge in risk assessment, as it is not a case of assessing the detailed design and application of a proven approach in a new situation, but is more likely to have to work from first principles in evaluating diverse concepts.

For certain developments, there may be some provision of offshore personnel accommodation, either on a vessel or platform, and again affecting the vessel requirements.

B.2.2.6 CONTRACTOR SELECTION

All appointments need to be made on the basis of an assessment of competence, as outlined in the CDM ACOP, Regulation 4, Competence and Training, which states that:

> "*Assessments should focus on the needs of the particular project and be proportionate to the risks, size and complexity of the work."*

When negotiating a contract for offshore works, the client and contractor will need to reach agreement on how weather risk is apportioned. Weather sensitivity will be affected by the methods and vessels being utilised by a particular contractor, in relation to the conditions at the development site; for some tasks the client may choose to provide the vessels. Contractual arrangements for weather risk may affect:

- Vessel selection: vessels with greater weather-tolerance may have a higher daily rate than less capable vessels, but may give a lower overall cost once the total cost of delays to the project is considered;
- Safe working: care must be taken to ensure that contractual arrangements do not encourage attempts to work in unsuitable conditions.

Where specialist vessels or other resources will be needed for particular tasks, it may be necessary to enter into a contract, or at least place a formal reservation, far in advance of the resource being needed. Such commitments will then form a constraint on design options and timescales for related components and activities.

B.2.3 HEALTH AND SAFETY CRITICAL INTERFACES AND COMMUNICATIONS

The interfaces may be considered in terms of inputs and outputs to / from the phase, together with the interfaces that will be present amongst the activities within the phase:

- Inputs from the Project Definition phase:
    - Information on the site conditions: normal operation, maintenance; survival;
    - Thorough concept studies to inform decision-making where new technologies or methods are proposed;
- Design Phase Activities:
    - Building the project team, consisting of the developer, contractors (who may include designers and consultants) and suppliers;
    - Financial close, which enables signing of contracts, and increased commitment of resources thereafter;
    - Integration of resource, design, and external stakeholder / regulatory requirements for consenting;

- Integration of design packages, such as the device, foundations, cabling, enabling the preparation of detailed plans for construction;
- Integration of health and safety management systems from different participants, to give a consistent approach and clear responsibilities;
- Risk assessments should be conducted in increasing detail as the project design is developed, with particular attention being given to interfaces between work packages;

- Design Phase Outputs:
  - The detailed design of the OREI is fit for purpose and in accordance with applicable standards, regulations and conditions relating to the consent for the development;
  - A realistic programme for the development, with appropriate resources, agreed responsibilities and clear interfaces;
  - Future lifecycle requirements have been considered in the project design; and
  - A decommissioning plan has been agreed with the consenting authorities.

B.2.4 Management and Operational Controls

Established design codes should be used where applicable; novel designs may require more individual modelling and analysis. This may apply both to physical equipment and operating systems.

Interface management is essential to the safe and efficient management of complex projects; research carried out for the HSE highlighted effective communication and interface management as being vital in minimising the risk of catastrophic events occurring in construction projects. Various tools exist, such as Responsibility Charting, which builds a matrix showing the actions that different parties are Accountable for, Responsible for, Consulted on, or Advised of. Such an approach should also take account of external stakeholders, and should be in place prior to tendering, and thereafter managed actively over the project lifecycle.

B.2.4.1 Construction Phase Plan

Where projects are managed under CDM, the Principal Contractor is responsible for preparation of the Construction Phase Plan (CPP) which will:

- Define how the construction phase will be managed and the key health and safety issues for the particular project;
- Set out the organisation and arrangements that have been put in place to manage risk and co-ordinate the work on site, but should not contain detailed generic risk assessments, records of how decisions were reached, or detailed method statements; and
- Specify requirements for the preparation of method statements.

Above all, the CPP should be well-focused, clear and easy for contractors and others to understand – emphasising key points and avoiding irrelevant material.

The CPP should also identify where project activities, that are not actually construction work, occur, and ensure that interfaces with such overlapping activities are addressed. For example, wildlife survey and monitoring work may have started well in advance of construction, continue while construction is in progress, and extend into the operational phase; while construction is in progress, this work would have to interface with the safety management arrangements defined in the CPP, but would still not become part of the construction work.

Sufficient time and resources need to be committed to preparation of the CPP, in the period between contractor appointment and the start of construction. For offshore developments, this should also take account of how the Client, Principal Contractor and Contractors will fulfil their responsibilities relating to marine co-ordination and emergency response arrangements.

As the CPP defines the overall safety management arrangements for the site, Contractors working on the project will generally be required to integrate their safety management systems with those defined in the CPP, with bridging documents being used to manage these interfaces. There may also be interfaces between projects; for example, there could be a separate project that undertakes construction of port facilities, which could still be in progress when the offshore installation project commences.

B.2.4.2 PRE-CONSTRUCTION PLANNING

While the CPP defines the safety management issues and arrangements for the construction phase, it does not define how the actual construction work is to be carried out; this should be described in a detailed project plan.

Construction of an OREI is a highly complex process, that in addition to the offshore construction and commissioning activities, relies on the supply chain and logistics functions to deliver components. Progress of offshore activities will be affected by weather, as well as other potential factors such as seabed conditions and equipment performance, so the project construction plan should be reviewed to determine sensitivity to such events, and appropriate contingency measures identified in advance, so that these can be thoroughly assessed prior to being needed.

The high level project construction plan will be supported by more detailed plans for specific activities, and ultimately by method statements for particular tasks. The PC is likely to be the owner of the project construction plan, with Contractors managing their work packages in detail, and ensuring that their work interfaces with the overall plan.

B.2.5 LEGISLATION, STANDARDS AND GUIDANCE

DNV-OS-J301: *Standard For Classification of Wind Turbine Installation Units*, available from DNV Offshore Standards webpage provides a design code for vessels that are purpose-built for offshore WTG installation.

HSE research into the causes of low probability, high severity events in construction, which provides guidance on approaches that can be taken to avoid such events: HSE Research Report RR834 - Preventing catastrophic events in Construction.

Further details and links to relevant regulatory guidance are given in the following sections of this guidance:

Construction (Design and Management) Regulations 2007 (CDM)
Interface with Grid, OFTOs etc.
Risk Management
Supply chain management
Safe systems of work
Emergency response & preparedness
Access and Egress
Aviation
Cable Laying and Entry
Fire
Geological Unknowns
Lifting
Metocean
Ports and Mobilisation
Vessel Selection

B.3 CONSTRUCTION & COMMISSIONING

The start of the construction phase represents a step change in the level of activity and risk exposure; the effectiveness of the preparations undertaken in the earlier phases of the project will be revealed.

The construction phase involves:

- Preparation of support sites for the construction and subsequent phases; this may involve major construction work to provide the necessary facilities in ports;
- Logistical operations relating to the equipment to be installed, including:
  - Receipt from manufacturing locations;
  - Storage and marshalling in / near port;
  - Load-out onto vessels and transportation to construction site;
- Personnel logistics, including:
  - Movements and support facilities in ports;
  - Offshore transfer, tracking and accommodation;
- Installation activities, including:
  - Foundations or moorings;
  - Devices;
  - Substation and array / grid connection cables; and
- Initial inspections of safety equipment, after it has been installed, and before being put into use for other activities later in the construction or subsequent phases.

Many of these activities involve movement of heavy, awkward and relatively fragile loads, in a challenging environment, and often in close proximity to people; any error or failure could endanger people and vessels. This applies both to major lifts, such as nacelles and tower sections, and to smaller "routine" lifts of lighter components and equipment; the full range of operations needs to be managed safely.

During commissioning, checks are carried out to confirm correct assembly and installation, after which systems can be powered up, and generation can commence. The nature of the commissioning activities will vary, depending on the devices being commissioned; a prototype or early production device is likely to be subject to an extended programme of testing to confirm that it is functioning as intended, whereas series-manufactured devices should only require basic checks before commencing normal operation, albeit with greater monitoring during initial operation than might be undertaken once performance has been demonstrated.

While it is usually intended that commissioning will follow almost immediately after construction, this may not always occur, particularly if cabling or substation works are not completed in time for the devices to commence operation. In the event of such delays, it may be necessary to implement measures to maintain the condition of the devices, possibly including the provision of a temporary power supply, usually by means of a generator.

B.3.1 RELEVANCE AND IMPACT ON SUBSEQUENT PHASES OF LIFECYCLE

As the OREI is actually built during the construction phase, the combination of the quality of the equipment installed, and the work undertaken during on-site assembly, will affect the rest of the life of the installation.

Commissioning is a key stage, as it prepares the OREI for operation; thorough checking of mechanical and electrical completion, SCADA configuration and the operation of safety-related systems will minimise the risk to people in subsequent activities.

The handover of information from construction and commissioning to operations and maintenance is also vital to enabling safe and effective working in subsequent phases.

B.3.2 Key Health and Safety Risks to be Considered

The construction phase can involve all of the activities and hazards addressed in Part 3 of this guidance; in broad terms, construction involves:

- Large numbers of people working offshore;
- Numerous lifting operations, some of which involve very heavy and awkward loads being lifted at height, while other smaller and more routine lifts can also endanger people and vessels;
- Intensive operation of a wide range of vessels;
- Executing weather-sensitive tasks within the available weather windows; and
- Potential for interaction with other sea users.

The risk from these physical hazards can be increased by the financial pressure that delays in offshore operations may create, and the need to achieve a pre-determined schedule.

B.3.3 Health and Safety Critical Interfaces and Communications

Inputs from earlier phases:

- Construction Phase Plan, which defines the safety management arrangements;
- Detailed project design and execution plans;
- Project team, with competent contractors and personnel appointed in all necessary roles; and
- Site information to enable activities to be planned in a manner that is suitable for the seabed and metocean conditions at the location.

Construction and commissioning phase activities:

- Port set-up / construction and operations;
- Marine co-ordination and management of large numbers of simultaneous operations, and tracking the locations of all personnel offshore;
- Emergency preparedness – interfaces within project team, with other sea users, and with external emergency services;
- Multi-contractor operations – clear project team structure, under the control of the PC;
- Multiple vessels in operation for individual operations and work packages;
- Safety-related systems, such as those for lifting, handling and work at height, need to be fully tested and commissioned prior to use, so initial inspections will be required during the construction phase; and
- Maintaining project information, for example recording locations where jack-up vessel leg punch-through has occurred, or subsea equipment / cables have been installed, and using this information to support the planning of subsequent operations.

Phase outputs:

- The physical output of this phase is a fully-operational OREI, with any temporary limitations due to outstanding snagging actions being clearly communicated as operational restrictions;
  - In many cases, this involves a phased handover, with some areas of the OREI being complete while others are still under construction;
- The phase also provides information to the O&M phase:
  - The extent, format and location of information should be agreed between the Client, PC and equipment suppliers;

- Ensuring that this information is accurate and accessible will help O&M activities to be established safely; it is not simply a matter of handing over the completed project health and safety file.

B.3.3.1 SAFETY DURING PHASED HANDOVERS

Given that a typical OREI comprises a large number of individual devices, and potentially an offshore substation, construction is likely to involve an extended time period, during which the installation of devices is completed in sequence. This will generally be followed by commissioning and then handover to operation, with the result that the OREI may simultaneously include incomplete devices, others undergoing commissioning, and others that are capable of normal operation. There are clear technical and economic benefits from bringing devices into normal operation at the earliest opportunity; however in order for it to be safe to have devices in these different states at once, it is necessary to:

- Design the cabling, control and isolation systems so that construction, commissioning and operation can proceed safely in parallel in different areas of the OREI;
- Maintain clear boundaries between areas that are construction sites, and those where commissioning and operation are in progress;
  - This can be more challenging offshore than onshore, as fences cannot be erected; however other approaches can be used, such as procedures and vessel tracking systems;
- Have a clear management structure that can maintain control of the different activities that a phased handover involves.

Given that the construction site is under the control of the Principal Contractor, one approach that can be used for managing a phased handover is for the Principal Contractor to remain in control of the site, with any activities relating to operational devices being managed as Contractor work, within the safe systems of work established by the PC. Once all construction activities on the site are complete, the entire site would then transfer to the operator, and the PC would cease to be involved – indeed, the situation could effectively reverse, if the PC or Contractor personnel had to return to site for any “snagging” activities, then these would be managed under the operator’s safe systems of work.

B.3.3.2 OFFSHORE TRANSMISSION INFRASTRUCTURE

Electricity transmission (at 132kV or higher) is a licensed activity that may only be undertaken by an entity that is permitted to do so; for OREIs, this will be the Offshore Transmission Owner. The regulatory regime is changing; under the “generator build” option, the OREI developer builds the offshore transmission infrastructure, and is then required to transfer the assets to an OFTO post-construction and pre-operation. As commissioning will involve electricity transmission, this counts as operation, so is required to be undertaken under the OFTO’s licence. This creates an organisational interface at this critical stage of the project.

In future developments where the OREI developer may choose the “OFTO build” option, in which the OFTO constructs the offshore substation and grid connection cable, then this could create a situation where two projects are to be constructed for different Clients at the same time; not only are they likely to be in overlapping areas, but they will also be physically connected by the array cables that enter the offshore substation. The situation could be further complicated if the offshore transmission infrastructure were to be connected to more than one OREI, potentially being constructed by different developers.

Under CDM, there can only be one Client, and one Principal Contractor on a project at any time; suitable arrangements between the OFTO and the OREI developer would be needed in order to satisfy this requirement.

B.3.4 MANAGEMENT AND OPERATIONAL CONTROLS

B.3.4.1 CONSTRUCTION

The safety of construction activities should be assured by operating in accordance with the safe systems of work defined in the Construction Phase Plan (CPP), prepared by the PC before commencement of construction activities, and updated as required during the construction phase. The PC has specific responsibilities during the construction phase, including:

- Managing and monitoring construction activities;
- Informing contractors of requirements under the CPP;
- Checking competence of appointees; and
- Provision of welfare facilities, site inductions and security.

Contractors working on the project are required to integrate their safety management systems with those defined in the CPP, to ensure that a common approach is adopted for all activities on the site. Auditing should be undertaken while work is in progress, both to monitor compliance with the CPP, and also the sufficiency of the measures defined in it.

Individual tasks will be subject to Risk Assessments and Method Statements (RAMS), the preparation of which is likely to involve the PC together with the contractors involved in the task, and key equipment suppliers such as WTG manufacturers, particularly where installation operations can affect warranties. RAMS need to cover the entire operation, from transport from port to completion of installation and handover of information to the next stage of work, with the level of effort in their preparation being proportional to the level of risk in the activities to which they relate.

B.3.4.2 COMMISSIONING

The extent of offshore commissioning requirements will be influenced by decisions made at the design stage, and during procurement; it may be possible to carry out more extensive testing prior to offshore installation, thereby reducing the scope of offshore commissioning work, although not entirely eliminating it.

The quality of work completed during design, manufacture and installation will determine the level of follow-up “snagging” work that is required after commissioning; in critical areas, this may delay handover to operation. Where a phased approach is being taken to construction and commissioning, effective feedback of issues experienced during commissioning of the earliest areas of the OREI to be handed over, can allow these to be addressed in subsequent areas, thereby reducing the need for rework at a later stage.

As commissioning involves making systems live for the first time, this must be carried out in accordance with detailed plans, with clear acceptance criteria to be achieved before moving on to the next stage, and with suitable precautions in place during testing work.

Where defects are identified during commissioning, decisions need to be made as to whether these defects:

- Prevent operation of the equipment, due to unacceptable risk to people, or the risk of equipment damage;
- Permit operation of the equipment, but with an operational restriction in place to mitigate the risk that a defect introduces; or
- Permit operation of the equipment, without restriction, but with snagging actions to be completed at a suitable opportunity.

The effective management of these handover conditions is critical to enabling safe operation in subsequent phases; the use of operational restrictions requires particular care, as this introduces a temporary procedural measure to compensate for a shortcoming in equipment, at the same time as handing management control from one organisation to another.

On completion of commissioning, any temporary measures, such as temporary power supplies, control system parameters or trip / override settings that were used to enable commissioning, must be safely removed or reset so that the equipment will operate normally when handed over to operations.

B.3.4.3 QUALITY ASSURANCE

The quality of work undertaken during this phase, together with the appropriateness of the device design for its intended use, and the quality of manufacture of the devices and foundation structures or moorings combine to determine the future reliability and maintenance needs of the OREI.

Amongst the many challenges of offshore work, attention to detail during construction and commissioning is vital, for example, even minor paint damage can rapidly lead to corrosion; rectification work may involve extensive risk exposure, and it is seldom possible to achieve the same quality in a field repair as during original application in a controlled environment.

B.3.5 LEGISLATION, STANDARDS AND GUIDANCE

Further details and links to relevant regulatory guidance are given in the following sections of this guidance:

Construction (Design and Management) Regulations 2007 (CDM)
Interface with Grid, OFTOs etc.
Leadership & Safety Culture
Management Systems
Workforce engagement
Occupational Health and Medical Fitness to Work
Safe systems of work
Simultaneous Marine Operations (SIMOPS)
Emergency response & preparedness
Access and Egress
Cable Laying and Entry
Confined Spaces
Ergonomics
Electrical Safety
Lifting
Marine Co-ordination
Metocean
Navigation
Noise
Piling and Grouting
Ports and Mobilisation
Subsea Operations
Vessel Selection
Vibration
Welfare
Work at Height

B.4 OPERATIONS & MAINTENANCE

The O&M phase will have the longest duration of any phase of the OREI lifecycle. The offshore O&M activities can relate to the devices, structures, moorings, cables, and substations; support facilities such as ports, vessels and work equipment also require appropriate maintenance. In all areas, the overriding aim should be to ensure that deterioration of assets does not jeopardise their continued availability and safe operation. An optimised maintenance strategy achieves these aims, while avoiding unnecessary interventions; not only do these expose people to health and safety risks, but they also have the potential to introduce faults to equipment that was previously operating reliably.

A variety of maintenance philosophies can be applied to different elements of an OREI, including reactive, condition-based and scheduled maintenance; the most appropriate strategy for an OREI is likely to involve a combination of these different approaches. The approach may also change over the operating lifetime of the OREI, with the device manufacturers leading maintenance while the devices are under warranty, then the operator or another contractor taking over after the warranty period has expired.

The O&M phase activities will occur both onshore and offshore:

- Remote monitoring techniques will be used to monitor device performance and component condition, and the correct function of Aids to Navigation, as well as metocean conditions, in order to support forecasting used for the planning of safe and efficient offshore work;
- Certain items of equipment offshore are subject to a time-based schedule of statutory inspections and reporting, these include:
    - Lifting equipment;
    - Lifts;
    - Work at height equipment and anchor points; and
    - Emergency equipment, such as rescue and evacuation equipment, fire detection and suppression, emergency lighting and first aid equipment;
- Asset integrity needs to be assured, especially in areas such as secondary steelwork that supports ladders, anchor points and lifting equipment;
- Some maintenance work may be planned as seasonal campaigns, which aim to make the best use of better weather conditions; such an approach may be preferred where major maintenance tasks, such as rectification of serial defects, have to be undertaken on a large number of devices;
    - Such campaigns may need a different management approach, more akin to the management of a construction project than routine daily activities;
- Offshore maintenance activities all involve people working at the offshore location, so offshore access is key to enabling maintenance work to take place; in some locations, and especially where major maintenance campaigns are planned, offshore accommodation may also be used to reduce the daily transfer distances and durations.

A challenge for maintenance of any renewable energy converter is the fact that as its energy source is the wind, waves or tides, it may not be possible to undertake a test run immediately after completing maintenance activities, while offshore, the metocean conditions that permit operation at full output may prevent personnel access. Achieving high rates of successful repairs in a single visit depends on having sufficiently clear understanding of faults on the basis of remote monitoring data, combined with good diagnostic work by technicians, in order to make best use of limited offshore working time, and to be certain that the fault will not recur once the device is back in operation.

The maintenance activities will be supported by operations management functions, including the provision of safe systems of work, marine co-ordination, metocean forecasting and monitoring the movement of other vessels in the vicinity of the OREI.

B.4.1 KEY HEALTH AND SAFETY RISKS TO BE CONSIDERED

During maintenance activities, people will be working in areas of the OREI that are normally unattended, in particular inside devices. In general, this will only occur with the devices having been handed over to the local control of the technician, and then isolated from sources of energy in accordance with the safe system of work that is being operated at the location. Residual risks remain, even after the application of these measures:

- Certain tasks may require isolations to be in place that disable essential services such as internal lighting, lifts and communications;
- Maintenance activities often involve transitions between equipment states, such as removal of rotor lock or restoration of motive power:
    - It is important to ensure that the equipment will behave in a predictable manner during such transitions;
    - The risk assessment should also consider whether safety relies on people not making mistakes, or if there are additional safeguards, for example, to ensure that WTG blades are pitched to stall before releasing the rotor brake to rotate the hub, in order to ensure that an uncontrolled overspeed cannot be initiated;
- Even with good remote diagnostic systems, there will be occasions where, after starting work on the device, it becomes clear that different, or additional work has to be undertaken. The safe systems of work need to be capable of managing such situations without undue delay, and without compromising the safety of the technicians involved.

Work inside devices also presents a range of ergonomic and welfare risks:

- Tasks may involve awkward working positions or work at height, and while the frequency of the task may be low on any given device, technicians are likely to repeat the task on many similar devices, giving repeated exposure;
    - The direct ergonomic risks combine with the effects of weather and offshore transfers;
- Technicians are likely to spend full working days inside individual devices, so need to have access to appropriate welfare facilities.

Some maintenance activities, such as those that relate to subsea structures, cables and corrosion protection, will involve subsea inspection and intervention; safe methods for this should be identified in order to minimise the use of divers. Other tasks may involve work in confined spaces, requiring specific safeguards to be in place.

B.4.2 HEALTH AND SAFETY CRITICAL INTERFACES & COMMUNICATIONS

Inputs from earlier phases:

- The design of equipment will determine the scope, ease and safety of subsequent maintenance activities; and
- The effectiveness of monitoring and diagnostic systems will determine the ability to identify problems before downtime occurs, and to diagnose the cause of downtime, thereby enabling the most efficient use of offshore working time, and minimising the pressure that unplanned downtime imposes on maintenance teams.

O&M phase activities:

- Maintenance activities will involve both daily minor work and periodic major maintenance campaigns, with each category requiring different management approaches;
- Various parties may be directly involved in maintenance activities, such as the operator, device manufacturer, balance of plant and other contractors;
- Other parties will perform supporting roles, such as marine co-ordination, vessel provision and emergency response;
- Where a change of responsibility occurs, such as a change of maintenance contractor, it is important that suitable handover arrangements are implemented;

    - Where such handovers are envisaged, this should be reflected in the requirements of contracts, for example, by including provisions for training of the owner's maintenance personnel by the device manufacturer.

Outputs:

- As the end of the useful life of equipment is approached, the maintenance effort is likely to be reduced, however sufficient attention should still be given to ensure that the OREI remains safe to decommission;
    - The integrity of areas such as secondary steelwork, access structures, ladders and anchor points for work at height will be particularly important in this respect.

B.4.3 MANAGEMENT AND OPERATIONAL CONTROLS

O&M activities need to take place within a safety management system that covers all of the areas of work that will be necessary. These include:

- Establishing and operating safe systems of work, such as the Wind Turbine Safety Rules, High Voltage Safety Rules or other permit to work systems;
    - Such systems are operated by competent personnel fulfilling defined roles, such as the Operational Controller;
    - The systems need to be able to manage non-standard situations, such as temporary operational restrictions that may affect the safety or performance of equipment;
- Ensuring that all personnel involved have the necessary training, competence and supervision to fulfil their roles and enable safe working;
    - The long-term nature of O&M activities is such that, in addition to ensuring initial competence, measures should be in place to maintain and further develop workforce competence; these will include arrangements for developing the competence of new employees;
    - Development of a wide range of competencies, particularly in relation to inspection tasks, can reduce the number of different people that will be required to visit OREIs to perform routine tasks, thereby improving the efficiency of offshore work, and minimising exposure to the risks of transfer and access;
    - Competence assessment should consider both normal work tasks, and the arrangements for response to emergencies;
    - Offshore work parties will typically be small self-managed teams, although this can be backed up by the provision of in-field supervision to audit the operation of safe systems of work, ensure that technical standards are maintained, and provide technical support on complex tasks;
- Monitoring and controlling the location and status of all vessels and personnel working offshore; these responsibilities are usually fulfilled by the Marine Co-ordination function, and are essential to being prepared for any emergency situations that may arise.

In addition to the safe management of discrete offshore activities, long term integrity management and effective planning of periodic maintenance campaigns enable the OREI to be maintained in a safe and reliable state.

B.4.3.1 MAINTENANCE ACTIVITIES AND CDM COMPLIANCE

Some maintenance activities will fall within the definition of Construction as given in the CDM regulations, and are therefore subject to the duties that these regulations impose, including notification of the project to the HSE if it exceeds the thresholds for duration or total level of effort. General maintenance activities, that do not involve "*substantial dismantling or alteration of fixed plant which is large enough to be a structure in its own right"* are not classed as construction.

B.4.4 LEGISLATION, STANDARDS AND GUIDANCE

Further details and links to relevant regulatory guidance are given in the following sections of this guidance:

Interface with Grid, OFTOs etc.
Leadership & Safety Culture
Ergonomics, Human Factors and Behavioural Safety
Management Systems
Workforce engagement
Occupational Health and Medical Fitness to Work
Supply chain management
Safe systems of work
Simultaneous Marine Operations (SIMOPS)
Emergency response & preparedness
First Aid
Access and Egress
Confined Spaces
Ergonomics
Electrical Safety
Fire
Hazardous Substances
Lifting
Marine Co-ordination
Metocean
Ports and Mobilisation
Remote Working
Vessel Selection
Vibration
Waste and Spillage Management
Welfare
Work at Height

B.5 DECOMMISSIONING

As a condition of consent for an OREI, a decommissioning plan is generally required to be submitted to, and approved by, the Department of Energy and Climate Change before construction starts. This enables the government to ensure that its obligations under international treaties to ensure the safety of navigation (under UNCLOS) and protection of the marine environment (under the OSPAR Convention for the Protection of the Marine Environment of the North-East Atlantic) are fulfilled. UNCLOS refers to IMO standards; in general, the aim of decommissioning activities is to restore the location of the OREI to its condition prior to the development having been installed.

Decisions made during the design phase, and subsequent modifications and upgrades, will determine the hazards that have to be addressed during decommissioning.

The general requirement in decommissioning is that the OREI should be completely removed; however in the case of items such as piles driven deep into the seabed, or buried cables, this may not be appropriate, in which case the Best Practicable Environmental Option (BPEO) is likely to be partial removal, as long as this can ensure that there is no hazard to future safe navigation or other sea uses such as fishing. Such partial removal is likely to entail cutting piles below the level of the seabed, removing any exposed sections of cable, and committing to a programme of monitoring to ensure that the buried components are not subsequently exposed due to seabed movement.

The level of detail in decommissioning plans submitted prior to construction will be limited, but should be sufficient to show that current regulatory requirements can be safely fulfilled with techniques that are available at the time of preparation of the plan. Both the regulatory requirements and the available techniques may change over the lifetime of an OREI, therefore the plan should be subject to periodic review.

B.5.1 RE-POWERING

As an alternative to full decommissioning when a device has reached the end of its working life, it may be possible to undertake repowering, in which a new device is installed in place of the original device, re-using infrastructure such as foundations, support structures and cabling. This represents a very complex operation, combining partial decommissioning and dismantling of the original device, with installation of the new device, and probably also involving major refurbishment and modification of retained sections of the original installation.

The ability to re-power an OREI will be strongly influenced by decisions taken earlier in the lifecycle:

- The initial specifications for structures and infrastructure such as cables will determine whether they have any additional capacity for increased loads;
- The design life of structures, and their condition at the time of proposed re-powering, will determine whether they are fit for further use, and the extent of refurbishment work that might be necessary;
- The detail design of structures will influence the ease with which the old device can be removed, and the new installed; and
- Detailed information on the original installation, together with any changes that have occurred over its operating lifetime, will be essential inputs for the design and execution of repowering work.

Despite these challenges, re-powering may offer a safe and cost-effective approach to maximising the value of earlier investments in offshore infrastructure.

B.5.2 KEY HEALTH AND SAFETY RISKS TO BE CONSIDERED

The same operation may be more hazardous in reverse than during original assembly: for example, in the apparently simple case of a bolted joint:

- During initial assembly:
    - Components are lifted in accordance with manufacturer's instructions, often under the supervision of the manufacturer's own specialist personnel, using

lifting points of known strength, and are then lowered into place (sometimes with the assistance of bumpers and guides), the holes aligned, the bolts inserted and tightened to the specified torque;

- During disassembly:
    - Integrity of lifting points may have deteriorated:
        - Condition will need to be assessed prior to lifting, and if the lifting points are no longer suitable, alternative safe means of attachment will be necessary;
            - The initial design and location of lifting points will affect the probability that they will still be serviceable when required for decommissioning;
    - Bolts are removed:
        - May break or need to be cut if corrosion has caused seizure of threads or loss of shape from the heads, preventing the safe application of sufficient torque;
            - Such failures can cause sudden release and movement of tools, introducing a hazard to people working nearby;
            - If fasteners have to be cut, then techniques such as burning or grinding introduce a fire risk, and / or high noise and vibration levels;
    - Flanges are separated:
        - Flanges may adhere to each other due to the effects of corrosion, or the application of paints and sealants;
            - Sudden release may shock-load lifting equipment, or lead to sudden swinging of loads, both of which can be hazardous to people;
            - The provision of jacking points as part of the original design can provide a safe means of separating flanges from each other prior to lifting operations being undertaken;
        - Flooded compartments may have unknown weight, and the centre of gravity can shift;
        - Marine fouling can add weight, and inhibit the release of components or the attachment of lifting equipment.

Other joining systems also present challenges; for example, grouted connections cannot be disassembled, so structures will have to be cut, usually at a location away from the grouted areas.

While piled foundations can be driven into the seabed without any subsea work being undertaken, cutting of piles beneath the sea floor involves intricate subsea work, followed by lifting of the cut section of the pile.

- While the pile is being cut, it will need to be supported, usually by attachment to a crane, as it may no longer be able to withstand wave loading from the sea;
- The cutting system needs to provide certainty that the structural element has been completely cut through, to enable safe lifting.

The design of structures, and selection of materials during the design phase should therefore consider how the OREI will eventually be decommissioned, in order to minimise the hazards that will be involved in this work.

In the event of a device or structure being damaged during its operating life, decommissioning may be more hazardous; for example, the centre of gravity of a broken blade will be different to that of a complete blade, affecting lifting operations, while access inside a fire-damaged structure will not be able to rely on the lift or ladder being in safe condition to use. In such cases, additional task-specific planning and risk assessment will be necessary, prior to starting decommissioning activities.

B.5.3 HEALTH AND SAFETY CRITICAL INTERFACES AND COMMUNICATIONS

Inputs from earlier phases:

- The risks that decommissioning will present should first be considered during project definition and detailed design phases. In addition to the requirement to prepare a decommissioning plan prior to construction of the OREI, Designers and manufacturers have specific legal duties with respect to decommissioning:
    - Under CDM, the Designer's responsibilities include considering "*the health and safety of those who will maintain, repair, clean, refurbish and eventually remove or demolish all or part of a structure*." The Designer must therefore consider how to reduce risk during decommissioning; this could include, for example, designing subsea structures that will be suitable for the use of Remotely Operated Vehicles (ROVs) during the expected decommissioning operations, thereby avoiding the need to deploy divers;
    - Under the Machinery Directive, the Essential Health and Safety Requirements aim to "*eliminate any risk throughout the foreseeable lifetime of the machinery including the phases of transport, assembly, dismantling, disabling and scrapping*". Where the manufacturer can take measures that contribute to this aim, such as avoiding the use of construction techniques or materials that increase hazards during dismantling or scrapping, then they should do so.

Decommissioning phase activities:

- At the start of preparations for decommissioning, the initial decommissioning plan, prepared prior to initial construction, and updated during the life of the OREI, should be reviewed, particularly as the condition of the OREI may not be as originally envisaged, and recognised industry good practice is likely to have evolved over this time period;
- Detailed decommissioning plans should consider how Aids to Navigation and other safety-related systems are to be maintained in the period between shut down of a device, and completion of removal. The requirements may differ from those that applied during normal operation:
    - At some point in this process, the device will be disconnected from external power sources, thereby removing the power for AtoN, communications, internal lighting, lifts and hoists;
    - Partially-dismantled structures can pose a greater navigational hazard than complete structures; for example, a monopile from which the transition piece has been removed will not be visible above the surface, or on radar, yet is within the draft of many ships. Navigational safety measures such as buoyage, guard vessels and Notices to Mariners should be determined by risk assessment, and agreed with the MCA and GLA;
- In many cases, decommissioning of parts of an OREI will take place while other parts are still in normal production. In order for such phased activity to be managed safely:
    - Clear boundaries and protocols will need to be established to avoid the risk of interference between parts of the site that are operational and those that are being decommissioned;
    - Suitable isolations and eventual permanent disconnection of electrical systems will be required;
    - Marine Co-ordination arrangements and the Emergency Response Co-operation plan will have to be revised to reflect the change in activity and occupancy on the site;
- Decommissioning will give rise to large quantities of equipment and structures that will need to be subject to suitable processing, with the aims of maximising recycling and

minimising environmental impact. The ability to achieve these aims will be influenced by material selection decisions made at the design stage, together with the availability of information on these at the time of decommissioning.

Outputs:

- On completion of decommissioning, the site should be restored to its original state, before the OREI was developed, and should not present any additional risks to navigation or the environment;
    - Third party surveys may be required by regulators to demonstrate that this has been achieved, with follow-up monitoring of any buried structures or cables that remain in areas where the seabed may be mobile.

B.5.4 MANAGEMENT AND OPERATIONAL CONTROLS

The activities involved in decommissioning fall within the definition of construction work under CDM. During the initial construction project, the CDM Co-ordinator will have prepared a Health and Safety file that is then passed on to the Client, and should include "*information regarding the removal or dismantling of installed plant and equipment*". Provided that this has been kept up to date by the Client, it will be an important source of information when preparing detailed decommissioning plans, and for provision of pre-construction information to potential contractors.

The Client has a duty to appoint a CDM Co-ordinator and Principal Contractor to undertake the decommissioning project in accordance with the requirements of CDM. The management arrangements for the decommissioning project will then be similar to those for an offshore construction project.

The UK Hydrographic Office (UKHO) and the Defence Geographic Centre should be informed once removal is complete, so that the OREI can be deleted from charts and information.

B.5.5 LEGISLATION, STANDARDS AND GUIDANCE

Department of Energy and Climate Change – Decommissioning of Offshore Renewable Energy Installations under the Energy Act 2004: Guidance Notes for Industry (Revised January 2011) takes account of obligations under international treaties and domestic legislation, and defines current regulatory expectations at the pre-construction stage.

International Association of Oil and Gas Producers - *Risk considerations in the lifecycle - Activity: Decommissioning and disposal* provides an outline of risk management issues relevant to offshore decommissioning; while some of these are specific to oil and gas issues, most are also relevant to OREIs.

Oil & Gas UK – *The Decommissioning of Steel Piled Jackets in the North Sea Region* summarises experience to date in the oil and gas industry, including safety lessons learned.

HSE OTH 349 - *Evaluation, Selection and Development of Subsea Cutting Techniques* provides detailed discussion of a wide range of techniques, considering their effectiveness and hazards, including FMECA analysis of each technique. As it was published in 1991, the state of the art has subsequently developed further, particularly with respect to ROV capabilities, but the principles are still relevant.

IMCA D-003 – *Guidelines for Oxy-Arc Cutting* provides an overview of subsea cutting techniques, together with detailed guidance on oxy-arc cutting.

Further details and links to relevant regulatory guidance are given in the following sections of this guidance:

Construction (Design and Management) Regulations 2007 (CDM)
Risk Management
Safe systems of work
Simultaneous Marine Operations (SIMOPS)
Emergency response & preparedness
Access and Egress
Confined Spaces
Electrical Safety

Fire
Hazardous Substances
Lifting
Marine Co-ordination
Metocean
Noise
Ports and Mobilisation
Subsea Operations
Vessel Selection
Vibration
Work at Height

B.6 SURVEY & GEOPHYSICAL

OREI development typically takes place in locations where there is minimal pre-existing information on the properties of the site. In order for the developer and regulators to make high quality decisions, a wide range of data is needed.

The data requirements change over the project lifecycle; early project definition decisions will be informed by data that covers a wide area in minimal detail, while later activities, such as site-specific detailed design and subsequent installation work, will require specific information about individual locations on the site.

A wide range of survey activities can be expected to take place, including:

- Geophysical: use of instruments, generally mounted on, or towed behind vessels, in order to assess the physical characteristics of the site, such as bathymetry and sub-bottom soil profiles; depending on the techniques used, the data may also support UXO assessment;
- Geotechnical: intrusive investigation of sub-bottom soil properties, generally undertaken by drilling from floating or jacked-up vessels;
- Environmental: ornithological and other wildlife surveys, which may be conducted from vessels or aircraft; and also benthic surveys and sampling carried out from vessels;
- Archaeological: using remote (geophysical) and visual (ROV / diving) techniques to identify any historical features of the site.

Their use will vary over the project lifecycle:

- Definition:
  - Geophysical site surveys to inform decisions on location of OREI and potential cable routes;
  - Limited geotechnical investigation to “truth” the geophysical data;
  - Environmental and archaeological surveys to support the EIA process; and
  - On-site metocean data collection campaigns;
- Project design:
  - Increased detail of geotechnical investigation to support site-specific foundation design and micrositing decisions;
- Installation & commissioning:
  - Consenting conditions may require environmental monitoring to be undertaken, for example, having marine mammal observers present when certain activities are being undertaken;
- Operations & maintenance:
  - Monitoring scour around foundations, and seabed movement that could affect cable protection;
- Decommissioning:
  - Initial evidence of seabed clearance, and subsequent monitoring of any cables or structures left in the sea bed, to ensure that they remain below the surface and do not present a hazard to other sea users.

B.6.1 RELEVANCE AND IMPACT ON SUBSEQUENT PHASES OF LIFECYCLE

The quality of data from surveys will affect subsequent decisions, and the technical, economic and health and safety success of the development. As the development progresses, it is necessary to maintain and update survey data over the lifetime of the project; this can include:

- Recording the precise location of cable routes and seabed changes due to jack-up vessel leg penetration; these represent discrete events that need to be permanently recorded onto the project chart data; or

- Monitoring ongoing processes such as seabed movement in relation to scour and cable protection, where the key information relates to how the situation is changing over time, rather than the precise situation at any given point in time.

B.6.2 KEY HEALTH AND SAFETY RISKS TO BE CONSIDERED

B.6.2.1 AERIAL SURVEYS

The health and safety aspects of aerial surveys are covered in Section C.2.2.

B.6.2.2 MARINE SURVEYS

Marine surveys can include:

- Visual observations from a vessel, such as seabird or mammal observations;
- Measurements being obtained from instruments fitted to, or towed behind, a vessel, such as sonar measurements of bathymetry and sub-bottom profiling;
- Geotechnical surveys, involving intrusive investigations into the seabed.

Surveys conducted from moving vessels rely on being able to follow a predetermined survey path; while there may be no technical restriction on the vessel's ability to change course in order to avoid danger to or from other vessels in the area, this may impair the quality of the data obtained. The quality and safety of the survey operation depend on selecting a vessel that is suitable for the intended activities, both in terms of its physical characteristics and operational arrangements.

Geotechnical investigations can expose vessels to risks from seabed hazards; these include geological hazards such as shallow gas pockets, unknown seabed bearing strength if jack-up vessels are to be used, and unexploded ordnance (UXO) on the seabed, or buried in sediments. Many of the world-wide jack up incidents (predominantly involving uncontrolled punch-through, and not only relating to OREIs) can be attributed to poor specification, conduct, data processing, interpretation and presentation of geophysical and geotechnical surveys.

Some survey activities will involve detailed visual inspection of particular seabed features of concern; in most cases, this can be obtained by deployment of an ROV to obtain video / photographic images, although divers are also used for some visual inspections.

B.6.3 HEALTH AND SAFETY CRITICAL INTERFACES AND COMMUNICATIONS

As survey activities run in parallel with all other project phases, surveys will have to interface with the project activities being undertaken, as well as the project activities that the survey data is to support.

When planning and undertaking surveys, communication with other sea and airspace users is critical, both to the safety of the survey, and to enabling it to proceed as planned.

Where surveys are undertaken with different objectives, this is likely to be reflected in the techniques used, the data obtained, and its format and resolution. While data from a range of sources can be combined to form a common model, to inform current decision-making and definition of the next phase of survey activity, it is important to understand the limitations of data within such a model. Further, if there is an intention to combine data in this way, the specification of surveys should ensure that the data is suitable for this, with particular respect to how the positional references are maintained.

Maintaining a clear understanding of the current stage and limitations of survey data is particularly important in cases where there is a change of ownership of the project being developed, as otherwise it may be assumed that the survey process is further advanced than it actually is.

B.6.4 MANAGEMENT AND OPERATIONAL CONTROLS

The nature of survey work is that it involves gaining an understanding of previously unknown information about a site, with each stage being used to inform the next. Survey work may well give rise to the first occasion on which a jack-up vessel jacks on a site; preparation for this depends on the suitable specification of earlier stages of survey work, together with detailed operating procedures for the jacking operation in order to minimise the risk presented by the limited understanding of seabed properties.

Survey work will also involve vessel deployment, which should be preceded by a suitable process of vessel selection, to ensure that the chosen vessels and their crews will be able to undertake the proposed activities safely and efficiently.

All offshore activities, including survey, should be under the control of the Marine Co-ordination function, in order to avoid adverse interactions between activities, and to monitor the status of vessels. Separate arrangements will be necessary to support aerial survey activities.

B.6.5 Legislation, Standards and Guidance

Further details and links to relevant regulatory guidance are given in the following sections of this guidance:

Supply Chain Management - Contracted Services
Simultaneous Marine Operations (SIMOPS)
Emergency response & preparedness
Aerial Surveys
Geological Unknowns
Marine Co-ordination
Metocean
Navigation
Remote Working
Subsea Operations
Unexploded Ordnance
Vessel Selection

B.7 LOGISTICS & MOBILISATION

OREI logistics involves the movement of people, components, equipment and materials between their original locations and the project site. Logistical activities will be particularly intensive during construction of the OREI, will continue at a lower level to support maintenance activities over its operating life, and then intensify again during decommissioning.

OREIs typically comprise equipment manufactured in various locations; the logistics function makes the necessary arrangements in order to supply offshore activities with all equipment as needed. This typically involves receiving deliveries of batches of components from manufacturers, and picking from these in order to provide the offshore activity with kits comprising the correct combination of components for each stage of offshore work, packaged as required for ease of handling offshore. In other cases, components may be shipped directly from manufacturer's factory or storage sites to the offshore site, in which case the logistics function has to agree precise scheduling and packaging arrangements between the supplier and the offshore installer.

B.7.1 RELEVANCE AND IMPACT ON SUBSEQUENT PHASES OF LIFECYCLE

The supply chain needs to be reliable, ensuring that all necessary items are available at the offshore site when required, as the lack of a tool or component offshore can lead to far greater delay than might be the case onshore. The logistics process also offers the final opportunity for quality control activities, to verify that components are in suitable condition to be installed offshore.

It is important to maintain full traceability of key parts and tools, as on a large development, it is likely that parts will be from different batches or even different suppliers; in the event of any defects or problems becoming apparent at a later stage, good traceability will allow any necessary checks or remedial actions to be targeted accurately.

Effective protection of components during onshore storage and offshore transfer will minimise the need for later repair / exchange activities. Areas of concern include ensuring that:

- Surface coatings are protected during handling operations;
- Partially-completed assemblies are weathertight;
- Power is available in order to operate critical systems that must remain in operation to satisfy warranty conditions or maintain component condition; and
- Storage areas are secure, as any theft / vandalism could compromise the operability and safety of equipment installed offshore.

Due to the size of components for OREIs, storage areas need to be capable of handling and storing extremely large and heavy components; any delays in the offshore installation programme can result in large areas of additional storage being required. Conversely any shortcomings in the logistics function can adversely affect offshore construction activities, potentially increasing the duration or number of operations, and hence increasing risk exposure.

B.7.2 KEY HEALTH AND SAFETY RISKS TO BE CONSIDERED

Many components are large, heavy and potentially fragile; and will be subject to lifting and handling operations as part of the logistics activities. Suitable methods must be utilised, otherwise the health and safety of those involved can be put at risk.

The logistics function will have to work closely with the Marine Co-ordinator and port authorities:

- The logistics base(s) will generally be in ports, and will give rise to large numbers of vessel movements, together with the potential for interaction with other users of the port;
- The movements of vessels and people working offshore should be continuously monitored, in order to avoid hazardous situations arising, and to respond to any emergencies.

Vessel mobilisation is a key enabling stage to support the logistics effort; this often involves undertaking modifications to equip vessels for specific tasks:

- The extent of such modifications will be determined by the degree to which the intended task differs from those for which the vessel is already equipped;
- The design of the modifications will determine the safety of the people involved; and
- People working with modified vessels will need to understand the particular characteristics of the vessel, and be especially aware of any danger areas that the modifications create on vessels, as these will vary between vessels, and change when modifications are implemented.

B.7.3 Health and Safety Critical Interfaces and Communications

Offshore work depends on effective material handling arrangements, as every item has to be transferred between the quayside, the access vessel and the OREI structure; this will generally involve lifting operations, so the necessary methods and equipment need to be identified in advance, in order to give safe and efficient transfers at every step from the factory to final installation. At an early stage in the process, suitable onshore bases for construction and O&M phases will have to be identified, and in many cases, facilities installed to support the project activities.

Fundamentally, the logistics system needs to be designed as a whole, considering both the physical components such as the vessels, cranes and storage locations to be used, as well as the operational systems to co-ordinate the work of multiple contractors and suppliers.

At a more detailed level, the design of packaging / seafastening and handling systems will affect the need for, and safety of, subsequent transfers, including whether or not transfers will involve lifting, and how the components are to be prepared for installation; for example, it may be possible to reduce the need for lifting operations if large components are supplied on wheeled stillages, but this only works if the vessels and ports to be used can accommodate roll-on roll-off operation.

The design of the logistical arrangements can be subject to conflicting demands; for example in the case of offshore WTG erection using a jack-up vessel:

- If the WTG installation vessel collects the major components from port, then:
    - This eliminates the complex and potentially-hazardous offshore lifting operation between a floating feeder vessel / barge, and the static installation vessel;
        - This may reduce weather sensitivity; however:
- If the WTG vessel is able to remain on station, and be supplied with components by means of feeder vessels, then:
    - This can reduce the duration of offshore operations by allowing better utilisation of weather windows, and of the installation vessel itself;
    - The feeder vessels may have better seakeeping characteristics than an installation vessel, reducing risk during component transport operations.

Such decisions will be project-specific, and should be based on a thorough assessment of the risks that different approaches present, and the characteristics of a particular site and its support base locations.

An interface exists at every physical handover of equipment and materials, and at every transfer of information; the risk of errors can be minimised by eliminating any unnecessary handovers, and ensuring that robust procedures are in place where handovers must occur.

B.7.4 Management and Operational Controls

The logistics operation depends on effective co-ordination of suppliers, contractors, vessel movements, and the operation of storage facilities. Marine Warranty Surveyors can assist in assessing the suitability of vessels and different approaches to installation.

Contractual arrangements should take account of the need to integrate activities into the project logistics processes, and also recognise the impact that any logistical breakdowns can have on overall project execution.

B.7.5 LEGISLATION, STANDARDS AND GUIDANCE

Further details and links to relevant regulatory guidance are given in the following sections of this guidance:

Supply chain management
Simultaneous Marine Operations (SIMOPS)
Lifting
Marine Co-ordination
Ports and Mobilisation
Vessel Selection

B.8 MODIFICATIONS & UPGRADES

Over the lifecycle of an OREI, a wide range of types and scales of change can be expected; these include:

- Technical changes to the design of equipment, or changes to software, that can affect its operation;
    - These range from minor component changes, to complete re-powering with new WTGs;
- Procedural changes, affecting the actions to be taken by people in a given situation; and
- Organisational changes, affecting the deployment of people to different activities, and the management arrangements relating to their work:
    - This includes situations such as when warranties and service contracts reach their expiry, and responsibilities transfer from one organisation to another; however
    - Organisational changes can also be gradual, significantly changing an organisation's capabilities over a period of years.

Changes may be sought by a number of different parties, for example:

- The OEM may identify a defect that requires rectification;
- The operator may identify an opportunity to implement an upgrade in order to improve performance; or
- Technicians may identify a change that would improve the safety or quality of their work.

B.8.1 DESIGN CHANGES

The pace of OREI development is such that many devices have relatively short operating histories, and the detail of designs is constantly being developed in order to eliminate identified defects, reduce both initial and lifetime costs, and improve energy yield. Over the design lifetime of an OREI, typically around 25 years, it is foreseeable that upgrades will become available to improve performance, or may be required if components, particularly those in electronic and SCADA systems, become obsolete. Other modifications may be needed much earlier in the lifecycle, for example if design details present unacceptable risks to people, or if serial defects are revealed in early operation; the probability of such situations occurring can be reduced by undertaking detailed assessment of prototypes before commencing series production, supported by subsequent careful control of design changes that deviate from the prototype.

Any change from an established design needs to be controlled and assessed carefully, as even relatively minor changes in design or component sourcing can introduce reliability or safety problems.

The priority should be to minimise the need for modifications, through thorough design review, prototyping of novel systems, assessment of existing installations before commencing series manufacture, and study of installation requirements. The risk of obsolescence forcing changes later in the lifecycle should be assessed as part of the tendering process; at the very least, the manufacturer's support strategy should be clearly understood, as this may influence future decisions on procurement of critical spare parts.

If a proposed design depends upon a particular installation method being used, then unless contractual arrangements can ensure that the required method will be available, it may be advisable to adopt a design, at the prototype stage, that maintains flexibility in the selection of installation approaches, otherwise modifications may be necessary even before the device has been installed.

The process for managing such changes is described in more detail in Section A.13.

B.8.2 ORGANISATIONAL CHANGES

Organisational changes are a key human factors issue that can contribute to causing incidents to occur, or increasing the severity of incidents if those involved do not respond correctly.

Organisational changes can arise from various causes:

- Transfer of ownership of an organisation or an OREI, or transfer of contracts from one organisation to another;
- Gradual turnover of personnel;
- Changes to the structure of an organisation, sometimes as a consequence of growth, or integration of new sites to an existing organisation; and
- Changes in the allocation of safety-related responsibilities.

Such changes can have a range of effects:

- Some effects are a direct consequence of the change, such as
  - The loss of experienced personnel;
  - Changes to procedures, or new people being unfamiliar with existing procedures; and
  - Increased pressure on staff, as a consequence of a reduction in staff numbers, or taking on additional work;
- The indirect consequences of changes can also affect the safety of operations:
  - Where an organisation's contract is expiring and not being renewed, there is a risk of short-term thinking prevailing in the period leading up to the end of the contract; and
  - Concerns about job security and future opportunities can distract people from their normal work activities, or if people leave before a contract expires, their skills and experience will be lost.

While most major organisational changes are obvious, others may not be so; for example, a gradual loss of experienced personnel, combined with additional workload and responsibilities could go unnoticed until an incident occurs, and reveals the weaknesses; having an effective internal audit process should reveal such drift before it affects the safety of an organisation's activities.

B.8.2.1 MANAGING MAJOR ORGANISATIONAL CHANGE

The risks arising from organisational change should be assessed, considering both the risk that will arise from the new arrangements, and from the manner in which the change is to be introduced. If a phased approach is adopted, rather than all changes being carried out simultaneously, then this avoids the total unfamiliarity that can otherwise occur; this is balanced with the extended period during which the organisation passes through a number of temporary states, each one of which must be capable of safe operation.

Major organisational changes can occur in any phase of the lifecycle, in the earlier phases, a developer may take a project as far as consenting, and then sell some or all of their stake in it to another investor, who will then be involved with later stages in the lifecycle. In addition to standard technical and commercial due diligence, it is important that the health and safety implications of such a transfer are recognised and managed:

- There needs to be an effective handover of information, such as risk assessments and registers, metocean and other survey databases;
  - In addition to the actual data, it is essential that its context, purpose and level of detail is understood; for example, a risk assessment or survey that may be suitable and sufficient for developing an outline design, will be inadequate for preparation of more detailed construction plans.

Where organisational changes affect established operations, such as the sale of an OREI that has been in operation for several years, changes in safety systems and cultures need to be recognised, and future objectives agreed. Various approaches may be used:

- It may be possible to combine systems, retaining the strengths of both the old and new owners' approaches; or

- The new owner may manage the development as an autonomous business unit, retaining its existing systems, and either maintaining them for the long term, or making a gradual transition to new systems; or
- The new owner may seek to maintain consistent approaches across their business; while this minimises complexity at a corporate level, it can result in major dislocation to an established operation.

There is no single correct approach to these situations; the most important point is to recognise that major organisational changes can have direct operational effects on health and safety, and ensure that they are properly managed.

Organisational changes are most likely to be implemented in a safe and successful manner if they are subject to thorough consultation with those who will be affected, both amongst staff and contractors, including meaningful opportunities to contribute to the development of the new arrangements.

B.8.3 LEGISLATION, STANDARDS AND GUIDANCE

IMCA SEL001 - *Guidance for the Management of Change in the Offshore Environment* describes the issues relating to control of change, and outlines a management process.

HSE *Human Factors Briefing Note No. 11 - Organisational Change* gives examples of how organisational changes can affect the safety of an organisation's activities, and approaches to adopt during change management in order to maintain safe operations.

Further details and links to relevant regulatory guidance are given in the following sections of this guidance:

Management of Change
Supply of Machinery (Safety) Regulations and Harmonised Standards
Ergonomics, Human Factors and Behavioural Safety
Risk Management
Safe systems of work

PART C OFFSHORE HAZARDS AND ACTIVITIES

INTRODUCTION

SCOPE

This section of the guidance addresses some of the key activities and hazards that are likely to arise over the lifecycle of an OREI, with the greatest emphasis being given to those that are most relevant, in terms of the level of risk, the degree to which they are specific to OREIs, and where guidance from existing sources is least adequate.

Within the scope of these guidelines, it is not possible to address every hazard in detail; the guidelines therefore aim to:

- Highlight some of the key risks to consider, and mitigation approaches that might be adopted:
  - This could be used to trigger consideration of other relevant risks, but is not a substitute for suitable and sufficient risk assessments, which must be undertaken as part of the safe management of any activity;
  - Where examples are given, they are neither exhaustive nor mandatory, and do not alter the duty-holder's responsibility to manage the unique combination of risks and resources on their own development;
- Signpost existing sources of guidance that provide more detail:
  - The referenced sources have been selected with care, and every effort has been made to ensure that they are relevant, with specific sections being identified where possible; however
  - Duty-holders must make their own assessment of its relevance and sufficiency for the activities that they are considering.

REGULATORY CONTEXT

All of the activities described in this part of the guidance take place within:

- The overall legal framework, described in Section A.1;
- The safety management systems that an organisation operates, as outlined in Section A.6; which will include:
  - Requirements for risks to be managed, as described in Section A.7; and
  - Control of individual tasks within a Safe System of Work, as described in Section A.9.

As these regulations and systems are addressed in more detail in Part A, they are only mentioned in this Part if they have specific implications for an activity or hazard; the regulatory references in this Part are focused on those which are specific to the topics addressed here.

STRUCTURE OF THIS GUIDANCE

Each topic in this Part of the guidance is addressed in a similar manner:

- An overview of the activity or hazard is given;
- Potential hazards and risks are outlined;
  - The main focus is on health and safety risks, although significant commercial, operational and indirect or consequential risks are also mentioned;
- Regulatory requirements, that are specific to the topic, are summarised;
- Risk management approaches are discussed; and
- Sources of further guidance, from regulators and industry bodies, are signposted.

For topics where marine energy developments involve specific challenges that differ significantly from those of offshore wind, these are addressed in separate sub-sections.

C.1 ACCESS AND EGRESS

C.1.1 OVERVIEW

Offshore wind development is presenting a unique access challenge, involving frequent transfer of small work parties between access vessels and wind farm structures; a worker undertaking routine offshore operations, potentially on a daily basis over the life of an offshore wind farm, is likely to undertake many thousands of transfers during their career.

Marine energy development presents different challenges, particularly in relation to operation in strong tidal currents.

Every transfer exposes the people involved to a number of significant hazards; given the expected frequency of transfers, extremely robust and repeatable systems are required in order to ensure that the overall risk remains at a tolerable level.

Access and egress in this section is taken to consist of:

- The transfer from an access vessel to the first safe platform on a fixed or floating OREI structure or accommodation vessel;
    - Note that risks relating to the vessel passage, up to the point of transfer, and any further climbing in order to access the structure, are covered in the sections on vessel selection and work at height; or
- The transfer by helicopter between a helipad (which may be onshore or offshore) and:
    - The nacelle of a WTG, by means of winching between the helicopter and a purpose-designed helihoist platform on the nacelle; or
    - A helideck where the helicopter lands on an offshore structure (such as a substation) or an accommodation or support vessel.

Both of the above types of transfer are regulated under the HSWA; additional maritime or aviation regulations will affect the use of vessels and aircraft for these purposes.

Suitable access arrangements are also required in ports and harbours, and for any other transfers between vessels.

C.1.2 TRANSFERS TO AND FROM VESSELS

A range of approaches has been adopted for offshore access from vessels, including:

- Direct step-over from workboats to ladders, with the vessel holding position by thrusting against vertical fenders adjacent to the ladder; this is the most common system in use at present;
- Mechanised systems:
    - Devices such as gangways that assist the transfer from the vessel to the ladder, and are largely passive systems;
    - Active motion-compensated platforms or gangways that give a level step-over from the vessel to a platform on the structure, known as “walk to work” systems.

C.1.2.1 VESSEL TO VESSEL TRANSFERS

Where vessels are provided with dedicated facilities such as boat landings to enable transfer, then the hazards are likely to be similar to transferring between vessels and structures, although with increased potential for risks due to relative movement.

Other forms of transfer may also be used, including:

- Personnel carrier, lifted between vessels using a crane; or
- Pilot ladders.

These approaches involve higher levels of risk, so operations should be planned in such a way as to avoid such methods. If circumstances dictate that an enforced change of vessel is necessary, then the proposed transfer should be subject to risk assessment, to determine whether or not the transfer can go ahead without exposing people to unacceptable risks, and identify necessary mitigation. The MCA and IMCA provide detailed guidance on these transfer methods.

C.1.2.2 POTENTIAL HAZARDS AND RISKS

C.1.2.2.1 Direct Health and Safety Risks

Transfers involving vessels may expose people to risks of:

- Falling down onto the vessel, or into the sea, or being suspended by a fall arrest system;
- Crushing or entrapment due to relative movement between the vessel and the ladder;
- Serious injury from any objects that may drop from the offshore structure during transfer operations;
- Stranding – if metocean conditions change, such as weather or sea state deteriorating, or if very low tides prevent access in areas of shallow water; and
- Whole Body Vibration during transfer in rough sea conditions.

OREIs may be located in areas without full radar / VHF coverage, which may affect the ability to monitor and control routine and emergency operations.

C.1.2.2.2 Commercial and Operational Risks

Any means of access will have a limit on the conditions under which it can be used safely; if the means of access does not have the necessary capability for the conditions at the location, then this may mean that access is not available for a large part of the year, potentially resulting in:

- Reduced revenue due to lost generating output if OREIs are awaiting repair; or
- Additional costs if staff and vessels are waiting for suitable weather.

As weather-related downtime is inevitable, it is important to ensure that contractual arrangements encourage the provision and operation of safe and capable systems.

C.1.2.2.3 Indirect and Consequential Risks

The method of access to be used will affect the specification of access vessels, and the design of corresponding interfaces on offshore structures. This represents a large investment; if it were later decided to change the access method; significant costs could be incurred, particularly if offshore structures were to require modification.

C.1.2.3 RELEVANCE TO KEY LIFECYCLE PHASES

Access to offshore structures is required at all stages of their lifecycle; during some construction operations, gangways from jack-up vessels may be used, rather than relying entirely on transfers from workboats.

Access and egress is a key consideration at the design phase, as the concept, vessel selection and detail design of interfaces must be compatible in order to provide safe and efficient access over the life of the OREI.

During the O&M phase, a variety of access methods may be used, depending on the maintenance and access strategy adopted. While some O&M work can be scheduled for seasons when favourable conditions can be expected, other work is reactive, so relies on access being available within a reasonable time in any season.

C.1.2.4 REGULATORY REQUIREMENTS

As access and egress involve a combination of activities, several different sets of regulations apply; these depend on the activity, such as the use of vessels, work equipment, machinery, PPE and work at height.

Marine aspects of access and egress, such as the operation of vessels, are regulated by the MCA.

C.1.2.5 MANAGING THE RISKS

A wide range of factors that could affect the risk to people transferring from vessels needs to be considered:

- Any access system needs to have a clearly-defined operating window, supported by robust evidence of capability relative to metocean condition limits such as:
    - Wind speed and direction;
    - Sea state – wave height (significant and maximum), direction and period (which combines with height to affect steepness);
    - Visibility – fog, hours of darkness;
    - Effect of tidal height and currents;
    - Sea temperature;
    - Air temperature, as very cold conditions, combined with rain or sea spray, can cause icing on ladders and fall arrest systems;
    - Uncertainty in measurements or variations across a site;
- Site characteristics, such as the distance to the onshore base or safe haven, will affect routine and emergency planning arrangements;
- Structure to be accessed:
    - Orientation of access point(s) relative to prevailing metocean conditions;
    - Design of interface:
        - Structural strength;
        - Compatibility with vessels, including maintaining a safety zone so that the person on the ladder cannot be injured by vessel movement relative to the ladder;
    - Condition of the interface at the time of transfer, such as damage / deterioration, and contamination;
        - Guano presents a range of health risks, including the potential to aggravate respiratory disorders such as asthma;
    - Relative movement of floating OREIs, or accommodation vessels, against access vessels, in response to the sea;
- Access vessel:
    - Capability relative to metocean conditions;
    - Skill and experience of crew(s);
    - The manner in which it interacts with the landing system, for example, whether it moves under a stick-slip friction regime, or gradual release;
- Human factors:
    - Pressure (from any source, including oneself) to get the job done:
        - Frustration if unable to transfer after long journey to site;
        - Wanting to get off vessel after journey in rough conditions;
        - Not wanting to be stranded, even if conditions have deteriorated while on the offshore structure;
        - Financial incentives for offshore working;
    - Ability to make objective safety / capability assessments prior to a transfer, particularly if cold, wet or suffering from seasickness;

    - Fatigue, due to factors such as long working hours, intensive campaigns, or long transit journeys in rough sea.

C.1.2.5.1 Approaches to Risk Assessment

Access and egress requires thorough risk assessment throughout the project lifecycle, starting with concept development, detailed design reviews and HazOp or equivalent studies to validate proposed designs and procedures, with the final stage being dynamic risk assessment immediately before each transfer decision.

The risk assessment needs to consider both normal operation and response to potential emergencies; as more capable vessels and access systems are introduced and operated in more demanding conditions, the difficulty of effecting a rescue increases. The use of dedicated man overboard systems, which make use of Personal Locator Beacons (PLBs) with homing signals to alert and guide vessels towards casualties, may be necessary, together with enhanced recovery equipment.

C.1.2.6 RISK MITIGATION MEASURES

C.1.2.6.1 Design and vessel selection

Strategic design decisions, such as the number and type of access points and vessels to be used, together with the detailed design of the vessel / boat landing interface, will have a major effect on the hazards to which people will be exposed over the lifetime of a development; it is important to ensure that all levels of design decisions are informed by a direct understanding of the reality of offshore operations, and good quality data on site conditions.

Typical measures to mitigate the risks of transfer include:

- Design of the vessel / boat landing interface to:
    - Minimise the risk of a fall, either onto the vessel or overboard;
    - Eliminate the potential for a person to be crushed or entrapped between the vessel and boat landing in foreseeable circumstances such as:
        - If relative movement occurs between the vessel and the ladder at any point in the transfer; or
        - If a fall occurs during transfer or climbing.
    - Ensure that the heights of the top and bottom of the boat bumper bars permit the foreseeable access vessel types to make safe contact, in limiting sea states, across the full range of tidal states at the location;
- Provision of rest platforms at suitable intervals on ladders, although these should not obstruct foreseeable access vessel types, taking account of maximum tidal range and heave.
- Provision of suitable lighting to allow safe transfer in hours of darkness;
- Provision of fall-arrest systems, which need to be:
    - Compatible with the foreseeable demands of transfer from a vessel;
    - Suitable for use in the splash zone; and
    - Compatible with other PPE in use, such as harnesses and lifejackets;
- Provision of suitable equipment to permit effective communication between the bridge, deck crew and personnel being transferred; such systems should:
    - Enable clear communication above the noise of the vessel and sea / weather – this becomes more difficult as new access systems allow operation in rougher conditions;
    - Leave hands free for climbing / holding on; and
    - Be reliable in the harsh offshore environment, including availability of backup systems.

If a standard interface concept is adopted, then this should ensure that specialist personnel who may support a number of different sites will be familiar with access arrangements. The range of potential access vessel designs should also be considered, to ensure compatibility at the interface.

The design and materials used for access structures and equipment located offshore should minimise maintenance requirements, and ease the removal of marine fouling.

C.1.2.6.2 Training and procedures

For transfers involving a vessel, the master of the vessel assesses the conditions, and authorises the transfer. Each individual who is to transfer has to make their own assessment of their capability to transfer safely, and inform their supervisor of any concerns. The precise criteria for transfer decisions, and site-specific safety management systems, should take account of the particular characteristics of the access systems and vessels being used.

Any personnel undertaking transfers should be trained and competent to do so, and medically and psychologically fit, taking account of any site-specific equipment and conditions. Completion of a basic training course does not guarantee competence; further, seasickness or fatigue may make a person unfit at the point of transfer.

Clear procedures are required for both normal operations and emergency situations such as:

- Vessel positioning and transfer decision criteria;
- Use of fall arrest systems, including when to attach and detach;
- Communications at each stage of the process, including:
    - Pre-deployment discussion between all parties, for example the managers of the activity to be undertaken, the vessel master, metocean forecasters and observers;
    - Pre-departure briefing, ensuring that all involved are clear on safety management processes, and operational procedures;
    - Confirmation with the Marine Co-ordinator of intention to transfer personnel, and updating personnel tracking;
- Person Over Board, including operation of any locating systems, roles of personnel involved, and other assistance that may be available;
- Rescue of a fallen and potentially injured climber, who may still be attached to the ladder by their fall arrest system; it cannot be assumed that other personnel will be present on the structure and able to assist in the rescue:
    - Operating procedures should include ensuring that a rescue kit is immediately accessible in such situations:
        - This may require a kit to be kept on each access vessel;
    - Personnel involved will require training in rescue and first aid techniques;
    - If a davit crane is to be used as an anchor point, or for man-riding, then it will require suitable specification and certification;
- Casualty evacuation:
    - A safe and effective means of casualty evacuation needs to be available at all times when people are on an offshore structure; the evacuation of a casualty who is unable to climb will be more demanding than most other transfer situations.

Procedures for emergency situations will require sufficient training and exercises to be carried out to ensure that they can be used efficiently when they are really needed.

C.1.2.6.3 PPE

The risk assessment should identify PPE requirements for transfers, taking account of the risks presented by both climbing and immersion in the sea; this is likely to comprise:

- Harness, helmet, lanyards, boots and gloves;
- Immersion suit, thermal clothing, lifejacket (with a light and possibly a PLB).

The combination of PPE must be compatible; for example, the lifejacket and harness must not interfere with the correct operation of either item. The precise clothing requirements may vary depending on prevailing weather, in order to ensure that a comfortable temperature can be maintained at different times of year. On sites where both helicopter and vessel access are used, additional issues must be considered, such as ensuring that all PLBs are of a type that is approved by the CAA for carriage on a particular helicopter operator's fleet.

The PPE used for transfer is likely to be removed by workers on arrival at the offshore structure; suitable storage should be provided in order to minimise the risk of damage to the PPE, and robust procedures including "buddy checks" should be in place to ensure that it is correctly refitted prior to subsequent tasks involving climbing or transfer.

C.1.2.7 Monitoring, Review and Change Management

Given the location of boat landings and ladders in the splash zone, they may be subject to marine growth, guano accumulation, and damage by vessels or floating debris in storm conditions. In addition to a scheduled maintenance / cleaning programme, the landing and ladders should be visually inspected to confirm that they are in a safe condition prior to every use. Operational and maintenance procedures should ensure that fall arrest systems, including mounting points, are inspected and exchanged / maintained at suitable intervals; if a fall arrest system has gone beyond its scheduled inspection date, then this must be clearly communicated, so that on the next occasion that the structure is accessed, alternative means of protection are used until a satisfactory inspection has been carried out.

The consistency of access decisions, and the investigation of any incidents, may be supported by the use of monitoring techniques such as having a continuously recording forward-facing camera on the access vessel, and bridge voice recording; these can also enhance the level of understanding amongst shore-based personnel, of the conditions being experienced offshore, and even be used to help improve the interpretation of weather forecasts and metocean data from instruments located elsewhere on the OREI.

Any repairs to boat landing structures are likely to be challenging, and very weather-sensitive, so if damage does occur, the affected structure may be out of service for an extended period of time, unless an alternative access point or method is available. In the longer term, corrosion may weaken such structures; due allowance should be made for this in the specification of materials and standards of construction.

When vessels are renewed, or hired on short term charters, or new access systems are brought into service, it is important to ensure that compatibility with boat landing structures is maintained, so that new risks are not introduced. The involvement of experienced users in the development, assessment and selection of new access methods or vessels can help to achieve practical and safe systems.

C.1.3 Mechanised Access Systems

C.1.3.1 Potential Hazards and Risks

Mechanised access systems may offer the potential for safe and reliable access in a wider range of conditions than is achievable by direct step-over from a vessel to a ladder; however such systems may introduce other risks that must be thoroughly assessed and mitigated:

- There needs to be clear understanding of the capability of a system relative to metocean conditions:
    - How is its operating point compared with operating limits, in real time?
    - Is there early warning of limits being approached?
    - If the system is operating within its limits, how does it react if there is a sudden strong gust or large wave?
- The reliability of a system may have safety implications, including failures of:
    - Mechanical or structural components;

  - Sensing and control systems, including software;
  - Functions provided by the vessel and its crew, including position-keeping, power and any control inputs.

If the use of a mechanised access system allows operation in more challenging conditions than would be possible with a conventional approach, then emergency response procedures, such as for the rescue of a person overboard, must also be capable of operating effectively in such conditions.

C.1.3.2 Approaches to Risk Assessment

Mechanised access systems should be subject to approaches such as FMEA to identify the safety implications of technical failures. The manufacturer is responsible for risk assessment as part of the design process, however, this risk assessment cannot take account of how the system will be deployed on a vessel, and any resulting interactions. These should be considered as part of the risk assessment under the MHSWR, which may need to be supported by the manufacturer of the access system, and people with specialist knowledge of vessel systems for positioning and stabilisation.

C.1.3.3 Risk Mitigation Measures

A mechanised access system, and the vessel to which it is fitted, need to be considered as a single system, to ensure compatibility in operation. This is particularly important where the access vessel is holding position under DP, rather than by contact with the offshore structure; for example, problems may occur if a DP system is holding the centre of a vessel in a stable position, as this may not always give a sufficiently stable position for an access platform mounted at the extremity of a vessel.

In the event that a fault occurs, then this should not be hazardous to users; potential failure modes should be identified, to ensure that the system fails safe under all foreseeable failure modes.

At the design stage, hardware and software that provides functional safety in mechanised access systems should be subject to design verification and validation, in order to demonstrate a suitable Safety Integrity Level for the duty on which it is used. The performance should be confirmed through thorough test programmes in real conditions.

The level of competence for the operator of a motion-compensated system should be clearly defined; where DP vessels are used, IMCA have defined a clear process to develop the training and experience of key personnel.

Operating procedures should ensure that walkway positioning is stable, prior to transfers taking place; this may include requiring a period of observation of the behaviour of the walkway and monitoring information from control systems. Procedures should also define the actions to take in the event that a walkway cannot be used, including whether any backup systems are available, and their operating limits, which will combine to determine whether the non-availability of the walkway leads to people being stranded on the OREI.

Maintenance requirements should also be considered, including:

- Provision of diagnostic systems;
- Definition of safety-critical systems and components, and performance standards;
- Location of components that may require repair or replacement;
  - This will be much easier if all such components are mounted on vessels, which can be repaired in port, than if components are located on offshore platforms;
- Testing and commissioning procedures following maintenance of safety-related components should ensure that normal operational performance has been restored.

C.1.4 Helicopter Hoist Access

C.1.4.1 Potential Hazards and Risks

Routine use of helicopter hoist access presents a different set of risks to people compared to the use of vessels; the vessel to structure transfer risks are replaced by the risks arising from winching between the helicopter and the helicopter hoist platform on top of the nacelle; these include:

- Minor injury if the person being hoisted swings against the hoist platform structure or stumbles on landing;
- Static discharge, if the helicopter has not been earthed by ensuring good contact between the zap lead and the hoist platform structure prior to transfer;
- Significant levels of noise and vibration, with the potential for hearing damage, impaired communication and exposure to Whole Body Vibration;
- Dropped objects when transferring tools and equipment between the helicopter and the hoist platform, or loose objects being blown about by the helicopter downdraught.

In addition to these risks that relate to the actual personnel transfer, the whole operation is subject to the low probability, but high severity, risk of catastrophic loss of helicopter and personnel aboard in the event of technical failure or human error, particularly when hovering in close proximity to the WTG.

C.1.4.2 APPROACHES TO RISK ASSESSMENT

While extensive data is available for conventional helicopter operations, which are subject to Quantitative Risk Assessment (QRA) for oil and gas industry use, the differences in the nature of the operations are so significant that this data may not provide a reliable indication of the level of risk involved in helihoist operations:

- Oil and gas transfers generally involve helicopters landing on helipads, with most workers staying offshore for extended periods;
    - Routine hoisting onto helicopter hoist platforms on nacelles will have a different risk profile:
        - The frequency of exposure to risk would be much higher if the operating pattern were to involve transfers at the start and end of every shift; this is more similar to the exposure for personnel attending Normally Unattended Installations (NUIs) than the traditional fortnightly transfer pattern to a manned platform;
        - However, helicopters are most commonly used as a secondary means of access, in conjunction with vessels, thereby reducing exposure;
- The hoisting operation requires precise hovering close to the nacelle for the duration of every transfer, which has a different risk profile compared to landing and take-off;
- Oil and gas helicopter transfers take place in a wide range of weather conditions, and in hours of darkness, whereas helihoist transfers to and from WTGs are only permitted under Visual Flight Rules (VFR), meaning by day and under Visual Meteorological Conditions (VMC);
    - This introduces a significant restriction on accessibility by helicopter, but eliminates operation in the most hazardous weather conditions.
- While the combination of European and UK helihoist experience to date now comprises tens of thousands of transfers, this is to be compared against an average of over 140,000 flight sectors per year (each comprising one take-off and landing) flown in support of UK Continental Shelf oil and gas activities.

The combination of these factors means that direct use of oil and gas helicopter safety data may not be appropriate, so adopting a semi-quantitative approach to risk assessment may be the most appropriate option. The assessment should consider the total contribution of helicopter transport, to the overall risk exposure of workers.

C.1.4.3 RISK MITIGATION MEASURES

Helicopter hoist platforms, and related systems such as remotely-controlled WTG rotor and yaw locking, should be designed in accordance with guidance published by the CAA, who also define the requirements for the provision and control of lighting. Helicopter hoist platform design requirements are not currently harmonised across all EU countries, although are based on International Civil Aviation Organisation (ICAO) guidance. Surfaces should be designed and maintained to minimise the risk of slips and trips occurring.

Operating procedures will define the limiting weather conditions for helicopter access, within the limitations of VFR. Even if visibility is suitable, it is still necessary to understand the air pressure and temperature, as this can affect the helicopter's performance, such as its hover capability or range. Deployment decisions therefore depend on having suitable meteorological observations available at the destination, with conditions being monitored while people are working offshore, in order to minimise the probability of stranding.

Detailed procedures, together with suitable work equipment and PPE will be needed in order to address specific risks such as those identified above; these will typically include:

- Provision of suitable PPE for use in helicopters, including immersion suits, lifejackets, emergency rebreathers, appropriate PLBs and hearing protection;
    - This may conflict with PPE requirements for use on vessel transfers, for example, lifejackets used on vessels will generally be auto-inflating, in order to assist an unconscious casualty in the water, but the use of such a lifejacket would not be appropriate in a helicopter, as it could hinder escape in the event of ditching;
- Communication systems and protocols between personnel on the WTG, and the helicopter crew; and
- Operating practices, including ensuring that there are no loose objects on the helihoist platform, and that all items to be carried are properly stowed in closed lifting bags.

A survivability study should be used to identify any requirements for a support vessel to be present within the wind farm site, and the specification of such a vessel, to ensure that in an emergency, a person in the water has a good prospect of being rescued and taken to a place of safety. Vessels may also be required as a backup means of egress, particularly if a change in weather conditions prevents transfer back to shore by helicopter; if helicopters had been used to gain access due to sea conditions preventing access from vessels, then the role of vessels would be limited to providing stranded personnel with ration packs.

All personnel involved in helicopter transfer – both technicians and helicopter crew – will require specific training in operating procedures to mitigate the risks that are present in the winching operation, in addition to emergency escape training. Such training should be reinforced by periodic refresher training, in order to ensure that personnel will be able to respond appropriately in an emergency situation.

The operation and its safety will be the responsibility of the helicopter operator, and they will seek the issue, by the CAA, of an Air Operator's Certificate (AOC) which is a legal requirement for the carriage of passengers.

The offshore oil and gas industry has implemented many helicopter safety improvement initiatives, such as:

- VHF rebroadcasting to improve coverage;
- Advanced helicopter condition monitoring systems to reduce the probability of catastrophic failures;
- Improvements to helideck design standards and operating practices;
- Use of automatic weather stations and trained observers for planning helicopter operations;
- Introduction of Wide Area Multilateration for monitoring helicopter traffic;
- Fitting of Traffic and Collision Avoidance Systems;
- Setting limits on the maximum age of helicopters; and
- Defining minimum crewing levels.

This experience can be used to ensure that helicopter operations for OREIs start from a higher safety level than would otherwise be possible.

C.1.5 Considerations for access to Marine Energy devices

While offshore WTGs have converged on a small number of standard foundation designs, wave and tidal energy devices are much more diverse, including a range of floating and piled designs, some of which are entirely submerged in normal operation, while others are surface-piercing.

The device design will determine the access requirements:

- The need for personnel access at sea can be eliminated if devices can be removed for maintenance:
    - This may involve towing a device to port, or recovery onto a suitable vessel or barge; the design should ensure that the device can be towed or lifted safely;
    - While this eliminates the metocean hazards from access, the design should still permit safe access to the device in port or on a vessel;
- If people are to board a floating device at sea, the relative motions of the device and the vessel, the design of the interface between them, and limiting sea conditions should be assessed to ensure that access is safe.

For surface-piercing tidal energy devices on fixed foundations, RIBs are currently in common use for access; this should not be taken as a default position, and vessel selection should always be undertaken on a site-specific basis. Considerations include the limiting sea state for access, taking account of the interactions between wind, waves and tides, and noting that the vessel will be required to stay near to the device, in order to provide safety cover, although it may well wait out of the main current.

Operating procedures should ensure that it is impossible for a person who is attached to the structure to fall far enough to land in the water, as in a fast current, the "safety" line could cause a person to be held under water, resulting in drowning; a knife may also be carried to enable a person to cut themselves free from any lines in which they become entangled. Access to the structure is normally taken from the downstream side, so that anyone in the water, or a vessel that loses propulsion, will be swept clear of the structure, rather than being at risk of being held against the structure by the current.

C.1.6 Codes of Practice and Guidance

C.1.6.1 Regulations and Standards – Vessels

HSE L22: *Safe use of work equipment. Provision and Use of Work Equipment Regulations 1998*.

MCA MGN 432 - *Safety during Transfers of Persons to and from Ships* is mainly focused on transfers between vessels, but many of the hazards and principles identified are applicable to other transfers involving vessels.

HSE HSG221 - Technical guidance on the safe use of lifting equipment offshore covers the requirements that apply to equipment for lifting people, such as transfers by crane, using a personnel carrier.

Work at Height Regulations 2005 define the legal requirements, together with specifying design requirements in the Schedules. Brief explanation is given in HSE INDG401 – *The Work at Height Regulations*.

EN ISO 13849-1:2008 - *Safety of machinery: Safety-related parts of control systems.*

EN ISO 14121-1:2007: *Safety of machinery: Risk assessment.*

IEC 61508:2010 - *Functional safety of electrical/electronic/programmable electronic safety-related systems.*

C.1.6.2 Other Relevant Guidance – Vessels

IMCA M117 - *The training and experience of key DP personnel*.

IMCA SEL 025 / M 202: *Guidance on the Transfer of Personnel to and from Offshore Vessels* covers the full range of transfer methods used in shipping.

RenewableUK *Guidelines for the Selection and Operation of Jack-ups in the Marine Renewable Energy Industry*: Chapter 16 addresses crew transfer between jack-up vessels and other vessels and structures.

Step Change in Safety – *Marine Transfer of Personnel* provides detailed guidance and generic risk assessments for the transfer methods used in the oil and gas industry (lifting capsule or access system). While it does not address the vessels and methods commonly used on OREIs, it contains guidance and checklists on topics such as passenger management, briefings, and inductions, which may be useful in a wider range of situations.

C.1.6.3 REGULATIONS, STANDARDS AND GUIDANCE – HELICOPTERS

Civil Aviation Authority CAP 437 - *Offshore Helicopter Landing Areas – Guidance on Standards*, in particular:

- Chapter 9: Helicopter landing areas on vessels;
- Chapter 10: Helicopter winching areas on vessels and on wind turbine platforms; and
- Appendix E: Additional guidance relating to the provision of meteorological information from offshore installations.

The guidance also defines requirements for the design and operation of helidecks, including on Normally Unattended Installations.

CAA *Guidance Relating to Air Operators Certificates*.

International association of Oil and Gas Producers (OGP) Report No. 390 – *Aircraft Management*: Section 5 addresses offshore helicopter operations, although this mainly relates to conventional operation where helicopters land on helidecks; Appendix 9 addresses hoisting operations.

Oil and Gas UK - *UK Offshore Commercial Air Transport Helicopter Safety Record (1981 – 2010)* – Appendix 1 provides a summary of the safety improvements and initiatives which have been introduced in this time period.

Oil and Gas UK HS067 - *Guidelines for the Management of Aviation Operations (2011)* (Priced publication)

OPITO Approved Training Standard: *Helicopter Landing Officer on a Normally Unattended Installation* outlines the procedures that have been established in the Oil and Gas industry.
OPITO Approved Training Standard: HUET (Helicopter Underwater Escape Training) specifies the training requirements for personnel transferring by helicopter in the oil and gas industry.

C.1.6.4 ELSEWHERE IN THIS GUIDANCE

Ports and Mobilisation
Vessel Selection
Metocean
Work at Height

C.2 AVIATION

This section relates to:

- Hazards that OREIs present to aviation that is not connected with the OREI itself; and
- Hazards encountered in airborne survey work in support of OREI development.

The use of helicopters for access is covered in Section C.1.4.

C.2.1 EFFECT OF OREIS ON AVIATION

C.2.1.1 DIRECT HEALTH AND SAFETY RISKS

Due to the height of the structures involved, WTGs and meteorological masts present a number of hazards to aviation, which have been recognised in onshore developments, and must also be addressed offshore; these include:

- Physical obstruction, giving a risk of collision with low-flying aircraft, such as:
  - Military low-flying, which routinely takes place offshore; note that unlike the situation onshore, it is not confined to designated areas, although is more likely to take place in the vicinity of designated danger areas or Areas of Intense Aerial Activity;
  - Helicopters involved in Search and Rescue (SAR) and civilian operations;
  - Commercial, leisure or military aircraft taking off or landing, which will be at low altitude close to aerodromes;
- Effects on air traffic management radar, including creation of false radar returns, and masking (known as “shadowing”) of genuine radar returns from aircraft.

Offshore wind developments may also introduce new air traffic, particularly if helicopters are to be used for personnel access, or in search and rescue operations.

While an offshore wind farm may present a large physical obstruction to aviation, an offshore meteorological mast, which may precede the development of the actual wind farm, are less conspicuous to aviators. This therefore needs to be taken into account when assessing the requirements for lighting or marking of the mast to increase visual conspicuity

C.2.1.2 COMMERCIAL AND OPERATIONAL RISKS

Aviation safety issues need to be addressed early in the consenting process, to minimise the risk of objections from aviation stakeholders.

Sufficient time needs to be allowed for the implementation of aviation safety mitigation measures, which may include upgrades to radar systems, otherwise construction may be delayed until the necessary measures have been commissioned.

C.2.1.3 RELEVANCE TO KEY LIFECYCLE PHASES

Offshore wind developments may affect aviation safety at any lifecycle stage during which tall structures, such as meteorological masts or offshore WTGs, are present; if the construction method involves the transport of tall subassemblies, or even entire WTGs, then the hazard extends to the port and the route to the development site.

The risk is likely to be highest in the early stages of a development, when it will be more likely that pilots are not aware of the presence of the structures.

C.2.1.4 REGULATORY REQUIREMENTS

Civil aviation is regulated under the Civil Aviation Act 1982, under which the Air Navigation Order and subsidiary regulations are introduced; these specify the requirements for obstruction lighting of structures.

The Civil Aviation Authority is an independent regulator, responsible for provision of advice on aviation safety; its published policy and guidelines should be used by developers, and will also be referred to by licensing authorities. Aerodrome operators have the responsibility for safeguarding their approach airspace.

The Ministry of Defence regulates military aviation, and is therefore the consultee for any matters affecting its safety.

C.2.1.5 MANAGING THE RISKS

C.2.1.5.1 Risk Mitigation Measures

All offshore structures (or groups of structures) that exceed 60 m above Highest Astronomical Tide (HAT) must be fitted with aviation obstruction warning lights in accordance with CAP 393. The light emission below the horizontal plane from these lights has the potential to create confusion for mariners; this can be avoided by the use of lights that flash a Morse Code “W”, rather than steady red illumination. The lights shall also be capable of remote switching, if required by a Search and Rescue pilot in an emergency situation to avoid dazzling helicopter crews.

The positions and heights of obstructions should be notified to the Defence Geographic Centre, who maintain the Digital Vertical Obstruction File, the information from which is shared with National Air Traffic Services Aeronautical Information Service (NATS-AIS), the UK Hydrographic Office and other parties as required. NATS-AIS maintain the UK Aeronautical Information Publication, which lists all en-route obstructions exceeding 300 ft (91 m);

While initial notification will take place as an outcome of the planning process, it is important to provide accurate and timely notification of the actual date on which a structure will be erected.

Consideration should be given to other forms of conspicuity, such as aeronautical marking, in addition to lighting.

C.2.1.5.2 Monitoring, Review and Change Management

In the event of an aviation warning light failure, the wind farm operator is required to restore the operation of the light as soon as reasonably practicable; if the failure is expected to last for more than 36 h, the NATS-AIS should be informed, in order to issue a Notice to Airmen (NOTAM). In order to ensure that the information is communicated as quickly as possible to the relevant people, the operator is also recommended to have arrangements in place to notify local aviation interests, such as the relevant Air Traffic Service unit, local airports and helicopter operators.

C.2.2 AERIAL SURVEYS

Aerial environmental surveys allow large areas of sea to be surveyed in a relatively short time, and with less disturbance to birds and other sea life than would be the case with a vessel-based survey. Due to the speed of survey, there may be a reduction in the level of detail in the data, particularly in relation to the ability to identify individual species. As an alternative to the established visual survey methods, which rely on trained observers recording information in real time during the flight, digital methods are also available.

C.2.2.1 POTENTIAL HAZARDS AND RISKS

The JNCC guidelines recommend an altitude of 80m and a transect spacing of 2km for such visual surveys, using a twin-engine aircraft to provide the necessary level of safety and endurance; digital survey techniques can use a higher altitude, around 300m or higher.

At these altitudes, aircraft are unlikely to be able to make use of VHF or UHF Radio Telephony (RT) systems, and will be below the level at which they can be monitored by Air Traffic Control (ATC) radar. This means that ATC are unable to undertake flight-following (monitoring of the position of the aircraft), and RT communication is impossible, preventing the exchange of information on the aircraft’s status, and the provision of alerts in relation to other traffic in the area. The effect of this is that if the aircraft were to get into difficulties of any kind, there could be a significant delay in responding to the incident, and locating the aircraft; this increases the risk to personnel on board,

Danger areas, where military low flying takes place, occupy large areas of sea; exercises can include fast jets flying at altitudes that may be both higher or lower than those used in aerial survey work, and making rapid altitude and heading changes; aircraft involved in such exercises may not be able to comply with the normal rules of the air.

C.2.2.2 Risk Mitigation Measures

Recognising the limitations of RT and radar systems at survey altitudes, alternative means of flight following and communications need to be provided. Various solutions to mitigate these risks are available, including:

- Standard practice during surveys is to arrange to climb to a contactable flight level and make an 'ops normal' call to ATC at predetermined times, depending on the exact survey requirements;
- Use of satellite communications, with dedicated hardware being deployed on the aircraft, supported by a monitoring centre;
- Aircraft will have an Emergency Locator Transmitter (ELT) which is triggered by the crew in the event of an emergency, along with broadcast of mayday or distress calls, which may be picked up by other aircraft or ATC depending on altitude. Individuals also wear EPIRBs so that they can be traced in the event of ditching into the sea; all such systems must be compatible with each other, to ensure that they are effective in an emergency.

The planning of aerial survey work needs to take account of the various restrictions on the use of airspace; some areas are completely prohibited, such as in the vicinity of nuclear installations, while areas such as military danger areas; and controlled airspace around airports will affect different flight levels in different ways.

If survey areas overlap such danger areas, risks can be reduced by:

- Advance notification of flight plans, which is mandatory in defined danger areas; in some cases, surveys can be accommodated at times when ranges are not scheduled to be used; the timings of activation of danger areas are published in Notices to Airmen (NOTAMS); and
- The use of transponders to provide an additional means of detecting the presence of an aircraft in an area.

C.2.3 Codes of Practice and Guidance

C.2.3.1 Regulations and Standards

CAA CAP393 – *Air Navigation: The Order and the Regulations*:

- Regulates the use of aeroplanes for aerial work, including survey, and defines permanently restricted areas of airspace in the UK;
- Part 28, Article 220 specifies the requirements for lighting of wind turbine generators in United Kingdom territorial waters.

Alternatively, aircraft regulated under EU-OPS (which applies to normal commercial passenger or cargo-carrying operations) can be used for aerial survey work.

CAA CAP764 - *CAA Policy and Guidelines on Wind Turbines* provides detailed technical and policy guidance on the interactions between wind turbines and aviation.

C.2.3.2 Other Relevant Guidance

CAA Directorate of Airspace Policy (DAP) - The Lighting and Marking of Wind Turbine Generators and Meteorological Masts in United Kingdom Territorial Waters supplements and updates the requirements given in Article 220 of the Air Navigation Order above.

CAA DAP *Guidance on Actions in the Event of the Failure of Aviation Warning Lights on Offshore Wind Turbines Listed in the UK Aeronautical Information Publication*.

The National Air Traffic Services Windfarms webpage provides access to advice, tools and services for assessment of windfarm effects on aviation.

RenewableUK *Guidance on Low Flying Aircraft and Onshore Tall Structures Including Anemometer Masts and Wind Turbines, July 2012* includes guidance on good practices in relation to notification and marking of structures, and relevant contact details.

MOD Specification for IR & Low Intensity Red Vertical Obstruction Lighting.

Information on current restrictions to airspace can be obtained from NATS-AIS.

C.3 CABLE LAYING AND ENTRY

C.3.1 OVERVIEW

Offshore renewable energy developments require subsea high voltage intra-array cable networks to collect the generated power and transmit it to a substation; if the substation is offshore, then a transmission or export cable will also be required to connect to the onshore grid. In most cases, the cables will also provide communication links within the OREI.

Key operations related to array and export cables include:

- Arrangements for landfall;
- Cable protection;
- Crossing other existing offshore cables or pipelines;
- Pulling the cable into offshore structures; and
- Offshore jointing, if the route exceeds the maximum available cable length, or if repairs are required.

Cable laying for arrays of wave and tidal devices presents additional challenges, due to the highly energetic environments in which these are developed.

To date, the OREI developer has generally been the client for all cable installation work, however, there is the option for export cables to be installed in future by the Offshore Transmission Owner (OFTO), introducing an additional interface during project development.

C.3.1.1 POTENTIAL HAZARDS AND RISKS

C.3.1.1.1 Direct Health and Safety Risks

Subsea cables are heavy and awkward to handle: export cables tend to be heaviest, having diameters of around 200 mm, a weight of around 80 kg per metre length, and can easily be damaged if not handled appropriately; if damage occurs, the subsequent repair work will increase offshore risk exposure.

Cable pulling operations involve high tensile forces being applied to cables, to overcome the effects of their weight, and friction against surfaces that they are being pulled over; pulling a cable into a WTG transition piece typically involves a tension of several tonnes, while pulling an export cable across or under a beach may involve a much higher tension. In the event of any equipment breaking or becoming detached, the stored energy will suddenly be released, presenting a hazard to any people nearby. Accurate tension control is particularly difficult to achieve when winches on floating vessels are pulling cables into fixed structures. Within structures such as offshore WTGs, space is very restricted, increasing the risk of people being close to such hazards.

Cable laying operations will extend outside the boundary of the main development area, increasing the risk of interaction with other sea users.

Purpose-designed cable lay vessels have well defined capabilities, and are often the only viable solution for the laying of large cables over long distances. If it were proposed to utilise general-purpose workboats, or to convert a vessel for work on smaller cables, then the additional hazards in relation to vessel stability when there is a length of subsea cable going down to the seabed, and the provision of sufficient safe working areas and handling facilities on the deck, would require to be assessed.

Due to the specialised handling facilities required, long lengths of subsea cables are generally spooled into carousels on cable lay vessels at the cable factory dock. In order to ensure that the cable is properly layered in the carousel, this is assisted by people working within the carousel as the cable is wound inside; any loss of control of speed or tension would be very hazardous to the people working in such close proximity to the cable. This is further complicated if cables are transpooled between vessels (i.e. wound from the carousel on one vessel to another). The design of the carousel may also mean that these operations involve work at height.

C.3.1.1.2 Commercial and Operational Risks

Cable faults from damage or installation defects can stop or curtail generation from all or part of a development, and also cut off communications and power supply for safety equipment such as navigation lights, and power for systems such as yaw drives that may be needed for equipment protection, forcing the temporary provision of generators on WTGs. Repair of subsea cables is very expensive, requiring specialised vessels and crews, and suitable weather windows; if these are not available then there may be significant waiting time between the fault occurring and the repair being undertaken.

Joining lengths of subsea cable is labour-intensive: making a flexible joint in a transmission cable involves about five days of work on the deck of a vessel, with accompanying risk exposure from the various operations including cutting and welding. In the event of a repair being required, then in addition to the time needed to make two joints (in order to insert a replacement section), further time will be needed in order to cut and retrieve the damaged cable from the seabed, lower the repair bight to the seabed and apply protection to it.

C.3.1.1.3 Indirect and Consequential Risks

Once laid, cables are generally protected by burial in the sea bed; this is either done with a plough during cable laying, or shortly afterwards by jetting a trench. In some locations, protection may be achieved by the use of concrete mattresses or rock placement.

If protection is not applied immediately, then the cable is at risk of damage from activities such as trawling or anchoring, unless these are prohibited where cables are exposed; damage can also be caused by over-stressing due to movement if cables are left unrestrained in locations with strong currents or wave motion. If a trawler fouls a cable, and does not recognise the situation and take appropriate action in time, then this may result in capsizing; this risk is not unique to cables, as other natural or man-made seabed obstructions present similar hazards.

Effective cable burial therefore protects sea users, as well as the cable itself, but within certain limits: extreme loads, such as those imposed by the leg of a jack-up vessel, can still damage cables that have been effectively protected against most other threats.

Data from cable owners in the telecommunications industry indicates that around half of all subsea cable damage is from trawling, and around a third from dragging anchors, either due to ships drifting off moorings, or anchors inadvertently being released in storm conditions.

C.3.1.2 RELEVANCE TO KEY LIFECYCLE PHASES

Lifecycle risk will be minimised if the cables are successfully installed with reliable protection, so that no further intervention is required over the lifetime of the development. Where problems occur that require further interventions, the risks to people increase.

C.3.2 REGULATORY REQUIREMENTS

There are no specific regulations for offshore cable installation; the activities fall under multiple sets of regulations:

- Marine activities must comply with IMO regulations and MCA requirements;
- The Electricity Safety, Quality and Continuity Regulations 2002 define general duties in relation to underground cables and substations; and
- Other work activities are covered by the HSWA and related regulations.

C.3.3 MANAGING THE RISKS

Risk management is best addressed in the context of the different lifecycle phases.

C.3.3.1 PROJECT DEFINITION

Potential cable routes will be subject to increasingly detailed surveys, to assess feasibility, and determine cable protection requirements. The Burial Protection Index, which considers the risk of damage and the properties of seabed soils, may be used to determine the required Depth of Lowering (distance from the surface of the seabed to the top of the cable). Surveys will be used to gather information on factors such as:

- Other cables and pipelines that may need to be avoided, or crossed;
- Areas of exposed rock and large boulders, which will prevent burial;
- Deep trenches, which the cable will have to be routed round;
- Mobility of sediment, which may cause buried cables to be uncovered over time;
- Excessive gradient, which may prevent ploughing unless prepared in advance;
- Areas in customary use as anchorages, and the types of anchor used;
- The nature of shipping and other existing marine activities in the area;
- Properties of seabed soils, which determine:
    - The degree of protection that a given depth of lowering will afford to the cable, against the identified hazards in the area; and
    - The feasibility of achieving a given depth of lowering, and suitable methods of burial;
- The risk of UXO being present on the cable route; and
- Underwater archaeology, which the cable route may have to avoid.

The viability of different installation options, and required vessel capabilities, should be assessed in the context of site metocean data. The risks that spoil from cable burial present to other sea users, such as lumps of seabed material becoming caught in fishing nets, should also be assessed.

Cable installation may be constrained by consenting conditions that seek to minimise environmental impacts; these can restrict the acceptable methods and times of year when work can be carried out, and potentially increase the risk to people, by increasing time pressure, and reducing available installation options.

C.3.3.2 PROJECT DESIGN

Detail design decisions will affect the ease and safety of cable installation; given that subsea cable laying is a specialised activity, designers should involve suitable specialists at an early stage, and ensure that suitable and sufficient cable lay analysis is undertaken. Design considerations include:

- Electrical scheme design, including: no, full or partial redundancy; cable topology; and configurations. The level of redundancy will determine the fault-tolerance of the system; if there is no redundancy, there may be increased pressure to perform rapid repairs in the event of a fault, with associated risks;
- Locations of substation platforms and landfalls relative to arrays, and the related impact on cable routes and route congestion;
- Deciding whether cables should be pulled in to WTGs before or after tower erection; access is easier for cable pull-in prior to tower erection, however, this has the effect that:
    - Cables are present in the seabed when vessels being used for WTG installation anchor or jack up; and
    - Access within the WTG is affected by the unavoidable presence of cable over-pull;
- Determining the direction of cable lay, from device to substation or vice versa; in turn, this determines the requirements for management of sub-sea cable ends in subsequent activities;
- Selection of jointing systems will affect the speed and weather-sensitivity of jointing operations, as well as the selection of installation methods;
- Ensuring that structures allow cables to be pulled in and tested safely, by providing suitable access where required, and strong points for attaching equipment:

  - Even if cables are initially pulled in before tower erection, it is essential that replacement cables could be pulled safely in to the completed tower in the event of a fault;
  - A range of different techniques and equipment can be used for cable pull-in, these should be selected to minimise the risk to people;
  - Modelling of cable installation operations, including tension calculations, helps to ensure that the operations can be completed safely; and
  - Ensuring that cable test equipment, such as the "pressure" test set to prove post lay electrical integrity, can be handled, used, and removed safely.
- Taking account of the need for vessels to anchor or jack up – particularly for structures such as substations, which have heavy components in fixed locations, and multiple cable connections. Cable layout design should ensure that sufficient seabed space remains available for future anchoring or jacking requirements;
- As cable-laying ploughs are towed by vessels, ploughing cannot be carried out right up to structures; this will leave a length of unprotected cable between the seabed and the point of entry into the structure itself. The need for protection in this area should be assessed, and the means of protection identified; this could include a combination of methods such as:
  - Jetting into the seabed;
  - Concrete mattress or rock placement on the seabed;
  - Polymeric casings fitted around the cables; and
  - Bespoke cable protection systems at the entry to the J-tube.

Cable pull-in represents a key physical interface between work packages, and frequently also spans contractual interfaces; early engagement of competent installation contractors, while the design can still be influenced, should enable the adoption of solutions that maximise safety and efficiency on a project. It is important to ensure compatibility of the design of the WTG, TP and foundation, with the intended pull-in methods, noting that some of these are likely to be project-specific.

C.3.3.3 CONSTRUCTION AND COMMISSIONING

Installation should be undertaken by competent contractors, with access to suitable vessels and other necessary plant. The methods adopted will determine the level of risk to people; for example:

- Use of ROVs or static underwater CCTV / sonar systems to monitor cable pulling into J-tubes avoids the need to have divers present for this task, although the risks associated with deployment and recovery need to be addressed;
- The risk of problems occurring during cable lay operations, due to obstructions or fouling of equipment, can be reduced by undertaking a pre-lay grapnel run of the cable route;
- Effective control of pull-in tension minimises risks to people, as well as the risk of equipment breakage or cable damage;
- Cable laying and burial in a single operation reduces the number of vessel movements, and minimises the risk of damage to the installed cable and consequential risks during repair;
- If concrete mattresses are to be placed over the cables, or to protect other cables or pipelines at crossing points, then this introduces additional lifting operations; both the mattresses and the lifting equipment need to be designed for dynamic offshore use. The detail design of the mattresses will determine the risks involved in installation; use of ROVs eliminates the risks to divers involved in mattress installation. The lifting and release systems need to be matched to the method to be used:

  - If ROVs are to be used, the lifting frame will need to have a suitable release mechanism, that can be activated by the ROV, but which minimises the risk of accidental release;
  - If divers are to be used, the mattress lifting beam or frame should have sufficient clearance from the mattress in its installed position so that divers will not come into contact with it; and
  - The beam or frame design should also avoid protruding parts that could injure divers or snag on ropes / umbilicals.

Vessels engaged in cable lay operations will be restricted in their ability to manoeuvre, due to:

- The need to lay the cable along defined routes to precisely determined points, and leave cable ends in a suitable orientation for pull-in to structures; and
- The application of very high towing tensions in order to pull the plough through the seabed when undertaking combined cable lay and burial.

These restrictions must all be recognised when planning simultaneous operations that include cabling, and will require considerable attention from the Marine Co-ordinator while the operations are under way. The Safety Zone around the vessel with restricted manoeuvring ability, from the approach of other vessels, shall be established in line with the COLREGS. The master of a vessel master engaged in such operations will normally request that all other ships maintain a safe distance of at least 1 NM.

Close to shore, the marine environment changes, as shallow water causes waves to break; even a benign swell offshore may create powerful waves, with a significant horizontal component to their motion. A transition has to be made between the cable-lay ship and land-based equipment; this may involve approaches including:

- Floating the cable to shore, using a smaller vessel to tow the cable, with divers later releasing the floats;
  - While this is a well-established practice, it involves the undesirable combination of heavy cables, ropes for float attachment, divers and vessels all being in close proximity to each other, potentially amongst breaking waves;
- Use of a cable-laying barge that can take the ground and / or use of specialised machines that can work both on the beach and in the shallow water in the surf zone.

The final section, crossing the beach, may be subject to difficult ground conditions such as marsh or soft sand, bringing the risk of excavation collapse, or flooding due to water from adjacent land or from the tide. Safe systems of work need to ensure that there is no lone working in such areas, and that suitable communications and backup arrangements are in place.

Alternatively, directional drilling may be used, eliminating the need for beach crossing, cable floating and operations in very shallow water.

As cables and joints cannot be fully tested until installation is complete, careful control and monitoring of installation operations is essential to minimise the risk of later problems.

During installation activities, warnings should be promulgated through Notices to Mariners, and a suitable exclusion zone maintained, probably also involving the use of a guard vessel to warn of subsea hazards. Charts should be updated (through the UK Hydrographic Office) to show cable routes, and markers may also be required to be installed at landfall. Other vessels working on the project should also be kept aware of the actual positions of cables, which may not always be in their planned routes, in order to ensure that cables are not damaged by other project activities.

C.3.3.4 OPERATIONS AND MAINTENANCE

Effective monitoring of cable protection, and maintenance as required, minimises the risk of cable damage occurring, thereby both protecting the asset and avoiding the exposure of people to the hazards that repairs entail. This can involve a range of methods, including:

- Periodic post lay surveys; and
- Embedded cable temperature and vibration monitoring systems.

Monitoring of shipping, by methods such as AIS, can help to identify unusual ship movements that may indicate events such as ships dragging their anchors, and allow action to be taken before the cables are at risk of damage.

C.3.3.5 Additional Considerations for Wave and Tidal Arrays

Cabling for marine energy developments needs to take account of:

- Work in high-energy locations, including landfall sites, may only be safely undertaken in calm conditions;
- Certain work in tidal streams, such as the use of ROVs, is only possible for a brief period at slack water, and any partially completed works and vessels remaining on station will require to withstand the current without danger to personnel until the next period of slack water;
- It may be impossible for a vessel to hold its position if it is beam on to the current;
    - The direction of the current alternates with flood and ebb tide, reversing the loading on vessels and cables;
- In the event of a DP run-off, or other loss of position control in a tidal channel, the situation can quickly escalate in severity:
    - Procedures and equipment should be in place to enable rapid cutting and release of the cable;
    - The consequences for downstream operations should also be considered;
- The cable touchdown point will be affected by the current, and ROVs will be unable to monitor it except at slack water;
    - The combination of site conditions and individual vessel capabilities will determine whether or not it is possible to lay cable along a particular route; a detailed engineering assessment should be undertaken before the cable route is consented;
- Ploughing of cables is unlikely to be possible, as there is generally minimal sediment in these locations;
    - Alternative methods such as rock cutting or surface lay and rock placement / concrete mattress protection may be utilised;
    - Rock bolting may be necessary to secure cables, particularly in tidal streams; this introduces additional subsea work, usually involving diving, which is likely to be limited to brief periods around slack water;
    - Protective coverings may need to be fitted to cables that are running on the seabed;
    - The risk of a surface-run cable being fouled by an anchor is much higher than for a buried cable;
- Weather sensitivity may be reduced if cable connection systems are adopted to allow quick connection of devices, either on a vessel deck or using a remote / subsea system, thereby minimising offshore work and eliminating diving;
- There is likely to be more cable in the water column for connections to floating devices than would be the case for fixed structures; this combines with the presence of device mooring lines for devices to restrict the safe movement of vessels within such arrays.

In general, there is much less industry experience of cable lay and connection operations in these environments, compared to more conventional locations.

C.3.4 Codes of Practice and Guidance

C.3.4.1 Regulations and Standards

DNV-RP-F401 - *Electrical Power Cables in Subsea Applications* obtainable from DNV Recommended Practices webpage.

ISO 13628-5:2002 *Petroleum and natural gas industries -- Design and operation of subsea production systems -- Part 5: Subsea umbilicals.*

C.3.4.2 OTHER RELEVANT GUIDANCE

IMCA M 103 - *Guidelines for the Design & Operation of Dynamically Positioned Vessels*, Chapter 8 provides guidance on the use of DP vessels for pipe laying, but is still relevant for cable laying.

IMCA R 016 - Diver and ROV Based Concrete Mattress Handling, Deployment, Installation, Repositioning and Decommissioning.

KISCA charts show the locations of subsea telecommunication and electricity transmission / distribution cables around the UK, and also have detailed maps of OREIs..

Subsea Cables UK Guideline No 6 - *The Proximity of Offshore Renewable Energy Installations & Submarine Cable Infrastructure*.

C.3.4.3 ELSEWHERE IN THIS GUIDANCE

Interface with Grid, OFTOs etc.
Simultaneous Marine Operations (SIMOPS)
Marine Co-ordination
Metocean

C.4 CONFINED SPACES

C.4.1 OVERVIEW

Confined spaces are defined as "*a place which is substantially (though not always entirely) enclosed and, secondly, there will be a reasonably foreseeable risk of serious injury from hazardous substances or conditions within the space or nearby*", noting that "*Some places which fall within the definition of a confined space may be so only occasionally, perhaps due to the type of work to be undertaken*".[16]

The implication of this is that while some places will always be confined spaces, with permanent measures in place to restrict entry, other places may only require to be managed as confined spaces when certain operations are to be carried out, such as the use of solvents within a WTG nacelle; safe systems of work therefore need to identify when a confined space entry may occur. If in doubt, it is best to treat a space as a potentially hazardous confined space, until it is known to be safe.

C.4.1.1 POTENTIAL HAZARDS AND RISKS

C.4.1.1.1 Direct Health and Safety Risks

Typical hazards that may endanger people in confined spaces in OREIs include:

- Loss of consciousness due to an increase in body temperature, as a result of working in a hot environment such as a transformer compartment;
- Loss of consciousness, or asphyxiation, due to the presence of hazardous substances, or lack of oxygen, in the atmosphere of a confined space:
  - Hazardous substances may be present in the confined space prior to work commencing, or may arise as a result of work activities;
  - Oxygen depletion may occur due to corrosion, work activities such as grinding, or workers' breathing using up available oxygen in a confined space with inadequate air exchange;
    - Inhaling an atmosphere that contains no oxygen can result in loss of consciousness within a few seconds;
    - Oxygen depletion commonly occurs inside foundation structures, as these are often sealed from the rest of the transition piece in order to exclude oxygen and retard corrosion, such locations may also accumulate gases released from sacrificial cathodic protection systems;
    - Inert gases such as nitrogen, which may be used in hydraulic accumulators, can cause dangerous oxygen depletion if released;
- Drowning, due to ingress of water to subsurface structures such as the inside of monopiles and transition pieces, or the sinking of floating devices; and
- Injury arising from fire or explosion of substances.

Due to the limited exchange of air in a confined space, a hazardous concentration of a substance may occur from a relatively small release, that would not endanger people in an open air situation.

C.4.1.1.2 Commercial / Operational risks

Any task to be carried out in a confined space will require greatly increased effort in preparation, supervision and overall resource levels, thus there is commercial benefit from eliminating or minimising the need to work in confined spaces.

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[16] HSE L101 - *Safe Work in Confined Spaces - Confined Spaces Regulations 1997: ACOP, Regulations and Guidance*

C.4.1.1.3 Potential Examples

Potential confined spaces should be identified at the design stage, and also through the operation of safe systems of work. The risks relating to proposed work in a confined space must be assessed, and appropriate precautions implemented if such work cannot be avoided.

In WTGs, there is the potential for several areas to constitute confined spaces; these include:

- The tower, nacelle, or hub, depending on the substances present, the work to be carried out, and the level of ventilation;
- The transition piece and internal areas of the monopile;
    - These may be oxygen-depleted as part of the corrosion-protection design, and may also contain secondary environmental by-products such as methane and CO_2;
    - Work in these areas may also involve work at height, over water and without permanently-installed lighting.

The structures of offshore substations present similar risks. Other confined space hazards may be present in topside compartments that house gas-insulated switchgear containing Sulphur Hexafluoride (SF_6): if there has been any leakage, the SF_6, which is heavier than air, will tend to collect in low parts of compartments; it should also be noted that certain decomposition products of SF_6 are more hazardous than SF_6 itself.

Wave and tidal devices may also include confined spaces, with additional hazards due to the presence of:

- High pressure systems;
- Stored gases; and
- Moving parts and equipment.

Depending on the design and the actual situation encountered, the device itself may be moving while a person is inside a confined space.

On vessels, there may be confined spaces such as holds, tanks, chain lockers and machinery spaces, any of which may have oxygen depletion or hazardous substances present; there should be no access to such spaces in normal circumstances, with any essential entry being properly controlled under a safe system of work, so that people are not put in danger.

C.4.1.2 RELEVANCE TO KEY LIFECYCLE PHASES

The Confined Spaces Regulations, impose a legal duty that "*no person shall enter a confined space to carry out work for any purpose unless it is not reasonably practicable to achieve that purpose without such entry*". The design stage offers the greatest scope to reduce the hazards presented by confined spaces over the lifecycle of a device, by means such as:

- Design of access arrangements to minimise the existence of confined spaces;
- Location of equipment to minimise the need to enter any confined spaces; and
- Selection of materials and systems to avoid the use or release of hazardous substances.

This reinforces the Designer's duties under CDM to avoid foreseeable risks to people over the whole lifecycle of a structure.

The same duty to avoid entry to confined spaces applies throughout the rest of the lifecycle, including Construction and Operations & Maintenance, requiring thorough consideration to be given to alternative approaches to achieve an objective, before confined space entry is adopted as the method.

C.4.2 REGULATORY REQUIREMENTS

Work in confined spaces must be managed in accordance with the Confined Spaces Regulations 1997, and the associated ACOP. On vessels, work in confined spaces should be undertaken in accordance with Chapter 17 of the Code of Safe Working Practices (COSWP) for Merchant Seamen, and the Merchant Shipping (Entry into Dangerous Spaces) Regulations 1988.

The duties under the Confined Spaces Regulations combine with duties under other regulations:

- Under the MHSWR, employers must:
    - Make a suitable and sufficient assessment of the risks to which they are exposed whilst they are at work; and
    - Appoint competent persons to provide assistance in undertaking the measures that are needed to comply with health and safety duties;
- Under the PPE regulations, employers must:
    - Provide suitable PPE to protect employees from the risks to which they may be exposed at work; and
    - Ensure that such PPE is used, maintained and / or replaced as necessary;
- Under PUWER, employers must:
    - Ensure that work equipment is suitable for the purpose for which it is to be used, and assess any additional risks that such equipment introduces; and
    - Ensure that work equipment is properly maintained in an efficient working state.

The key duties under the regulations are to:

- Carry out a risk assessment, with the priority being to identify measures that avoid the need to work in the confined space;
- If it is shown that it is not reasonably practicable to carry out the necessary work without entering the confined space, then it is necessary to determine the measures that are needed in order to provide a safe system of working in the confined space;
    - The priority is then to eliminate sources of danger to people who will enter the confined space; and thereafter to:
    - Determine the necessary precautions for entry.

C.4.3 MANAGING THE RISKS

The risks of a proposed operation must be assessed, first of all to determine if there is a reasonably practicable alternative to confined space entry, and if not, to manage the risks of such entry. This is achieved by a combination of design measures, to reduce the risk that a confined space presents, and then by adoption of a safe system of work to manage entries.

C.4.3.1 DESIGN OF UNAVOIDABLE CONFINED SPACES

In cases where, at the design stage, it is identified that it will not be reasonably practicable to eliminate the need for work to be carried out in a confined space, and especially in cases where repeated entry to the confined space will be necessary over the operating lifetime of a device, then consideration should be given to design measures that can reduce the risk that these unavoidable entries will entail.

Design measures could include:

- Provision of monitoring systems to detect:
    - Hazardous conditions prior to entry, such as water ingress, flooding, release of gases or liquids, fire or smoke; and
    - The presence of hazardous substances, or oxygen depletion while work is in progress;
- Physical separation of compartments that may contain identified hazards, such as oxygen-depleted atmospheres, from those where work will be undertaken;
- High integrity seals to prevent water ingress into compartments below the waterline;
- Provision of internal lighting, with due consideration to how it is to be maintained;
- Provision of robust isolations, to provide safety from hazards such as substances, electricity and movement of equipment;

- Ensuring that access and egress routes have suitable dimensions and characteristics for use when wearing all necessary PPE (which may include a breathing apparatus set), and for the rescue of a casualty;
- Provision of appropriate anchor / mounting points in suitable locations for rescue equipment and PPE;

C.4.3.2 RISK ASSESSMENT FOR CONFINED SPACE ENTRY

The potential for tasks to involve entry into a confined space, and the presence or potential introduction of hazards that may endanger people in a confined space, must be assessed. Where a need to enter a confined space has been established, the ACOP lists factors to be assessed; these include risks arising from:

- The conditions of the space itself, such as:
    - Substances that may previously have been present in the space;
    - Residues, including rust;
    - Contamination, which may have entered the confined space from adjacent equipment or other sources;
    - Oxygen deficiency or enrichment; and
    - Physical dimensions and layout of the space;
- The operation to be carried out, such as:
    - Chemicals to be used or handled during the operation; and
    - Sources of ignition;
- Ingress of substances, such as seawater, or gases.

The potential requirements for emergency rescue must also be assessed, and suitable rescue plans prepared, including the availability of the necessary equipment and personnel to safely extract an unconscious casualty. In the offshore environment, any such rescue is likely to be more complex than onshore, as well as being remote from further assistance, and subject to rapid changes in conditions.

C.4.3.3 RISK MITIGATION MEASURES

The ACOP specifies in detail the precautions to be included in a safe system of work for confined space work.

These include:

- Arrangements for training, supervision, and the required competence of workers, which should be in proportion to the risk, and are necessary both for those workers who will enter the confined space, and those who will support them;
- Communication systems, between workers within the confined space, with supporting personnel outside, and to summon help in an emergency;
- Arrangements to test and monitor the atmosphere within the confined space, together with the monitoring of external influences such as metocean conditions or other vessel operations that could affect the safety of the confined space;
- Means of purging hazardous gases or vapours from the space;
- Ventilation, whether natural or forced;
- Arrangements for removal of residues;
- Isolation from hazards, including materials, electrical and mechanical equipment, and sources of stored energy;
- Methods of fire prevention, and response in the event of fire;
- Selection and use of work equipment, PPE and Respiratory Protective Equipment (RPE);

- Arrangements for the use of gases, such as for welding, whether supplied from portable cylinders or hoses;
- Physical arrangements for, and control of, access and egress, for all situations including planned operations, escape and rescue;
- Provision of suitable lighting, taking account of the intended task and working environment;
- Protection against static electricity;
- Arrangements for rescue of personnel, including:
  - Selection of suitable rescue equipment, training of users, and bringing the equipment to the required location;
  - Notification of others, beyond the immediate work group, that a confined space entry is in progress, in case assistance is required for evacuation after initial rescue;
- Assessment of the need to limit working time;
- Use of a Permit to Work system.

C.4.3.4 Monitoring, Review and Change Management

Any work in a confined space will require ongoing monitoring during the task. If there is any change of intent, or conditions, from those envisaged when the Risk Assessment and Method Statement (RAMS) for the task were prepared, then arrangements will have to be reviewed before the task can continue.

RAMS for work in confined spaces should include a plan for rescue of personnel from inside the confined space. In an emergency, a dynamic risk assessment should be carried out prior to undertaking a rescue, to check that the risks that the situation presents are adequately controlled in the pre-prepared rescue plan, and identify any additional precautions that may be necessary.

The effectiveness of emergency arrangements will depend on all personnel involved being fully familiar with their roles and responsibilities; this can be achieved through a combination of training and exercises, with the learning from exercises being reviewed in order to identify any necessary improvements. Confined space rescue plans should also interface with more general emergency response plans, for example in ensuring that arrangements are in place for evacuation of casualties to hospital after rescue.

C.4.4 Codes of Practice and Guidance

C.4.4.1 Regulations and Standards

HSE L101 - *Safe Work in Confined Spaces - Confined Spaces Regulations 1997: ACOP, Regulations and Guidance*.

The Merchant Shipping (Entry into Dangerous Spaces) Regulations 1988.

MCA *Code of Safe Working Practices for Merchant Seamen*: Chapter 17 addresses the safety of work in confined spaces.

C.4.4.2 Other Relevant Guidance

HSE INDG258 - *Safe work in confined spaces*, provides a less detailed overview than the ACOP.

HSE OCM1 – *Offshore COSHH Essentials – Confined Spaces* provides a concise summary of key points.

C.5 ELECTRICAL SAFETY

C.5.1 OVERVIEW

The scope of this section is to consider the risks to people from electrical hazards in the course of work on OREIs, and therefore does not address issues such as grid codes, standards and procedures. However, suitable interface arrangements are needed with the OFTO and grid, in order to ensure that these do not introduce risks to people on the OREI.

OREIs utilise a wide range of electrical systems, including:

- HV systems for power collection and export, such as transformers and switchgear within individual devices, offshore substations, and cabling within the array and for export;
- LV systems in generators and for ancillary functions within devices;
- Temporary installations, such as the use of generators during commissioning and major maintenance; and
- Portable equipment used by technicians.

These diverse systems present a range of risks to people.

C.5.1.1 POTENTIAL HAZARDS AND RISKS

C.5.1.1.1 Direct Health and Safety Risks

Any technical or procedural failures relating to electrical systems can expose people to a variety of hazards including:

- Electric shock, which has a range of adverse effects on people, including involuntary muscular contraction (which could indirectly lead to injury, for example by falling from height), respiratory failure, cardiac arrest and death;
- Internal burns due to heating when an electrical current passes through body tissues;
- Fire and smoke, which may be caused by a wide range of reasons including overheating of components that are overloaded, leakage current through defective insulation, failure of cooling systems, presence of combustible material adjacent to hot surfaces, or arcing / sparking at terminations;
- Arc flash, which releases high levels of UV radiation, causing skin and eye damage, and potentially very severe burns if a person is enveloped by the arc; and
- Explosion, such as the rupture of switchgear or other equipment due to an internal fault, or the ignition of a flammable atmosphere due to a spark.

Even after all electrical supplies external to an equipment item have been isolated, stored energy, for example in batteries within a UPS, or in capacitors within converters, can still present a hazard to people.

C.5.1.1.2 Commercial and Operational Risks

Electrical faults may result in damage to adjacent equipment, potentially causing extended downtime for repair. If an electrical fault causes an extended period where parts of an OREI do not have a power supply, then this may invalidate warranties on the affected device(s).

C.5.1.1.3 Indirect and Consequential Risks

In the event of failure of electrical systems, OREIs may be left without operable Aids to Navigation and aviation obstruction lighting, creating a hazard to sea users or aviators. Depending on design decisions, the loss of the ability for a WTG to yaw may also invalidate the design basis for extreme wind survival. Further, loss of power can affect the availability of systems such as communications, lifts and internal lighting that are needed to enable work to be carried out within the WTG, and also mean that the WTG no longer provides a suitable refuge for stranded personnel.

C.5.1.2 RELEVANCE TO KEY LIFECYCLE PHASES

C.5.1.2.1 Project Design

Electrical safety should be assessed as an integral part of the overall safe design of the OREI, which should comply with relevant British and European / IEC standards on equipment supply; note that certain key British Standards relating to electrical installations have not been harmonised with those of other EU member states.

Competent electrical design is critical to safety, and has to consider many factors including:

- Appropriate capability to isolate, earth and lock off installed equipment, in order to allow maintenance activities to be carried out safely;
    - The design of isolating systems should take account of the locations of isolators, so that a safe system of work can be implemented without introducing requirements for additional personnel transfers to / from structures in order to access isolators for routine tasks;
- Suitable interfaces and separation between mechanical, LV and HV systems;
- Appropriate specification of electrical equipment and cables, particularly where they are subject to additional demands as a consequence of the offshore environment;
- Potential fault conditions, and their effects on equipment and the safety of people, such as fault current levels, protection, capacitive switching capabilities, accidental single or two-phase operations, harmonic resonances, and overvoltages; and
- The need for backup systems or redundancy, depending on the risks that foreseeable failures would introduce.

The design should also specify:

- Assembly criteria and workmanship standards to be achieved; and
- Inspection, test and commissioning criteria and documentation.

C.5.1.2.2 Construction and Commissioning

Contractor selection and ongoing management should ensure that electrical assembly and installation work is performed by appropriately qualified and competent technicians, and completed in accordance with the relevant IEE regulations and IEC standards for electrical installation. Attention to detail is required in the mounting of components and making of terminations, to ensure safe and reliable operation. On completion of construction, as-built drawings should be produced, and the accuracy of labelling of components confirmed.

The handover from construction to commissioning is a safety-critical activity, as dead systems are made live for the first time. Formal certification that systems are sufficiently complete to hand over from construction to commissioning is essential, and the isolations and earthing that form the basis of safety must be proven. There will typically be an incremental handover, starting with the grid connection being made live, and progressing through the substation systems to individual strings of devices; absolute clarity on responsibilities and the status of systems is essential throughout this process, which will involve the Grid, the OFTO, the PC and the OREI operator.

At the device level, during commissioning, functional testing of electrical safety systems should be carried out, together with SCADA checks, particularly in relation to remote switching operations. Any SCADA system used for switching operations must have sufficient integrity to avoid inadvertent operations.

C.5.1.2.3 Operations and Maintenance

The safety of maintenance activities depends on the operation of safe systems of work, especially at the interfaces between LV and HV systems, where different sets of rules apply, with different people holding safety roles. The scope of individual maintenance tasks must be clearly defined, to ensure that all work is authorised in advance, and that safety from the system is assured by proven and locked isolations. All HV equipment specified must allow for normal operational requirements such as isolation and earthing to be implemented.

Maintenance programmes should take account of requirements for condition monitoring and periodic risk-based inspection / testing activities to ensure that safety systems are functional, and that components and terminations are in satisfactory condition, thereby minimising the risk of fire or arcing that may occur at defective terminations, or on contaminated / damaged components. The condition of backup systems, such as UPS, should be monitored to ensure that safety systems such as aids to navigation and pitch control / braking systems remain available in the event of an electrical fault.

Maintenance activities should be subject to risk assessment, and need to be undertaken within suitable safe systems of work. In order for maintenance work to be carried out safely, it is important to ensure that the people involved have the necessary training and competence to undertake their responsibilities, both for the maintenance tasks themselves, and the operation of the safe systems of work.

Over the life of the OREI, electrical safety should be subject to ongoing monitoring and periodic review, so that new risk information arising out of incidents or condition monitoring can be addressed appropriately.

C.5.2 REGULATORY REQUIREMENTS

The Electricity at Work Regulations 1989 lay down principles of safety that apply to the generation, provision, transmission, transformation, rectification, conversion, conduction, distribution, control, storage, measurement and use of electrical energy.

The purpose of the regulations is to require precautions to be taken against the risk of death or personal injury from electricity in work activities. As such these regulations impose requirements for de-energising systems prior to starting work.

The regulations impose duties with respect to systems, electrical equipment and conductors, and work activities on or near electrical equipment.

The Electricity Safety, Quality and Continuity Regulations 2002 (as amended) apply to electricity generators (including OREIs), distributors and suppliers, and their contractors or agents, with the main aim of protecting the general public and consumers from danger. The regulations impose duties regarding aspects of supply and distribution, including such topics as protection and earthing, substations, underground cables and equipment, generation, and supplies to installations and to other networks.

The Electrical Equipment (Safety) Regulations 2004 implement the requirements of the EU Low Voltage Directive, which set common safety requirements for low voltage (50-1000V AC, 75-1500V DC) equipment throughout EU member states. These requirements may be satisfied by conformity with harmonised standards, or with certain national standards, provided that the national standards themselves satisfy the safety requirements of the regulations.

C.5.3 MANAGING THE RISKS

Electrical safety needs to be addressed as an integral part of the safety of the project as a whole, ensuring that the design enables safe commissioning, operation and maintenance, and that residual risks are identified, communicated and mitigated through safe systems of work. Effective implementation of the design intent and safe systems of work depends on having competent people involved at each stage.

C.5.3.1 APPROACHES TO RISK ASSESSMENT

At the design stage, studies should be undertaken to ensure that:

- The specification of all equipment is suitable for its duty, including under fault conditions such as short circuits;
- The design complies with the GB Grid or Distribution Code, or European Networks Codes;
- Protective systems provide suitable fault clearance times and discrimination; and
- The design and layout of panels, WTGs and other devices, platforms and substations enables safe access for future inspection and maintenance requirements.

Provision of remote switching systems reduces the risk to people by minimising any requirement for people to be close to switchgear when it is being operated, given that the probability of failures occurring is highest during switching operations.

C.5.3.2 RISK MITIGATION MEASURES

Safe systems of work will be necessary to control work activities on or near live electrical systems. The Wind Turbine Safety Rules provide a basis for such a system in relation to mechanical and LV electrical systems; HV systems will be under a suitable set of HV safety rules, and clear interface arrangements must be implemented. While the rules are based on the distinction between LV and HV, the fault current levels at different locations on the system must also be considered, as these determine the hazard that a fault will present.

Signage should be installed on all electrical generating equipment, junction boxes, switchgear panels and doors to warn of the risks to which people may be exposed. All covers, doors and panels should be locked, or otherwise prevented from being opened without the use of tools, to restrict access and prevent exposure to live electrical components and systems. The use of interlocking on doors can ensure that panels are not opened unless in a safe condition.

The potential for electric shock and burns to occur should be considered as part of the first aid risk assessment, and appropriate training and first aid supplies provided.

Where portable equipment is to be used, this should generally operate on a Reduced Low Voltage (RLV), Separated Extra Low Voltage (SELV) or Protective Extra Low Voltage (PELV) system; such systems minimise the risk of a person receiving a dangerous electric shock. The specification of the equipment should ensure that it is suitable for the working environment.

C.5.3.3 MONITORING, REVIEW AND CHANGE MANAGEMENT

Procedures for the control of electrical safety throughout an OREI should be established, and should consider:

- Maintenance activities and the use of method statements, procedures, and safe systems of work including HV Safety Rules, permits, control of isolations and earthing, and PPE;
- Control of interfaces with systems under the control of other parties, such as the OFTO;
- The use of non-intrusive inspection techniques to monitor the condition of critical electrical equipment such as switchgear and cable terminations, in order to reduce the risk of failures that could result in arcing or explosions;
- Risk-based integrity testing of the electrical infrastructure and equipment at suitable intervals across all areas of the OREI;
- Defining authorisation levels for the work that people can perform;
- Providing ongoing training and awareness to all staff on site;
- Emergency response to accidents / incidents involving electricity;
- Management of temporary electrical supplies, whether provided by means of connection into fixed wiring within an OREI, or by provision of temporary generators;
- Portable appliance testing (PAT) for all hand-held or portable electrical equipment used on site, to ensure that the equipment is safe to use. Inspections should be carried out at a frequency that reflects the likelihood of damage occurring; users should also carry out a pre-use check and arrange for repair of any damage noted; and
- Where shore power supplies are to be used in ports and harbours, their specification and maintenance / testing status should be verified before use.

C.5.4 CODES OF PRACTICE AND GUIDANCE

Numerous standards and regulations pertain to the design, installation, maintenance and operation of electrical systems; as with all lists of guidance in this document, the list provided below is not exhaustive.

C.5.4.1 Regulations and Standards

HSE HSR25 – *Memorandum of Guidance on the Electricity at Work Regulations 1989*.

DTI *Guidance on the Electricity Safety, Quality and Continuity Regulations 2002*, and the 2006 Amendment which extended the regulations to the full extent of the REZ.

BS7671:2008– *Requirements for Electrical Installations. IEE Wiring Regulations. Institution of Electrical Engineers 17th Edition* – applicable for voltages up to 1000 V AC or 1500 V DC.

BS 7375:2010 *Distribution of electricity on construction and demolition sites – Code of practice.*

BS 6626:2010 - *Maintenance of electrical switchgear and controlgear for voltages above 1 kV and up to and including 36 kV. Code of practice.*

BS EN 62271:2008 - High-voltage switchgear and controlgear: multiple parts of this standard address different aspects of this equipment.

IEC 61140:2001 - Protection against electric shock – Common aspects for installation and equipment.

DTI PRODUCT STANDARDS - *Electrical Equipment (implementing the Low Voltage Directive) Guidance Notes on the UK Electrical Equipment (Safety) Regulations 1994*.

Energy Networks Association standards address many areas of HV electrical engineering.

C.5.4.2 Other Relevant Guidance

HSE HSG 85 – *Electricity at Work – Safe Working Practices*.

HSE HSG107 – *Maintaining Portable and Transportable Electrical Equipment*.

HSE HSG230 – *Keeping Electrical Switchgear Safe*.

HSE HSG253 – *The Safe Isolation of Plant and Equipment*.

HSE INDG354 - *Safety in electrical testing at work: general guidance*.

HSE EIS37 - Engineering Information sheet: Safety in electrical testing: Switchgear and control gear.

RenewableUK *Wind Turbine Switchgear Safety*.

RenewableUK: *Health and Safety Circular - Reporting requirements under the ESQC Regulations. 2002*.

IET Code of Practice for In-service Inspection and Testing of Electrical Equipment (4th Edition), ISBN: 978-1-84919-626-0 – priced publication, available from the IET

C.5.4.3 Elsewhere in this Guidance

Interface with Grid, OFTOs etc.
Safe systems of work

C.6 ERGONOMICS

Ergonomics considers the nature of tasks to be undertaken, the equipment and information available to workers, and the working environment, in order to reduce the risks of injury, errors and inefficiency that may be caused by these factors.

This section concentrates on the physical and health risks that relate to ergonomics; the role of ergonomics and human factors in initiating and escalating incidents is covered in Section A.4.

The principal duty is that under the intended conditions of use, the discomfort, fatigue and physical and psychological stress faced by the operator must be reduced to the minimum possible, taking into account ergonomic principles such as:

- Allowing for the variability of the operator's physical dimensions, strength and stamina;
- Providing enough space for movements of the parts of the operator's body;
- Avoiding a machine-determined work rate;
- Adapting the man / machinery interface to the foreseeable characteristics of the operators.

In offshore oil and gas, manual handling, slips, trips and falls, and the use of hand tools, together account for 70% of over 3-day lost time injuries; good ergonomic design can reduce the occurrence of such incidents.

C.6.1 OVERVIEW

C.6.1.1 POTENTIAL HAZARDS AND RISKS

Many operations in WTGs present ergonomic difficulties, such as:

- Access from the tower to the nacelle is often obstructed by major components in the nacelle; it is often difficult for technicians to undertake this transfer without putting themselves at risk by disconnecting from the fall-arrest systems; or
- Cable over-pull during construction may obstruct access at the base of the tower, causing temporary ergonomic difficulties until the cable has been terminated.

Where work is carried out on open decks of vessels, such as preparing loads for lifting, the people involved may be working in cold, wet conditions, wearing a combination of PPE to provide insulation, waterproofing and buoyancy, but which may also be bulky. The use of gloves (or having cold hands) will reduce dexterity, making otherwise simple tasks, such as pressing the correct buttons on a handheld radio, more difficult. The selection of equipment, and design of tasks, should take account of the environment in which the work is to be carried out.

C.6.1.1.1 Direct Health and Safety Risks

Poor ergonomics increases the risk of immediate injury or long term development of musculoskeletal disorders; these could be caused by factors such as:

- Restricted space on the yaw deck, or in the nacelle of a WTG, forcing the adoption of awkward working positions; or
- Regular climbing of access ladders, particularly if they are climbed quickly in adverse conditions.

The susceptibility of workers to injury as a consequence of ergonomic challenges may be increased by whole body vibration during transfers on fast access vessels in rough sea conditions or unsteadiness as a result of “sea legs”, combined with nacelle movement in the wind.

C.6.1.1.2 Commercial and Operational Risks

Given the high cost and inconvenience of deploying people onto offshore structures, it is important that they are able to work efficiently; poor ergonomic design can increase the time taken to complete tasks, and impair the quality of the work done.

C.6.1.1.3 Indirect and Consequential Risks

If, through poor ergonomics, employees are exposed to the risk of developing long term musculoskeletal disorders, then their working lives may be shortened, and this may cause a loss of experienced personnel from technician roles.

C.6.1.2 Relevance to Key Lifecycle Phases

The ability to adapt devices, workplaces and systems to achieve good ergonomic standards is greatest at the design and prototype stage; if a need for modifications is identified later in the lifecycle, when such issues become more obvious, then the cost of adaptation will be much higher. Where poor ergonomics is identified as introducing a risk of injury or long term adverse health effects, the ALARP principle should be applied in deciding on risk reduction measures.

Ergonomic issues should be considered during device selection, to ensure that foreseeable maintenance tasks can be undertaken without unacceptable risk; early consideration of these issues can ensure the greatest benefit at a lower cost than would be possible later in the lifecycle.

During the O&M phase, ergonomics should be considered when carrying out risk assessments of individual tasks, and mitigation such as the provision of suitable access, tools, lighting and ventilation should be implemented as required.

C.6.2 Regulatory Requirements

The Essential Health and Safety Requirements (EHSR) of the Machinery Directive include requirements for machinery manufacturers to minimise ergonomic risks to operators and maintainers of machinery, including ensuring that components are designed to facilitate handling (manually or using lifting equipment, as appropriate), and that there is adequate space and lighting.

Good ergonomic design will also help to:

- Fulfil the employer’s general duty to reduce risk, under the HSWA; and
- Reduce the risks arising from manual handling, which includes tasks involving pushing and pulling as well as lifting, and which must be assessed and minimised under the Manual Handling Operations Regulations (MHOR).

C.6.3 Managing the Risks

Ergonomic considerations should include:

- Design for construction, including ensuring that safe access is available on part-completed structures;
- Design for maintenance and access, including:
    - Consideration of the working environment, in terms of:
        - Space to work, including lay down of components and tools during maintenance tasks without creating undue congestion or introducing tripping hazards;
        - Workplace conditions such as temperature and ventilation;
        - The level of lighting, which not only affects the ability of technicians to move around and work safely, but, if poor, can also encourage the adoption of awkward postures;
        - Provision of safe access for foreseeable tasks, so that there is no temptation to use inappropriate means such as climbing on handrails or equipment, in order to get the job done;
        - The effects of foreseeable deviations from normal operation, such as ensuring that dropped objects can be retrieved safely, and that spills or leakage can be contained and cleaned up;

    - Provision of suitable lifting equipment in nacelle / machinery spaces to minimise manual handling;
    - Considering whether to provide any specialised tools on each WTG, to avoid the risks of injury to people and damage to equipment that can arise from the use of improvised tooling, and also to minimise equipment transfer requirements;
- Design for isolation:
    - Clear and accurate labelling and identification of components and isolators to assist WTSR compliance, in convenient locations for the task;
        - This may be strengthened by interlock or monitoring systems, which enforce or monitor isolation requirements in an environment where supervision is limited.

As ergonomics is about the interaction of people with equipment and systems, the range of physical and psychological characteristics of different people should be considered, as a task or workplace that suits one person may cause problems for another.

C.6.3.1 APPROACHES TO RISK ASSESSMENT

Ergonomic risks can be identified by:

- Reviewing designs and operating procedures, to assess the layout of equipment, available access, and the requirements of maintenance tasks;
    - This should be informed by the learning gained through experience on other developments;
- Observation of tasks being carried out, and discussion of ergonomic issues with employees; and
- Reviewing errors, incidents and reports of discomfort to identify where ergonomic problems may be present.

For complex ergonomic issues, specialist help may be obtained from ergonomists.

Resolution of issues should be prioritised, taking account of activities where individuals may have a high level of exposure, such as regular service activities, or construction activities where specialist teams undertake the task repeatedly on multiple WTGs.

Ergonomic risks may change over time, for example in some situations, such as when work is being carried out on HV systems, or following cable damage, a WTG may be entirely isolated from all sources of power, leaving any workers on it dependent on emergency lighting systems and torches, and unable to use powered lifting equipment to move loads, or the tower lift to access the nacelle. The risk assessment for the work should address the provision of lighting if access is likely to be required for longer than the emergency lighting is maintained, and consider limitations on the movement of people and loads.

C.6.3.2 RISK MITIGATION MEASURES

Where ergonomic risks cannot be eliminated, workers’ exposure should be reduced ALARP by measures such as provision of suitable tools, and job rotation.

C.6.3.3 MONITORING, REVIEW AND CHANGE MANAGEMENT

In addition to formal consideration of ergonomics at the design stage, and within risk assessments, employees should be encouraged to identify ergonomic issues that they encounter when carrying out tasks, and propose improvements where possible. Where residual ergonomic risks are identified, the information needs to be communicated to the people who will be affected, so that they can take account of these risks in planning their working methods.

Modifications to improve ergonomics should be subject to risk assessment, to ensure that they do not introduce other risks.

Given that the ergonomic risks are largely determined at the design stage, but encountered later in the lifecycle, effective feedback mechanisms will be required in order to improve designs.

C.6.4 Codes of Practice and Guidance

C.6.4.1 Regulations and Standards

HSE L23 – *Manual handling. Manual Handling Operations Regulations 1992. Guidance on Regulations*.

BS EN 13861:2011 - *Safety of machinery. Guidance for the application of ergonomics standards in the design of machinery.*

BS EN 614-2:2000+A1:2008 *Safety of machinery. Ergonomic design principles. Interactions between the design of machinery and work tasks.*

BS EN 894:1997+A1:2008 *Safety of machinery. Ergonomics requirements for the design of displays and control actuators.*

BS EN ISO 11064:2001 *Ergonomic design of control centres*.

BS EN ISO 6385:2004 *Ergonomic principles in the design of work systems.*

HSE Leaflet INDG143 – *Getting to grips with manual handling: A short guide for employers*.

C.6.4.2 Other Relevant Guidance

HSE Human Factors and Ergonomics webpages

HSE HSG38 – *Lighting at work*

HSE HSG60 – *Upper limb disorders in the workplace*

HSE INDG90 – *Understanding ergonomics at work*

HSE HSG115 – *Manual handling: Solutions you can handle*

C.6.4.3 Elsewhere in this Guidance

Ergonomics, Human Factors and Behavioural Safety

C.7 FIRE

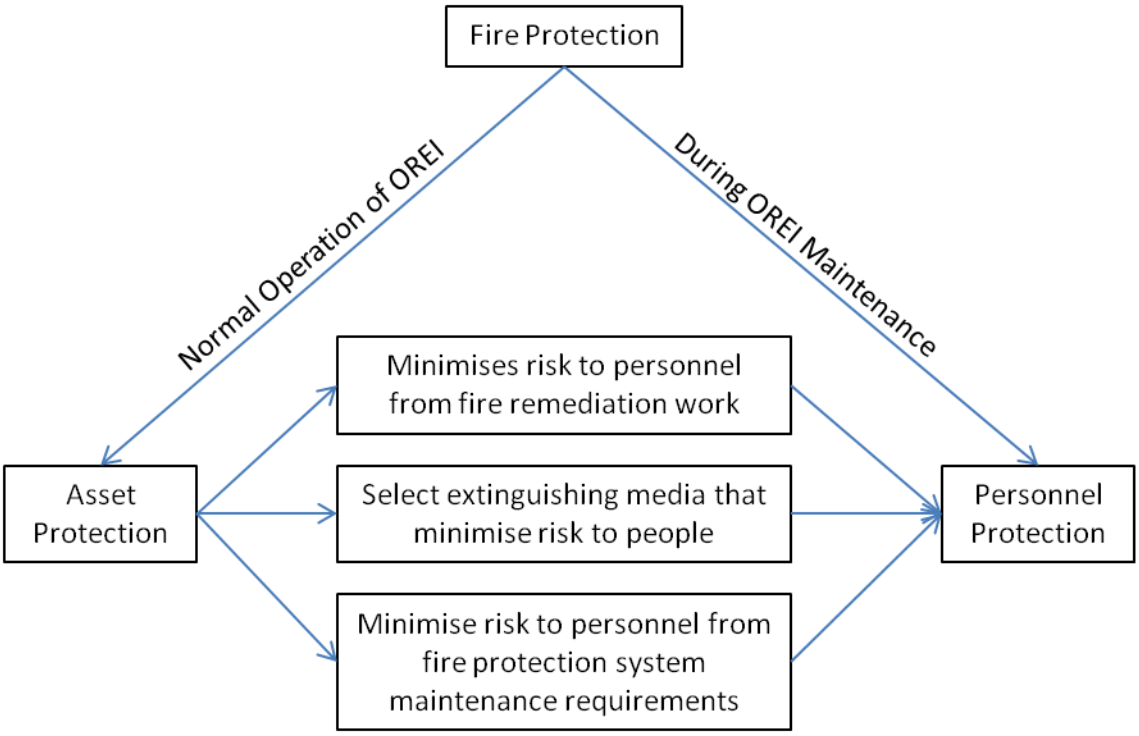
C.7.1 OVERVIEW

Fires introduce a range of risks to people and assets, and are particularly challenging offshore. The priority is to protect people; systems that protect the asset may directly and indirectly assist in this:

- An effective fire protection system will minimise the need for fire remediation work to be undertaken, thereby reducing potential future risk exposure; however
- Some fire extinguishing media are hazardous to people; and
- The maintenance requirements of the fire protection system should be considered, to minimise the risks to which they will expose people;

These relationships are summarised in Figure 5 below.

Figure 5: Interrelationship of fire risk and protective measures during normal operation and maintenance.



C.7.1.1 POTENTIAL HAZARDS AND RISKS

The different areas of an OREI, and the different activities undertaken during its lifecycle, present a range of fire risks.

WTGs and most offshore substations normally operate as unmanned structures, so there is only a direct risk to people during maintenance visits:

- As the WTGs will be stopped during maintenance, the most likely initiator of fire at such times will be the maintenance activities; also
- Temporary generators may be used during commissioning and some major maintenance activities, introducing an additional initiator and fuel source.

Other structures may be developed to provide offshore accommodation; such as:

- A dedicated accommodation platform or vessel; or
- An accommodation module on the offshore substation platform, either for routine use, or as a temporary refuge.

Such structures present a range of fire risks, such as those related to:

- Helicopter landing and refuelling;
- Galley and laundry areas;
- Switchgear and transformers, either those related to the substation, or for accommodation platform services; and
- Standby generators and their associated fuel storage / pipework.

In addition to the offshore structures and accommodation, there is also a risk of fire:

- On vessels used for personnel transfer or installation / maintenance operations; and
- In onshore bases, where materials are stored and maintenance tasks undertaken.

C.7.1.1.1 Direct Health and Safety Risks

Fires pose a range of hazards to people:

- Flames and hot surfaces can cause burns;
- Smoke inhalation may cause people to suffer asphyxiation and death, even if they are not in the immediate vicinity of a fire, particularly if the materials that are burning release toxic combustion products;
- Glowing fires may release toxic carbon monoxide as a consequence of incomplete combustion;
- Explosions and arc flashes from electrical faults can lead to immediate serious injury.

Even the smallest of fires can rapidly escalate if air and combustible materials are present. The chimney effect created by the tower can cause smoke to spread rapidly throughout the WTG.

C.7.1.1.2 Commercial and Operational Risks

Any fire is likely to lead to significant downtime, potentially involving high remediation costs or even the loss of an asset.

C.7.1.1.3 Indirect and Consequential Risks

Fires may block normal exit routes, or these could be obscured by smoke, requiring personnel to evacuate by emergency routes, such as descending from the nacelle.

Normal services such as internal lighting may be lost, so evacuation will depend on the provision of emergency lighting.

After a fire has been extinguished, restoration of fire-damaged equipment is a specialist operation, being very labour intensive, and involving exposure to a range of additional hazards:

- The fire may have caused structural damage; while major components such as tower sections may be unaffected, other items such as aluminium ladders and floor plates may no longer be safe to use;
    - Even gaining access to the tower in order to assess the extent of damage will require thorough risk assessment;
- Cable insulation may have been damaged, requiring isolation until this has been assessed and repaired;
    - This may disable internal lighting and normal communications systems; and
- Combustion products such as Hydrochloric and Hydrofluoric acids may be present, introducing a hazard to people, and requiring thorough clean-up to enable equipment operation to be restored.

Fire suppression systems may introduce hazards to people, depending on the gases / substances used.

C.7.1.2 RELEVANCE TO KEY LIFECYCLE PHASES

An initial fire risk assessment should be undertaken at the design stage, to identify the precautions that will then require to be maintained throughout the lifecycle. Fire safety design codes exist for vessels and offshore substations, while onshore bases are subject to building regulations. There are no specific fire safety design codes for offshore WTGs and transition pieces. Selection of materials at the design stage will determine the risks that a fire may present, such as the potential for structural damage, and the presence of hazardous combustion products.

The commissioning plan should ensure that fire protection systems are commissioned sufficiently early that they are available to protect people involved in commissioning work.

If fire suppression systems introduce a risk to people, such as from the use of asphyxiant gases, then they will need to be isolated when maintenance tasks expose people to this risk, thereby disabling the protective system, and requiring it to be de-isolated on completion of the task. Where systems that do not introduce such hazards can be used, then the protection of the asset can be continuous, and may also help to protect people while they are in attendance.

C.7.2 REGULATORY REQUIREMENTS

C.7.2.1 ONSHORE BASES AND OFFSHORE STRUCTURES

The principal regulations are the Regulatory Reform (Fire Safety) Order 2005 in England and Wales, the Fire (Scotland) Act 2005, and the Fire and Rescue Services (Northern Ireland) Order 2006. These define similar duties relating to general fire safety, including a duty on employers to:

- Ensure the safety of employees in respect of harm caused by fire in the workplace; and
- Carry out a fire risk assessment, and implement the measures identified in it to protect employees.

General fire safety includes measures to reduce the risk of fire occurring, and if one does occur, to:

- Minimise its spread;
- Ensure that people can escape;
- Have the means to fight the fire;
- Detect the fire and warn people;
- Have arrangements in place for the actions to be taken, and ensure that employees have been trained / instructed; and
- Mitigate the effects of fire.

The regulations also establish local fire authorities, which as well as operating fire and rescue services, are the enforcing authorities for fire safety measures under the regulations, and may undertake compliance checks on onshore bases and substations. Offshore enforcement will be by the HSE, which is also the enforcing authority for fire safety on construction sites, and in relation to work processes that involve the use of plant, machinery or dangerous substances.

C.7.2.2 ON VESSELS

Fire safety on vessels is regulated by the MCA in accordance with SOLAS Chapter II, which applies to all ships, with specific requirements according to their classification. The regulations address the following aspects of fire safety:

- Prevention of fire and explosion, including:
  - Reducing the probability of ignition of combustible materials or flammable liquids, by avoiding leakage and sources of ignition;
  - Limiting the fire growth potential in every space of the ship;
  - Reducing the hazard to life from smoke and toxic products generated during a fire in spaces where persons normally work or live;

- Suppression of fire and minimising its consequences, including:
    - Detecting a fire in the space of origin and initiating an alarm for safe escape and fire-fighting activities;
    - Controlling the spread of smoke in order to minimize the hazards from smoke;
    - Containing a fire in the space of origin;
    - Suppressing and swiftly extinguishing a fire in the space of origin;
    - Maintaining structural integrity of the ship, preventing partial or whole collapse of the ship structures due to strength deterioration by heat;
- Arrangements for evacuation of people, including the provision of:
    - Emergency alarm and public address systems to notify people of a fire; and
    - Suitable means of escape from any parts of the ship where people may be.

While the SOLAS regulations only pertain to ships, the approach could be applied to other structures at sea.

These technical and organisational measures for vessels are supported by regulatory requirements to maintain their effectiveness, train people, carry out exercises and provide operating instructions and information. COSWP addresses fire safety, emergency response, and safe systems of undertaking hot work on ships in detail.

The MCA's Small Commercial Vessels code regulates the transport of dangerous goods on workboats.

C.7.2.3 DANGEROUS SUBSTANCES

Substances that present a risk of harmful physical effects (such as fire or explosion) are covered by the Dangerous Substances and Explosive Atmospheres Regulations (DSEAR) 2002. These require that a risk assessment is carried out of the hazardous properties of materials, their use and storage, and the potential for a hazardous explosive atmosphere and a source of ignition to be present, in order to identify necessary measures to reduce risk. The regulations specify a hierarchy of risk reduction:

- Eliminate the risk by changing the substance or process;
- Apply control measures, such as containment or removal of spillages, and ensuring that temperature limits are not exceeded, to reduce the probability of fire or explosion; and then
- Mitigation measures to reduce the risk to people and equipment in the event of a fire or explosion occurring, such as blast walls around transformers, which contain a fire or vent an explosion to a safe location.

C.7.3 MANAGING THE RISKS

Fires may be initiated by equipment malfunction, such as faults in switchgear and cable terminations, hot surfaces on brakes, and failures in cooling systems for electronic components. The design should address the need for provision of high temperature alarms, while condition monitoring and scheduled inspection can provide warning of equipment deterioration.

Safe systems of work should ensure proper control of hot work that can introduce a source of ignition, such as welding or grinding.

High standards of housekeeping and maintenance avoid the build-up of combustible materials, and ensure that any leaks are repaired in a timely manner. Hidden locations, such as the inside of ventilation ducting, should also be considered, in order to ensure that these do not accumulate combustible dusts.

The risks will vary between different parts of an OREI, therefore different mitigation approaches are likely to be needed.

C.7.3.1 Approaches to Risk Assessment

In general, a fire requires the presence of:

- Fuel, which can be any combustible material;
- Oxygen, generally from air; and
- A source of ignition such as heat, a spark or flame;

If any of these is eliminated, then a fire cannot be sustained.

The risk assessment process should reflect the specific requirements of the relevant regulations, depending on the structure being considered.

C.7.3.2 Risk Mitigation Measures

In the event of a fire, it is essential that all personnel know what to do; this is achieved by a combination of training, practice drills, and provision of information. Areas of training may include fire detection, arrangements for firefighting, communication, team roles, and escape / evacuation arrangements. Clear information should be displayed at the entrance points of offshore structures, so that personnel are informed about:

- Fire protection systems, and instructions on their operation;
- Means of summoning help in the event of a fire or other emergency;
- Types, usage and locations of manual fire extinguishers; and
- Any automatic fire extinguishing systems, including any risks that they present to people, steps to be taken to control these risks, and clear indication of the status of such systems.

Emergency escape routes should be indicated, and kept clear at all times. The time needed for emergency escape from challenging locations such as the lift or the hub should be assessed, through exercises, to ensure that the fire protection measures provide sufficient time for people to escape. Design codes for structures such as substations include requirements to ensure that fire escape routes are protected against the effects of fire in adjacent compartments that house high risk items such as transformers, generators and fuel storage.

If it is proposed that emergency evacuation by external descent from the nacelle of a WTG may be required in any circumstances, then this needs to be thoroughly planned and practiced in advance, as this method involves several significant risks:

- Opening hatches on the nacelle, either to dissipate smoke or enable evacuation, may intensify the fire due to the chimney effect in the tower; the risk of this occurring will depend on the location of the fire and the available routes for air flow;
- People descending out of the nacelle hatch may land in the sea; if the lifejackets, immersion suits and Personal Locator Beacons that they used for transfer from a vessel to the WTG were left in the base of the tower, then they would not be available in an emergency; and
- Vessels may be unable to approach if burning debris is falling from the nacelle;

The precise arrangements to mitigate these risks are likely to be site-specific, taking account of WTG, foundation and vessel designs.

C.7.3.3 Monitoring, Review and Change Management

Fire suppression systems are safety-critical, and must be maintained in an operable state; corrosion has been an issue on offshore oil and gas installations that use seawater deluge systems.

Given the risks and expense involved in offshore work, the maintenance requirements of a proposed fire protection system should be considered at the design stage, to ensure that they do not lead to an increase in the overall risk exposure; the use of self-monitoring systems can minimise the maintenance burden.

C.7.4 CODES OF PRACTICE AND GUIDANCE

C.7.4.1 REGULATIONS AND STANDARDS

The *Regulatory Reform (Fire Safety) Order 2005*; the *Fire (Scotland) Act 2005*; and the *Fire and Rescue Services (Northern Ireland) Order 2006* define, for their respective areas, fire safety duties and arrangements for enforcement.

HSE L138 - *Dangerous Substances and Explosive Atmospheres Regulations 2002 Approved Code of Practice and guidance* (DSEAR) provides guidance on risk assessment and reduction, considering requirements in storage of substances, design of facilities, control and mitigation measures, and procedures for maintenance, repair and cleaning..

MCA Code of Safe Working Practices for Merchant Seamen: Chapter 9 addresses fire precautions; Chapter 10 addresses emergency procedures, and Chapter 23 addresses hot work.

MCA MGN280 - *Small Commercial Vessel and Pilot Boat Code of Practice* defines the regulations for transport of dangerous goods on workboats (See section 30 of the annex).

SOLAS Chapter II-2 - *Construction - Fire Protection, Fire Detection And Fire Extinction*, the requirements of which are implemented in the Merchant Shipping (Fire Protection) Regulations 2003.

BS ISO 23932:2009 - Fire safety engineering. General principles.

C.7.4.2 OTHER RELEVANT GUIDANCE

HSE INDG370 - *Fire and Explosion - How Safe is your Workplace?* gives practical advice about the basic requirements of DSEAR.

DNV-OS-J201 - *Offshore Substations for Wind Farms*, obtainable from DNV Offshore Standards webpage – Section 6 provides principles for the design, construction and installation of fire protection systems on offshore substations, including fire detection, active and passive protection, and requirements for portable extinguishers.

DNV-OS-D301 – *Fire Protection*, obtainable from DNV Offshore Standards webpage provides detailed technical specifications for fire-resistant construction; it mainly relates to offshore oil and gas installations, but is relevant for substations – particularly if backup generators and fuel storage are present.

HSE HSG 51 - *The storage of flammable liquids in containers* may be particularly relevant to onshore bases, where dedicated facilities for storage of flammable materials may be necessary.

C.8 GEOLOGICAL UNKNOWNS

C.8.1 OVERVIEW

The leased areas for OREIs cover thousands of square kilometres of the seabed; projects will therefore encounter a very wide range of geological conditions, some of which may present hazards to people during development. In contrast to the situation onshore, there is very little existing survey or regional information about geological conditions offshore, so developers are starting from a position with more unknowns.

C.8.1.1 POTENTIAL HAZARDS AND RISKS

The design of foundations and the installation method need to be suitable for the geological and metocean conditions at a location. If there is insufficient understanding of a site's characteristics; then this increases the risk of problems occurring, such as early pile refusal during installation. Where jack-up vessels are to be used for installation or subsequent O&M work, there needs to be sufficient understanding of the seabed to be certain that the vessel will be adequately supported in normal operating and storm survival conditions. Gaining the necessary information requires extensive offshore survey work, including:

- Geophysical surveys, carried out using instruments deployed from vessels;
- Intrusive investigations, including soil sampling and geotechnical investigation, which may involve drilling to take samples at depths exceeding the deepest pile depth.

While these investigations reduce overall risks during the project lifecycle, the risks involved in undertaking this work need to be managed.

C.8.1.1.1 Direct Health and Safety Risks

Offshore geophysical survey activities involve extensive operation of vessels along defined survey routes, often including towing subsea survey equipment:

- The routes are specified to meet survey requirements, limiting the ability to adjust the route with respect to sea conditions at the time of the survey;
- Vessels that are towing may be restricted in their ability to manoeuvre.

These constraints increase the risks to vessels, compared to normal passage.

Geotechnical investigations involve drilling or insertion of probes into the seabed, either from a floating drillship which holds position using an anchor spread and / or Dynamic Positioning, or from a jack-up vessel. Geological hazards to drilling operations include the potential for shallow gas pockets to be present, either as free gas or dissolved in water, trapped in anomalies in the subsurface strata:

- The stored pressure in gas pockets may suddenly be released in a "gas kick", with the potential to eject down-hole tools, mud and gas out of the drill-string;
- The gas itself may be flammable and / or toxic.

In some locations, even the most thorough geophysical survey campaign cannot be guaranteed to give a totally reliable prediction of the presence or absence of shallow gas, therefore a residual risk may remain.

Operations involving sampling from, or drilling into the seabed introduce risks from contact with UXO (see Section C.19) and subsea utilities.

Where cable routes cross from sea to land, the surf zone is a particularly difficult area to survey, being at the transition between marine and land-based survey techniques, with the level of seabed disturbance making it difficult to gather and interpret the necessary data.

C.8.1.1.2 Indirect and Consequential Risks

As surveys are undertaken at the earliest stage of development, they occur at a point where the developer has the most limited site-specific information, for example:

- Bathymetric source data for charts is often limited to locations of historic leadline surveys, so seabed features between sounding points may not be indicated, and the survey itself may have been conducted over 150 years ago;
    - In certain locations, such as where sand waves are present, significant changes in bathymetry can occur in relatively short time periods;
- Seabed conditions are likely to be unknown, so if jack-up barges are to be used, there is a risk of the seabed not providing suitable support.

As survey work will cover large sea areas before other on-site work starts, there is likely to be interaction with other sea users.

C.8.1.2 Relevance to Key Lifecycle Phases

Geological unknowns are a key issue in project definition and design; the surveys carried out during these phases should provide the necessary information to enable the structures to be designed, and installation (including lifting operations and cable routes) to be planned.

Following installation, there will be an ongoing survey requirement to monitor seabed behaviour, such as scour around foundations, and to provide ongoing geological information to assist in the planning of O&M activities.

C.8.2 Regulatory Requirements

Geotechnical (but not geophysical) surveys fall within the definition of construction in the CDM Regulations; a Principal Contractor is required to have been appointed prior to this phase.

C.8.3 Managing the Risks

Investigations are carried out in a structured process, with each stage developing a more detailed characterisation of the site in order to answer specific questions, and inform subsequent investigations and risk assessments:

- Desktop studies are used to collate existing information about the site, including charted bathymetry, large-scale geological characteristics and an initial assessment of risks such as wrecks, subsea pipelines and cables, extraction and dumping sites, seismic activity, UXO and lost fishing gear;
- Geophysical surveys utilise a range of remote sensing instruments, to determine the physical shape of the seabed, the sub-surface geological structure, and the presence of ferrous metallic objects, which could include pipelines, cables and some forms of UXO;
- Geotechnical investigations utilise a range of drilling, sampling and in-situ testing devices to provide detailed characterisation of subsurface properties at the test location. This minimises the risk of problems being encountered during piling or other construction work.

The investigation process may also involve iterations to achieve the necessary level of detail; for example, initial geophysical work may be validated by geotechnical sampling, before another phase of geophysical work; at each stage of the process, it is important to:

- Ensure that the survey design and technical specification are appropriate to delivering the required final outputs;
- Undertake QA/QC of the survey data while they are being acquired;
- Ensure that seismic data are appropriately and fully processed post-acquisition; and
- Have the processed data properly interpreted by experienced seismic interpreters who are familiar with the techniques used on, and the purpose of, a particular survey.

If there is any transfer of ownership or change of contractor during project development, it is important to understand the level of detail to which surveys have been completed.

Due to the volume and specialised nature of the data involved, the geological database is most commonly held by a contractor; considerable attention will be required at interfaces, these can be:

- Organisational, such as ensuring that data supplied to designers, who will use it in subsequent stages of the project lifecycle, is in a form that they can use and interpret, or
- Physical, such as at the offshore / onshore transition.

If the interfaces are not managed adequately, errors and inefficiencies may occur, affecting subsequent work.

C.8.3.1 APPROACHES TO RISK ASSESSMENT

Specific risk assessments to consider prior to commencing work at a location include:

- Metocean conditions and vessel operating capabilities;
- Seabed type, conditions and obstructions;
- Specific hazards such as shallow gas and UXO; and
- Leg penetration prediction, before the first use of jack-up vessels.

C.8.3.2 RISK MITIGATION MEASURES

Selection of methods and vessels will affect the risk profile of the work to be carried out:

- Geophysical surveys may either use purpose-built vessels, or “vessels of opportunity”, typically small vessels that “day run”, returning to port at the end of each day. Vessel suitability should be subject to thorough assessment, in particular considering:
    - The effects of towing on stability and handling, in normal operation and foreseeable situations such as towed instruments or lines being snagged on seabed obstructions or lost fishing gear, or in deteriorating weather;
    - Provision of safe working areas for people on vessels with respect to cables under tension, and minimising the risk of people falling overboard, particularly during instrument deployment and retrieval;
- Geotechnical drilling may be carried out using a demountable rig on a standard vessel, a jack-up vessel, or a dedicated drill ship; the selection process should assess vessel capability to perform the required tasks in the foreseeable conditions at the survey location.

Local seafaring knowledge may indicate areas where wind, wave and currents interact to give particularly difficult conditions; this may be especially important for marine energy developments, as tidal channels and near-shore sites may exhibit very variable sea conditions.

Where there is the potential for shallow gas pockets to be present, suitable drilling equipment and procedures should be employed, which may include maintaining the ability for a vessel to move off station immediately in the event of a gas release – although this will not always be possible, particularly in the case of jack-up vessels.

C.8.3.3 MONITORING, REVIEW AND CHANGE MANAGEMENT

As some seabed features are mobile, the survey data will require ongoing updating in key areas, such as along cable routes and adjacent to structures, and effective communication mechanisms need to be established so that the geological database can inform operations over the lifetime of the development. This should also take account of feedback from operations, for example locations where jack-up barge legs have punched through surface layers need to be recorded and made available in the planning of subsequent operations, as these locations cannot be used again over the life of the project.

C.8.4 CODES OF PRACTICE AND GUIDANCE

C.8.4.1 REGULATIONS AND STANDARDS

Construction (Design and Management) Regulations 2007 (CDM)

Maritime Regulation

C.8.4.2 OTHER RELEVANT GUIDANCE

IMCA Offshore Survey Division guidance covers a wide range of topics including contracting policies, technical aspects, competence and checklists for vessels and mobilisation.

International Association of Oil & Gas Producers - Managing HSE in a geophysical contract; Report No. 432; December 2009; note that this is written for international application, so does not refer to CDM or other UK regulations, and also relates to both land and marine geophysical survey work. Table 2 in Appendix 5 gives comprehensive checklists relating to specific risk areas.

RenewableUK Guidelines for the Selection and Operation of Jack-ups in the Marine Renewable Energy Industry

C.9 HAZARDOUS SUBSTANCES

C.9.1 OVERVIEW

Hazardous substances can be in solid, liquid or gaseous form and may:

- Always be present in a device, such as coolants or lubricants;
- Be introduced during specific operations, such as cleaning fluids; or
- Arise as a by-product of work activities, such as fumes from welding, paints and glass fibre repair compounds.

In some cases, hazardous substances may not be readily visible, such as dusts and vapours in the air.

The same substance may present different hazards in different stages of the lifecycle: for example, a coating may release solvents during application, but form a dust if mechanically abraded during removal.

Substances may present hazards to health as a result of their:

- Chemical or physical composition; or
- Explosive or flammable properties.

Different regulations apply in each of these cases; the same substance may present both types of hazard, and require management under both sets of regulations; fire and explosion hazards are considered in Section C.7, Fire.

When hazardous substances are used in confined spaces, the risk will be greatly increased, compared to use in less complex conditions; see Section C.4, Confined Spaces.

C.9.1.1 POTENTIAL HAZARDS AND RISKS

C.9.1.1.1 Direct Health and Safety Risks

People may be harmed by any form of contact with hazardous substances, including skin contact or puncture, ingestion, absorption and inhalation. The severity and duration of the effects range from minor, temporary irritation, to chronic illness and death, and the onset of symptoms may range from an immediate reaction, to years after exposure. The potential combination of delayed onset and serious illness means that any use of hazardous substances requires careful management.

C.9.1.2 RELEVANCE TO KEY LIFECYCLE PHASES

Design decisions will determine the level of risk that substances will present in subsequent lifecycle phases. The design philosophy should seek to:

- Avoid the use of hazardous substances, by selecting less hazardous alternatives. For example, traditional transformer oils have generally been superseded in WTGs by non-hazardous alternative fluids, or dry designs;
    - The Restriction of Hazardous Substances (RoHS) directive bans the placing on the market of new electrical and electronic equipment that exceeds specified levels of certain hazardous substances, including mercury, lead, hexavalent chromium, cadmium and various flame retardants;
    - Where products such as biocides are used, for example to treat the water inside monopiles, then in addition to assessing the hazards to people, they must be approved under the Offshore Chemical Notification Scheme, which is mainly concerned with their environmental impact;
- Minimise the quantities present; and
- Provide systems for containment / separation / handling, to minimise the exposure of people to the substances.

The designer should also consider:

- Lifecycle requirements for maintaining systems that contain hazardous substances; for example, by ensuring that good access is available for changing gearbox oil, the risk of spillage and contact with people is minimised; and
- Hazards presented by materials in foreseeable damaged states; for example, certain materials used for cable insulation release hazardous vapours in the event of a fire.

In considering the lifecycle risk, the designer needs to balance the different risks that substances present; for example, when comparing alternative surface coating systems, the designer should consider both the hazards that the coatings present during application (such as the levels of solvent vapours), and their expected lifetimes and performance, which will determine how often people are exposed to the risks that maintaining the coating system may present, such as work at height.

During the O&M phase, periodic replacement of substances such as lubricating oils and greases may be required; additional care may be necessary as used fluids may be more hazardous than when equipment was first manufactured.

Hazards presented by non-routine repairs, which may involve hot work such as welding or grinding, should also be assessed, both in terms of the substances directly involved (such as fumes from welding) and any reaction products, such as fumes that may be released from surface coatings if exposed to excessive heat from these operations.

Exposure to hazardous substances can also occur as a result of natural environmental processes, without the substances having been introduced deliberately; for example, Hydrogen Sulphide (H_2S) or methane can be released as a consequence of seabed disturbance.

C.9.2 REGULATORY REQUIREMENTS

The use of substances that are hazardous to health as a result of their chemical or physical composition is covered by the Control of Substances Hazardous to Health (COSHH) Regulations 2002; the employer has the principal duties under these regulations. Other relevant regulations include:

- The Chemicals (Hazard Information and Packaging for Supply) (CHIP) Regulations 2009 set common standards for classification, labelling and packaging of chemicals. These regulations are being superseded by the Classification, Labelling and Packaging (CLP) regulation, which is being phased in between 2010 and 2015, and under which, classification and labelling will transition to the Globally Harmonised System. The supplier of a substance is the duty holder under these regulations, but users will see changes in the content of Safety Data Sheets; and
- The Registration, Evaluation, Authorisation & restriction of Chemicals (REACH) regulations impose duties on suppliers relating to provision of safety information, and will also lead to some particularly hazardous substances being withdrawn.

C.9.3 MANAGING THE RISKS

Any use of hazardous substances must be managed in accordance with the COSHH Regulations 2002.

COSHH imposes a number of duties on employers, including a duty to ensure that a competent person carries out a suitable and sufficient assessment of the risk to health that is presented by the use of a substance; detailed guidance on factors to consider is given in the ACOP. Assessments made by the supplier, under REACH, are based on a hypothetical exposure scenario; these may be used to inform an assessment under COSHH, but do not replace it. Based on the outcome of the risk assessment, further duties may include:

- Prevention or control of exposure to the hazardous substance;
- Ensuring that control measures are used properly, are appropriate for the task, and, where more than one control measure is in place, that they are compatible with each other. For example, if both respiratory protective equipment (RPE) and eye protection are required, then they should be of compatible designs;

- Ensuring that control measures are maintained, so that they continue to provide the necessary level of protection;
- Provision of necessary information, instruction or training;
- Having suitable arrangements in place to deal with accidents, incidents and emergencies; and
- Monitoring workplace exposure and health surveillance, where the risk assessment identifies this requirement.

These duties apply in different ways for the protection of employees, others who share the workplace, and other people who may be affected by the activity. Employees have duties to co-operate with their employers in ensuring that the requirements of the regulations are fulfilled, ensuring that necessary PPE is used and suitably taken care of, and maintaining appropriate hygiene practices.

As the COSHH risk assessment primarily relates to the use of a substance, then if the intended use changes, the risk assessment must be reviewed.

While the CHIP regulations set the standards for labelling and packaging of substances from the supplier to the customer, the employer has a duty to ensure that suitable standards of labelling and packaging are maintained if substances are transferred to different containers for use offshore, or if used substances are collected in containers that differ from the original packaging. Likewise, users must read the labels, and use the substances in accordance with the precautions identified. Some substances will, for environmental protection reasons, be subject to additional restrictions for use in the aquatic environment, compared to onshore.

C.9.4 Codes of Practice and Guidance

C.9.4.1 Regulations and Standards

HSE L5 - *Control of Substances Hazardous to Health Regulations 2002 (as amended) Approved Code of Practice and guidance*.

HSE EH40/2005 *Workplace Exposure Limits*: contains the list of workplace exposure limits for use with the COSHH Regulations.

HSE L131 - *Approved Classification and Labelling Guide (Sixth edition) - Chemicals (Hazard Information and Packaging for Supply) Regulations 2009 (CHIP 4)* details the basis for the different risk and safety phrases used in the labelling of substances.

C.9.4.2 Other Relevant Guidance

The HSE COSHH Essentials web pages provide concise summaries of the substance-related hazards of a wide range of offshore operations, and their management; these include *Offshore*, covering topics such as painting, pressure cleaning, cementing and legionella; and *Welding, Hot work and Allied Processes*.

HSE INDG136 - *Working with substances hazardous to health - What you need to know about COSHH.*

HSE INDG233 – *Preventing Contact Dermatitis at Work*.

The HSE has published further details of REACH, and an explanation of the relationship between COSHH, CLP and REACH on its website.

C.9.4.3 Elsewhere in this Guidance

Emergency response & preparedness
Confined Spaces

C.10 LIFTING

C.10.1 OVERVIEW

OREI construction, and some major maintenance activities, involve the lifting of large and heavy loads at sea, such as foundations, WTG rotors, and even entire offshore substations. The construction phase of a project typically involves many repetitive lifts of major components and sub-assemblies, together with numerous smaller lifts of tools and consumables.

Maintenance activities over the life of an OREI generally involve a wide range of lifting operations, ranging from the routine lifting of tools and equipment between support vessels and offshore structures, to complex lifts of major components. In many cases, further lifting within the structure will be necessary in order to bring the load to the precise location where it is needed, which may also involve moving the load in very restricted spaces.

Lifting operations involve both the use of cranes mounted on structures, and on vessels, which range from large floating, leg-stabilised and jackup crane vessels to versatile workboats. Vessels may either have been purpose-designed for lifting, or have had cranes retrofitted; in either case it is essential to have a clear understanding of the combined capability of the vessel and its crane.

Any load that is carried on a vessel will also require to be transferred between the quayside and the vessel, usually by lifting, and seafastened for transit offshore.

C.10.1.1 POTENTIAL HAZARDS AND RISKS

C.10.1.1.1 Direct Health and Safety Risks

In any lifting operation, the main hazards to people arise from dropped objects, which may be caused by failure of lifting equipment or attachment points on the load itself. As well as the high potential risk to any people beneath the suspended load, the consequences of any such event may be increased offshore, particularly if it causes a vessel to be damaged or destabilised, thereby endangering all personnel on board.

Operating in the offshore environment greatly increases the technical and organisational complexity of lifting, compared to onshore:

- Lifts may be performed between floating vessels (transport vessels / floating cranes) and static structures (jack-up vessels / WTGs);
- Lifts may involve more interfaces than onshore; typical participants may include the:
    - Master of each vessel involved;
    - Crane operator;
    - Offshore Lifting Supervisor;
    - Marine Co-ordinator; and
    - Installation contractors or equipment suppliers;
- The marine environment will accelerate the deterioration of structural and mechanical components of lifting equipment, or of attachment points on loads;
- Vessels and their crews may be from a number of different countries, bringing the potential for difficulties arising from communication problems or differences between regulatory systems;
- Proximity hazards are increased, as a consequence of the restricted space on vessels or structures; and
- Metocean conditions may change rapidly and unexpectedly, affecting both equipment and personnel.

Lifting operations involving floating vessels are subject to the dynamic effects of vessel movement, including:

- Increased stresses in lifting equipment, or vertical impact between loads and fixed objects or boat decks;
- Swinging of load, with potential for impact against adjacent structures / objects / people;

- Changes in vessel trim or list when a heavy load is moved;
- If the load or hook of a crane becomes entangled or caught on another structure or vessel, and there is relative movement of the crane and the structure or vessel, then this can lead to almost instant overload of the crane, with the potential for breakage of the crane or lifting equipment, and resulting risks to people and vessels;
    - The risk of such entanglement is increased if loads have to be placed in small laydown areas, particularly where they are surrounded by railings.

Where objects are lifted into or out of water, there is additional complexity due to:

- Buoyancy effects;
- Weight of water within flooded objects, and potential for its movement to shift the object's centre of gravity;
- Effect of waves acting on the object as it crosses the waterline.

Offshore lifting therefore comprises a hazardous combination of increased complexity, increased stresses, degraded equipment performance, and more severe consequences in the event of a failure.

C.10.1.1.2 Commercial and Operational Risks

Lifting operations are restricted to suitable metocean conditions; the degree of restriction depends on how the lifting equipment and vessels are matched to the site conditions and the demands of the intended operation.

C.10.1.1.3 Indirect and Consequential Risks

Certain offshore lifting operations involving particularly heavy loads, or high lift heights, may only be undertaken by a relatively small number of heavy lifting vessels; any late changes or additional requirements could incur high costs, or lengthy delays until the required vessel became available.

C.10.1.2 RELEVANCE TO KEY LIFECYCLE PHASES

Lifting operations are likely to be required over the entire lifecycle of a development; construction and major maintenance operations may involve significant heavy lifting activity, while even light maintenance is likely to involve lifting of components or tools between levels, and to / from access vessels.

Decisions made at the design stage will determine the nature of the lifts that may be required later in the project lifecycle; these decisions range from device assembly and installation concepts, to determining the capability of lifting equipment that is to be provided within nacelles or on transition pieces, and should be considered together with the access strategy.

C.10.2 REGULATORY REQUIREMENTS

Lifting equipment is subject to the Provision and Use of Work Equipment Regulations (PUWER), which require that it is suitable for the purpose for which it will be used, in terms of properties such as materials of construction, accessibility, protection of personnel, and withstanding the effects of high wind. Powered lifting equipment is also subject to the Supply of Machinery (Safety) Regulations, which implement the Machinery Directive; in addition to the Essential Health and Safety Requirements (EHSRs) that apply to all machinery, Annex 1, Part 4 of the Directive contains supplementary EHSRs that apply specifically to lifting equipment.

All lifting operations and lifting equipment are subject to the requirements of the Lifting Operations and Lifting Equipment Regulations (LOLER), which include:

- Lifting equipment, supporting structures, and the load, must all have adequate strength and stability;
- Equipment used for lifting persons is subject to additional design and operational safeguards;
- Positioning and installation of lifting equipment should minimise the risk to people, from suspended loads or crushing;

- Equipment must have appropriate marking, and be maintained under a system of inspection, thorough examination and record keeping;
    - The statutory minimum inspection frequencies are unlikely to be sufficient to monitor deterioration in lifting equipment that is subject to the extreme wind loads and intensive and repetitive use that can be expected in large scale offshore wind development; suitable systems for inspection and quarantine need to be established;
- Lifting operations must be properly organised; this includes planning, supervision and execution:
    - Lifting operations should be planned in accordance with BS 7121 by an Appointed Person, with the level of detail reflecting the complexity and hazards of a lift.
    - The LOLER ACOP states that the purpose of the plan is "*to address the risks identified by the risk assessment and identify the resources required, the procedures and the responsibilities so that any lifting operation is carried out safely. The plan should ensure that the lifting equipment remains safe for the range of lifting operations for which the equipment might be used".*

For offshore lifting, the design of sea-fastening systems to secure or release loads needs to be compatible with the lifting methods to be employed.

The plan should also define the actions and necessary equipment in emergency situations, including the ability to abort a lift that has already started. In certain cases where the lift passes a "point of no return", the only way to abort the lift without endangering people or vessels may involve emergency release of the load into the sea; clearly the planning and execution of the lift should avoid this point being reached.

All personnel involved in the lift need to have a full understanding of the plan before operations commence; as teams may be mobilising from different locations, duplicate toolbox talks may be necessary in order to provide this final briefing.

C.10.3 MANAGING THE RISKS

While there are common risks across all types of lifting operation, proportionality demands that the effort devoted to planning and managing health and safety should reflect the risks and complexity of the intended operation; planning may therefore range from detailed modelling and hazard studies carried out in advance by a specialist team, to basic checks on the load and equipment, carried out by a competent person before executing the lift.

C.10.3.1 CLASSIFICATION OF LIFTS

Lifts are classified by different bodies in terms of whether they are:

- Routine or non-routine (IMCA);
- Heavy / light (DNV);
- Restricted / unrestricted (by weather) (Noble Denton).

Under the IMCA classification, a routine lift is one where:

- A suitable generic lifting plan is already in place for the intended operation;
- All of the lift team involved has prior experience of the particular lift, and have previously performed the same roles during the lift; and
- The lift team is trained in the use of the specific equipment involved, and understands its limitations.

A lift that does not meet these criteria is non-routine. It should be noted that, on this basis, lifting the same load under different circumstances may change the category from routine to non-routine. A routine lift will, by definition, result in more frequent exposure to risks than a one-off lift, and therefore requires a proportionate level of effort in initial risk assessment, together with very clear criteria for when the generic lifting plan is applicable; effective management is essential to avoid complacency in routine operations.

When considering whether a lift is heavy or light, under the DNV classification, this is mainly determined by the ratio of the load weight to the vessel displacement; where this exceeds 1-2% (or in any case where the weight exceeds 1000 te), the lift is heavy, and may affect vessel motion characteristics.

Under the Noble Denton classification, if a lifting operation cannot be completed within the time limit of a favourable weather forecast, then it can only proceed if it is designed to allow for the foreseeable extremes of weather at the location, taking account of the time of year; this is classed as an unrestricted operation. Conversely, if it can be completed within the forecast time limit, then it can proceed as a weather-restricted operation, provided that there is a suitable margin between the design and operational weather limits.

C.10.3.2 Approaches to Risk Assessment

Once a requirement to carry out a lift has been established, a lifting plan should be prepared; as a minimum, the plan should cover:

- The load, its properties, and how it is to be lifted, taking account of effects such as buoyancy, water movement inside the load, and adhesion of the load to supporting surfaces;
- Selection of the crane / vessel;
- Selection of lifting equipment;
- Positioning of the crane and load throughout the operation;
- Hazards arising from characteristics of the site;
- Arrangements for crane erection / dismantling, and attachment to / release of the load; and
- Environmental conditions that may constrain the operation.

Based on the outline plan, a suitable and sufficient risk assessment of the proposed operation must be carried out, in accordance with the Management of Health and Safety at Work regulations. The risks identified by this assessment are then to be addressed by the method statement, prepared by an Appointed Person in accordance with LOLER requirements. This may either be a generic method statement, for a series of routine lifts, or a specific method for a non-routine lift.

The guidance on LOLER details many of the factors to consider when planning each stage of a lifting operation; for offshore lifting, additional sources such as the IMCA Guidelines for Lifting Operations should be consulted.

The planning process will differ, depending on whether the lift is routine or non-routine; a suggested approach is given in the IMCA Guidelines. For some lifts, it may be appropriate to carry out numerical modelling, to take account of the effects of metocean conditions on the lift. The level of effort invested in planning the lift should be proportionate to the hazards and risks that the lift presents.

C.10.3.3 Risk Mitigation Measures

This risk of problems arising from lifting operations can be minimised by:

- Giving thorough consideration to lifting requirements when designing offshore equipment, so that it matches the capabilities of foreseeable vessels, and adopts best practices in the lifting operation;
    - Design details may make it possible to lift the load into its final position without needing people to guide the load, thus avoiding placing people beneath the suspended load, or close to pinch-points between the load and the location that it is being lowered onto;
- Carrying out thorough early planning of lifting operations, so that firm vessel requirements can be established;

- Selecting an appropriate crane for the task; for example, lifting light equipment onto a foundation, using the main block of a heavy lift crane, may result in difficulty controlling the load, as its weight will be too small in comparison to the block and lifting cables; use of an auxiliary crane / block that is more suited to the light load will avoid this problem;
- Ensuring that the suspended load will not pass over locations where people will be present during the lifting operation, so that if, despite all the planning and selection work, the load (or part of the load) drops, people will not be in immediate danger – even a small object can cause severe injury if dropped from sufficient height; and
- Ensuring that all cranes are designed and certified for offshore use.

Even where thorough planning is carried out, problems can still occur, such as interruptions in power and communications systems, failures of load-bearing components, and unexpected problems with the parts to be assembled, so advance contingency planning is essential.

Where floating vessels are involved in lifting, either carrying the load or the crane, technical measures to enable safe offshore lifting may include the use of:

- Dynamic Positioning (DP), for good station-keeping;
- Vessel stabilisation;
- Heave-compensated cranes;
    - Note that if heave compensation is used, no other auxiliary equipment such as tugger winches should be attached to the load, as this has the potential to interfere with the operation of the heave compensation system; and
- Automatic or Manual Overload Protection Systems (AOPS / MOPS) to protect the crane from damage if the hook becomes entangled.

While such systems can enable operations to take place from floating vessels in a wider range of metocean conditions than would otherwise be possible, the risk assessment needs to consider the potential effects of failure of such systems, and identify any required backup systems so that the risks are reduced ALARP.

Jack-up vessels (either self-elevating or column-stabilised) minimise dynamic lifting issues, but require specific assessment of aspects such as:

- Limiting sea states for survival when elevated / in transit / jacking;
- Seabed properties, including load-bearing capacity, gradient, and obstructions such as boulders;
- Areas to avoid when jacking, such as cable routes; and
- The ability to remove the vessel, and transit to a place of safety, should forecast conditions exceed limits.

C.10.3.4 Monitoring, Review and Change Management

During lifting operations, monitoring should include:

- The crane’s Rated Capacity Indicator, to take account of sea-state and wind; and
- Incident metocean conditions, by measurement and watch-keeping.

The information from this monitoring needs to be used within well-defined procedures to determine whether to proceed with or abort operations.

In the long term, the marine environment may accelerate the deterioration of lifting equipment, requiring enhanced specification and inspection regimes. Inspection should include the condition of hydraulic systems, as leakage could pose a direct hazard to people in the vicinity, as well as impairing operation. Lifting equipment installed on WTG transition pieces (or equivalent) will have a particularly high level of exposure to salt spray over its operating life, which is likely to accelerate deterioration of materials.

Vessel-mounted cranes are generally designed to a specification that is matched to the particular vessel on which they are to be installed, particularly where heave compensation is used; a change of vessel may bring a significant change in lifting capability, requiring all lifting plans to be reviewed.

C.10.3.5 CONSIDERATIONS FOR MARINE ENERGY

In the marine energy industry, most lifting is currently undertaken using vessels hired on short-term contracts, due to intermittent demand, which precludes the long-term chartering that is used for most offshore wind lifting activities. If a device has particularly specialised lifting requirements, then this may restrict the range of suitable and affordable vessels. The combination of a non-standard load, which may even be a prototype, being lifted with a vessel that has not previously been used for this purpose, and which is operating in an exceptional environment, can lead to a high level of risk. On tidal energy developments, the limited working time available at slack water can be an additional source of pressure on people during the lifting operation, as well as being a direct hazard to vessels and people.

Such non-routine lifts require even greater care in planning; standard approaches to planning lifts should be applied, but with the recognition that the loads in question may behave differently. Robust selection of lifting contractors and vessels is essential; as contractors and vessel crews may not have direct experience of the precise task to be undertaken, evidence of other non-standard operations previously undertaken, and the processes by which they were managed, should be evaluated.

At an operational level, the risk may be further mitigated by undertaking trial lifts in a benign location, such as a harbour basin, to ensure that the behaviour of the load and vessel is fully understood on a practical basis, prior to lifting at the project site. The owner / developer's representative on board vessels undertaking such operations will need to establish an effective working relationship with the vessel master and crane operator, as their role is likely to involve more of an advisory function, in addition to monitoring operations.

As an alternative to lifting loads to and from the deck of a vessel, floating and ballasting may be used, with tension applied by cables from deck winches, over the stern roller. Such operations should be planned in the same manner as conventional offshore lifting, with additional consideration of the hazards that tensioned cables across the deck present to people aboard. Where this is combined with towing the load to site, then the towing operation also requires thorough planning.

C.10.4 CODES OF PRACTICE AND GUIDANCE

C.10.4.1 REGULATIONS AND STANDARDS

HSE L113 - *Lifting Operations and Lifting Equipment Regulations (LOLER) 1998 - Approved Code of Practice and Guidance*. Note that LOLER Regulation 3 exempts lifting operations, undertaken as part of the normal operation of a ship (such as such as loading, fuelling, provisioning, repair and maintenance of the ship), using lifting equipment that is part of the ship's equipment, from LOLER. Use of lifting equipment on a ship for activities such as offshore construction is subject to LOLER.

HSE L22 - *Provision and use of Work Equipment Regulations (PUWER) 1998 - Approved Code of Practice and Guidance*, apply in full to lifting operations on vessels.

MCA MGN 332 – *Merchant Shipping and Fishing Vessels (Lifting Operations and Lifting Equipment) Regulations*, regulate the use of lifting equipment on ships, for ship-borne activities that are exempt from LOLER.

European Commission – Enterprise and Industry - *Guide to application of the Machinery Directive 2006/42/EC* especially Annex 1, Part 4 (§327 onwards): Supplementary essential health and safety requirements to offset hazards due to lifting operations.

BS EN 13852-1 *General purpose offshore cranes.*

BS 7121 *Safe use of Cranes: Part 1 – General*, and *Part 11 – Offshore Cranes.*

C.10.4.2 OTHER RELEVANT GUIDANCE

HSE HSG 221 - *Technical guidance on the safe use of lifting equipment offshore*, is mainly focused on lifting by fixed equipment on offshore installation, but has useful guidance on general considerations for offshore lifting equipment.

HSE INDG422 - *Thorough Examination of Lifting Equipment - A simple guide for employers*.

HSE Website – *Work Equipment and Machinery*.

DNV RP-H103 - *Modelling and Analysis of Marine Operations*, obtainable from DNV Recommended Practices webpage – Sections 3,4 provide detail on modelling of lifting operations through the wave zone; Section 5 addresses Heave Compensation, and Section 9 classifies lifts as light / heavy.

GL Noble Denton *Guidelines for Marine Lifting Operations*: describes an approval process for lifting operations undertaken by a wide range of vessel types, including loadout from the quay to a vessel. They form a useful checklist for planning of marine lifting operations, and define the criteria for restricted / unrestricted operation.

GL Noble Denton *Guidelines for Marine Transportations* provide a process for the planning and approval of the transport of non-standard cargos, either on a ship or barge, or by floating.

RenewableUK *Guidelines for the Selection and Operation of Jack-ups in the Marine Renewable Energy Industry*: gives detailed guidance for all aspects of work involving the use of jack-up vessels.

IMCA M223 - *Guidance for the positioning of dynamically positioned (DP) jack-up vessels on and off the seabed* provides guidance on the issues that can arise when DP vessels transition between floating and jacked-up operation.

IMCA M187 - *Guidelines for Lifting Operations*, provides detailed guidance, flowcharts and checklists for planning offshore lifts, determining whether a lift is routine or non-routine, and include example lift plans and risk assessments in the appendices.

IMCA M171 - *Crane Specification Document*, gives an overview of offshore crane design criteria, and may be used to guide the selection of crane vessels for particular tasks.

IMCA SEL022 - *Guidance on Wire Rope Integrity Management for Vessels in the Offshore Industry*, provides detailed guidance on how to ensure the long term safety of wire ropes used in lifting operations in the marine environment.

HSE Website: *Hazards During Maintenance - Falls of Heavy Items*.

Fédération Européenne de la Manutention - Guideline - *Safety Issues in Wind Turbine Installation and Transportation* addresses the onshore transport and lifting of WTGs and components, however much of the content, particularly in relation to the effect of wind on WTG components being lifted, is relevant. (Freely available, but requires entry of name and email address to download).

C.11 MARINE CO-ORDINATION

C.11.1 OVERVIEW

The development of OREIs typically involves large numbers of people and vessels, working in small groups, in multiple locations, which may include vessels and offshore structures, on a remote site for an extended period. The Marine Co-ordination function has a key role in the safe preparation and execution of such activities, in order to minimise the probability of an incident occurring, and to provide an effective response if an incident does occur. The Marine Co-ordinator is a key member of the project management team; offshore operations should only take place when permitted by the Marine Co-ordinator, and in accordance with the method that has been agreed with them.

C.11.1.1 POTENTIAL HAZARDS AND RISKS

C.11.1.1.1 Direct Health and Safety Risks

Offshore operations, and the associated vessel traffic, introduce risks including:

- Interference between operations leading to vessel collision or other accident;
- Inability to account for all personnel and their locations in routine or emergency situations;
- Vessels working in close proximity to each other, possibly also with restricted manoeuvrability due to the nature of the vessel or the operations being undertaken; and
- Simultaneous operations being undertaken on vessels, structures and subsea.

There are also risks associated with interactions with other sea users, including:

- Restriction of safe movement of other vessels, including pleasure craft, particularly in peak seasons and in tidal channels or other confined waterways;
- Other commercial and leisure sea users may be unfamiliar with OREIs and hence interested in the devices and their associated operations; this may encourage close approaches to structures, exposing themselves to risk, particularly in tidal channels or for floating OREIs; and
- Acoustic emissions from offshore operations, such as pile driving, may disturb or be hazardous to sea users, particularly divers.

C.11.1.1.2 Commercial / Operational Risks

In the absence of effective marine co-ordination, it is unlikely that vessels will be utilised in an efficient manner. A lack of control of vessel operations could also result in damage to equipment or site infrastructure, such as anchor damage to cables, or release of hazardous materials to the environment.

For tidal energy developments, the demand on the Marine Co-ordination function is likely to be particularly uneven, with peaks of activity occurring at slack water and neap tides.

C.11.1.1.3 Indirect and consequential Risks

In the event of an offshore construction programme falling behind schedule as a result of poor marine co-ordination, the severity may escalate if vessel charter periods are exceeded; similarly, if operations have been planned for a particular season, delays could result in work not being undertaken until the following year, potentially incurring significant additional costs.

C.11.1.2 RELEVANCE TO KEY LIFECYCLE PHASES

The Marine Co-ordination function must be in operation prior to commencement of on-site operations; however some of the controls, particularly relating to other sea users, will be determined as part of the Environmental Statement. In addition, the Marine Co-ordinator should be involved in the selection and approval of contractors and vessels, and in making arrangements for the use of ports and harbours. For these reasons, marine co-ordination needs to be considered early in project definition.

C.11.2 Regulatory Requirements

Both CDM and MHSWR require employers who share a workplace to co-operate and co-ordinate their activities in the interest of health and safety; for a workplace that is at sea, marine co-ordination will contribute to fulfilling this duty.

MGN 371 imposes specific duties on developers to apply mitigation and safety measures during construction, operation and decommissioning:

> *"Mitigation and safety measures will be applied to the OREI development appropriate to the level and type of risk determined during the Environmental Impact Assessment (EIA). The specific measures to be employed will be selected in consultation with the Maritime and Coastguard Agency's Navigation Safety Branch and will be listed in the developer's Environmental Statement (ES)."*

The specific measures for any given development would be identified by undertaking a Navigational Safety Risk Assessment; typical measures that MGN 371 identifies are listed in Section C.13.3.2.

It is the developer's responsibility to fulfil these duties, generally by means of establishing an effective Marine Co-ordination function, with sufficient numbers of competent people, and suitable supporting systems to manage the workload in each phase of the project lifecycle.

The supporting systems need to include suitable marine communications hardware, and may also include software systems to assist in the planning and monitoring of operations. All such systems need to be sufficiently robust, together with backup systems, for the safety-related functions that they fulfil. Communications systems should be used in accordance with established marine protocols, to minimise congestion on the available frequencies. Mobile phones should not be relied upon.

C.11.3 Managing the Risk

C.11.3.1 Risk Mitigation Measures

Typical responsibilities of the Marine Co-ordination function relate both to planning ahead for future operations or situations, and managing current activities. Preparatory activities include:

- Provision of advice on marine operations;
- Preparation of Emergency Response Co-operation Plan (ERCoP);
- Liaison with those who may be affected by the operations, including other sea users (fishing, leisure and merchant shipping) and port authorities;
- Auditing of vessels and operational plans;
- Planning of vessel movements, particularly in areas with high levels of vessel traffic, such as ports and areas of intense construction activity; and
- Involvement in planning of SIMOPS.

While operations are in progress, the Marine Co-ordination function will be responsible for:

- Provision of information and warnings to project vessels and other sea users; this includes both formal Notices to Mariners, and advising of site-specific weather forecasts and tide information;
- Continuous co-ordination and monitoring of all marine activities, including movements of non-project vessels in the vicinity;
- Continuous control of access, and tracking of personnel and vessels;
- Emergency co-ordination, including liaison with emergency services as required;
- Carrying out site inductions for offshore work; and
- Ongoing liaison with other sea users, particularly when different phases of activities are about to commence.

The Marine Co-ordinator will define and manage these processes, which require the full co-operation of all parties involved in the offshore operations, and close liaison with the Principal Contractor and logistics function. The responsibilities and authority of the Marine Co-ordinator also apply to operations taking place in supply or mobilisation ports; such locations may experience a very high level of vessel traffic in a concentrated area, which is also shared with other port users; vessel movements may be further restricted by tidal access constraints.

Procedures should be established for:

- Management of vessel movements, especially when several vessels may need to be in the vicinity simultaneously;
- Transfer of personnel to and from a vessel or a wind farm;
- Transfer of personnel onto and off offshore structures;
- Tracking personnel between the wind farm and an accommodation vessel; and
- Unloading and back loading supply vessels.

Procedures regarding vessels and personnel transfers at sea and in port should all be under the control of a Marine Co-ordinator.

Sea users should be notified about the hazards associated with approaching OREIs and project activities. Notifications and warnings should be broadcast through various media and in a range of locations; it should be noted that some sea users may travel large distances to popular locations for leisure activities such as diving, therefore, in order to maximise exposure and allow advance planning, it may be helpful to provide notifications well beyond the immediate vicinity of the project.

Given the wide range of safety-related responsibilities that the Marine Co-ordinator fulfils in routine and emergency situations, selection of suitably competent and experienced people for this role is essential. Employers may wish to develop formal competence profiles, and training and development programmes, to ensure that suitable people are available. Marine Co-ordinators must have a thorough understanding of the vessel operations that will be taking place under their oversight; in many cases this experience will have been gained as a Master of a vessel engaged in offshore construction activities.

The extent of the necessary Marine Co-ordination function will depend on the requirements and lifecycle phase of the project. For very small developments, such as the installation of a single device, with daytime working only, it may be appropriate to have an appointed person who is responsible for marine co-ordination. However, for large OREI developments it would be more appropriate to utilise a larger team, with shift working to allow 24 hour provision of the marine co-ordination function.

C.11.4 Codes of Practice and Guidance

C.11.4.1 Regulations and Standards

Management of Health and Safety at Work Regulations (1999), in particular Regulations 11 (*Co-operation and co-ordination*) and 12 (*Persons working in host employers' or self-employed persons' undertakings*).

HSE L144 - *Construction (Design and Management) Regulations 2007 Approved Code of Practice and Guidance*, in particular Regulations 5,6 – *Co-operation and Co-ordination.*

MCA MGN 324 - *Radio: Operational Guidance on the Use Of VHF Radio and Automatic Identification Systems (AIS) at Sea*, provides guidance on the performance and correct operation of these marine communication systems, and should be used in conjunction with MCA MGN 324 Correction - *Radio: Operational Guidance on the Use Of VHF Radio and Automatic Identification Systems (AIS) at Sea*

MCA MGN 371 - *Offshore Renewable Energy Installations (OREIs) - Guidance on UK Navigational Practice, Safety and Emergency Response Issues*, Annex 4: Safety and mitigation measures is recommended for OREIs during construction, operation and decommissioning.

C.11.4.2 OTHER RELEVANT GUIDANCE

IMCA M205 - *Guidance on Operational Communications*.

DNV-OS-H101 - Marine Operations, General, obtainable from DNV Offshore Standards webpage, provides a framework to ensure that marine operations are performed within defined and recognised safety levels.

RenewableUK - *Incident response for offshore wind and marine projects*.

C.11.4.3 ELSEWHERE IN THIS GUIDANCE

Simultaneous Marine Operations (SIMOPS).

C.12 METOCEAN

C.12.1 OVERVIEW

Metocean factors comprise the combination of weather and sea conditions. They are relevant to the entire lifecycle, as robust equipment performance and safe operations can only be assured if the systems that are adopted on a project are matched to the conditions at the development site. This section concentrates on the risks that metocean conditions present to activities over the lifecycle of an OREI, together with brief consideration of the risks involved in metocean data acquisition.

C.12.1.1 POTENTIAL HAZARDS AND RISKS

C.12.1.1.1 Direct Health and Safety Risks

The power of the sea, and the effect of wind and visibility on offshore operations, must never be underestimated. Attempting to undertake offshore operations in unsuitable conditions can expose people to risks of injury, stranding and death.

Adverse conditions can both increase the probability of incidents and errors occurring, and increase the severity, by hindering recovery or containment actions.

Conditions can change rapidly, so procedures should be in place to cope with foreseeable changes.

In addition to wind, wave and tidal conditions, including currents:

- Lightning is also a hazard to people on offshore structures;
- Cold temperatures can cause hypothermia, and icy surfaces can prevent safe movement;
- Rain, hail, snow and fog can all affect visibility, and also impede vision through safety spectacles or similar PPE; and
- Warm air temperatures can cause heat stress, whether as a consequence of working in hot enclosed spaces such as WTG nacelles, or climbing an access ladder while wearing a survival suit.

Even if a given set of weather conditions does not prevent execution of a task, the potential for accelerated fatigue should be considered.

C.12.1.1.2 Commercial and Operational Risks

Operations cannot take place unless conditions are suitable; if the operating capability is poorly matched to the operating environment, then programmes of work may suffer significant delay. If activities were planned to be completed within a particular season, then any overrun may mean that work has to wait until the following year, or a different method has to be adopted, with attendant cost and delay.

The protection of people is the priority; in some cases, such as in lifting operations, once a point of no-return has been passed, the only way to ensure the safety of people and vessels may be to jettison a load.

Suitable meteorological conditions are also essential for aeronautical operations, both for survey and access activities; if conditions are found to be unsuitable on arrival, then the aircraft will have to return to base, without undertaking the intended task, and at considerable cost.

If the design of an OREI is poorly matched to the location where it is to be deployed, then this may affect the ability to install it, its ongoing reliability and survival, or the ability to access it when required for commissioning and maintenance, potentially giving low availability under conditions when output should be at its highest.

C.12.1.2 RELEVANCE TO KEY LIFECYCLE PHASES

During project definition, a dataset is gathered from a combination of on-site and remote measurements to:

- Assess the resource;

- Enable device selection and site-specific design;
- Inform construction and O&M strategies;
- Support the selection of vessels, helicopters, and access systems for construction and O&M; and
- Plan the construction phase.

This dataset is likely to span several years' data, although not all of this would be from on-site measurements. Data collection should continue throughout the operational life of the development, in order to refine forecasting capabilities and enable better decision making. Given the cost of data collection, and the impact of the decisions that it will inform, it is important to ensure that the data collection campaign is designed and managed by competent specialists, who understand how the data are to be used, and can present it in a form that is suitable for the end users.

Design codes for foundations and structures require a suitable dataset from calibrated instruments, deployed in a validated measurement campaign, as input for design calculations.

The detail design of structures, and the selection of installation methods, access systems and vessels will determine the weather-sensitivity of all operations over the project lifecycle; the early stages of the project will therefore determine the level of risk that weather will present to people and the viability of the project.

Construction work may need weather windows of several days' duration for some tasks, together with regular site-specific forecasts for ongoing vessel operations. The forecast will need to consider both the conditions that enable the intended task to be carried out, and the conditions that may be necessary for safe transit of vessels if the task has to be abandoned.

The O&M phase has the potential to be particularly sensitive to the effects of weather, as any task that involves personnel transfer onto offshore structures requires suitable weather conditions for the vessels and access systems in use. If generation has been stopped by a fault, and cannot resume until a manual intervention has been carried out, then significant downtime may arise while waiting for a weather window.

C.12.1.3 ON-SITE METOCEAN DATA ACQUISITION

On-site data acquisition generally involves the installation of temporary or permanent instruments, including subsea instruments such as Acoustic Doppler Current Profilers (ADCPs); floating wave buoys, and offshore meteorological masts. While this data is first used in design activities, later phases of the OREI life cycle will require sea state information to be available in real time, to support operational decision making.

On-site instrument deployment will represent the first physical presence of the OREI on the site; this introduces the risk of interaction with existing sea users and infrastructure, including subsea services. While these are addressed as part of the consenting process, the involvement of experienced contractors can help to ensure that risks presented by the proposed equipment and operations are adequately assessed, and that suitable mitigation is identified. Both vessels and instruments may be damaged in the event of collision, or fouling of nets, and the finding and recovery of damaged or drifting instruments increases the exposure of people to marine hazards. The risk of such events occurring can be minimised by thorough preparation, including consultation with, and notification of, other sea users, together with the use of markings and lights to assist in collision avoidance, and position-indicating beacons to assist in retrieval.

The deployment of an offshore meteorological mast represents a significant construction project in its own right, and therefore introduces all of the risks inherent in such work, but with additional factors due to the early stage in the project lifecycle:

- Site-specific measured metocean data to assist design and selection of access arrangements is likely to be very limited, increasing the reliance on models or remote sources;
- Construction vessels are only required for a few days, so are more likely to be from the spot-market than a long-term charter as would be the case for multiple installations during the main construction phase, so may not be as well matched to the demands of the project and the location;

- There is likely to be greater flexibility in the selection of vessels for instrument deployment;

- Access vessels for commissioning and O&M are likely to be vessels of opportunity, as the vessels that will eventually be used for supporting the OREI will not yet have been sourced;
    - If the development is in a sea area with very different characteristics to existing developments, then a different type of access vessel may be required;
    - The interface between access vessels and offshore structures must permit safe personnel transfer.

In all of these cases, thorough vessel selection processes must be operated, to ensure that the chosen vessels are suitable for the tasks for which they are to be used.

On-site data are likely to be gathered at the smallest possible number of locations, due to the cost involved, while forecasting and modelling will be more accurate if data are available from multiple locations; there may be potential for adjacent developments to share data in order to improve the quality of the forecasts that will be available to each of them.

C.12.2 MANAGING THE RISKS

In addition to task-specific risk management, it is important that contractual arrangements handle metocean risk in an appropriate manner; contracts need to:

- Ensure provision of capable vessels;
    - For example, if a contractor is on a fixed price contract, including vessel provision, and the client is covering all weather costs, this could incentivise the contractor to provide the lowest-cost vessel, which may not achieve the lowest overall cost for the client;
- Balance the costs of vessels, people and lost output; and
- Encourage safe behaviour.

The process and data sources for decision-making with respect to metocean conditions should be agreed as part of the contract, including consideration of on-site processes.

C.12.2.1 APPROACHES TO RISK ASSESSMENT

Risk assessments need to consider:

- Operating capability with respect to potential metocean conditions, based on a combination of evidence, experience and modelling, including:
    - Planned activities and foreseeable deviations, including emergency response and casualty evacuation;
    - The effect of metocean conditions on people, including fatigue, cold and seasickness;
- Planned duration of activities, and uncertainties in the duration arising from the potential for operations to over-run;
- The expected duration of suitable weather windows, and the level of uncertainty in the forecast;
- Actions to be taken if a task cannot be completed within the weather window; these may range from:
    - Suspend operations; vessels stay on station and resume operations when safe;
    - Suspend operations, remove people and vessels to a place of safety and return to site conditions permit;
        - This requires that safe access to a place of safety is still available;
    - Suspend operations, keeping people safe, but having passed a point of no return, this involves the loss of equipment / materials;

        - This requires that there is still a route available for the safety of personnel.

A point of no return for the safety of people must never be passed.

C.12.2.2 Risk Mitigation Measures

For weather-sensitive activities, an effective forecasting regime is essential in order to predict suitable weather windows:

- Five days is considered to be a reasonable maximum forecast outlook duration; any attempt to predict conditions further in advance would be subject to high levels of uncertainty;
    - An operation that would take more than five days therefore needs to be capable of being divided into a series of shorter operations;
- Activities are typically supported by a combination of:
    - Six-hourly site-specific forecasts;
    - Real-time feed of data from instruments and observations local to the site, including lightning detection;
    - Additional alerts issued in the event of a rapid and significant change to forecast conditions; and
    - An on-site forecaster may be present for particularly critical operations, to monitor conditions and provide updates as required.

When forecasts are used in the planning of operations, the level of uncertainty / confidence in forecast conditions should be considered. The effort in measuring and forecasting conditions should be proportional to the safety and economic risk of the planned operations.

Engineering planning should consider metocean forecasts and include contingency measures in planning the duration and methods of operations, recognising that different operations have different weather sensitivities; for example, wind is likely to have a greater effect on lifting operations than subsea work.

It is important to ensure that the right data are available for decision-making in both the planning and execution phases of an operation; the gust strength and maximum wave height may be more relevant than averages, and the safety of an operation will be determined by a combination of factors, such as wave height, period, direction and wind speed. On a large site, or where there is complex bathymetry such as shoals, the conditions may vary across the site.

The ultimate decision on whether to authorise an operation to proceed or continue lies with the master of each vessel; this decision is based on a combination of data and experience relating to:

- Vessel capability limits for the operation involved; and
- Observed and forecast conditions, and the level of uncertainty in these.

Conditions should continue to be monitored while operations are in progress, making use of observations, data from site meteorological instruments, and feedback from equipment, such as wind speeds measured on crane anemometers, or the level of demand on heave compensation systems when lifting.

The safest and most efficient use of weather windows will be achieved if:

- Reliable site-specific weather forecasts are available, and validated against real-time data on site conditions;
- O&M requirements can be predicted from condition monitoring / remote diagnostic systems; and
- OREIs have a level of redundancy / fault-tolerance in their designs, to reduce the pressure to undertake offshore interventions in borderline conditions.

C.12.2.3 Additional Considerations for Marine Energy

Due to the early stage of development of the marine energy industry, there is limited experience of carrying out construction, commissioning and maintenance activities in the highly energetic environments where wave and tidal developments are located.

The provision of clear Pre-Construction Information, followed by robust contractor and vessel selection, and evaluation of relevant experience, is critical, and should be further supported by ensuring that sufficient time is given to prepare the vessel and brief all those who will be involved. It is important to establish good working relationships between contractors, the masters of vessels, and client representatives, so that client experience from previous operations can be used to support the planning and execution of subsequent operations. Such increased involvement of the client representative may be a significant change from normal ways of working; the responsibilities and authority of the different parties involved must be clearly understood.

Operations in tidal streams require particular care, due to the short duration of slack water, and the rapid deterioration in conditions thereafter. The speed of the current generally varies in a sinusoidal manner, and:

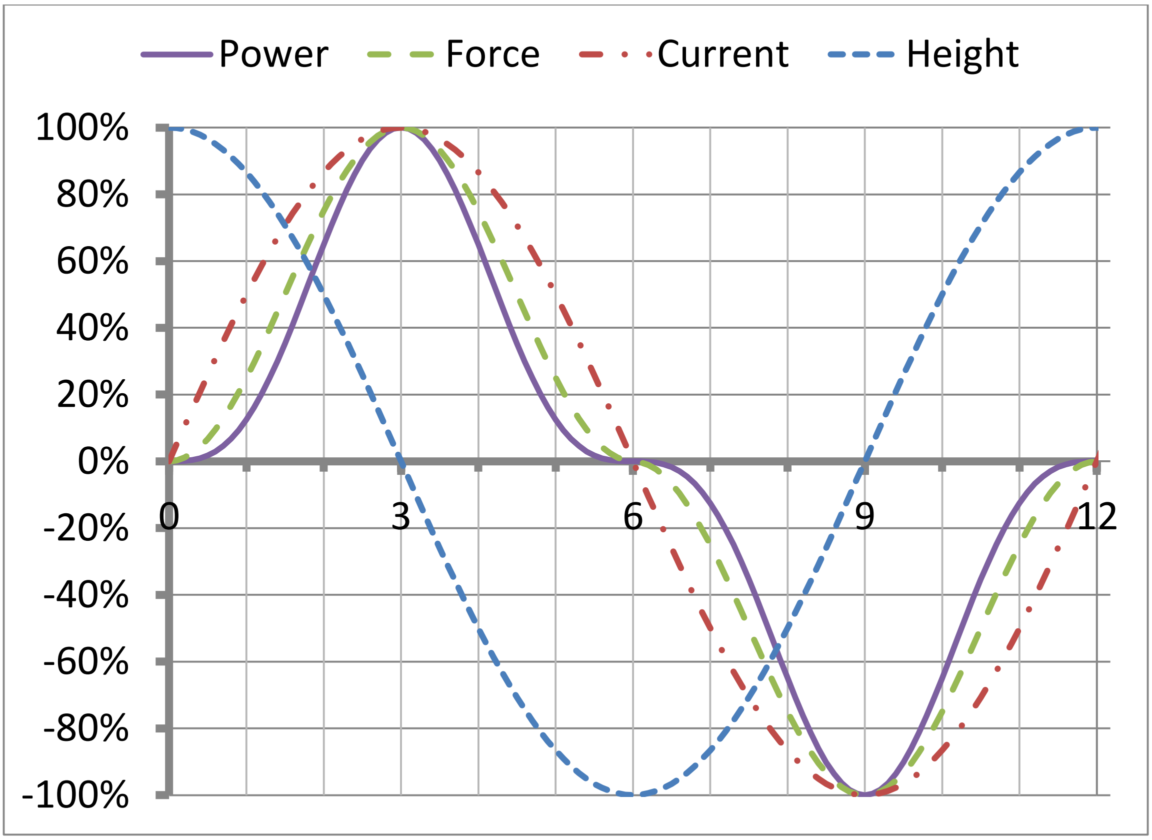
- The force on an object in the water column is proportional to the square of the current;
- The power required to hold position is proportional to the cube of the current.

Figure 6 below shows an idealised tidal cycle, with the effect of the above relationships. Note that this is an idealised situation: some locations may exhibit very different behaviour, so local tidal information should always be consulted., while atmospheric conditions can cause significant changes in the timing and speed or height of an individual tide. Based on this model, it can be seen that:

- One hour after slack water:
  - The current will be at half of its maximum speed; while
  - The power required to maintain a vessel’s position will be approximately 12% of that which would be required when the current is at its maximum speed;
- During the next 20 minutes, the power requirement will double, and the deterioration in conditions will continue to accelerate thereafter.

If any operations are not completed as scheduled, or vessels or people get into difficulty, then the severity of the situation will escalate rapidly.

Figure 6: Idealised tidal cycle, showing 12 hours after high water. The Height of the tide is scaled such that 100% represents high water, and -100% represents low water. The Force exerted on an object in the water column, the speed of the Current, and the Power required to hold a vessel in position are all scaled such that 100% represents the maximum value in one direction, and -100% represents the maximum value in the opposite direction.



The speed of the current also varies within the water column, generally being slowest at the seabed, and fastest at the surface, so if an object is to be lifted through the water, the drag force on it will increase as it approaches the surface; this can hinder the safe retrieval of divers or subsea equipment such as ROVs. Jack-up vessels will also be subject to significant drag loads, and potentially flow-induced vibration due to vortex shedding, as the fast tidal currents act on their legs.

While tides are predictable, the sea conditions within a tidal channel will vary with time and position, sometimes resulting in rapid localised changes:

- Eddies may cause the direction and localised speed of the current to vary;
- The interaction of wind, waves and currents can give rise to challenging conditions, including overfalls and confused seas that may be particularly difficult for small vessels; and
- Atmospheric conditions can cause the precise timing of tides to vary from the prediction.

Operations should therefore be planned so that they are ready to start before the time when tidal conditions are predicted to become suitable; this will avoid loss of working time during slack water, if the tide changes earlier than expected. While the operation is in progress, the speed of the current under the hull and the observed sea state should be monitored, to give early warning of conditions changing, and ensure that the vessel and all personnel involved can be brought to a safe condition or location before the limits of working conditions are reached.

If any parties involved in operations are not familiar with working in tidal streams, comprehensive briefings should be given to prepare them and highlight the characteristics of such sites. Even experienced personnel should ensure that they are familiar with the specific location as conditions can vary dramatically across a site.

C.12.3 Codes of Practice and Guidance

Clear guidance exists on metocean considerations for offshore structural design, metocean survey and helicopter operations; however there is no standard guidance for many offshore renewable energy activities, such as transfer from vessels to WTG foundations.

C.12.3.1 Regulations and Standards

DNV-OS-J-101 - *Design of Offshore Wind Turbine Structures*, obtainable from DNV Offshore Standards webpage: Section 3, Parts B-E give a detailed description of Metocean data required for design purposes.

BS EN 61400-3:2009 Wind turbines - Part 3: *Design requirements for offshore wind turbines* specifies the metocean data requirements for the design of offshore WTGs and their foundation structures.

EN ISO 19901 *Petroleum and natural gas industries - Specific requirements for offshore structures - Part 1*: *Metocean design and operating considerations*: while this is written for oil and gas structures and a global perspective, it gives very clear explanations of metocean parameters.

CAA CAP 746 - *Requirements for Meteorological Observations at Aerodromes*.

C.12.3.2 Other Relevant Guidance

DNV-OS-H101 - *Marine Operations, General*, obtainable from DNV Offshore Standards webpage: Sections 3,4 cover the integration of metocean parameters with operational planning.

CAA CAP 437 - *Standards for Offshore Helicopter Landing Areas*: Chapter 6, Part 4 and Appendix E provide detailed guidance on weather observing and reporting requirements for helicopter operations.

International Association of Oil and Gas Producers - Report 447 - *HSE Guidelines for Metocean and Arctic Surveys*: provides guidance on the health and safety aspects of metocean survey work, including use of vessels and deployment of instruments.

RenewableUK *Vessel Safety Guide* provides detailed guidance on the process of selection, mobilisation and management of vessels to ensure that all are Fit for Purpose and are operated within a robust Health & Safety management system at any stage of the lifecycle. Appendix 1 provides describes specific considerations for survey activities.

C.12.3.3 Elsewhere in this Guidance

Vessel Selection

C.13 NAVIGATION

C.13.1 OVERVIEW

Offshore wind and marine energy development introduces a number of navigational hazards, affecting both existing sea users, and those directly related to the development. Safe navigation relies on appropriate steps being taken, both by developers and sea users.

C.13.1.1 POTENTIAL HAZARDS AND RISKS

C.13.1.1.1 Direct Health and Safety Risks

The installation of fixed or moored structures into a previously unobstructed area of sea introduces new collision hazards, bringing obvious risks to people aboard vessels:

- A vessel that is not under command (for example, due to failure of steering or propulsion) may collide with structures, if it drifts due to its own momentum, or the effects of wind or tide;
    - While this could affect any type of OREI, this is a particular concern for tidal energy developments, as a vessel not under command may no longer be swept through a channel by the tide, if devices located within its draft obstruct its path;
- If OREIs cause shipping to be more concentrated in remaining unobstructed sea areas, or impinge on access routes to ports or anchorages, then the risk of collision between vessels may increase; and
- The location of floating OREIs, although moored, will vary within a fixed radius of their moorings, presenting a mobile collision hazard.

The presence of multiple tall structures such as WTG towers may also interfere with radar operation, preventing vessels within, or at the far side of, an offshore wind farm from being detected. This could impede the monitoring and control of both normal and emergency operations.

In addition to the effects on commercial shipping and fishing, the effects on recreational sea users should be considered, including addressing concerns about the effects of WTG wakes on sailing vessels and kite surfers.

It is likely that sea users, both commercial and recreational, will be unfamiliar with wave and tidal devices and their motion; this inexperience could present a hazard as it will be more difficult for them to judge safe positioning when passing at close quarters to the devices. Curiosity may also lead to some sea users ignoring standard navigational practice in order to get a closer look at OREIs, potentially putting themselves at risk.

Navigational safety concerns are likely to be greatest for developments that are adjacent to busy shipping lanes, especially where currents could bring a vessel not in command into danger.

While the hazards summarised above are all potentially relevant to offshore wind and marine projects, they should be set in context with the mitigation measures set out below and the other controls set out throughout these guidelines.

C.13.1.1.2 Commercial and Operational Risks

In addition to the risks to people, any collisions with ships may result in damage to OREIs; even relatively minor damage, such as to access ladders and platforms, may be difficult to repair, and result in downtime if access for maintenance is impeded.

C.13.1.1.3 Indirect and Consequential Risks

In the event of a collision, as well as the risks to people, the potential for pollution must be considered, either from leakage of ships' fuel, or any hazardous materials being carried.

C.13.1.1.4 Use of Dynamic Positioning (DP)

DP vessels are being used to an increasing extent, in applications such as floating cranes, dive support, cable lay, and for operating in tidal streams.

Under DP, the vessel position is controlled relative to external position references; different classes of DP exist, and should be selected with respect to the safety-criticality of the functions that the DP system is to perform.

The required level of reliability of the positioning system should be determined by the criticality of the operation for which it is to be used; the assessment should consider the whole system including signal sources, receivers, power, control and propulsion subsystems, and a suitable class of DP vessel selected. For operations where a "drive-off" (loss of position keeping) could put people at risk, it is likely that at least two independent positioning systems will be necessary, designed and operated so as to minimise the risk of common-mode failures that could disable both systems.

Jamming of GPS signals may periodically occur, for example during military exercises; such interruptions will be advised in advance by means of Notices to Mariners. An increasing number of illegal GPS jamming incidents is occurring onshore; these could potentially affect signals received by vessels working close to shore, such as in harbour approaches, resulting in a loss of position control if a DP vessel were relying on GPS signals alone, in order to hold station. .

The performance of DP vessels may also be impaired in shallow water.

C.13.1.2 RELEVANCE TO KEY LIFECYCLE PHASES

Navigational safety needs to be considered early in project definition, as part of site selection and array layout design activities. The aim is to reduce navigational safety risks ALARP.

A formal Navigational Safety Risk Assessment (NSRA) is required to be submitted, during the consenting process, as part of the developer's Environmental Statement. The risk assessment should be supported by suitable consultation with stakeholders in the area of the development.

In addition to the array location and layout, the cable routes and protective measures, such as anti-scour materials, require careful consideration, taking account of factors such as recognised anchorage areas, seabed conditions, existing cable or pipeline routes, and areas used for other activities such as trawling.

During construction, in addition to the risks presented by the development itself, there will be numerous additional vessel movements to consider, as well as frequent use of vessels that will be restricted in their ability to manoeuvre, for example when undertaking activities such as cable-laying or support of subsea operations. The presence of additional vessels during this phase may, however, mitigate some safety risks, by providing additional support capability in the event of an emergency.

During the O&M phase, the Aids to Navigation will need to be maintained, in order to continue to warn other sea users of the presence of the OREI.

The decommissioning plan should ensure that the risks to other sea users are minimised, after the structures are removed.

C.13.2 REGULATORY REQUIREMENTS

Under the United Nations Convention on the Law Of the Sea (UNCLOS), shipping has a "right of innocent passage" through the territorial sea, and signatory states have a duty not to carry out developments that interfere with the use of sea lanes that are essential to international navigation; such sea lanes may be taken to include deep water routes, areas with Traffic Separation Schemes or other recommended routeing measures, and certain straits around the coast of the UK. These responsibilities, as well as information on other uses of sea areas, are considered within marine spatial planning and consenting processes.

Section 34 of the Coast Protection Act 1949 regulates Works Detrimental to Navigation; if it is judged that a development "will cause or is likely to result in obstruction or danger to navigation" then the relevant licensing authority (which depends on the location and size of the development) "*shall either refuse their consent or give their consent subject to such conditions as they may think fit, having regard to the nature and extent of the obstruction or danger which it appears to them would otherwise be caused or be likely to result.*"

Deemed consent for developments is now given under one of the following:

- Marine and Coastal Access Act 2009 – by the Marine Management Organisation;

- Marine (Scotland) Act 2010 – by Marine Scotland; or
- Planning Act 2008 – IPC, >100 MW.

The Energy Act 2004 regulates OREIs beyond territorial waters, in the UK's REZ; this states that consent cannot be granted for an OREI that is likely to interfere with the use of "*recognised sea lanes essential to international navigation*", in accordance with the requirements of UNCLOS.

C.13.3 Managing the Risks

C.13.3.1 Approaches to Risk Assessment

A detailed methodology for Navigational Safety Risk Assessment has been jointly published by the DTI, Department for Transport and the MCA; the scope and depth of the assessment should be proportional to the scale of the development, and the magnitude of the risks. It seeks to ensure that a consistent approach is adopted for all developments, and the completed risk assessment will be scrutinised as part of the consenting process.

The methodology addresses the existing and expected future characteristics of marine traffic, and the marine environment, and assesses how the presence of the proposed development will alter the overall risk level. Specific inputs to the process include:

- Marine traffic survey of the site and activities in adjacent sea areas, including transit routes, ports and anchorages, fishing grounds, archaeological sites, military activities, and oil and gas installations, with sufficient detail and duration to ensure that the level of uncertainty is acceptable;
- Features of the OREI structures, and any danger that they would pose to vessels in normal operation, and to emergency services;
- An assessment of the feasibility of navigation within the development site in its future state;
- The effects of tide and weather on navigation adjacent to the development;
- The effects of the structures on visual navigation, whether in terms of sighting other vessels, or landmarks;
- The effects of the structures on communications, radar and positioning systems;
- Proposed arrangements for marking the development, such as lights, radar beacons, sound signals, identification markings, and arrangements for maintenance of these systems; and
- Hydrographic survey, to form a baseline for monitoring over the life of the development.

The NSRA may, depending on the risks identified, also require to be supported by a:

- Detailed Search and Rescue Operations Assessment, in locations with high traffic density, significant marine safety hazards, or frequent passenger vessel operations; and / or an
- Emergency Response Assessment, in relation to the risk of spillage of flammable or hazardous substances.

C.13.3.2 Risk Mitigation Measures

The MCA provides a template, which can be used at layout design stage, to determine acceptable distances between site boundaries and shipping lanes. Risk mitigation measures that are specified in MGN 371 include:

- *"Promulgation of information and warnings through Notices to Mariners and other appropriate media.*
- *Continuous watch by multi-channel VHF, including Digital Selective Calling (DSC).*
- *Safety zones of appropriate configuration, extent and application to specified vessels.*
- *Designation of the site as an area to be avoided (ATBA).*

- *Implementation of routeing measures within or near to the development.*
- *Monitoring by radar, AIS, closed circuit television (CCTV) or other agreed means.*
- *Appropriate means for OREI operators to notify, and provide evidence of, the infringement of safety zones or ATBA's.*
- *Any other measures and procedures considered appropriate in consultation with other stakeholders.*
- *Creation of an Emergency Response Co-operation Plan with the relevant Maritime Rescue Co-ordination Centre from Construction Phase onwards".*[17]

The MCA specifies the required Aids to Navigation for marking OREIs, while the CAA specifies the aviation obstruction lighting requirements.

The need for, and likely configuration of, safety zones should be established as part of the consenting process; the detailed application should be made after consenting, and a formal notice is required to be published in relevant newspapers and gazettes, as well as being sent directly to the masters of ports whose users are likely to be affected. Following consultation, the application is determined by the relevant government minister. Detailed guidance on considerations in defining a safety zone, and the application process, has been published by BERR (now BIS).

Use of guard vessels should be considered; for example, to mark submerged buoys or unmarked / unlit hazards. These vessels should be suitable for remaining on site for extended periods, maintaining radar and visual watch, and capable of warning any vessels that are creating a risk to themselves or others.

Floating OREIs represent a more complex navigational hazard than fixed structures. Consideration of floating OREIs should extend to major buoyant components that could present a hazard if they were to become separated from the structure of the OREI. To minimise the risk to navigation, systems should be in place to:

- Monitor the position of floating devices or large buoyant components, and raise an alarm if the position deviates from the expected location; and
- Ensure that floating OREIs are visible to sea users, by day, by night and on radar.

The possibility of vessel collision should be considered during the design stage; the likely effects on the structure, and the means of recovery after a collision should be considered, together with the detail design of the structure, to ensure that it will not present an unnecessary level of risk to vessels or people.

If dumb barges are to be utilised, safety may be enhanced by the fitting of AIS as a contractual requirement of the supply of the vessels. This will assist other vessels in identification and monitoring of the positions of dumb barges.

Notices to Mariners (NtoM) are issued to inform mariners of issues that affect the safety of navigation, in addition to Admiralty Notices to Mariners issued by the UKHO. They can be issued by a variety of bodies such as port authorities, General Lighthouse Authorities and OREI duty holders. These are disseminated by hosting on corporate websites, issuing to UKHO, Kingfisher Fortnightly Bulletin, local sailing clubs and others and should follow established conventions. They should also be promulgated via local broadcasting stations or through project guard vessels as a Sécurité broadcast initially on Channel 16 with further information provided on a secondary non-emergency channel. This should occur at 6h intervals unless otherwise directed.

C.13.3.3 MONITORING, REVIEW AND CHANGE MANAGEMENT

The risk mitigation measures identified above are a combination of management systems, which would generally be led by the Marine Co-ordination function, and physical systems such as lights and markings, which would be subject to ongoing maintenance.

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[17] MCA MGN 371 - *Offshore Renewable Energy Installations (OREIs): Guidance on UK Navigational Practice, Safety and Emergency Response Issues*.

C.13.4 CODES OF PRACTICE AND GUIDANCE

C.13.4.1 REGULATIONS AND STANDARDS

DTI / MCA / DfT - Guidance on the assessment of the impact of offshore wind farms: Methodology for assessing marine navigational safety risks of offshore wind farms.

Marine and Coastal Access Act – specifies the activities for which a Marine Licence is required, and creates the Marine Management Organisation, which is the Licensing Authority for applications of up to 100 MW in English waters.

MCA MGN 371 - *Offshore Renewable Energy Installations (OREIs): Guidance on UK Navigational Practice, Safety and Emergency Response Issues*.

MCA MGN 372 - *Offshore Renewable Energy Installations (OREIs): Guidance to Mariners Operating in the Vicinity of UK*.

MCA MSN 1781 (M + F) – *The Merchant Shipping (Distress Signals and Prevention of Collisions) Regulations 1996*.

BERR - *Applying for Safety Zones around Offshore Renewable Energy Installations - Guidance Notes - August 2007* describes the process for applying for a safety zone, and the criteria for defining it.

C.13.4.2 OTHER RELEVANT GUIDANCE

IALA Recommendation O-139 - On the Marking of Man-Made Offshore Structures

IMCA M103 - *Guidelines for the design and operation of dynamically positioned vessels*.

Kingfisher Information Service – Cable Awareness - submarine cable route charts, emergency contacts and advice.

HSE - *Warning to offshore industry on blocking of data communications in dynamic positioning systems*

Maritime Data - data source for sea use; requires free registration.

RenewableUK *Health & Safety Circular: Notices to Mariners* provides detailed guidance for drafting and issuing NtoM.

C.13.4.3 ELSEWHERE IN THIS GUIDANCE

Access and Egress

Maritime Regulatory Publications

C.14 NOISE

C.14.1 OVERVIEW

Exposure to high levels of noise may result in people suffering permanent or temporary hearing loss or damage.

The HSE notes that hearing loss is entirely preventable if:

> *"(a) employers take action to reduce exposure to noise and provide personal hearing protection and health surveillance to employees;*
>
> *(b) manufacturers design tools and machinery to operate more quietly; and*
>
> *(c) employees make use of the personal hearing protection or other control measures supplied."*[18]

C.14.1.1 POTENTIAL HAZARDS AND RISKS

C.14.1.1.1 Direct Health and Safety Risks

Prolonged exposure to high levels of noise may result in people suffering gradual hearing loss, which may only be apparent later in life, and is permanent and irreversible.

Hearing damage may also result from sudden, extremely loud noises. Such incidents may cause temporary hearing loss, but could also cause longer lasting or permanent hearing damage.

A noisy working environment also impairs communication, while the safety of operations may be affected if personnel involved are unable to hear safety alarms.

Noise exposure may occur from a range of activities including:

- Use of noisy power tools such as impact tools or angle grinders;
- Use of temporary power sources such as generators or compressors;
- Piling, where the underwater component of noise is also of environmental concern; and
- Offshore transfers on vessels (especially high speed craft) and helicopters.

The noise exposure is likely to be more severe when tools are used in restricted spaces within structures such as WTG towers and transition pieces, compared to undertaking the same task in the open air. Divers may also be exposed to noise arising from subsea operations.

C.14.1.1.2 Indirect and Consequential Risks

Hearing loss affects a person's ability to communicate, adversely affecting their ability to work effectively, and potentially having a severe impact on their quality of life outside work, and for the rest of their life.

C.14.1.2 RELEVANCE TO KEY LIFECYCLE PHASES

The main exposures to noise are likely to occur during construction and non-routine maintenance work, rather than normal operation. Specialist teams who carry out such activities in campaigns on multiple sites, such as securing transition pieces or bolting tower sections together with impact tools, are likely to have a higher level of exposure than employees undertaking more varied tasks.

C.14.2 REGULATORY REQUIREMENTS

The Control of Noise at Work Regulations 2005 requires employers to:

- Assess the risks to employees from noise at work;
- Take action to reduce the noise exposure that produces those risks;

[18] HSE L108 – *Controlling noise at work – The Control of Noise at Work Regulations 2005 – Guidance on Regulations*

- Provide employees with hearing protection if noise exposure cannot be reduced sufficiently by using other methods;
- Make sure the legal limits on noise exposure are not exceeded;
- Provide employees with information, instruction and training; and
- Conduct health surveillance where there is a risk to health.

The regulations also address noise exposure beyond normal working hours; this is relevant to offshore construction, where if project and marine personnel are to be accommodated on vessels or platforms, it is important to ensure that accommodation areas are sufficiently quiet to allow undisturbed sleep, particularly if 24-hour working is planned.

C.14.3 MANAGING THE RISKS

C.14.3.1 APPROACHES TO RISK ASSESSMENT

An initial assessment should be carried out using the guidance provided by the HSE, in Table 8 below.

Table 8: Initial workplace noise assessment criteria (Source: HSE L108)

Test	**Probable noise level**	**A risk assessment will be needed if the noise is like this for more than:**
The noise is intrusive but normal conversation is possible	80 dB	6 hours
You have to shout to talk to someone 2 m away	85 dB	2 hours
You have to shout to talk to someone 1 m away	90 dB	45 minutes

If the initial assessment indicates that a noise risk assessment may be required, then it should be carried out by a competent person, in order to:

- *"identify where there may be a risk from noise and who is likely to be affected;*
- *contain a reliable estimate of employees' exposures, and compare the exposure with the exposure action values and limit values;*
- *identify* what measures need to be taken *to comply with the law, e.g. whether noise-control measures or hearing protection are needed, and, if so, where and what type; and*
- *identify any employees who need to be provided with health surveillance and whether any are at particular risk*."

The risk assessment needs to be based on reliable information, which may already be available from suppliers, or may have to be gathered by direct measurements.

C.14.3.2 RISK MITIGATION MEASURES

Employers have a general duty under the Noise at Work regulations to reduce the noise exposure and risk to their employees so far as is reasonably practicable, even if a specific exposure limit is not exceeded. The risk should be mitigated according to a hierarchy of controls:

1. Eliminate the source of loud noise, for example by adopting a different process, such as using hydraulic bolt tightening in place of pneumatic impact tools, or using equipment that is designed and maintained to give lower noise emission;
2. Modify equipment to reduce noise and vibration emission, such as fitting silencers on air tool exhaust outlets;
3. Limit workers' exposure to noise by reducing the time spent in noisy areas or operations, for example by rotating workers between deck operations and WTG tower assembly.

If, after implementing technical and organisational control measures to reduce noise levels so far as is reasonably practicable, workers are still exposed to noise levels that exceed specified levels, then the employer's duties can be summarised as:

- No employee is permitted to be exposed to noise exceeding the Exposure Limit Value;
- If the upper Exposure Action Value is likely to be exceeded, hearing protection provision and use is mandatory; and
- If the lower Exposure Action Value is likely to be exceeded, hearing protection should be provided if requested, but its use is voluntary;

In all cases, employers should ensure that employees who are exposed to noise at work receive information on the risks, and instruction on the use of work equipment and PPE to reduce their noise exposure.

C.14.3.3 Monitoring, Review and Change Management

Use of personal hearing protection should be carefully managed, to ensure that it is targeted at the areas, and times when it is required, rather than as a blanket instruction if it is not always necessary.

Ongoing health surveillance, usually involving periodic audiometry, may be required as an outcome of the noise risk assessment.

The use of tools and equipment should be monitored, to ensure that:

- The patterns of use that the risk assessment was based on, correspond to actual practice;
- Noise mitigation measures are in operation, for example, the acoustic housings on generators and compressors are not being left open when in use; and
- Powered tools and accessories are being maintained or replaced as necessary, to ensure that their noise emissions do not exceed the specified levels.

C.14.4 Codes of Practice and Guidance

C.14.4.1 Regulations and Standards

Both sets of regulations listed below implement the requirements of EC Directive 2003/10/EC, which sets common minimum health and safety standards for exposure of workers to risks from noise, and therefore impose the same limits:

HSE L108 – *Controlling noise at work – The Control of Noise at Work Regulations 2005 – Guidance on Regulations*.

MCA MGN 352 - The Merchant Shipping and Fishing Vessels (Control of Noise at Work) Regulations 2007.

C.14.4.2 Other Relevant Guidance

HSE INDG362 - *Noise at work - Guidance for employers on the Control of Noise at Work Regulations 2005*.

MCA Code of Practice for Controlling Risks due to Noise on Ships – priced publication.

C.15 PILING AND GROUTING

C.15.1 OVERVIEW

Most fixed offshore structures are supported by piles, which are driven into the seabed, with a grouted connection between the piles and the structure. The commonest offshore WTG foundation arrangement is a monopile, connected to a transition piece (TP) by means of a grouted connection close to sea level. Monopiles typically weigh around 10 tonnes per metre of length, and, depending on site conditions, may be over 60 m long. Jacket foundations are generally supported by multiple smaller piles, with grouted connections just above the seabed.

Various alternatives to grouted connections exist, or are in development; their adoption can eliminate the risks involved in grouting, but should also be subject to appropriate risk assessment.

C.15.1.1 POTENTIAL HAZARDS AND RISKS

C.15.1.1.1 Direct Health and Safety Risks

Piles are generally transported to site horizontally, and then lifted and up-ended to enable vertical driving. They may be transported on the deck of the installation vessel, a feeder vessel or barge, or by floating them and towing to site. Transportation involves a number of hazards:

- Storage of monopiles at ports, prior to offshore installation, requires large areas of land with sufficient bearing capacity to enable safe storage and movement;
- Deck space on vessels is at a premium, which may impede safe access for people to attach lifting gear and remove sea fastening;
- Where lifting involves a floating vessel or load, the lift is made more complicated by dynamic loading effects;
- Where piles are floated to site, any water ingress may result in the centre of gravity of the load shifting during subsequent lifting operations, with the potential for unexpected movement of the load during lifting; severe water ingress may cause monopiles to sink and require retrieval from the seabed.

Piling operations are typically conducted over the side of a jack-up or floating crane vessel; the pile generally passes through a guidance system to ensure that it remains vertical during installation; the structure of the guidance system may introduce hazards of working at height and over water.

Piling involves high noise levels, both from the piling hammer itself, and from powerpacks on the deck of the vessel. Subsea noise must be also considered:

- Its potential environmental impact may lead to consenting conditions that impose mitigation actions; and
- Divers may suffer hearing damage if they are exposed to high noise levels.

Piling hammers are generally powered by high-pressure hydraulic systems; intensive use in the arduous offshore environment may lead to damage or other deterioration; any resulting leakage of fluid under high pressure is a hazard to people and the environment.

The grouted connections between the piles and the structures that they support, such as the TP, allow for levelling of the structure; this is typically achieved by means of hydraulic jacks between the pile and transition piece, to support the TP while grout is injected and allowed to harden. Preparation for jacking may involve working at height and in a confined space to gain access, and a combination of lifting and manual handling operations to install the jacks.

The grout is prepared by mixing a cement-based powder with water, with the mixture then being pumped into the annular gap between the components to be connected. Key hazards in this operation include:

- Material handling: the powder may either be handled in silo-based systems, or big bags:
    - Cement dust is recognised to irritate the nose and throat, is hazardous to the eyes, and longer-term exposure could lead to occupational asthma;

    - Use of big bags can involve additional manual interventions, including lifting, handling and potentially work at height or cutting, depending on the design of handling facilities;
        - Disposal of empty bags can lead to release of dust;
- Grout pumping: the wet mixed grout is transferred at high rates through flexible hoses at high pressure (A typical situation would involve several tonnes per hour, being pumped at around 60 bar);
    - Damage to hoses could result in leakage, with the potential for large releases if a hose coupling were to fail, bringing the risk of workers being splashed or sprayed with grout.

Grout mixing and pumping equipment is generally electrically powered; due to the operating environment, this is likely to be Extra Low Voltage equipment to minimise electric shock risk, although with high currents to provide the necessary power.

C.15.1.1.2 Commercial and Operational Risks

If the driving of a pile is interrupted, soil setup may occur, resulting in increased hammer energy being required when piling restarts. If a piling hammer is already being operated near to its limit of capacity, then a higher-capacity hammer may be required, leading to further delays if not readily available.

C.15.1.1.3 Indirect and Consequential Risks

Failures in the performance of grouted connections have been well publicised, and can increase risk exposure in later life cycle stages due to the need for inspection and / or remedial work. Typical remedial measures can involve extensive exposure of people to hazards including welding and grinding in confined spaces, working over water, work at height, lifting and manual handling operations, in addition to the general hazards that are inherent in a major programme of offshore work.

C.15.1.2 Relevance to Key Lifecycle Phases

Piling and grouting activities are concentrated in the early stages of offshore construction, although in the event of any problems with long-term performance of the grouted connection, major remedial work might be necessary in later stages.

C.15.2 Regulatory Requirements

Although piling and grouting are principally conducted from vessels, they constitute construction work, so are regulated by the HSE.

Specific regulations to consider include CDM, the Manual Handling Operations Regulations (MHOR), LOLER and COSHH. The work equipment involved (which comprises all of the material handling, mixing and pumping systems) is subject to the requirements of PUWER, which include ensuring that work equipment is suitable for its purpose, properly installed and maintained, and that users are suitably trained and competent.

C.15.3 Managing the Risks

C.15.3.1 Risk Assessment and Mitigation

Piling or grouting equipment and specialist personnel are generally mobilised as required onto project vessels; the detailed design of the temporary installation will affect the risks to people, and the efficiency with which the equipment can be operated. The risks that any particular layout and selection of equipment presents should be assessed; key areas to consider include:

- Lifting operations:
    - Layout design to avoid situations where loads might be lifted over people;
    - Capability of pile up-ending tools;
    - Minimising handling of cement bags (such as by the use of bulk silos), and where bags have to be lifted, ensuring that appropriate lifting frames are used;

- Piling and grouting:
    - Protection of pipework to minimise the risk of damage causing leakage;
    - Use of grout mixing systems that minimise exposure of people to cement dust and grout slurry;
    - Design of grout pipework to minimise the risk of blockages and ease flushing; and
    - Minimising exposure to noise on deck, due to emissions from equipment such as generators and pumps, through the location of equipment, use of acoustic enclosures, and good maintenance;
- Work at height, and work over water;
    - The design of systems should minimise these, and suitable procedures should be adopted to minimise the risks.

The Environmental Management Plan for a development will define the required response to any spillages, such as grout and hydraulic fluids.

Commencement of piling is likely to introduce the first major navigational hazard to other sea users, particularly as piles are much less visible than completed structures; the Navigational Safety Risk Assessment will have defined the required mitigation measures, which may include provision of temporary marking on installed piles, updating Notices to Mariners, and maintaining exclusion zones around the project site.

C.15.3.2 Monitoring, Review and Change Management

Once mobilised, the project programme is likely to involve intensive use of the equipment in an arduous working environment; it is important to ensure that sufficient care is taken in the use of equipment, particularly with respect to items such as flexible hoses and couplings, which can be vulnerable to damage, and that suitable maintenance arrangements are in place.

Procedures should be in place to handle foreseeable deviations from normal operation, for example, in the event of blockage of a grout pumping hose, cleaning with water is generally recommended – attempts to clear blocked hoses with compressed air can risk serious or fatal injury from uncontrolled flailing of hoses due to the release of stored energy.

C.15.4 Codes of Practice and Guidance

C.15.4.1 Regulations and Standards

HSE L144 - *Managing health and safety in construction - Construction (Design and Management) Regulations 2007 - Approved Code of Practice*.

HSE L22 – *Safe use of work equipment – Provision and use of Work Equipment Regulations 1998 - Approved Code of Practice and Guidance*.

HSE L23 - *Manual handling – Manual handling operations regulations 1992 – Guidance on regulations*, defines the employer's duties and approaches to be taken in order to reduce the risk of injury from manual handling.

HSE L5 - *Control of Substances Hazardous to Health Regulations 2002 (as amended) Approved Code of Practice and guidance*.

C.15.4.2 Other Relevant Guidance

HSE CIS26 – *Construction Information Sheet*, provides information on hazards and precautions relevant to the use of cement-based materials.

HSE OCE24 – Offshore COSHH Essentials - Cementing provides a concise summary of the substance-related hazards, and their management, in cementing operations.

C.15.4.3 Elsewhere in this Guidance

Confined Spaces
Hazardous Substances
Lifting

Noise

C.16 PORTS AND MOBILISATION

C.16.1 OVERVIEW

Offshore renewable energy development introduces challenging demands on port infrastructure. During the construction phase, these may include:

- Deep water quays for loading deep-draughted construction and accommodation vessels;
- Suitable seabed conditions to allow jacking up;
- Extensive storage / pre-assembly areas for foundations, tower sections, nacelles and blades;
  - These require suitable bearing capacity and surfacing for heavy vehicle movement and crane usage;
- Cable-laying requires special load-out facilities, capable of handling loads that may exceed 5000 te, and so is often performed at the cable manufacturing site.

In addition to the movement of large vessels and their cargoes, there may also be numerous movements of workboats and people, with daily and seasonal peaks in activity. There is also likely to be the need for office and amenity facilities. The demands from the construction phase are temporary – although the work may last for several years on large developments with phased construction programmes. Development of dedicated facilities that are only expected to be needed on a temporary basis can be difficult, and it is likely that some facilities and access areas will be shared with existing uses of the port, however the quality of the facilities provided will affect the safety and efficiency of key activities that support offshore construction work.

During the O&M phase, the main demands will be:

- Fleet of access vessels requiring daily resupply, efficient boarding of work parties, and passage to / from the sea;
- Material handling involving the use of Fork Lift Trucks, mobile or static cranes and / or vessel-mounted cranes; and
- Occasional requirements for large vessels for major maintenance / repair work.

As the O&M phase represents a long-term commitment to a port, there may be more scope to develop dedicated facilities such as secure storage areas, loading and embarkation points, offices, workshops, welfare facilities and parking.

C.16.1.1 POTENTIAL HAZARDS AND RISKS

C.16.1.1.1 Direct Health and Safety Risks

A wide range of activities take place in ports, both in relation to the OREI and existing uses, requiring careful management of the associated hazards including:

- Congestion, involving vehicles on land or vessels on water, may result in collision or crushing;
  - In addition to congestion involving vessels under way, the presence of moorings and buoys can prevent safe use of substantial areas of a port, due to the risk of a vessel's propeller becoming fouled on ropes;
- Lifting operations, ranging from major components to small loads such as tool bags, equipment and spare parts;
  - Note that ports may often include areas of reclaimed land, which may not have been engineered for high bearing capacity;
- Refuelling and vessel waste disposal operations;
- Interaction with other users and visitors, both on land, in harbour basins, and in entrance / exit channels;
- Hot work for removal / fitting of sea-fastening introduces a fire hazard;

- Additional interfaces, involving multiple shore-based contractors as well as marine, may introduce a variety of safety cultures and ways of working;
- Unprotected edges on piers / jetties;
- Tripping hazards from ropes, hoses and cables;
- Failure of equipment or infrastructure due to poor condition, inadequate capacity, or unanticipated use;
- Mooring of large vessels: mooring lines under tension have significant stored energy, while errors during mooring could result in damage to the vessel or others nearby;
    - Aerodynamic loads on large vessels may complicate mooring in strong winds, possibly requiring the vessel to take a different approach and use a greater area of the port to allow safe manoeuvring.

C.16.1.1.2 Commercial and Operational Risks

Any incidents or restrictions affecting port operations may result in damage to, or loss of, components, and delays to operations, which may affect the overall schedule and efficiency of the project.

C.16.1.1.3 Indirect and Consequential Risks

The port is a key interface with the local community; any adverse effects from the project may lead to a loss of community acceptance, and increased difficulty in planning and consenting activities. The port is likely to be used by a number of different contractors on the project, as well as existing users; co-operation and co-ordination of project activities, and good liaison with port authorities and the MCA will be essential.

Any inadequacies in site security could lead to:

- Unauthorised visitors, potentially including children, being put at risk by operations such as lifting and vehicle movements within the port; and
- Theft, damage or vandalism of equipment, including safety-related items:
    - If such damage were to be noticed prior to offshore installation, then the impact could be confined to the cost of repair / replacement and any delay; if the damaged parts were to be installed offshore, the risk to people from subsequent failure and remediation, as well as the costs involved, could be much higher.

Project activities, for example the storage, lifting and movement of critical components, such as WTG blades, could also put people and equipment at risk, if not properly controlled and segregated.

C.16.1.2 RELEVANCE TO KEY LIFECYCLE PHASES

The port and mobilisation requirements should be identified during project definition, as there are very few ports that already have suitable facilities, and any required developments may have a long lead time, involving reaching agreement with owners and obtaining planning consent; early dialogue with stakeholders is likely to assist in this. Any enabling works in the port will typically be managed as separate construction projects, to be completed before they are needed to support offshore construction.

The construction and O&M phases involve the greatest use of port facilities; the demands that they impose are quite different, and may even be served by different ports.

C.16.2 REGULATORY REQUIREMENTS

Ports and harbours are regulated under the Harbours Act 1964 and related statutory instruments. Many port authorities are established under individual acts of parliament; these regulations may give port authorities the power to implement bylaws governing the use of the port facilities.

The HSE is currently consulting on the revocation of the Docks Regulations 1988, as they have effectively been superseded by more recent regulations which combine to cover the relevant activities, such as CDM, LOLER, PUWER and MHSWR.

C.16.3 MANAGING THE RISKS

C.16.3.1 APPROACHES TO RISK ASSESSMENT

Thorough modelling of operations should be undertaken at the design stage, to determine the required facilities, including those for berthing, storage, workshops, lifting, waste disposal, vehicle and pedestrian movement and segregation.

C.16.3.2 RISK MITIGATION MEASURES

In all phases, it is beneficial to have good access by sea and land, so that offshore work is not constrained by the port, thereby avoiding the introduction of additional time pressure on people and offshore operations. This may include supporting 24h working, in which case suitable lighting will be required; the potential effects of night time and weekend working on neighbours must be assessed, including aspects such as noise and light pollution, and vehicle movements between the port and support facilities or trunk roads.

Transport management will be an important part of the detailed logistical arrangements; key considerations include the management of:

- Deliveries by road and sea, including arrangements for offloading and storage;
- Vehicle movements within the port, which may range from private cars to large abnormal loads, including the use of roadways that are shared with other port users; and
- Segregation of vehicles and pedestrians.

As part of the preparation of the port for use in support of an OREI, it may be necessary to undertake road works in order to provide the type and quality of facilities that are needed.

The port should ideally be accessible in any conditions that permit work on the offshore site; this may be an issue if the port and the site are exposed to weather from different directions, as may occur on sites adjacent to islands / peninsulas, or if port access is affected by tidal height, currents, draught restrictions, or lock gates.

Normal operations will require suitable facilities for loading / unloading, refuelling and routine maintenance of vessels; storage of consumables and waste disposal. Where it is proposed to make use of existing port facilities for such purposes, effective management of change processes need to be applied, in order to verify that they are suitable for any new purpose, maintained to a satisfactory standard, and that responsibilities are clear between the different parties involved. On-going site management arrangements will need to address issues such as:

- Tracking personnel between vessels and onshore areas;
- Shift work, and potentially lone working;
- Housekeeping, including the need to maintain clear access routes, and waste disposal;
- Storage and movement of materials, possibly including use of temporary storage areas;
- Response to severe weather, including storms and winter conditions; and
- Emergency response, either relating to an incident in the port, on the offshore site, or an external emergency event.

Ports and shore-based contractors will have their own safety management systems; bridging documents will be needed in order to manage the interface with the OREI operator's systems, in normal operation and emergency situations. Common arrangements should be put in place for the management of visitors and contractors who are not normally on the site, such as vehicle repair technicians.

The Marine Co-ordination function will have a key role in managing the use of the port, including planning all vessel movements, in conjunction with construction / O&M planners who manage corresponding onshore logistics, and possibly also involving Vessel Traffic Control where harbour authorities operate such systems.

Given the wide range of requirements and associated mitigation actions, early dialogue with port authorities, existing users, onshore contractors and workforce representatives is beneficial to establishing safe and efficient port operations.

C.16.3.3 Monitoring, Review and Change Management

In order to sustain safe operations, port facilities will require ongoing maintenance to ensure that they remain in suitable condition, typical maintenance and inspection requirements include roadways, walkways, pontoons, gangways, fencing / barriers, ladders, lifting equipment, shore power, moorings, lighting and signage. Some or all of these may be the responsibility of the port management / landlord, so effective interface management is needed.

Auditing should be undertaken, to give assurance of the condition of facilities, the use of safe working practices, and the maintenance of appropriate standards of housekeeping; this may be most effective where it involves representatives of the different parties involved.

Where changes are proposed, such as pre-assembly of larger sections of offshore WTGs, or adoption of different maintenance strategies, the technical and logistical effects of such proposals on port operations should be assessed.

C.16.4 Codes of Practice and Guidance

C.16.4.1 Regulations and Standards

HSE INDG446 - *A quick guide to health and safety in ports*.

HSG177 - *Managing health and safety in Dockwork*, outlines the principal responsibilities of those engaged in managing dockwork.

Port Marine Safety Code defines safety-related duties of harbour authorities.

A new ACOP is due for issue in April 2014: HSE L148 - *Safety in docks - Approved Code of Practice and guidance*

Safety in Ports guidance from Port Skills and Safety, including:

- SIP001 - *Guidance on Workplace Transport - Port and Terminal Planning*;
- SIP002 - *Guidance on General Cargo*;
- SIP005 - *Guidance on Mooring*;
- SIP009 - *Guidance on Lighting*.

International Labour Office (ILO) Code of Practice - *Safety and Health in Ports* provides wide-ranging guidance on issues relevant to port operations.

C.16.4.2 Other Relevant Guidance

Other guidance documents may be downloaded or purchased from Port Skills and Safety.

C.17 REMOTE WORKING

C.17.1 OVERVIEW

Offshore WTG maintenance typically involves deploying small teams of workers to a number of WTGs across an offshore wind farm, with access vessels remaining present in the wind farm; similar approaches might be used for some wave and tidal developments. Each team is therefore remote from immediate support and supervision, and the OREI itself is remote from the full support that is available at the onshore base.

Remoteness is not simply about distance from shore, but should be considered in terms of:

- Project remoteness – the physical remoteness of site / project activities from a place of safety (generally the onshore base) and the risk that metocean conditions may further limit access;
  - This will influence the emergency response arrangements for the OREI as a whole;
  - In some cases, the onshore base may itself be remote from supporting services such as hospitals with Accident and Emergency facilities; and
- Task remoteness – potential for remote working as part of routine construction and O&M tasks on parts of an OREI that may not be perceived as particularly "remote", but where direct supervision and support of work teams can be difficult;
  - This will influence the safety management arrangements for the task.

On this basis, the degree of remoteness can change significantly if metocean conditions change; in an extreme case, if egress from an offshore structure were to become impossible, then any people on the structure would be stranded, and work in progress on that structure would have to be suspended, as there would no longer be the means of evacuating a casualty.

The challenges of remoteness will be quite different for large far-offshore OREIs, where teams have extensive support nearby, such as construction and accommodation vessels, compared to a nearshore site with a small number of people at work, a single support vessel on site, and few other vessels in the area.

C.17.1.1 POTENTIAL HAZARDS AND RISKS

C.17.1.1.1 Direct Health and Safety Risks

In the event of an incident occurring on an offshore WTG, considerable time may elapse before additional help arrives, so even a fairly simple problem can escalate in severity.

The remote nature of work on offshore WTGs also brings challenges in the provision of supervision and auditing, with each team being responsible for working in a safe manner, in accordance with approved procedures, and leaving the workplace in an appropriate condition.

C.17.1.1.2 Commercial and Operational Risks

Remote operations are likely to be carried out with minimal direct supervision; this may introduce risks to the quality of work, the condition that the workplace is left in, or the adherence to approved methods of working.

C.17.1.2 RELEVANCE TO KEY LIFECYCLE PHASES

Almost all work on an offshore wind farm may be considered as remote working; the exact arrangements will vary over the lifecycle, and the issues may be greatest during the O&M phase, when there are likely to be multiple small teams on a number of WTGs across the wind farm, and a reduced number of vessels present compared to during the construction phase.

C.17.2 REGULATORY REQUIREMENTS

There are no specific regulations or guidance on remote working, but it should be addressed as part of an employer's general duties under HSWA and MHSWR (as an aspect of the work activity to be considered in the risk assessment).

The effects of remoteness should also be considered when planning work such as lifting (LOLER), work in confined spaces, the use of hazardous substances, and work at height.

C.17.3 MANAGING THE RISKS

Any work to be carried out offshore requires thorough planning, to ensure that the necessary resources are in place to support the task, and foreseeable incidents that may occur while it is in progress. The planning of tasks at remote locations needs to ensure that all necessary work equipment, consumables, and means of waste disposal are provided, with appropriate spares as necessary. In the event of a shortfall in provision, there can be a temptation to improvise, using unsuitable equipment that may help to get the job done despite inadequate preparation, but expose the people involved to additional risks.

Offshore work parties need to have the competence and equipment to manage foreseeable situations up to the point where additional help will be available, making safe decisions in real time as situations develop, while maintaining communication with others, and staying within their competence.

The potential risks with remote working also highlight the importance of suitable fitness to work assessments in order to identify any significant underlying health conditions.

C.17.3.1 APPROACHES TO RISK ASSESSMENT

It is important that all actual or potential remote working situations are assessed and managed on a case by case basis. This is due to the variability of the risk profile for each project and lifecycle phase, and also the potential for rapid changes in operational and environmental conditions. This may require additional attention to be given to:

- The competence of employees and contractors to assess and manage remote working situations, such as their ability to undertake dynamic risk assessments, first aid, rescue and evacuation; and
- The effectiveness of procedures to monitor and supervise workers.

The risk assessment for offshore working should consider:

- The residual risk of injury that the proposed tasks present, after mitigation actions have been implemented;
- The time that may elapse from when an incident occurs to when:
    - Additional support can be provided by other work parties on WTGs or wind farm vessels in the vicinity; and then
    - Evacuation to medical care can be completed, noting that metocean conditions at the time of an incident may increase the time taken for support to arrive, or evacuation to be completed.

These factors combine to determine the required level of provision of competent people and facilities at the remote location.

The risk assessment would typically be provided to personnel as part of their work pack, to assist their preparations, and provide a starting point for their point of work risk assessment.

C.17.3.2 RISK MITIGATION MEASURES

It is important to maintain effective communication with all personnel working in diverse areas of an OREI. Communication systems and protocols need to be capable of working across the whole operating area of a wind farm, and coping with the potentially large numbers of people who may be at work at any time, not all of whom will have the same first language. As well as being vital for safety, a good communications system may also be used to provide technical support and a degree of remote supervision to personnel undertaking technical tasks offshore. Direct communications should be possible between:

- WTGs and vessels;
- WTGs and the onshore base, usually by a fixed voice and data link;
- Vessels and the onshore base;

- Vessels within the OREI.

Given that the ability to communicate is safety-critical, at least two independent systems should be available at every location. Communication becomes more challenging with larger developments, located further offshore; for example, if marine VHF is being used there may be a large number of people using the limited number of channels available, and the distances involved may exceed the range of handheld VHF radios.

It is essential to know the location of all personnel and vessels at all times; this requirement can be satisfied by a number of different personnel tracking systems, ranging from procedures that require manual reporting over radio, to RFID (Radio Frequency Identification) contactless swipe cards, and GPS systems. Each option has its own costs and benefits, in terms of system set-up, ongoing administrative burden, reliability and ease of use in an emergency. As well as performing a tracking function, such systems may also be used to control access, by ensuring that personnel only go offshore if they have provided the required evidence of current training, competence, medical fitness and next of kin information.

Each offshore work party should have sufficient training in skills such as first aid and rescue, to ensure self-sufficiency and preservation of life in the event of an accident, until further support is in attendance. Lone working in remote offshore locations should not be contemplated.

Suitable arrangements should be in place for supervision and audit, to ensure that safe working practices are being used, and that approved procedures are being followed, and updated if improved methods are identified. Provision of in-field supervision may help to achieve this, as well as providing technical support to technicians and assisting in quality assurance.

C.17.3.3 Monitoring, Review and Change Management

The safety of remote working can be affected by changes that range from real-time changes in the operational situation, to major organisational changes.

Procedures should be in place to ensure that temporary changes and operational restrictions are communicated to all necessary parties so that planned operations can be modified accordingly; typical situations could include:

- If the crane on a transition piece were to develop a fault, or become due for inspection, then this could prevent its use for lowering a casualty to the support vessel; or
- In the event of an incident occurring that prevents the access vessel from supporting work parties that are already on offshore WTGs, either because the vessel is involved in, or responding to the incident, then those work parties may be required to stop work until they once again have vessel support available.

More significant changes, such as the introduction of new procedures and service providers, could fundamentally alter the safety of remote working; thorough assessment of such changes, and effective communication, is essential in order to minimise the associated risks.

C.17.3.4 Lone Working

While there are no absolute restrictions on working alone, there is in effect an industry convention that lone working should be avoided, other than in exceptional circumstances where there is a serious or imminent safety reason that could justify it.

C.17.4 Codes of Practice and Guidance

C.17.4.1 Regulations and Standards

There are no specific regulations for remote or lone working; however, work in a remote location must be conducted in accordance with the general duties of the HSWA, and managed in accordance with the MHSWR.

C.17.4.2 Other Relevant Guidance

HSE INDG73 – *Working alone – Health and safety guidance on the risks of lone working*, although not specific to remote working, many of the points that are covered in this document are transferable to work in remote locations.

RenewableUK - *Incident response for offshore wind and marine projects*.

HSE HSG65 - Managing for Health and Safety.

C.18 SUBSEA OPERATIONS

C.18.1 OVERVIEW

Diving is a high-hazard activity that depends upon specialist personnel with a high level of training and experience to plan, support and carry out diving operations in a safe manner; if not properly managed, serious incidents, including fatalities can occur. In the light of the inherent risks involved, a principal objective at the design phase of any OREI development is to aim to prevent or, where not practicable, minimise the need for diving operations. This is reinforced by an employer's duties under the MHSWR, which can be summarised as:

1. A suitable and sufficient assessment shall be made of the risks to health and safety of employees and others who may be affected by work activities;
2. Where measures are taken to reduce the risks that have been identified, then under the principles of prevention that the regulations define, the first step described in the ACOP is "*if possible avoid a risk altogether, e.g. do the work in a different way, taking care not to introduce new hazards*".

The risks involved in diving can be avoided if subsea operations are designed out, or alternative methods such as Remotely Operated Vehicles (ROVs) or Autonomous Underwater Vehicles (AUVs) adopted. However, most offshore projects will still require some diving operations to be conducted before and during the construction phase, and subsequently for certain O&M activities. It is therefore vital that whenever there is a possibility of diving activities, early planning is conducted to eliminate and minimise diving risks.

C.18.1.1 POTENTIAL HAZARDS AND RISKS

C.18.1.1.1 Direct Health and Safety Risks

The principal risk to divers arises from working in the underwater environment, at a pressure that may be several times greater than normal atmospheric pressure. Depending on the depth, divers will either breathe air, or a mixture of gases, at a pressure that matches the water pressure at their working depth; the correct management of breathing gases and decompression is vital to avoiding acute physiological effects (such as decompression sickness), or longer term harm.

The breathing gas is supplied to the diver through an umbilical, which is connected (either directly or through a diving bell) to a support system on the surface, and which also provides for communications.

Divers may be vulnerable to a wide range of hazards as a result of the works on site and the inherent nature of the underwater environment. These include, but are not limited to:

- Differential pressure, for example breaching a seal on a J-tube underwater, could cause a sudden flow of water due to the difference in water levels inside and outside, with the potential to trap and seriously injure a diver;
- Adjacent marine operations involving vessel movement, and particularly the wash and mechanical hazards of propellers and thrusters;
- Any work being carried out above the dive location, presenting the risk of dropped objects;
- Restricted visibility, both on the surface and subsea, which may be further impaired by sediment disturbed by the subsea operations or other simultaneous operations;
- Working with cranes in limited visibility can result in entrapment and crushing, particularly if combined with vessel movement, due to wave action, causing the load to move;
- Underwater noise can impede communication, or, in extreme cases, cause hearing damage;
- Electricity;
- Entrapment or severing of divers' umbilicals by vessel thrusters, cables or other equipment;

- Apparently simple dives, such as those in shallow water, can result in complacency in dive planning, and inadequate mitigation of hazards;
- Changes in sea conditions during a dive, which may result in hazardous conditions for divers when exiting the water;
- Many divers are self employed, so may perform other work during 'rest' periods and also use their own equipment;
- Use of equipment such as high pressure water-jetting, abrasive cutting discs or ultrathermic cutting lances is particularly hazardous; and
- Breakdown in communication, either due to language or equipment issues.

The unforgiving subsea environment, combined with decompression requirements preventing immediate evacuation, can rapidly escalate the severity of any accident or health issue.

The exposure of people to the above hazards is eliminated whenever a method is found to achieve the necessary work objectives without the deployment of divers.

C.18.1.1.2 Additional Considerations for Marine Energy Developments

Marine energy developments involve working in environments that are very different to more normal offshore diving.

Underwater currents, particularly in tidal streams, can exert significant forces on divers and their umbilicals, impeding their ability to work, and to return to a place of safety:

- After slack water has passed, the speed of the current increases at an accelerating rate, leading to rapid deterioration in conditions (as shown in Figure 6 in Section C.12.2.3);
    - If anything goes wrong, there is likely to be very little time available to deploy a standby diver in order to render assistance to a diver who is in difficulties;
    - The combined effect of the limited duration of slack water, together with the need to allow for decompression stops, and for recovery of a diver following an incident, means that actual working time on each tidal cycle will be very limited;
        - Any partially-complete subsea works will have to be left in a state that enables them to withstand the tidal currents until the next suitable period of slack water;
- The speed of the current increases towards the surface, so if a diver is working at depth, they will experience faster currents during their ascent;
    - This can severely impede return to the surface, and in-water decompression stops;
    - The current will also impede the retrieval of a diving bell or basket onto a vessel.

Wave energy developments are generally located in sea areas with exposure to ocean swell; in water that is shallow, relative to the wavelength of the swell, the wave action will create significant horizontal motion at the seabed, which may impede safe diving operations even in conditions that allow divers to enter the water and return to the vessel safely.

Lack of experience of similar dive conditions can put divers at risk, even if they are qualified and highly experienced in more standard operations.

C.18.1.1.3 Indirect and Consequential Risks

If it is proposed to carry out an operation by means of diving, consideration must be given to the challenges that divers face, including limited visibility, restricted manoeuvrability, and cold temperatures. Some divers may be able to achieve more than others in difficult dive conditions; this can add uncertainty to the length of time that is required to complete individual tasks during diving operations, although this will tend to average out over the course of a project.

Consideration should also be given to the limitations that mitigation measures may impose on diving operations, such as wearing bulky suits and gloves to provide insulation against cold, thereby reducing dexterity.

C.18.1.1.4 Typical Examples

Diving may be necessary in order to carry out complex subsea operations, such as assembly, repair, cutting and welding, however, if these tasks can be designed to enable the work to be done without diving, the project risk profile will be improved.

C.18.1.2 Relevance to Key Lifecycle Phases

Decisions made at the design stage will determine the extent of diving operations that will be required over the project lifecycle, and affect the ease with which they can safely be carried out. It may be possible to complete some tasks, especially those that only require inspection work, using either Remotely Operated Vehicles (ROVs), Autonomous Underwater Vehicles (AUVs) or surface-deployed static cameras for monitoring specific tasks such as cable pull-in to structures. For other tasks, remotely-operated release systems, or stab-in connections, can eliminate the need for diving. Such techniques may also benefit project economics over the full lifecycle.

Under the CDM regulations, the Designer has a duty to avoid foreseeable risks to people over the lifetime of a structure, as do all employers under the MHSWR; in relation to diving, these duties may be fulfilled by:

- Reviewing proposed subsea operations to determine whether they can be eliminated, and if not, whether they can be carried out without the use of divers, thereby minimising the exposure of people to the hazards that are inherent in diving; and
- Where a need for diving is confirmed, ensuring that the practicalities of diving are taken into account in the detail design, to minimise the duration and complexity of diving operations:
    - Diver-friendly designs include features such as handles for the diver to hold onto, clear labelling, liftable covers, and ensuring that components can be manipulated when wearing gloves;
    - Production of diver-friendly designs requires that design teams understand diving; this may be achieved by provision of dive awareness training and / or the involvement of external diving specialists in the design process;
- Where an alternative to diving, such as the use of ROVs is proposed, the detail design may require modification to enable effective use of ROVs, and avoid later pressure to revert to the use of divers; for example, if the ROV is to be used to attach lines for subsequent lifting operations, then this will be easier if oversize pad-eyes are provided. Recognising that in certain circumstances diving operations may still be required, the design should also be diver-friendly.

These decisions will be assisted by the involvement of personnel with extensive subsea experience in design reviews.

C.18.2 Regulatory Requirements

All diving operations are subject to the Diving at Work Regulations 1997, which require a risk assessment approach for all diving activities, which, if correctly applied to work-scope, location and other information relating to the diving project, should dictate the dive plan and the resources required to carry out the diving work safely. Given the wide range of diving activities that these regulations address, there are five ACOPs, which address Offshore, Inshore, Scientific & Archaeological, Media and Recreational diving. The ACOPs give very specific and detailed guidance to those involved in commissioning or undertaking diving work.

The non-standard nature of diving operations on OREIs, especially marine energy developments, may require a more precautionary approach that that set out in the relevant ACOP. For example, the requirements set out for commercial inland / inshore diving may not be fully appropriate to the more complex and extreme environments that may be encountered on some OREIs located in inshore sea areas. Competent advice should always be obtained from an experienced diving contractor / organisation when making any judgement about the suitability of an agreed diving plan.

C.18.3 MANAGING THE RISKS

The Diving at Work Regulations place a duty on any person whose acts or omissions could have an adverse effect on the health and safety of the dive team to take reasonable measures to comply with the Regulations; this duty may affect Clients, Principal Contractors, project managers and consultants, the masters of vessels, and diving contractors.

C.18.3.1 CLIENT DUTIES

The duties of a client (defined as the entity that places a contract for a diving project, which may not be the same entity as the Client under CDM) include:

- Ensuring the competence of personnel involved in planning diving operations; unless the client has sufficient competent personnel within the project team, the client will need to engage competent external specialists in order to fulfil its duties;
- Appointment of a competent Diving Contractor for the diving project;
- Provision of information, including the findings of risk assessments or details of known hazards in the project location, that could affect the health and safety of the dive team, such as:
    - Project information:
        - Task / dive / project outcomes and deliverables;
        - Anticipated workloads / volume;
        - Method statements, lift plans, technical information, etc.;
        - Interface with adjacent operations;
        - Tooling requirements and quality assurance requirements;
        - Anticipated boundaries of the dive site;
        - Historical information (technical and safety);
    - Environmental conditions:
        - Water depth across site and at each dive location (across full tidal range);
        - Seabed make up and topology;
        - Known/expected underwater visibility;
        - Tidal data: speed, directions and timing;
        - Statistical weather data: wind/wave/surface visibility;
        - Seabed hazards: existing seabed infrastructure / works, contaminants / gas pockets, wrecks, marine life and other natural hazards;
        - Shipping hazards and anchoring hazards;
    - Worksite arrangements:
        - Site location, layout and marine charts;
        - Details on mobilisation port, such as tidal restrictions, facilities available to diving contractors, access and egress arrangements to / from vessels, contact details;
            - The same information should be provided for any alternative ports;
        - Emergency beach heads;
        - Dive vessel restrictions / requirements (if not provided by the client): maximum air draft, maximum draft for port access, anchoring restrictions, minimum technical requirements (AIS, radio channels);

    - Dive vessel details (if provided by the client): deck space available, freeboard, power supply, transit time to port;
    - Shipping movements (both construction and passing);
    - Site emergency plan, site rules, site-specific training requirements and induction requirements;
    - Site control arrangements, including who will issue the permit to dive;
    - Other activities that will be taking place during diving operations;
- Provision of facilities and support in the event of an emergency, including rescue and medical care; such support should be agreed in the diving project plan and with local providers.

C.18.3.2 DIVING CONTRACTOR SELECTION

The selection of a diving contractor should be based on the competence of the contractor carrying out the work, and the individual capabilities of the divers. The basic principles of contractor selection, as given in the CDM ACOP, should be followed; specific areas to consider include:

- Direct experience of relevant diving work;
- Health and safety policies and arrangements;
- Details of health and safety performance such as accidents / incidents / enforcement;
- Specific diving qualifications and skills held;
- Medical and health surveillance provision;
- Details of risk assessments, diving plans and method statements;
- Details of diving training and supervision provided;
- Worker consultation procedures;
- Independent assessments of diving and organisational competence;
- Membership of a relevant trade or professional body (e.g. ADC-UK, IMCA); and
- Relevant insurance.

C.18.3.3 MANAGEMENT OF DIVING WORK

The Regulations require that for any Diving Project, there is exactly one Diving Contractor:

- A Diving Project is the term used for an activity, that involves one or more diving operations, and covers the whole time period from commencement of preparation for diving, until the last diving operation has been completed, and sufficient time has elapsed thereafter that access to decompression facilities is no longer needed;
- The Diving Contractor has the principal responsibility for ensuring that the diving project is carried out safely. Detailed steps to achieving this are set out in the relevant ACOP. Areas that need to be considered in planning and managing a diving project include:
    - Appointment of a person to supervise the project;
    - Keeping records detailing appointments;
    - Competence and numbers of people to perform the diving project;
    - Suitable and sufficient diving equipment available to carry out the project;
    - Additional equipment to address first aid and foreseeable emergencies connected with the diving project;
    - Maintenance and examination of plant and equipment; and
    - Procedures to ensure persons comply with statutory provisions and the diving project plan;

- The Diving Contractor should work with the Principal Contractor and Marine Co-ordinator to ensure that other activities do not present a hazard to the diving project;
- The Diving Supervisor has the duty to manage safely the operation for which they are responsible; they should only accept this responsibility for an operation that they consider can be conducted safely, and that they are competent to supervise.

The Diving Project Plan is a vital component of every diving project. It is based on a detailed assessment of the risks to the health and safety of any person taking part in the diving project. It records the planning carried out and the information and instructions necessary to give advice to, and to regulate the behaviour of, those taking part in the diving operation.

Due to the high risks associated with diving work, independent advice may need to be obtained to provide advice on the detailed legal, technical and procedural requirements of particular diving work for renewable energy projects.

C.18.3.4 RISK MITIGATION MEASURES

Risks associated with diving operations may be mitigated by ensuring that a competent person undertakes a comprehensive risk assessment of detailed plans for the operations, to identify hazards at every stage of the diving operations, and necessary mitigation measures.

The different forms of diving affect the risk profile; examples are outlined below:

- Saturation diving: the divers remain at the pressure that they will experience during the dive (and therefore continue to use the breathing mixture), for the duration of their tour of duty;
  - This is commonly achieved by living in a hyperbaric chamber on the vessel in between dives, and transiting from the vessel to the working depth in a closed bell, thereby eliminating the need for in-water decompression stops, and reducing the number of times that divers undergo decompression;
  - While working at depth outside the bell, the divers remain connected to it by means of an umbilical, which provides the breathing gas supply, power for lights, and communications with the dive supervisor on the surface, thereby enabling constant monitoring of the diver’s condition, and often including live video feed;
  - Saturation diving is generally used for work at depths in excess of 50m;
- Surface-supplied offshore diving (Air / Nitrox gas mixture): the divers are attached to the support vessel by an umbilical, with the same functions as in saturation diving, but as the divers return to the surface on completion of each dive, in-water decompression is required;
  - Dive tables are used to determine decompression requirements, which depend on the depth and duration of a dive, and the breathing gas mixture used;
  - The bottom time (measured from entry into the water, until the start of ascent and in-water decompression) is limited to 20 minutes for a dive to 50m depth;
- Self-Contained Underwater Breathing Apparatus (SCUBA) is viewed by regulators and trade bodies as being inappropriate for offshore diving.

It should be noted from the above descriptions that the water depths in which many OREIs are planned to be built, are close to the limit for surface-supplied diving, but shallower than most saturation dives; this transition depth is recognised by divers as being a particularly hazardous depth at which to work.

C.18.4 USE OF ROVS

Whenever a task is completed using a ROV rather than divers, the exposure of people to the hazards of subsea work is avoided. The main health and safety risks in ROV use relate to their interaction with vessels.

If ROVs are used in shallow water, movement of the ROV under a vessel introduces the risk of its umbilical fouling the vessel’s thrusters, potentially disabling the vessel, as well as the ROV.

If a ROV is used in a location subject to strong tidal currents, and is not recovered to the support vessel before the current exceeds its operating limit, then it may be impossible to recover the ROV, thereby endangering the vessel to which it is attached. This is further complicated by the fact that the surface current is likely to be stronger than the current at the ROV's operating depth.

Procedures should therefore be in place to determine the point at which a ROV that cannot be recovered onto the vessel, should be cut free; any delay in releasing it could endanger the vessel and its crew as the tidal currents increase at an accelerating rate after slack water. Follow-up procedures should also be in place for:

- Notification of other mariners and emergency services, including information on any locating signal being transmitted, to avoid potential confusion and false alarms; and
- Tracking and recovery of the ROV, noting that this cannot be undertaken by a standby vessel that is on location to ensure the safety of personnel.

Cutting a ROV free from a vessel may be a significant commercial loss, due to the high cost of some ROVs; should the work be reliant on ROV use, loss or other failure of a ROV will prevent operations from proceeding. These risks are easier to bear than the risk to human life that an equivalent situation involving divers would present.

C.18.5 Codes of Practice and Guidance

C.18.5.1 Regulations and Standards

The Diving at Work Regulations are supported by five ACOPs, the most relevant of which are summarised below:

Table 9: Diving at Work ACOPs

HSE ACOP	Qualifying Criteria for Diving Project
L103 – *Commercial Diving Projects Offshore*	• Any diving taking place outside the 12 NM limit of the Territorial Sea (e.g. all Round 3 offshore wind projects); or • Diving in any location that involves: o Saturation or Closed Bell techniques; or o Diving taking place from vessels that are maintaining their station using Dynamic Positioning (DP); or o Diving below 50 m, unless qualifying as Media, Recreational or Scientific and Archaeological Diving.
L104 – *Commercial Diving Projects Inland / Inshore*	• Diving taking place within the 12 NM limit, unless qualifying as Offshore diving.
L107 – *Scientific and Archaeological Diving Projects*	• Diving taking place for the purposes of research, education or investigation of historic remains, unless qualifying as Offshore diving.

C.18.5.2 Other Relevant Guidance

HSE INDG266 – *Are you involved in a diving project at work? A brief guide to complying with the law*, provides basic guidance on the responsibilities of clients, contractors and others whose actions could affect the safety of a dive team.

International Association of Oil and Gas Producers Report No. 411 - *Diving Recommended Practice* provides a recommended practice for management of diving projects, together with an overview of the main diving methods, equipment and operational considerations in its appendices.

The IMCA Diving Division has a wide range of diving publications on its website, giving detailed coverage of many technical and operational issues.

IMCA D014 - *International Code of Practice for Offshore Diving* provides an overview of all aspects of diving operations, however note the specific requirements of IMCA D 14/07 - *UK Appendix* which identifies areas where the UK ACOPS impose higher standards.

IMCA D016 – *Underwater air lift bags*, discusses the examination, testing, certification and maintenance of underwater lift bags.

IMCA D033 – *Limitations in the use of SCUBA offshore*, discusses reasons why SCUBA is considered to be unsuitable for use in commercial offshore diving operations.

IMCA D035 - *Guidance on the Selection of Vessels of Opportunity for Diving Operations*.

IMCA D044 – *Guidelines for Isolation and Intervention: Diver Access to Subsea Systems*.

IMCA D045 - Code of Practice for The Safe Use of Electricity Under Water.

IMCA AODC047 – *The Effects of Underwater Currents on Divers' Performance and Safety*.

IMCA M 103 - *Guidelines for The Design and Operation of Dynamically Positioned Vessels*: Chapter 2 is relevant where the use of Dynamically Positioned (DP) diving support vessels is proposed.

IMCA R 004 – *Code of practice for the safe & efficient Operation of Remotely Operated Vehicles*.

IMCA R 005 – *High Voltage Equipment: Safety Procedures for Working on ROVs*.

The HSE publishes a series of Diving Information Sheets on its website, including guidance on operating practices and equipment standards.

The Association of Diving Contractors provides guidance to assist personnel involved in Engaging Diving Contractors for Inland / Inshore Diving Projects.

C.18.5.3 ELSEWHERE IN THIS GUIDANCE

Emergency response & preparedness
Lifting
Marine Co-ordination
Metocean

C.19 UNEXPLODED ORDNANCE

C.19.1 OVERVIEW

During the hostilities of WW1 and WW2, and in the years after the wars, a wide range of ordnance was deposited in the seas around the UK; it is estimated that around 190,000 sea mines were deployed and never recovered, in addition to other ordnance such as torpedoes, depth charges, explosive shells and ordnance dropped by aircraft. Individual items of unexploded ordnance (UXO) may contain up to 1000 kg of high explosive. Ship wrecks, and military aircraft that were lost over the sea, may also contain UXO. Finally, after the hostilities ended, around two million tonnes of surplus munitions were disposed of by dumping in fifteen designated sites at sea, the largest of which, Beaufort's Dyke (located in the North Channel to the north of the Irish Sea) contains over a million tonnes of munitions, including both conventional and chemical warheads.

While some of the UXO will no longer be viable, many items retain their full explosive capacity, and can be very unstable due to deterioration of their condition in the years since they were deposited.

C.19.1.1 POTENTIAL HAZARDS AND RISKS

C.19.1.1.1 Direct Health and Safety Risks

Disturbance to UXO can lead to detonation, which may cause damage to vessels, potentially including sinking; even if the detonation is relatively far from the vessel, the impact on the vessel, of the shock wave resulting from the explosion, can cause injury to people aboard.

As both the seabed and UXO may be mobile, due to wave and current action, over time UXO can move or be uncovered.

C.19.1.1.2 Commercial and Operational Risks

UXO can also damage assets, including subsea cables and installation equipment.

C.19.1.2 RELEVANCE TO KEY LIFECYCLE PHASES

The risk from UXO is highest when undertaking works that disturb the seabed, such as OREI installation and subsea cabling. UXO may also be discovered during harbour works, particularly if dredging is carried out in new locations. It must be noted that some forms of UXO can be mobile, depending on the seabed conditions and currents, so under these conditions, it must not be assumed that a location that was previously clear of such UXO will remain safe.

C.19.2 REGULATORY REQUIREMENTS

There are no specific regulations relating to UXO, however the risk should be managed as part of an employer's general duties under the HSWA.

C.19.3 MANAGING THE RISKS

UXO risk should be assessed prior to undertaking any works that disturb the seabed, with the effort invested in the assessment being proportional to the risk that UXO presents to the proposed works at the intended location. Undertaking a suitable and sufficient UXO risk assessment is likely to require the involvement of competent specialists who should be able to demonstrate relevant experience and suitable management systems.

C.19.3.1 APPROACHES TO RISK ASSESSMENT

The first stage in UXO risk assessment is to research the history of a site, in terms of previous military action and subsequent activities. The study should identify the nature and probability of UXO being present, and how they may be affected by the proposed works. Some operations, such as cable laying, could make direct contact with ordnance on, or just below, the seabed along the route of the cable; in contrast, percussive piling takes place at single point locations, but the resulting pressure waves could affect ordnance beyond the actual piling location.

The findings of the desktop study will help to determine the requirements and strategy for subsequent activities, including:

- If no threat, or a very low threat is identified, then it may be safe to proceed with the planned project activities without further survey work, although continuing to monitor the situation, particularly if new information emerges; or
- If survey work is required, the objectives for the survey need to be defined, particularly in relation to the potential types of UXO that the survey is to look for, as this will affect the selection of appropriate survey techniques.

UXO survey work may be undertaken in conjunction with geophysical surveys, as similar technologies may be used, although the operating method will have to reflect the survey objectives. The results from a single survey technique may not be conclusive: for example, a large non-ferrous object could be a rock, or a parachute mine; a large ferrous object could be a benign piece of scrap metal, or a sea mine, so a combination of techniques, together with interpretation based on the knowledge of the expected types of UXO in the survey area, may be required in order to narrow down the number of suspect objects.

In some cases, visual inspection (by ROV or diver) may be necessary in order to make a final decision.

UXO risk assessment will also draw upon information from other surveys: the seabed soil properties will affect the potential depth of burial of UXO, while the interaction of metocean conditions and seabed properties will affect the mobility of UXO or sediment.

C.19.3.2 Risk Mitigation Measures

If an unacceptable risk from UXO is identified, then it may be possible to alter the design of the OREI in order to avoid carrying out operations in the affected areas, for example by routing cables well away from sites of wartime wrecks. Alternatively, a suitable specialist Explosive Ordnance Disposal (EOD) contractor might have to be engaged to undertake safe disposal of UXO on the site, prior to other offshore works being undertaken.

OREI ERCoPs should include procedures to be followed in the event of UXO being discovered. Where there is a perceived threat to life, the MCA can draw on support from military EOD teams; however this is an emergency measure, and not a substitute for UXO risk assessment and site clearance.

C.19.3.3 Monitoring, Review and Change Management

Given the potential for seabed and UXO mobility, the validity of survey data may reduce over time; the risk assessment should identify requirements for future updating. If changes to OREI design or operations are being considered, then the UXO risk assessment should be reviewed to ensure that the changes do not increase the risk from UXO.

C.19.4 Codes of Practice and Guidance

C.19.4.1 Regulations and Standards

MCA MGN 323 (M+F) - *Explosives Picked Up At Sea* sets out the instructions to be followed if explosives are picked up at sea, although proper management of UXO should ensure that this does not occur.

CEN CWA 15464:2005 defines competence standards for operators and supervisors involved in EOD work; this should be backed up by specific training on the types of munitions likely to be present at a site.

United Nations Mine Action Service IMAS 09.30 - *Explosive ordnance disposal* provides specifications and guidelines for the safe conduct of Explosive Ordnance Disposal (EOD) operations.

C.19.4.2 Other Relevant Guidance

This section has largely been based on guidance contained in *Unexploded Ordnance Risk - Considering Unexploded Ordnance Risk on and around the British Isles*, which was prepared by PMSS, with contributions from 6 Alpha Associates, and provided to RenewableUK for inclusion in industry guidance.

The Crown Estate Guidance Note March 2010 - Dealing with munitions in marine sediments.

CIRIA (Construction Industry Research and Information Association) *Unexploded ordnance (UXO) A guide for the construction industry*; Publication code C681; ISBN: 978-0-86017-681-7 provides detailed information on types of UXO, survey methods etc.

C.19.4.3 ELSEWHERE IN THIS GUIDANCE

Survey & Geophysical
Geological Unknowns

C.20 VESSEL SELECTION

C.20.1 OVERVIEW

OREI development involves large numbers of vessels of diverse types, undertaking a wide range of marine operations such as personnel transfer, survey work, movement of materials and components, offshore installation and lifting, dive support and provision of temporary offshore accommodation. In order to procure vessels that can meet these requirements in a safe and efficient manner, a robust vessel selection process is necessary to ensure that each vessel that is selected is fit for its intended purpose, defined as:

> "*A vessel with the appropriate capability, equipment and crewing levels to carry out planned activities at a specific site for a defined duration, taking due consideration of the activity, site location, conditions and any changes to plans or incidents which may reasonably be foreseen*".

This section of guidance provides an overview of vessel selection issues; detailed guidance on regulation of vessels, and a process for vessel selection is provided in the RenewableUK Vessel Safety Guide.

C.20.1.1 POTENTIAL HAZARDS AND RISKS

C.20.1.1.1 Direct Health and Safety Risks

Any accident involving a vessel has the potential to harm personnel on board; in the most extreme cases, if the vessel is severely damaged or destabilised, then sinking or capsize could result, with the lives of all aboard being endangered. The risk of accidents is highest if a task is being undertaken that goes beyond the capability of the vessel, or the competence of its crew.

C.20.1.1.2 Commercial and Operational Risks

When chartering a vessel, or entering into contracts for activities that will involve the use of a vessel, it is important to understand fully the responsibilities and liabilities that the charter agreement imposes on each party to the charter, otherwise unexpected, and hence uninsured, liabilities may be incurred.

C.20.1.1.3 Indirect and Consequential Risks

If a design has progressed without sufficient consideration of vessel availability at an early stage, then the choice of vessels may be extremely constrained, potentially leading to delays while waiting for a vessel to become available, and high costs to charter a highly specialised vessel. Alternatively, the design might have to be modified, which could again incur cost and delay.

C.20.1.2 RELEVANCE TO KEY LIFECYCLE PHASES

The existence and availability of suitable vessels should be considered from the earliest stages of project definition, in order to ensure that it is possible to build and maintain the proposed device concept or OREI development. Decisions that are made as the design process progresses may either ease or constrain vessel selection, and the safety of vessel operations over the rest of the project lifecycle, so vessel requirements should be considered as part of the design review process.

Vessel selection will be required prior to engaging vessels at any stage of the lifecycle; this is likely to involve significant effort in the early stages of construction and O&M, when large numbers of vessels are introduced to the development.

C.20.2 REGULATORY REQUIREMENTS

The applicable regulations for the construction, operation and crewing of vessels depend on the type (various classes of cargo / passenger / high speed / self-propelled / barge) and size (Gross Tonnage) of the vessel, its area of operation, and its country of registration.

As vessels operate in a global market, many of the regulatory requirements are defined by the International Maritime Organisation through conventions such as SOLAS. Design rules for the structure, machinery and equipment of ships are defined by a number of international classification societies such as Lloyd's Register and DNV.

The main regulator for vessel operations in the UK is the MCA, which is responsible for enforcement of all merchant shipping regulations as well as publishing codes for vessels below 500 GT. Under Port State Control, the MCA has the responsibility for inspection of foreign ships in UK ports, to verify their compliance with international rules for the condition, manning and operation of ships.

C.20.3 Managing the Risks

C.20.3.1 Approaches to Risk Assessment

The vessel selection process begins with defining a vessel specification, based on:

- The activity to be undertaken;
- Site specific conditions and hazards, and methods to be used; and
- The facilities that are required on the vessel.

Vessels can then be compared against the specification, enabling suitable vessels to be identified; the vessel management arrangements should also be assessed, in areas such as training, certification, safety management, communications and the competence and capacity of the crew to support the intended operations.

For many operations, there will be a range of vessels and barges that can accomplish the task with varying levels of cost and safety. All use of vessels should be preceded by a suitable selection process, the level of which should be proportionate to the risks involved. The process should be applied both to self-propelled vessels and to dumb barges; while these are outside the scope of many marine regulations, their use can still affect the safety of a project.

While there is increasing understanding of the requirements for vessels in offshore wind development, and purpose-designed vessels are available, the wave and tidal sector does not yet have a sufficient level of activity to attract dedicated vessels, and also operates in particularly challenging locations where experience is more limited. Developers are therefore required to make use of general-purpose vessels, and short-term charters of vessels from the spot market. This combination of factors increases the importance of operating thorough vessel selection and management processes.

C.20.3.2 Monitoring, Review and Change Management

If a vessel is to be used in a manner that differs from its original design intent, and especially in cases where mobilisation will include the conversion or modification of the vessel for the work that it is to undertake, then such changes should be subject to design review and risk assessment, considering factors such as equipment selection, effects on structural strength, stability, and the provision of safe working areas for the crew.

Major modifications can affect the conformity of a vessel with classification society rules, therefore requiring formal assessment and approval in order for the vessel classification to remain valid.

The modifications should be audited after installation, to ensure conformity with the design intent, and to check for any previously unidentified hazards.

C.20.4 Codes of Practice and Guidance

C.20.4.1 Regulations and Standards

MCA MGN280 - *Small Commercial Vessel and Pilot Boat Code of Practice* applies to vessels constructed since 2004; vessels that were constructed before this date continue to be regulated under the superseded codes below:

MCA Brown Code - *The Safety of Small Workboats & Pilot Boats*;

MCA Yellow Code - *Code of Practice for the Construction, Machinery, Equipment, Stability, Operation and Examination of Motor Vessels, of up to 24 Metres Load Line Length, in Commercial Use and which do not carry Cargo or more than 12 Passengers*.

IMO Safety regulations for different types of ships summarises different types of ship, defined in IMO instruments, and the codes that apply; these may form the basis for future codes that are specific to vessels used in OREI construction and support.

C.20.4.2 Other Relevant Guidance

RenewableUK *Vessel Safety Guide* provides detailed guidance on the process of selection, mobilisation and management of vessels to ensure that all are Fit for Purpose and are operated within a robust Health & Safety management system at any stage of the lifecycle. Appendix 1 provides describes specific considerations for survey activities.

RenewableUK *Guidelines for the Selection and Operation of Jack-ups in the Marine Renewable Energy Industry* provides industry guidance aimed at jack-up operators, developers and contractors.

Noble Denton 0021/ND - *Guidelines for the Approval of Towing Vessels* provides guidance for the approval of towing vessels for specific tows.

Noble Denton *Guidelines for Marine Transportations* provides a process for the planning and approval of the transport of non-standard cargos, either on a ship or barge, or by floating.

DNV-OS-J301 *Standard for Classification of Wind Turbine Installation Units*, obtainable from DNV Offshore Standards webpage covers self-elevating and column-stabilised vessels.

C.20.4.3 Examples of Relevant Classification Society Rules

DNV *Rules for Classification of Ships*: Part 5, Chapter 7 covers Offshore Service Vessels, Tugs and Special Ships, which include:

- Barges (Section 14);
- Crane Vessels (Section 17);
- Cable Laying Vessels (Section 19);
- Wind Turbine Installation Vessels (Section 22); and
- Large Windfarm Maintenance Vessels (Section 23).

DNV Rules for Classification of High Speed, Light Craft and Naval Surface Craft: Part 5, Special Service and Type contains tentative rules for:

- Windfarm service craft carrying up to 12 passengers (Chapter 9); and
- Windfarm service craft (Chapter 10).

C.21 VIBRATION

C.21.1 OVERVIEW

People may be exposed to different forms of vibration in the course of offshore work:

- Hand-arm vibration (HAV), most commonly arising from the use of certain tools; or
- Whole body vibration (WBV), which may arise from shocks and jolts during transit on vessels in rough sea conditions.

Both of these can lead to painful conditions that impair or prevent people from carrying out their normal work and social activities.

C.21.1.1 POTENTIAL HAZARDS AND RISKS

C.21.1.1.1 Direct Health and Safety Risks

HAV can cause damage to blood vessels, nerves and joints, resulting in permanent pain and disablement. The exact nature of the damage varies; resulting medical conditions include Hand Arm Vibration Syndrome (HAVS) and Carpal Tunnel Syndrome. The risk depends on the level of exposure to vibration, both in terms of magnitude and duration, so workers repeatedly carrying out tasks with vibrating tools are at highest risk. Depending on the level of vibration, exposure limits may be reached in timescales ranging from a few minutes to a large proportion of the working day.

Vibration-related health problems can permanently impair a worker’s capability, including becoming unable to carry out fine work with small components, sensitisation to cold / wet conditions, and reduced grip strength, which may affect activities such as ladder climbing.

WBV can lead to back pain, either due to unusually high levels of exposure, or more commonly in combination with other risk factors such as muscle strains caused by heavy physical activity. A small vessel, at high speed, in rough sea conditions can subject those aboard to severe impacts. Even if no injury occurs, a rough passage will contribute to physical and mental fatigue.

Use of helicopters can also expose workers to WBV, but of a different nature to that experienced in a vessel.

C.21.1.2 RELEVANCE TO KEY LIFECYCLE PHASES

C.21.1.2.1 Hand-Arm Vibration

As the risk from hand-arm vibration increases with exposure, the people at greatest risk are workers who repeatedly undertake tasks with vibrating tools, such as:

- Assembly teams who move from one structure to another, and repeat tasks such as nut running with impact drivers; or
- Teams undertaking major maintenance / modification work, involving tasks such as grinding, cutting, and mechanical surface preparation on a large number of structures in turn.

Exposure is reduced where jobs are rotated between different members of a work team, or where a wide variety of tasks is undertaken during the working day.

C.21.1.2.2 Whole Body Vibration

As OREIs increase in size and remoteness from shore, the risk from exposure to WBV during transit from shore bases may increase, due to the longer distances involved, which may result in greater duration of journeys, potentially higher speed vessels, and rougher seas.

During the O&M phase, workers may be in transit for a number of hours per day, on the majority of working days, leading to a high level of exposure; access vessel specifications need to take account of the foreseeable conditions.

C.21.2 REGULATORY REQUIREMENTS

The Control of Vibration at Work Regulations 2005 regulate work activities that expose workers to either hand-arm or whole body vibration.

Where vibration exposure arises from vessel operations, the relevant regulations are the Merchant Shipping and Fishing Vessels (Control of Vibration at Work) Regulations 2007.

C.21.3 MANAGING THE RISKS

Both sets of regulations place a duty on any employer, whose activities may expose workers to risk from vibration, to carry out a suitable and sufficient risk assessment of the risk to employees that a work activity creates, in order to decide on any measures necessary to protect employees from the effects of vibration. The first step is to assess the level of exposure, averaged over an eight-hour period, which is then compared against the:

- Exposure Limit Value (ELV); this must not be exceeded, so if the assessment shows that this is being exceeded, then steps must be taken to bring exposure below this limit;
- Exposure Action Value (EAV); if this is likely to be exceeded, then:
    - Exposure must be reduced ALARP;
    - Health surveillance of exposed employees is required; and
    - The employer must provide employees with suitable and sufficient information, instruction and training.

The duty is always to reduce exposure ALARP, even if the assessment shows that it is below the EAV.

C.21.3.1 APPROACHES TO RISK ASSESSMENT

C.21.3.1.1 Hand-Arm Vibration

The risk assessment should consider:

- All the factors related to the risk, which include:
    - The estimated daily exposure;
    - Working conditions, including factors such as:
        - Temperature: circulation is reduced in cold hands, increasing susceptibility to HAV;
        - The nature of the exposure (intermittent or continuous);
        - Working position and weight of tools; and
        - Any pre-existing health problems;
- Whether exposure can be prevented, for example by using a different process, or tools that are mounted or supported rather than being hand-held.

C.21.3.1.2 Whole Body Vibration

WBV can be assessed, in a similar manner to HAV, in terms of exposure averaged over an eight-hour reference period. However, this approach does not adequately assess the risks presented if the WBV arises from shocks and jolts, which are better measured in terms of a Vibration Dose Value (VDV).

C.21.3.2 RISK MITIGATION MEASURES

Where prevention of exposure is not reasonably practicable, then the duty is to limit the exposure.

C.21.3.2.1 Hand-Arm vibration

Exposure may be limited by measures such as:

- Use of improved tools, mounting arrangements and consumables;
- Ensuring that tools are properly maintained, and suitable for the task; and
- Limiting duration of exposure, by changing methods of work to reduce the need for processes which give rise to HAV, or by rotating the work amongst members of a team.

It should be noted that while PPE is available in the form of “anti-vibration” gloves, it is not judged by the HSE to be particularly effective, and may even increase vibration at certain frequencies. However, PPE which protects the worker against cold conditions, and thereby maintains circulation in the hands, reduces susceptibility to HAV.

C.21.3.2.2 Whole Body Vibration

Mitigation of the risk associated with whole body vibration aboard vessels requires a combination of:

- Appropriate vessel design and selection, to minimise impact forces at service speed in the intended operating conditions;
- Careful detail design and set-up of engineered mitigation, such as suspension seating, to maximise its effectiveness, and ensure that it does not worsen the most severe impacts; and
- Correct handling of vessels, including speed reduction where conditions dictate.

C.21.3.3 Monitoring, Review and Change Management

Where manufacturer’s data is used in assessing the level of vibration, then it is important that the actual conditions of use match the reference conditions. Worn tools, or changes in consumables, may significantly increase hand-arm vibration levels; workers should report any such increases in vibration from a tool, and particularly if they experience symptoms such as numbness or tingling after working with tools.

The risk of developing vibration-related health problems varies between individuals; genetic factors, pre-existing health conditions affecting circulation, and muscle / back strains from other work can greatly increase susceptibility, so effective monitoring of workers who have been identified as being exposed to vibration is required.

C.21.4 Codes of Practice and Guidance

C.21.4.1 Regulations and Standards

HSE L140 – *Hand-arm vibration – The Control of Vibration at Work Regulations 2005*.

HSE L141 – *Whole-body vibration – The Control of Vibration at Work Regulations 2005*, is mainly focused on WBV arising from onshore activities, such as construction vehicles, but the guidance is relevant for vessels in rough sea conditions.

MCA MGN 353 – *The Merchant Shipping and Fishing Vessels (Control of Vibration at Work) Regulations 2007*, address both HAV and WBV. While these apply to ships’ crew, Annex B addresses WBV arising from the motion of a vessel.

MCA MGN 436 – *Whole Body Vibration: Guidance on Mitigating Against the Effects of Shocks and Impacts on Small Vessels.*

MCA MGN 446 - *The Merchant Shipping and Fishing Vessels (Control of Vibration at Work) Regulations 2007 - Procedure for Seeking Exemptions*. Note that any exemption has to be justified on the grounds that compliance with the procedure will have adverse health and safety consequences; for example, emergency rescue capabilities could be impaired if speed had to be limited to limit WBV. Commercial considerations alone are not sufficient justification.

C.21.4.2 Other Relevant Guidance

Control the risks from hand-arm vibration - Advice for employers on the Control of Vibration at Work Regulations 2005.

Control back-pain risks from whole-body vibration - Advice for employers on the Control of Vibration at Work Regulations 2005.

Vibration solutions - Practical ways to reduce the risk of hand-arm vibration injury is mainly focused on the manufacturing and construction industries, but provides some relevant examples of adjusting processes, and managing the provision of tools.

C.22 WASTE AND SPILLAGE MANAGEMENT

C.22.1 OVERVIEW

Wastes and spillages can arise from various activities over the lifetime of an OREI; introducing a range of hazards, both directly, as well as during remedial actions such as the disposal and transport of waste. The nature and extent of the waste or spillage will determine the level of risk that is associated with it. This section addresses the health and safety risks to people in the course of dealing with wastes and spillages, rather than the environmental risks and disposal requirements.

C.22.1.1 POTENTIAL HAZARDS AND RISKS

A range of different waste streams may arise over the lifetime of an OREI:

- Routine O&M work may give rise to small quantities of waste on a regular basis;
- Periodic maintenance, such as oil changes in gearboxes and transformers, will generate larger quantities on a less frequent basis; and
- Offshore accommodation, whether used routinely or as a refuge in the event of stranding, will require the removal of human wastes.

The risks from waste streams should be considered, both in terms of the hazard presented by the wastes themselves, and from any disposal measures required. Disposal of wastes from offshore locations is much more complex than onshore, due to the need to transfer the waste to shore on vessels.

C.22.1.1.1 Direct Health and Safety risks

Spillages and leakage, whether occurring during normal operation, maintenance activities, or waste disposal, present a range of hazards:

- Contamination of floors and ladders increases the risk of slips and falls;
- Contamination of equipment can degrade its performance, for example if oil leakage contaminates the surface of a brake; and
- Leakage of combustible materials, onto components that may become hot in normal or abnormal operation, introduces a fire risk.

Wastes and spillages of hazardous substances are considered in more detail in Section C.9.

C.22.1.1.2 Indirect and Consequential Risks

Spillages or leakages that are not contained within the OREI are likely to present a risk to the marine environment. The severity of this risk, and the extent of subsequent work that has to be undertaken to contain the release, will depend on the nature of the material that is spilled and the extent of the spillage.

C.22.1.2 RELEVANCE TO KEY LIFECYCLE PHASES

The design phase needs to consider:

- The inventory of materials, potential for leakage, and requirements for scheduled changeover (for example of oils or lubricants) over the lifetime of the OREI:
    - It may be possible to incorporate systems that extend the life of fluids such as lubricants and substation transformer oils, through effective filtration and moisture removal;
    - This may also bring cost savings, and extended equipment life;
- How scheduled changeover of fluids will be carried out:
    - Where large volume changeovers are required, such as on substations, it may be beneficial to install pipework to enable fluid transfer, rather than handling in containers;
    - Where fluids are to be drained manually, suitable access is needed.

If portable generators are required to be used to provide a temporary power supply between installation and completion of commissioning, or during major maintenance works, then if diesel fuel is used, this may present one of the most significant risks, in terms of spillage and environmental impact, as there will be a large volume of liquid fuel stored in a temporary container, connected to a temporary generator. The design and operation of such arrangements should be subject to thorough risk assessment to ensure that its temporary nature does not give rise to elevated risk of spillage or leakage. The severity of such a spillage would be higher than for other spillages due to the toxic nature of the fuel.

While the design phase will determine the risks, most of the challenges of managing waste and spillages will arise during the O&M phase.

C.22.2 REGULATORY REQUIREMENTS

An employer's general duties under the HSWA include:

- Ensuring, "*so far as is reasonably practicable, safety and absence of risks to health in connection with the use, handling, storage and transport of articles and substances"*; and
- Maintaining places of work "*in a condition that is safe and without risks to health".*

Employees are required to co-operate so far as is necessary to enable these duties to be performed.

More specifically, the Workplace (Health, Safety and Welfare) Regulations 1992 impose a duty on employers to ensure that:

- Every workplace is kept sufficiently clean; and
- So far as is reasonably practicable, waste materials shall not be allowed to accumulate in a workplace except in suitable receptacles.

Waste discharges from ships exceeding 400 GT or 15 passengers are regulated under MARPOL, which is given effect in the UK in the Merchant Shipping (Prevention of Pollution by Sewage and Garbage from Ships) Regulations 2008; and may be applied on a voluntary basis by owners of smaller vessels. Discharge of plastics, and other wastes that do not degrade rapidly in the environment, is prohibited.

When electrical or electronic components are replaced, their disposal is subject to the Waste in Electrical and Electronic Equipment (WEEE) Regulations, under which the original supplier of such equipment (if supplied after August 2005) is responsible for taking it back, and disposal through an Authorised Treatment Facility; this responsibility may be discharged in a variety of ways, including contractual arrangements with the purchaser, or membership of collection schemes.

C.22.3 MANAGING THE RISKS

Maintaining a working environment that is free from wastes and spillages requires good attention to housekeeping; this requires more effort in offshore locations, due to the additional complications in waste transfer and disposal, and limited opportunities for auditing and inspection.

Employers should aim to establish a culture where the importance of maintaining a clear workplace is emphasised:

- Encourage personnel to report any leakage or poor workplace conditions, and ensure that remedial action is taken:
  - Spillages and leakage should be cleared up as soon as possible, particularly if they are contaminating floors or ladders; this may require the use of suitable spill kits;
  - The cause of the leakage should also be identified and rectified;
- The Transfer of Control, on completion of a work package under the Wind Turbine Safety Rules, should include confirmation that wastes have been removed, and the work location left in a clean and tidy state.

Practical steps should also be taken, including ensuring that containers to be used for transferring fluids are suitable for handling within the WTG, and during transfer to / from vessels, probably involving a combination of manual and mechanical handling:

- A sufficient supply of suitable containers should be available to technicians, thereby reducing the temptation to improvise and use unsuitable containers for the transfer of fluids;
    - Containers used for potable water or foodstuffs should never be used for any other purpose;
- Wastes should be segregated according to storage and disposal requirements, and clearly labelled at all times.

C.22.3.1 Monitoring, Review and Change Management

Inspections and audits of OREIs should include checks for any leakage, or build-up of wastes; where these are found, they should be followed up promptly.

As a requirement of the consenting process, OREIs will operate Environmental Management Systems, which include a Marine Pollution Contingency Plan; this will define the actions to take in the event of any major spillages occurring.

C.22.4 Codes of Practice and Guidance

C.22.4.1 Regulations and Standards

HSE L24 - *Workplace (Health, Safety and Welfare) Regulations 1992 - Approved Code of Practice* – see in particular Regulation 9.

The Merchant Shipping (Prevention of Pollution by Sewage and Garbage from Ships) Regulations 2008.

C.22.4.2 Other Relevant Guidance

HSE INDG225 – *Preventing Slips and Trips at Work* provides practical guidance.

C.23 WELFARE

C.23.1 OVERVIEW

Working conditions affect the health and safety of employees in relation to the risk of accidents, illnesses, and development of longer term health conditions. Offshore WTGs are workplaces that are normally unoccupied, but will be subject to intensive periods of occupation and work during construction, commissioning and maintenance activities. Other offshore structures such as substations or accommodation facilities may be occupied for longer time periods.

Key welfare issues to consider include:

- Maintaining appropriate conditions in the workplace, including ventilation, temperature, lighting, cleanliness and tidiness;
- Provision of suitable facilities for sanitary, eating and refuge requirements;
- Conditions for workers based offshore for extended periods, for example on construction or accommodation vessels or platforms;
- Working time, which will generally involve managing various forms of shift work; and
- Workplace stress.

Within this section, welfare issues relating to workplace conditions are considered first, with those relating to working time and stress being considered in C.23.3.

C.23.2 WORKPLACE CONDITIONS

C.23.2.1 POTENTIAL HAZARDS AND RISKS

C.23.2.1.1 Direct Health and Safety Risks

The risk of accidents is increased in a workplace that has inadequate lighting, is dirty or untidy, or has inadequate access for the tasks to be undertaken. A lack of ventilation or control of temperature leads to discomfort, loss of concentration, and a tendency to rush tasks so that the worker can move to a more comfortable environment.

If workers are unable to maintain appropriate hygiene standards, then this introduces a risk of illness or infection.

C.23.2.1.2 Commercial and Operational Risks

If sanitary facilities are only available on access vessels, then if workers are to use these, there will be a loss of productivity arising from time spent waiting for and transferring to the vessel; workers will also face an increased exposure to risk arising from additional transfers, and the vessel will not be available for other purposes.

C.23.2.1.3 Indirect and Consequential Risks

If welfare provision is inadequate, then this may affect the retention of staff in key offshore roles, and might also raise issues of gender equality.

C.23.2.2 RELEVANCE TO KEY LIFECYCLE PHASES

Welfare provision is a key issue affecting people working on the OREI, from the start of construction to the completion of decommissioning.

The greatest challenges in welfare provision may arise during the O&M phase, as workers will be remote from the facilities provided on vessels or onshore / offshore bases. For offshore technicians, this will affect most of their time at work.

The working conditions will be determined by decisions made at the design stage, such as the layout of equipment and provision of lighting and ventilation, together with the effectiveness of arrangements to maintain satisfactory conditions.

C.23.2.3 REGULATORY REQUIREMENTS

Under CDM, the Client has to ensure that there are suitable management arrangements in place for the provision of project welfare facilities, and must also ensure that construction (the definition of which includes decommissioning) does not start on a notifiable project until such facilities are provided. The Principal Contractor (PC) is responsible for providing and maintaining suitable facilities throughout the construction phase, although may subcontract the actual provision.

Workplace conditions and welfare provisions are specified by the Workplace (Health, Safety and Welfare) Regulations 1992, which expand on an employer's general duties under the HSWA. Amongst other issues, the regulations address:

- Conditions in the workplace, such as cleanliness, lighting, temperature and flooring;
- Provision of sanitary conveniences, washing facilities, drinking water, clothing accommodation, changing facilities and facilities for rest and eating meals;
    - At temporary work sites (i.e. those which are only used infrequently or for short periods), such facilities are to be provided so far as is reasonably practicable;
        - Note that the EC Workplace Directive (89/654/EEC), which underlies these regulations, does not apply to temporary or mobile work sites, so suppliers from other member states may not be familiar with the UK regulatory requirement.

An onshore base should provide all facilities required under the regulations, which also specify the level of provision in relation to the foreseeable needs of a workforce.

The HSE provides guidance on provision of lighting; note that this states that "*the lighting objectives for temporary installations should be the same as for permanent ones*". The guidance also covers the provision of suitable emergency lighting systems.

The requirements for the provision of welfare facilities, and maintenance of suitable working conditions on ships are set out in maritime regulations, including the Small Commercial Vessels Code, and the Code of Safe Working Practices for Merchant Seamen.

C.23.2.4 MANAGING THE RISKS

C.23.2.4.1 Risk Mitigation Measures

At the design stage, it should be recognised that a WTG is a temporary workplace, so the relevant requirements should be considered. The duty under the Workplace regulations is therefore to provide sanitary, washing, rest and eating facilities so far as is reasonably practicable; the specific approach to be adopted will depend on the circumstances of a particular OREI:

- It is not expected that there would be the same amenity facilities or arrangements as would be provided at an onshore location;
- Arrangements might include:
    - A dry toilet system with the necessary privacy for personnel who will use it;
    - Means of cleansing the hands; and
    - Another area where technicians can eat and potentially warm up in cold weather conditions;

These might be combined with provision of an overnight refuge, for use in the event of stranding, and should be designed to simplify maintenance and waste disposal requirements.

C.23.2.4.2 Monitoring, Review and Change Management

Employers should set appropriate standards for maintaining workplace conditions, supported by suitable supervision or audit arrangements.

C.23.3 WORKING TIME AND STRESS

Offshore work, particularly for developments that are located far from shore, is likely to involve long working days, sometimes over 12h, and fall within the definition of shift work as given in HSE guidance.

Shift work may also be planned to enable 24h working during construction and major maintenance campaigns, possibly combined with use of offshore accommodation, to avoid the lost time and fatigue implications of long daily transit journeys from and to an onshore base. Even routine O&M may involve extended working days, to take advantage of favourable weather, and allow for a full working day at the offshore site, with additional time for transit from and back to an onshore base.

Where tidal access constraints affect the use of ports, this may affect the planning of work, and prevent working hours being optimised for the tasks and people involved.

For these reasons, the management of working time on OREIs is likely to constitute the management of shift work. The duties are complicated by the fact that different rules apply to mariners, compared to OREI personnel who will depend on the mariners for transfer to and from their place of work, and for provision of emergency assistance.

C.23.3.1 POTENTIAL HAZARDS AND RISKS

C.23.3.1.1 Direct Health and Safety Risks

There is strong evidence that fatigued workers are more likely to make mistakes, increasing the risk of accidents occurring, or errors adversely affecting operations.

Working patterns may also lead to an increased susceptibility to, or worsening of symptoms of, chronic health problems such as cardiovascular disorders and diabetes.

C.23.3.1.2 Indirect and Consequential Risks

While the risks related to stress and long hours may be particularly clear for offshore workers, work related stress can occur in any workplace, especially if work is being undertaken against unrealistic schedules. In addition to the direct health impacts on the people affected, if tired people are making poor decisions, then this can adversely impact the implementation of a project, and the safety of those affected by the decisions.

If workers are living in temporary accommodation away from home, then this may not encourage a healthy lifestyle and sufficient rest between shifts; this could potentially affect short-term performance on specific tasks, as well as increasing the risk of longer term health problems.

C.23.3.2 REGULATORY REQUIREMENTS

The Working Time regulations define:

- A limit to the average working week of no more than 48h over a defined reference period, although individual employees can choose for this limit not to apply to them; and
- The entitlement of workers to minimum rest periods between shifts and breaks during the working day.

In addition to compliance with working time regulations, employers have duties under the MHSWR to carry out a suitable and sufficient assessment of the risk of stress-related ill health arising from work activities, and under the HSWA to take measures to control that risk.

C.23.3.2.1 Working Time for Mariners

Mariners are subject to the Merchant Shipping (Hours of Work) Regulations 2002, which are implemented in MSN 1767, and specify hours of work, rest periods, and arrangements in cases where these have to be varied for operational reasons or emergency response. It should be noted that any collective agreement to adopt a pattern of work and rest periods that does not comply with those specified in the regulations can only be implemented if approved by the MCA; this differs from the situation onshore where employees can choose to opt out of the limits defined in the Working Time regulations without any regulatory approval being required. The arrangements for exemptions were further amended in 2012 by the Manila amendments to STCW, as described in MGN448.

In summary, the regulations require that seafarers have an absolute minimum of 10h rest in every 24h period (with no provision for averaging across more than one period), and a minimum of 77h rest in every 7 days.

C.23.3.3 Managing the Risks

C.23.3.3.1 Approaches to Risk Assessment

Individual workers have different degrees of susceptibility to adverse effects of shift work, due to each person's unique combination of physiological and psychological factors; while such factors cannot be controlled by the employer, they should be aware that the effects of the same work pattern may differ between individuals.

The risk assessment should consider factors such as the shift pattern, the workload, and the nature of the work, in terms of the intensity, level of concentration required, the working environment, and the consequences of an error.

The HSE recommends that the Management Standards approach be used in assessing risk of workplace stress; this considers the demands on workers, the extent of their control of their working pattern, how they are supported in their work, relationships within the organisation, clarity of roles, and how organisational change is managed.

C.23.3.3.2 Risk Mitigation Measures

The HSE provide detailed recommendations of good practice, to minimise the effects of shift work on the safety and productivity of workers; these range from the overall design of shift patterns, to the detailed planning of tasks during a shift, so that safety-critical or hazardous tasks are avoided at times when workers are likely to be less alert.

The design of offshore accommodation, and the planning of operations, should ensure that off-duty workers are able to get proper rest, thereby safeguarding the wellbeing of the offshore workforce; noisy operations, such as jacking a jack-up platform, may disturb sleep and increase fatigue.

C.23.3.3.3 Monitoring, Review and Change Management

Employers have a duty under the Working Time Regulations to ensure the employees are fit for night time working, and to offer regular free health assessments to such workers. In addition, monitoring of actual working hours, effective supervision, and ensuring that employees can raise concerns relating to working time, can all help to identify issues at an early stage, before significant health and safety impacts occur.

Working hours need to be pro-actively managed; for example, there will be occasions where a task is incomplete at the end of a normal working day; in this situation, a risk assessment needs to consider the relative risks of leaving completion for another day, handover to another team, or extending the working day. The decision will also have implications for others beyond the immediate team that is working on the task, for example, it may be necessary to mobilise another access vessel to support the extended working, and allow the original crew to keep to their normal working hours. For such reasons, the progress of tasks needs to be monitored, so that decisions can be made well before the end of the normal working day, and any necessary arrangements implemented in an orderly manner.

C.23.4 Codes of Practice and Guidance

C.23.4.1 Regulations and Standards

HSE L24 - *Workplace (Health, Safety and Welfare) Regulations 1992 Approved Code of Practice*, describes workplace conditions and requirements for facilities.

HSE HSG218 – *Managing the causes of work-related stress*, and HSE INDG430 – *How to tackle work-related stress* provide detailed guidance on how to manage work-related stress through the adoption of the Management Standards approach.

HSE HSG256 - *Managing Shift Work*.

HSE HSG38 – *Lighting at* Work, gives details on the requirements for workplace lighting.

BS 5266-1:2011: *Emergency lighting. Code of practice for the emergency escape lighting of premises.*

MCA MSN1767 – *Hours of Work, Safe Manning and Watchkeeping* defines the management arrangements for working time of seafarers in merchant shipping.

MCA MGN 448 - *Standards of Training, Certification and Watchkeeping Convention, 1978 as Amended; Manila Amendments: Medical Certification, Hours of Work and Alcohol Limits* brings provisions for working time exemptions into line with the ILO Maritime Labour Convention, which was ratified in August 2013.

C.23.4.2 OTHER RELEVANT GUIDANCE

HSE RR446 – *The development of a fatigue / risk index for shiftworkers*, may assist risk assessment of shift work arrangements; an associated fatigue and risk calculation spreadsheet and guidance notes are also available, although note that the guidance cautions against its use in work patterns that only involve day working, or for shift patterns that are worked offshore.

C.24 WORK AT HEIGHT

C.24.1 OVERVIEW

A place is considered to be “at height” if a person could be injured by falling from it; this means that work at height may occur in many situations in addition to the more obvious activities such as ladder climbing.

Work at height is inherent in the nature of WTGs; however the frequency of exposure and complexity are both increased when offshore:

- Access to the transition piece platform will generally involve ladder climbing, rather than the stairway entry to the base of an onshore WTG tower;
- The lack of solid ground around the WTG may require some tasks, that could be performed onshore from a Mobile Elevating Work Platform, to be carried out by roped access; while both approaches constitute work at height, they present different risks;
- Fixed and portable equipment may be subject to accelerated deterioration, due to marine fouling and corrosion; and
- If work at height also involves work over water, then rescue and evacuation procedures become more complex.

While WTGs are likely to pose the greatest challenges, work at height may also occur on vessels, wave and tidal devices, and offshore substations, depending on the designs and operations involved.

C.24.1.1 POTENTIAL HAZARDS AND RISKS

C.24.1.1.1 Direct Health and Safety Risks

Work at height can expose people to a range of hazards:

- Falls from height can result in severe injury or death;
    - Falls from height are the biggest single cause of workplace fatalities;
    - Any injury that incapacitates a worker offshore will lead to a more complex evacuation being required than would be the case onshore;
- If people are beneath work being carried out at height, then dropped objects present a hazard; and
- If a person is suspended in an upright position for a period of time, as may occur after a fall has been arrested, suspension trauma or syncope may lead to loss of consciousness.

C.24.1.1.2 Commercial and Operational Risks

Any work at height must be undertaken by a competent team who can effect a rescue in the event of a fall; clearly if tasks can be completed without the requirement to work at height, then this burden is reduced.

C.24.1.2 RELEVANCE TO KEY LIFECYCLE PHASES

At the design stage, it is essential that the specification and detailed design of safety systems for work at height take account of the offshore environment; this may affect the types of system to be used, as well as material selection, and ensuring that moving parts are protected by suitable sealing arrangements.

During construction and commissioning, it is possible that safety systems for work at height will be incomplete or uninspected, leading to greater reliance on PPE than would otherwise be the case. Where it is possible to assemble and inspect systems onshore, prior to offshore deployment, then not only does this allow the systems to be used at an earlier stage, but it also reduces the number of offshore tasks to be carried out.

The O&M phase needs to consider the inspection and maintenance requirements of height safety systems, together with the long term integrity of structures that are used as anchorages. While it may be possible to conduct most routine O&M tasks without working at height, other than for initial access, care needs to be taken if tasks lead to the creation of temporary openings, such as open access hatches or gaps in floors where equipment has been removed, which may create situations where work at height occurs in a location that would not otherwise be at height.

C.24.2 Regulatory Requirements

The Work at Height Regulations require employers to assess the risks of work at height, and, so far as is reasonably practicable, take steps to avoid those risks, according to a clear hierarchy:

1. Avoid work at height;
2. Where work at height cannot be avoided, use work equipment or other methods to prevent falls from occurring; and
3. Where the risk of falls cannot be eliminated, take suitable measures to minimise the distance and consequences of a fall.

Adoption of measures at the lowest level of this hierarchy, such as fall-arrest systems, reduces but does not eliminate the risk of serious injury:

- Even if the system works perfectly, the climber will still be subject to impact forces of up to 6 kN, transmitted through their harness, and is also at risk of impact against adjacent structures during their fall, prior to the fall being arrested;
- If the system is not used correctly, then it may not be effective, for example if an error is made in scaffold-hook placement or connection, or if there is inadequate vertical clearance between the climber and solid objects below;
- Where fall-arrest systems with detachable components such as “sliders” are used, then these must be compatible with the fixed rail or wire, otherwise they may fail to operate;
- The harmonised standard for guided type fall arresters including a rigid line (or rail), EN 353 has deficiencies that introduce dangerous shortcomings in performance, with the effect that a fall arrester that complies with this standard may fail to arrest a fall where the person falls away from the ladder, rather than straight down. These shortcomings are addressed in the UK National Annex to the standard, which specifies improved testing methods;
    - Until EN 353-1 has been revised, the HSE advise duty holders who use / purchase equipment that meets the requirements of BS EN 353-1:2002 to ensure that it has also passed suitable additional tests in order to address those deficiencies in the standard. Duty holders should check the scope of these tests with a relevant Notified Body, normally via the applicable manufacturer.

The schedules to the regulations specify mandatory requirements for:

1. Places of work, and access and egress at height;
2. Guard rails, barriers and other collective means of protection;
3. Working platforms;
4. Collective safeguards for arresting falls;
5. Personal fall protection systems;
6. Ladders; and
7. Inspection reports.

C.24.3 Managing the Risks

The project definition and design phases offer the greatest opportunity to reduce the risks from work at height over the rest of the development lifecycle:

- The detailed design of structures and equipment will determine whether foreseeable tasks over their operating lifetimes can be carried out without the need to work at height;
- Where an unavoidable need to work at height is identified, the design should ensure that the risks are minimised; this may involve measures such as:

- Provision of suitable and sufficient anchor points for use with equipment for work positioning and fall-arrest; and
- Provision of fixed fall-arrest systems on ladders.

The detail design of structures will also determine the risk posed by dropped objects, in situations where it is foreseeable that work may be in progress at different levels of a structure; for example the use of boat landing structures is likely to involve personnel being present on the transition piece at the same time as on the vessel deck, with loose goods to be transferred between these levels.

C.24.3.1 APPROACHES TO RISK ASSESSMENT

The design risk assessment process needs to consider the potential requirements for work at height over the lifecycle of the WTG.

Construction and maintenance tasks must be risk-assessed, to ensure that risks from working at height are identified and managed.

C.24.3.2 RISK MITIGATION MEASURES

The risks arising from work at height can be mitigated by ensuring that the hierarchy of measures required by the regulations is followed.

Where work at height is necessary, then it must be:

- Properly planned, including ensuring that there are suitable arrangements for:
    - Planned access and egress;
    - Foreseeable emergencies and rescue situations;
    - Management of any changes in working methods that may be identified as the task proceeds;
- Carried out by a team with suitable competence, fitness, supervision and equipment for the task;
- Carried out in suitable weather conditions, particularly with respect to wind and lightning.

Personnel involved in work at height also require a suitable level of health and fitness to undertake the intended work, considering both general health and fitness on the day.

C.24.3.3 MONITORING, REVIEW AND CHANGE MANAGEMENT

Safe work at height depends on the integrity of anchor points, and the strength and reliable operation of all equipment, including PPE. The offshore environment, together with the demanding nature of construction and maintenance work, may lead to accelerated deterioration, so a robust inspection regime is essential. This is a complex area, so competent advice should be obtained in order to determine the nature and frequency of any inspection regime that is to be implemented.

Exposed offshore structures, such as access ladders, will require regular removal of fouling and guano contamination in order to provide safe access. Supporting steelwork and components such as floor plates and internal steps will require ongoing inspection and maintenance to ensure their long term integrity, with respect to both corrosion and other forms of deterioration such as loosening of fastenings as a consequence of vibration. Duty-holders should ensure that the scope and frequency of such inspections reflects the rate of deterioration; prompt repair of minor corrosion or damage to surface coatings can delay the onset of more serious loss of structural strength that would require more extensive remedial work.

C.24.4 PROVISION OF LIFTS

Lifts should be provided, where reasonably practicable, for personnel access within WTG towers, as this eliminates the risks associated with repeated climbing of long ladders. The provision of a lift should be considered as reflecting the state of the art for new large WTGs, but does not therefore necessarily require retrofitting of earlier towers.

However, the introduction of lifts brings new risks that need to be managed, including the potential for:

- Falls from landings that are used to access the lift;
- Crushing or entrapment between moving parts of the lift and adjacent structures; and
- The potential for malfunction or failure of the lift.

Lifts installed in WTGs are subject to the Machinery Directive, rather than the Lifts directive, and should therefore conform to the Essential Health and Safety Requirements (EHSRs) of the Machinery Directive, in accordance with the General Principles, which recognise that machinery may represent the state of the art, even where this may not fulfil every aspect of the EHSRs. (See Section A.1.6.1) The combined system of the lift and its interfaces with the WTG, such as landings and working areas, requires a Declaration of Conformity to be issued by a notified body.

Operating procedures should take account of reasonably foreseeable malfunctions, such as the lift stopping at a level other than a designated landing, and ensure that a safe means of escaping from the lift is available, and that personnel using the lift are trained and competent in this procedure. Inspection and maintenance programmes should ensure that the lift operation is safe and reliable throughout the lifetime of the WTG.

C.24.5 CODES OF PRACTICE AND GUIDANCE

C.24.5.1 REGULATIONS AND STANDARDS

Work at Height Regulations 2005, define the legal requirements, together with specifying design requirements in the Schedules. Brief explanation is given in HSE INDG401 – *The Work at Height Regulations*. For the avoidance of doubt, note that the Work at Height Regulations revoke Regulation 13(1-4) of the Workplace regulations, which relate to work at height, and are still in the Workplace ACOP.

RenewableUK standard for Working at Height and Rescue.

BS EN 353-1+A1:2002 - Personal protective equipment against falls from a height. Guided type fall arresters including a rigid anchor line; the amendment in 2005 added a National Annex to address dangerous shortcomings in the EN standard.

Official Journal of the European Union Commission Decision of 19 March 2010 withdrawing the reference of standard EN 353-1:2002 ‘Personal protective equipment against falls from a height — Part 1: Guided type fall arresters including a rigid anchor line’.

BS EN 795:2012 - Personal fall protection equipment. Anchor devices.

BS 7883:2005 - Code of practice for the design, selection, installation, use and maintenance of anchor devices conforming to BS EN 795.

BS 8437:2005+A1:2012 - Code of practice for selection, use and maintenance of personal fall protection systems and equipment for use in the workplace.

BS ISO 22846-1:2003 - Personal equipment for protection against falls. Rope access systems. Fundamental principles for a system of work.

C.24.5.2 OTHER RELEVANT GUIDANCE

RenewableUK *PPE (Work at height) procurement guidance sheets*, provide detailed guidance on PPE for work at height, including references to appropriate standards. (*Note: Some of the content is now out of date. However copies are available on request from RenewableUK*.)

Renewable UK - Lifts in Wind Turbines.

IRATA – information about roped access.

European Commission – Enterprise and Industry – *Guide to Application of the Machinery Directive 2006/42/EC, 2nd Edition, June 2010:* see Article 24 (§151), the borderline between the Machinery Directive and the Lifts Directive; Annex 1 (from §157), the Essential Health and Safety Requirements; and Annex 1, Part 6 (from §368), Machinery for lifting persons.

HSE RR258 *Preliminary investigation into the fall-arresting effectiveness of ladder safety hoops* has now been followed up by RR657 *Investigation into the fall-arresting effectiveness of ladder safety hoops, when used in conjunction with various fall-arrest systems*; the HSE policy arising from this research is summarised in *Safety Bulletin CCID 1-2012*.

C.24.5.3 ELSEWHERE IN THIS GUIDANCE

Supply of Machinery (Safety) Regulations and Harmonised Standards.
Medical Fitness to Work.

APPENDIX: EU DIRECTIVES AND ASSOCIATED UK REGULATIONS

Table 10: EU Directives and the principal HSWA and Maritime regulations. Note that most directives will affect multiple regulations, in addition to the principal regulations listed here.

EU Directive	Principal HSWA Regulation	Principal Maritime Regulation
Framework (89/391/EC)	Management of Health and Safety at Work Regulations 1999	Merchant Shipping and Fishing Vessels (Health and Safety at Work) Regulations 1997 MGN 20
Workplace (89/654/EEC)	Workplace (Health, Safety and Welfare) Regulations 1992	N/A
Work equipment (89/655/EEC, superseded by 2009/104/EC)	Provision and Use of Work Equipment Regulations 1998	The Merchant Shipping and Fishing Vessels (Provision and Use of Work Equipment) Regulations 2006 MGN 331
	Lifting Operations and Lifting Equipment Regulations 1998	The Merchant Shipping and Fishing Vessels (Lifting Operations and Lifting Equipment) Regulations 2006 MGN 332
PPE (89/656/EEC)	Personal Protective Equipment at Work Regulations 1992	Merchant shipping and Fishing Vessels (Personal Protective Equipment) Regulation 1999 MSN 1731
Manual Handling (90/269/EEC)	Manual Handling Operations Regulations 1992	Merchant Shipping and Fishing Vessels (Manual Handling Operations) Regulations 1998 MGN 90
Noise (2003/10/EC)	Control of Noise at Work Regulations 2005	Merchant Shipping and Fishing Vessels(Control of Noise at Work) Regulations 2007 MGN 352
Vibration (2002/44/EC)	Control of Vibration at Work Regulations 2005	Merchant Shipping and Fishing Vessels(Control of Vibration at Work) Regulations 2007 MGN 353, 436
Temporary or Mobile Construction Sites (92/57/EEC)	The Construction (Design and Management) Regulations 2007	N/A
Safety and / or health signs (92/58/EEC)	Health and Safety (Safety signs and signals) Regulations 1996	The Merchant Shipping and Fishing Vessels (Safety Signs and Signals) Regulations 2001 MSN 1763
92/29/EEC - medical treatment on board vessels	N/A	The Merchant Shipping and Fishing Vessels (Medical stores) Regulations 1995 MSN 1768
2001/45/EC - provisions concerning the use of work equipment provided for temporary work at a height	The Work at Height Regulations 2005	The Merchant Shipping and Fishing Vessels (Health and Safety at Work) (Work at Height) Regulations 2010 MGN 410

Source: European Union – Occupational Safety and Health Agency

PART D FURTHER REFERENCES AND GLOSSARY

D.1 FURTHER REFERENCES

EN 349:1993+A1, *Safety of machinery – Minimum gaps to avoid crushing of parts of the human body*

EN 362:2004, *Personal protective equipment against falls from a height – Connectors*

EN 547-1:1996+A1:2008, *Safety of machinery – Human body measurements – Part 1: Principles for determining the dimensions required for openings for whole body access into machinery*

EN 547-2:1996+A2:2008, *Safety of machinery - Human body measurements - Part 2: Principles for determining the dimensions required for access openings*

EN 547-3:1996+A1:2008, S*afety of machinery – Human body measurements – Part 3: Anthropometric data*

EN 795:1996/A1:2000, *Protection against falls from a height - Anchor devices - Requirements and testing*

EN 953+A1:2009, *Safety of machinery - Guards - General requirements for the design and construction of fixed and movable guards*

EN 1088:1995+A2, *Safety of machinery - Interlocking devices associated with guards - Principles for design and selection*

EN 1263-1:2002, *Safety nets - Part1: Safety requirements, test methods*

EN 1263-2:2002, *Safety nets - Part2: Safety requirements for the positioning limits*

EN 1838:1999, *Lighting applications – Emergency lighting*

EN ISO 12100:2010, *Safety of machinery - General principles for design - Risk assessment and risk reduction*

EN ISO 13849-1:2008, *Safety of machinery - Safety-related parts of control systems- Part 1: General principles for design*

EN ISO 13850:2008, *Safety of machinery - Emergency stop - Principles for design*

EN ISO 13857:2008; *Safety of machinery - Safety distances to prevent hazard zones being reached by the upper and lower limbs*

EN ISO 14122-1:2001+A1:2010, *Safety of machinery - Permanent means of access to machinery - Part 1: Choice of fixed means of access between two levels*

EN ISO 14122-2:2001+A1:2010, *Safety of machinery – Permanent means of access to machinery – Part 2: Working platforms and walkways*

EN ISO 14122-3:2001+A1:2010, *Safety of machinery – Permanent means of access to machinery – Part 3: Stairs, stepladders and guard-rails*

EN ISO 14122-4:2004+A1:2010, *Safety of machinery – Permanent means of access to machinery – Part 4: Fixed ladders*

EN 50172:2004, *Emergency escape lighting systems*

EN 60204-1:2006, *Safety of machinery - Electrical equipment of machines. Part 1: General requirements*

EN 60204-11:2000, *Safety of machinery - Electrical equipment of machines. Part 11: Requirements for HV equipment for voltages above 1000 V a.c. or 1500 V d.c. and not exceeding 36 kV.*

EN-61310-1:2008, *Safety of machinery - Indication, marking and actuation - Part 1: Requirements for visual, acoustic and tactile signals*

EN 61310-2:2008, *Safety of machinery - Indication, marking and actuation - Part 2:*

Requirements for marking

EN 61310-3:2008, *Safety of machinery - Indication, marking and actuation - Part 3: Requirements for the location and operation of actuators*

EN 61400-1:2005, *Wind turbines – Part 1: Design requirements*

EN 61400-3:2009, *Wind turbines – Part 3: Design requirements for offshore wind turbines*

EN 61400-24:2010, *Wind turbines – Part 24: Lightning protection*

EN 62061:2005, *Safety of machinery - Functional safety of safety-related electrical, electronic and programmable electronic control systems*

EN 62305-3 A11:2009, *Protection against lightning - Part 3: Physical damage to structures and life hazard*

D.2 ABBREVIATIONS

Abbreviation	Definition
ACOP	Approved Code Of Practice
ADCP	Acoustic Doppler Current Profiler
AIS	Automatic Identification System
ALARP	As Low As Reasonably Practicable
AOC	Air Operator's Certificate
ATBA	Area To Be Avoided
ATC	Air Traffic Control
AUV	Autonomous Underwater Vehicles
AWP	Approved Written Procedure
BERR	Department for Business, Enterprise and Regulatory Reform
BIS	Department for Business, Innovation & Skills
BPEO	Best Practicable Environmental Option
BS	British Standard
CAA	Civil Aviation Authority
CCTV	Closed Circuit Television
CDM	Construction (Design and Management)
CDMC	CDM Co-ordinator
CHIP	Chemicals (Hazard Information and Packaging for Supply)
CLP	Classification, Labelling and Packaging
COLREGS	International Regulations for Preventing Collisions at Sea
COSHH	Control Of Substances Hazardous to Health
COSWP	Code Of Safe Working Practices for seafarers
CUSC	Connection and Use of System Code
DECC	Department of Energy and Climate Change
DGC	Defence Geographic Centre
DNO	Distribution Network Operator
DNV	Det Norske Veritas
DP	Dynamic Positioning
DSC	Digital Selective Calling
DSEAR	Dangerous Substances and Explosive Atmospheres Regulations
DTI	Department of Trade And Industry
EAV	Exposure Action Value
EHSR	Essential Health and Safety Requirement
EIA	Environmental Impact Assessment
ELT	Emergency Location Transmitter (on aircraft)
ELV	Exposure Limit Value
EMEC	European Marine Energy Centre
ENG1	UK seafarer medical fitness certificate
EOD	Explosive Ordnance Disposal
EPIRB	Emergency Position Indicating Radio Beacon

Abbreviation	Definition
ERCoP	Emergency Response Co-operation Plan
ERP	Emergency Response Plan
FMEA	Failure Mode and Effects Analysis
GLA	General Lighthouse Authority
GPS	Global Positioning System
GT	Gross Tonnage, a measure of vessel size
HAT	Highest Astronomical Tide
HAV	Hand-Arm Vibration
HAVS	Hand-Arm Vibration Syndrome
HazOp	Hazard and Operability
HSE	The Health & Safety Executive
HSG	Health and Safety Guidance
HSWA	Health and Safety at Work etc. Act 1974
HV	High Voltage (>1000 V AC or >1500 V DC)
IEC	International Electro-Technical Commission
IEE / IET	Institution of Electrical Engineers (now Institution of Engineering and Technology)
IJUBOA	International Jack-up Barge Owners Association
IMCA	International Marine Contractors Association
IMO	International Maritime Organisation
INDG	Industry Guidance
IOSH	Institute of Occupational Safety and Health
IPC	Infrastructure Planning Commission
IRATA	Industrial Rope Access Trade Association
ISO	International Organization for Standardization
KISCA	Kingfisher Information Service - Cable Awareness
LOLER	Lifting Operations and Lifting Equipment Regulations
LV	Low Voltage
MARPOL	International Convention for the Prevention of Pollution from Ships
MCA	Maritime and Coastguard Agency
MGN	Marine Guidance Note
MHSWR	Management of Health and Safety at Work Regulations
ML5	Seafarer Medical Report Form / Certificate
MOD	Ministry of Defence
MSN	Merchant Shipping Notice
NATS-AIS	National Air Traffic Services - Aeronautical Information Service
NOTAM	Notice To Airmen
NSRA	Navigational Safety Risk Assessment
NUI	Normally Unattended (oil / gas) Installation
O&M	Operations and Maintenance
OREI	Offshore Renewable Energy Installation
OSC	On-Scene Co-ordinator

Abbreviation	Definition
PC	Principal Contractor
PELV	Protective Extra Low Voltage
PLB	Personal Locator Beacon
PPE	Personal Protective Equipment
PTW	Permit to Work
PUWER	Provision and Use of Work Equipment Regulations
QRA	Quantitative Risk Assessment
RAMS	Risk Assessment / Method Statement
RCS	Risk Control System
REACH	Registration, Evaluation, Authorisation & Restriction of Chemicals
REZ	Renewable Energy Zone
RIB	Rigid Inflatable Boat
RLV	Reduced Low Voltage
RNA	Rotor – Nacelle Assembly
RNLI	Royal National Lifeboat Institution
ROP	Routine Operating Procedure
ROV	Remotely Operated Vehicle
RPE	Respiratory Protective Equipment
RR	Research Report
SAR	Search And Rescue
SCADA	Supervisory Control And Data Acquisition
SELV	Separated Extra Low Voltage
SIMOPS	Simultaneous Operations
SOLAS	International Convention for the Safety of Life at Sea
STC	System Operator – Transmission Owner Code
STCW	(International convention on) Standards of Training, Certification and Watchkeeping for seafarers
TP	Transition Piece
UK	United Kingdom
UNCLOS	United Nations Convention on the Law of the Sea
UXO	Unexploded Ordnance
VDV	Vibration Dose Value
VFR	Visual Flight Rules
VHF	Very High Frequency
VMC	Visual Meteorological Conditions
WBV	Whole Body Vibration
WTG	Wind Turbine Generator
WTSR	Wind Turbine Safety Rules

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Our vision is for renewable energy to play a leading role in powering the UK.

RenewableUK is the UK's leading renewable energy trade association, specialising in onshore wind, offshore wind, and wave & tidal energy. Formed in 1978, we have a large established corporate membership, ranging from small independent companies to large international corporations and manufacturers.

Acting as a central point of information and a united, representative voice for our membership, we conduct research, find solutions, organise events, facilitate business development, advocate and promote wind and marine renewables to government, industry, the media and the public.