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Task 5: Wave Energy Conversion Device Performance

WEC Ocean Testing: Operational Documentation

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LIST OF ABBREVIATIONS

ABR.	DESCRIPTION
Abr.	Abbreviation
COLREG	International Regulations for Preventing Collisions at Sea - also IMO COLREGs
DNV	Det Norske Veritas
DOE	United States Department of Energy
DPI	Dye Penetrant Inspection
EIA	Environmental Impact Assessment
EMEC	European Marine Energy Centre
EU	European Union
GL	Germanischer Lloyd
GL GH	Garrad Hassan America, Inc.
GMDSS	Global Maritime Distress & Safety System
HAZID	Hazard Identification
HINMREC	Hawaii National Marine Renewable Energy Center
HIRA	Hazard Identification & Risk Assessment
IALA	International Association of Lighthouse Authorities
IMCA	International Marine Contractors Association
IMO	International Maritime Organization
MCBH	Marine Corps Base Hawaii
MOB	Man Over-Board MOB
MOP	Marine Operations Procedure
MWS	Marine Warranty Surveyor
NAVFAC	Naval Facilities Engineering Command
NTM	Notice to Mariners
O&M	Operations and Maintenance
PMR	Personal Mobile Radio
POB	Persons Onboard
PTW	Permit to Work
QHSE	Quality, Health, Safety, and Environment
QMS	Quality Management System
RAMS	Risk Assessed Method Statement
SAP	Senior Authorized Person
SDIP	Standard Developer Information Pack
SOLAS	International Convention for the Safety of Life At Sea
UH HNEI	University of Hawaii, Hawaiian National Energy Institute
USCG	United States Coast Guard
WEC	Wave Energy Converter
WETS	Wave Energy Test Site (at Marine Corps Base Hawaii, Kaheohe Bay, Oahu)

1 INTRODUCTION

1.1 Background

This report is issued to The Research Corporation of the University of Hawaii (the "Client" or "RCUH") pursuant to a written Agreement for Services effective 14 March 2013 and RCUH Purchase Order #Z10027978. The Client has requested that Garrad Hassan America, Inc. (GL GH) prepare Operational Documentation to be used by those accessing the Wave Energy Test Site (the "Project" or "WETS") located in O'ahu, Hawaii.

The Project includes a pre-existing test site in 30m of water, adjacent to the U.S. Marine Corps Base Hawaii – Kaneohe (MCBH-K) which is located on the east coast of Oahu. The infrastructure for the existing 30m site was developed and installed between 2000 and 2003. It was used to test various wave energy devices developed by Ocean Power Technologies (OPT) between 2003 and 2012. With the completion of the OPT testing and removal of their wave energy device in July of 2012, the test site has become available for testing devices from other wave energy developers.

The Naval Facilities Engineering Command (NAVFAC) Engineering Service Center has undertaken a project to develop an expanded wave energy test facility that will leverage the unique position of MCBH-K. The expanded WETS facility will develop two deep-water berths at depths of 60m and 80m, for testing large wave energy converter (WEC) devices, and will incorporate the existing shallow water site located about one kilometer off shore in a water depth of 30 meters. The project is leveraging funding from both the U.S. Navy and U.S. Department of Energy (DOE). The University of Hawaii, Hawaii Natural Energy Institute (UH HNEI) is working in collaboration with the Navy to develop WETS, and the Hawaii National Marine Renewable Energy Center (HINMREC) at UH HNEI has roles including support of testing operations, independent evaluation of WEC system performance, environmental impact studies, evaluation of mooring system & power cable life expectancy, and calibrated wave forecasting for operations planning. It is anticipated the additional deep-water berths will be operational by a target date of September 2014.

1.2 Scope of this Technical Note

The purpose of this Technical Note is to provide operational documentation to be used by those accessing the test site. The intention is not to provide detailed proscriptive documentation and procedures, but rather:

- to identify the main activities, process and controls that need to be set in place at WETS to enable safe marine operations at the site(s);
- to provide overviews of the main safety and operational issues that need to be considered at the various stages of the projects, and;
- to provide checklists to assist both the WETS management and the device developers in the preparatory works and the daily marine operations.

The checklists cover the following phases of a typical test program at the site:

- Installation & Commissioning
- The testing period itself, including data logging
- Access to and/or retrieval of the devices for maintenance
- Final decommissioning

This note has been prepared by staff from GL GH's Marine and Offshore Wind groups, bringing to bear direct hands-on experience of installing and operating wave and tidal devices at the European Marine Energy Centre (EMEC) and extensive experience of installing offshore wind turbines. The procedures outlined here, in particular those for preparing Risk Assessed Method Statements (RAMS) for installation, operation and decommissioning, are standard practice in the Oil & Gas and Offshore Wind industries, and have been developed in the light of the experience gained over decades.

A detailed review of legislation and U.S. regulations is not included in the GL GH scope of work. As will be seen from the documentation below, there are several areas where GL GH has identified the issues that need to be considered, but has flagged that the WETS management will need to complete documentation in accordance with the pertaining U.S. Regulations.

Where relevant, this note makes reference to a series of internationally recognized guidelines for marine operations and wave energy test devices, from a variety of sources:

- Germanischer Lloyd (GL), and subsidiaries, including GL Noble Denton
- Det Norske Veritas (DNV)
- International Marine Contractors Association (IMCA)
- Documents prepared by other research programs, such as the EU EQUIMAR project

These documents offer highly detailed design and marine operational guidance for WETS and developers; they are not copied here, but links are provided to the source references.

1.3 GL GH approach and layout of this document

Rather than simply presenting a series of written documents, GL GH has provided a set of process and decision-making flowcharts to indicate the type of activities and controlling documents which are required at each stage, both from WETS and the developer, and how they fit into the overall life cycle of a wave energy test project. These flowcharts are presented in Section 2. The individual document and operational procedures are then discussed in detail in Sections 3 to 5.

The key factors to a successful deployment are early engagement between the developer and WETS, starting from the point when a developer first applies to come to the facility, and the continued mutual transfer and review of comprehensive, validated and controlled data. Data will flow in one direction from WETS management to the developer regarding the WETS facility, site characteristics, consents and local operational constraints, etc. and in the other direction from the developer to WETS regarding the machine and mooring design, demonstrating electrical compatibility, securing final device consents and 3rd party design assurance, and evidence of adequate insurances, etc. The process culminates in the Hazard Identification and Risk Assessment (HIRA)/Hazard Identification (HAZID) meetings between all stakeholders and the issue of final RAMS for each of the marine operations, by which point the WETS marine coordinator should be satisfied that a Permit to Work can be issued by WETS management for the developer to access the site and install the device.

Because of the importance of the early engagement and data management processes, the process flowcharts presented in Section 2 start from the point at which a developer first applies to WETS, rather than at the point of device installation as might be imagined from the description of the scope in Section 1.1 above. Although this appears slightly beyond the original specified scope of this note, GL GH considered it important to identify the earlier

procedures because they have such a strong bearing on successful marine operations at the later stages. It also enables the marine operations documents to be set within an overall management and Quality Assurance (QA) framework for the WETS facility; GL GH is not trying to impose a particular framework on WETS, but rather to illustrate how the deliverables in this note would ideally integrate with the facility management. The idea being that that this illustration can provide WETS management with a suggested approach.

1.4 Introduction to flow chart symbol conventions used in this document

As discussed above, the sequence of operations is shown graphically in flowcharts in Section 2 below. Standard flowchart symbols have been used, and their conventional meanings are defined here. In addition to symbol shape, the flowcharts in this technical note contain a superimposed color coding, also explained below, which indicates the responsibility, or ownership of the activity (e.g. WETS management or the developer).

1.4.1 Flowchart color coding

- Dark Green being used to used denote activities owned by WETS Management, and
- Blue refer to those to be carried out by the Device Developer.

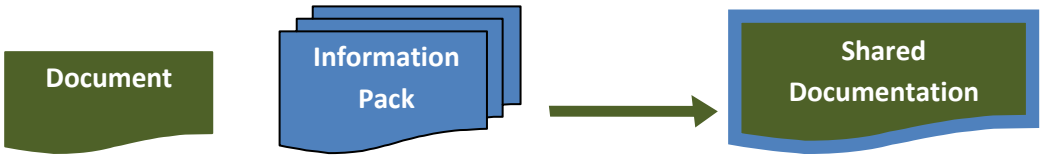
1.4.2 A Process- Analysis or Desk-Based Studies

Processes denote thought processes and activities, e.g. calculations during design or following a procedure.

1.4.3 Manual Activities

All processes which are not thought-processes or desk-based development of documentation, for example a Marine Warranty Surveyor touring a vessel, with the purpose of assessing its Suitability or Condition, is deemed a “manual” process.

1.4.4 Documents



Where forms, documents, or information packs are required, the appropriately colored symbol is used. Where one organization generates the documentation, but the next stage of processing the document is the responsibility of a different organization, the arrow color is changed to designate where in the sequence of events the responsibility transfers between organizations. If there is shared responsibility, this is denoted by a symbol which has different fill coloration to border color.

1.4.5 Electronic Data Storage – Uploading to the Dataroom

When documents are APPROVED, the signed copy is scanned, and uploaded to the Dataroom.

1.4.6 "Off-page" Flowchart – Connectors

Where a set of tasks is required which is too complex to neatly fit in the flowchart, the headings of the key "mission critical" activities are included, but an "off-page" connector is used to redirect the reader to the detail. This denotes that there is a separate sequence of flowcharted activities which are to be carried out this stage of operations. The text in the off page connector, e.g. "P99", means that the next step in the sequence of events is to carry out "Procedure 99".

1.5 Documentation Numbering Convention

In order to encapsulate information on the ownership and function of the various elements of the Marine documents within the quality management system, the key documents referred to in this technical note are given an alphanumeric numbering system as follows:

D. P. 4. 1. W. 3

<u>Ownership</u>
D – Any document owned by the "D"evice Developer
T – Any document owned by the "T"est Centre

<u>Type of Document</u>
P – Procedure
F – Flowchart

<u>Serial Number of Document</u>

<u>Subordinate Document Number</u>

<u>Supporting Documentation Type</u>
W – Work Instruction
F – Form

<u>Supporting Document Serial No.</u>

2 MARINE OPERATIONS PLANNING AT WETS

2.1 Introduction

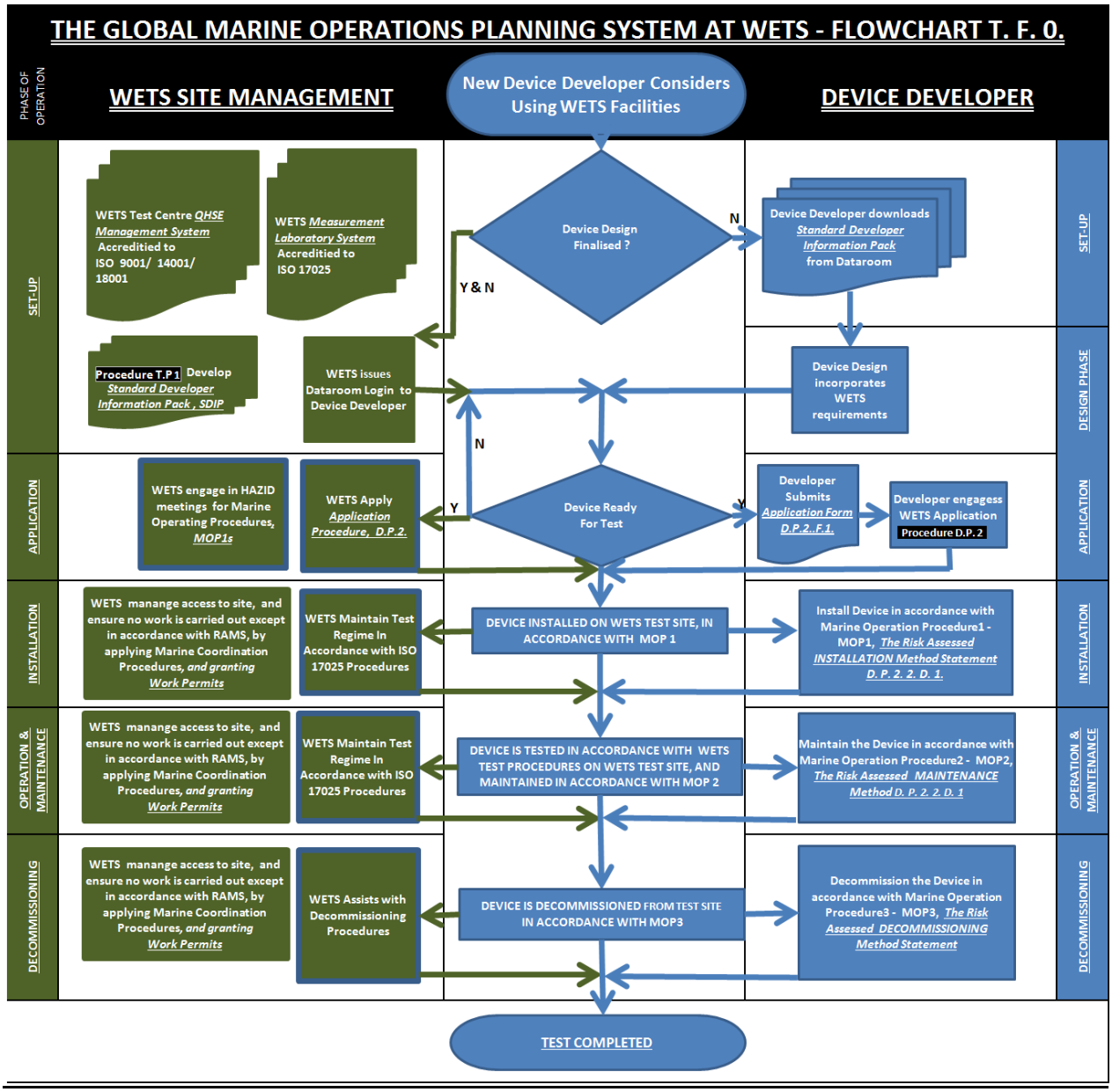


Figure 2-1 : The Master Flowchart for Marine Operations Planning – Document No: T. F. 0.

The master flowchart is presented in Figure 2-1. A spreadsheet containing the flowcharts presented here accompanies this report [1], from which larger copies may be printed for ease of viewing.

The chart is designed to give a graphical representation of the decision process, and show how the Marine Operations procedures fit into it. It has been arranged to provide a chronological representation of the life-cycle of a

device test at the WETS facility. The earliest activities occur at the top of the chart, and progress downwards through the various phases of development. The stages in the project life cycle are:

- Set-up – related both to WETS and the Device Developer's organizations
- Device Design
- Application for Test Berth
- Device Installation
- Operation, Maintenance & Testing
- Decommissioning

The key milestones are shown in the central area of the chart, and simultaneous perspectives are identified for the activities and responsibilities of both the WETS (in the area on the left of the central timeline), and the Device Developer (in the area to the right).

WETS Activities & Responsibilities

WETS activities start with preparing a Dataroom for the device developers, containing all the relevant site data in the Standard Developer Information Pack (SDIP). The content of the SDIP and the process for updating and controlling it are presented in Section 2.3. The SDIP is a key document source for a developer and should ideally include:

- Site physical data (metocean, bathymetry, seabed surveys, ground conditions, electrical network characteristics etc.)
- Local maritime regulations, vessel traffic control systems, procedure for publication of Notices to Mariners, Coastguard Liaison etc.
- Local data – marine contractors for workboats, diving & ROV, Port and Quayside facilities, fabrication and engineering support services etc.
- Environmental data, licensing conditions and any operational constraints, navigational risk assessments etc.
- Site Safety & Emergency Response Procedures – covering all marine and onshore activities

The next area of WETS activity is the review of a developer's application to come to the site, and the procedures for establishing that the WETS requirements have been properly met. This is discussed in Sections 2.4 & 2.5 below. In this activity, WETS needs to satisfy itself through the exchange and review of documentation and participation in HAZID meetings, that the following have been achieved (amongst others):

- The device design and outline plans for installation are fit for purpose
- The design and plans have been subject to independent 3rd party review/assurance
- The device is compatible with the local electrical network at MCBH
- The developer has taken on board the environmental constraints and licensing conditions for the WETS site, and has secured any device-specific licenses (if applicable)
- The developer has secured the necessary insurances (employer, 3rd party, public liability, etc.)

WETS then needs to participate in the project HIRA meetings with the developer, vessel operators and marine contractors to assist the developer preparing final RAMS for the main marine operations. The number and content of RAMS required will be project-specific but may typically include:

- Health & Safety arrangements
- Sequence and program of works – the basic project plan
- Pre-installation seabed video and physical surveys
- Diver operations (safety vessel, offshore chambers, and access to medical facilities)
- ROV operations (inspections and device interventions)
- Cable installation (offshore)
- Mooring analysis
- Pre-installation survey for moorings
- Mooring installation and proving
- Quayside assembly and deployment of device into water – including lift plans
- Towage & installation
- Commissioning
- Site access for maintenance – including personnel transfer onto device from workboats
- Device recovery to shore for maintenance
- Device re-deployment
- Marine coordination with WETS and local maritime organizations
- Operation & Testing
- Decommissioning

During the operation, testing and maintenance phases, WETS will need to have in place a number of its own operational procedures under which the developer and its subcontractors must work. These typically include:

- Emergency response procedures
- Marine coordination including simultaneous operations (more than one developer working on site)
- Operational monitoring and provision of WETS duty manager
- Permit to Work system
- Permit to test (electrical)
- Electrical substation - access and operations by Senior Authorized Person (SAP)
- Vessel audit checks

Developer's Activities & Responsibilities

The developer's activities and responsibilities closely mirror those of the WETS above.

The Marine Operation Procedures development process will be one of the most complex elements of the preparations for deployment a wave energy device; it will be central to making an application to use a berth at WETS.

Each Method Statement developed will require a thorough parallel process of Risk Assessment. The Developer will need to base their approach on a clear and thorough appreciation of all aspects of both the marine environment at WETS, but also the electrical monitoring and controls, cabling and transmission infrastructure.

The developer will initially need to review the SDIP, prepare designs and RAMS, and interface with WETS in meeting the requirements of its procedures. The selection and audit of vessels and subcontractors will be an important part of the developer's work, and also demonstrating via the RAMS and HIRA meetings that safe systems of work are planned for all activities.

In GL GH's experience, attendance at the HIRA meetings should include as many of the key operational staff as possible in order to ensure that all aspects are covered, including:

- WETS operational managers/ marine coordinators
- Developer's design engineers
- Developer's site supervisors/representatives
- Representatives of the Principal Contractor and key subcontractors
- Skippers and/or deck foremen of the proposed vessels – main installation vessel, workboats, survey, diving & ROV, personnel transfer
- Lifting Supervisors
- Dive supervisors
- ROV operators

Final HIRA meetings should be held close to the planned deployment date, but allowing time for any changes and additional risk mitigations to be implemented prior to device deployment.

2.2 Marine Operating Procedures (MOP's) and the WETS Quality Management System (QMS)

It's highly recommended WETS have its own Quality Management System (QMS). For the purposes of this Technical Note, it is assumed that this Quality Assurance system will be written to conform to ISO 9000. Similarly it is assumed that there will be a desire for WETS to hold accreditations to the Occupational Health and Safety Management standard ISO 18000, Environmental Management standard ISO 14000, and possibly also ISO 17025 Laboratory accreditation.

It is important that the interactions between the Device Developers, WETS and other stakeholders are fully integrated into the WETS QMS. This section is not intended to prescribe a QMS for WETS, but rather to provide an overview of International Standards and best practice guidelines in order to illustrate how the marine operational procedures might be integrated.

The flow chart in Figure 2.1 shows set-up activities at the top which encompass the Quality, Health, Safety & Environment (QHSE) systems; marine operations planning documents flow from these higher-level accreditations. The ISO's 18000, 14000, 9000 & 17025 are foundational activities, and subsequent procedures policies and practices must be carried out in accordance with, founded upon, and fully integrated into, these umbrella management systems.

Reference is made in this note to Marine Planning Guidance notes, and the most widely respected examples internationally are those from organizations including:

- Germanischer Lloyd (GL), and subsidiaries, including GL Noble Denton
- Det Norske Veritas (DNV)
- International Marine Contractors Association (IMCA)

The GL Noble Denton Guidance for Marine Projects is accepted internationally as an example of Best Practice. They are available for download free from GL Noble Denton's website, and cover all aspects of marine operations from the perspective of Marine Warranty requirements. Full references are given below, but in summary they cover the following areas:

Ref	Title	Link
001/ND	General guidelines for marine projects	http://www2.gl-nobledenton.com/l/21052/2013-06-28/q6bt/21052/11132/0001_0_General.pdf Accessed 18.07/2013
030/ND	Guidelines for Marine Transportations	http://www2.gl-nobledenton.com/l/21052/2013-06-28/q6ch/21052/11148/0030_5_Transport.pdf
013/ND	Guidelines for load-outs	http://www2.gl-nobledenton.com/l/21052/2013-06-28/q6bm/21052/11126/0013_7_Load_out.pdf
015/ND	Guidelines for Concrete Gravity Structure Construction & Installation	http://www2.gl-nobledenton.com/l/21052/2013-06-28/q6br/21052/11130/0015_4_Concrete.pdf
027/ND	Guidelines for Marine Lifting Operations	http://www2.gl-nobledenton.com/l/21052/2013-06-28/q6c5/21052/11138/0027_10_Lifting.pdf
028/ND	Guidelines for Steel Jacket Transportation and Installation	http://www2.gl-nobledenton.com/l/21052/2013-06-28/q6c7/21052/11140/0028_5_Jackets.pdf
032/ND	Guidelines for Moorings	http://www2.gl-nobledenton.com/l/21052/2013-06-28/q6cf/21052/11146/0032_1_Moorings.pdf
035/ND	Guidelines for Offshore Wind Farm Infrastructure Installation	http://www2.gl-nobledenton.com/l/21052/2013-06-28/q6cf/21052/11146/0032_1_Moorings.pdf

Table 2-1: GL Noble Denton Marine Guidelines

At the outset, in GL ND001 "General Guidelines for Marine Projects", the foundation stones are laid that organizations should have established procedures for Health and Safety and Quality Assurance. These are dealt with in Chapter 5 - Health, Safety and Environment, and in Chapter 6 - Organisation, Planning and Documentation. There is also a specific section 6.3 - Quality Assurance and Administrative Procedures.

2.3 The Procedure for Writing the Standard Developer Information Pack, T. P. 1.

The Master Flowchart highlights some vital procedures which will be required at key times during the life-cycle of testing a new device. These are expanded with individual flowcharts and explanatory notes in the following sections.

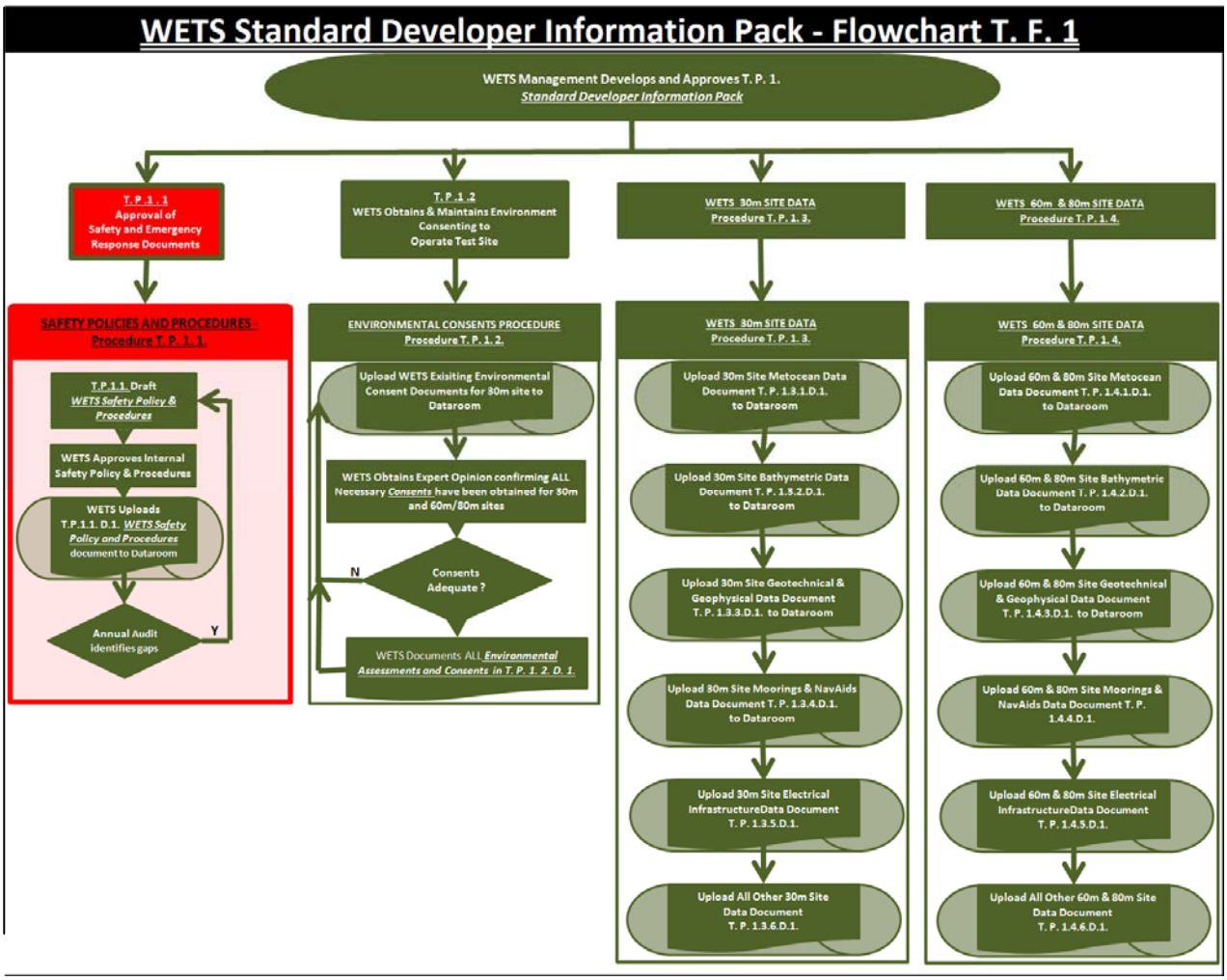


Figure 2-2: Flowchart T.F.1. for Procedure T.P.1. – Standard Developer Information Pack

On the Master Flowchart, the first activity for which WETS Management should undertake, is the development of a Standard Developer Information Pack, the SDIP.

As this is the first procedure to be expanded upon, it is worth reviewing its Document Number "T. P. 1" to underline what information this is conveying to the reader on the procedure's place within the overall system:

- The "T" informs that this procedure is owned by the WETS "T"est Center.
- The "P" informs that it is a procedure
- The "1" informs that it is the first procedure carried out by WETS.

The purpose of the information supplied by WETS is to be used by the Developer either:

- to check if their existing design is suitable for deployment at WETS, or
- to ensure that during the design phase, no design decisions are made which could preclude its suitability.

The contents of the SDIP within WETS procedure T. P. 1 should include ALL the information necessary to enable the Device Developer to comply with WETS procedures and gain approval for access to site. This high level of "transparency" at an early stage between the Contracting Parties should reduce or eliminate any time wasted with inadequate or poorly conceived applications.

WETS has already developed and collated several documents which could issued to potential Device Developers. The following is intended to have a limited scope, and refer solely to the documentation which will be needed to ensure that the Marine Operations Procedures can be developed. It is therefore highly likely that the Client may wish to expand and extend this list to other aspects of the testing at a WETS berth.

The following are seen as vital information for all three currently proposed sites. To allow swift identification of existing documents and documents which GL GH foresee as being required, but which are not known to exist currently, the current adequate documents are highlighted in light green, and named (with full details in References section), and documentation in need of upgrading or not known to exist is highlighted in yellow.

2.3.1 T. P. 1. 1 - Safety and Emergency Response Procedures

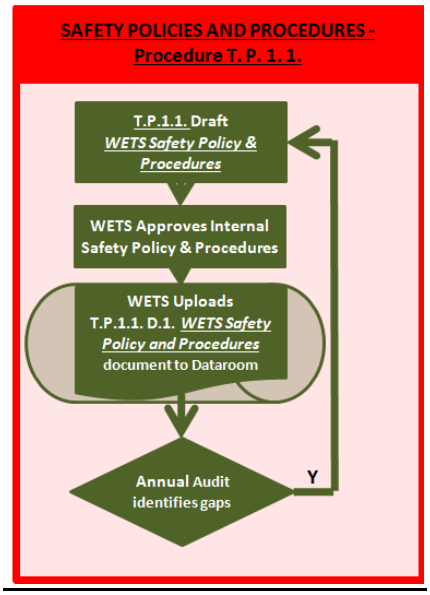


Figure 2-3: Flowchart for Procedure T. P. 1. 1 - WETS Safety & Emergency Response Procedures

There seems little point in setting up separate safety rules for the 30m and 60m/80m sites, but there will clearly need to be some requirement for scheduling any significant differences between the berths, and the electrical and physical infrastructure where appropriate. The SDIP can therefore contain a single document:

- T. P. 1. 1. D. 1. "Safety and Emergency Response Requirements at WETS"

Within the safety documentation there will be a defined approach to Risk Management and the procedure to be adopted by WETS and developers when preparing any RAMS for marine operations. A suggested approach to Risk Management, taken from Offshore Wind practice is given in Appendix 3. The approach is based on applying a five by five risk matrix allowing assessment of identified hazards, by consideration of the probability, and severity of occurrence. The approach in Appendix 3 meets the requirements of ND-001 General Requirements, Section 5.4.

GL GH envisages that there will be a requirement for a number of marine-related safety requirements within the drafting of the Safety Documentation for the SDIP. These will probably include, but not be limited to, the inclusion of specific sections on the following:

- Hawaiian Specific Issues associated with IMO COLREGs and SOLAS (if applicable)
- Liaison with Search and Rescue Helicopter Services on Oahu
- Liaison with Emergency Lifeboat Services on Oahu
- IALA Navigation Aids & Additional Lighting Requirements of CAA/ FAA/ Military Aviation Authorities
- Emergency Broadcasts on Marine Band Radio Channels – Information Services and GMDSS Services
- Emergency Contact Details of Marine Authorities and key WETS Safety Personnel
- Publicizing "Notice to Mariners" and Maintenance of Marine Exclusion Zones
- WETS Requirements for Carrying Out Safety-Related Risk Assessments
- Personal Protective Equipment Requirements for Operations Offshore at WETS
- Personal Protective Equipment Requirements for Operations Onshore at WETS
- "Lessons Learned" document from past Marine Operations at WETS

There will need to be clear allocation of Responsibilities at all stages, and statements on the

- Qualification and Training
- Safety Plan
- Security and Tracking System
- Contingency and Emergency Planning and Procedures

Detailed guidance on the approach to be adopted for each of these areas can be found in 001/ND General Guidelines [3], Section 5.

Work Instructions for Emergency Response Procedures

GL GH also envisages a requirement for a number of Work Instructions on how to handle specific foreseeable emergencies and safety-related scenarios. The following individual Work Instructions are likely to be required, each of which can be an appendix to the umbrella Safety and Emergency Response document T. P. 1. 1. D:

- T. P. 1. 1. W. 1. Extreme Weather Warnings – Hurricane Warnings
- T. P. 1. 1. W. 2. Unexploded Ordnance (UXO)
- T. P. 1. 1. W. 3. Serious Injury & Evacuation of Casualties – Offshore
- T. P. 1. 1. W. 4. Man Overboard – Offshore
- T. P. 1. 1. W. 5. Diving Incident - Offshore
- T. P. 1. 1. W. 6. Partial or Total Failure of Moorings fitted to a Device under Test
- T. P. 1. 1. W. 7. Collision or Potential Collision Between a Vessel and a Device under Test
- T. P. 1. 1. W. 8. Damage or Break to Subsea Cable
- T. P. 1. 1. W. 9. Failure or Loss of Navigation Aids fitted to a Device under Test
- T. P. 1. 1. W.10 Onshore Emergency – Fire & Serious Injury
- T. P. 1. 1. W.11 Emergency Electrical Isolation of Wave Energy Device

2.3.2 T. P. 1. 2 - Environmental Assessment Data

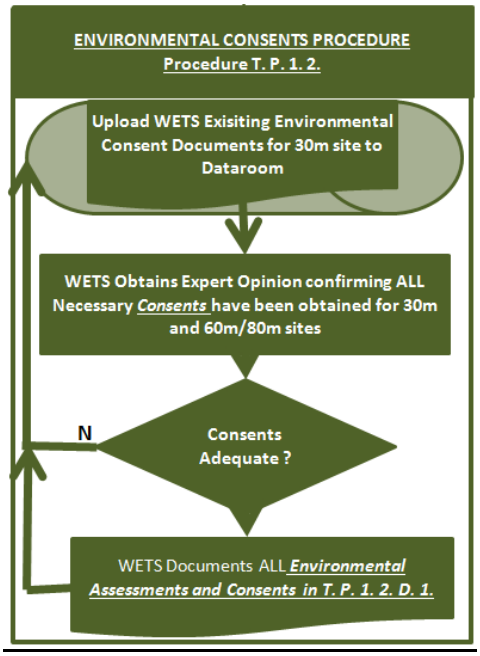


Figure 2-4: Flowchart for Procedure T. P. 1. 2. - Obtaining Environmental Consents

The flowchart for issuing, updating and reviewing the Environmental information is given in Figure 2-4.

It is envisaged that there will be little difference in the Environmental Requirements for the 30m and 60m/80m sites so a single document should be capable of defining requirements suitable for both areas. Currently, Section 6 of the report on "Marine Biological Resources" within WETS (2012), "Thirty-Meter Test Site Characteristics" [2], covers the habitat and species present to a depth of 30m, so the data-pack to be issued for the 30m site is already covered. It is anticipated that with minimal outlay, given the experience in Oceanographic experience of the UH HNEI partners, that it could be reviewed and its scope extended to cover to the 60m/80m sites. The revised and extended document number would be designated:

- T. P. 1. 2. D. 1. "Environmental Assessment and Consenting Information for WETS"

This document should contain the environmental data for the site and the site licenses, and should identify the terms and conditions of operating at the site and any environmental constraints. Typically it will contain the following as a minimum:

- Copies of the site licenses for WETS and any conditions pertaining (for example underwater noise limits, seasonal constraints on operations for avoiding migration/breeding seasons, etc.)
- The EIA and supporting studies and surveys
- Benthic survey data
- Sea mammals and birds –baseline monitoring data
- Fish surveys
- Navigational risk assessments and other user of the sea
- Device marking and buoyage requirements
- Requirements for permanent and temporary exclusion and safety zones
- Requirements for guard and safety vessels during operations on site
- Any requirements for device-specific licenses required in order to deploy at the 30m or 60m/80m sites
- A list of national, regional and local stakeholders, both statutory and recommended
- A schedule of the potential environmental impacts required to be considered

2.3.3 T. P. 1. 3 – 30m Site Physical Data

The flowchart for issuing, updating and reviewing the 30m site physical data is shown in Figure 2.5. Since historically there was a single berth in 30m of water, the sufficiency of the existing SDIP documentation to adequately cover deployment at the two deep-water sites will have to be reviewed. The data required are as follows:

T. P. 1. 3 - 30m Site Standard Developer Information Pack

- T. P. 1. 3. 1. <u>Metocean data</u>

  T. P. 1. 3. 1. D. 1

  Details exist within WETS (2012) "Thirty-Meter Test Site Characteristics"

- T. P. 1. 3. 2. Bathymetric data
  - T. P. 1. 3. 2. D. 1

    Details exist within WETS (2012) "Thirty-Meter Test Site Characteristics"

- T. P. 1. 3. 3. Seabed Geotechnical/Geophysical Site Investigation data

  T. P. 1. 3. 3. D. 1

  Details exist within WETS (2012) "Thirty-Meter Test Site Characteristics"

- T. P. 1. 3. 4. Moorings and Marine Navigational Marking Requirements

  T. P. 1. 3. 4. D. 1

  Moorings laid out at the 30m site are described in WETS (2012) "Thirty-Meter Test Site Characteristics".

  The GL Noble Denton Guidance Note "Guidelines for Moorings" contains industry-standard methodologies for mooring design, reference [10]. There are specific sections associated with wind, wave, tide and currents and the loads associated contained in Sections 7 - Design Environmental Conditions, and Section 8 - Environmental Loads and Motions. The WETS SDIP would benefit from ensuring that it details all of the necessary information to carry-out the calculations contained in this guidance.

  In addition to the offshore mooring of the device and the mooring of any vessels during installation offshore, it is important that the mooring of vessels whilst in port, and particularly during any loading or unloading operations, should also be considered in accordance with this guidance.

  Navigational Aids were not scheduled but are merged with moorings as both the WEC device and its moorings will need to be designed with the requirements of the U.S. Coast Guard (USCG), International Maritime Organisation's International Regulations for Preventing Collisions at Sea (IMO COLREGs), and the International Association of Marine Aids to Navigation and Lighthouse Authorities (IALA) in mind.

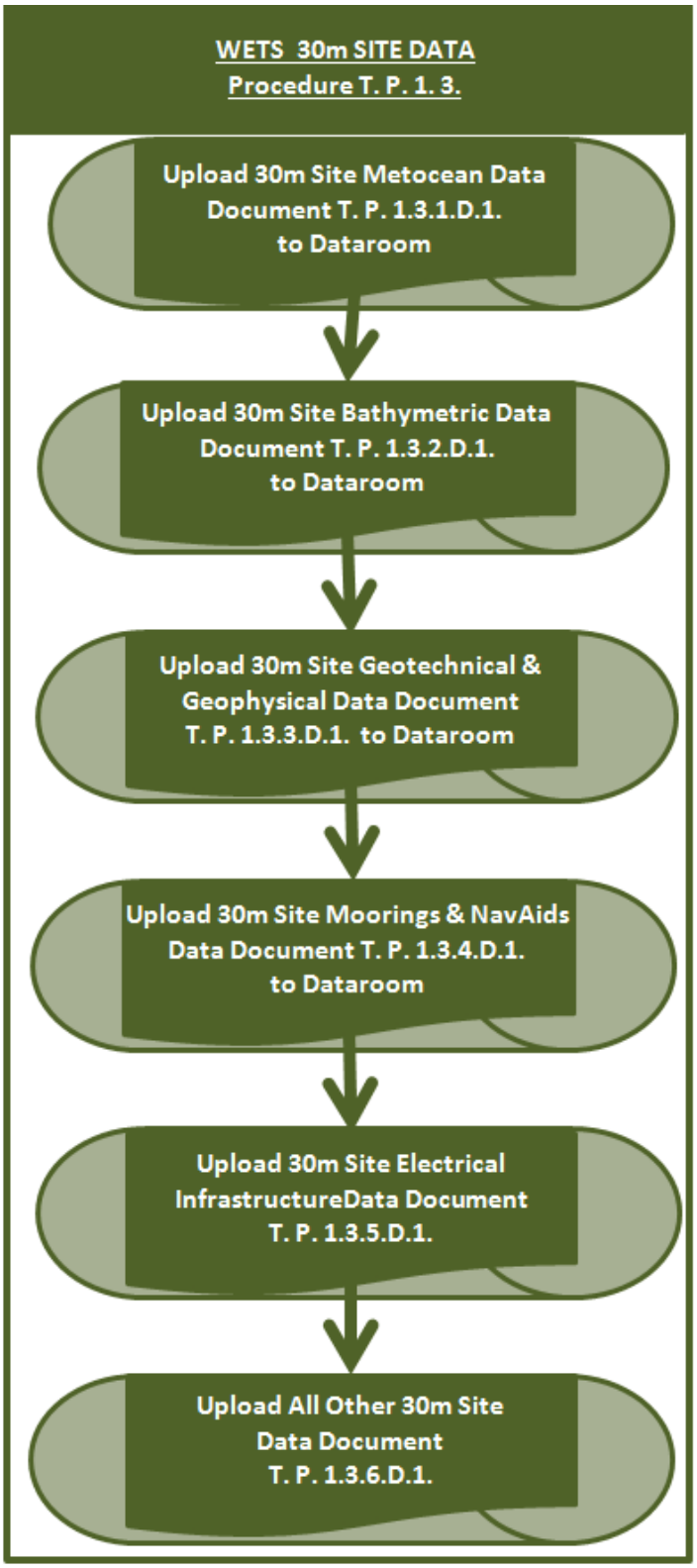


Figure 2-5: Flowchart for Procedure T.P.1.3 – Data for the 30m Test Site

- T. P. 1. 3. 5. WETS Electrical Infrastructure
  - T. P. 1. 1. 5. D. 1. WETS Electrical Infrastructure at the 30m site

    A device tested at WETS must ensure that it is compliant with the existing electrical infrastructure. To ensure that this is the case, WETS previously included Section 8 Site Infrastructure in the WETS (2012) "Thirty-Meter Test Site Characteristics". This has clearly proved sufficient in the past for Developers to assess their devices, and no changes are proposed, unless changes are made which may have a significant impact on interfacing with the site. The present Transformer voltage of 4160 V and maximum capacity of capacity of 45kVA are highly unlikely to be suitable for any devices which are using the site in the future, but it is conceivable that other elements of the infrastructure can be re-used with minimal adaptation.

- T. P. 1. 3. 6. All other Requirements for obtaining Consent to Lease a WETS Berth
  - T. P. 1. 1. 6. D. 1. Other Requirements for Applicants for the 30m site

    All commercial, insurance, and other necessary assurances required by WETS to assess the suitability of an applicant transparently are listed here.

2.3.4 T. P. 1. 4 - Standard Developer Information Pack - 60m & 80m Water Depth Test Sites Nos.1 & 2

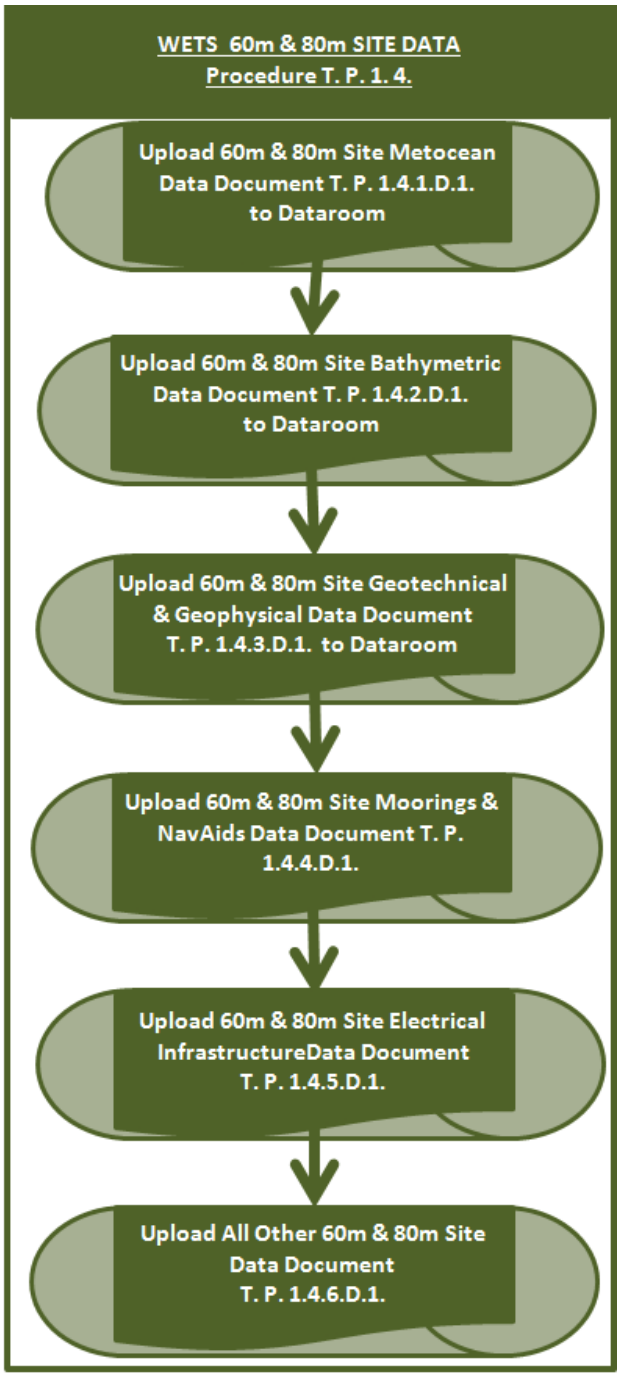


Figure 2-6: Flowchart for Procedure T.P.1.4 – Site Data for 60m - 80m Test Sites

The newly proposed 60m and 80m sites are not covered by existing documentation seen by GL GH to date. Therefore it is proposed that a set of documents analogous to the material produced for the 30m site be commissioned for the new sites. The flowchart is shown in Figure 2-6, and is the same as that for the 30m site.

A significant part of these new documents could be derived from reviewing and extending the data for the 30m site, but whilst it is not seen as an onerous task from the excellent starting position afforded by past work, it is still necessary to provide site-specific data for Developers.

- T. P. 1. 4. 1. Metocean data
  - T. P. 1. 4. 2. D. 1. Metocean Conditions at the WETS 60m & 80m Sites

    It is likely to be possible to measure data at the two deeper sites and the 30m site, and obtain a robust correlation between the them, although the wave climate may be different owing to the water depth. Then the existing data in WETS (2012) "Thirty-Meter Test Site Characteristics," could be post-processed to address this requirement.

- T. P. 1. 4. 2. Bathymetry
  - T. P. 1. 4. 2. D. 1. "Bathymetry of the WETS 60m & 80m Sites"

    It is envisaged that details that exist within WETS (2012) "Thirty-Meter Test Site Characteristics," can be easily extended to cover this requirement, owing to the coverage of the surveys.

- T. P. 1. 4. 3. Seabed Geotechnical/Geophysical Site Investigation data
  - T. P. 1. 4. 3. D. 1. "Geotechnical and Geophysical Character of the WETS 60m & 80m Sites".

    The ground conditions relevant for mooring design and operational aspects of wave capture devices at each of the 2 deeper WETS sites will be required by developers. It is envisaged that this will involve little more than confirming that the existing ground conditions detailed in WETS (2012) "Thirty-Meter Test Site Characteristics", extend to the 60m & 80m contours, and that conditions are similar across both deeper sites. This should be confirmed, however, through diver and video surveys.

- T. P. 1. 4. 4. Moorings and Marine Navigational Marking Requirements
  - T. P. 1. 4. 4. D. 1. Moorings and Navigational Aids for WETS 60m & 80m Sites

    A document scheduling and obvious opportunities or constraints on device mooring, and the Navigational Aids which will be prescribed will have to be derived, probably following the pattern of the 30m site documentation.

- T. P. 1. 4. 5. WETS Electrical Infrastructure
  - T. P. 1. 4. 5. D. 1. Electrical Infrastructure at WETS 60m & 80m Sites

    The electrical infrastructure for the two deeper sites does not exist to date. The WETS site and Device Developers therefore have flexibility to set-up any system within reason, ideally with the capability to interface with the existing Military Base, but not necessarily so if this proves restrictive. This document could make some broad recommendations to minimize the infrastructure development costs, but need not be prescriptive in any way.

- T. P. 1. 4. 6. ALL OTHER Requirements for obtaining Consent to Lease a WETS Berth
  - T. P. 1. 4. 6. D. 1. ALL OTHER Requirements for Applicants for a 60m/80m site

    This document will need to specify all other commercial, insurance, and other necessary assurances required by WETS to assess the suitability of an applicant. This may include:

- Independent 3rd party review of structures, mooring and safety systems, carried out by a competent authority (e.g. certification authority or design house). This is to satisfy WETS that the developer's designs will withstand the test period, safely and without failure, and without threatening other users of the site or seabed infrastructure.
- Provision of insurances.
- Evidence of financial stability and provision of bonds for decommissioning. WETS must ensure that it does not end up carrying liability for decommissioning in event of a developer becoming bankrupt.
- Legal agreement for berth rental.
- Research cooperation agreement setting out how the developer intends to work with the Navy and UH HNEI in terms of data gathering and performance assessment, and data sharing.

2.4 T. P. 2. – THE APPLICATION PROCEDURE – PHASE 1

The procedure for controlling the application by a developer to use a WETS berth is a critical activity, for both WETS and the Developer. It is therefore important that both perspectives are reflected in the development of site procedures.

The flowchart is given in Figure 2.7. The application process is split into two phases:

> Phase 1 is preliminary works leading to device consents and agreed safety procedures being in place; these are discussed in Sections 2.4.1 and 2.4.2 below.
>
> Phase 2 is the preparation of the RAMS in readiness for site deployment, securing 3rd party assurance on the device design and meeting all the other requirements of the WETS berth agreement; these are discussed in Sections 2.5 to 2.12 below.

Activities in Phase 1 are shaded light yellow and Phase 2 are shaded light brown.

It is envisaged that it will be a “staged” process, and at the end of each stage, there will be an “approval gate”, at which a “Go / No go” gate is reached. This approach to project management is described as a “Stage-Gate” project development approach.

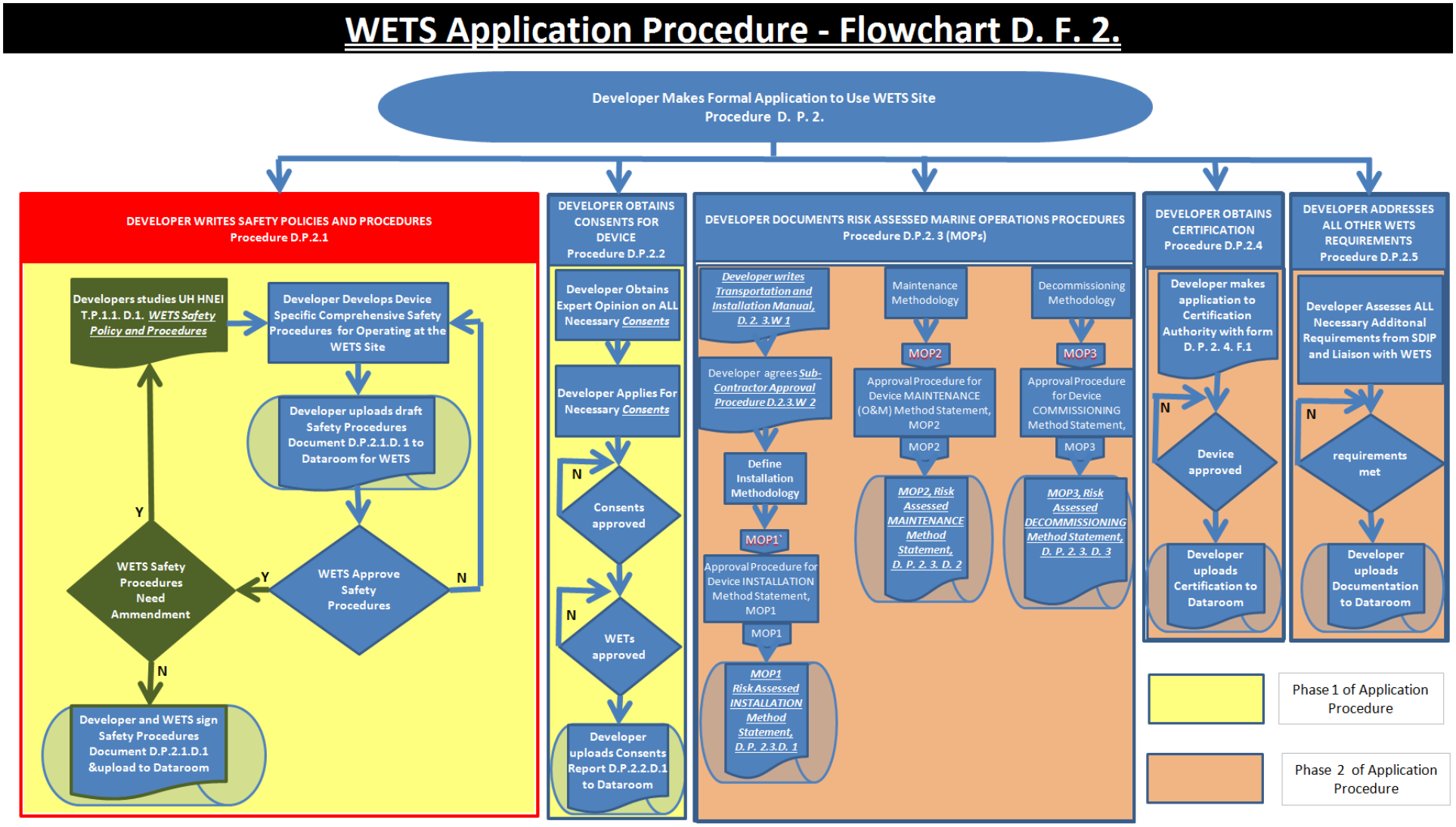


Figure 2-7: Flowchart for Procedure D.P.2 - Developer Application Procedure

2.4.1 PHASE 1 of Application Process - D.P. 2.1. Procedure for Writing Developer Safety and Emergency Response Procedures

The Safety information supplied in the SDIP will be generic, of necessity. When a Developer with a specific WEC device applies to use a berth, the information supplied by WETS will need to be reviewed to ensure that it covers all of the developer and WETS site requirements, and any unforeseen aspects identified.

It is envisaged that this process will involve close cooperation between the Developer and WETS Management, and the above flowchart aims to capture the key activities during this inter-relationship.

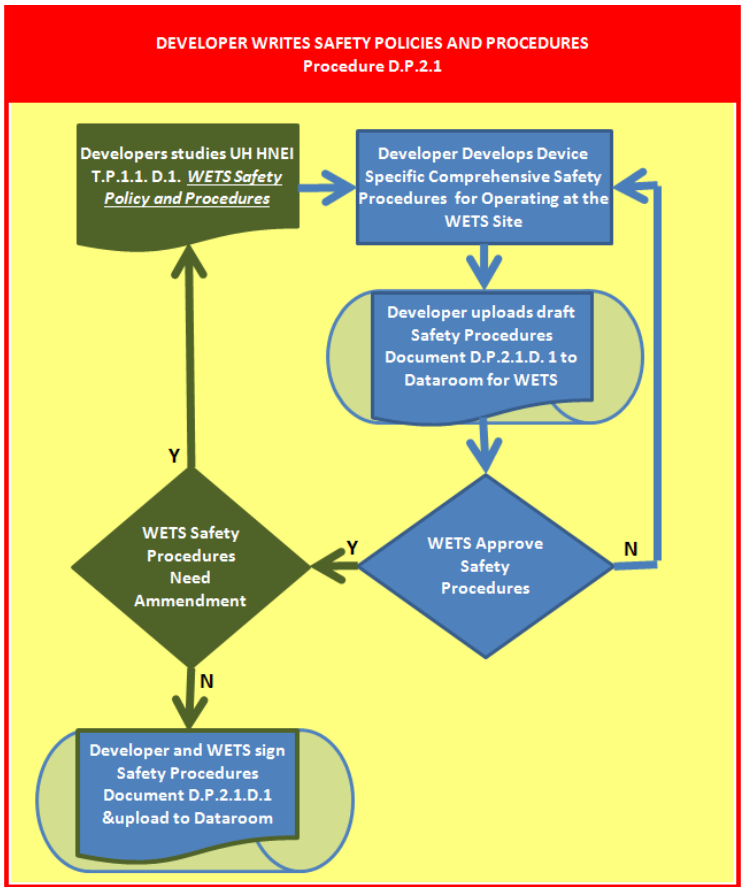


Figure 2-8: Flowchart for Procedure D. P. 2. 1 - Developer Safety and Emergency Response Procedures

This activity is carried out during Phase 1 of the Application, which is shown with the yellow-colored shading in Figure 2-8.

At the end of this procedure, the Developer will be required to submit their Safety and Emergency Response documentation for approval by WETS in a document entitled ;

- D. P. 2. 1. D. 1. Developer Safety Policy and Procedures

It is worth noting here that there is a strong likelihood that for marine insurance purposes, the device developer will be required to engage a Marine Warranty Surveyor. Should this be stipulated, attention is drawn to the GL Noble Denton Guidance Notes. These documents are written to inform in a transparent manner the rationale which will be followed by GL Noble Denton during marine warranty activities, and these are introduced and summarized in Chapter 4, on The Approval Process in their General Guidelines for Marine Projects [4] .

2.4.2 PHASE 1 of Application Process - D. P. 2. 2 Developer obtains necessary Consenting

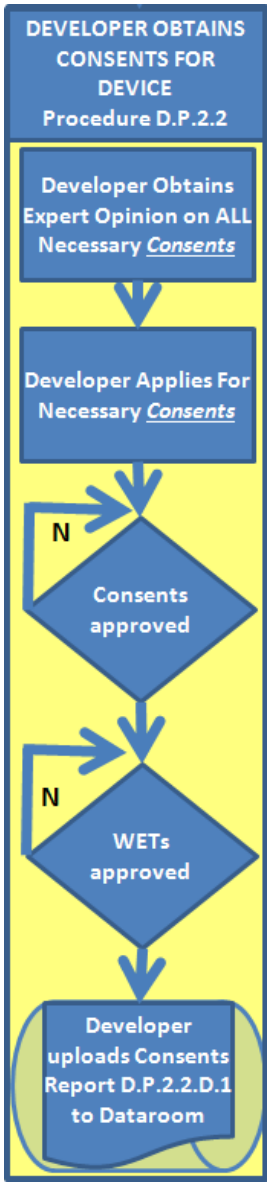


Figure 2-9: Flowchart for Procedure D.P.2.2 - Obtaining Consents During Application Phase

The details supplied in the SDIP include details of the Environmental Assessments which have been carried out in the past associated with the 30m test site, and additional details of the 60m & 80m sites, which form part of the documentation in section T. P. 1. 3. 6. D. 1.

The Developer will need expert assistance to confirm which flora, fauna, and habitats, etc. will be impacted by their device, and what Consent Applications will be required as a result.

When all consent applications have been concluded successfully, the Developer will be required to document the entire Consenting Process in which they engaged, and the successful conclusion of each application, with any consent conditions imposed in a single document, for approval by WETS. This document is called;

- D. P. 2. 2. D. 1. Consenting Applications and Awards

Once all of the above documents have been received and WETS management confirms that all of the prerequisites for device deployment scheduled in the SDIP have been addressed, the Device Developer can be advised that they have been approved to proceed to the next stage of the application process, the approval of Marine Operations.

2.5 T. P. 2. – THE APPLICATION PROCEDURE – PHASE 2

2.5.1 PHASE 2 of Application Process - D.P.2.3 Developer Writes Draft Risk Assessed Method Statements for All Marine Operations

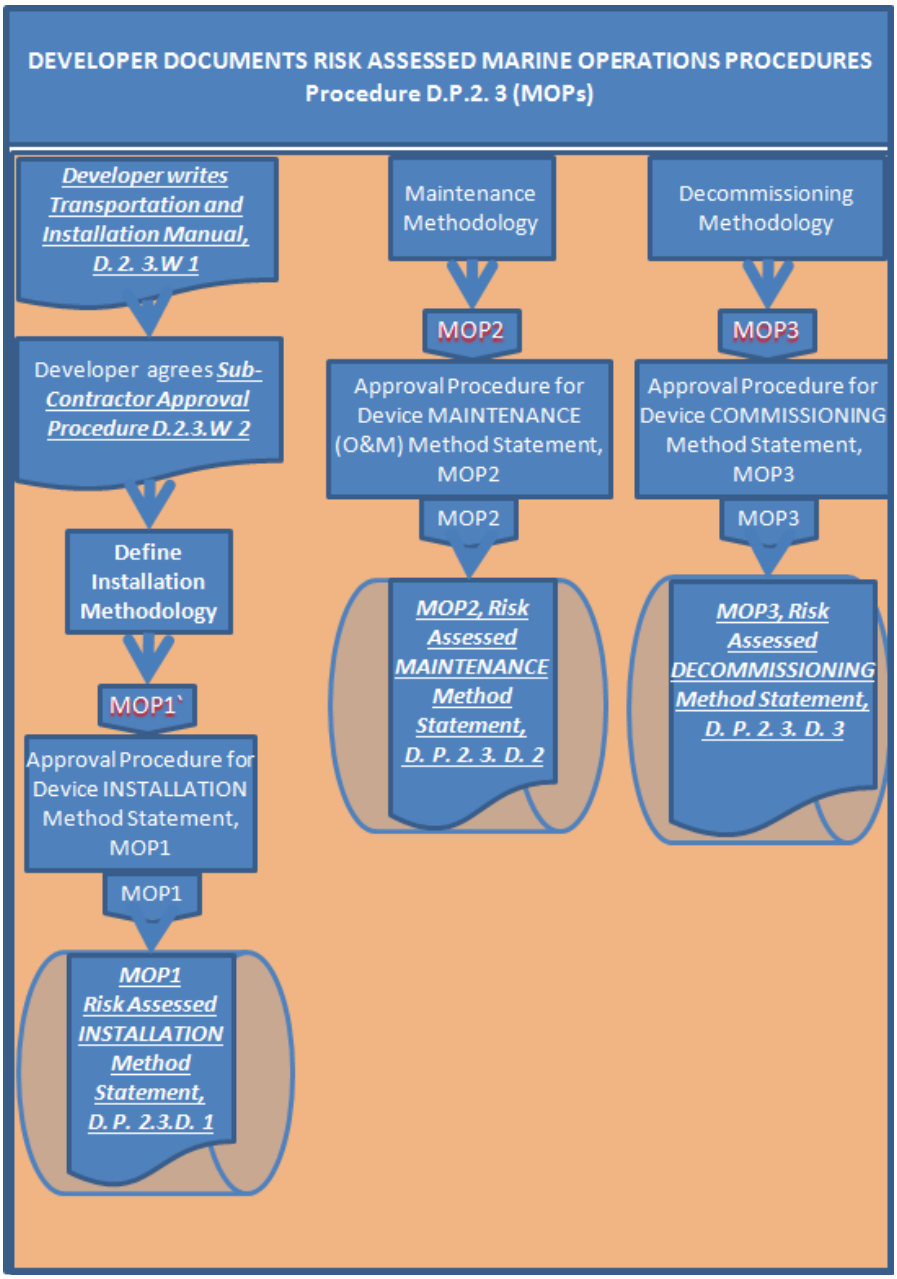


Figure 2-10: Flowchart D.F.2.3 for Procedure D.P.2.3 –Writing Risk Assessed Method Statements for Marine Operations

In general, the prototyping phase of any WEC device will broadly follow the same stages. Initially there is a period of design, which will progress into procurement of the components and fabrication of the structure and machinery.

During this time there is a necessity to carry out the planning and approval of the following three distinct phases of Marine Operations, and each will require an approved and Risk Assessed Method Statement (RAMS):

- Installation
- Operation and Maintenance (routine and major)
- Decommissioning

Since there are three distinct Marine Operating Procedures (MOPs) required, and each requires its own Risk Assessed Method Statement, the processes of deriving these documents have been designated as:

- D. P. 2. 3. 1. Drafting of Risk Assessed Method Statement for Installation, MOP1
- D. P. 2. 3. 2. Drafting of Risk Assessed Method Statement for Operation & Maintenance, MOP2
- D. P. 2. 3. 3. Drafting of Risk Assessed Method Statement for Decommissioning, MOP3

2.6 The Draft Risk Assessed Method Statement for Device Installation - D. 2. 1. D. 1

While it is necessary to have a reasonable level of detail in the proposed marine operations procedures at Application Stage, it is not possible for all details to be finalized since vessel charters, final consenting, and contracts with WETS are unsigned.

It is still prudent to approach the process by writing the document in depth with generic vessel classes or characteristics such that it can be approved in principle, and will require minimal adaptation when the specific vessel within the class considered is actually formally chartered.

In their "Rules for Planning and Execution of Marine Operations, Part 1 General Requirements", Det Norske Veritas advocate the following sequence of activities:

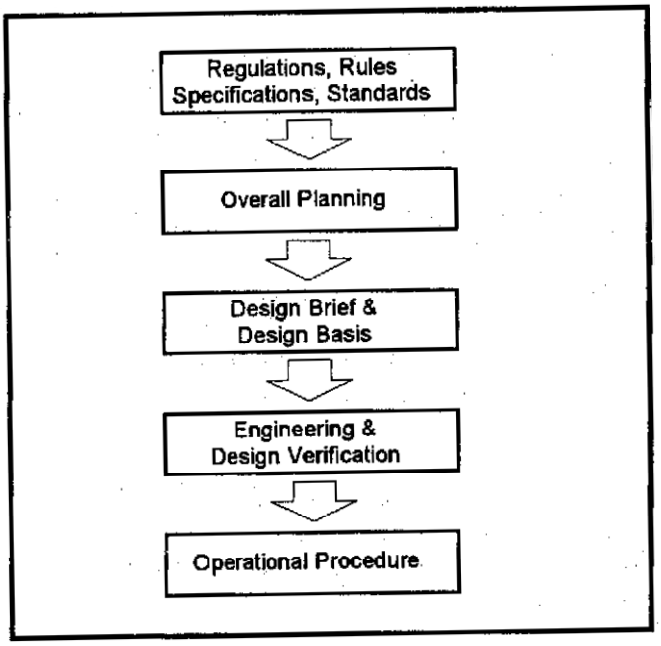


Figure 2-11: DNV Recommended Marine Planning and Design Sequence

It is therefore proposed that the first stage of approval of the first Marine Operations Procedure, MOP1, is to adopt a standard systematic approach, and in drafting the Installation Method Statement, to start including the items above within the standard pro-forma document as each is finalized.

Good practice guidance dictates that any such documentation should include the following essential elements:

- Introduction
- Reference documents
- Outline execution plan
- Organogram and lines of command
- Job-descriptions for key personnel
- Safety plan
- Authorities and permits including notification and approval requirements
- Contractual approvals and hand over
- Environmental criteria, including design and operational criteria
- Operational bar chart, showing the anticipated duration of each activity, interrelated activities, key decision points, hold points
- Specific step-by-step instructions for each phase of the operation including sequence, timing, resources and check lists
- Reference to related drawings and calculations, e.g. environmental loads, moorings, ballast, stability, bollard pull
- Contingency and emergency plans
- Emergency Preparedness Bridging Document.

A standard pro-forma for a Method Statement based on the above has been included in Appendix A for reference.

However, before such a document can be drafted, several preparatory phases must have been completed. Supplier auditing and preparatory documentation needs to be drafted to document all of the pertinent engineering variables of the device. In this way it will be possible to ensure that there is a clear understanding by the marine civil engineering contractor who is selected, on the loads and dimensions of all components, and their installation methodologies. Then the process can commence to select which vessels and techniques can be used to safely and efficiently install the device.

2.6.1 Wave Energy Device Transportation and Installation Work Instruction, D. 2. 3. W. 1

The Transportation and Installation Work Instruction, is designated as document, D. 2. 3. W. 1, and is highlighted in yellow, as it is likely that developers will not have all of the necessary information drafted into an appropriate format as they enter the prototyping phase.

During the process of engagement with potential local marine installation contractors this document will be valuable, and it will vary on a case-by-case basis whether it is most appropriate for the Device Developer or the Contractor to take a lead in the drafting of documents. Developers should bear in mind that as well as forming a requirement of the

application for WETS application, the documents should be written so that they form a useful draft for an analogous document which Developers are required to produce during future commercial deployments of the devices.

GH GL would advise that all documentation be drawn up in accordance with industry best practices, and the GL Noble Denton Guidelines are internationally respected in this regard. In addition to 001.ND General Guidelines, [4] for this aspect of this of the work, reference should be made to 030/ND Guidelines for Marine Transportations [5]. It is noted that this document is written to comprehensively cover any type of marine transportation, and therefore some large proportions of the contents will not be applicable to the level of detail required by a Device Developer transporting a prototype wave energy converter. However, it is of value for developers to become aware of the detailed requirements which will apply, should their devices achieve production status. It is also prudent to address the relevant requirements of this set of guidance notes such that revision at a later stage will simply involve reviewing a document in a standard structure and extending its scope, to encompass more of the same guidance document's requirements.

Appendix A of 030/ND Guidelines for Marine Transportations [5] suggests that the following initial information will be required for approval, and gives details of the expectation for each aspect:

- Towing or Transportation Manual
- Details of Towed or Transported Object
- Details of Transportation Vessel
- The Strength of the Vessel and Sea Fastenings
- Proposed Route, and Seasonal & Environmental Limiting Criteria
- An Assessment of the Stability of the Vessel

In drafting the document, the Developer's attention can be drawn to the GL Guideline for the Certification of Offshore Wind Turbines [11]. Whilst this documentation is associated with equipment designed for a different sector of the renewable energy industry, the sector is acknowledged as being significantly more advanced than wave energy. As such, there are likely to be lessons which can be learned from the requirements placed upon Wind Energy Device Developers by Product Certification guidelines produced by Certification Authorities in the wind industry.

The GL Guidelines provide the scope of contents required for four Manuals which are of direct relevance to a wave developer at WETS. These manuals are reproduced in Appendix B for reference:

1. Sea Transport & Offshore Installation Manual
2. Commissioning Manual
3. Operating Manual
4. Maintenance Manual

The GL guidelines schedule the details required to carry out the assessment of the marine transportation of Offshore Wind Turbines, and until there is a greater convergence of device types within the wave energy sector, it would seem prudent to suggest that the appropriate sections of the wind guidelines be used as a first port of call, and requirements therein for the Transportation Work Instruction be used to inform on the analogous documentation required at WETS.

The Developer, when carrying out preparations for a program of testing at WETS, is not acting in a completely analogous way to a wind energy device manufacturer in the established wind industry. Not only is it necessary for them to define how their device should be transported, but they are also likely to be heavily involved with their Marine

Installation Contractor, in the process actual transportation and installation. Depending on their level of experience and competence, there will be some division in the scope of works with regards to Marine Operations Planning, but from WETS point of view, the Device Developer is responsible for preparation of the documentation.

To ensure that there is maximization of localization, and to ensure a cost-effective project, the precise minimum transportation and installation requirements of the device should be defined to a high degree of accuracy.

The format and level of detail of the sea transportation and installation manual shall be such that the resulting loads and risks can be evaluated and that the qualified technical personnel performing the required tasks are able to understand the instructions, to serve as a means of facilitating contracting negotiations with Marine Civil Contractors. As a minimum, this document must contain:

- Sizes and weights of all components, with sketches showing key dimensions
- Location, and variations of component center of gravity
- Lifting and attachment points for conventional lift-gear or bespoke devices
- Limiting angular and linear relative displacements & dynamic accelerations
- Any constraints associated with rain, visibility, temperature (hot or cold)
- Any perceived health hazards, e.g.
    - Hazardous chemicals
    - Details of any safety devices whose function should be checked

In addition, any device-specific, in-transit, or routine-maintenance requirements must be specified. For example, any requirements for maintenance of power to the device during transit, or requirements to ensure parts are rotated regularly to maintain oil-coverage of moving parts to avoid fretting, should be established.

2.6.2 Device Installation Methodology

In Appendix A, there is a GL GH recommended pro-forma of a Method Statement. The methodology developed under this part of the procedure should be suitable to address the requirements of section 6 "Description of the Scope of Work".

There are innumerable WEC device configurations, and some consist of a discrete foundation and a separate energy capture device. For the purposes of simplicity, when there are two components, each will need to be considered separately and it will be down to an agreement, at the discretion of the Test Site Manager and Developer, whether it is most appropriate to document the Installation Method Statement as a single document or to separate out the foundation installation from the energy capture device itself. The following text uses the single term "device" to refer to either a single unit, or a WEC device with a separate foundation.

The sequence of operations which the Device Developer foresees at being the most practical installation methodology shall be written down, and accompanied by enough sketches and explanation of each activity to ensure a clear appreciation of the construction concepts. In some cases the Device Developer will be an organization with in-house marine construction capabilities, and this should greatly improve the simplicity of drafting the required documentation as staff will have a clear appreciation of the capabilities of their own equipment and vessels.

Other developers will have a varying degree of practical experience with marine construction and installation operations, and will need a greater or lesser degree of support from Marine Installation Contractors and/or WETS, as appears most appropriate on a case-by-case basis.

Since the quality and safety of any installation methodology could depend heavily upon a third-party subcontractor to the Device Developer, it is important that the WETS site impose a rigid selection procedure which the Developer must follow for their appointment.

2.6.3 Marine Installation Subcontractor Approval Procedure

The assessment of subcontractors is a clearly defined process under standard Quality Assurance procedures, and forms the approval phase of development of the "Approved Supplier List" which all accredited organizations should routinely develop and maintain.

The International Marine Contractors Association, IMCA, has over 900 members. While membership is no guarantee of the Contractor being ideal for any particular role, such an accreditation is indicative of a firm which wishes to engage with pioneers of good practice, and as a first step, it would be prudent to check the Association's member companies list, which can be accessed from their website.

Many of the Device Developers who seek to deploy devices at WETS berths will not have a recognized and accredited QA Management System in place. Even so, there is nothing to stop any organization "cherry-picking" the most appropriate elements of the global requirements of a system like ISO 9000 and developing and using individual operational procedures appropriate to their organizational needs.

It is recommended that since installation is such a vital part of the prototyping activities, and it is generally subcontracted, that any Device Developer who has not got an accredited QA system in place be required to develop a Subcontractor Approval procedure, and have this independently assessed by a third party for compliance with the limited scope of the appropriate element of ISO 9000.

In turn, this 3rd-party approved Subcontractor Approval procedure document should be submitted to WETS for comment, in advance of any final appointment of a marine civil contractor.

In this way, some assurance can be gained by WETS that the subcontractors appointed to carry out any installation work on their site have been assessed as having appropriate capabilities to conduct the work required of them.

The Developer should submit the Subcontractor Approval Procedure to WETS for approval, which will be designated D. 2. 2. D. 2.

2.6.4 Vessel and Equipment Availability Survey

The costs of installing a single prototype are often little different from the costs of installing a several-unit array. Both require vessels to be chartered, surveyed, mobilized & demobilized and method statements to be written, approved and Hazard Identification (HAZID) meetings held, etc. The additional cost of what is often a relatively short extension to the Charter Period to install several devices, as opposed to one, can add as little as a few tens of per cent to the overall installation Capital Expenditure budget.

It is therefore sensible that prototypes are installed as economically as possible, and this places a strong pressure on developers to utilize the most minimum specification vessels possible, for the shortest possible duration. However, this can promote over-ambitious planning, and extra vigilance is required when both preparing and approving Method Statements for prototype installation, maintenance and decommissioning, to ensure that all operations are in accordance with best practice, and above all that no cost-corners have been cut which in any way compromise

safety. This particularly applies to items such as mooring integrity, sea fastenings, towage plans, lifting plans, and offshore Health & Safety arrangements.

In sea areas where there is limited availability of vessels and equipment there will be a requirement to apply a higher level of ingenuity to adapting existing equipment to fulfill the roles required.

Most WEC device developers are unlikely to be familiar with all of the vessels and equipment which are available in Hawaii, and the capabilities of the local Contractors. While it is not an explicit requirement and has not been included as documentation required in T. P. 1. – Development of the Standard Developer Information Pack, it would seem to be of great benefit to developers, and also prudent for WETS, to ensure that a brief introductory document be made available, scheduling the local availability of vessels and equipment spreads, as well as a selection of the most respected, and appropriately accredited local marine contractors. For instance, any which are members of the International Marine Contractors Association IMCA would seem particularly appropriate for inclusion in such a list.

2.6.5 Design and Installation of Moorings

The Metocean Data for the WETS site, in conjunction with the respective geotechnical and geophysical data, are sufficient for a Device Developer to carry out a set of mooring calculations for their device. The SDIP contains the appropriate detail in:

- T. P. 1. 3. 4. D.1. Moorings and Marine Navigational Marking Requirements for the 30m WETS Site, and
- T. P. 1. 4. 4. D. 1 Moorings and Marine Navigational Marking Requirements for the 60m & 80m WETS Sites

The Developer will assess the information supplied, and carry out and submit their mooring calculations for all operational conditions of their device in all appropriate wave conditions foreseen at the site. In response to the documentation in the SDIP, referring to either the 30m or 60m/80m water depth test sites, the Developer will include these in the Method Statement as a clearly identified sub-section. Alternatively, they may wish to submit a separate document called either:

- D. P. 2. 3. 4. D. 1. Assessment of the Moorings and Navigational Aids for the [Device] at WETS 30m site, or
- D. P. 2. 4. 4. D. 1. Assessment of the Moorings and Navigational Aids for the [Device] at WETS 60m/80m sites.

The proposed mooring arrangements contained in any documents now require formal approval by a Marine Warranty Surveyor (MWS). At the same time, the vessel selection and installation methodology used to deploy the moorings and connect to them to the device will be approved by a MWS. Guidance on the design, analysis and component specification for offshore moorings is contained in the GL Noble Denton Guideline 032/ND – Guidelines for Moorings.

2.6.6 Risk Assessment of Draft Method Statements

The developer and the selected Installation Contractor will invite WETS representatives and other stakeholders to a Hazard Identification and Risk Assessment (HIRA) meeting. Several meetings may be required with different stakeholders, depending on which operations are being discussed. Well in advance of the meeting, the latest draft of the RAMS documents will be circulated to all invitees, inviting their early observations of hazards that they perceive will require addressing in the Risk Assessment. Every perceived hazard will be included in the first draft of a Risk Assessment. Each Hazard will be quantified in accordance with an assessment of the probability and severity of occurrence, preferably in accordance with documented good practice using a standard 5 by 5 risk assessment matrix (see example procedure in Appendix C). The Risk Level is given a numeric value based on the Severity of

occurrence (from 1 to 5) multiplied by the Probability of occurrence (from 1 to 5). The risk levels are then banded by thresholds of acceptance, and color-coded with a U.S. Traffic Light system Red, Yellow, Green.

After assessment of the initial risks of each hazard a process of risk mitigation will be carried out. It is recommended that each hazard be reviewed and a seven-level hierarchy of mitigation measures applied, which in order of diminishing effectiveness are:

1. Elimination
2. Substitution
3. Engineering controls
4. Signals / warnings and administrative controls
5. Personal protective equipment
6. Damage Control
7. Prescriptive Rules

After mitigation methods are suggested, a re-assessment of the residual risk will be made, assuming the mitigation measure has been effectively applied.

Since each operation is defined within the Installation Methodology and all key ancillary support activities are referenced, in this way, the scope of the HAZID will cover all marine operations associated with the Method Statement.

The Risk Assessment should be documented in a tabulated format. A pro-forma set of headings is suggested below in Table 2-2 below.

Activity Description	Hazard Identified	Risk	Persons at Risk	Severity of Occurrence	Probability of Occurrence	Risk Level	Mitigation Measure Proposed	Residual Severity of Occurrence	Residual Probability of Occurrence	Residual Risk Level	Comments

Table 2-2: The Documentation of the Marine Operations Risk Assessment Process

2.7 Submission of Draft Risk Assessed Method Statement D. P. 2. 3. D. 1 to WETS

The Draft Installation Method Statement, documented in accordance with the pro-forma contained in Appendix A, with its associated Risk Assessment, documented in accordance with the tabulated format of Table 2-2 attached as an appendix must be submitted to WETS for their approval.

WETS will then assess the document within a certain period (e.g. two weeks), and will notify the developer of their acceptance, or schedule any queries and concerns which they would like to be addressed prior to approval.

2.8 Issue of a Certificate of Acceptance

Once WETS is satisfied with the quality of the RAMS, it will issue a document recording this, typically called a 'Certificate of Acceptance'. It should be noted that WETS should not "Approve" the developers' (or contractors') RAMS, since that would imply taking responsibility for them in some way, thus attracting liability; rather, WETS will "Accept" the RAMS. The instrument of control if RAMS are not accepted is the Permit to Work (PTW) – WETS can refuse to issue a PTW until satisfied that all issues arising from the HIRA meetings have been adequately addressed.

2.9 D.P.2.4 - Developer obtains independent 3rd party assurance

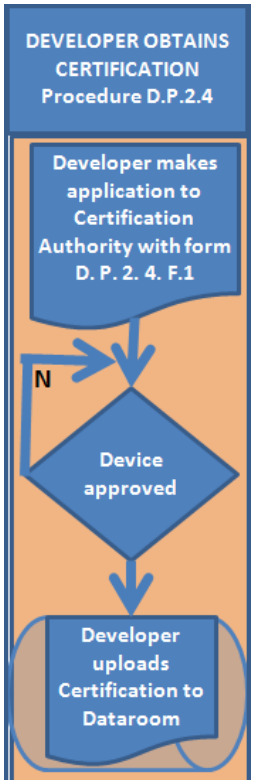


Figure 2-12: Flowchart for Procedure D.P.2.4 – Developer obtaining independent 3rd party assurance

It is likely that the WETS will require evidence that the device design, safety systems and installation methods have been subjected to some form of independent review by a recognized 3rd party authority. There are options for how this can be achieved, the choice of which will depend mostly on the stage the technology has reached (i.e. whether the device is a small-scale prototype or a full-scale pre-commercial device), but partly on developer preference:

- Submit the design to a certification authority (e.g. GL or DNV) to undergo a prototype design review. There are as yet no established certification guidelines for WEC devices, however use is generally made of existing offshore standards for structure and machinery. The result is a so-called "Plausibility Assessment" which will review the structural integrity and safety systems and the transport & installation procedure, and certify operation for a fixed period (for ocean current turbines, for example, GL provides for 3,000 running hours or 2 years, whichever is reached earlier).
- The certification authority route is not mandatory, however, and 3rd party review can also be provided by a recognized authority, for example an offshore design house or an established and independent wave energy consultancy.

2.9.1 PHASE 2 of Application Process - D. P. 2. 5. All Other Requirements for Application

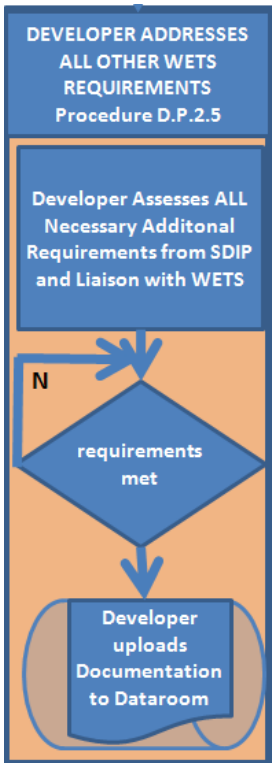


Figure 2-13: Flowchart for Procedure D.P.2. - Approving all other Requirements for Application

In response to the specific information supplied in the SDIP, the device developer will need to supply documentation evidencing that they have addressed ALL of the requirements laid down in each area of the SDIP.

In principle, provided the device developer can demonstrate that they have addressed all of the stipulations made by WETS in the SDIP and can demonstrate in the above referenced documentation that they meet every requirement, the foundations should be laid for their acceptance to use a WETS berth.

2.10 PHASE 2 of Application Process - DRAFT OPERATION & MAINTENANCE METHOD STATEMENT MOP2

In essence the planning of the marine operations associated with the routine maintenance of the device should be analogous to the procedures followed during the installation phase. Clearly the actual activities are going to be of a lesser scale, as routine maintenance in most cases involves general checks, and at maximum, changing of wear-parts and lubricants. The primary requirement is that all routine maintenance requirements are documented in method statements, and risk assessed.

It is good practice that if one maintenance technique requires that a particular class of vessel be available, that several alternative methodologies be documented, to ensure the greatest possible flexibility for operational planning, and vessel chartering options.

The same pro-forma Method Statement contained in Appendix A should be used to record the details of the maintenance methodologies. The engagement of all stakeholders in the risk assessment

The process of obtaining a Permit to Work, and the documentation required, will follow the pattern for the Installation Method Statement. It is likely that there will be greater emphasis placed upon the supervision during installation; so the nominated person or persons carrying out the Marine Coordination role may be different, but there are requirements for a thorough list of all persons working on site at all times, and checks to ensure that they have had an appropriate site induction, associated with their level of training.

The vessels used for routine maintenance will probably be different from those used during installation. The same care and attention to detail will be needed to ensure that vessels are selected capable of operating in the entire range of conditions anticipated on site. Alternatively, it is acceptable to stipulate different vessel selections for good-weather windows, and other more capable craft with higher operability limits.

2.11 PHASE 2 of Application Process - DRAFT DECOMMISSIONING METHOD STATEMENT MOP3

In essence, the planning of the marine operations associated with the routine maintenance of the device should be analogous to the procedures followed during the installation phase.

Many decommissioning plans are drawn-up to be direct reverse operations of installation. There is a strong likelihood that the equipment used to place the device will be favored to remove it, not least because by the time the device is installed, very useful information will have been accrued on how it can be handled with that equipment.

2.12 T. P. 2. 1 - Marine Operations Checklists

2.12.1 Marking of Wave Energy Test Areas

Appropriate markings for Wave Energy Test Tests
Approval has been received from the Appropriate Authorities in Hawaii to consider the 30m test site as a Wave Energy Device Test Site. Similar authority has either been received, or applied-for with respect to the other two 60m/ 80m test sites.

As part of this process, it is possible that the granting of a Lease or Approval to use this area as a Test Site will automatically trigger a system to notify Marine Chart producing authorities. If not, WETS should communicate with the Marine Cartographic Authorities for Hawaii to ensure that the three areas proposed are designated as Test Sites, and have appropriate exclusion zones marked on Marine Charts of the area throughout the duration of the lease period.

Type of buoys to be used
The type of buoys to be used may already be prescribed in the Lease or Approval to use the Test Site. If not, reference should be made to the U.S. Coast Guard and/or local port authority, and in lieu of any prescriptive guidance for wave test sites it would seem reasonable to propose to install Cardinal Buoys at the extremities of the Test Site, to warn mariners to avoid the area.

Radar reflectors
Most buoys are equipped with a passive radar reflector to ensure that vessels approaching the Test Site to identify the perimeter buoys. Since WETS is being developed in cooperation with the U.S. Navy, clarity should be sought that there will be no issues with having radar reflectors positioned on these buoys, from a Security perspective.

Automatic Identification System AIS
Many Offshore Renewable Energy Installations provide additional identification of the perimeter of their site in the form of AIS devices fitted to the Cardinal Buoys at the extremities of the leased area. These devices provide information on not only the location, but also the details of the device to which they are fitted. They also appear on suitably equipped modern Radar systems aboard vessels, allowing the person at the helm to realize that they are close to a Wave Energy Test Site, and take suitable evasive action.

Visual
The buoy selection will give some visual information to mariners during the hours of day-light. This can be supplemented with color-coding to comply with the Navigational Aids conventions in use in the area.

Further, at night, there will be a requirement for navigational aids in the form of lights. These will be required to conform to the marine lighting regulations prescriptions of the U.S. Coast Guard (USCG), and probably International Marine Organisation's Regulations for Preventing Collisions at Sea (IMO COLREGs) and also by the requirements of the International Association of Lighthouse Authorities, IALA

Audible
Some buoys are equipped with bells which toll as the buoy moves in the waves, and provides a continuous audible warning to mariners to avoid the area.

Other buoys are required to have fog-horns fitted, to warn mariners of their whereabouts in conditions of reduced visibility. If an automated fog-horn system is fitted there will be an associated maintenance regime required to ensure its continued functioning. Likewise, the functioning of all navigational aids will require an analogous maintenance regime.

2.12.2 Notice to Mariners

A system of Notices-To-Mariners (NTM's) is in effect in most Marine Authorities to highlight smaller pieces of work which have to be carried out from time to time. It is also prudent to both notify the publishers of NTM's of the on-going perimeter of the Test Site 500m exclusion zone, but also to leave a date-unlimited NTM in place to inform mariners when particular activities are known to be occurring on site regarding installation and commissioning.

2.12.3 Appropriate anchorage to be deployed

The design of the anchorages for the permanent markers for the perimeter of the site may well be prescribed by the manufacturers of the buoys used, and in that case, it will be a simple case of following the documented deployment and recovery procedures as well as any routine maintenance recommendations. If this is not the case, a reputable marine design will be required which is suitable for the device to be restrained, in the wave and wind climate, and suitable for the seabed conditions documented in the Standard Developer Information Pack, SDIP.

Environmental consenting may influence the fixing techniques to be used – this is discussed in greater depth later. The original WETS site had one of its three mooring lines fixed by a deadweight anchor, which was used as an anchorage of opportunity, as it was available at time of deployment of the device. Deadweight anchors offer a low-environmental impact solution to mooring on rock seabed and may be considered preferable to drilled solutions from that perspective.

2.13 Who is the appropriate authority providing Marine Coordination at WETS on a day to day basis

At WETS it will be necessary to define the administrative approach to Marine Coordination. Since Marine Coordination will be required at all stages of the life-cycle of the Device Test, a single Marine Coordination Regime will be defined which is applicable to the Installation, Operation & Maintenance and Decommissioning phases of

operation. But all Marine Operations Procedures must integrate their activities stating all interface requirements and hold points prescribed by the WETS Marine Coordination Procedures.

WETS will need to define who is the appropriate authority designated to carry out the coordination role on a day-to-day basis. This responsibility is often vested in a named Marine Coordinator, and a Deputy, to whom reference is made for all necessary approvals to carry out approved Marine Operations on site.

It should be noted that the limit of the Marine Coordinator's authority is to assist on coordination of previously approved Marine Operations Procedures which are to be carried out in accordance with Risk Assessed Method Statements. The Marine Coordinator does NOT approve Method Statements.

2.13.1 The First Time a Vessel Obtains a Work Permit

On the first occasion that a vessel wishes to engage in Marine Operations within the WETS Test Site Area in accordance with a Risk Assessed Method Statement the Master Mariner (the person in charge of the vessel) must supply at least a minimum set of documentation. The minimum list will need to be set by WETS and should be drawn from the following, with the other documentation on the list below being requested, rather than required:

- Statement of Which Approved Marine Operations Procedures are to be followed
- Developer will submits Marine Operations Declaration from Marine Warranty Surveyor
- Certificate of Class
- Sailing Permit
- Ship Safety Construction and Equipment Certificate
- Vessel On-Charter Condition Survey
- Safe manning Level Document
    - Qualifications requirements of all necessary Crew
    - Qualification of Crew proposed by Vessel Operator
    - GMDSS qualifications of designated Master Mariner
    - Engineering / Seamanship qualifications
- Documents on specifications of Communications Equipment
- Ship Safety Radio Certificate
- Documents on specifications of Navigation equipment
- Documents on Maintenance Contracts for Communications Equipment
- Documents on Maintenance Contracts for Navigation equipment
- Informal confirmation for functioning AIS on board
- Documents on MARPOL procedures (if required):
    - POB List Crew and Passenger
    - All entry/exit requirements of Port Authority if Leaving Harbor
- All Immigration requirements if leaving territorial waters.
- Crew and Personnel list
- Issued Bridge Document

On subsequent occasions there may be a relaxation of this requirement by the Marine Coordinator while each document remains within its expiry date.

In order to issue a work permit the Marine Coordinator requires further information regarding:

- planned work
- where in the construction site shall the work be carried out
- within which period of time shall the work be carried out

The work permit allocates the above mentioned points (effectuation, location, duration) to the vessel.

The Marine Coordinator must always receive information about:

- actual number of persons within the construction site
- which vessel transports how many persons to the construction site
- which vessel returns how many persons to the harbor

The aim is that in case of an emergency, the Marine Coordinator is able to give detailed information about the persons remaining in the field.

Prior to personnel transfer the Marine Coordinator receives a personnel list. This list contains the following information:

- name of the persons
- company name
- trade – to inform where their "workplace" is within the construction site
- number of identity card – issued at time of Site Induction Training
- kind of safety training of the respective persons

2.13.2 What standard Radio frequencies will be used on site for inter-vessel and project coordination

The Marine Coordination activities during the approval phase are generally conducted in paper via email communications. When offshore, communications are generally conducted on Marine Band radio, using the standard Radio frequencies used on site for inter-vessel coordination. A decision will be required (if it is not prescribed by local Marine Authorities) on whether initial communications will be on Channel 16, or whether no "pick-up" channel is to be used as a channel to engage in communications with other vessels, and all communication will be carried out on some other designated marine band channel which is generally locally free from other communications traffic.

There are often regulations governing the usage of onshore frequencies for "inshore or offshore" applications, and equally that Marine Band radios should not be used for any onshore operations. These regulations may demand that Marine Band communications be used, and in cooperation with local Marine Authorities ensuring that all other mariners are made aware to avoid usage of the selected channel(s) during operational periods.

If it is deemed necessary to have un-interruptible safety channel, as is sometimes the case during critical lifting operations, arrangements must be put in place as early as is possible. For onshore or nearshore operations it may be appropriate for a dedicated Personal Mobile Radio, PMR, frequency to meet the need. In this case, a dedicated set of equipment may be required, as these are not the same frequencies as Marine Band. It will also be necessary to apply for permission to the appropriate authority overseeing radio frequency licensing allocations, for such a channel to meet this need.

There is a possibility that the U.S. Navy may be prepared to assist with a frequency and the subject could be broached with them that if a requirement arose, should they be prepared to consider such an application.

3 INSTALLATION PHASE

The primary document driving the installation phase will be the Risk Assessed INSTALLATION Method Statement. This document will be owned by the device developer's appointed Marine Construction Contractor. However, in the process of drawing up the RAMS there will be a requirement to work closely with a large number of stakeholders in the operation, to ensure safety and technical sufficiency of all materials, equipment vessels and operational procedures well in advance of the actual installation itself.

The following factors will be necessary consideration for various kinds of operations

3.1 Vessel Selection

During the application phase, the Device Developer will have submitted documentation about the technical specification of the device in terms of its size and weight which is documented in the Device Transportation Manual, and an outline Installation Methodology.

When potential Marine Installation Contractors have been audited and passed the criteria to be added to the device developer's Approved Supplier List, it will be necessary to shortlist potential installation vessels, so that Risk Assessed Method Statements can be developed based on actual available craft. Ideally more than one vessel will be identified which is capable of fulfilling the role, to ensure that there is a contingency plan, should the primary vessel of choice be unavailable.

3.2 Vessel Suitability and On-Charter Condition Survey

In cooperation with the Marine Insurance Brokers, and their appointed Marine Warranty Surveyor, vessels which have the appropriate technical specifications to conduct the installation operation will be considered. If it is deemed necessary the MWS will carry out a Suitability Assessment Survey of the vessel or vessels shortlisted. If the MWS is very familiar with the craft, this may be deemed unnecessary, and in a relatively small vessel, spot-purchase vessel charter market this is likely to be the case.

When the vessel has been approved and Chartered, prior to its usage to carry out the Device Installation, the Marine Warranty Surveyor will carry out an on-Charter condition survey. This document provides both assurance that all operating equipment necessary for the installation procedure are in good working order, as well as forms the baseline against which any damage or failures of equipment, prior to the end of the Charter, would be assessed. As such, the survey is of value to both the Vessel Owner and the Charterer, and the costs of the on-charter and off-charter surveys may be shared, but this will be documented as a term in the governing Charter.

As part of the Suitability and Condition Surveys any essential towage or lifting equipment etc. associated with device deployment will also need to be checked for technical sufficiency, and inspected to ensure that it is in good working condition. It is prudent therefore to ensure that the device and vessel are co-located, at least during the mobilization phase of the work, to cut down the Marine Warranty Surveyors travel distances and costs.

At the end of the process the Device Developer shall obtain a Marine Operations Declaration from the Marine Warranty Surveyor. This shall be the mutually agreed acceptance criteria between the Device Developer and the Installation Contractor regarding the acceptability of the Risk Assessed Installation Method Statement, and subsequently the corresponding method statements for operation & maintenance, and decommissioning.

3.3 Compliance with Requirements of Environmental Consents

Within the SDIP, a number of rare creatures and habitats are described. It is necessary for the RAMS to address the requirements laid down in the Environmental Consents governing the Installation and operation of the WEC Device.

As a result, when the RAMS has been drafted, and the process of Hazard Identification (HAZID) is entered into, it is standard practice to invite all stakeholders to the HAZID meeting, and it would be good practice to invite any Environmental Monitoring Agencies who will be involved in the installation to the meeting. This will engender an open working relationship in which all agencies can work together to ensure that environmental consenting is adhered to, thereby smoothing the waters for all parties.

3.3.1 Piling, Drilling or other Underwater, or Airborne Noise

Underwater noise is a form of pollution. During pile driving there is a lot of noise generated. In order to mitigate this, noise bubble-curtaining techniques have been developed which have been proven to reduce noise significantly, and this effect can be scaled by ringing sites with multiple curtains by laying hoses in a spiral.

Given the bare –rock seabed at the 30m WETS site, it seems unlikely (but not impossible) that piling will be an option in such close proximity at the 60m sites.

Drilling into rock and anchoring can be done in several ways. Impact drilling will generally take a lesser duration, but will generate more noise than pure rotary drilling. This was the technique used to locate two of the three original foundations at the WETS 30m site.

It is anticipated that the Device Developer will be required to follow U.S. Navy guidance on the procedures for ensuring that marine mammals and other marine flora and fauna are appropriately considered during planning operations. Methodologies for maintaining a safe radius at which the threshold noise level deemed to cause harm will be required. Such operations may also need to avoid critical seasons of migration/breeding.

3.4 Statement of which Symbols and Lights are to be hoisted - IALA / COLREGs

The Vessel deploying the ROV will become a “vessel restricted in its ability to maneuver” during the period when it is using a ROV, and it will also be “engaged in underwater operations”. As such, there are prescribed marine identification symbols to be hoisted during operations to make other vessels in the area aware, and likewise at night, should operations extend beyond the hours of daylight, there will be an analogous set of navigations lights which must be displayed.

The ROV contractor will be well aware of these requirements and will be able to advise the Installation Contractor, and in turn the Vessel Owner can ensure that all such navigation aids are available to be viewed when the Marine Warranty Surveyor carries our surveys of the vessel.

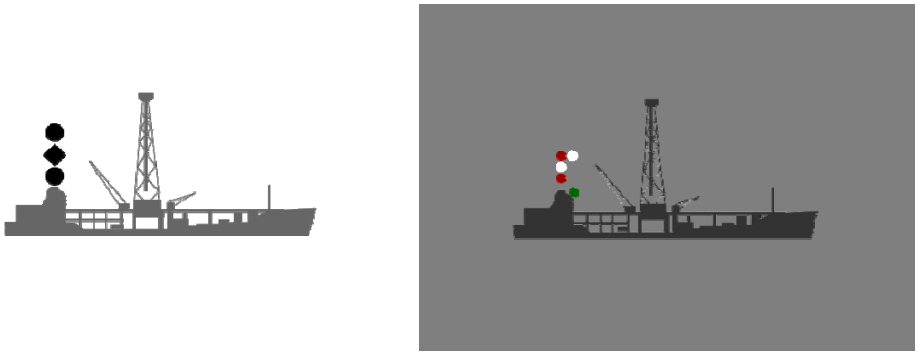


Figure 3-1: Lights and Navigational Symbols – Vessel restricted in ability to maneuver

3.4.1 Radius of exclusion appropriate to facilitate marine operations & Guard Vessels

The official approval documentation associated with the Wave Energy Test Site will probably prescribe an exclusion zone of a fixed radius, often approximately 500m around which other vessels should not encroach during periods when Marine Operations are underway. The buoys surrounding the site are generally located to give a visual point of reference as to where this exclusion zone ends. The RAMS should assess whether the exclusion zone is adequate for the proposed operations, and document this to be the case.

An assessment of the necessity for a Guard Vessel should also be made. This is a vessel which remains on-station during marine operations, and ensures that any vessel entering a fixed proximity to the site are hailed and advised to keep away from the area. Due to WETS proximity to MCBH, the Navy may already have procedures/methods in place which supersede the following suggested approach.

If a guard-vessel is felt to be necessary, it is customary to include in either the RAMS or the Marine Coordination Procedures of the WETS Site, a series of radii which represent different proximity and severity thresholds. For example, it may be felt appropriate to hail every vessel entering within a 10 Nautical Mile radius of the site to notify them that they are near the site and that Marine Operations are underway. The Guard Vessel could also ensure that she is appropriately located to intervene if the vessel maintains its course. If the vessel enters a zone within 5 miles of the site, the Guard Vessel should again hail the craft and advise them again that Marine Operations are underway on the site, and that an official exclusion zone exists around the site. At this juncture, it would also seem prudent for the Guard Vessel to advise the site that a vessel is passing close to the site perimeter. It may also be appropriate for the Guard Vessel to make way to position herself generally between the vessel and the site to ensure that she is well placed if the situation worsens. If the vessel enters say a 1 mile radius of the exclusion zone, the Guard Vessel advises site that operations should be returned to a safe condition, and also advises the Port Authorities, and Coast Guard that a vessel is passing within close proximity of an authorized exclusion zone. If a vessel enters the exclusion zone around the WETS sites, this will be an offence which will be dealt with by the Marine Authorities, and the Guard Vessel should merely remain on station and take direction from the Coast Guard.

The Guard Vessel itself, as well as all of the appropriate safety and first aid equipment to meet her Class Certification requirements, should be equipped with any necessary additional radar and communications equipment to fulfill the role. This will include AIS, ARPA radar, Marine Band and Satellite Radios and Telephone & Internet access. The Guard Vessel should also have a davit-mounted fast RIB, for assistance with Man Overboard (MOB) incidents during Marine Operations on the WETS site.

Contractually, it is normal practice for the Guard Vessel to remain on station throughout the deployment phase, including any period over-runs, should the Installation Process not progress smoothly. There will be a maximum safe operational limit for the vessel, often stated as both a maximum wave state, and a maximum wind speed in which it is

safe for the vessel to operate. Should conditions deteriorate, the vessel will remain on station as long as it can before it has to return to port to ensure it has reached safe-haven before conditions deteriorate beyond its operability limits. At such a time the site is not covered by a vessel, and before departure from site the Guard Vessel should notify the Coast Guard that she is about to put into port until conditions are safe for her to return to site, and advise if there are any serious threats to navigation remaining on the site. The Coast Guard can then monitor marine traffic, and advice them if they stray too close to any dangerous obstructions.

3.4.2 ROV Specifications

The Device Developer may have made specific stipulations which will be required to carry out the installation of their device.

The RAMS should state any such operational capability requirements, and then give details of the type of ROV to be used. The specifications of interest are likely to be:

- Make and Model (with Specification Sheet attached in an Appendix)
- Type of ancillary equipment to be fitted to ROV
- Maximum operating conditions of current under which ROV can work
    - Maximum wave conditions in which ROV can be deployed
    - Maximum wave conditions in which ROV can be recovered
- ROV deployment vessel's maximum safe transiting wind and wave conditions (survival conditions)
- Vessel maximum safe operating wind and wave conditions

3.5 Carrying Out Hot-Works

"Hot Works" is a term used to describe a wide-range of activities involving naked flames or electric arcs. It is highly likely that during operations associated with mobilization there will be are to be carried out within a mobilization port, during sea-lashing or adaptation of the equipment spread.

It is transparently obvious that there are fire or explosion risks, and potential for electrocution risks if safe practice is not followed with regard to electrical earthing. Both welding technologies, like Manual Metal Arc (or "stick" welding), Metal Inert Gas (MIG), etc. and cutting technologies, like oxy-gas cutting, air-arc or gas gouging, plasma cutting all provide a source of ignition and so consideration must be given to ensuring that there are safe control measures applied to other two sides of the "fire triangle" – namely, "fuel" and "oxygen". Flammable liquids of gases like oils, petroleum, or bottled gases must therefore be carefully controlled and kept well aware from areas of hot-works. Likewise, all flammable solids, like wood and plastics, must be protected from weld-spatter and molten metal.

The Device Developer should be made aware of all Health and Safety Legislation applicable in Hawaii. It is recommended that an appropriate Permit to Work system should be operated, to allow coordination of activities requiring hot-working.

3.6 Non Destructive Testing

As part of the installation of sea-lashings it is important not only to design welds to react loads, but to ensure that welding is quality controlled. Various techniques like Magnetic Particle Inspection (MPI) and Dye Penetrant Inspection (DPI) are used to detect surface cracks. Critical welds may also be subject to Ultrasonic Inspection, or X-ray or radiographic techniques.

3.7 Weather Forecasts

The offshore marine operations planning guidance documents referenced, like the DNV standards and GL standards, all place requirements for regular weather reports to be obtained. Some standards suggest that for critical operations more than one independent source should be use, but in the case of marine operations at WETS this is unlikely to be made a requirement.

A reasonable level of information which would suffice to inform offshore operations is recommended in the following specification.

- Every 12 hours a forecast will be obtained
- It will contain a Short Range weather forecast for the next 24 hours
- It will contain Long Range forecasts for the next 5 days, with details at least every 6 hours
- With numeric predictions for the following
    - Wave height - wind waves
    - Swell height
    - Wind at 10m
        - Average wind - including Duration of averaging – e.g. 2 minute average
        - Gust maximum anticipated
- Risk of precipitation, lightning, fog / mist-impairment to long range visibility (including estimated maximum)
- A statement of the accuracy of the forecast (e.g. High accuracy for 24 hours)

There is a strong likelihood that local marine contractors will have an approved local forecast supplier, and format in which they prefer to receive forecasts, as well as the regularity and details to be contained in weather forecasts. A copy should be supplied to, and discussed with the Marine Warranty Surveyors during the drafting of Method Statements to get their approval.

3.8 Diving Operations Coordination

WETS will doubtless have existing procedures for sub-sea operations. These may be adequate to guide developers while writing method statements and to inform risk assessments. It will be necessary to ensure that all local regulation is incorporated in documentation.

The Developer will need to work with subcontractors to provide, as a minimum, the following for approval by WETS before appointment of any diving contractor.

- Qualifications of all Divers
- Equipment List Proposed (appropriately approved)
- Maintenance regime (appropriately approved)
- Standard operating procedures

3.9 Lifting Operations

A very great emphasis must be placed upon lifting as it is a highly dangerous activity if not carefully planned and executed. The following guidelines should be followed:

- All lifting operations will be identified when drafting Method Statements.
- A Lift Plan will be developed for each operation
- The Lift Plan will be documented in accordance with a standard lift plan format
- The IMCA Lift Plan format will be used, unless pre-agreed between WETS and the Developer.
- Lift plans will include
    - The model of all crane(s) to be used
    - The lift radius
    - What boom length and configuration is proposed
    - The rope reeving configuration
    - The safe working load as per the lift chart
        - Including a statement of whether the SWL includes hook block and lift tackle
    - All lift gear to be used

4 OPERATION PHASE

In the process of applying for a berth at WETS, the Device Developer is required to write a Risk Assessed Method Statement for Operation and Maintenance (O&M).

This term suggests that this is a single document, but in many cases it may be more appropriate to have several method statements which together form a library; in which case, each is effectively a section of the global requirement for RAMS covering all operations.

The Operation Phase will largely involve the repeated application of the Risk Assessed Operation and Maintenance Method Statement.

The Developer will probably require some premises to use as a base to carry out operations, and store spares, consumables and tools, as well as any vessel berths and bunkering arrangements. It may also be necessary to have a regular or permanent presence maintaining an awareness of the status of measurement program during the test phase. Details of the Developer's requirements and how these can be accommodated will need to be agreed with WETS management during the application process, and it would be prudent to schedule routine periodic meetings with WETS management to ensure that the previously agreed facilities are proving adequate and discuss how to adapt for any shortcomings encountered.

5 DECOMMISSIONING PHASE

As has been observed, many decommissioning plans are drawn-up to be direct reverse operations of installation. Very useful information will have been accrued on vessel capabilities, and how the device is best handled on the WETS site with the installation equipment, and this can inform the decommissioning.

The Decommissioning Phase will largely involve the repeated application of the Risk Assessed Decommissioning Method Statement. The method statement will require to address the safe and clean disposal of all parts which the Developer does not wish to retain, and the principles of the IMO Marpol will need to be applied to any discharges or disturbance caused to the marine environment during the process.

It is common practice for regulatory bodies granting a Lease for a renewable energy installation, and/or a test site operator, to require that adequate funds be made available prior to installation of the device to ensure that should anything happen to the device developer's organization, that adequate resources are available to decommission and dispose of the device, to free the berth for another user.

It is worth engaging at the earliest stage, the development of a "Dispute Resolution Procedure". It is best if an independent body can be agreed upon by both parties, which is prepared to act as an Arbiter in situations where minor disputes arise. If this is agreed while all parties have a good working relationship it can avoid major relational breakdowns or litigation.

6 REFERENCES

Always include References as a final section of main report with full numbered section heading.

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[3] GL (2012), GL Guideline for the Certification of Offshore Wind Turbines

[4] 001/ND "General guidelines for marine projects". GL Noble Denton. Technical Policy Board http://www2.gl-nobledenton.com/l/21052/2013-06-28/q6bt/21052/11132/0001_0_General.pdf Accessed 18.07/2013.

[5] 030/ND "Guidelines for Marine Transportations". GL Noble Denton. Technical Policy Board http://www2.gl-nobledenton.com/l/21052/2013-06-28/q6ch/21052/11148/0030_5_Transport.pdf

[6] 013/ND. "Guidelines for load-outs". GL Noble Denton. Technical Policy Board. http://www2.gl-nobledenton.com/l/21052/2013-06-28/q6bm/21052/11126/0013_7_Load_out.pdf

[7] 015/ ND. "Guidelines for Concrete Gravity Structure Construction & Installation". GL Noble Denton. Technical Policy Board. http://www2.gl-nobledenton.com/l/21052/2013-06-28/q6br/21052/11130/0015_4_Concrete.pdf

[8] 027/ND. "Guidelines for Marine Lifting Operations". GL Noble Denton. Technical Policy Board. http://www2.gl-nobledenton.com/l/21052/2013-06-28/q6c5/21052/11138/0027_10_Lifting.pdf

[9] 028/ND. "Guidelines for Steel Jacket Transportation and Installation". GL Noble Denton. Technical Policy Board. http://www2.gl-nobledenton.com/l/21052/2013-06-28/q6c7/21052/11140/0028_5_Jackets.pdf

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[11] IV - Industrial Services, Part 6 - Offshore Technology Chapter 1-6 (GL Maritime Rules & Guidelines). http://www.gl-group.com/infoServices/rules/pdfs/english/glrp-e.pdf

[12] DNV-OS–H101. Marine Operations, General. Det Norsk Veritas. http://exchange.dnv.com/publishing/Codes/download.asp?url=2011-10/os-h101.pdf

[13] DNV-OS–H102. Marine Operations, Design and Fabrication - 2012. Det Norsk Veritas.

APPENDIX A METHOD STATEMENT – GL GH PRO-FORMA

WETS Document Number: {Device Name} D. P. 3. 1. [1/2]*. D. [1/2/3]**. Rex. X (MM/ DD/ YYYY)
Device Developer Document No : XXXXXX . XXX (MM / DD/ YYYY)

* 1 for 30m site, or 2 for 60m/80m site **1 – Installation, 2 – O&M, 3 - Decommissioning

WETS RISK-ASSESSED METHOD STATEMENT - Pro-Forma

{ Device Name} – Installation / O&M/ Decommissioning Method Statement-delete as applicable

APPROVAL STATUS			
NAME	JOB DESCRIPTION	SIGNATURE	DATE

DESCRIPTION OF REVISIONS		
Serial No	Description of Revision	Initials

REVISION STATUS					
Rev	Date	Issue Purpose	Authored by (inits)	Checked By (inits)	Approved by (inits)
A	/ /				

DISTRIBUTION LIST		
NAME	JOB DESCRIPTION	COMPANY

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6. Vessels, Equipment and Materials to be Used
7. Methodology
A. Appendices
A1. Risk Assessment
A2/3/X Specification Sheets of all Vessels, Equipment and Materials

1. Introduction

[In this section a brief description of the general layout of the site is followed by a description of the Wave Energy Converter Device to be deployed and the methodology to be employed]

2. Other Project Documents Referenced in Method Statement

SERIAL No	DOCUMENT NO: DEVELOPER DOCUMENT NO: [WETS]	DOCUMENT TITLE
1		
2		

3. Abbreviations

ABR.	DESCRIPTION
Abr.	Abbreviation.

4. Organograms

[Insert Organizational Structure diagrams relevant to the Method Statement, preferably including interfaces between organizations.]

5. Description of the Scope of Work

[Include a clear description of both the precise commencement of the Methodology in the document, and also the point at which the document ceases to be applicable as well as the activities which are covered, as well as scheduling which related activities are not covered, but with which there are interface requirements.]

6. Vessels, Equipment and Materials to be Used

[Brief description of all of the key technical characteristics of all major items.]

7. Methodology

[Description in chronological order of all mission critical activities, and safety-related aspects of the entire cycle, containing adequate information for Site Personnel to carry out the operations within the scope of the Method Statement, as well as containing all necessary information for Supervision of the Activities so as to ensure the finished quality meets specification.
All marine operations will include necessary weather window, operation anticipated duration, metocean/current and wind limits (including measurement-height/steady speed/gust/averaging period), etc.]

A. Appendices

A1. Risk Assessment

[Risk assessment of each operation will be conducted and documented in accordance with all good practice. Ideally assessments will be made based on a 5 x 5 “Probability of Occurrence”, “Severity of Occurrence” matrix.

A2/3/4/etc. Specification Sheets of all Vessels, Equipment and Materials

APPENDIX B EXTRACTS FROM GL (2012) GUIDELINES FOR THE CERTIFICATION OF OFFSHORE WIND TURBINES

5. Sea Transport & Offshore Installation Manual
6. Commissioning Manual
7. Operating Manual
8. Maintenance Manual

Rules and Guidelines
IV Industrial Services

2 Guideline for the Certification of Offshore Wind Turbines

9 Manuals

Edition 2012

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9.1 Sea Transport and Offshore Installation Manual

9.1.1 General

(1) The manual for sea transport and offshore installation shall describe all working steps that have to be performed at sea during transport to the installation location, positioning, assembly and erection of the offshore wind turbine.

(2) The manual applies for one type of offshore wind turbine and, if applicable, for its variants.

(3) The form sheet for the record of sea transport and offshore installation shall be used to document the execution of the individual working steps during the sea transport and offshore installation process. A blank form sheet of the sea transport and offshore installation report shall be added to the sea transport and offshore installation manual.

(4) For the instructions regarding the construction of the foundation, please see Sections 6.7 and 6.82.

9.1.2 Objective and format of the manual for sea transport and offshore installation

(1) The objective of the manual for sea transport and offshore installation is to provide information for the on-sea and offshore activities and procedures to all parties involved, including the turbine designer and certification body.

(2) The format and level of detail of the sea transport and offshore installation manual shall be such that the resulting loads and risks can be evaluated and that the qualified technical personnel performing the required tasks are able to understand the instructions.

(3) For the issuance of the Project Certificate, the sea transport and offshore installation manual shall be expressed in a language which the qualified technical personnel at the installation site of the wind turbine are able to understand, plus a version in English or German.

(4) Notes regarding safety and regulations for the prevention of accidents shall be so arranged in the text that they appear before the operating action in question. They shall be highlighted clearly as being safety and accident-prevention notes.

(5) IEC 62079:2001 (Preparation of instructions – Structuring, content and presentation), especially section 5.9.3, shall be observed for the preparation of the sea transport and offshore installation manual in addition to this Guideline.

9.1.3 Scope of the manual for sea transport and offshore installation

9.1.3.1 Content of the manual

The manual shall contain the following information at least:

- identification of the type of offshore wind turbine and the installation site (see Section 9.1.3.2)
- prerequisites for the sea transportation and installation (see Section 9.1.3.3)
- sequence of the sea transport and installation (see Section 9.1.3.4)
- warnings and measures against hazardous situations (see Section 9.1.3.5)
- blank form sheets for the record (see Section 9.1.3.6)

The sea transport and offshore installation manual may contain documents and information which vary from site to site (e.g. water depth, vessels, buoys, lights). The variable information shall be given with upper and lower limiting values and documents (e.g. arrangement of vessels) shall be given as example for the Type Certification process. Finalized documents with site-specific information shall be issued in the Project Certification.

9.1.3.2 Identification of type of the offshore wind turbine and installation site

At least the following information shall be provided:

- manufacturer, supplier, importer
- designation, type and, if applicable, type variant
- type of rotor blade
- rotor diameter, hub height(s), water depth
- identification and position of the offshore site
- rated power

9.1.3.3 Prerequisites for sea transport and offshore installation

(1) All prerequisites for the execution of the work shall be stated, e.g. requirements for the weather conditions (limiting wind speeds, temperatures, rainfall, precipitation, wave height, water level and current speed), requirements for site access and working area or adequate curing of the foundation or any grouted connections.

(2) The precise designations and dimensions of all plant components to be assembled and erected shall be specified, together with all data needed for erection, such as weights, lifting points etc.

(3) Special tools or equipment necessary for the installation shall be specified with due consideration for the loads and weights during installation. Requirements for these tools or equipment, e.g. testing or regular inspections, shall be specified.

(4) The maximum admissible delay between installation of the substructure and erection of the rest of the support structure and the maximum admissible delay until mounting of the topsides structure shall be stated.

(5) Requirements for the vessels (tug power, navigation equipment etc.) and other equipment used (floating cranes etc.) shall be stated.

(6) A listing including quantities of all equipment and material necessary for the installation shall be given, e.g. grouting material, bolts, mooring and fastening equipment, special tools.

(7) The required qualifications for the technical personnel shall be defined in the manual for sea transport and offshore installation.

(8) The intended route and duration of sea transport shall be stated.

9.1.3.4 Sequence of sea transport and offshore installation

(1) All working steps needed for installation shall be described. Auxiliary equipment and resources shall be specified exactly (e.g. lubricants, grouting materials, oil for filling up the gearbox).

(2) The sea transport and offshore installation manual shall refer to drawings, specifications or instructions necessary for the sea transport and offshore installation of the offshore wind turbine.

(3) Arrangement of vessels, buoys, lights etc. shall be described, including the mooring/positioning equipment.

(4) Lifting, lowering, touchdown and ballasting procedures shall be described where relevant, including admissible draft(s) and/or bottom clearance(s).

(5) The work instructions as per Section 6.5.1 item b for making the bolted connections needed during installation shall be included in the manual.

(6) All necessary tests and checks shall be listed.

(7) Procedures for energizing electrical equipment shall be provided.

(8) Necessary monitoring of seabed conditions, scouring etc. shall be described where relevant.

9.1.3.5 Warnings and measures against hazardous situations

(1) Hazardous situations which may arise through deviation from the planned working sequence shall be described and countermeasures shall be specified. Such situations may include: lightning, snow, icing, visibility, extreme temperatures, very high winds, waves or currents during installation, prolonged periods of the substructure and/or the support structure standing without topsides structure at critical wind speeds and/or wave frequencies.

(2) Hazardous situations which may arise due to unintended motion or rotation shall be named, and countermeasures shall be specified to avoid this.

(3) Safety and accident-prevention measures that are necessary before or during assembly, installation and erection, e.g. use of personal protective equipment, guards or locking devices, shall be specified.

(4) For personnel entering any enclosed working space, such as the hub or blade interior, safety provisions shall be stated, e.g. standby personnel.

(5) Emergency procedures and rescue operations shall be described.

Note:

For the aspects of occupational safety, please refer to Note 2 of Section 1.1.1.

9.1.3.6 Form sheet for the record of sea transport and offshore installation

(1) The record shall document the execution of all checks and working steps of the sea transport and offshore installation process. For each check and working step, there shall be appropriate fields to be filled in, together with fields for recording measurement values and test results.

(2) All adjustment settings and set values as well as the expected measurement results shall be specified.

(3) The sea transport and offshore installation record may consist of several sub-records (e.g. for different assemblies or phases of work).

(4) The following fields shall be provided as a minimum:

- type identification of the offshore wind turbine as per Section 9.1.3.2
- serial number, operator and installation site of the offshore wind turbine
- name of the person carrying out the corresponding working step
- weather conditions, if the weather is able to influence the quality of work (e.g. temperature, rain, snow, range of sight, lighting, average wind speed, gust wind speed, wave height and tidal condition)
- reports of the execution of all working steps
- reports of the execution of all tests and checks
- extra space for possible remarks or items outstanding
- date and signature of the person(s) responsible

9.2 Commissioning Manual

9.2.1 General

(1) The commissioning manual describes all working steps that have to be performed during commissioning in order to ensure safe functioning of the offshore wind turbine.

(2) The commissioning manual applies for one type of offshore wind turbine and, if applicable, for its variants.

(3) The commissioning report documents the execution of the individual working steps during the commissioning process. A blank form sheet of the commissioning report shall be added to the commissioning manual.

9.2.2 Format of the commissioning manual

(1) The format and level of detail of the commissioning manual shall be such that qualified technical commissioning personnel performing the required tasks are able to understand the instructions.

(2) For the issuance of the Project Certificate, the commissioning manual shall be expressed in a language which the qualified technical personnel at the installation site of the offshore wind turbine are able to understand.

(3) IEC 62079:2001, especially section 5.9.4, shall be observed for the preparation of the commissioning instructions in addition to the present Guideline.

9.2.3 Scope of the commissioning manual

The commissioning manual shall contain the following information as a minimum:

- type identification of the offshore wind turbine (see Section 9.2.3.1)
- checks required before the start of commissioning (see Section 9.2.3.2)
- working steps of the commissioning process (see Section 9.2.3.3)
- checks required to conclude the commissioning (see Section 9.2.3.4)
- warnings against hazardous situations (see Section 9.2.3.5)
- blank form sheets for the commissioning report (see Section 9.2.3.6)

9.2.3.1 Type identification of the offshore wind turbine

- At least the following information shall be provided:
- manufacturer, supplier, importer
- designation, type and, if applicable, type variant
- rotor diameter, hub height
- type of rotor blade
- rated power

9.2.3.2 Checks before commissioning

(1) All checks required before the start of commissioning shall be listed. The following statements shall be provided as a minimum:

- installation and assembly – completed to full extent
- commissioning of the auxiliary systems and subsequent external equipment needed for operation of the offshore wind turbine (e.g. transformer, grid connection station) – completed
- any trial runs of individual components which may be necessary in the factory or on site – completed
- filling up of all operating media (e.g. lubricants, coolants, hydraulic fluid, nitrogen in pressure tanks) – completed
- any acceptance tests needed according to governmental regulations (e.g. for pressure vessels, lifts) – completed

(2) The required qualifications for the technical commissioning personnel shall be defined in the commissioning manual.

9.2.3.3 Working steps for commissioning

(1) All working steps needed for commissioning shall be described. For the commissioning of individual assemblies (e.g. yaw system), reference may be made to subordinate commissioning manuals for such assemblies.

(2) All prerequisites for the proper execution of commissioning, e.g. lowest/highest offshore wind speed, wave heights and necessary outside temperatures, shall be specified.

(3) Tests of all functions of the safety systems and the braking systems shall be described. The switching values to be set and the criteria to be met shall be specified. The following tests shall be performed as a minimum:

- function of all emergency stop pushbuttons
- function of all sensors and switches which also act on the safety system (e.g. overspeed test)
- measurement of the essential parameters of the braking systems, e.g. speed of blade pitching, hydraulic pressure of the mechanical brake(s)
- response of all necessary plant functions after activation of the safety system (e.g. braking systems, generator disconnection)
- test to verify that the functions responding to the activation of the safety system are independent of the control system
- grid loss
- testing of all limiting values and parameters that have been set for the safety system

(4) All tests regarding the functions of the control system of the offshore wind turbine shall be described. The switching values to be set and criteria to be met shall be specified. The following tests shall be performed as a minimum:

- automatic start-up
- shut-down with all braking procedures
- plausibility check of the yaw system
- plausibility check of the measurement values
- comparison of the limiting values and parameters which were set with the prescribed values as documented

(5) Furthermore, the following working steps shall be described:

- registration of the data on the rating plates of the primary components
- possible settings to be made in the control system on the basis of the measurement results (e.g. natural frequency of the support structure)
- familiarization of the offshore wind turbine operating personnel

9.2.3.4 Checks to conclude commissioning

All checks required to conclude commissioning shall be listed. The following statements shall be provided as a minimum:

- visual inspections (e.g. rotor blades, corrosion protection, tightness of hydraulic system)
- checking of the required notices and warning plates

9.2.3.5 Warnings against hazardous situations

(1) Hazardous situations which may arise during commissioning shall be named and countermeasures shall be specified. Such situations can include: grid loss, lightning, icing or very high winds or waves during commissioning.

(2) Hazardous situations which may arise due to unintended motion or rotation shall be named, and countermeasures shall be specified to avoid this.

(3) Safety and accident-prevention measures which are necessary before or during commissioning, e.g. use of personal protective equipment, guards or locking devices shall be specified.

(4) For personnel entering any enclosed working space, such as the hub or blade interior, safety provisions shall be stated, e.g. standby personnel.

Note:

For the aspects of occupational safety, please refer to Note 2 in Section 1.1.1.

9.2.3.6 Form sheet for the commissioning report

(1) The commissioning report shall document the execution of all checks and working steps of the commissioning process. For each check and working step, there shall be appropriate fields to be filled in, together with fields for recording the measurement values and test results.

(2) All adjustment settings and set values as well as the expected measurement results shall be specified.

(3) The commissioning report may consist of several sub-reports (e.g. for primary components, for familiarization of the operating personnel).

(4) The following fields shall be provided as a minimum:

- type identification of the offshore wind turbine as per Section 9.2.3.1
- serial number, operator and installation site of the offshore wind turbine
- manufacturer, type and serial number from the rating plates of the primary components, at least of the rotor blades, gearbox, generator and tower
- persons present during commissioning
- weather conditions on the day of commissioning
- confirmation that all checks required before the start of commissioning as per Section 9.2.3.2 have been completed
- report on the execution of all working steps of the commissioning as per Section 9.2.3.3
- confirmation that all checks required to conclude commissioning as per Section 9.2.3.4 have been completed
- extra space for possible remarks, items outstanding or parts replaced
- date and signature of the person(s) responsible

9.3 Operating Manual

9.3.1 Purpose of the operating manual

(1) The operating manual is intended to provide the operator or his representative with the knowledge necessary for proper operation of the offshore wind turbine.

(2) The operating manual applies for one type of offshore wind turbine and, if applicable, for its variants.

9.3.2 Format of the operating manual

(1) The format and level of detail of the operating manual shall be such that qualified personnel with technical training are able to understand the instructions.

(2) For the issuance of the Project Certificate, the operating manual shall be expressed in a language which the qualified personnel at the installation site of the offshore wind turbine are able to understand.

(3) IEC 62079:2001, especially section 5.10, shall be observed for the preparation of the operating instructions in addition to this Guideline.

9.3.3 Scope of the operating manual

The operating manual shall contain the following information:

- type identification of the offshore wind turbine (see Section 9.3.3.1)
- notes for users (see Section 9.3.3.2)
- warnings against hazardous situations (see Section 9.3.3.3)
- help with fault-finding (see Section 9.3.3.4)
- operating records (see Section 9.3.3.5)

9.3.3.1 Type identification of the offshore wind turbine

At least the following information shall be provided:

- manufacturer, supplier, importer
- designation, type and, if applicable, type variant
- rotor diameter, hub height
- rated power

9.3.3.2 Notes for users

At least the following information shall be provided:

(1) General description of the operation concept

(2) Description of the functions and operational modes of all the operating and indicating elements (switches, pushbuttons, lamps, measuring instruments)

(3) Description of starting and stopping procedures

(4) Description of emergency shut-down

(5) Explanation of fault messages (insofar as these are issued)

(6) Description of all work procedures required for the operating of the offshore wind turbine (e.g. necessary communication)

(7) Emergency procedure plans, e.g. action required in the event of overspeeding, ice formation, lightning storms, earthquakes, brake failure, rotor imbalance, loose fasteners or fire at the offshore wind turbine

(8) Description of the functions and operating modes of all the operating and indicating elements (switches, pushbuttons, lamps, measuring instruments)

(9) Explanation of malfunctions and how to clear them

(10) Description of components and functions that need to be taken into/out of service on a seasonal basis or for other reasons

(11) Description of measures to be taken if the offshore wind turbine is taken out of operation for a longer period, e.g. because of damage to the grid connection. These measures could be e.g. lockage of the blade pitch system and/or rotor, or installing a backup power supply.

(12) Description of measures to be taken if the offshore wind turbine is taken into operation after a longer period of standstill. The measures could be e.g. opening of locks

and/or drying/heating of components that need to be dry when re-powered.

9.3.3.3 Warnings against hazardous situations

(1) Hazardous situations which may arise when operating the offshore wind turbine on site shall be named and countermeasures shall be specified. Such situations can include fire, lightning, ice formation, and very high wind speed or waves.

(2) Hazardous situations which may arise due to unintended motion or rotation shall be named and countermeasures (e.g. emergency procedure plans) shall be specified to avoid this.

(3) Safety and accident-prevention regulations, e.g. use of personal protective equipment, guards or locking devices shall be specified.

Note:

For the aspects of occupational safety, please refer to Note 2 in Section 1.1.1.

(4) The behaviour of the offshore wind turbine in case of an emergency shut-down shall be described.

(5) Safety measures, e.g. action required in the event of ice formation at the offshore wind turbine

(6) Accident prevention regulations; behaviour during dangerous situations and potentially hazardous malfunctions

9.3.3.4 Help with fault-finding

(1) Without carrying out any repairs himself, the operator should be capable of recognizing the cause of a malfunction and – insofar as it cannot be cleared simply by an operating action – of providing the qualified technical maintenance personnel with useful advance information.

(2) The operator should be able to judge whether a fault constitutes or can develop into a hazardous situation (see Section 9.3.3.3).

9.3.3.5 Operating records

- Operating records shall be kept and shall include the following:
- type identification of the offshore wind turbine (see Section 9.3.3.1)
- serial number, operator and installation site of the wind turbine
- operating hours
- shut-down hours
- date and time of fault
- nature of fault
- date and time of maintenance or repair activity
- nature of maintenance or repair activity

9.4 Maintenance Manual

9.4.1 General

(1) The maintenance manual describes all working steps that have to be performed during maintenance in order to ensure safe functioning of the offshore wind turbine; this includes supervising actions, reconditioning, repairing, adjusting and cleaning.

(2) The maintenance manual applies for one type of offshore wind turbine and, if applicable, for its variants.

(3) The maintenance record documents the execution of the individual working steps during the maintenance process. A blank form sheet of the maintenance record shall be added to the maintenance manual.

(4) The maintenance shall be carried out by qualified technical maintenance personnel.

9.4.2 Format of the maintenance manual

(1) The format and level of detail of the maintenance manual shall be such that qualified technical maintenance personnel performing the required tasks are able to understand the instructions.

(2) For issuance of the Project Certificate, the maintenance manual shall be expressed in a language which the qualified technical personnel at the installation site of the offshore wind turbine are able to understand.

(3) IEC 62079:2001 especially section 5.11 to 5.14 shall be observed for the preparation of the maintenance manual in addition to this Guideline.

9.4.3 Scope of the maintenance manual

The maintenance manual shall contain the following information at least:

- type identification of the offshore wind turbine (see Section 9.1.3.1)
- prerequisites for maintenance (see Section 9.4.3.2)
- working steps of the maintenance (see Section 9.4.3.3)
- warnings against hazardous situations (see Section 9.4.3.4)
- blank sheet for the maintenance record (see Section 9.4.3.5)
- maintenance plan (see Section 9.4.3.6)

9.4.3.1 Type identification of the offshore wind turbine

At least the following information shall be provided:

- manufacturer, supplier, importer
- designation, type and, if applicable, type variant
- rotor diameter, hub height
- type of rotor blade
- rated power

9.4.3.2 Prerequisites for maintenance

(1) All prerequisites for the execution of the maintenance work shall be stated, e.g. requirements for the weather conditions (wind, waves, temperatures).

(2) Special tools or lifting devices necessary for the maintenance shall be specified.

(3) All tools, spare parts and auxiliary materials that have to be stored permanently in the offshore wind turbine shall be listed. The intervals for regular checks for completeness of these parts shall be specified.

(4) Technical documentation of the offshore wind turbine and their subsystems including e.g. wiring diagrams, hydraulic schemes or lubrication charts.

(5) The required qualifications for the technical maintenance personnel shall be defined in the maintenance manual.

9.4.3.3 Working steps for maintenance

(1) All working steps needed for maintenance or inspections shall be described. The descriptions may be supplemented by appropriate pictorial representations. The objectives of the individual maintenance operations (oil levels, brake settings, oil pressures etc.) shall be indicated clearly.

(2) The frequency of the schedule maintenance (e.g. half-yearly, yearly or five-yearly) shall be specified.

(3) A set of work instructions as per Section 6.5.1.5 for the inspection of bolted connections shall be added to the maintenance manual.

(4) A detailed listing and description of the necessary tests for the safety system (e.g. overspeed test, emergency shut-down functions, measurement of the nitrogen content in hydraulic accumulators) shall be included in the maintenance record. The required frequency of these tests shall be indicated (e.g. annually). The completion of the tests shall be recorded in the maintenance report.

(5) A detailed listing and description of the necessary inspection and tests of the lightning protection system shall be included in the maintenance manual. The required frequency of these inspections and tests shall be indicated (e.g. annually).

(6) If applicable, the investigations of technical experts and authorized persons, as required by the relevant national regulations (e.g. for lifts, fire-extinguishing systems and pressure vessels) and conditions of the building permits, shall be included in the maintenance manual, and columns/sections shall be provided in the maintenance report for the confirmation that these investigations have been carried out.

(7) All components and auxiliary materials of the offshore wind turbine that have to be exchanged according to schedule during the operating life (e.g. hydraulic hoses, brake pads, sliprings, gear oil) shall be listed. The intervals or criteria for the exchange shall be specified.

(8) A description of all inspections and tasks to be carried out at the outside lighting and emergency shelter equipment as well as rescue at sea equipment and possible backup power supply units shall be included in the maintenance manual if applicable.

(9) A detailed listing and description of the necessary inspections to be done at the scour protection system at the foundation shall be included in the maintenance manual. Actions and corrective measures to be taken in case of damages or inadmissible wear shall be stated.

(10) A description of all inspections and tasks to be carried out at the corrosion protection system (both coating and cathodic protection systems, as applicable) shall be included in the maintenance manual.

(11) An instruction to at least yearly take samples of the oil from the main gearbox and analyse these samples (including measurement of the cleanliness) shall be included in the maintenance manual.

(12) In addition, information shall be given about the quality and quantity of spare parts and auxiliary materials to be used, e.g. lubricants (spare parts list).

9.4.3.4 Warnings against hazardous situations

(1) Hazardous situations which may arise during maintenance shall be named and countermeasures shall be specified. Such situations can include fire, lightning, icing and very high winds.

(2) Hazardous situations which may arise due to unintended motion or rotation shall be named and countermeasures shall be specified to avoid this.

(3) Safety and accident-prevention measures that are necessary before or during maintenance, e.g. use of personal protective equipment, guards or locking devices shall be specified.

(4) For personnel entering any enclosed working space such as the hub or blade interior, safety provisions shall be stated, e.g. standby personnel.

Note:

For the aspects of occupational safety, please refer to Note 2 in Section 1.1.1.

9.4.3.5 Form sheet for the maintenance report

(1) The maintenance report shall document the execution of all checks and working steps of the maintenance process. For each check and working step, there shall be appropriate fields to be filled in, together with fields for recording measurement values and test results.

(2) All adjustment settings and set values as well as the expected measurement results shall be specified.

(3) The maintenance report may consist of several sub-reports (e.g. for primary components such as rotor blades or tower).

(4) The following fields shall be provided as a minimum:

- type identification of the offshore wind turbine as per Section 9.4.3.1
- serial number, operator and installation site of the offshore wind turbine
- persons present during maintenance
- weather conditions on the day of maintenance
- operating hours

- shut-down hours
- report on the execution of all working steps of the maintenance as per Section 9.4.3.3
- confirmation that all checks required to conclude maintenance have been completed
- parts replaced
- extra space for possible remarks or items outstanding
- date and signature of the person(s) responsible

9.4.3.6 Maintenance plan

(1) The maintenance plan shall present all required maintenance in tabular form and shall state the appropriate time sequence.

(2) If the maintenance and inspection work is scheduled by using a database instead of tables, a printout of all maintenance work from this database for the wind turbine lifetime shall be submitted to the customer.

(3) If maintenance work is scheduled in regular intervals (e.g. quarterly, annually), it is helpful to compile a list of all working steps applicable in one interval.

APPENDIX C WIND INDUSTRY STANDARD RISK ASSESSMENT METHODOLOGY

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Task risk assessment

1 PURPOSE

This procedure describes the method to manage risks in terms of safety, health and environment. This involves identifying hazards, determining risks related to working environment, workplace and working conditions associated with a particular task and evaluating those risks. Certain measures have to be taken to reduce those risks to the lowest risk possible.

2 SCOPE AND CRITERIA

The procedure applies to all routine and non-routine activities within the organization. i.e. within the , workshop, jack-up's, projects, (de-)mobilizations and dockings.

A task risk analysis should be obtained before the start of an activity.

A new task risk analysis should be formulated if a task is not secured by a generic risk assessment, providing clear working instructions.

3 INDEX

4 ABBREVIATIONS AND DEFINITIONS

Term	Description
PM	Project Manager
TD manager	Technical Department manager
WM	Works Manager
SI	Superintendent
PE	Project Engineer
TRA	A task risk assessment is a risk assessment that shows the dangers of a particular task and the measures that have to be taken to reduce the danger and the risk to an acceptable level. If the danger and/or risk can completely be eliminated, this MUST be done. A good task risk assessment results in a safe working method.
Task	A task is a part of an activity performed by an employee in a certain function. A task consists of the performance of a series of instructions (steps, actions,...) necessary to obtain a particular goal.
Danger	Danger is an intrinsic characteristic of products or situations by which damage can be caused.
Risk	A risk is the odd that a danger will lead to an undesired event with injury.
Damage	There are several kinds of damages, like human damage, material damage, damage at the consumption of resources (time, money, equipment,...).
MEEPO	MAN: hazard that an individual or Group of persons can cause during the execution of their job, such as behavior, age, motivation. EQUIPMENT: dangers that machines (labour- or auxiliary equipment), present in and around the workplace can cause. ENVIRONMENT: physical (eg.: noise, division of the workplace), psychosocial (eg.: company culture, communication) and socioeconomic (eg.: employment, redistribution) factors can cause hazards. PRODUCT: hazards caused by used or made products. ORGANISATION: hazards that may occure because of a moderate organization (eg.: selection of personnel, training, used procedures, purchase)

5 RESPONSABILITIES

5.1 HEAD OF A DEPARTMENT (PM, TD MANAGER,..)

The head of a department will ensure that the procedure is applied when necessary within his department and that those procedures are applied according the established criteria. He/she can also instruct to conduct a TRA, even though the TRA is not according to specified criteria but because the risks and/or works are so specific.

5.2 QHSE ENGINEER

The QHSE engineer will verify if the correct method is applied and advices you about the appropriate corrective and preventive measurements to reduce risks. He/ she will centralize TRA's after working activities at the QHSE department (office database) so that TRA's can always be consulted.

5.3 SUPERVISORS (WM, SI, PE)

Operational managers with a certificate in basis safety and safety advisor level III or equivalent are responsible for the preparation of a TRA. He/ she will ensure that all hazards and risks relating to the task are included in the TRA. The supervisor composes a TRA team in colloquy with the head of the department.

5.4 TRA TEAM

The TRA has to be executed in team. The team can best be composed of:

- The initiator of the TRA. By preference the owner of the task (supervisor, head of department, planning engineer, persons confronted very closely with the task, QHSE engineer,…)

  AND

- Experts and specialists (TD, tender department, safety advisors,…). If neccessary.

  AND

- The responsible, an operational manager. He/ she is obliged to be present by the preparation of the TRA or should at least be consulted before execution of the task.

5.5 EMPLOYEES

Employees will take all measurements and will fully comply to the rules imposed by the formatted TRA.

6 EXECUTION OF A TASK RISK ANALYSIS

The implementation of a TRA will be done before the execution of certain tasks. For projects, the TRA should be established during the preparation of the project. For the use of new techniques or equipment, the TRA should be prepared before deployment of those techniques and equipment. Goal is:

- To record all various steps of the task that has to be executed
- To assess the risks of the various steps and to take appropriate corrective and preventive measures.
- To involve several employees by the draft of the TRA so all usefull experiences can be used to reduce risks.

6.1 INVENTARISATION OF RISKS AND HAZARDS

1) Start by describing the various steps of the task Please use the standard Method Statement template.

2) Identify the real dangers and risks that could occur by each step. Describe them clearly and concisely.

Bv.: activity working with a forklift

Task	***Hazard***	***Risk***
Driving backwards with a forklift	*Crush into a person*	*Bone fracture crushed person*

To identify the risks of a particular task as completely as possible, one should take into account the aspects of MEEPO. This system is used as a framework to detect hazards.

3) It is also important to review whether there are still missing hazards relating to the working circumstances. Those can strongly influence the welfare of the employee. They are divided in seven areas:

- Safety at work
- Protection of the health of the employee at work
- Psychosocial stress caused by the job and protection against violence, bullying and sexual harassment at work.
- Ergonomics
- Hygiene at work
- Embellishment of the workplaces
- Measures taken by the company in respect of the environment, for what concerns their impact on the points mentioned above.

6.2 EVALUATING RISKS

After making an inventory of the hazards and risks, the risks have to be evaluated. Evaluation happens by assignation of a number of risk using a risk assessment matrix, *see table 1.*

Consequence (severity) → waarschijnlijkheid ↓	(1) minor (no lost time incident)	(2) slight (lost time incident)	(3) serious	(4) very serious	(5) Rampage/ dead persons
(1) very unlikely	1	2	3	4	5
(2) unlikely	2	4	6	8	10
(3) possible	3	6	9	12	16
(4) high	4	8	12	16	20
(5) very high	5	10	15	20	25

Table 1: risk assessment matrix

The risk assessment matrix shows the severity of a specified risk. It takes into account the probability (chance) that the risk will result in an undesirable event and the likely severity of these undesirable events (the possible damage). Table 2 shows the height of the gravity.

	(1) minor (no lost time incident)	**(2) slight (lost time incident)**	**(3) serious**	**(4) very serious**	**(5) Rampage/ dead persons**
Personal Iness/Injury	Negligible injury or health implications; no absence from work	Minor injury requiring first-aid treatment or headache, nausea, dizziness, mild rashes	Event leading to a lost time incident	Involving a single death or severe injury, poisoning or dangerous infection	Multiple deaths, lung diseases, permanent disability or fatality
Environment	no damage to environment	minor impact to the environment	moderate pollution incurring some restitution costs	Severe pollution with short term localized implications incurring significant restitution costs	Major pollution with long-term implication and very high restitution costs
Damage at equipment and production losses	negligible loss of function / production with no damage to equipment	damage to equipment requiring minor remedial repair, minor loss of production	localized damage to equipment requiring extensive repair, significant loss of function/production	Damage to equipment resulting in production shutdown and significant production loss of a couple of days	Massive damages
Impact damage	No impact	Local impact	Limited national impact	Extensive national impact	International impact/ negative exposure

Table 2: description of the gravity

After assigning a risk rating number, you need to see if the risk is acceptable. *Table 3* explains this.

LOW RISK	No further actions are neccessary. If possible, take measures to cover up small risks.
MEDIUM RISK	Take measures so that risks are reduced to an acceptable level.
HIGH RISK	Unacceptable risk, take corrective measures to reduce the risk to an acceptable level.

Table 3: assessment of the risk

6.3 PREVENTIVE MEASURES

After assessing the risks, you should take the appropriate actions. This has to be done according to the preventive hierarchy because the effectiveness of the measures can vary. Some will remove the risk, others will reduce the risk and still others will reduce the damage. The hierarchy displays the effectiveness of the measures.

(1) **Elimination**: This measure will remove the risk completely
(2) **Replacement**: replace the risk by using a less risky device, material or machine.
(3) **Collective protective measures**: a protective measure that protects several persons.
(4) **Organizational measures**: such as providing training, procedures, working instructions, work permits,...
(5) **Personal protective equipement** and apprapriate working clothes.
(6) **Harm reduction measures**: such as medical monitoring, technical testing, spindle kits and emergency plans.
(7) **Safety signalisation**

6.4 APPLICATION OF PREVENTIVE MEASURES

After creating a task risk assessment, preventive measures must be included into the working instructions and the work must be well prepared by using the provided measures. Working instructions will be discussed with the employees during the first working meeting. The supervisor must ensure that preventive measures are implemented.