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Guidance on Safety Considerations for the installation of Marine Renewable Energy Devices (MRED) at *bimep*, the Biscay Marine Energy Platform

BIMEP-531-P

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Version: 3

Review: 0

Date: August, 9th, 2012

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DET NORSKE VERITAS

REPORT

BIMEP PROJECT (EVE)

ENTE VASCO DE LA ENERGIA (EVE)

REPORT NO./DNV REG NO.: LDN-PP040027.01 / 1-55HVSP
REV 0, 2012-08-09

MANAGING RISK

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Date of Current Issue:	9th August 2012	Project No.:	PP040027
Revision No.:	0	Organisation Unit:	Approval Centre
DNV Reg. No.:	1-55HVSP	Report No.:	LDN-PP040027.01

Summary:

Report on DNV's review of guidance document for installation of MREDs at bimep.

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Keywords

Rev. No.	Date	Reason for Issue	Prepared by	Verified by	Approved by
0	2012/08/09	First issue signed and verified	RH	CBF	BW

Reference to part of this report which may lead to misinterpretation is not permissible.

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1 INTRODUCTION

1.1 General

DNV was contracted by Ente Vasco de la Energia (EVE) to provide support for the development of their guidance protocol, document number *BIMEP-531-P*. The purpose of the document is to outline EVE's requirements for developers of marine renewable energy devices (MRED) wishing to deploy MRED equipment for development trials at the Biscay Marine Energy Platform (bimep). More specifically, the document aims to provide assistance to MRED developers to ensure that acceptable levels of safety are achieved for people, the environment, navigation and bimep infrastructure. It is intended that the guidance document be read in conjunction with a suite of additional information sources, provided by bimep to prospective developers, to fully describe bimep's requirements of developers and exchange other salient details about the facility.

EVE submitted the original draft *BIMEP-531-P* document to DNV for review. The draft document content was reviewed and DNV provided EVE with several general comments relating to the overall philosophy of the document, a number of specific technical queries and suggestions and several recommendations on non-technical matters such as layout and language. Based on these, EVE made alterations to the guide document for submission to DNV for final review at revision 3. DNV has no outstanding comments with regard to satisfying the intended scope of the document.

1.2 Relevance

Within the nascent MRED industry it is vital that methodical framework documents guide developers as they apply concepts in new and inhospitable operating environments. At present no internationally recognised design standards specifically applicable to the design and manufacture of MREDs exists. The gap that this leaves exposes MREDs to potential risks which may either become evident during initial trials, or only manifest themselves as developers transition into serial production of their MREDs when their original concepts are exposed to scaling for multi megawatt utility production, mass-producing fabrication techniques, outsourcing of fabrication, commercial pressure to optimise design and commercial and public scrutiny under potential failures.

DNV, a leading independent provider of risk management services to the offshore industry, recognises the importance of such a guidance document in encouraging developers to achieve high standards of safety for personnel, equipment and environmental protection.

2 DISCUSSION

In its guidance document, EVE has established a philosophy of the risk based approach to design. This utilises a risk matrix to define the level of risk tolerance that bimep, on its own behalf and on the behalf of other stakeholders, are prepared to accept for aspects related to risk assessment and to overall acceptance of standards and their requirements. In DNV's experience, systematic and methodical processes of risk analysis, such as this, are vital in identifying and mitigating risks.

The guidance document defines high-level approaches that must be followed to satisfy bimep's expectations, without specifying isolated details from, or undermining, reference standards.

Additionally, in its guidance document, EVE requires developers to involve independent third parties at key points in the design and construction (including reviews of test plans, reviews of structural designs and calculations, inspections at key points of fabrication) to provide objective verification that, with reference to specified standards, a given MRED design is acceptable and that manufacturing is performed in accordance to approved designs.

EVE has outlined the key steps in the process for applicants, clearly defining its expectations with regard to the minimum documentation that are required for review and acceptance by bimep prior to the installation of MREDs in its infrastructure. Early definition of the responsibilities in this manner encourages a consistent approach by prospective developers allowing bimep to maintain consistency through its approval process for new developers.

3 CONCLUSION

DNV believes that the guidance document fulfils requirements of the original scope to provide an acceptable level of safety for people, the environment, navigation and bimep infrastructure. It is, however, acknowledged that EVE is ultimately the sole owner of the guidance document and has final responsibility for adjusting the content in response to findings during the operations at bimep.

DNV understands that EVE intends to provide a suite of additional information and guidance documents to fully describe other information on the bimep facility. EVE should consider referencing these documents in any relevant sections of the present guidance document to provide developers clarity of the various categories of requirements at bimep.

All comments made within the review of the document have been closed.

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DOCUMENT CHANGES LOG.

See.	Rev.	Date	Person Responsible	Comments
1	0	02/02/2011	Antonio Rico / Pablo Ruiz-Minguela	Initial Document
2	0	03/06/2011	Antonio Rico / Pablo Ruiz-Minguela	Change from Protocol to Guide. Inclusion of Responsibilities
3	0	09/08/2012	Antonio Rico / Pablo Ruiz-Minguela	DNV Review

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1. INTRODUCTION

1.1. Background

01 *bimep* provides grid-connected offshore infrastructure and onshore facilities to support research, technical testing and commercial demonstration of pre-commercial prototype utility-scale MREDs. These are ready-to-use facilities and thus no further administrative permits are required. In December 2011, the company Biscay Marine Energy Platform, S.A. was established to develop, install, operate and manage the bimep facility.

02 The offshore infrastructure has a total power capacity of 20 MW, distributed in 4 berths of 5 MW each. Each berth is connected to the onshore substation via a dedicated three-phase submarine cable in series with a land three-phase line, both at 13.2 kV. The onshore electricity substation houses electrical protection systems, measurement systems and transformer, allowing the berths to be connected up to the national power grid. The berths are designed to enable swift connection and disconnection of MREDs, thus reducing offshore work time as far as possible.

03 In summary, the main characteristics of the infrastructure are as follows:

- 5.3 km^2 navigational exclusion zone, marked with 7 navigation buoys.
- Depth in installation area between 50 and 90 m.
- Closest point to land: 1.7 km
- 1 Metocean Buoy (operating since Feb. 2009)
- Total power: 20 MW.
- 4 three-phase submarine lines of 13.2 kV and 5 MW.
- 4 underground three-phase land lines of 13.2 kV and 5 MW.
- 4 berths or offshore connection points.
- Onshore electricity substation for connecting the MREDs to the grid, and house the electrical protection systems and measuring instruments for the four berths.
- Research and Control Centre with offices available to MRED developers, access to a Monitoring and Control System (SCADA) and Warehousing and Workshop facilities.

04 The *bimep* test site is located in the sea off the coast at the village of Armintza, in the municipal area of Lemoiz, some 30 kilometres north of Bilbao, in the Basque Country, Spain. Bilbao is the largest city in the Basque Country and stands close to the North Atlantic coast, at the south-eastern end of the Bay of Biscay. Armintza stands close to both Bilbao port and Bilbao Airport, hence communications and services around the test site are very good.

1.2. Scope

01 *bimep* has identified the need to promote high standards of safety to protect the marine environment and nearby navigational routes in addition to *bimep*'s infrastructure, MRED developers or subcontractors operating on the site and the MRED assets themselves.

02 This document constitutes a framework of potential risk items to be considered by MRED developers prior to being granted acceptance to install their equipment within *bimep*'s infrastructure. Due to the relative technological immaturity of developing MREDs, great diversity in the designs of devices and lack of practical experience, it is impractical to encompass all potential situations within this guide. Therefore, the items herein should not be considered an exhaustive list or minimum requirements to satisfy, but a reference to some of the risk areas that MRED developers may, if applicable to their design, need to demonstrate awareness of and document mitigations for.

03 Additionally, due to the present lack of industry experience, the standards listed are not specific to marine renewables and therefore compliance with those standards does not guarantee success. The standards should be used in conjunction with a risk based approach to identify both where the standards are directly applicable and where a more detailed qualification of risk is needed. Consequently, MRED developers are required to provide a specific risk assessment for their device (identification, analysis, control and mitigation) based on an internationally validated methodology/standard.

04 It is the sole responsibility of MRED developers to address the risks they have identified. All aspects described in this document must be considered in the risk assessment unless otherwise specifically justified to, and accepted by, *bimep*. Developers are responsible to submit the necessary documentation to accompany applications to install MREDs at bimep. The review of this documentation forms a crucial part of the approval process. Final acceptance by *bimep* may be subjected to some contractual conditions derived from this risk assessment process.

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1.3. Procedure

01 The following flow diagram describes the overall route through *bimep*. The Guidance document is mainly intended to help in Phase 2, but is applicable in general throughout the whole process.

Phase 1: Project Application

- Initial contact
- Information exchange
- Feasibility analysis
- Preliminary agreement

Phase 2: Project Development

- Risk assessment and documentation produced by developer
- Independent evaluation of design and construction
- Contract signature
- Readiness review prior to installation
- Information to Spanish Authorities

Phase 3: Project Installation and Testing

- Monitoring of marine operations
- Device performance assessment
- Further technical assessment of device

Phase 4: Project Decommissioning

- Report produced by bimep
- Monitoring of marine operations
- Berth vacated
- Contract terminated

02 Under phase 1, following an initial contact by the MRED developer with *bimep*, a formal application and information exchange will occur, leading to an internal feasibility analysis mainly focused on technology readiness. Should this analysis not find any major issue, a preliminary agreement will be signed.

03 In phase 2, the MRED developer will then provide sufficient documentation to fully describe the MRED's compliance with the requirements in this guide. There will be an independent evaluation of device design, construction, operational plans and contingency measures. A dialogue between the MRED developer and *bimep* will be established in order to deal with non-conformances until an adequate level of safety is achieved. It is the responsibility of the MRED developer to provide additional information, evidence or measures to demonstrate the risks have been reduced to an acceptable level. A final readiness review will be conducted by bimep before installation.

04 During phases 3 and 4, under installation, testing and decommissioning marine operations will be monitored by bimep taking into account the plans and procedures the MRED developer has provided and the requirements in this Guide.

05 *bimep* will provide support to MRED developers in order to assist them along the whole process, to assess device performance and to complete further technical assessment of device.

1.4. Further Measures

01 The risk areas that will be introduced in the following chapters of this document must be addressed by the MRED developer. Where bimep deem it necessary, either during the documentation review or during operations, to achieve satisfactory safety levels, additional requirements may be imposed on MRED developers.

02 These additional measures might include:

- Laboratory testing of materials, structures, mooring, elements or procedures.
- Complementary monitoring via a vessel permanently anchored nearby.
- Monitoring by additional specialised personnel in the control centre.
- Installation of means for a quick disconnection of the unit, both from the mooring system as well as from the umbilical cable for transport to a safe harbour in anticipation of storms or seasonal heavy sea-states in case they exceed the maximum environmental load considered
- Additional coverage from insurance companies, based on conditions set forth by the Spanish Administrations.

03 MRED developers may, for their own interests, wish to apply these or other requirements to their devices. In such event, notification should be given to bimep prior to

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implementation. It is assumed that these are complementary requirements, in no way affecting the validity of the requirements outlined in this document or to be taken in lieu of those requirements.

1.5. Definitions and acronyms

- **bimep:** Biscay Marine Energy Platform
- **MRED:** Marine Renewable Energy Device. It can encompass Wave Energy Converters, Floating or submerged marine components and systems, and Floating Offshore Wind
- **SCADA:** Supervisory Control And Data Acquisition
- **KN:** Cross curves of stability
- **GM**: Metacentric height
- **IMO:** International Maritime Organization
- SOLAS: Safety of Life at Sea
- **LRFD:** Load and Resistance Factor Design
- **ULS:** Ultimate Limit State, corresponding to the ultimate resistance for carrying loads.
- **FLS:** Fatigue Limit State, related to the possibility of failure due to the effect of cyclic loading.
- **ALS**: Accidental Limit State, corresponding to damage to components due to an accidental event or operational failure.
- **SLS:** Serviceability Limit State, corresponding to the criteria applicable to normal use or durability.
- **CE mark:** Conformité Européenne, European Conformity
- **VHF:** Very High Frequency, i.e. radio frequency range from 30 MHz to 300 MHz
- **RAO:** Response amplitude operators
- **NDT:** Non-Destructive Testing
- **MARPOL 73/78**: International Convention for the Prevention of Pollution from Ships
- **PE:** Spanish State Ports Authority
- **DGMM:** Spanish Directorate-General for the Merchant Marine
- **MI:** Spanish Ministry for Industry
- **EIA:** Environmental Impact Assessment
- **DNV:** Det Norske Veritas
- **IALA**: International Association of Lighthouse Authorities
- **MBS**: Maritime Bouyage System.
- **ODAS**: Oceanographic Data Acquisition System.

1.6. Document structure

01 The standards referenced within this document are taken from regulations in effect in offshore, electrical or safety applications. These standards may be of international, national or regional applicability. A small number of the outlined requirements are *bimep*'s own and result either from administrative requirements necessary to obtain applicable permits or the requirements of bimep's insurers.

02 Following this introduction, Chapter 2 identifies the responsibilities of both bimep and MRED developers. Chapter 3 outlines the risk assessment philosophy by which bimep expects developers to conduct MRED risk analyses. Chapters 4, 5 and 6 outline the majority of general and design requirements for MRED structures and moorings. Chapter 7 identifies requirements specific to the fabrication of MREDs. Chapter 8 identifies the principal electrical requirements. Chapter 9 outlines environmental considerations for MRED design and operation.

03 A full document list, to be submitted to bimep for evaluation, may be found in Annex I.

04 A list of applicable DNV standards can be found in Annex II. For practical purposes, applicable DNV rules and standards have been gathered for reference in this document. Other Classification Society's rules and standards may be used if it is demonstrated that an equivalent, or higher, level of safety is provided.

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2. RESPONSIBILITIES

2.1. MRED developer responsibilities

01 The MRED developer is directly responsible for providing an adequate level of failure risk protection by means of:

- Reducing all safety risks to as low as reasonably practical during the design and construction phases.
- Designing measures aimed at controlling risks in the installation phase which cannot be completely eliminated.
- Notifying bimep of all changes that affect the risk levels and their corrective measures.

02 Consequently, compliance with this guide does not relieve MRED developers from responsibilities in safety matters.

03 The MRED developer shall be liable for any direct damage caused by their MRED, installation and maintenance support vessels including damage to *bimep*'s facilities, navigation buoys, people, other MREDs or the environment.

04 The MRED developer shall be responsible not only for the safety of their MREDs during the installation, operation and decommissioning, but also for providing maintenance procedures aimed at minimising the risks caused by their MREDs.

05 Finally, compliance with this guide does not discharge from the duty to comply with other applicable regulations, such as those regarding labour issues or Port Authority towing requirements. The developer shall be responsible for the knowledge and compliance with other applicable regulations.

2.2. *bimep* responsibilities

01 *bimep* responsibilities toward MRED developers are as follows:

- Navigational safety: bimep will be responsible for the correct operation of all equipment related to navigational safety, such as marking systems and infrastructure monitoring systems and for the availability of support and rescue vessels and their crews.
- Keep onshore and offshore facilities in an adequate operational status: bimep will be responsible to keep in adequate operational status all facilities offered to the MRED developers, according to contractual terms.
- Calibration of all infrastructure measurement and protection equipment: measurement and protection equipment will be calibrated by bimep, according to recognised standards and protocols.
- Operational environmental plan: bimep is responsible for the execution of the operational environmental surveillance and campaigns as required by Spanish Authorities.
- Administrative Consenting: bimep will be responsible for keeping all administrative permits required by Spanish Administration.

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3. RISK ASSESSMENT

3.1. Methodology

01 This document presents a compilation of *bimep*'s high level requirements aimed to guide MRED developers to achieve an adequate safety level for installations at *bimep*. It clarifies WHAT developers need to comply with. International standards and Classification Societies rules should guide developers on HOW to comply with them.

02 The MRED developer will provide a detailed **risk assessment** and full documentation on all items covered in this Guide as described in Annex I. The MRED risk assessment will define the specific requirements for MRED.

03 Having identified a requirement through the MRED risk assessment, MRED developers should refer to applicable international standards and Classification Societies rules for specific data and calculations or identify other actions to reduce risks if standards do not cover the aspect properly. Annex II provides a complete list of Det Norske Veritas (DNV) applicable rules and standards for reference. However, MRED developers will have the freedom to choose from any other equivalent rules or standards

04 *bimep* will supply specific site information and documentation to facilitate performing calculations and identification of potential risks.

05 The Risk Matrix Method for identifying hazards and addressing risks should preferably be employed. This assessment must clearly define the probability of a particular risk occurring, describe its consequences and propose actions to mitigate it.

3.2. Acceptance Criteria

01 *Bimep* will use the classification for risks and mitigation measures in Table 1.

Risk Class		Developer Actions
Lowest	1	None - Acceptable risks
Low	2	Risk control required
Medium	3	Risk reduction/control required
High	4	Risk reduction required
Highest	5	None - Unacceptable risks

Table 1. Classification for risk and mitigation measures.

02 MRED systems with Risk Class 5 are unacceptable. MRED systems with Risk Class 1 are acceptable with no further measures necessary.

03 For MRED systems where the developer's risk assessment identifies a Risk Class of 2-4, mitigations such as risk reduction, risk control or further qualification activities must be proposed by the MRED developer. The MRED developer must identify that the risks have been satisfactorily reduced to an acceptable level either through an adequate reduction of Risk Class or by accepting the risk of operating at a given Risk Class. In each case the proposed actions must be documented and accepted by *bimep*.

04 Examples of risk reduction, risk control or qualification activities might include: re-designing aspects of the MRED prior to construction, procedural controls to tighten the operating envelope, or enhanced inspection and action strategies.

05 *Bimep*'s order of preference for risk mitigation measures is as follows:

- Inherent safety
- Prevention
- Detection
- Control
- Reduction
- Emergency response

06 The MRED developer should use the Table 2 Risk Matrix to establish the Risk Classification.

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			Consequence			
			Insignificant	Minor	Major	Catastrophic
	Description / Indicative annual failure rate		No significant harm to people, environment or property	Harm to people, environment or property	Significant harm to people, environment or property	Individual fatality, long term environmental impact or total loss of property
Frequency	Inevitable / frequent occurrence	10^{-1}	3	4	5	5
	Occasional occurrence	10^{-2}	2	3	4	5
	Rare occurrence	10^{-3}	1	2	3	4
	Very rare occurrence	10^{-4}	1	1	2	3

Table 2. Risk Matrix.

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4. GENERAL REQUIREMENTS

4.1. General Arrangement; Bulkheads

01 The developer should assess the need to include watertight bulkheads in the design of their MRED to ensure buoyancy in any working or damaged conditions.

02 The number and arrangement of those watertight bulkheads will be defined by the risk assessment referred in section 3.

4.2. Stability and Buoyancy

01 The MRED design must satisfy the requirements of IMO MODU Code. A stability report of the MRED must be made which sets outs the following data:

- Load cases, establishing the centre of gravity and displacement for each one.
- Hydrostatics for different depth and trim conditions that sufficiently meet load cases. KN cross curves.
- Initial stability report of the MRED for different load cases. GM (metacentric height).
- Report of the possible heeling moments when facing environmental design conditions described in section 5.3.3. This shall be established based on a free mooring unit.
- Righting arm curves and dynamic stability. Comparison with the heeling moments provided for environmental loads. Influence of the mooring in the stability.
- Report of flooding hatchways and angle of down flooding.

02 The **International Convention on Load Lines, 1966** shall be applicable, with particular attention to the areas regarding watertight closings, non-watertight tanks, ventilation and other issues of progressive flooding.

03 The following must be considered regarding minimum stability criteria:

- Under normal operating conditions, the MRED must be able to have positive stability when facing environmental heeling moments. The influence of the mooring shall be taken into account in this section. The most adverse down flooding angle shall always be above the greatest heeling angle caused by environmental loads defined in section 5.3.3.
- Taking on water. The number and placement of interior bulkheads must be such that the unit has positive buoyancy when facing flooding, due to damage, in the most critical of its compartments, according to MRED risk assessment described in section 3. All ventilations or possible water entry points must remain above any of the foreseeable flooding buoyancy waterlines. Environmental loads given in 5.3.3 must be considered to calculate the equilibrium buoyancy waterline in flooding condition above mentioned.
- The attitude when one any compartment is damaged must be such that the MRED can still be retrieved. The design of mooring and electrical connections must consider the need for disconnection methods to remain operable during adverse attitude changes. There should be no extra risk to divers or operators who must operate in this situation.
- When facing the loss of one line of the mooring system, the MRED must maintain positive buoyancy. The MRED must be retrievable in any resulting attitude changes. All ventilations or possible water entry points must remain above any of the foreseeable buoyancy waterlines. Divers should be exposed to no additional risks under these situations.

04 For MREDs that are unable to meet all of these criteria, due to particular limitations in their design or means of operation, a report shall be compiled analysing the risks to navigation, to people, to the environment, to other MREDs and to the facilities of *bimep* (See section 3). Means shall be proposed by the developer to mitigate the risks identified.

4.3. Safety equipment

01 When MRED developer's staff or their subcontractors are on board an MRED, they shall be equipped with the following safety and rescue equipment, stored in a readily accessible watertight case:

- 1 life jacket per person, SOLAS or CE 150N type..
- 6 red lights parachute rockets + 6 hand flares per MRED.
- 2 water proof flashlights with light bulbs and spare batteries per MRED.
- First aid kit SOLAS Type C per MRED.
- 20 m long and no less than 22 mm in diameter nylon rope per MRED.
- Manual bilge pump that can be operated from the outside. Where the MRED has internal access, this manual pump may be

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portable without the need to have an external operation system per MRED.

- Marine VHF radiotelephone with spare batteries or with rechargeable means to ensure adequate charge for its operation per MRED.

02 This safety equipment could be permanently kept inside the MRED or could be carried on board the personnel transportation vessel. In this case, the safety equipment must be onboard while personnel are in the MRED.

03 Furthermore, MREDs shall also have available fixed on them:

- If the MRED is not made of metallic material or if the MRED air draught is less than 2 m: a RADAR reflector situated at a height that is over 2 m above the normal load line of the MRED.

- If the MRED has a deck or step way which are necessary for maintenance or operation: At least 1 lifebuoy with light and lanyard shall be stowed in a location which has external access.

- Electric bilge pumping system. Each watertight compartment shall have an electric bilge pump with a capacity of at least 2 m2/h for baling out small amounts of water due to leakage. These electric bilge pumps shall run even if the MRED is not connected to the grid. Additional bilge pumping requirements, such as extra capacity or duration of running without grid connection, should be based on the risk assessment defined in section 3.

04 Alternative measures shall be proposed by the developer for deviations from fulfilling the above requirements. These alternative measures will be based on the Risk Assessment referred in section 3.

4.4. Fire Protection

01 When personnel are on board an MRED, they shall be equipped with the following fire protection equipment:

- Two 21 B or CO2 fire extinguishers in a readily accessible place from the outside. Special attention shall be paid to the electric compatibility of the extinguishing agent.

02 Preferably, the fire protection equipment should be permanently kept inside the MRED in a readily accessible place from the outside. If it is not possible, this equipment will be carried on board by the personnel accessing the MRED.

03 Modifications on fire extinguisher type, capacity, location, number or extra fire protection measures should be based on the risk assessment referred in section 3.

4.5. Access and Entry

01 All MREDs which will be boarded at sea must have adequate provision for the docking of the developer's specified access vessel. Adequate attachment points shall be provided to safely secure access vessels.

02 Additionally, all such MREDs shall be provided with adequate landing platforms, hand rails and ladders to execute safe transfers between MREDs and access vessels.

03 For MREDs which will be entered during fabrication or operation, the developer must take appropriate measures to identify and manage the risks associated with confined space entry. The necessary procedures identified must be included in the relevant plans, per section 4.9.

04 Access hatches, if provided, shall have an opening system from both sides of the hatchway as well as a restraining system that avoids accidental closings. Access hatches should be designed to provide means of entry with self-contained breathing apparatus and rescue of injured personnel.

4.6. Towing

01 All MREDs shall be equipped with towing facilities capable of achieving a safe way for transport and emergency recovery of the unit.

02 In the *bimep* context, ordinary towing means the MRED transport from port to *bimep*; emergency towing refers to marine operations to recover the unit in case an MRED loses position. Every MRED shall have, during normal operations, an emergency towing cable. The permanent presence of an emergency towing cable is intended to negate the need for onboard access under potentially hazardous emergency situations. The purpose of emergency towing is primarily to keep the MRED in position in case of mooring loss.

03 A study for the towing of the unit shall be presented in which the following issues are addressed.

4.6.1 Towing Equipment

01 Every MRED shall have, at least, **two bollards or towing eyes** which shall each have independently sufficient resistance in order to perform towing manoeuvres in the sea conditions and speed defined as maximum (see section 4.6.3 for towing conditions).

02 The towing bollards or eyes shall be located at opposite ends of the MRED (bow and stern, if

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possible) and in such a way so that the towing line runs free from impingement on the MRED.

03 An emergency towing cable shall be permanently secured by one end to either of the MRED's towing bollards or eyes. The cable's other end shall be secured to an easily recognisable red or orange buoy, of sufficient buoyancy to allow ease of recovery by a towing vessel. This cable shall be 30 m in length and rated at double the maximum tension estimated for the critical towing conditions, according 4.6.4. The submerged length of emergency tow cable shall hang freely between its attachments at the towing bollard and the buoy. Another suitable arrangement may be proposed by developer.

04 If the MRED developer specifies a longer cable, the rest of the additional cable length shall be stored aboard the MRED deck with a suitable means of attachment. Those attachments shall be weak enough to break, releasing the stored cable with the tension of the towing itself.

05 The MRED developers must specify what protective or maintenance measures will be applied to the emergency towing cable to prevent its degradation during normal operations.

06 The MRED developers shall provide *bimep* with the necessary layouts to describe the arrangement and characteristics of the towing equipment.

4.6.2 Ordinary Towing

01 MRED developers must provide the following calculations, according to the towing conditions referred in section 4.6.3:

- Maximum sea state in which towing can be conducted safely.
- Maximum speed at which towing can be conducted safely.
- Departure Port, route, average speed and estimated time for arrival.
- Maximum tension in the towing line for maximum sea state combined with a maximum speed.
- Minimum power (BHP) of the tug boat that is necessary for carrying out the towing operations in that maximum sea state combined with the maximum speed.
- Analysis of the stability and floodable openings of the MRED in towing conditions. When being towed, the MRED must have positive stability when facing the most adverse forecasted environmental conditions for towing, according to 4.6.3. The most adverse down flooding angle shall always be above the greatest heeling angle during the towing operation.

4.6.3 Towing Conditions

01 The maximum sea conditions and maximum speed which shall be taken into account to calculate the requirement described in 4.6.2 are defined by the departure Port Authority.

02 Depending on the departure Port Authority requirements, these Towing Conditions could significantly differ. For this reason, MRED developers shall adhere to the specific requirements for ordinary towing with the corresponding Port Authority once the departure port is established.

03 For indicative purposes, *bimep* will supply the MRED developer with the specific requirements for Bilbao's Port Authority.

4.6.4 Emergency Towing

01 MRED developers must provide the following calculations regarding emergency towing:

- Maximum sea conditions for emergency towing. The highest sea conditions will be defined as those to which the MRED may be kept in position with the help of a towing vessel, assuming a total loss of mooring.
- Maximum tension in the towing line for the emergency towing in this maximum sea condition.
- Minimum power (BHP) of the tug boat that is necessary for emergency towing in this maximum sea condition.

4.7. Marking of the MRED

01 Every MRED shall have a marking signal according to Spanish Administration consenting procedure. This marking signal shall consist of a yellow light with a flashing rhythm of ODAS buoy (5 flashes in 10 seconds followed by 10 seconds of darkness, in accordance with IALA MBS normative) with a 1 nautical mile reach.

02 The marking light is to be operated automatically when visibility conditions are reduced, even when MRED is not generating or connected to the grid. The marking light shall be connected to either solar panels or a shore power supply via the umbilical connection and charge batteries that can guarantee an indefinite period of running. The light shall be installed on top of a yellow mast with a length that can guarantee the required reach of 1 nautical mile.

03 The MRED shall be painted in a colour according to IALA provisions. Particularly, Spanish Authorities recommend that the MRED should be

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painted as Special Mark (yellow or orange colours). Green and red colours will be avoided to prevent confusion with IALA Lateral Signals. Other colour combinations that could be similar to any IALA signal different from that of Special Marks must be avoided.

4.8. Position monitoring

01 Each MRED shall have a position monitoring system to establish its position. This position shall be transmitted, via Radio Frequency, to the control centre.

02 The position monitoring system related shall be according with Spanish Authorities Consenting (commercial AIS type or similar)

03 If there is a loss of position, in accordance with the maximum calculated excursions in the mooring report, an alarm shall be activated in the control centre.

4.9. Plans for the Installation, Operation, Contingency, Maintenance and Decommissioning

01 All documentation supplied to *bimep* will be treated in strict confidence and will only be used with the aim of reducing all safety risks to as low as reasonably practical during the operational phase.

02 The developer shall provide *bimep* with a set of MRED and mooring plans and protocols. Specifically, it shall be compulsory to submit and comply with the following plans and protocol:

- **Mooring Installation Plan**: A detailed description of the necessary steps for the installation of the mooring in the selected area for its location shall be provided. The necessary means to undertake the manoeuvres and operations shall be provided as well as the characteristics (sea state and duration) of the estimated weather windows that are needed to undertake the installation. The expected time period for the installation shall be provided.

- **MRED Installation Plan**: A detailed description of the necessary steps for the installation of the MRED in the selected area for its location shall be provided. The necessary means in order to undertake the manoeuvres, operations towing, umbilical and mooring connection, etc. shall be provided, as well as the characteristics (sea state and duration) of the estimated weather windows that are needed to undertake the installation. The expected time period for the MRED installation shall be provided.

- **Mooring Operation Plan**: The routine plan for the testing of the mooring system shall be provided and, when applicable, the necessary manoeuvres, the configurations or actions to be implemented in the mooring system during normal operations. The means necessary to carry out this plan shall be listed.

- **MRED Operation Plan**: The routine plan for MRED testing and monitoring shall be provided and, when applicable, the necessary manoeuvres or the configurations or actions to be implemented in the MRED during normal operations. The means necessary to carry out this plan shall be listed.

- **A disconnection plan** shall be provided for the MRED with a detailed step by step procedure to be followed when disconnecting the unit from its mooring and its grid connecting power cable. The plan must consider disconnection under all conditions including normal condition, damaged condition and one mooring line lost condition.

- **Contingency Plan**: The MRED developer must make a risk analysis of the unit in order to identify which risks are critical and propose a contingency or action plan for each of them.

All risks which have an effect on the lives of people, on the navigation of vessels that are not part of the installation, on the environment and on possible damages to the infrastructure of bimep or with other users of the installations shall be looked at with detail. An acceptable risks should have actions defined to reduced them to as low as reasonably practical.

- **Maintenance and Inspection Plan**: The developer shall make available to bimep a maintenance plan of all systems and equipment mentioned in this guide as well as any other that has bearing on safety of people, facilities of bimep, environment, navigation and other MREDs. This maintenance plan shall identify the different systems to be controlled, the expected life span of the most critical components, their useful life, necessary means in order to perform the maintenance, necessary weather timeframes, etc.

The developer shall propose a record book format that logs all maintenance actions of its unit.

Notwithstanding the earlier, the developer must notify bimep of all necessary means in order to perform any other necessary maintenance to its unit.

- **Decommissioning Plan**: This plan shall provide all necessary operations and manoeuvres for the complete dismantling of

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the unit and the towing of all elements to port, including the mooring system.

The MRED developer shall consider in these plans the specific restrictions imposed by Spanish Authorities in the Environmental Permit. These restrictions are:

- The employed vessel for any operation shall be less than 80 m length.
- The employed vessel may only operate at a speed less than 10 knots.
- No operation may be done during marine mammals breeding.

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5. MRED STRUCTURE DESIGN REQUIREMENTS

01 This section defines the design principles to be considered in the structural analysis of the MRED. The structure comprises all elements of the MRED that contribute to its structural integrity, including all elements of the primary structure, mooring and towing points. Secondary elements that do not contribute towards, and whose failure do not threaten, the structural integrity of the MRED may be designed to engineering best practices.

02 The aim of the structural design is to withstand loads liable to occur during all temporary, operating and damaged conditions of the MRED in addition to maintaining acceptable levels of safety for personnel and the environment and to have adequate durability against deterioration during the design life.

03 Developers shall design their MREDs in accordance with the requirements specified by design standards that have been identified as sufficient to control the risks they have identified. The developer shall enlist an independent offshore certification body to produce an independent verification, certifying the developer's structural designs in the expected operating environment.

5.1. Design Principles

01 Structural design shall be conducted in the load and resistance factor design (LRFD) format. The LRFD format of strength capacity verification involves the following:

- Identify all relevant limit states.
- For each limit state define the relevant characteristic loads and design conditions.
- For each limit state find the design loads by applying the relevant load/design factors.
- For each limit state determine the design load effect.
- For each limit state determine the characteristic resistance.
- For each limit state determine the design resistance.
- Ensure an adequate level of safety by proving that the design load effect does not exceed the design resistance.

02 The developer shall specify the conditions and assumptions made in the design and detail the load combinations in their documents.

5.2. Limit States

01 A limit state is a condition beyond which a structure or a part of a structure exceeds a specified design requirement.

02 The following limit states should be considered by the MRED developer:

- Ultimate limit states (ULS) corresponding to the ultimate resistance for carrying loads.
- Fatigue limit states (FLS) related to the possibility of failure due to the effect of cyclic loading.
- Accidental limit states (ALS) corresponding to damage to components due to an accidental event or operational failure.
- Serviceability limit states (SLS) corresponding to the criteria applicable to normal use or durability.

5.3. Design Loads

01 This section defines the loads to be considered in the design.

5.3.1 Permanent Loads

01 Permanent loads are those that will not vary in magnitude, position or direction during the service life of the MRED. Examples of these include:

- The mass of the MRED, permanent ballast and equipment.
- Hydrostatic pressures of a permanent nature.

5.3.2 Functional Loads

01 Functional loads are those that will vary in magnitude, position or direction during MRED operation. These include:

- Personnel.
- Loads associated with installation operations.
- Variable ballast or other liquids/equipment loads.
- Stored materials, fluids and equipment.
- Mooring loads.
- Loads induced by the umbilical power cable employed by the MRED.

5.3.3 Environmental Loads

01 Environmental loads may vary in magnitude, position and direction during the service life of the MRED. Examples of these loads, and the load effects associated with them, include:

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- Hydrodynamic loads from wave loading and tidal currents.
- Diurnal tidal loads.
- Wind loads.
- Marine growth.
- Wave induced inertial loads.

02 The developer shall specify assumptions about marine growth for the service life of the MRED in regard to the impact on drag profile and the effect on mooring system.

03 The return conditions to be considered should be related to the duration of the operation according Table 3.

Return Conditions.	
Duration of use	**Environmental criteria**
Up to 3 days	Specific Weather Window
3 days to 1 week	More than 1 year, seasonal
1 week to 1 month	10 years return, seasonal
1 month to 1 year	100 years return, seasonal
More than 1 year	100 years return, all year.

Table 3. Return Conditions.

04 As a general guidance, the criteria given below may be applied.

- Upon request, Bimep will supply environmental data, such as the metocean buoy time registers or long-term distribution analysis, for characterisation of environmental loads.
- The risk analysis produced by the developer should define the most unfavourable load direction combinations against an appropriate standard.
- In addition to the above, the structure must be analysed for resonant response due to excitation from waves close to the natural frequency of the MRED.

5.3.4 Inertia Loads

01 The load effect from wave induced inertia forces shall be taken into account in designing the MRED. The accelerations shall be based on direct calculations or model tests unless specified in the standards.

5.4. Primary Hull Strength

01 The risk analysis produced by the developer should define the requirements for design loads and primary hull strength against an appropriate standard.

02 In accordance with these design loads, the scantling of the unit shall take place taking into account:

- The calculation of the structure shall be made through the use of a linear elastic analysis method.
- Safety factors shall be considered, depending on each type of structural member in accordance with applicable existing offshore regulations.
- All structural members must be checked for buckling.
- Special attention must be placed to the fatigue in the most critical elements, such as lugs or mooring connections points.

5.5. Local Strength

01 The risk analysis produced by the developer should define the requirements for design loads and local strength against an appropriate standard.

02 The following issues must be taken into account:

- The calculation must be accomplished through the direct application of some of the widely accepted applicable offshore regulations.
- The applicable safety factors shall be those established in the applicable regulation.
- If applicable, the corrosion increments established by the chosen regulation shall be used.

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6. MOORING SYSTEM REQUIREMENTS

01 This section defines the design principles to be considered in the analysis of the MRED mooring system. The mooring system comprises any elements to which the MRED is secured. These elements may include:

- Anchors to the sea bed (plate, pile, gravity, suction, fluke, helicoidal)
- Mooring line and connections (stud chain, studless chain, steel cables, textile cables, hawsers)
- Mooring connections (chain, shackles, kenters, grommets)
- Additional accessories (auxiliary buoys, thimbles, distribution)

02 The aim of the mooring design is to withstand loads liable to occur during all temporary, operating and damaged conditions of the MRED. The design shall maintain acceptable levels of safety for personnel and the environment and have adequate durability against deterioration during the design life.

03 Developers shall design the MRED moorings in accordance with the requirements specified in the design standards of an accredited independent offshore certification body. The developer shall enlist the offshore certification body to produce an independent verification, certifying the developer's mooring designs in the expected operating environment.

04 The developer must consider the potential need for temporary moorings, for example to support deployment or retrieval operations, in addition to position mooring for the intended service life of the MRED.

6.1. Design Principles

01 The following must be considered in the design of the mooring system:

- Hydrodynamic analysis of the floating unit without mooring restrictions.
- Analysis of the movement of the moored unit (influence of the mooring).
- Analysis of mooring excursions and tensions on the mooring elements.

02 The risk analysis produced by the developer should define the mooring requirements against an appropriate standard. In any case, the unit's mooring shall be studied at least in two situations:

- **Intact:** Reassuming that all mooring lines are fully operational, the tensions and excursions shall be analysed as noted earlier.
- **Breakdown:** The failure of one mooring line in its most unfavourable situation shall be studied.

03 Developers must specify safety factors for each of the elements of the mooring system and justify these, for example by reference to an appropriate offshore standard.

04 From the analysis, the following data must be gathered:

- Forces and displacements due to the effects of the seasonal loads of swell, wind and currents. Influence of the tides in the tensioned mooring systems (Taut type).
- Movements and accelerations based on the frequency of the swell. Response amplitude operators (RAOs).
- Displacements and forces of low frequency for second degree swell forces as well as the effect of wind gusts.

05 Developers must consider the possible interference between the mooring lines and the umbilical power cable as well as interferences between different MREDs or other infrastructure.

6.2. Limit States

01 A limit state is a condition beyond which the mooring system or a part of this exceeds a specified design requirement.

02 The limit states referred in section 5.2 should be considered by the MRED developer.

6.3. Environmental Loads

01 The mooring system shall be designed to bear environmental loads that are caused by swell, wind, currents, tide and storm surge.

02 All considerations referred at 5.3.3 shall be applied for mooring system design.

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7. FABRICATION REQUIREMENTS

7.1. Materials

01 The materials selected shall be suitable for their intended applications over the service life of the MRED and its moorings. The materials shall have the dimensions and mechanical properties, such as strength, ductility, toughness, corrosion and wear resistance, necessary to satisfy the assumptions made in the design. Materials shall be supplied with inspection documents in accordance with EN 10204 or agreed equivalent to confirm compliance with material specifications.

7.2. Fabrication Processes

01 To ensure the quality of the constructed MRED is within the tolerances specified by the design, those processes undertaken in fabrication, or approved modification and repair of the MRED must be conducted within the framework of an appropriate offshore construction standard, as per Annex II - Applicable DNV Rules and standards.

02 The fabrication of structural members shall be conducted by contractors with a documented and implemented quality management system according to ISO 9001, or equivalent, which specifies how production activities are controlled.

03 The developer shall establish fabrication procedures, inspection and test plans and work instructions for the execution and control of fabrication activities to identify, for example, responsibilities for the execution of work, procedures for specific tasks, hold points, tolerances and acceptance criteria.

04 Additionally, in accordance with Spanish regulations, fabricators shall provide MRED developers with the following documentation:

- Accredited certification of the suitability of the construction workshop to undertake the works related with the construction, refit or repair of the converter system. Activity reports issued by the Spanish Ministry of Industry or the certificate of establishment as a shipyard by the Spanish Ministry of Public Works are considered valid.

- Accredited welder qualification certificates (according to EN 287-1 or equivalent) for welders who undertake welding of structural or connection to anchors, moorings or towing systems.

05 Prior to commencement of fabrication the fabricator shall submit a plan for non-destructive testing (NDT) requirements, procedures and NDT inspector qualification certificates for acceptance by the MRED developer. The extent of NDT and procedures used shall be in accordance with a relevant offshore standard. Suppliers of NDT services and their personnel conducting NDT must be approved by an accredited body for those services that they will conduct and the relevant certification provided to the MRED developer.

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8. ELECTRICAL SYSTEM AND DATA TRANSFER

8.1. Umbilical power cable

01 This section defines the design principles to be considered in the analysis of the MRED umbilical power cable. The umbilical power cable comprises any elements for electrical connection of the MRED to bimep's electrical infrastructure. These elements may include:

- Electrical connectors
- Umbilical cable itself
- Additional accessories (bend restrictors, floaters, auxiliary buoys, …)

02 The aim of the umbilical power cable is to connect the MRED to the grid, transfer data for MRED control and to supply auxiliary power for MRED ancillary systems.

03 Developers shall design the MRED umbilical power cable in accordance with the requirements specified in the design standards of an accredited independent offshore certification body. The developer shall enlist the offshore certification body to produce an independent verification, certifying the developer's cable designs in the expected operating environment.

8.1.1 Design Principles

01 The following must be considered in the design of the umbilical power cable:

- Analysis of the umbilical movement of the connected unit.
- Analysis of umbilical bending radii.
- Analysis of tensions on the umbilical cable elements, particularly at the bimep's subsea connector.

02 The unit's umbilical power cable shall be studied under the same situations as the mooring system described in section 6.1, namely mooring lines fully operational and failure of one mooring line in its most unfavourable situation.

03 Developers must specify safety factors for each of the elements of the umbilical power cable and justify these, for example by reference to an appropriate offshore standard.

04 The subsea connector to be installed in the MRED shall follow the requirements established by *bimep*. It must be guaranteed that the umbilical power cable of the MRED does not impair the connector owned by *bimep*.

05 Developers must consider the possible interference between the mooring lines and the umbilical power cable as well as interferences between different MREDs or other infrastructure.

8.1.2 Limit States

01 A limit state is a condition beyond which the umbilical cable system or a part of this exceeds a specified design requirement.

02 The limit states referred in section 5.2 should be considered by the MRED developer.

8.1.3 Environmental Loads

01 The umbilical power cable shall be designed to bear environmental loads that are caused by swell, wind, currents, tide and storm surge.

02 All considerations referred at 5.3.3 shall be applied for umbilical power cable design.

8.2. Electrical system requirements

01 Electrical systems are key to avoid risks at *bimep*. Therefore, MRED developers will adopt the appropriate actions to keep electrical and electronic equipment in good condition in order to ensure its functionality. The developer must take appropriate measures to identify and manage the risks associated with electrical hazards, particularly those ensuring arc-flash prevention. The necessary procedures identified, such as permitting to work and means of electrical isolation and interlock, must be included in the relevant plans, per section 4.9.

8.2.1 Connection requirements

01 For MREDs that are connecting to the network at *bimep*, the point of connection must fulfil the following requirements:

- Three-phase connection.
- Output nominal voltage equal to 13,2 kV ± 5%.
- Nominal frequency equal to 50 ± 1% Hz.
- Maximum peak power output of 5MW.

02 Power quality must satisfy the requirements of the network operator to connect the MRED to the grid for electrical generation. For this purpose, the necessary power electronics could be used.

03 Power factor equal to 1 will be accepted without any further provisions.

04 Power factor up to 0.9 could be connected, subject to economic penalties described on the Power Purchase Agreement.

05 Connection of MREDs with power factors less than 0.9 will be strictly forbidden for electrical generation, however, MREDs can perform electrical generation tests at bimep provided they

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safely dissipate the energy produced. MREDs will be allowed to take power for ancillary systems (DC), an additionally to connect to the main AC supply to power ancillary systems (i.e. backfeeding).

06 Power supply of 220 Vdc is available for ancillary equipments.

8.2.2 Electrical Protection

01 Electrical protection devices are needed in order to guarantee the connection and disconnection to the network in the following cases:

- A failure throughout any of the cables that connect the MRED to the test infrastructure.
- A failure in the network.
- When voltage or frequency are out of the range specified by the network operator.
- Any type of breakdown or failure of MREDs.

02 MREDs shall have a protection system and switch to allow automatic disconnection in case of network or MRED generation faults.

03 In order to guarantee automatic disconnection under a fault situation, the minimum protection will be as follows:

- Minimum voltage protection (Function 27): Voltage setting: 85% of phase to phase voltage. Time setting between 0,1 and 1 s.
- Maximum voltage protection (Function 59): Voltage setting: 110% of phase to phase voltage. Time setting between 0,1 and 1 s.
- Maximum and minimum frequency protection (Functions 81O y 81U): Between 49 and 51 Hz. Time setting between 0,1 and 1 s.
- Time and instantaneous Phase Overcurrent protection, (Functions 51/50): The instantaneous overcurrent unit allowwed at 130% of fault current in the power transformer secondary winding.

04 After use of protections, MRED connection to the network will be recovered as soon as the power conditions return to the normal state.

8.2.3 Islanding mode

01 Islanding mode is not an acceptable mode of operation. Islanding mode refers to the condition in which a generator continues supplying power even though subsea cable power is no longer present. Islanding can be dangerous to maintenance staff who may not realize that a circuit is still powered, and it may prevent automatic re-connection of devices.

02 For that reason, MRED developers must detect islanding and immediately stop producing power and disconnect itself from the grid; this is referred to as anti-islanding.

8.2.4 Electrical metering

01 *Bimep* will provide calibrated electrical measurements at each power line and at the onshore substation. If it is needed to discriminate electrical measurements for each individual MRED, then *bimep* will request the MRED to install a homologated measuring equipment on board. This system will be directly connected to *bimep*'s monitoring and control system.

02 All electrical and electronic power measuring equipment must be accredited according to current regulations. The Spanish Royal Decree RD1110/2007 establishes the requirements for measuring points.

8.3. Data Transfer Requirements

01 All data transferred to *bimep* will be treated in strict confidence and will only be used with the aim of reducing all safety risks to as low as reasonably practical during the operational phase.

8.3.1 Communication Equipment

01 Regarding data transfer between the MRED and the Control Centre, the following aspects must be taken into account.

- Bimep shall provide each MRED developer with a private room in the building that houses the R&D Centre in which it can house its SCADA and where personnel authorised by the owner of the system may have confidential access to.
- The developer shall have available one single-fiber optical fiber of 1.550nm for the transmission of information from the capture systems and one identical spare optical fiber for use in case of failure of the first one.

8.3.2 Device Control and Alarms

01 The MRED developer shall supply to *bimep*, the data related to the electrical magnitudes, as voltage, current, frequency, active and reactive power, active and reactive energy, etc.

02 All MREDs will have a set of alarms, according to the risk assessment provided by the MRED developer.

03 The MRED developer shall supply to *bimep*, in real time, the data relevant to the sensor's security alarms. These alarms may include fire, smoke or excess heat detectors and bilge alarms.

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8.3.3 Telecontrol

01 The MRED developer's SCADA shall allow remote connection and disconnection of the MRED to the grid when the safety requirements recommend so.

02 The MRED developer's SCADA will communicate with the Control Centre to get the state of protections and MRED connection as well as to send the open/close connection commands.

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9. ENVIRONMENTAL ISSUES

01 Every MRED must comply with the applicable requirements of the **International Convention for the Prevention of Pollution from Ships (MARPOL 73/78).** This convention is also applicable to all auxiliary vessels that are necessary for the installation, operation or dismantling of MREDs.

02 Additionally, the requirements imposed by Spanish Administration in the environmental authorisation *of bimep* shall also be applicable.

03 The risk analysis produced by the developer should define the environmental impacts. **Critical environmental impacts**, defined as those that produce permanent damage without possible recovery, even with the adoption of preventing or corrective measures, will not be permitted.

04 In any case, at least the following aspects relative to the safety of the environment shall be considered.

9.1. Discharges

01 Prior to the installation in *bimep*, the developer must provide written details of all discharges that the MRED performs during its normal operation, both to the sea as well as the atmosphere.

02 Discharges from MREDs, other than sea water from heat exchangers, bilge and ballast system, are not permitted.

03 Attention shall be paid to the discharge of waste on land caused by the works of dry dock maintenance.

04 The developer must provide *bimep* with a list of all pollutant substances and their quantities for use or storage on board: Hydraulic oils, fuels, paints, solvents, batteries, etc.

05 Also, the developer must provide a list of the waste generated by the MRED in operations or maintenance in accordance with the European Waste Framework Directive (2008/98/EC).

06 All waste whose appraisal in value is technical and economically viable shall be sent to a duly authorised waste appraiser.

07 Waste shall only be destined for disposal if there is a previous justification that its appraisal is not technically, economically or environmentally feasible.

08 Containers for the storage of dangerous waste must comply with established safety rules and shall remain closed until they are delivered to a waste manager to prevent loss due to spillage or evaporation. The containers must be labelled in a clear, legible and indelible manner and in accordance with the guidelines established in the legislation in force.

09 Used oils must be managed in accordance with legislation in force. The regulations established in the Autonomous Community of the Basque Country must be followed.

10 If short-term storage of dangerous waste is required prior to delivery to an authorised waste manager, storage shall be in a roofed building, on a waterproof floor and inside bunds or embankment systems for the prevention of possible spills or leaks.

11 For waste generated in MRED operations or maintenance, the developer must provide *bimep* with documentation demonstrating they meet the requirements of waste management specified within this guide.

9.2. Accidental spillage

01 Every MRED must have adequate means to prevent accidental spillage to the air or sea.

02 The developer shall provide adequate means to contain any potential release of harmful substances. This might include bunds and catch trays.

9.3. Paints and coatings

03 The MRED developer's requirements for corrosion protection and antifouling shall be defined in their design with reference to an applicable offshore standard. Areas for consideration include: coating materials, surface preparation, thickness of individual layers, inspection and testing. Consideration should be given to international conventions restricting certain materials (such as TBT).

9.4. Mooring

01 Mooring systems that cause critical environmental impacts on the sea bed, flora or fauna shall not be used. If there is evidence of any type of critical environmental impact caused by the mooring system of an MRED, *bimep* will require the MRED developer to immediately remove the unit from operation.

02 A mooring system decommissioning plan shall be supplied before installation at *bimep*. Mooring systems shall be entirely dismantled and removed at decommissioning. At *bimep*'s discretion, this requirement may be lifted if, for example, the mooring can be re-used.

03 The elements of the mooring system must not go beyond the limits established in *bimep's* Spanish Administration permit, delineated by the

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bimep marking buoys. Additionally, if as an inherent part of the anchor design, some drag is expected at installation, this expected distance must be deducted from the limits of bimep.

9.5. Materials and Products

01 The use of materials that could cause critical environmental impacts is prohibited.

02 All hydraulic fluids employed shall be of biodegradable type. The certificate of the type of oil employed shall be submitted by the MRED developer.

9.6. Noise and Vibrations

01 If there is evidence of critical environmental impact caused by noise or vibrations emitted by an MRED, the MRED shall immediately halt power generation until it has been demonstrated that noise and vibration emissions have been returned to non-critical levels.

9.7. Maintenance works

01 In accordance with the conditions established in the *bimep*'s environmental consenting, maintenance operations that involve the use of grease or paints are prohibited at sea. For these operations MREDs must be returned to port. Information about these works must be submitted to *bimep* before proceeding.

9.8. Visual Impact

01 Prior to the installation of the MRED, the developer shall provide *bimep* with a visual impact analysis.

9.9. Marine Mammal Impact

01 In accordance with the conditions established in the *bimep* environmental permit, MRED installation vessels shall have a maximum length of 80 m and shall observe a 10 knot speed limit within the *bimep* boundaries. Their use must be authorised by *bimep* which shall take into account the possible presence of cetaceans in seasons of greater sensitivity.

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Annex I – Documentation to be submitted to bimep

1. **Risk Assessment** in accordance with section 3.
2. **General description** of the MRED in accordance with section 4.
   - MREDs specifications.
   - Main dimensions.
   - Anticipated time period and conditions for the tests.
   - Stability and buoyancy study in accordance with section 4.2.
   - Safety and fire protection equipment in accordance with section 4.3 and 4.4.
   - Access aids in accordance with section 4.5.
   - Towing calculation and layout of towing arrangement in accordance with section 4.6.
   - Details of marking and position monitoring systems in accordance with section 4.7 and 4.8.
   - Operational plans in accordance with section 4.9:
   - Installation Plan.
   - Operation Plan.
   - Decommissioning Plan.
   - Contingency Plan.
   - Maintenance Plan.
   - Structural design calculations in accordance with section 5.
   - Details and certificates of the materials employed in its construction and traceability of records, in accordance with section 7.1.
   - Details and certificates of the constructive processes in accordance with section 7.2.
3. **Description of the converter system**.
   - Specifications of the power capture system and PTO.
   - Maximum expected power.
4. **Mooring system** description.
   - Specifications of the mooring system.
   - Environmental loads in accordance with section 6.3.
   - Mooring Reports in accordance with section 6.
   - Mooring system materials and certificates in accordance with section 7.
5. **Electrical system** description.
   - Specifications of the umbilical power cable and environmental loads in accordance with section 8.1.3.
   - Specifications of the electrical system. Voltages, currents and power.
   - Specifications of the electrical equipment on board. Protections.
   - Description of the data transfer system. Communication equipment, device control and alarms and telecontrol.
6. **Environmental issues** in accordance with section 9.
   - Specifications of possible polluting elements on board.
   - Analysis of the environmental risks and measures to be taken.
7. **Plans** to be submitted:
   - General arrangement drawings, including safety and fire protection equipment, access aids, towing equipment, marking signals and positioning system locations and details.
   - Site location plan within the concession.
   - Mooring system plan.
   - Site location plan of safety means and equipment on board.
   - General structural plan with indications of the type of materials and constructive processes.
   - Plan with the location of possible polluting elements on board.

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Annex II - Applicable DNV Rules and Standards

DNV Documents relevant for Tidal and Wave Energy Converters	
Design Standards	
Reference	***Title***
DNV-DS-J102	Design and Manufacture of Wind Turbine Blades, Offshore and Onshore Wind Turbines
Offshore Standards	
Reference	***Title***
DNV-OS-A101	Safety Principles and Arrangements
DNV-OS-B101	Metallic Materials
DNV-OS-C101	Design of Offshore Steel Structures, General (LRFD Method)
DNV-OS-C102	Structural Design of Offshore Ships
DNV-OS-C201	Structural Design of Offshore Units (WSD Method)
DNV-OS-C301	Stability and Watertight Integrity
DNV-OS-C401	Fabrication and Testing of Offshore Structures
DNV-OS-C501	Composite Components
DNV-OS-C502	Offshore Concrete Structures
DNV-OS-D101	Marine and Machinery Systems and Equipment
DNV-OS-D201	Electrical Installations
DNV-OS-D202	Automation, Safety, and Telecommunication Systems
DNV-OS-D203	Integrated Software-Dependent System (ISDS)
DNV-OS-D301	Fire Protection
DNV-OS-E301	Position Mooring
DNV-OS-E302	Offshore Mooring Chain
DNV-OS-E303	Offshore Mooring Fibre Ropes
DNV-OS-E304	Offshore Mooring Steel Wire Ropes
DNV-OS-E403	Offshore Loading Buoys
DNV-OS-F201	Dynamic Risers
DNV-OS-J101	Design of Offshore Wind Turbine Structures

Table 4. DNV Documents relevant for Tidal and Wave Energy Converters.

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DNV Recommended Practices	
Reference	***Title***
DNV-RP-A201	Plan Approval Documentation Types – Definitions
DNV-RP-A203	Qualification of New Technology
DNV-RP-A204	Quality Survey Plan (QSP) for Offshore Class New-building Surveys
DNV-RP-B101	Corrosion Protection of Floating Production and Storage Units
DNV-RP-B401	Cathodic Protection Design
DNV-RP-C101	Allowable Thickness Diminution for Hull Structure of Offshore Ships
DNV-RP-C102	Structural Design of Offshore Ships
DNV-RP-C201	Buckling Strength of Plated Structures
DNV-RP-C202	Buckling Strength of Shells
DNV-RP-C203	Fatigue Design of Offshore Steel Structures
DNV-RP-C204	Design against Accidental Loads
DNV-RP-C205	Environmental Conditions and Environmental Loads
DNV-RP-C207	Statistical Representation of Soil Data
DNV-RP-D101	Structural Analysis of Piping Systems
DNV-RP-D201	Integrated Software Dependent Systems
DNV-RP-D202	Power Cables in Offshore Dynamic Applications
DNV-RP-E301	Design and Installation of Fluke Anchors in Clay
DNV-RP-E302	Design And Installation of Plate Anchors in Clay
DNV-RP-E303	Geotechnical Design and Installation of Suction Anchors in Clay
DNV-RP-E304	Damage Assessment of Fibre Ropes for Offshore Mooring
DNV-RP-F109	On-Bottom Stability Design of Submarine Pipelines
DNV-RP-F111	Interference Between Trawl Gear and Pipelines
DNV-RP-F112	Design of Duplex Stainless Steel Subsea Equipment Exposed to Cathodic Protection
DNV-RP-G103	Non-Intrusive Inspection
DNV-RP-H101	Risk Management in Marine and Subsea Operations
DNV-RP-H102	Marine Operations during Removal of Offshore Installations
DNV-RP-H103	Modelling and Analysis of Marine Operations
DNV-RP-H104	Ballast, Stability, and Watertight Integrity - Planning and Operating Guidance
DNV-RP-J101	Use of Remote Sensing for Wind Energy Assessments
DNV-RP-O401	Safety and Reliability of Subsea Systems

Table 5. *DNV Recommended Practices.*

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DNV Guidelines and Classification Notes	
Reference	***Title***
No. 7	Non-destructive Testing
No. 10.2	Guidance for Condition Monitoring
No. 20.1	Stability Documentation for Approval
No. 30.4	Foundations
No. 30.6	Structural Reliability Analysis of Marine Structures
No. 30.7	Fatigue Assessment of Ship Structures
No. 33.1	Corrosion Prevention of Tanks and Holds
No. 41.2	Calculation of Gear Rating for Marine Transmission
No. 41.3	Calculation of Crankshafts for Diesel Engines
No. 41.4	Calculation of Shafts in Marine Applications
No. 41.5	Calculation of Marine Propeller
No. 41.6	Schematic Principles for Steering Gear Hydraulics
No. 57.1	Shock Testing of Equipment and Systems - Naval Applications

Table 6. *DNV Guidelines and Classification Notes.*

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