



BSI Standards Publication

Marine energy — Wave, tidal and other water current converters

Part 10: Assessment of mooring system for marine energy converters (MECs)

National foreword

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The UK participation in its preparation was entrusted to Technical Committee PEL/114, Marine energy - Wave, tidal and other water current converters.

A list of organizations represented on this committee can be obtained on request to its committee manager.

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TECHNICAL SPECIFICATION



**Marine energy – Wave, tidal and other water current converters –
Part 10: Assessment of mooring system for marine energy converters (MECs)**

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

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CONTENTS

FOREWORD.....	6
INTRODUCTION.....	8
1 Scope.....	9
2 Normative references.....	9
3 Terms and definitions	9
4 Abbreviated terms	10
5 Principal elements	10
5.1 General.....	10
5.2 Technology qualification.....	10
5.3 Safety and risk consideration.....	11
5.4 Safety levels	11
5.5 Design procedure.....	11
5.6 Inspection and maintenance requirements	11
6 Environmental and site conditions	11
6.1 General.....	11
6.2 Primary environmental conditions	12
6.3 Secondary environmental conditions.....	12
6.3.1 General	12
6.3.2 Marine growth	12
6.3.3 Seabed conditions	12
6.4 Site characteristics.....	12
6.4.1 General	12
6.4.2 Environmentally sensitive and protected areas and marine animals.....	12
6.4.3 Nearshore impact.....	12
6.4.4 Vandalism and misuse	13
6.4.5 Marine traffic.....	13
6.4.6 Shallow water conditions	13
7 Design load cases	13
7.1 General.....	13
7.2 Analysis procedure overview	13
7.3 Load categories	14
7.3.1 General	14
7.3.2 Dynamic analysis of MEC response to environmental conditions	15
7.3.3 Low frequency loads	15
7.3.4 Wave frequency loads on mooring components	15
7.3.5 Wave frequency loads on MEC.....	15
7.3.6 High frequency loading.....	16
7.4 Interaction with waves, currents, wind, water level and ice	16
7.4.1 General	16
7.4.2 Resonant response	17
7.4.3 Design return period for short term deployments.....	17
7.5 Mooring line components.....	17
7.5.1 General	17
7.5.2 Component strength.....	17
7.5.3 Component fatigue life	18

7.5.4	Redundancy.....	18
7.5.5	Clearance	18
7.6	Umbilical considerations.....	18
7.6.1	Umbilical response.....	18
7.6.2	Umbilical strength	18
7.6.3	Umbilical offset and clearance limits	18
7.7	Limit states	19
7.7.1	General	19
7.7.2	Ultimate limit state (ULS)	19
7.7.3	Accidental limit state (ALS)	19
7.7.4	Serviceability limit state (SLS).....	19
7.7.5	Fatigue limit state (FLS).....	19
7.7.6	Consequence class safety factors	20
7.7.7	Mooring component failure	20
7.7.8	Anchor holding capacity	20
7.7.9	Load case modelling and simulation	21
7.7.10	Design conditions.....	22
8	In-service inspection, monitoring, testing, and maintenance.....	32
8.1	General.....	32
8.2	Anchor proof loading	33
8.3	Component replacement.....	33
8.3.1	General	33
8.3.2	Fibre rope component inspection and replacement	33
8.3.3	Inspection and predictive procedures.....	33
8.4	In air and splash zone mooring line sections	34
8.5	Submerged mooring line sections	34
8.6	Commissioning and decommissioning procedures.....	35
Annex A	(informative) Moorings and anchoring systems	36
A.1	Types of moorings and anchoring systems.....	36
A.1.1	General	36
A.1.2	Mooring systems.....	36
A.2	Mooring line components.....	38
A.2.1	General	38
A.2.2	Chain.....	38
A.2.3	Wire rope.....	39
A.2.4	Synthetic rope.....	39
A.2.5	Elastic tethers	46
A.2.6	Clump weights	47
A.2.7	Buoyancy aids	47
A.2.8	Connectors and accessories.....	47
A.3	Anchors	48
A.3.1	General	48
A.3.2	Drag embedment anchor	48
A.3.3	Pile anchor	49
A.3.4	Suction anchor.....	49
A.3.5	Gravity installed anchor.....	50
A.3.6	Gravity anchor	51
A.3.7	Plate anchor	52
A.3.8	Screw and rock anchors	52

A.3.9	Type selection	53
A.3.10	Holding capacity	53
A.3.11	Sediment and rock conditions	54
A.3.12	Fluke setting	54
A.3.13	Installation	54
A.3.14	Proof loading	55
A.3.15	Directional anchor loading	55
A.3.16	Failure mode	55
A.3.17	Environmental loading	55
A.3.18	Failure point	55
Annex B (normative)	Safety and risk considerations	56
B.1	General	56
B.2	Risk	56
B.2.1	General	56
B.2.2	Definition	56
B.2.3	Consequence types	56
B.3	Risk assessment methodology	57
B.3.1	General	57
B.3.2	Methodology flowchart	57
B.4	Consequence considerations for mooring failure	59
B.5	Consequence classification	59
B.5.1	General	59
B.5.2	Consequence impact considerations	60
B.5.3	Risk mitigation considerations	61
B.5.4	Risk acceptance	61
Annex C (informative)	Numerical modelling considerations	63
C.1	General	63
C.2	Mooring, umbilical, and dynamic cable models	63
C.2.1	General	63
C.2.2	Static and catenary models	63
C.2.3	Discrete models	63
C.2.4	Floating unit numerical models	63
Bibliography		65
Figure 1	– Recommended conceptual mooring analysis procedure	14
Figure A.1	– Spread mooring configuration	36
Figure A.2	– Catenary anchor leg mooring configuration	37
Figure A.3	– Single anchor leg mooring configuration	37
Figure A.4	– Turret mooring configuration	38
Figure A.5	– Studless and studlink chain	38
Figure A.6	– Typical wire rope construction	39
Figure A.7	– Parallel yarn rope	41
Figure A.8	– Parallel core rope	41
Figure A.9	– Rope construction with 18+12+6+1 format	42
Figure A.10	– Three strand laid construction	42
Figure A.11	– Rope with 8 plait braid construction	43
Figure A.12	– Rope with braid on braid construction	43

Figure A.13 – Types of connectors	48
Figure A.14 – Drag embedment anchor	49
Figure A.15 – Pile anchor.....	49
Figure A.16 – Suction anchor	50
Figure A.17 – Gravity installed torpedo anchor	51
Figure A.18 – Gravity installed anchor with rotating load arm	51
Figure A.19 – Gravity anchor.....	52
Figure A.20 – Suction or pile driven plate anchor.....	52
Figure A.21 – Screw anchor.....	53
Figure A.22 – Rock anchor.....	53
Figure B.1 – General risk methodology flowchart	58
Table 1 – Potential nearshore impacts.....	13
Table 2 – Combinations of uncorrelated extreme events	17
Table 3 – Consequence class associated safety factors for dynamic analysis techniques.....	20
Table 4 – Safety factors for holding capacity of drag anchors.....	21
Table 5 – Safety factors for holding capacity of anchor piles and suction piles	21
Table 6 – Safety factors for holding capacity of gravity and plate anchors	21
Table 7 – Design load cases for WECs.....	24
Table 8 – Design load cases for CECs	26
Table A.1 – Generalized comparison of mooring line material characteristics	40
Table A.2 – Properties for selection of synthetic fibre	44
Table A.3 – Generalized comparison of common rope relevant material properties	44
Table B.1 – Consequence categories	59

INTERNATIONAL ELECTROTECHNICAL COMMISSION

**MARINE ENERGY –
WAVE, TIDAL AND OTHER WATER CURRENT CONVERTERS –****Part 10: Assessment of mooring system
for marine energy converters (MECs)**

FOREWORD

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IEC TS 62600-10 has been prepared by IEC technical committee 114: Marine energy – Wave, tidal and other water current converters. It is a Technical Specification.

This second edition cancels and replaces the first edition published in 2015. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

- a) Added specific Design Load Cases in alignment with 62600-2.
- b) Added additional robustness check requirements.
- c) Rearranged document for ease of use and alignment with 62600-2.
- d) Added additional informative clauses on mooring materials.

The text of this Technical Specification is based on the following documents:

Draft	Report on voting
114/390/DTS	114/395/RVDTS
	114/395A/RVDTS

Full information on the voting for its approval can be found in the report on voting indicated in the above table.

A list of all parts in the IEC 62600 series, published under the general title *Marine energy – Wave, tidal and other water current converters*, can be found on the IEC website.

The language used for the development of this Technical Specification is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/standardsdev/publications.

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- withdrawn,
- replaced by a revised edition, or
- amended.

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INTRODUCTION

This document defines rules and assessment procedures for the design, installation and maintenance of mooring system with respect to technical requirements for floating marine energy converters.

The proposed work aims to bring together expert knowledge from the marine energy power and offshore engineering industries in order to formulate a guideline specification of the design, installation and maintenance requirements for mooring system of floating Marine Energy Converters.

In addition to safety and ocean environmental requirements, this document focuses on the strength requirements of mooring systems for Marine Energy Converters.

MARINE ENERGY – WAVE, TIDAL AND OTHER WATER CURRENT CONVERTERS –

Part 10: Assessment of mooring system for marine energy converters (MECs)

1 Scope

The purpose of this document is to provide uniform methodologies for the design and assessment of mooring systems for floating Marine Energy Converters (MECs) (as defined in the TC 114 scope). It is intended to be applied at various stages, from mooring system assessment to design, installation and maintenance of floating Marine Energy Converters plants.

This document is applicable to mooring systems for floating Marine Energy Converters units of any size or type in any open water conditions. Some aspects of the mooring system design process are more detailed in existing and well-established mooring standards. The intent of this document is to highlight the different requirements of Marine Energy Converters and not duplicate existing standards or processes.

While requirements for anchor holding capacity are indicated, detailed geotechnical analysis and design of anchors are beyond the scope of this document.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC TS 62600-1: 2020, *Marine energy – Wave, tidal and other water current converters – Part 1: Vocabulary*

IEC TS 62600-2:2019, *Marine energy - Wave, tidal and other water current converters - Part 2: Marine energy systems - Design requirements*

IEC TS 62600-4:2020, *Marine energy – Wave, tidal and other water current converters – Part 4: Specification for establishing qualification of new technology*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC TS 62600-1 apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at <http://www.electropedia.org/>
- ISO Online browsing platform: available at <http://www.iso.org/obp>

4 Abbreviated terms

ALARP	As low as reasonably practicable
ALS	Accidental limit state
API	American Petroleum Institute
CALM	Catenary anchor leg mooring
CEC	Current Energy Converter
CFD	Computational fluid dynamics
DP	Dynamic positioning
FLS	Fatigue limit state
HAZID	Hazard Identification
HHP	High holding power
IEC	International Electrotechnical Commission
ISO	International Organisation for Standardisation
LTM	Long term mooring
MBL	Minimum breaking load
MEC	Marine energy converter
MEP	Marine environmental protection
MPM	Most probable maximum
PTO	Power take-off
PT	Project team
ROV	Remotely operated vehicle
SALM	Single anchor leg mooring
SF	Safety factor
SLS	Serviceability limit state
SPM	Single point mooring
TEC	Tidal Energy Converter
ULS	Ultimate limit state
UV	Ultraviolet
VIM	Vortex induced motion
VIV	Vortex induced vibration
WEC	Wave Energy Converter

5 Principal elements

5.1 General

The engineering and technical requirements to ensure integrity of a mooring system for a MEC are given in this document. This document is used in conjunction with IEC TS 62600-2.

5.2 Technology qualification

Technology qualification for mooring system components shall be completed in accordance with IEC TS 62600-4.

5.3 Safety and risk consideration

Understanding risk factors is important in quantifying the consequence class of the mooring design. The consequence class dictates the required level of safety of the mooring design. A mooring related risk assessment shall be completed. Guidelines for a mooring related risk assessment is discussed in more detail in Annex B. Additional guidelines for risk assessment can be found in IEC TS 62600-2:2019, 5.4 and IEC TS 62600-4.

5.4 Safety levels

The assessment of consequences of failure shall cover all phases of MEC installation, operation, maintenance, and decommissioning, where the mooring system is affected or affects the overall system. Related consequences shall consider:

- Risk to life and injury
- Environmental impact
- Economic consequences
- Loss of public reputation and other political and societal consequences

The requirements in this document, including safety factors are intended to comply with 10^{-4} per year probability of failure for normal consequence class. This is in alignment with the objective of IEC TS 62600-2. However, a more conservative consequence class is provided along with associated safety factors that may be applicable for a smaller associated target probability of failure.

Where the risk can be controlled by short term deployments, or other factors, particularly for prototype deployments, a larger probability of failure may be tolerated. More information and guidance on safety and risk considerations can be found in Annex B.

5.5 Design procedure

The design process is iterative in nature. The potentially complex nature of MEC dynamic behaviour and external loading effects mean that careful consideration of the definition of environmental conditions, specific design load cases in the limit states required, and the limitations of analysis techniques used should be made. Guidance on environmental and site conditions are described in Clause 6.

The MEC mooring system design shall be regarded as completed when the integrity is verified by the limit state analysis described in Clause 7.

5.6 Inspection and maintenance requirements

The integrity of a station keeping system and its serviceability throughout the design service life are not only strongly dependent on a competent design, but also on the quality control exercised in manufacture, supervision on-site, handling during transport and installation, and the manner in which the system is used and maintained. Further information on inspection and maintenance requirements are described in Clause 8.

6 Environmental and site conditions

6.1 General

External conditions include metocean and other environmental factors that will vary based on location and should be considered on a site specific basis.

6.2 Primary environmental conditions

The environmental conditions described in 6.2 of IEC TS 62600-2:2019 shall be considered in the modelling, analysis, and prediction of environmental loads on and resulting dynamic response of MECs for the purpose of resolving the mooring design. The return periods for combinations of environmental conditions listed in 7.4 shall be used and are intended to align with IEC TS 62600-2:2019.

Wind, wave, current, water elevation variations, snow and ice, and other conditions at each site shall be considered. Guidelines for determining metocean conditions can be found in ISO 19901-1. Annex A.5.7 of ISO 19901-1:2005 provides guidance to establish metocean conditions with larger return periods. The confidence interval of statistical extrapolations to establish return periods from measured site specific data can have a significant effect on the return period values and should be selected carefully.

The return period of metocean conditions in the design load cases are a minimum. The sensitivity to the system response to return period can be considered.

6.3 Secondary environmental conditions

6.3.1 General

Secondary environmental conditions listed in 6.3 of IEC TS 62600-2:2019 shall be considered when the potential exists for significant effects on the MEC and mooring at the deployment site.

6.3.2 Marine growth

The type and accumulation rate of marine growth at a specific site can affect mass and hydrodynamic properties and therefore the dynamic response of the MEC and mooring lines. This shall be taken into consideration for mooring systems designed without any regular marine growth removal or protection plan. Indicative marine growth rates for a variety of locations can be found in ISO 19901-1. Increased line weight and drag coefficients representative of site-specific marine growth accumulation profiles should be considered.

6.3.3 Seabed conditions

Seabed conditions and type are required for anchor selection. More information on anchor selection can be seen in Annex C.

6.4 Site characteristics

6.4.1 General

Characteristics of the deployment site location may have special considerations that may directly affect the mooring design through various requirements or component selection.

6.4.2 Environmentally sensitive and protected areas and marine animals

Selected sites for MECs can be located near sensitive or protected habitats. Any device located in such a habitat can impact the ecology and environment via direct contact or indirectly by harassment. Mooring systems can have impact without a failure event. Consequences can include reduction in water quality from sediment churn and bottom scour due to normal mooring motion, marine life entanglement with mooring components, and habitat damage from anchor placement and installation activities. In addition, noise produced by strum, mooring line interaction with the seabed, and mooring component rattle can be considered harassment.

6.4.3 Nearshore impact

Nearshore impact is defined as impacts associated with any developmental activities related to the installation or operation of MECs that can take place in the area between the shoreline and

the area defined as the offshore zone. Nearshore impacts can have unintended consequences that can be financial, environmental, or societal. Nearshore impacts may include but are not limited to the following, listed in Table 1.

Table 1 – Potential nearshore impacts

Impact type	Description of impact
Noise	Noise generated during installation, recovery, or other operations involving the mooring system that can disturb marine life
Proximity	Dredging operations in coastal zones can disrupt MEC moorings or umbilical systems

6.4.4 Vandalism and misuse

Vandalism is the deliberate defacement, destruction, or theft of an existing MEC mooring system or mooring components. The misuse of floating structures as temporary tie-off buoys for sport and commercial vessels is common in nearshore areas. Accessibility of mooring components and connections should be considered.

6.4.5 Marine traffic

The type and frequency of other marine traffic traversing the site should be considered. For example, local or commercial fishing vessels can accidentally entangle in the MEC mooring system that could lead to failure. In addition, any restriction within the water column to mooring line components with regards to safe keel clearance regardless of limit state shall be considered. A notice to mariners should be filed with the applicable regional authority and nautical charts updated to reflect the location of the MEC and associated moorings.

6.4.6 Shallow water conditions

Synthetic ropes may contact the seabed during operations and installation if appropriately designed. Synthetic ropes should use protective jacket designs that have been tested and verified for specific conditions of sharp rocks or other features that could potentially cause damage to the lines.

7 Design load cases

7.1 General

Each mooring design will be a function of the site specific environmental conditions and specific MEC characteristics. Determining the mooring design that satisfies the limit states may not be obvious and may require an iterative process. Static, quasi-static, and dynamic analysis procedures can apply in the process.

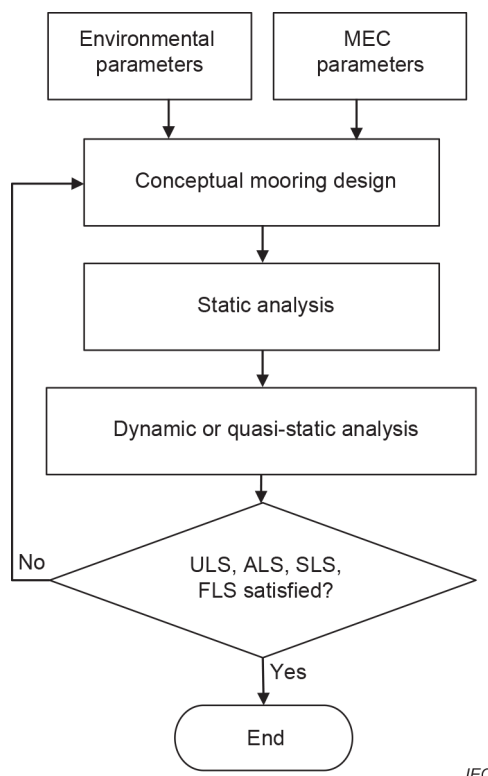
The following subclauses elaborate on specific considerations for mooring design for MECs as well as clarifying analysis procedures and load cases.

7.2 Analysis procedure overview

The various limit states, ULS, ALS, FLS, and SLS, and associated load cases define the minimum set of criteria the mooring design shall satisfy. A recommended analysis procedure is summarized by the flow chart seen in Figure 1. This is the recommended procedure but is not necessarily the procedure that shall be used for design. This procedure is based on similar processes presented in IEC TS 62600-2:2019 and ISO 19901-7:2013. This procedure can be summarized as follows:

- a) Determine site specific metocean and external conditions for the location.

- b) Establish a conceptual mooring pattern. Properties of the mooring components shall be established. Mooring pretension should be considered including impacts due to water level variations and achievable installation tolerance.
- c) Determine external loads on the mooring and MEC due to metocean and external conditions.
- d) Complete an analytical or static analysis using mean environmental loading to allow rapid initial iteration on mooring components, pretensions, and mooring envelope. Iterate and modify the mooring design as needed.
- e) Perform a dynamic analysis on the mooring system for each of the limit states considered.
- f) If the resulting design criteria for any limit state are not satisfied, iterate on the mooring design concept or restart the process with a new mooring design concept.



IEC

Figure 1 – Recommended conceptual mooring analysis procedure

7.3 Load categories

7.3.1 General

Environmental loads listed in IEC TS 62600-2:2019, 7.2, and the effects described in this clause, shall be considered, unless they can be shown to have either no significant effect or are not applicable to the deployment site, in assessing the combined MEC system and mooring response. Further discussion on these environmental load types are discussed here. A range of possible combined loads may result:

- a) Low frequency current, wind and wave drift loads.
- b) Wave frequency loading.
- c) High frequency VIV, seismic, PTO, ice and ship impact.

The combined assorted loadings, including those from winds, currents, and waves, on the MEC and mooring system are required to determine the motion response and mooring loads. The assorted loadings may be determined by relevant analytical, numerical, or experimental methods. Some loading can only be determined through the use of experimental methods or specialized software. Interaction between and directionality of wind, current, and waves shall be examined.

7.3.2 Dynamic analysis of MEC response to environmental conditions

In comparison to static and quasi-static modelling, dynamic modelling considers the acceleration and velocity of all components in the system. Inertia, damping, and stiffness of the MEC and mooring as well as PTO effects may be incorporated in the dynamic model. Dynamic modelling may be coupled or uncoupled and performed in the frequency domain or the time domain. Time domain modelling is the preferred approach. For time domain modelling, the simulation time duration and time step should be considered such that all pertinent dynamic effects are captured. Adequate time domain simulation realizations shall be generated for each sea state to ensure consistent statistics of extreme peak responses. The frequency domain analysis may not accurately capture the peak resonance response of the system due to challenges incorporating nonlinear mooring response and loading effects in this technique.

Analysis techniques that can be shown to be more conservative than accepted time domain techniques may be used to evaluate the design load cases. Alternative analysis techniques or equivalent experimental evaluation of the defined load cases may be considered if the environmental effects cannot be practically evaluated by accepted time domain techniques.

Additional information on numerical modelling of these effects for mooring system design can be seen in Annex C.

7.3.3 Low frequency loads

7.3.3.1 Mean current and wind loads on mooring components

The effect of current actions on mooring lines and umbilical cables shall be evaluated. Actions on these entities due to currents can be calculated as a drag force.

7.3.3.2 Mean current and wind loads on MECs

As a guideline, the mean wind and current loading can be estimated with a drag force approximation.

7.3.3.3 Mean wave drift loads on MECs

The mean wave drift load is a time average load that arises from the effects such as but not limited to reflection of ocean waves on the floating MEC hull.

7.3.3.4 Low frequency wind, current, and wave loads on the MEC

The wave drift force can vary at low frequencies and can have effects proportional to the difference between frequencies of waves present in the spectrum. The geometry of the MEC can interact with prevailing wind direction to produce low frequency loading. The motion of the MEC and mooring system can also interact with prevailing current direction to produce low frequency loads. If the MEC mooring system has any low natural frequency, large motions and mooring loads can result. For example, in existing floating structure systems, low frequency yaw motions can result with a single point mooring system.

7.3.4 Wave frequency loads on mooring components

Wave frequency loading on mooring components are a function of wave orbital velocities and accelerations and may cause dynamic loading on the mooring system.

7.3.5 Wave frequency loads on MEC

If the MEC geometry is large relative to the ocean wavelengths present, wave radiation and diffraction loading will have a significant influence on the MEC motion and mooring system response.

7.3.6 High frequency loading

7.3.6.1 Turbulence

Turbulence in high flow tidal zones may induce high frequency loading directly on the mooring lines or via the PTO response of the system. The implications for ultimate loads and fatigue life of the mooring lines should be assessed if there is significant turbulence in the flow at the site.

7.3.6.2 Vortex induced vibrations of mooring system and vortex induced motions of MECs

For mooring lines and umbilicals, the possibility of vortex induced vibrations (VIV) in areas with prevailing current should be considered due to potential impact on fatigue life. Fatigue life from direct VIV flexural vibration is mainly a concern at discontinuities such as connectors like sockets. Mooring lines with socket connections or other discontinuities should be assessed for fatigue life effects. Vortex induced motions (VIM) of the MEC with mooring system should be investigated.

Commercial software tools are available to evaluate VIV and VIM for certain offshore oil and gas systems but not necessarily for MEC technologies and their moorings. However, their applicability to MEC systems may be considered. Additional guidance on the effect of VIV and VIM can be found in DNVGL RP C205.

7.3.6.3 High frequency wave loads

Loading proportional to the sum of the frequencies of waves present in the spectrum can exist and should be considered in determining the response of systems with high natural frequencies.

7.3.6.4 MEC PTO response

The PTO system may have a significant influence on the dynamic response of the MEC and mooring system. The dynamic loading from the PTO on the system shall be considered.

7.4 Interaction with waves, currents, wind, water level and ice

7.4.1 General

If there is no other project site information available about the combination of the extreme environmental conditions, the return periods as stated in Table 2 can be used to derive environmental combinations for a 50 year return period.

Wind, wave, and current heading may be applied in co-linear fashion. However, depending on site-specific conditions or specific MEC characteristics, the combination of wind, wave, and current headings consistent with the metocean conditions at the site that results in the most severe response and mooring loads should be considered.

Note environmental combination ID 6 has a significantly different return period compared to the other conditions. The purpose of this combination is a robustness check to detect disproportionately large load increases. For example, in semi-submersible platforms, wave loads on the bottom surface of the deck will significantly increase loads on the system. These kinds of abrupt nonlinear increases in the nature of loads on the system can cause catastrophic failures. Environmental combination ID 6 has a significantly lower probability than 50 year return period because it is intended as an check for abnormal conditions. It is not intended to replicate the effect of extreme events such as a hurricane or tropical cyclone. A project site that may be susceptible to hurricane or tropical cyclone conditions may observe a coefficient of variation greater than 15 % in annual environmental condition maximums. Extra care should be used to ensure that the 500 year return period conditions are not unduly influenced by large variations in annual recorded maximums for a project site from extreme environmental hurricane and tropical storms.

Table 2 – Combinations of uncorrelated extreme events

Environmental combination ID	Environmental event and return period (years) to define characteristic value of corresponding load effect					
	Waves	Current	Water level	Wind	Ice	Dominating event
1	50	5	50	5	–	Ground swell
2	5	50	50	5	–	Sea currents
3	–	5	NWLR	5	50	Sea ice
4	50	5	50	50	–	Wind swell
5	-	50	50	5	-	River current
6	500	5	NWLR	500	-	Wind swell

7.4.2 Resonant response

Due to the potential complexity of MEC dynamic response, the environmental conditions that produce the most extreme response and mooring loads may not be obvious and may even be counter-intuitive.

A screening process should be performed to determine whether a particular wave period, which may be less than that associated with extreme conditions, generates the highest loads. Note that to maintain the environmental even return period, the associated wave height should be adapted for each associated wave period. This may be near MEC resonance in various degrees of freedom. Some WEC designs will resonate at specific wave periods and should be considered specifically.

7.4.3 Design return period for short term deployments

A short term deployment is significantly less than a typical MEC design service life. Short term deployments are intended to facilitate technology development and evaluation. Short term deployments may use a return period equal to 5 times the short term deployment life, with a minimum of 5 year return period and maximum of 50 year return period that corresponds to full design service life. These are intended as minimum requirements. The designer shall consider failure mode and effects when considering the environmental return period. Additional failure modes and effects analysis can be assessed using guidance from IEC 60812.

7.5 Mooring line components

7.5.1 General

Examples of mooring component types can be seen in Annex A. More detailed guidance is included for fibre ropes in Annex A.

7.5.2 Component strength

The minimum breaking load (MBL) of components can be provided by supplier technical specification sheets or from experimental measurements. Consideration should be given to flexural and chaffing effects of mooring components on MEC surfaces. As mooring line components wear, corrode, and fatigue, the MBL of the line components will decrease. Consequently, the reduction in MBL during the system's design life should be considered during the design of the mooring system otherwise planned replacement of the affected components may be required during the design life. The expected break strength of the components at the end of life should be used in the mooring analysis.

The dynamic MEC motion and consequent complex mooring interaction may require special consideration of selection of mooring components.

7.5.3 Component fatigue life

The fatigue damage accumulated in mooring components is the result of cyclic loading. Specific guidance for determining fatigue life can be found in Clause A.9 of ISO 19901-7:2013. However, an increased factor of safety fatigue life may be used to account for various factors such as inaccessibility of components for inspection, site specific environmental loading and unique PTO operational characteristics.

7.5.4 Redundancy

A redundant system is able to maintain the position of the MEC and the integrity of components, such as remaining mooring lines or umbilical cable, subject to the failure of one of its components. A loss of a component may be one mooring line.

Non-redundant mooring systems shall have special consideration to address ALS assessments. Moorings without sufficient redundancy are not always single point moorings. Non-redundant moorings shall not evaluate ALS design load cases involving a failed mooring line. However, non-redundancy shall be addressed through a safety factor larger than consequence class 2. The degree of increase of safety factor should be in accordance with a failure modes and effect analysis study. Failure modes and effects analysis can be assessed using guidance from IEC 60812.

7.5.5 Clearance

Contact between mooring lines and other mooring lines, the umbilical, the MEC and adjacent structures in all limit states shall be avoided. The required clearance can be determined on a case by case basis, but the minimum value should be considered on the basis of consequences of impact. Clearances should include consideration of the effect of marine growth accumulation. For locations sensitive to bottom disturbance by normal mooring motion and operating conditions, the mooring lines may need to be clear of contact from the seabed.

7.6 Umbilical considerations

7.6.1 Umbilical response

The umbilical is intended to carry a fluid or electrical power or both between the MEC and another location. A key output of the mooring analysis is the offset of the MEC for input to the design of the umbilical. The design of the mooring and umbilical may require an iterative approach to determine a suitable configuration for both items.

7.6.2 Umbilical strength

The umbilical strength and allowable bending radius should be provided by the manufacturer. Specific consideration shall be given to reduce stress concentration at umbilical termination or other areas of high curvature. Fatigue due to the dynamic motion responses should be carefully considered during the design of the umbilical lay-up and configuration.

7.6.3 Umbilical offset and clearance limits

The offset due to MEC movement in all limit state conditions shall be considered. The clearance between the umbilical and the mooring lines, seabed, MEC, and other potential hazards shall be considered.

The effect of the umbilical during ALS conditions shall be considered. ALS condition load cases may incur large MEC offsets, particularly for non-redundant systems, and may cause significant damage.

The installation and hook-up of umbilicals should be planned in consideration of any mooring, jack leg deployment, or live manoeuvring required by any maintenance or installation vessels.

Active control systems that can control mooring loads through PTO response or other mechanisms may be used to limit offsets of the system; however, consideration should be given to fault states of that control system that may result in larger excursions.

7.7 Limit states

7.7.1 General

The performance of a MEC with mooring system shall be described with reference to a specified set of limit states beyond which the MEC no longer satisfies design requirements. The following limit states shall be considered. Specific design load cases associated with each limit state to be considered are specified in Table 7 and Table 8.

7.7.2 Ultimate limit state (ULS)

This limit state corresponds to the intact mooring system's resistance to extreme expected actions, such as those arising from design environmental events. Consideration for the ULS shall be made to determine whether the extreme response corresponds to the MEC configured in survival or operational mode. The ULS for some MECs may occur at lower current or wave conditions than the extreme sea state or current 50-year return period level.

7.7.3 Accidental limit state (ALS)

The purpose of this limit state is to ensure the system can survive low probability events. Consideration for the ALS shall be made to determine whether the extreme response corresponds to the MEC configured in survival or operational mode.

For short term deployments of less than 1 year, the ALS may not be necessarily evaluated. The designer shall consider failure mode and effects when considering the consideration of evaluation of FLS. Additional failure modes and effects analysis can be assessed using guidance from IEC 60812.

7.7.4 Serviceability limit state (SLS)

This limit state represents mooring system installation, MEC installation and connection with mooring system, and operation and maintenance modes of the MEC. The effect on mooring components from commissioning, decommissioning, and delivery of MECs should be considered. If the duration of time the MEC is not connected is considerable, more detailed analysis of the mooring system in this configuration may be necessary.

7.7.5 Fatigue limit state (FLS)

The fatigue limit state refers to cumulative damage in the system components of the MEC due to environmental cyclical action. Consideration of the effect of the PTO on the FLS shall be made for those occurrences that are associated with the PTO being active. Consideration should be given to additional fatigue that could occur during periods of PTO fault. Guidance for various procedures to evaluate fatigue life can be found in Clause A.9 of ISO 19901-7:2013. This guidance includes information for the effect of mean tension on wire rope and chain components in calculating fatigue life. The effect of mean tension load on synthetic rope materials is significantly lower than metal components like wire and chain. The exception is some synthetic rope materials, such as aramids and LCAP, are susceptible to compression fatigue from low mean tension or slack events and shall be considered.

Fatigue life calculations should include damage expected in all conditions representative of the long term statistical occurrences of the local environment inclusive of both normal and extreme conditions expected during the duration of the deployment.

For short term deployments of less than 1 year, the FLS may not be necessarily evaluated. The designer shall consider failure mode and effects when considering the consideration of