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Edition 2.0 2021-07

TECHNICAL SPECIFICATION

colour inside

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

IEC TS 62600-10:2021-07(en)

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FOREWORD

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.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under "http://webstore.iec.ch" in the data related to the specific document. At this date, the document will be

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- withdrawn,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

IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

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.