



# TECHNICAL SPECIFICATION



---

## Marine energy – Wave, tidal and other water current converters – Part 2: Marine energy systems – Design requirements

INTERNATIONAL  
ELECTROTECHNICAL  
COMMISSION

---

ICS 27.140

ISBN 978-2-8322-7420-0

**Warning! Make sure that you obtained this publication from an authorized distributor.**

## CONTENTS

FOREWORD.....	7
INTRODUCTION.....	9
1 Scope.....	10
2 Normative references .....	11
3 Terms and definitions .....	13
4 Symbols and abbreviated terms.....	13
5 Principal elements .....	14
5.1 General.....	14
5.2 Design objectives.....	15
5.3 Technology assessment.....	15
5.4 Risk assessment.....	16
5.5 Safety levels .....	17
5.6 Basis of design .....	18
5.7 Environmental conditions .....	18
5.8 Life cycle considerations.....	18
5.9 Load definition and load combinations .....	18
5.10 Limit state design.....	19
5.11 Partial safety factors .....	19
5.12 Structural modelling and analysis.....	20
6 Environmental conditions.....	20
6.1 General.....	20
6.2 Primary environmental conditions .....	20
6.2.1 General .....	20
6.2.2 Waves .....	20
6.2.3 Sea currents .....	22
6.2.4 Water level .....	24
6.3 Secondary environmental conditions .....	25
6.3.1 General .....	25
6.3.2 Breaking waves .....	25
6.3.3 Breaking wave-induced surf currents .....	26
6.3.4 Wind conditions .....	26
6.3.5 Sea and river ice .....	26
6.3.6 Earthquakes and tsunamis.....	26
6.3.7 Marine growth.....	27
6.3.8 Seabed movement and scour.....	27
6.3.9 Other environmental conditions .....	27
7 Design load cases .....	27
7.1 General.....	27
7.2 Load categories .....	28
7.3 Design situations and load cases .....	29
7.3.1 General .....	29
7.3.2 Interaction with waves, currents, wind, water level and ice .....	30
7.3.3 Design categories and conditions .....	30
7.3.4 Limit states .....	31
7.3.5 Partial safety factors .....	32

7.3.6	Load case modelling and simulation .....	33
7.3.7	Design conditions .....	34
8	Materials .....	43
8.1	General.....	43
8.2	Material selection criteria .....	44
8.3	Environmental considerations .....	44
8.4	Structural materials.....	45
8.4.1	General .....	45
8.4.2	Metals .....	45
8.4.3	Concrete.....	46
8.4.4	Composites .....	46
8.5	Compatibility of materials.....	48
9	Structural integrity .....	48
9.1	General.....	48
9.2	Material models .....	48
9.3	Partial safety factors for materials.....	49
9.4	Design of steel structures .....	49
9.4.1	General .....	49
9.4.2	Steel partial safety factors .....	49
9.5	Design of concrete structures.....	50
9.5.1	General .....	50
9.5.2	Concrete material partial safety factors.....	50
9.5.3	Reinforcing steel.....	51
9.6	Design of composite structures .....	51
9.6.1	General .....	51
9.6.2	Composite material partial safety factors .....	51
9.6.3	Joints and interfaces.....	53
10	Electrical, mechanical, instrumentation and control systems .....	54
10.1	Overview.....	54
10.2	General requirements .....	54
10.3	Electrical.....	54
10.3.1	General .....	54
10.3.2	Electrical system design .....	55
10.3.3	Protective devices .....	55
10.3.4	Disconnect devices.....	55
10.3.5	Earth system .....	56
10.3.6	Lightning protection .....	56
10.3.7	Electrical cables .....	56
10.4	Mechanical .....	57
10.4.1	General .....	57
10.4.2	Bearings .....	57
10.4.3	Gearing .....	57
10.5	Piping systems.....	57
10.5.1	General .....	57
10.5.2	Bilge systems .....	57
10.5.3	Ballast systems .....	58
10.5.4	Hydraulic or pneumatic systems .....	58
10.6	Instrumentation and control system.....	58
10.6.1	General .....	58

10.6.2	Locking devices .....	58
10.6.3	Protection against unsafe operating conditions .....	58
10.7	Abnormal operating conditions safeguard .....	59
11	Mooring and foundation considerations .....	59
11.1	General .....	59
11.2	Unique challenges for wave energy converters .....	59
11.3	Unique challenges for tidal energy converters .....	59
11.4	Fixed structures .....	60
11.5	Compound MEC structures .....	60
12	Life cycle considerations .....	60
12.1	General .....	60
12.2	Planning .....	61
12.3	Stability and watertight integrity .....	61
12.3.1	General .....	61
12.3.2	Stability calculations .....	61
12.3.3	Watertight integrity and temporary closures .....	61
12.4	Assembly .....	61
12.4.1	General .....	61
12.4.2	Fasteners and attachments .....	61
12.4.3	Cranes, hoists and lifting equipment .....	62
12.5	Transportation .....	62
12.6	Commissioning .....	62
12.7	Metocean limits .....	63
12.8	Inspection .....	64
12.8.1	General .....	64
12.8.2	Coating inspection .....	64
12.8.3	Underwater inspection .....	64
12.9	Maintenance .....	64
12.9.1	General .....	64
12.9.2	Maintenance planning .....	64
12.9.3	Maintenance execution .....	65
12.10	Decommissioning .....	65
Annex A (normative)	Corrosion protection .....	66
A.1	General .....	66
A.2	Steel structures .....	66
A.2.1	General .....	66
A.2.2	Corrosion rates .....	67
A.2.3	Protective coatings .....	67
A.3	Cathodic protection .....	67
A.3.1	General .....	67
A.3.2	Closed compartments .....	68
A.3.3	Stainless steel .....	68
A.4	Concrete structures .....	68
A.4.1	General .....	68
A.4.2	Provision of adequate cover .....	69
A.4.3	Use of stainless steel or composite reinforcement .....	69
A.4.4	Cathodic protection of reinforcement .....	69
A.5	Non-ferrous metals .....	69
A.6	Composite structures .....	70

A.7	Compatibility of materials .....	70
Annex B	(normative) Operational and structural resonance .....	71
B.1	General.....	71
B.2	Control systems .....	71
B.3	Exciting frequencies.....	71
B.4	Natural frequencies.....	71
B.5	Analysis .....	72
B.6	Balancing of the rotating components .....	72
Annex C	(informative) Wave spectrum .....	73
C.1	Overview.....	73
C.2	The Pierson-Moskowitz spectrum.....	73
C.3	Relationship between peak and zero crossing periods .....	76
C.4	Wave directional spreading .....	76
Annex D	(informative) Shallow water hydrodynamics and breaking waves .....	78
D.1	Selection of suitable wave theories .....	78
D.2	Modelling of irregular wave trains.....	79
D.3	Breaking waves .....	79
Bibliography	.....	82
Figure 1	– Marine energy converter system boundary for IEC TS 62600-2 and interfaces.....	10
Figure 2	– Design process for a MEC.....	15
Figure 3	– Definition of water levels .....	25
Figure 4	– Process for determining design loads via load cases.....	28
Figure A.1	– Profile of the thickness loss resulting from corrosion of an unprotected steel structure in seawater (1 mil = 0,025 4 mm).....	66
Figure C.1	– PM spectrum .....	74
Figure C.2	– JONSWAP and PM spectrums for typical North Sea storm sea state .....	75
Figure D.1	– Regions of applicability of stream functions, Stokes V, and linear wave theory .....	78
Figure D.2	– Breaking wave height dependent on still water depth.....	80
Figure D.3	– Transitions between different types of breaking waves as a function of seabed slope, wave height in deep waters and wave period.....	81
Table 1	– Technology classes.....	16
Table 2	– Safety levels .....	17
Table 3	– Types of loads that shall be considered.....	29
Table 4	– ULS combinations of uncorrelated extreme events .....	30
Table 5	– Design categories and conditions .....	31
Table 6	– ULS partial load safety factors $\gamma_f$ for design categories.....	33
Table 7	– Design load cases for WECs .....	35
Table 8	– Design load cases for TECs .....	37
Table 9	– ISO test standards for composite laminates.....	47
Table 10	– Material partial safety factors $\gamma_m$ for buckling.....	50
Table 11	– Values for test value uncertainty, $\gamma_{m1}$ .....	51

Table 12 – Values for manufacturing variation  $\gamma_{m2}$  ..... 52

Table 13 – Values for environmental factors,  $\gamma_{m3}$  ..... 52

Table 14 – Values for fatigue,  $\gamma_{m4}$  ..... 53

Table 15 – Values for adhesive joints,  $\gamma_{mj}$  ..... 54

## INTERNATIONAL ELECTROTECHNICAL COMMISSION

---

**MARINE ENERGY –  
WAVE, TIDAL AND OTHER WATER CURRENT CONVERTERS –****Part 2: Marine energy systems – Design requirements**

## FOREWORD

- 1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as “IEC Publication(s)”). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
- 2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
- 3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
- 4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
- 5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
- 6) All users should ensure that they have the latest edition of this publication.
- 7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
- 8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
- 9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

The main task of IEC technical committees is to prepare International Standards. In exceptional circumstances, a technical committee may propose the publication of a Technical Specification when

- the required support cannot be obtained for the publication of an International Standard, despite repeated efforts, or
- the subject is still under technical development or where, for any other reason, there is the future but no immediate possibility of an agreement on an International Standard.

Technical Specifications are subject to review within three years of publication to decide whether they can be transformed into International Standards.

IEC TS 62600-2, which is a Technical Specification, has been prepared by IEC technical committee 114: Marine energy – Wave, tidal and other water current converters.

This second edition cancels and replaces the first edition published in 2016. This edition constitutes a technical revision.

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

- a) The first edition published in 2016 was based on design methodologies developed by TC88. The second edition sets forth design conditions unique to marine energy converters.

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

Enquiry draft	Report on voting
114/306/DTS	114/322/RVDTS

Full information on the voting for the approval of this Technical Specification can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

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

- transformed into an International Standard,
- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

A bilingual version of this publication may be issued at a later date.

**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 part of IEC 62600 outlines minimum design requirements for marine energy converters (MECs) and is not intended for use as a complete design specification.

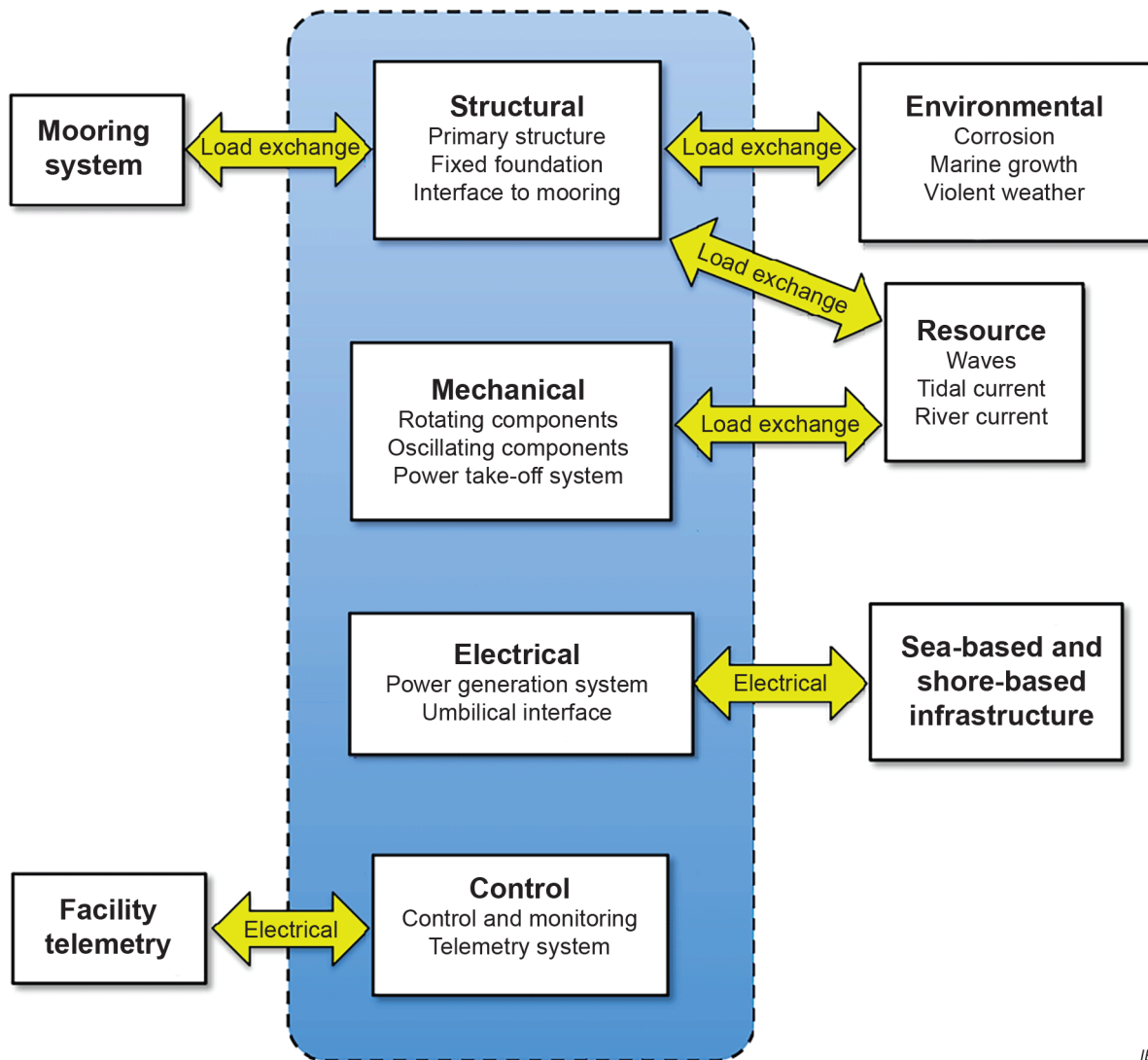
Any of the requirements of this document may be altered if it can be demonstrated that the overall safety of the marine energy converter is not compromised. Compliance with this document shall be done in observance of applicable regional regulations.

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

## Part 2: Marine energy systems – Design requirements

### 1 Scope

This document provides design requirements to ensure the engineering integrity of wave, ocean, tidal and river current energy converters, collectively referred to as marine energy converters. Its purpose is to provide an appropriate level of protection against damage from all hazards that may lead to catastrophic failure of the MEC structural, mechanical, electrical or control systems. Figure 1 illustrates the scope of this document and critical interfaces with other elements of a marine energy converter installation.



IEC

**Figure 1 – Marine energy converter system boundary for IEC TS 62600-2 and interfaces**

This document provides requirements for MEC main structure, appendages, seabed interface, mechanical systems and electrical systems as they pertain to the viability of the device under site-specific environmental conditions. This document applies to MECs that are either floating or fixed to the seafloor or shore and are unmanned during operational periods.

NOTE Refer to IEC 62600-10 for guidance on the design of moorings for floating MECs.

In addition to environmental conditions, this document addresses design conditions (normal operation, operation with fault, parked, etc.); design categories (normal, extreme, abnormal and transport); and limit states (serviceability, ultimate, fatigue and accidental) using a limit state design methodology.

Several different parties may be responsible for undertaking the various elements of the design, manufacture, assembly, installation, erection, commissioning, operation, maintenance and decommissioning of a marine energy converter and for ensuring that the requirements of this document are met. The division of responsibility between these parties is outside the scope of this document.

This document is used in conjunction with IEC and ISO standards cited as normative references, as well as regional regulations that have jurisdiction over the installation site.

This document is applicable to MEC systems designed to operate from ocean, tidal and river current energy sources, but not systems associated with hydroelectric impoundments or barrages. This document is also applicable to wave energy converters. It is not applicable to ocean thermal energy conversion (OTEC) systems or salinity gradient systems.

Although important to the overall objectives of the IEC 62600 series, this document does not address all aspects of the engineering process that are taken into account during the full system design of MECs. Specifically, this document does not address energy production, performance efficiency, environmental impacts, electric generation and transmission, ergonomics, or power quality.

This document takes precedence over existing applicable standards referred to for additional guidance. This document adheres to a limit state design approach utilizing partial safety factors for loads and materials to ensure MEC reliability in accordance with ISO 2394.

MECs designed to convert hydrokinetic energy from hydrodynamic forces into forms of usable energy, such as electrical, hydraulic, or pneumatic may be different from other types of marine systems. Many MECs are designed to operate in resonance or conditions close to resonance. Furthermore, MECs are hybrids between machines and marine structures. The control forces imposed by the power take-off (PTO) and possible forces from faults in the operation of the PTO distinguish MECs from other marine structures.

The document is applicable to MECs at the preliminary design stage to those that have progressed to advanced prototypes and commercial deployment. It is anticipated that this document will be used in certification schemes for design conformity.

## **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 60092-301, *Electrical installations in ships – Part 301: Equipment – Generators and motors*

IEC 60092-350, *Electrical installations in ships – Part 350: General construction and test methods of power, control and instrumentation cables for shipboard and offshore applications*

IEC 60204-1:2016, *Safety of machinery – Electrical equipment of machines – Part 1: General requirements*

IEC 60204-11:2018, *Safety of machinery – Electrical equipment of machines – Part 11: Requirements for equipment for voltages above 1 000 V AC or 1 500 V DC and not exceeding 36 kV*

IEC 60228, *Conductors of insulated cables*

IEC 60364-5-54, *Low-voltage electrical installations – Part 5-54: Selection and erection of electrical equipment – Earthing arrangements and protective conductors*

IEC 60812, *Failure modes and effects analysis (FMEA and FMECA)*

IEC 61508 (all parts), *Functional safety of electrical/electronic/programmable electronic safety-related systems*

IEC 61643-11, *Low-voltage surge protective devices – Part 11: Surge protective devices connected to low-voltage power systems – Requirements and test methods*

IEC 61882, *Hazard and operability studies (HAZOP studies) – Application guide*

IEC 62305-3, *Protection against lightning – Part 3: Physical damage to structures and life hazard*

IEC 62305-4, *Protection against lightning – Part 4: Electrical and electronic systems within structures*

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

IEC TS 62600-201, *Marine energy – Wave, tidal and other water current converters – Part 201: Tidal energy resource assessment and characterization*

IEC TS 62600-10, *Marine energy – Wave, tidal and other water current converters – Part 10: Assessment of mooring system for marine energy converters (MECs)*

ISO 2394, *General principles on reliability for structures*

ISO 12473, *General principles of cathodic protection in sea water*

ISO 17776, *Petroleum and natural gas industries – Offshore production installations – Major accident hazard management during the design of new installations*

ISO 19900, *Petroleum and natural gas industries – General requirements for offshore structures*

ISO 19901-1: 2015, *Petroleum and natural gas industries – Specific requirements for offshore structures – Part 1: Metocean design and operating considerations*

ISO 19901-4, *Petroleum and natural gas industries – Specific requirements for offshore structures – Part 4: Geotechnical and foundation design considerations*

ISO 19901-6, *Petroleum and natural gas industries – Specific requirements for offshore structures – Part 6: Marine operations*

ISO 19902, *Petroleum and natural gas industries – Fixed steel offshore structures*

ISO 19903, *Petroleum and natural gas industries – Fixed concrete offshore structures*

ISO 31010, *Risk management – Risk assessment techniques*

DNVGL-OS-C301, *Stability and watertight integrity*

DNVGL-RP-C205, *Environmental conditions and environmental loads*

EUROCOMP, *Structural design of polymer composites*