

TECHNICAL SPECIFICATION



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

This is a preview. [Click here to purchase the full publication.](#)



THIS PUBLICATION IS COPYRIGHT PROTECTED

Copyright © 2016 IEC, Geneva, Switzerland

All rights reserved. Unless otherwise specified, no part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from either IEC or IEC's member National Committee in the country of the requester. If you have any questions about IEC copyright or have an enquiry about obtaining additional rights to this publication, please contact the address below or your local IEC member National Committee for further information.

IEC Central Office
3, rue de Varembe
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
Fax: +41 22 919 03 00
info@iec.ch
www.iec.ch

About the IEC

The International Electrotechnical Commission (IEC) is the leading global organization that prepares and publishes International Standards for all electrical, electronic and related technologies.

About IEC publications

The technical content of IEC publications is kept under constant review by the IEC. Please make sure that you have the latest edition, a corrigenda or an amendment might have been published.

IEC Catalogue - webstore.iec.ch/catalogue

The stand-alone application for consulting the entire bibliographical information on IEC International Standards, Technical Specifications, Technical Reports and other documents. Available for PC, Mac OS, Android Tablets and iPad.

IEC publications search - www.iec.ch/searchpub

The advanced search enables to find IEC publications by a variety of criteria (reference number, text, technical committee,...). It also gives information on projects, replaced and withdrawn publications.

IEC Just Published - webstore.iec.ch/justpublished

Stay up to date on all new IEC publications. Just Published details all new publications released. Available online and also once a month by email.

Electropedia - www.electropedia.org

The world's leading online dictionary of electronic and electrical terms containing 20 000 terms and definitions in English and French, with equivalent terms in 15 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.

IEC Glossary - std.iec.ch/glossary

65 000 electrotechnical terminology entries in English and French extracted from the Terms and Definitions clause of IEC publications issued since 2002. Some entries have been collected from earlier publications of IEC TC 37, 77, 86 and CISPR.

IEC Customer Service Centre - webstore.iec.ch/csc

If you wish to give us your feedback on this publication or need further assistance, please contact the Customer Service Centre: csc@iec.ch.

TECHNICAL SPECIFICATION



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

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 27.140

ISBN 978-2-8322-3580-5

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

CONTENTS

FOREWORD.....	8
INTRODUCTION.....	10
1 Scope.....	11
1.1 General.....	11
1.2 Applications	11
2 Normative references.....	12
3 Terms and definitions	13
4 Symbols and abbreviated terms	13
5 General considerations	15
5.1 General.....	15
5.2 Regulations.....	15
5.3 Suitability and/or relevance of standards.....	15
5.4 Quality assurance and quality control	15
5.5 Safety levels	16
5.6 Design principles – structure and foundations	17
5.7 Load definition and load combinations	17
5.8 Other considerations	18
5.8.1 Stability and watertight integrity.....	18
5.8.2 Electrical, mechanical, instrumentation and control systems.....	18
5.8.3 Reliability issues	18
5.8.4 Corrosion protection.....	18
5.8.5 Design for operation, inspection, maintenance and decommissioning	18
5.9 Operational and structural resonance	18
5.10 Basis of design	19
6 External conditions	19
6.1 General.....	19
6.2 Waves	19
6.2.1 Normal sea state (NSS).....	19
6.2.2 Normal wave height (NWH)	19
6.2.3 Extreme sea state (ESS)	20
6.2.4 Extreme wave height (EWH).....	20
6.2.5 Breaking waves.....	21
6.2.6 Wave run-up	21
6.3 Sea currents	21
6.3.1 General	21
6.3.2 Sub-surface currents.....	21
6.3.3 Wind-generated near-surface currents.....	22
6.3.4 Tidal currents.....	22
6.3.5 Breaking wave-induced surf currents	22
6.3.6 Normal current model (NCM).....	23
6.3.7 Extreme current model (ECM)	23
6.3.8 Normal turbulence model (NTM).....	23
6.3.9 Extreme turbulence model (ETM)	23
6.4 Wind conditions.....	24
6.5 Water level.....	24
6.5.1 General	24

6.5.2	Normal water level range (NWLR)	25
6.5.3	Extreme water level range (EWLR)	25
6.6	Sea and river ice	25
6.7	Earthquakes	26
6.8	Marine growth	26
6.9	Seabed movement and scour	26
6.10	Ship collisions	26
6.11	Other environmental conditions	26
7	Loads and load effects	26
7.1	General	26
7.2	Loads	26
7.3	Design situations and load cases	28
7.3.1	General	28
7.3.2	Interaction with waves, currents, wind, water level and ice	28
7.3.3	Design categories	29
7.3.4	Limit states	29
7.3.5	Partial safety factors	30
7.3.6	Simulation requirements	31
7.3.7	Design conditions	32
8	Materials	40
8.1	General	40
8.2	Material selection criteria	41
8.3	Environmental considerations	42
8.4	Structural materials	42
8.4.1	General	42
8.4.2	Metals	42
8.4.3	Concrete	43
8.4.4	Composites	43
8.5	Compatibility of materials	45
9	Design of primary structures for wave and tidal/current energy converters	45
9.1	General	45
9.2	Design of steel structures	45
9.2.1	General	45
9.2.2	Load and resistance factor design (LRFD)	46
9.2.3	Ultimate limit state	46
9.2.4	Fatigue limit state	47
9.2.5	Serviceability limit state	47
9.3	Design of concrete structures	47
9.3.1	General	47
9.3.2	Limit states	47
9.3.3	Bending moment and axial force	48
9.3.4	Slender structural members	48
9.3.5	Transverse shear	48
9.3.6	Torsional moments	48
9.3.7	Bond strength and anchorage failure	48
9.3.8	Fatigue limit state	48
9.3.9	Serviceability limit state	49
9.3.10	Stresses in pre-stressed reinforcement	49
9.3.11	Stresses in concrete	49

9.3.12	Detailing of reinforcement	49
9.3.13	Corrosion control	49
9.4	Design of grouted connections	49
9.4.1	General	49
9.4.2	Design principles	49
9.5	Design of composite structures.....	49
9.5.1	General	49
9.5.2	Design principles	50
9.5.3	Joints and interfaces	52
10	Electrical, mechanical, instrumentation and control systems	52
10.1	Overview.....	52
10.2	General requirements.....	52
10.3	Abnormal operating conditions safeguard	53
11	Mooring and foundation considerations	54
11.1	Overview.....	54
11.1.1	General	54
11.1.2	Unique challenges for wave energy converters	54
11.1.3	Unique challenges for tidal energy converters.....	54
11.2	Tethered floating structures.....	54
11.3	Fixed structures	55
11.4	Compound MEC structures.....	55
12	Inspection requirements.....	57
12.1	General.....	57
12.2	Consideration during the design stage	57
12.3	Inspection and maintenance planning	58
12.4	Data management.....	58
12.5	Condition assessment and integrity evaluation (against performance requirements).....	59
12.6	Maintenance execution.....	59
13	Life cycle considerations.....	60
13.1	General.....	60
13.2	Planning	62
13.2.1	General	62
13.2.2	Installation conditions.....	62
13.2.3	Site access	62
13.2.4	Environmental conditions	62
13.3	Documentation.....	63
13.4	Receiving, handling and storage.....	63
13.5	Assembly of and installation of MECs	63
13.5.1	General	63
13.5.2	Access.....	64
13.6	Fasteners and attachments	64
13.7	Cranes, hoists and lifting equipment.....	64
13.8	Decommissioning.....	64
Annex A	(normative) Load definition and load combinations.....	66
A.1	Load combinations	66
A.2	Load calculations	67
A.3	Floating and moored devices	69

A.4	Flow analysis methodology.....	69
Annex B	(normative) Reliability issues.....	71
B.1	General.....	71
B.2	Structure and foundation	71
B.3	Mechanical system.....	71
B.4	Electrical system.....	72
B.5	Control and protection system	72
B.6	Instrumentation	72
B.7	Testing during qualification.....	72
Annex C	(normative) Corrosion protection	73
C.1	General.....	73
C.2	Steel structures.....	73
C.2.1	General	73
C.2.2	Corrosion rates	74
C.2.3	Protective coatings.....	74
C.3	Cathodic protection	74
C.3.1	General	74
C.3.2	Closed compartments.....	75
C.3.3	Stainless steel	75
C.4	Concrete structures.....	75
C.4.1	General	75
C.4.2	Provision of adequate cover	75
C.4.3	Use of stainless steel or composite reinforcement.....	76
C.4.4	Cathodic protection of reinforcement	76
C.5	Non-ferrous metals.....	76
C.6	Composite structures	77
C.7	Compatibility of materials	77
C.8	Chains, steel wire and fibre rope	77
Annex D	(normative) Operational and structural resonance.....	78
D.1	General.....	78
D.2	Control systems	78
D.3	Exciting frequencies	78
D.4	Natural frequencies	78
D.5	Analysis	79
D.6	Balancing of the rotating components	79
Annex E	(informative) Requirements for a basis of design.....	80
E.1	General.....	80
E.2	Design life.....	82
E.3	Design standards	82
E.4	Regional regulations	82
E.5	Environmental conditions	82
E.5.1	General	82
E.5.2	Meteorology and climatology	82
E.5.3	Air/water conditions.....	82
E.5.4	Water level	83
E.5.5	Currents	83
E.5.6	Waves	83

E.5.7	Marine life.....	83
E.6	Seabed conditions.....	83
E.6.1	General	83
E.6.2	Bathymetry and coastal topography	83
E.7	Material standards and testing	84
Annex F (informative)	Wave spectrum	85
F.1	Overview.....	85
F.2	The Pierson-Moskowitz spectrum	85
F.3	Relationship between peak and zero crossing periods.....	88
F.4	Wave directional spreading	88
Annex G (informative)	Shallow water hydrodynamics and breaking waves.....	89
G.1	Selection of suitable wave theories.....	89
G.2	Modelling of irregular wave trains	90
G.3	Breaking waves.....	90
Annex H (informative)	Guidance on calculation of hydrodynamic loads.....	93
H.1	General.....	93
H.2	Large bodies	94
H.3	Hybrid structures.....	94
H.4	Short term statistics	95
H.5	Breaking wave loads	95
H.6	Dynamic loads due to turbulent flow	96
Bibliography	97
Figure 1	– Definition of water levels (see IEC 61400-3).....	24
Figure 2	– Examples of compound position mooring systems for wave (a, b) and tidal (c, d) energy conversion systems	56
Figure C.1	– Profile of the thickness loss resulting from corrosion of an unprotected steel structure in seawater (1 mil = 0,025 4 mm).....	73
Figure E.1	– Quality assurance system.....	81
Figure F.1	– PM spectrum.....	86
Figure F.2	– JONSWAP and PM spectrums for typical North Sea storm sea state.....	87
Figure G.1	– Regions of applicability of stream functions, stokes V, and linear wave theory.....	89
Figure G.2	– Breaking wave height dependent on still water depth	91
Figure G.3	– Transitions between different types of breaking waves as a function of seabed slope, wave height in deep waters and wave period.....	92
Figure H.1	– Relative importance of mass, viscous drag and diffraction forces on marine structures.....	93
Table 1	– Safety levels.....	16
Table 2	– Types of loads that shall be considered.....	27
Table 3	– ULS combinations of uncorrelated extreme events	29
Table 4	– Design categories.....	29
Table 5	– ULS partial load safety factors γ_f for design categories	31
Table 6	– Design load cases for WEC	33
Table 7	– Design load cases for TEC	35
Table 8	– ISO test standards.....	44

Table 9 – Material factors γ_M for buckling	46
Table 10 – Summary of model factors	52

INTERNATIONAL ELECTROTECHNICAL COMMISSION

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

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.

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

Enquiry draft	Report on voting
114/168/DTS	114/176A/RVC

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.