IEC TS 62600-102

Edition 1.0 2016-08

TECHNICAL SPECIFICATION

colour inside

Marine energy – Wave, tidal and other water current converters – Part 102: Wave energy converter power performance assessment at a second location using measured assessment data

IEC TS 62600-102:2016-08(en)

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

ICS 27.140

ISBN 978-2-8322-3530-0

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

IEC TS 62600-102, 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
114/179/DTS	114/187A/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- withdrawn,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.

INTRODUCTION

This technical specification, IEC TS 62600-102, provides a uniform methodology for estimating and reporting the performance of a Wave Energy Converter (WEC) at a prospective new deployment location. The performance estimation methodology is based primarily on observations and measurement results gathered during field deployment of the WEC at a primary location (as per IEC TS 62600-100) with different metocean conditions compared to the prospective new location. Further, it is possible that the WEC design will incorporate changes to accommodate the new site conditions. To assess the performance, inclusion of additional information based on validated numerical and physical models is specified. In this technical specification the completed field deployment location is referred to as “Location 1” and the prospective deployment location is referred to as “Location 2.”

The specification provides a methodology for arriving at the mean annual energy production (MAEP) for the WEC at Location 2. Other Technical Specifications in this series (IEC TS 62600) are drawn upon to provide the wave resource and WEC performance information needed to enable this analysis. The methodology involves:

- assessment of the wave resource at Location 1 and Location 2,
- characterization of the WEC performance at Location 1,
- assessment and compensation for the impact of discrepancies in the metocean conditions between Location 1 and Location 2 on the WEC performance characterization,
- assessment of the impact of changes to the WEC configuration between Location 1 and Location 2 on the WEC performance characterization,
- complementing the performance observations from Location 1 with fit, experimental or numerically modelled data,
- estimating the MAEP based on the composite performance characterization of the WEC.

This technical specification provides:

a) guidance on the use of observations from Location 1,
b) methods for assessing and reporting the validity of numerical and physical models,
c) limits on the permissible changes to the WEC between Locations 1 and 2,
d) limits on the use of data fitting techniques, and
e) requirements for reporting.

The wave power industry is at an early stage of development. There is little practical experience with field-scale WECs deployment. Because of this, the present document is designated as a technical specification and will be subject to change as more data is collected and experience with wave energy converters develops. This Technical Specification, when used in conjunction with other Technical Specifications in this series (IEC TS 62600), is intended for several types of users, including, but not limited to, the following:

- Project developers – income, return on investment
- Device developers – performance of device
- Utilities/investors – reliability/predictability of supply, return on investment
- Policy-makers/Planners – usage of seascape, optimisation of resource, power supply issues
- Consultants to produce resource data/due diligence – compatible/readable data format

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1 Scope

Wave Energy Converters (WEC) need to be designed to operate efficiently at different locations. Systematic methods should be used to evaluate the power performance of a WEC at a second location (hereinafter Location 2) based on power performance assessment at a first location (hereinafter Location 1). The degree of similarity of the measured WEC (WEC 1) and the metocean conditions at Location 1 to the secondary WEC (WEC 2) at Location 2 determine the methodology and the applicability of this technical specification.

This part of IEC 62600, which is a Technical Specification, describes the required methods and the required conditions to determine the power performance of the WEC 2 in Location 2, possibly at a different scale and with configuration changes to accommodate the new site conditions, in all cases based on measured power performance of WEC 1 in Location 1. This technical specification allows for assessment at Location 1 or Location 2 based on limited/incomplete data material, as long as this is accompanied by a validated numerical model or physical model and assessment of the uncertainty involved. Another key element is transparency in the assessment.

This technical specification includes:

a) Specification of data requirements needed from the original measurements at Location 1 including an assessment of the uncertainty involved (if based on limited/incomplete data material) in addition to those specified in IEC TS 62600-100 and IEC TS 62600-101.
b) Limitation on the changes that are allowed to the WEC and the specification of the location.
c) Wave data required at Location 2, as a minimum the requirements found in IEC TS 62600-101.
d) Development of the power matrix at Location 2.
e) Validation of the power matrix at Location 2.
f) Assessment of uncertainties in the derived performance parameters at Location 2.
g) Requirements for the allowable power performance transfer by geometric, kinematic and dynamic similarity.
h) Requirements for the allowable incorporation of additional empirical model data.
i) Requirements for the allowable incorporation of additional numerical model data.

The technical specification does not cover the following items:

j) The original data measurement at Location 1 (see IEC TS 62600-100).
k) Environmental concerns.
l) Operation and maintenance.

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

IEC TS 62600-100, *Marine energy – Wave, tidal and other water current converters – Part 100: Electricity producing wave energy converters – Power performance assessment*

IEC TS 62600-101:2015, *Marine energy – Wave, tidal and other water current converters – Part 101: Wave energy resource assessment and characterization*

International Towing Tank Conference (ITTC), *Recommended Guidelines 7.5-02-07-03.7, Wave Energy Converter Model Test Experiments*

3 Symbols and units

For the purposes of this technical specification, the symbols and units listed in Table 1 apply. The terms and definitions are in accordance with IEC TS 62600-1.

Table 1 – Symbols and units

Symbol	Definition	Units
C_g	Group velocity	m/s
θ_{Jmax}	Direction of maximum directionally resolved wave power	deg
f	Frequency	Hz
f_i	Frequency at component i	Hz
h	Water depth	m
H_{m0}	Spectral estimate of significant wave height	m
H_s	Significant wave height	m
J	Omnidirectional measured wave power	W/m
J_i	Omnidirectional measured wave power per bin	W/m
$\overline{J}$	Average wave power	W/m
$\wedge J$	Minimum wave power	W/m
$\vee J$	Maximum wave power	W/m
L	Capture length	m
L_i	Capture length per bin	m
$\overline{L}$	Average capture length	m
$\wedge L$	Minimum capture length	m
$\vee L$	Maximum capture length	m
$MAEP$	Mean Annual Energy Production	W·h
n	Number of records	-
N	Number of bins	-
P	Measured power output	W
P_i	Measured power output per bin	W
P_h	Hydraulic power input	W

Symbol	Definition	Units
S	Spectral density	$\frac{m^2}{Hz}$
$S(f)$	Spectral density as function of frequency	$\frac{m^2}{Hz}$
$S(f, \theta)$	Directional spectrum as a function of frequency and direction $S(f) \cdot G(\theta, f)$	$\frac{m^2}{Hz \cdot rad}$
S_i	Spectral density at frequency component i	$\frac{m^2}{Hz}$
T_e	Energy period	s
f_i	Frequency spacing	Hz
θ	Wave direction	Deg
P_{abs}	Absorbed power	W
P_e	Electrical power output	W
P_{pto}	Power loss (dissipated) in the PTO	W
η_{pto}	Power take off efficiency	-
ρ	Density	kg/m^3
σ	Standard deviation	-

4 Sequence of work

The sequence of the work is outlined below:

a) Describe the WEC technology.

b) Assess and characterize wave resource at Location 1 and Location 2 using IEC TS 62600-101.

c) Calculate the capture length matrix from WEC power capture data at Location 1 using IEC TS 62600-100.

d) Evaluate the appropriate dimensionality of the capture length matrix from Location 1 for Location 2 and complement the capture length matrix from Location 1 to cover the range of metocean conditions at Location 2 using numerical or experimental data.

e) Validate the model against measured data from Location 1.

f) Specify changes to the WEC to accommodate the new metocean conditions.

g) Evaluate the impact of changes to the capture length of each bin using validated numerical model data incorporating the parameters in question. If the capture length in a bin is changed by more than 10 % it shall be filled using physical or numerical modelled data.

h) Perform quality assurance on capture length matrix for application at Location 2.

i) Calculate MAEP at Location 2 using the complemented capture length matrix and Location 2 resource data.

j) Report separately the MAEP at Location 2 contributed by the cells of the power matrix that are based on either:

   1) measured data at Location 1, or

   2) interpolation or extrapolation from measured data, or

   3) modelled data.

k) Estimate the uncertainty related to the MAEP calculated at Location 2.

Annex A provides a detailed illustration of the concepts and calculations in each step in the sequence of work.

5 Limitations of this technical specification

This specification allows for changes to the WEC when moved from Location 1 to Location 2 in order to accommodate the new metocean conditions. Changes to the WEC should be clearly specified and may include: dimensions, geometry, power take off system, control logic and moorings system. Allowable changes and procedures are specified in Clause 10.

6 Description of wave energy conversion (WEC) technology

The wave energy converter WEC 1 deployed at Location 1 and the WEC 2 to be deployed at Location 2 shall both be described in terms of:

- Operational principle.
- Geometry and dimensions.
- Mass properties.
- PTO system.
- Mooring arrangement.

7 Assess and characterize wave resource related to Location 1 and Location 2

7.1 General

Similar to 6.1 of IEC TS 62600-101:2015, a site description shall be prepared for each of the WEC locations under consideration.

7.2 Ambient condition

For each location this description should include a map or chart, geographic coordinates, the water depth as well as general description of the following:

- The shoreline geography and bathymetry.
- The prevailing wave and wind conditions.
- Typical tidal range and currents.

7.3 Wave resource at Location 1 and Location 2

A description of the wave resource at Location 1 and Location 2 shall be provided and include:

- Directional rose plots.
- Scatter tables and plots.
- Exceedance and persistence.
- Joint probability analysis.

8 WEC power capture data at Location 1

An analysis of the WEC electrical power performance at Location 1 should be undertaken using the methodologies stated in IEC TS 62600-100. The measured WEC power production records along with the concurrent wave measurements should be used to calculate and report the following: