# IEC TS 62600-40

Edition 1.0 2019-06

# TECHNICAL SPECIFICATION



## Marine energy – Wave, tidal and other water current converters –
## Part 40: Acoustic characterization of marine energy converters



colour inside

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

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

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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 62600-40, 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 Specifications based on the following documents:

| Draft TS | Report on voting |
|---|---|
| 114/297/DTS | 114/307/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 document 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.

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

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- withdrawn,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.



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

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# INTRODUCTION

The purpose of this document is to provide uniform methodologies that will ensure consistency and accuracy in the measurement and analysis of acoustical emissions from marine energy converters. These systems include wave, current (tidal, ocean, and river), and ocean thermal energy conversion. The document provides guidance on the measurement, analysis, and reporting of acoustic emissions from marine energy converters and has been prepared with the anticipation that it would be applied by:

- Marine energy converter manufacturers striving to meet well-defined acoustic emission performance requirements and/or a possible declaration system;
- Purchasers of marine energy converters to specify such performance requirements;
- Operators of marine energy converters who may be required to verify that stated, or required, acoustic performance specifications are met for new or refurbished units;
- Operators of marine energy test sites, who may be required to assess conformity with consented acoustic levels at their sites;
- Marine energy converter planners or regulators who must be able to accurately and fairly define acoustical emission characteristics of marine energy converters in response to environmental regulations or permit requirements for new or modified installations.

The methods and reporting requirements in this document ensure that continuing development and operation of marine energy converters is carried out in an atmosphere of consistent and accurate communication relative to environmental concerns.

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

## Part 40: Acoustic characterization of marine energy converters

## 1 Scope

This part of IEC 62600 provides uniform methodologies to consistently characterize the sound produced by the operation of marine energy converters that generate electricity, including wave, current, and ocean thermal energy conversion. This document does not include the characterization of sound associated with installation, maintenance, or decommissioning of these converters, nor does it establish thresholds for determining environmental impacts. Characterization refers to received levels of sound at particular ranges, depths, and orientations to a marine energy converter. Informative Annex B provides guidance on additional measurements that would be necessary to estimate source levels.

The scope of this document encompasses methods and instrumentation to characterize sound near marine energy converters, as well as the presentation of this information for use by regulatory agencies, industry, and researchers. Guidance is given for instrumentation calibration, deployment methods around specific types of marine energy converters, analysis procedures, and reporting requirements.



This document is applicable to characterization of sound from individual converters and arrays. This document primarily describes measurement procedures for individual converters, with extension to arrays discussed in informative Annex A.



## 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 60565, *Underwater acoustics – Hydrophones – Calibration in the frequency range 0,01 Hz to 1 MHz*

IEC 61108-4, *Maritime navigation and radiocommunication equipment and systems – Global navigation satellite systems (GNSS) – Part 4: Shipborne DGPS and DGLONASS maritime radio beacon receiver equipment – Performance requirements, methods of testing and required test results*

IEC 61400-12-1, *Wind energy generation systems – Part 12-1: Power performance measurements of electricity producing wind turbines*

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

IEC TS 62600-20, *Marine energy – Wave, tidal and other water current converters – Part 20: Design and analysis of an Ocean Thermal Energy Conversion (OTEC) plant – General guidance*

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 62600-200, *Marine energy – Wave, tidal and other water current converters – Part 200: Electricity producing tidal energy converters – Power performance assessment*

ISO 17208-1, *Underwater acoustics – Quantities and procedures for description and measurement of underwater sound from ships – Part 1: Requirements for precision measurements in deep water used for comparison purposes*

## 3 Terms and definitions

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

**3.1**
**acoustic self-noise**
sound at a receiver caused by the deployment, operation, or recovery of the receiver, and its associated platform

[SOURCE: ISO 18405:2016, 2.1.1.5]



**3.2**
**ambient noise**
all sound, except **acoustic self-noise** and sound associated with a specified signal



[SOURCE: ISO 18405:2016, 2.1.1.6, modified – Notes not relevant to this document have been removed.]

**3.3**
**flow-noise**
non-acoustic pressure fluctuations measured by a pressure-sensitive instrument

Note 1 to entry: This is sometimes referred to as “hydrodynamic noise”.

Note 2 to entry: Moving water can also excite structures, causing them to radiate acoustic pressure, but this is categorized as acoustic self-noise.

**3.4**
**mean-square sound pressure spectral density**
distribution as a function of frequency of the mean-square sound pressure per unit bandwidth of a sound having a continuous spectrum

Note 1 to entry: Mean-square sound pressure spectral density is expressed in units of pascal squared per hertz ($Pa^2/Hz$).

Note 2 to entry: For operational purposes, mean-square sound pressure spectral density is estimated as the mean-square sound pressure in a finite frequency band divided by the frequency bandwidth. The averaging time and frequency band shall be specified.

[SOURCE: ISO 18405: 2016, 2.1.3.13, modified – Notes 2, 4, and 5, which are not relevant to this document, have been removed, as has the preferred formula.]

**3.5**
**mean-square sound pressure spectral density level**
ten times the logarithm to the base 10 of the ratio of the **mean-square sound pressure spectral density** to the specified reference value, in decibels

Note 1 to entry: Mean-square sound pressure spectral density level is the level of the power quantity mean-square sound pressure spectral density.

Note 2 to entry: Mean-square sound pressure spectral density level is expressed in decibels.

Note 3 to entry: In underwater acoustics, the reference value of mean-square sound pressure spectral density is 1 μPa$^2$/Hz.

[SOURCE: ISO 18405:2016, 2.2.1.10, modified – Symbolic notation and formulas from the definition and Notes 1 and 3 have been removed and Note 4 has been removed because it is not relevant to this document.]

### 3.6
**marine energy converter sound pressure level**
ten times the logarithm to the base 10 of the ratio of the integrated mean-square sound pressure spectral density over the measurement frequency range to the specified reference value, in decibels

Note 1 to entry: Marine energy converter sound pressure level is expressed in decibels.

Note 2 to entry: The reference value is 1 μPa$^2$ – see: mean-square sound pressure spectral density level.

### 3.7
**decidecade sound pressure level**
ten times the logarithm to the base 10 of the ratio of the integrated **mean-square sound pressure spectral density** over a specified decidecade frequency band to the specified reference value, in decibels



Note 1 to entry: The frequency ratio corresponding to a decidecade (1 ddec) is $10^{0,1}$. One decidecade (0,1dec) is equal to 0,1 $\log_2(10)$.

Note 2 to entry: Decidecade bands are defined in IEC 61260-1:2014 as “one-third octave bands”.



Note 3 to entry: Decidecade sound pressure level is expressed in decibels (dB).

Note 4 to entry: The reference value is 1 μPa$^2$ – see: mean-square sound pressure spectral density level.

### 3.8
**sound pressure**
difference between instantaneous total pressure and pressure that would exist in the absence of sound waves

Note 1 to entry: Sound pressure is expressed in pascals (Pa).

[SOURCE: ISO 18405:2016, 2.1.2.1, modified – Notes 2, 3, 4, and 5, which are not relevant to this document, have been removed, the preferred formula has been removed, and it has been made explicit that this is an instantaneous quantity.]

### 3.9
**self-noise**
fluctuations in signal caused by the combination of **acoustic self-noise** and non-acoustic self-noise

Note 1 to entry: An example of acoustic self-noise is hydrodynamic excitation of the sound measurement system that generates propagating sound.

Note 2 to entry: An example of non-acoustic self-noise is electrical noise internal to the sound measurement system electronics.

[SOURCE: ISO 18405:2016, 2.6.1.6, modified – Note 1, which is not relevant to this document, has been removed and notes have been added with examples of acoustic self-noise and non-acoustic self-noise.]

## 4 Symbols and abbreviated terms

| | |
|---|---|
| $H_{m0}$ | significant wave height |
| $T_e$ | energy period |
| $L_{p,f}$ | mean-square sound pressure spectral density level |
| $L_{p,ddec}$ | decidecade sound pressure level |
| $L_{p,MEC}$ | marine energy converter sound pressure level |
| $\overline{V_f^2}$ | mean-square voltage spectral density |
| $\overline{p_f^2}$ | mean-square sound pressure spectral density |
| CEC | current energy converter |
| MEC | marine energy converter |
| OTEC | ocean thermal energy converter |
| WEC | wave energy converter |
| AEP | annual energy production |

## 5 Outline of method



Measurements of underwater sound around marine energy converters (MECs) are undertaken to characterize MEC sound. This document focuses on measurements of underwater sound utilizing hydrophones, which are sensitive to fluctuations in acoustic and non-acoustic pressure. Deployment mechanisms to minimize measurement contamination by non-acoustic pressure fluctuations are given for each class of MEC, specifically current energy converters (CECs), wave energy converters (WECs), and Ocean Thermal Energy Conversion (OTEC) systems. These measurements are complemented by contextual observations of metocean conditions, sound speed profiles, and MEC operation (e.g., rated capacity, annual energy production (AEP)). The acoustic frequencies of interest for these measurements coincide with those of aquatic species, extending from a few Hz to over one hundred kHz. Two levels of characterization are described. Level A characterization describes the temporal and spatial characteristics of MEC sound. Level B characterization describes the characteristics of MEC sound at reduced temporal and spatial detail. Both levels utilize the same instrumentation, analysis, and reporting. “Level B” characterization is included within the document to provide a mechanism for reduced-effort reconnaissance surveys to be compliant with the specification. For example, a Level B characterization might be sufficient for a prototype demonstration of a MEC, whereas as Level A characterization might be more suitable for a commercial deployment. For both levels of characterization, analysis requires identifying, from all collected acoustic samples, a sufficient valid set at specified marine energy converter operational conditions and spatial positions. Measurement procedures for the three classes of MEC are summarized in Table 1.