



IECRE OPERATIONAL DOCUMENT

IEC System for Certification to Standards Relating to Equipment for Use in Renewable Energy Applications (IECRE System)

ME Certification Scheme: Test Report for wave, tidal and other water current converters – Measurement of mechanical loads



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CONTENTS

CONTENTS	2
Summary	3
1. Introduction	4
2. Purpose of tests	4
2.1 Test outcome and deliverables for the test laboratory & client.....	4
2.2 Procedure	4
2.3 Test Report requirements	5
3. Procedure for an RETL to apply to perform loads measurements under IECRE ME sector	7
4. Peer assessment.....	7
Annex A : Test Report Form for full scale testing at a wave, tidal or other water current test site according to IEC/TS 62600-3 clause 12.....	8
Annex B: Test Report form for laboratory blade testing according to IEC/TS 62600-3 Annex A.12.....	13

Summary

The purpose of this Operational Document is to establish a common approach amongst all IECRE Test Laboratories (RETLs) operating within the IECRE System, Marine Energy Sector, regarding the competence area “IEC TS 62600-3: Marine Energy – Wave, Tidal and other water current converters – Part 3: Measurement of mechanical loads” via the following:

- Guidance for a RETL issuing a Renewable Energy Test Report (RETR) stating compliance with the IEC TS 62600-3, as well as a format for the Test Reports
- Procedures for a RETL to apply to perform mechanical load measurement tests and other structural mechanical load testing within the IECRE System Marine Energy Sector
- Details on the eventual peer assessment of RETLs for the measurement of mechanical loads at wave, tidal and other water current converters as well as perform laboratory mechanical load testing on structures and components.

OD 300-3: Test Report for wave, tidal and other water current converters – Measurement of mechanical loads

1. Introduction

This Operational Document covers the assessment of mechanical loads measurement tests for RETLs. The scope of this OD is the IEC/TS 62600-3 Technical Specification.

There is limited published experience on the measurements of mechanical loads on deployed MECs. Also, there is a wide variety of MEC types. Therefore, it is possible that not all MEC types can fully comply with all clauses of IEC/TS 62600-3. In case the RETL is not able to comply with clauses in the TS, this should be justified by technology qualification according to IEC/TS 62600-3 clause 5.3.

For some specific MEC type it might be necessary to perform additional loads measurement or testing, in addition to the tests described in IEC/TS 62600-3. The need for additional testing is described in IEC/TS 62600-3 clause 6.3.

The measurement of mechanical loads as defined in IEC/TS 62600-3 is governed by additional Rules and Operational Documents in the IECRE Marine Energy sector. These include the following:

- AD 007 – Marine Energy IECRE Certification Body (RECB) and IECRE Testing Laboratory (RETL) Application Form
- OD 005-2 – Testing Laboratory / Customer Test Facility Assessment Report
- OD 008 – Checklist for testing and calibration laboratories ISO/IEC 17025:2017
- OD 300 – Test Report Requirements

2. Purpose of tests

The purpose of mechanical load measurement and testing is:

- To prove that the structure, subsystem or structural component will be able to bear the loads that will be exerted on the structure, subsystem or structural component in the operational environment during its functional life.
- To demonstrate that the measured loading is equivalent to or lower than the calculated loading and thus to validate load simulation models.

2.1 Test outcome and deliverables for the test laboratory & client

The details of testing shall be included in the Test Report according to Clause 2.3.

2.2 Procedure

The measurements of loads shall take place in accordance with the relevant IEC 62600 series of standards:

IEC/TS 62600-3 Marine energy – Wave, tidal and other water current converters – Part 3: Measurement of mechanical loads.

Adherence to this Technical Specification shall be made when planning, performing, analysing and reporting the tests.

The procedure for mechanical load tests is detailed below:

The following procedures should normally be checked:

- Test plan prior to start of campaign
- Identification of the MEC or MEC subsystem under test
- Test requirements

- Instrumentation
- Determination of calibration factors
- Data verification
- Processing of measured data
- Uncertainty estimation
- Minimum Test Report results

Results will be reported according to section 2.3 below.

2.3 Test Report requirements

The Test Report shall include:

- Identification of the test procedure document and document revision that the test was carried out to
- Type of test according to IEC TS 62600-3:
 1. Report of full scale on site mechanical load testing according to IEC TS 62600-3 Clause 12;
 2. Report of full-scale laboratory rotor blade testing according to IEC/TS 62600-3 Annex A.12;
 3. Report of other subsystem or structural component laboratory load tests according to 2.3.1 (see IEC/TS 62600-3 clause 6.3 for guidance);

and in addition:

- Names of the staff involved in testing and the applicant's staff approving the report
- Table of contents
- Summary
- Introduction
- Deviations from the procedure as detailed in IEC/TS 62600-3 clause 5.3
- Any significant unexpected behaviour
- Conclusion
- References
- Attachments (if applicable)
- Appendices (if applicable)

It is recommended that the channel list, the instrumentation and the coordinate system (if applicable) are made available early in the measurement campaign as an instrumentation and calibration report. For consistency, the results of reporting shall be documented in the format provided in Annex A (full-scale on-site testing) or Annex B (blade testing).

2.3.1 Test Report requirements for laboratory load tests according to IEC/TS 62600-3 clause 6.3

This clause describes the Test Report format for other mechanical load testing; other than the full-scale laboratory blade testing (Annex A.12 of IEC/TS 62600-3) or the full scale on site load testing (clause 12 of IEC/TS 62600-3).

The Test Report shall include the following items, depending on the type of test(s):

- Table of contents
- Summary
- Introduction
- Contractor for the test
- Names of the staff involved in testing and the applicant's staff approving the report
- Dates and locations for the test
- Structural component/subsystem identification
- Structural component/subsystem description
- Test set-up and procedures
- Description of test loading
- Test equipment used (including make, model, serial numbers, etc.)
- Reference to calibration records of measurement equipment and data acquisition system
- Locations of sensors and measurement points
- Structural component/subsystem calibration details (for example specific strain-stress-load relations at the strain gauges accounting for the stresses induced by gravity and auxiliary equipment (tare loads))
- Estimated uncertainties
- Description of inspections, repairs and observations
- Test results
- Deviations from test plans, laboratory procedures or normative references
- List of references (test plans, laboratory procedures, normative references)
- The evaluation of the test in relation to the design requirements shall at least include:
 - Evaluation of test loads
 - Evaluation of test results with respect to the DLCs (see IEC TS 62600-2)
- Conclusions
- References
- Attachments (if applicable)
- Appendices (if applicable)


3. Procedure for an RETL to apply to perform loads measurements under IECRE ME sector

Acceptance of RETLs is detailed in the IECRE Rules. The application for the acceptance of a laboratory as an RETL shall be submitted to the IECRE Executive Secretary using the Application Form, AD 300.

4. Peer assessment

For acceptance as an RETL to deliver this testing activity, Test Laboratories must indicate their agreement to undergo peer assessment on a periodic basis according to IECRE Rules. Guidance can be found in OD 008 and AD 300-3, among other documents.

Annex A: Test Report Form for full scale testing at a wave, tidal or other water current test site according to IEC/TS 62600-3 clause 12

	Test Report issued under the responsibility of: RETL Logo
<p>TEST REPORT IEC TS 62600-3 Marine energy – Wave, tidal and other water current converters – Part 3: Measurement of mechanical loads: Full-scale testing at a wave, tidal or other water current test site</p>	
IECRE Report Number. : IECRE.ME.TR.TPP.yy-000X-R0	
RETL internal Report Number.. :	
Date of issue	
Total number of pages	
RE Testing Laboratory:	
Testing location/ address..... :	
Applicant's name	
Address	
Test MEC description	
Manufacturer/supplier	
Model/Type reference	
Rated Power:	
Tested by (name, function, Printed name/function signature)..... :	Signature
Approved by (name, function, Printed name/function signature)..... :	Signature
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General disclaimer:	
The test results presented in this report relate only to the object tested. This report shall not be reproduced, except in full, without the written approval of the Issuing RE Testing Laboratory (RETL). The authenticity of this Test Report and its contents can be verified by contacting the RETL, responsible for this Test Report.	


Test Report	
<i>Content</i>	<i>Comments</i>
	<i>(general comment: the references point to IEC/TS 62600-3, unless stated otherwise)</i>
<u>Table of contents</u>	
<u>Summary</u>	Summary of the tests
<u>Introduction</u>	
Test objective	
Test period	
<u>Identification and description</u>	
Make	
Type	
Serial Number	
Production Year	
Structural characteristics	Structural characteristics e.g.: Wave, tidal or other water current converter? Type of hydrodynamic converter? Floating or fixed to the seabed? With or without blades connected to a rotor shaft? For a MEC with blades connected to a rotor shaft: rotor diameter, rotor speed or rotor speed range, type of support substructure or tubular column, if applicable blade data: make, type, serial numbers, number of blades, fixed or variable pitch, and pitch angles.
Dimensions	Insert diagram with main dimensions and photograph of test MEC
Control system	Description of control system and software version
Changes	Any changes made to the test MEC during the test period classified per 6.8.
<u>Description of the test site</u>	
Bathymetry of the location	
Geographical location	Sufficient information to locate the test MEC
Test site map	Map showing the surrounding area covering a radial distance of at least 20 times the MEC (e.g., rotor) diameter and indicating the topography, location of the MEC, location of oceanographic and meteorological measuring devices, significant obstacles, other MECs and the measurement sector (if applicable)
Site calibration	If site calibration is performed, the site calibration results including the limits of the final measurement sector if applicable and the rationale for any changes from the results of the site assessment
<u>Channel list</u>	List of measuring channels

<u>Coordinate system</u>	The coordinate system used for the test
<u>Instrumentation</u>	
Data acquisition system	Description of data acquisition system (sample rate, filters, synchronization if applicable)
For each channel:	1: Details of instrumentation (make, model, serial number)
	2: Details on signal conditioning
	3: For each instrument, its actual location and orientation, mounting details
	4: The slope, offset, their derivation method and calculation
	5: Calibration data (actual measured data or calibration sheet cover page, end to end checks); for loads channels, also the inputs used for the calibration and their sources (e.g. manufacturer or measured)
	6: Any changes made to the instrumentation or calibration during the test period covered in the report
<u>Data verification</u>	Data verification checks per requirements of Clause 9
<u>Data rejection criteria</u>	Data rejection criteria (e.g., measurement sector, MEC status signals) and data classification (criteria for data to go in different capture matrices)
<u>Post processing methods</u>	Post processing methods such as: filtering during post processing despiking; description of calculated channels; rainflow cycle counting method; current speed trend detection method; any additional data treatment.
<u>Results</u>	At a minimum the following results should be included in the Test Report (except where it is marked as optional):
For the test period	1: Plots of oceanographic and meteorological conditions as a function of time (see Table 10);
	2: For TECs and other water current converters: TI as a function of current speed
	3: For TECs and other water current converters: TI detrended and as-measured as function of current speed (ratio, difference or both)
	4: Scatter plot of oceanographic conditions as a function of wave direction (10-min averages, or other intervals if necessary); a) wave height; b) wave period; c) wave energy vertical distribution in case of submerged WECs
	5: Scatter plot of oceanographic conditions as a function of current direction (10-min averages, or other intervals if necessary); a) current speed; b) TI; c) current vertical distribution;
For the power production MLC	For the power production steady state MLC see 6.4.2.2:

	1: Capture matrix according to IEC TS 62600-100, IEC TS 62600-200 or IEC TS 62600 300
	2: Time series of oceanographic and meteorological quantities (mandatory signals in Table 10), MEC operation quantities (mandatory signals in Table 11 or 13) and mandatory loads identified in Table 9 or 12.
	3: Scatter plots (e.g., 10-min maxima, minima, mean, standard deviation and DEL's (loads only) as a function of mean current speed and sea state) of oceanographic and meteorological conditions (mandatory signals in Table 10), MEC operational data (mandatory signals in Table 11, Table 9 or Table 12), with binned values on top of the scatter plots (mean of means)
	4: Frequency spectra indicating the frequency values of found peaks in the spectrum
	5: Cumulative rainflow spectrum for loads in Table 9 or Table 12
	6: Table with mean of means, maximum of 10-min maxima, minimum of 10-min minima and bin averaged damage equivalent loads (e.g., for current speed in 0,1 m/s bins) for all oceanographic signals (mandatory signals in Table 10, all WEC or CEC operation quantities) mandatory signals in Table 11 or Table 13 and all loads quantities (Table 9 or Table 12) (optional)
	7: Plots of power production as a function of current speed (CEC) or wave energy flux (WEC) (optional)
	8: Items above for any other mandatory signals
For the parked MLC	For the parked steady state MLC see 6.4.2.3:
	1: Capture matrix linking to filenames (see Table 4 or Table 8)
	2: Time series for example for yaw misalignment, if applicable;
For transient MLCs	For transient MLCs see 6.4.3
	1: Capture matrices, including reference to the file identifier containing the events (see Table 5 and Table 6)
	2: For one of each type of event: time series of mandatory oceanographic and meteorological, MEC operation quantities, and load quantities identified in Table 9, Table 10, Table 11, Table 12, Table 13 (whichever applicable)
	3: Table with statistics of each channel during the transient (recommended)
For dynamic MLCs	For dynamic MLCs see 6.4.4 or 6.5.2:
	1: Spectra for each MLC for the targeted load quantities
For abnormal operating conditions MLC	for abnormal operating condition MLC see 6.4.5:
	1: Description of the behaviour of the MEC after switching off the control system
	2: Time series and frequency spectra of mandatory oceanographic and meteorological, MEC operation quantities, and load quantities identified in Table 9, Table 10, Table 11, Table 12, Table 13 (whichever applicable and for the operation quantities: whichever is available after switching off the control system)
Uncertainty	Uncertainty per the requirements of Clause 11:

For measured quantities	1: A table of values of the uncertainty sources that were used in the estimation of the total standard uncertainty of the quantity (for guidance see Annex E)
	2: A statement of the total standard uncertainty of the measured quantity (percentage and constant)
For binned results	1: A table with the total standard uncertainty for the bin-averaged value of the measured quantity as a function of bin-average current speed or sea state
	2: A table with the total standard uncertainty for the bin-averaged value of the DEL of the measured quantity as a function of bin averaged current speed of sea state
For damage equivalent loads and cumulative rainflow spectra	1: The statement of the total standard uncertainty of the 10-min DEL for the measured quantity (percentage only);
	2: Uncertainty of the cumulative rainflow spectrum (percentage on the ranges)
<u>Deviations</u>	Deviations from the IEC/TS 62600-3 technical specification, as detailed in IEC/TS 62600-3 clause 5.3
<u>Unexpected</u>	Any unexpected behaviour
<u>Conclusions</u>	
<u>References</u>	List of references (test plans, laboratory procedures, normative references)
<u>Attachments</u>	List of attachments
<u>Appendices</u>	Maps, plots, matrices, figures or tables may be placed in appendices, if clear references are placed in the report main text.

**Annex B: Test Report form for laboratory blade testing according to
IEC/TS 62600-3 Annex A.12**

	Test Report issued under the responsibility of:	
	RETL Logo	
<p align="center">TEST REPORT IEC TS 62600-3 Marine energy – Wave, tidal and other water current converters – Part 3: Measurement of mechanical loads: Laboratory blade testing</p>		
IECRE Report Number. :	IECRE.ME.TR.TPP.yy-000X-R0	
RETL internal Report Number.. :		
Date of issue		
Total number of pages		
RE Testing Laboratory:		
Testing location/ address..... :		
Applicant's name		
Address		
Test component description :		
Manufacturer/supplier		
Model/Type reference		
Load rating..... :		
Tested by (name, function, Printed name/function signature)..... :	Signature	
Approved by (name, function, Printed name/function signature)..... :	Signature	
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Test Report		

<i>Content</i>	<i>Comments</i>
<u>Table of contents</u>	
<u>Summary</u>	Summary of the tests
<u>Introduction</u>	Test objective
	Test period
<u>Identification and description</u>	Locations for the tests
	Blade identification with picture and main dimensions
	Blade description according to IEC/TC 62600-3 Annex A.6.2
<u>Test set-up and procedures</u>	Description of test load and a free body diagram of the loading on the blade
	Test equipment used (including make, model, serial number etc. and a picture of the test setup). Details of the connection of the blade to the test equipment. The stiffness of the mounting frame in relation to the applied loading (if applicable).
	References to calibration records of measurement equipment and data acquisition system
	Locations of sensors and measurement points
	Blade specific calibration details: for example the specific strain-stress-load relation at the strain gauges in the blade accounting for the blade stresses induced by gravity and auxiliary equipment (tare loads)
	Data acquisition system
	Any changes made to the instrumentation or calibration during the test period
<u>Uncertainty</u>	Estimated uncertainties
	Description of inspections, repairs and observations;
<u>Tests and test results</u>	Summary of tests and test results:
	Static test results
	Fatigue test results (including the stiffness of the blade during testing, if measured)
	Other blade property tests
	Test results evaluation including: 1: Catastrophic failure 2: Permanent deformation, loss of stiffness or change in other blade properties 3: Superficial damage 4: Failure evaluation

<u>Deviations</u>	Deviations from test plans, laboratory procedures or normative references
<u>Unexpected</u>	Any unexpected behaviour
<u>Evaluation of tests</u>	Evaluation of tests in relation to design requirements 1: Evaluation of test loads including test load distribution 2: Evaluation of test results with respect to the DLCs (IEC TS 62600-2) 3: Evaluation of blade stiffness
<u>Conclusions</u>	
<u>References</u>	List of references (test plans, laboratory procedures, normative references)
<u>Attachments</u>	List of attachments
<u>Appendices</u>	Plots, matrices, figures or tables may be placed in appendices, if clear references are placed in the report main text.

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