



BSI Standards Publication

Marine energy — Wave, tidal and other water current converters

Part 103: Guidelines for the early stage development of wave energy converters — Best practices and recommended procedures for the testing of pre-prototype devices

National foreword

This Published Document is the UK implementation of IEC TS 62600-103:2024. It supersedes PD IEC TS 62600-103:2018, which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee PEL/114, Marine energy - Wave, tidal and other water current converters.

A list of organizations represented on this committee can be obtained on request to its committee manager.

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**Marine energy – Wave, tidal and other water current converters –
Part 103: Guidelines for the early stage development of wave energy converters –
Best practices and recommended procedures for the testing of pre-prototype
devices**

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

**MARINE ENERGY – WAVE, TIDAL AND OTHER
WATER CURRENT CONVERTERS –****Part 103: Guidelines for the early stage development of
wave energy converters – Best practices and recommended
procedures for the testing of pre-prototype devices**

FOREWORD

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IEC TS 62600-103 has been prepared by IEC technical committee 114: Marine energy – Wave, tidal and other water current converters. It is a Technical Specification.

This second edition cancels and replaces the first edition published in 2018. This edition constitutes a technical revision.

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

- a) Revised several numeric values (e.g. test durations) to align with best testing practice;
- b) Introduced guidance and requirements relating to PTO testing and closed-loop control.

- c) Introduced uncertainty clause in normative part of the document;
- d) Strengthened the document sections relating to Stage 3, the first sea trials;
- e) Updated the data synchronisation requirements to align with best testing practices.

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

Draft	Report on voting
114/510/DTS	114/523/RVDTS

Full information on the voting for its approval can be found in the report on voting indicated in the above table.

The language used for the development of this Technical Specification is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/publications.

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 document will remain unchanged until the stability date indicated on the IEC website under webstore.iec.ch in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn, or
- revised.

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INTRODUCTION

Developing wave energy converters (WECs) will always be a demanding engineering process. It is important, therefore, to follow a design path that will minimise the risks encountered along a route of increasing technical complexity and fiscal commitment. This document presents a guide that addresses these issues, the approach being based on a proven methodology adapted from other technology areas, especially NASA and similar heavy maritime engineering industries.

The scope of the work is defined in Clause 1. Normative references and definitions of important terms are introduced in Clause 2 and Clause 3 respectively. The core of the document then follows a twin-track approach, relying on:

- a) a structured or staged development approach outlined in Clause 4, and
- b) a set of model specific and goal orientated clauses (Clause 9 to Clause 11) ensuring that targets are clearly defined and attained with confidence. Testing specific requirements such as test planning (Clause 5), reporting and presentation (Clause 6), characterisation of the surrounding wave environment (Clause 7), data acquisition and real-time control (Clause 8), and testing uncertainty Clause 12 are also included.

The structured development schedule makes use of the ability to accurately scale wave energy converters such that sub-prototype size physical models can be used to investigate the relevant device parameters and design variables at an appropriate dimension and associated budget.

The parallel development of mathematical models describing a wave energy converter's behaviour and performance is encouraged, but the procedure is not included in the document.

This document is quite exacting in terms of both the approach and requirements for the development of wave energy converters since it takes a professional approach to the process.

An essential element for any published Technical Specification or International Standard is to allow an opportunity to provide feedback on its contents to the appropriate TC 114 Working Group. TC 114 utilizes a standard methodology to allow this.

To submit feedback such as proposed changes, corrections and/or improvements to this document, please send an email to the TC 114 Chair using the Contact TC 114 Officers feature on the IEC TC 114 Dashboard, accessible at www.iec.ch/tc114. On the right side of the Dashboard under Further information select the link to contact the TC 114 Officers. On the subsequent page find and select the Send Email link for the Chair to access the email tool.

Complete all the required elements within the email pop-up. For the Subject field please include the document title and edition you are providing feedback for (ex: feedback for TS 62600-1 ED2). In the Message field, include text which summarizes your feedback and note if further information can be made available (note attachments are not allowed). The Chair may request added information as needed before forwarding the submission to the remaining TC 114 Officers for review and then to the appropriate Working Group for their consideration.

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

Part 103: Guidelines for the early stage development of wave energy converters – Best practices and recommended procedures for the testing of pre-prototype devices

1 Scope

This part of IEC TS 62600 is concerned with the sub-prototype scale development of wave energy converters (WECs). It includes wave tank test programmes, where wave conditions are controlled so they can be scheduled, and first sea trials, where sea states occur naturally and the programmes are adjusted and flexible to accommodate the conditions. Commercial-scale prototype tests are not covered in this document.

This document prescribes the minimum test programmes that form the basis of a structured technology development schedule. For each testing campaign, the prerequisites, goals and minimum test plans are specified. This document addresses:

- Planning an experimental programme, including a design statement, technical drawings, facility selection, site data and other inputs as specified in Clause 5.
- Device characterisation, including the physical device model, PTO components and mooring arrangements where appropriate.
- Environment characterisation, concerning either the tank testing facility or the sea deployment site, depending on the stage of development.
- Specification of specific test goals, including power conversion performance, device motions, device loads and device survival.

Guidance on the measurement sensors and data acquisition packages is included but not dictated. Provided that the specified parameters and tolerances are adhered to, selection of the components and instrumentation can be at the device developer's discretion.

An important element of the test protocol is to define the limitations and accuracy of the raw data and, more specifically, the results and conclusion drawn from the trials. A methodology addressing these limitations is presented with each goal, so the plan always produces defensible results of defined uncertainty.

This document serves a wide audience of wave energy stakeholders, including device developers and their technical advisors; government agencies and funding councils; test centres and certification bodies; private investors; and environmental regulators and NGOs.

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 62600-2, *Marine energy – Wave, tidal and other water current converters – Part 2: Marine energy systems – Design requirements for marine energy systems*

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, *Marine energy – Wave, tidal and other water current converters – Part 101: Wave energy resource assessment and characterization*

3 Terms, definitions, symbols and abbreviated terms

3.1 Terms and definitions

For the purposes of this document, the following terms and definitions 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>

3.1.1

dynamic

forces responsible for the object's motion

Note 1 to entry: Dynamic side of absorbed power: "Load measurement" (force, torque, pressure, etc.).

3.1.2

kinematic

motion of object, irrespective of how this motion was caused

Note 1 to entry: Kinematic side of absorbed power: "Velocity measurement" (velocity, angular velocity, flow, etc.).

Note 2 to entry: The terms "dynamic" and "kinematic" as defined above are used extensively throughout this document. These terms are used to ensure that a range of WEC conversion concepts are covered. For example, "dynamic" side of load measurement may refer to forces, torques or pressures, and as such provides a convenient and concise means of relating to a range of technologies.

3.1.3

operational sea states

wave conditions where the wave energy converter is in power production mode

3.1.4

peak distribution

distribution of peak magnitude values

3.1.5

stage 1 <of wave energy converter testing>

small-scale testing in the laboratory

Note 1 to entry: Stage 1 is equivalent to technology readiness level 3.

3.1.6

stage 2 <of wave energy converter testing>

medium-scale testing in the laboratory

Note 1 to entry: Stage 2 is equivalent to technology readiness level 4.

3.1.7

stage 3 <of wave energy converter testing>

first testing at sea

Note 1 to entry: Stage 3 is equivalent to technology readiness level 6.

3.1.8**storm conditions <of a marine energy converter>**

sea state with return period as defined in IEC TS 62600-2

3.2 Symbols and abbreviated terms

For the purposes of this document, the following symbols and abbreviated terms apply.

g	Acceleration due to gravity	[m/s ²]
H	Wave height	[m]
H_{m0}	Significant wave height	[m]
J	Wave energy flux	[W/m]
P	Wave power	[W]
T	Wave period	[s]
T_e	Wave energy period	[s]
T_p	Wave peak period	[s]
T_z	Zero up-crossing period	[s]
λ	Length scale factor	[-]
θ	Wave direction	[rad]
ρ	Density	[kg/m ³]

AD	Analogue to digital
CoG	Centre of gravity
DAQ	Data acquisition
DFT	Discrete Fourier transform
DoF	Degree of freedom
FFT	Fast Fourier transform
FMECA	Failures mode, effects, and criticality analysis
IMU	Inertial measurement unit
OWC	Oscillating water column
PCC	Power conversion chain

NOTE The power conversion chain is made up of a drivetrain, generator, storage, and power electronics.

PTO	Power take-off
RAO	Response amplitude operator
SCADA	Supervisory control and data acquisition system
SWL	Still water level
TRL	Technology readiness level
ULS	Ultimate limit state in the context of structural engineering
WEC	Wave energy converter

4 Staged development approach

4.1 General

Clause 4 introduces the staged development of the design for a WEC through physical model testing. Each stage of development is motivated by risk reduction. The primary goals for each stage address elements that shall be completed before proceeding through the user's pre-defined Stage Gate for that stage.

Scaled wave conditions produced in the wave tank should be representative of anticipated full-scale wave conditions at the expected deployment sites, including sea state spectral characteristics.

Figure 1 shows an overview of the process from the early design concept to the deployment of the first limited device number array. Each stage is based on a different physical scale range carefully selected to achieve a set of specific design objectives prior to advancing the device trials to the next stage. This clause outlines the scope and Stage Gates for Stages 1, 2 and 3, guiding the development process from Technology Readiness Level (TRL) 1 to 6 (Figure 1). Stages 4 and 5 (Figure 1) concern commercial scale (or near commercial scale) testing and are not covered in this document.

This document does not dictate a scale for each of the Stages 1 to 3. The model testing scale heavily depends on the type of WEC developed, the fidelity of the available instrumentation, and to some extent on the availability of appropriate test facilities. The scales provided in Figure 1 are included as indicators of previous WEC development efforts.

Every type of WEC will have slightly different requirements so a bespoke programme should be drawn up around these basic testing requirements. The necessary and recommended goals and experimental activities for Stages 1 to 3 are described in detail in Clause 5 to Clause 11. Activities are to be defined in the context of good engineering practice, where factor of safety, reliability or other design philosophy are followed.

Although the ordering of the test schedule is of paramount importance, it is equally essential that a Stage Gate process is applied at the conclusion of each set of trials to evaluate if the WEC has achieved the required experimental objectives before advancing forward. This due diligence should be monitored against the design statement produced by the device developer prior to each stage and the standards being established by the industry based on the other WEC's performances.

A set of Stage Gate criteria for the evaluation of the WEC behaviour and performance at the conclusion of each testing period are defined. These shall be achieved before advancing to the next stage. The criteria are defined as a general framework and allow for a high degree of flexibility to suit the design requirements.

At Stage 1, it should be anticipated that several iterations of a device will be required to optimise the performance, reliability, safety, and economics. More than one iteration may still be required at Stage 2, and a single implementation should normally suffice at Stage 3.

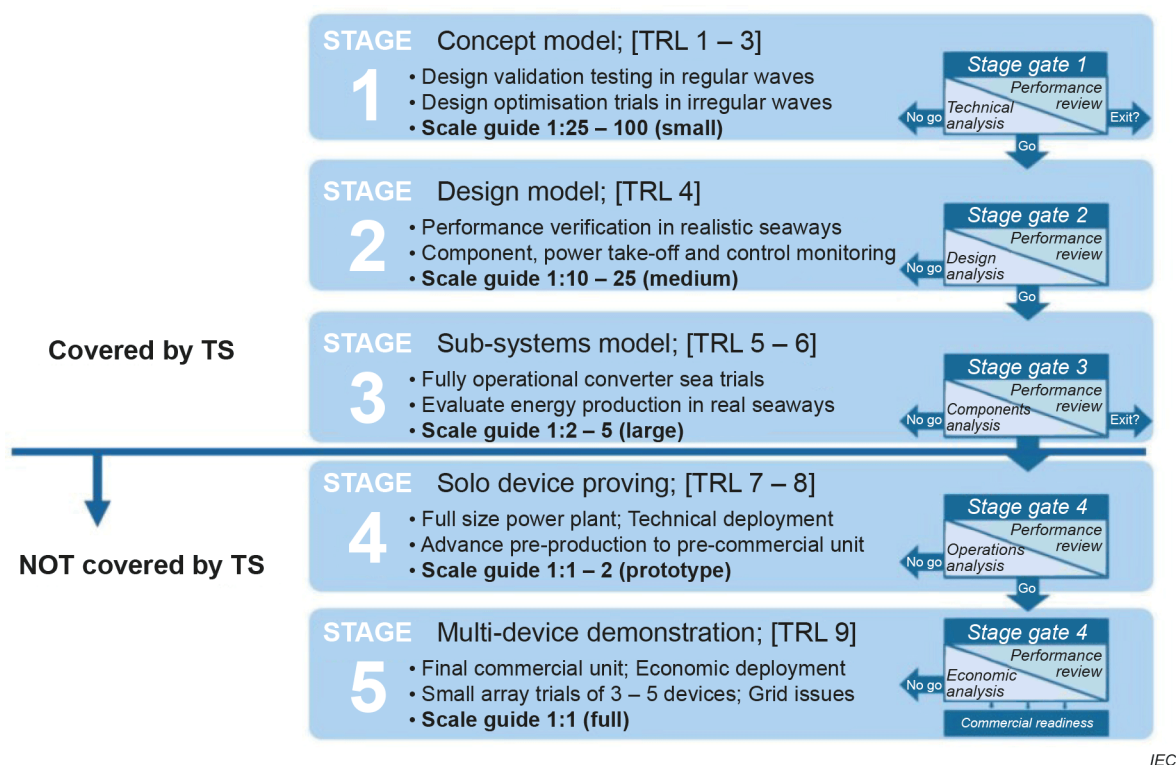


Figure 1 – Staged development approach

4.2 Stage gates

4.2.1 General

At the conclusion of each stage of device model testing, an evaluation procedure should be initiated to assess the overall performance of the design. The appraisal may include a technical and economic review based on three elements of the proposed device design:

- Analysis of the results from the appropriate preceding test programme.
- A comparison with the related device design statement produced at the beginning of the stage.
- An overall design review by a third party, independent, established engineering company.

NOTE See also Annex A for an informative description of the Stage Gate process.

4.2.2 Criteria

The review shall follow the same set of evaluation criteria at each Stage which are based on the test goals specified for each Stage in Clause 9, Clause 10 and Clause 11. As the test scale enlarges, the complexity of the model and trials increase to produce more accurate results with less uncertainty in the data extrapolation. The Stage Gate evaluation criteria reflect this decreasing uncertainty.

The evaluation criteria shall include:

- Energy absorption.
- Device seakeeping (motions).
- Mooring loads.
- PTO loads.
- Ultimate Limit State (ULS) verification.

The minimum specifications for each Stage Gate criterion that experimental testing can contribute to are outlined in Clause 9, Clause 10 and Clause 11 and summarised below.

Each stage can comprise more than one model testing campaign, using progressively optimised models, to maintain relevance as the device design progresses, and to comprehensively meet the Stage requirements and Stage Gate criteria.

NOTE Physical model testing is often run in conjunction with a mathematical model development, with model validation criteria similar to those listed in Clause 4.

4.3 Stage 1

4.3.1 Scope

Stage 1 is intended to demonstrate that the design has potential and can be realised or transitioned up to TRL3. A key purpose of Stage 1 testing is to explore initial design choices.

NOTE 1 Stage 1 is often used to explore several device configurations without a detailed design for the commercial scale prototype.

There are three facets to Stage 1 tests:

- Proof of concept: to verify that the device design concept operates under wave excitation as predicted and described (under TRL1).
- Optimisation of design: to evolve the most favourable device configuration(s) in regular and irregular waves.
- Device performance: to obtain a first indication of power performance for the optimised PTO setting of the device.

All three facets are required to provide input to Stage Gate 1.

For the proof-of-concept phase of Stage 1, the testing can rely on an idealised physical model. This model can be restricted to a limited number of DoF if this can be justified.

The PTO can be represented by a simplified, but accurate, mechanism. The selected PTO mechanism shall provide forcing that can be characterised across an appropriate range of settings.

A generic station keeping system can be used if the mooring behaviour is not an integral part of the device hydrodynamic motion and energy conversion scheme.

Established ocean spectra can be utilised at this stage to generate the irregular wave excitation time histories, such as Bretschneider, JONSWAP or ITTC.

NOTE 2 At Stage 1, parts of the testing are commonly undertaken using non-natural wave spectra distributions. This includes white or pink spectra for system identification purposes.

NOTE 3 References [1]¹, [2], [3] provide guidelines for generic test site data, which might assist with the Stage 1 sea state selection.

The methodology of testing recommended here follows established best practice for Stage 1 testing. The results of this stage are lessons used to converge on a commercial-scale design and data to be validated in the next stage.

¹ Numbers in square brackets refer to the Bibliography.

4.3.2 Stage Gate 1

Energy absorption appraisal shall be based on:

- a set of power response transfer function (RAO, for similar wave heights);
- power capture prospects estimated from selected sea states, with details provided in Clause 9.

Seakeeping appraisal shall be based on:

- the RAO for the dominant or relevant degrees of motion.

Mooring appraisal if implemented:

- the time series and associated analysis (e.g. RAOs) of the mooring line loads.

NOTE For a simple model with linear PTO damping, power absorption generally scales with the velocity squared, or the wave height squared. It can hence be beneficial to express the power response as a quadratic transfer function of form Power/Height², rather than an RAO that is of the form Power/Height.

4.4 Stage 2

4.4.1 Scope

The purpose of Stage 2 testing is to fully evaluate the device design identified in Stage 1. Stage 2 testing can be associated with a significant amount of design variables, particularly in the PTO description, but shall be based on similar performance indicators as adopted during Stage 1.

Stage 2 testing shall specifically address the following key objectives:

- Stage 1 validation: To validate the technical conclusions drawn from the previous test programme and to identify potential scaling issues between the two stages;
- mooring function check: to verify the proposed commercial-scale mooring and anchorage system design and assess a realistic mooring response;
- device performance: to verify the energy conversion performance;
- device dynamics and kinematics;
- survivability check: introducing storm conditions to observe device response in extreme conditions, and to discover device-specific failure modes;
- use the largest scale feasible for available facilities to reduce the influence of scale effects;
- if practical the flexible umbilical electrical cable should be incorporated in selected tests.

It is also recommended that Stage 2 testing incorporates an advanced PTO model, exhibiting an accurate representation of the proposed commercial-scale unit, and introducing a PTO control mechanism by which control strategies can be evaluated.

The primary use of the medium-scale Stage 2 test data shall be to obtain statistically significant values that can be scaled to commercial-scale values with appropriate factors of safety. The data shall also (i) be suitable to confirm any mathematical or numerical models of the device where available; and (ii) be capable of extrapolation beyond one deployment location.

For validation of the Stage 1 results, both the wave and the device parameters should be as close as possible to those adopted during Stage 1, adjusted to the Stage 2 scale. It is recommended to include a representative set of conditions, including regular and irregular waves. In selecting these conditions, it is recommended to include the range of each parameter (wave period, wave height and PTO settings) that supported the main Stage 1 conclusions. The medium-scale model can be idealised for parts of the test campaign to undertake the comparison to Stage 1 testing. Any deviation between the two Stage set-ups shall be clearly reported.

4.4.2 Stage Gate 2

At Stage 2, the proxy for the annual energy production should be based on a power matrix and site scatter diagram. This type of approach more accurately determines the performance and limits the uncertainty.

Energy absorption appraisal shall be based on:

- a power response transfer function (RAO, for similar wave heights);
- power capture estimate based on a selected number of standard sea states (power matrix), with details given in Clause 9.

Seakeeping appraisal shall be based on:

- the RAO for the dominant or relevant degrees of motion.

Mooring appraisal if implemented:

- the time series and associated analysis (e.g. RAOs) of the mooring line loads.

4.5 Stage 3

4.5.1 Scope

The motivation for Stage 3 is to demonstrate in smaller scale the operating principles in “real world” uncontrolled wave conditions before building a commercial scale prototype many times more expensive. Stage 3 sea trials are conducted to prove the whole WEC system to reduce the technical and economic development risk. The test programme should still concentrate on verifying the device power conversion performance in real sea conditions but shall include other validation monitoring, as specified by the design statement i.e. survivability.

There are several purposes for conducting testing at this stage, ranging from advanced technical and engineering issues, through to deployment and operation matters and including environmental monitoring requirements. The key objectives for testing at this larger scale are:

- deployment check: to test at-sea procedures for deployment and retrieval;
- operational check: to verify expected performance in uncontrolled weather and seas with an electrical load;
- survivability check: to verify failure mitigation strategies;
- corrosion check: Using materials representative for the future prototype, to monitor the model for symptoms of galvanic corrosion or stress corrosion cracking;
- fatigue (cyclic) stress evaluation: to install sensors at locations where cyclic stresses is likely to determine system life.

To achieve the Stage 3 objectives, the trials move from the laboratory to an outdoor test site. This means that wave conditions are no longer controllable, or produced on demand, so sea trial programmes shall reflect this and be robust and adjustable to accommodate the naturally occurring sea state. The selected scale should be large enough to include a functioning PTO, electrical generator, power electronics and a downstream energy dissipation method. A grid emulator can substitute for connection to a grid.

The selected scale should strongly consider the overlap of wave heights and periods between the commercial site and the test site when appropriately scaled using Froude scaling. For sea-floor mounted devices, the scale of the model should preferably be chosen as the ratio between the water depth at the anticipated commercial site and the water depth at the test site. This recommendation is also advised, though less critical, for other WECs such that other systems (moorings, umbilical, etc) are representative.

The scale should be used to scale any other parameters that affect the device and its subsystems. One issue can be the scaling of the water level variations and the local currents.

A comprehensive sea trial programme shall be developed for Stage 3 that provides sufficient confidence to move towards a commercial-scale prototype. Tests shall be designed such that they are of adequate duration to enable detailed post-trial inspections to detect symptoms of future cyclic failures. The resulting findings of a well-defined set of trials will provide data as significant as commercial scale but with a significantly reduced budget and technical risk.

NOTE Selecting an appropriate Stage 3 site is a challenging process, and the perfect site that suits all scaling and testing criteria might not exist. Some locations offer ideal water depth but not sufficient wave action, some locations meet the wave height criteria but do not scale well in terms of wave periods, and some locations provide the ideal wave climate, but only for very limited times during the year. To ensure that all testing objectives can be met, Stage 3 testing can be undertaken at more than a single location, where each location can meet part of the overall objectives.

4.5.2 Stage Gate 3

The Stage Gate in this case includes:

- the evaluation and verification of the PTO efficiency and control;
- the evaluation and verification of risk and safety management;
- the evaluation and verification of the power matrix;
- the assessment of environmental impact;
- the evaluation of installation and maintenance procedures and durations;
- the evaluation of fabrication methodology and cost;
- the evaluation of mooring loads and survivability;
- the evaluation of structural loads.

Partial verifications are often undertaken before sea trials commence. For example, evaluating the PTO efficiency and control can be undertaken in a test-stand setup before final device fabrication.

5 Test planning

5.1 WEC similitudes

5.1.1 General

For model scale testing of WECs, perfect scaling would come from:

- geometric similitude for the WEC and its mooring;
- structural similitude for the WEC and its mooring (Cauchy);
- hydrodynamic similitude for the WEC and its mooring (Froude, Strouhal, and Reynolds);
- PCC similitude for the WEC.

Since not all of these can be met simultaneously, model scale testing of WECs shall generally be based on Froude and Strouhal similitudes for the hull and structural similitude for the mooring. If other scaling methods are used, then both Froude and Strouhal concerns shall be addressed. The importance of each similitude that cannot be met shall be addressed and documented as the scale-up is completed. Further guidance on similitudes outside of PCC similitude (unique to the testing of WECs) is given in Annex C.

Viscous losses and vortex shedding can be significant at small model scales. To mitigate this, it is recommended to minimise their causes (sharp edges, narrow fluid gaps). Careful assembly is necessary for small models to limit magnification of viscous forces that are not expected to be representative of full-scale effects.

NOTE 1 Inaccuracies might be introduced through Reynolds, structural, and PCC non-similarities for the WEC, and geometric and hydrodynamic non-similitude for the mooring. There are techniques that can specifically address these non-similarities. However, if they are not addressed, the uncertainty in the scale-up of model data to prototype will be increased. In general, as the Froude scale factor decreases and as the testing progresses in stage, the uncertainty and inaccuracy of scale-up decreases.

NOTE 2 Density differences between laboratory testing (typically fresh water) and Stage 3 conditions (typically sea water) cause a discrepancy in terms of buoyancy, mass distributions and pressures or forces measured. Hydrodynamic forces are appropriately 2,5 % larger in sea-water conditions, and buoyancy can change significantly.

5.1.2 Power conversion chain (PCC) similitude

In general, measuring and scaling the absorbed power is possible for most devices.

Since the WECs response to the environment can be altered through control strategies executed through the PTO, the controls shall also be reproduced at model scale, and hence are considered as part of the PCC similitude.

The PCC is made up of prime movers, generators, storages, and power electronics. Each of these components has efficiencies based on the state of the system, and limitations (such as max voltage or torque values) associated with them. The combination of the prime mover and generator is often referred to as the PTO, and it is often the only item that is represented in Stage 1 and Stage 2 testing.

A specific goal of the Stage 3 testing is to implement a scaled PCC. However, in Stage 2 and Stage 1, it is often not possible to scale the physical components down. Hence representational PTOs that capture the dynamic-kinematic (force-velocity, torque-angular velocity, pressure-flow, etc.) characteristics are often used. However, these representational PTOs can introduce frictional effects, like stiction, or non-physical hysteretic effects. Further, these representational PTOs might not be able to imitate limitations that will exist in the prototype, such as maximum forces or slew rates from the generator.

One major issue surrounding PCC similitude relates to the inability to truly scale bearing surfaces such that frictional losses are also scaled. To improve the predictions of power performance, a friction analysis can be completed to determine the difference in performance that is being lost to the inability to scale frictional losses.

The ability to mimic the anticipated commercial-scale control strategy at model scale is very important. The way in which this strategy is implemented is not relevant. However, for Stage 2 and 3, the effect of the control strategy should be demonstrated to be a scaled version of the commercial-scale approach through the desired dynamic-kinematic characteristics.

NOTE 1 It is more common for control strategy investigations to be undertaken from Stage 2 onwards.

NOTE 2 Commonly the efficiencies associated with each component of the PCC are dependent on the state of the system. Hence, it is often the case that only the absorbed power (not mechanical or electrical on which these state dependent efficiencies act) will be scaled up.

If the device is an OWC device, special considerations shall be given to the uncertainty of the scale-up since the PTO relies on aerodynamics which is fundamentally governed by Reynolds scaling in addition to being subject to air compressibility.

5.2 Design statement

A design statement shall be available prior to device testing.

a) For Stage 1 laboratory testing programmes the design statement

Shall include:

- clear statement of the testing goals;
- technical drawing of the experimental device indicating the anticipated scaling factor to commercial scale;
- description of the experimental mooring system and its anticipated functionality, including position keeping (mooring system does not play an active part in power absorption) or active mooring (mooring system plays an active part in power absorption);
- supporting calculations to provide approximate device physical properties and behaviour.

Should include:

- a description of any mathematical device model, where available, detailing how the testing may assist in advancing and refining such model, and verifying that the model includes the governing physics.

May include:

- technical advantages and improvements the device introduces over other WECs;
- literature review of similar systems.

b) For Stage 2 laboratory testing programmes the design statement

Shall include:

- clear statement of the testing goals;
- technical drawing of the preliminary device design in anticipated commercial scale and the experimental design at model scale;
- definition of the anticipated commercial-scale PTO and its characteristics;
- supporting calculations to provide approximate device physical properties and behaviour;
- technical drawing of the preliminary mooring design in anticipated commercial scale and the experimental design(s) at model scale;
- characteristic site conditions for the anticipated device deployment location, including typical wave period, wavelength, water depth, significant wave height, spectral representation and directionality, spreading coefficient (see IEC TS 62600-101 for details);
- indicate the scale to be used on the above site conditions to fit the model tests at each scale (see Annex D Table D.1).

Should include:

- a description of any mathematical device model, where available, detailing how the testing may assist in advancing and refining such model, and verifying that the model includes the governing physics.

May include:

- technical advantages and improvements the device introduces over other WECs;
- literature review of similar systems.