Standardisation of Offshore Energy System Testing

Deliverable 2.4: Test Verification Process

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MaRINET2

Deliverable 2.4: Test Verification Process

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ABBREVIATIONS

HSE – Health, Safety and Environment

IPR – Intellectual Property Rights

NDA – Non-Disclosure Agreement

ROM – Rough Order of Magnitude (for example, of a cost estimate)

TECS – Tidal Energy Converter Systems

TRL – Technology Readiness Level

WECS – Wave Energy Converter Systems

1. Introduction to verification

This document describes a process by which test results may be verified by a third-party to ensure that the methodology and analysis have been applied in a scientific and logical way.

The intention is so that there is a process which MaRINET2 test facilities can follow to ensure independence, quality, repeatability and robustness. The steps of this process are outlined in Figure 1.

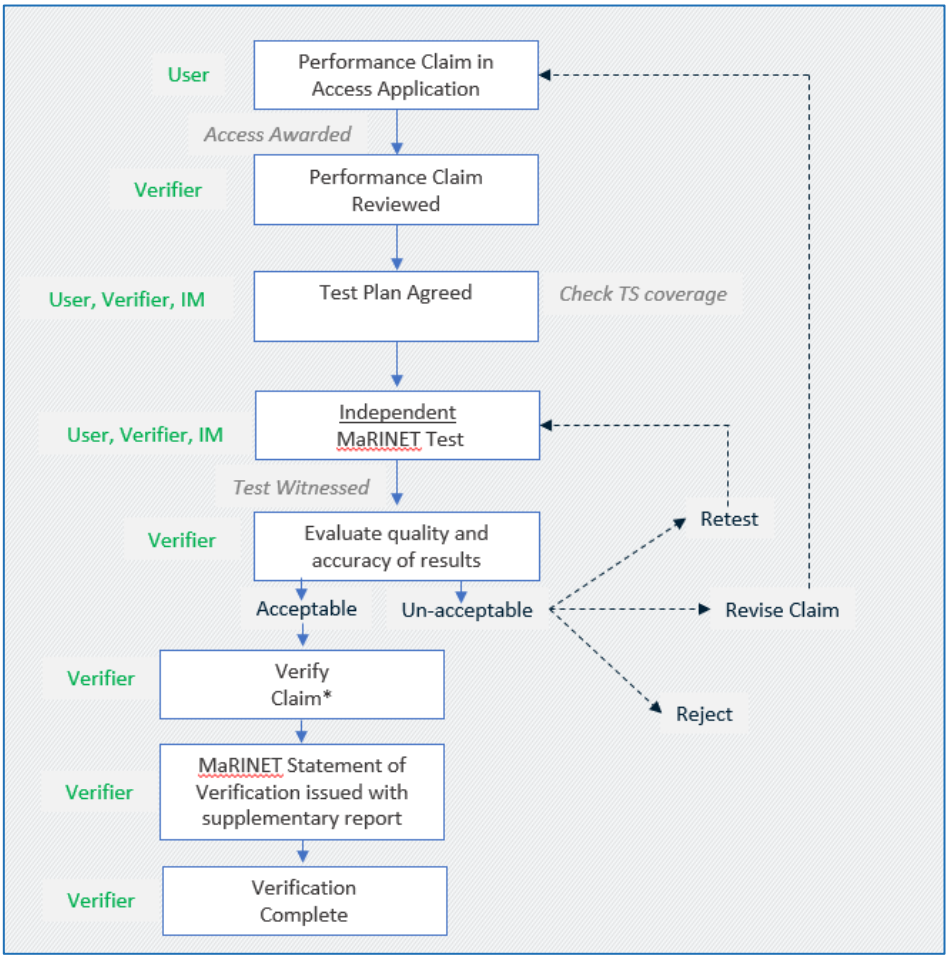

Figure 1: MaRINET2 test verification process

The contents of this document describe how independence may be maintained, protocols for communication between parties, detailed advice on experiment design and uncertainty analysis as well as reporting requirements and other general guidance.

2. Terms and definitions

The following terms are used in various places through this document and are helpful in understanding terminology.

TERM	Definition
Additional parameter	'Additional parameter' means other effects that will be described but are considered secondary.
Amendment	´Amendment´ is a change to the verification protocol or a test plan made before the verification or test step is performed.
Deviation	´Deviation´ is a change to the verification protocol or the test plan made during the verification or test step.
Operational parameters	'Operational parameters' means measurable parameters that define the application and the verification and test conditions. Operational parameters could be production capacity, concentrations of non-target compounds, etc.
Performance claim	'Performance claim' means a set of quantified technical specifications representative of the technical performance of a technology in a specified application and under specified conditions of testing or use (operational parameters).
Purpose	'Purpose' means the measurable property that is affected by the technology and how it is affected. Purpose could be the reduction of nitrate concentration in wastewater effluent measured as mg NO3 -/l reduction.
Test performance audit	'Test performance audit' means the quantitative evaluation of a measurement system as used in a specific test, e.g. evaluation of laboratory control data for relevant period (precision under repeatability conditions, trueness), evaluation of data from laboratory participation in proficiency test and control of calibration of online measurement devices.
Test system audit	'Test system audit' is the qualitative on-site evaluation of test, sampling and/or measurement systems associated with a specific test. E.g. evaluation of the testing done against the requirements of the verification protocol, the test plan and the quality manual of the test body.
Test system control	'Test system control' is the control of a test system as used in a specific test. E.g. test of stock solutions, evaluation of stability of operational and/or on-line analytical equipment, test of blanks and reference technology tests.
Verification	'Verification' means the provision of objective evidence that the technical design of a given technology ensures the fulfilment of a given performance claim in a specified application, taking any measurement uncertainty and relevant assumptions into consideration.
Verification protocol	'Verification protocol' means the protocol describing the specific verification of a technology.

Table 1 - List of terminology

3. Process phases overview

The following sections outline at high level the sequential phases of the process. It should be acknowledged that the process will not necessarily be entirely linear in practice and may require revision of the different phases as events unfold.

3.1 Contact phase

In the contact phases the objective is to determine whether the technology to be tested and the nature of the test requirements fall within the scope of the facility and the third party verifier. In this phase the following will be determined and recorded:

a) Name of technology
b) Basic architecture and working principles
c) The requirements or performance criteria or claims to be verified by test
d) Timescales available for the verification

This is carried out by means of a technical verification questionnaire which describes the attributes of the technology, details of which are provided in appendix 1. From this a ROM cost will be identified by the facility and the verifier independently. At this stage both the facility and verifier will agree on whether to take the process forward.

3.2 Application phase

The first objective is to refine the proposed test and verification activity sufficiently to write a contract for services outlining the high-level steps to be taken, timescales and cost.

It may be necessary at this stage to request more detailed technical information about the technology in question.

In this phase the client will submit a proposal for verification for which there is a standard proposal form. The details required by this form are given in appendix 2. This application will then be reviewed by the facility and verification managers in order for a description of services to be drawn up forming the basis of the verification contract.

During this phase it may be necessary to refine the requirements (claims) such that they are concise and capable of verification. The following categories, or combination thereof, may apply:

- Functional requirements
- Non-functional performance requirements
- Non-functional system requirements
- Methods for expressing requirements and documenting them

3.3 Preparation phase

In the preparation phase the verification requirements and any supplementary evidence will be considered in detail by the test facility manager.

In this phase the experiment design must be reviewed to ensure that effects of random error, bias etc, are minimised appropriately.

Required calibrations must be identified and procured or confirmed to exist by examination of calibration documentation.

Quality assurance and control measures to be in place.

In advance of testing the following should be understood:

1. Requirements of test design and data quality
2. Definition of calculation methods
3. Description of operational and additional parameters to be dealt with
4. Assessment of any existing predictions/data or expectations
5. Preliminary Uncertainty Assessment prepared

An output of this phase will be the Test Plan which is covered in section 7 "Test Plan Agreement" and the Verification Protocol the contents of which are listed in appendix 3.

Where applicable international standards might be followed, these will be noted. Where the client has existing evidence to support verification of requirements, the value of this evidence will be reviewed and any gaps which are to be filled by the proposed verification activity will be understood and incorporated in the Test Plan.

3.4 Testing phase

The testing shall be carried out to the agreed Test Plan which was detailed in the preparation phase. Records will be kept which enable this to be proven. The duration and conditions of testing will form part of the agreed Test Plan.

Audits to assess compliance with the Test Plan will be made – as a minimum these will normally include a performance test audit and a test system audit, both are described in section 2 – Terms and Definitions.

3.5 Verification phase

During the verification phase the evidence pertaining to the requirement to be verified will be reviewed. At this stage an understanding of uncertainty and statistical significance of results will be necessary to provide an impartial view of the result. The Verification Protocol (from the Preparation Phase) will be used to carry out the verification against the Test Plan as described in section 7.

A report detailing the Test Plan, compliance to the plan, noted deviations and the results, including uncertainty and statistical analysis, will be compiled. In addition, an executive summary will be drafted and included on a verification certificate highlighting the key findings.

3.6 Publication phase

There will be a final technical review of all of the verification material which will then be sent to the client.

The client will have the chance to review the report and the conclusions and determine the degree to which information that may be commercially sensitive can appear in any published document.

The reporting requirements and MaRINET statement are outlined in section 11.

4. Verification bodies

Organisations providing personnel to carry out the verification process described by this document are required to ensure that personnel carrying out verification receive appropriate training and support to competently deliver the services described.

Table *2* lists MaRINET2 partners capable of acting as verification bodies and their scope.

MaRINET Verification Body	Scale test tank	Sea trials	Electrical	Cross-cutting
EMEC	✓	✓		Materials
Ifremer	✓			
UNEXE	✓	✓		Moorings
ECN	✓	✓		
SINTEF			✓	
Tecnalia	✓	✓	✓	Materials
UCC MaREI	✓		✓	

Table 2: MaRINET2 verification bodies and scope

It is preferred that bodies performing testing are independent from organisations performing testing. If this is not the case, then sufficient evidence of independence between staff carrying out verification and testing must be demonstrated.

5. The performance claim(s)

The Technology Developer's proposal must address the following items as shown in section 3 of MaRINET 2 User Guidelines for Transnational Access:

Eligibility Criteria – this is to ensure the application is placed and evaluated in the correct category.

Technical Feasibility Criteria – these relate to whether or not the receiving facility can accommodate the technology and meet the requirements of testing to enable the claims to be verified.

Scientific Evaluation – these are the key points of science that the panel of technical experts evaluate. The application will only be submitted to the experts if the above matters have been cleared and approved.

Selection Committee Issues – these include available access time and general project management matters.

The Developer drafts claims formally as part of application phase (2.2 above) but the essential points of claims should be mentioned at initial contact (2.1 above) as these are the matters around which any testing must be designed, it is a key part of determination of the correct site and facilities required to verify the claim(s).

Claim(s) must be SMART – specific, measurable, achievable (in the reasonable belief of the Developer), realistic (relate properly to the TRL, etc of the device), and timely so that testing can be delivered in an acceptable timescale compatible with the requirements of the MaRINET2 rules (e.g. the normal testing period of 6 months).

6. Performance claim review

This is the formal review of claim(s) from which they are to be confirmed as feasible or otherwise for proving in any proposed independent MaRINET Test.

It will describe the level of test required, which must form the basis of the agreed Test Plan. A range of issues will be addressed focused around the quantification and measurement of the parameters included in the claim(s). An example might be: how closely the claim can be measured to fit with requirements for traceability of measurement. Traceability of calibration must show a firm link of procedures that are essentially measurements of mass, length and time to be deemed fully traceable. If an ILAC[1] laboratory (e.g. UKAS in the UK) stamp is required, all measurements will need to be fully traceable and the laboratory must either be ISO 17025 accredited or an audit must be carried out to ascertain that a non-accredited laboratory meets the requirements of the standard.

The implications for the Test Plan of the proposed test facilities must also be considered. This could be connected to a range of issues including: the quality of the resource characterisation at the site; the physical dimensions of the site, water depth, channel width, etc; grid connection and means of measuring electrical power output from the test device.

Relevant technical specifications or standards are important; MaRINET2 deliverable D2.1[2] provides a comprehensive literature review of standards and guidance relevant to the marine renewable energy sector. Particular attention may be paid to:

- IEC TS 62600-100 (for WECS)
- IEC TS62600-200 (for TECS)
- IEC 61400- part 12
- IEC TS 62600-103, Best practice guidelines and recommended procedures for the testing of pre-prototype devices
- IEC TS 62600-2, Design requirements for marine energy systems
- IEC TS 62600-3, Loads measurement of marine energy devices
- IEC TS 62600-4, Technology qualification

The extent and number of likely deviations from the relevant standard will be assessed and the impact of these on the performance measurement will be considered.

This initial review may involve re-draft of claim(s) where it can be shown that the measurement is not feasible, or some other aspect of the device or test site renders the form of the claim to be non-viable.

Where results of a previous test are made available the same issues described above will be reviewed for those results. That would include the calibration status of all instrumentation involved in essential measurements, their applicability and traceability and impact on uncertainty measurement of the results. This process may show up gaps in the integrity of such test results that may only be resolved by further testing.

General areas covered by ISO 17025 that the test site would follow are outlined in appendix 4.

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[1] ILAC –is the International Laboratory Accreditation Cooperation (see https://ilac.org/about-ilac/)

[2] D2.1: Test recommendations and gap analysis report, Revision 1.3, D Noble, S Draycott, 18th May 2018

7. Test plan agreement

This section outlines the content of the Test Plan to be agreed between the Developer, Verifier and Infrastructure Manager (IM). It is assumed that previous testing has gaps that may only be resolved by testing further. The Test Plan will be documented as part of the verification protocol, full contents of which are described in appendix 3.

The Test Plan begins with an overview of the test method including: the precise objectives of testing, facility specification, site readiness[3], estimating the acquisition of sufficient data to meet the objectives bearing in mind the need for statistical significance. It may refer to standards and the test site's internal methods.

For sea trials, there is a need to ensure test site characterisation is satisfactory (IEC TS 62600-101 and -201) for the proposed test. The exposure of the site and its impact on access to the device is also important as this may be affected by timing of the test in relation to environmental conditions.

For small scale devices IEC TS 62600 -202 and IEC TS 62600-103 are relevant for tidal stream and wave energy devices respectively. In such cases particular care must be given to ensuring that the specifications of the facility enable testing at the required non-dimensional parameters for inferring full scale results.

Deployment of measuring devices will be considered either for the duration of the test, for specified periods as well as the need for any modelling ahead of the test period.

The requirements of a data gathering and measurement system will be specifically defined for both incident resource and produced voltage and current[4].

The detailed method statement for testing will include:

- Duration and timing
- Requirements of foundations/moorings
- Installation method including sub-contractor responsibilities and specialised equipment
- Safety plan incorporating any bridging document required to interface with the IM's HSE system
- Data gathering and record keeping
- Confirmation of relevant standards to be used and consideration of deviations
- Instrumentation and measurement, calibration and traceability issues
- Initial review of uncertainty budget
- Preparation for logbook and reporting

The overall budget and Developer's ability to fund the activity not eligible for reimbursement should be checked as excessive delay in raising funding may exclude the opportunity to test.

[3] Here it is assumed that the device readiness has been substantially established at the Application Phase
[4] If the device produces some other vector such as pressurised water, appropriate instrumentation and data gathering must be specified

8. Independent MaRINET2 test

This will be conducted according to the agreed plan and the number and initial impact assessment of likely deviations from testing standards must be acceptable to the Verifier.

Shortcomings in results or excessive missing data (exceeding the agreed levels specified in the Test Plan) may require full or partial re-test or specific aspects of test to be repeated. Note that testing is unlikely to be repeated more than once (whole test) and then only under very exceptional circumstances.

Reporting will conform to test standards with acceptable deviations reported and impact assessments on performance.

The key elements of the test report to comply with the Test Plan will be:

- Analysis and measurements
- Preservation and storage of data
- Uncertainty contributions as given in validation documentation and adjusted for changed values[5]
- Calibration certificates where required
- Measurement data where required
- Test report – significant events from log of test
- Deviations report including estimated impact on performance

The Verifier, Developer and IM will agree on the conduct of the test and the report contents as a true record of testing before proceeding to verification.

[5] The documents by UKAS:" Lab 12 Ed 2 "The Expression of Uncertainty in Testing" (2016) and M3003 Ed 4 "The Expression of Uncertainty and Confidence in Measurement" (2019 draft) are appropriate guides

9. Verification – quality and accuracy

The verification body will ideally be accredited to ISO 17020 (2012) or will be audited to ascertain compliance. A content list of this standard is given in appendix 5.

Verifier must test the aspects and criteria given in sections 5 to 8 above, Firstly to ensure the following steps are implemented:

- Assessment of data and review of test procedure and that testing has complied with the plan
- Verification – the activities covered in this section
- Drafting Verification Report and preparing the Verification Certificate (described in section 11)

The verification process will identify a range of issues:

Assessment of Data

The Verifier will consider at this point any data that was accepted at the application stage together with results from the MaRINET2 testing. The intent is to be satisfied that the whole set of data is suitably complete. That is to say that missing data falls within the prescribed limits in the plan and is agreed with the IM if arising from the test. It is permissible in the event of problems to revise the requirements in the Test Plan and verification protocol if all parties agree. As shown in Figure 1 it is acceptable to re-test or test some subset of the test programme subject to the MaRINET2 rules and the availability of the test facilities. Once the final dataset is agreed it may be included in the report.

Verification

This is essentially the collation and detailed review of all information and reports obtained, with particular emphasis on the quality assurance aspects that were required by the plan.

If additional information is made available (perhaps arising from the test operations) that could not have been assessed earlier, this should now come under review and assessment. The Verifier will determine the acceptability of such additional information for inclusion in the report.

The verification will conclude that the report and all associated data provide reasonable and fair evidence that the performance claim(s) are met.

The Verification Report will follow the format given here:

1 Introduction

2 Description of the technology and application

3 Existing data

4 Evaluation

5 Quality assurance

6 References

Appendix A: Terms and definitions

Appendix B: Contact questionnaire

Appendix C: Proposal
Appendix D: Verification protocol
Appendix E: Amendment and deviation report
Appendix F: Test Plan (where relevant)
Appendix G: Test report (where relevant)

10. Verifying claims

The Verification Report will be reviewed with the Developer and any consideration of modified claims should be made at this time.

Revised claims to be checked and assurance provided and agreed that evidence from tests adequately supports claim(s). Uncertainties must not be such that they effectively invalidate claims.

11. MaRINET verification statement

The Verification Statement will consist of a summary Verification Report and a Verification Certificate. A typical format of a certificate is given in appendix 6. The form of the summary report will be agreed with the Developer.

Particular attention must be paid to the Developer's IPR to ensure that nothing is published that breaches the terms of the IPR and NDA's that have been signed between Verifier, IM and Developer.

The Verification Statement will consist of:

- A summary description of the technology verified
- The verified parameters or verified performance claim(s), including the conditions and assumptions under which the verified performance is met
- References to the verification protocol and report
- Any information necessary to understand and use the verified performance claim(s); if this includes information not verified during the verification procedure this should be clearly stated and explained.

12. Appendices

These to include checklists and requirements under key standards as well as any information that is bulky and destroys the run of main text.

12.1 Appendix 1 – Technical Verification Questionnaire

The questionnaire requires details of the Developer and is focused on the technology to provide details enabling the feasibility of verification. In addition, market readiness, level of innovation, legal requirements, IPR status and data from any previous tests are covered.

Technology questionnaires may include the following topics:

- Name of the technology
- Outline of the specific problem areas or opportunities that the technology is intended to address
- The main purpose of the technology showing how it meets the problems and opportunities
- Provision of "relevant alternatives" to assist the determination of added value and innovation by means of a qualitative and/or quantitative (subject to data availability) comparison with another technology that is at least TRL3 and which performs a similar (or the same) function as the applicant's technology
- The scientific principle(s) and techniques on which the technology is based
- The main claims, the first of which is performance, that are to be verified. These claims may be modified in the verification process. They must be couched in absolute rather than comparative terms.
- Details of operating parameters and limiting conditions under which the claimed performance is to be demonstrated
- Technical standards, regulations or other references that govern the design of the technology. This could include any existing guidelines that would be useful in the verification process.

The market readiness of the technology is then questioned which refers to TRL, the scale of the device and the possible impact of any changes that would be made in developing into a commercial version of the technology. Any forecast effect of these changes on performance is to be documented.

The Innovation level is to be addressed by comparison with a relevant alternative technology. Apart from performance, differentiators such as energy or emissions embedded in the production process, recyclability or ease of final disposal may be included here.

The extent to which the technology meets user needs is to be documented; this should be in relation to the market highlighting the real advantages to the user.

Existing data, which could include results of previous testing, may also be submitted in support of performance claims

The extent to which the technology meets legal and regulatory requirements of the target market(s) is to be defined.

IPR status, in terms of ownership or any licensing or contractual rights conferred, enabling the technology claims to be verified. Any issues relating to IPR that could affect the infrastructure provider or the verification body shall be declared.

If there is any aspect of the technology that is relevant to verification but has not been made clear by the foregoing questions, should also be described.

It may be taken that all the data and information supplied under this questionnaire will be held in confidence by the MaRINET2 partners and permission must be given for the sharing of this information in a confidential manner. This is relevant to the harmonisation and improvement of the verification service.

12.2 Appendix 2 – Verification Proposal Form Content

This form is prepared initially by the applicant and contains more detail than the Questionnaire described in the previous appendix.

The main elements of the proposal contents are:

- Basic details of the Applicant
- Note of any previous verification of the technology
- Any relevant remarks from the Contact Questionnaire to be taken into account
- Unique name and detailed description of the technology including documentation of:
  - Overall narrative description
  - Design drawings including schematics, component details, sub-assemblies and circuits
  - Manufacturing drawings
  - Narrative description in support of the drawings required for clarity
  - List of relevant standards or technical specifications
  - Results of design calculations and any examinations carried out
- Intended Application of the technology which will be a measurable property verifiable by testing together with any conditions that apply
- The initial performance claim(s) may then be defined in quantitative terms including any assumptions made
- A full description of the testing already performed and the associated existing data, including the qualification of the test body and a complete test plan if possible

The second part of the form is for the Verification Body to fill out following review of the above information. This will include conclusions as to whether or not previous testing is admissible for the verification and whether or not the previous testing supports the claim(s).

The form is signed by both Applicant and Verification Body.

12.3 Appendix 3 – Verification Protocol Contents

The Table of Contents is as follows:

12.4 Appendix 4 – Outline of ISO 17025: 2017 requirements

This appendix is selective in providing an insight into the major requirements of the standard to give the general intent. For full details the standard itself should be referenced.

Scope
This document specifies the general requirements for the competence, impartiality and consistent operation of laboratories.
This document is applicable to all organisations performing laboratory activities, regardless of the number of personnel.
Laboratory customers, regulatory authorities, organisations and schemes using peer-assessment, accreditation bodies, and others use this document in confirming or recognising the competence of laboratories.

General Requirements
Impartiality, confidentiality

Structural requirements
Legal entity, management, defined activities, methods of implementation

Resource Requirements
General, personnel, facilities and environmental conditions, equipment, metrological traceability, externally provided products and services

Process requirements
Review of requests, tenders and contracts
Selection, verification and validation of methods
7.2.1 Selection and verification of methods
7.2.2 Validation of methods
7.3 Sampling
7.4 Handling of test or calibration items
7.5 Technical records
7.6 Evaluation of measurement uncertainty
7.7 Ensuring the validity of results
7.8 Reporting of results
General
7.8.2 Common requirements for reports (test, calibration or sampling
7.8.3 Specific requirements for test reports
7.8.4 Specific requirements for calibration certificates
7.8.5 Reporting sampling – specific requirements
7.8.6 Reporting statements of conformity
7.8.7 Reporting opinions and interpretations
7.8.8 Amendments to reports
7.9 Complaints
7.10 Nonconforming work
7.11 Control of data and information management

8 Management system requirements
General
Options
8.1.2 Option
8.1.3 Option B – ISO 9001 organisation

8.2 Management system documentation
8.3 Control of management system documents
8.4 Control of records
8.5 Actions to address risks and opportunities
8.6 Improvement
8.7 Corrective actions
8.8 Internal audits
8.9 Management reviews

ISO/IEC 17025:2017(E)

Annex A (informative) **Metrological traceability**
Annex B (informative) **Management system options**
Bibliography

12.5 Appendix 5 – Contents of ISO17020 (2012)

12.6 Appendix 6 – Typical Form of Verification Certificate

Remove this text box before using this template.
If printing this template always print in colour.

LOGO of Test Facility/IM

Verification Certificate

Proposer: ***Insert Developer company name here***
Insert Developer address here
Name of Technology: ***Insert name of technology here***

The *insert name of technology* was tested at *insert test site name here*, on the *insert test date(s) here*. Verifier XXXXXXX verifies that the *insert name of technology here* met the following performance claim(s):

- *Insert the performance claim(s) verified here*

Documentation used for showing compliance with the requirements:

Reference	Title	Issued by	Version	Date
REPxxx	*Insert verification report reference on last line.*			

NOTE: This Verification Certificate is part of the full verification report identified above and should be read in conjunction with it.

Authorised by:

Name: *Insert name of Verifier staff authorising the verification*
Title: *Insert the position of Verifier staff authorising the verification*
Date: *Insert date*
Signature:

Insert Verifier Details here

Insert logo of accreditations here