IECRE OD-551-12

Edition 1.0 2016-02-26

IECRE OPERATIONAL DOCUMENT

IEC System for Certification to Standards relating to Equipment for use in Renewable Energy applications (IECRE System)

Power performance measurements of electricity producing wind turbines

IECRE OD-551-12:2016(EN)

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INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

PRICE CODE ZZ

CONTENTS

1 Introduction

This OD covers the assessment of a power performance test for Test Laboratories who want to get this competence area recognised under IECRE.

Specifically, this ODs covers the standard assessment as per the WE-OMC Rules of Procedure. The scope of this OD is the IEC 61400-12-1 standard with the following Annexes excluded:

- Annex F: Anemometer calibration
- Annex I: Classification of anemometry
- Annex J: Assessment of cup anemometry

This scope is referenced in this OD as 'the standard'.

The standard assessment is based on four elements:

– A review of three reports issued by the Applicant within the last three years
– Successful participation in a power performance proficiency test
– Review of key internal procedures
– Witnessing of one anemometer calibration

In this document, the Applicant is the organisation asking for an assessment according to this OD. The applicant may be an already recognised RETL or an organisation not yet recognised under IECRE for this competence area. An RETL refers to an IECRE recognised Test Laboratory.

2 Review of reports issued

In order to have three reports reviewed, the Applicant shall submit an overview of reports submitted the last three years with the IECRE logo. In case the assessment is for a candidate RETL or the Applicant has issued fewer than three IECRE test reports for power performance testing, the Applicant shall submit to the IECRE Secretariat a list of reports issued that state compliance with the standard

The Lead Assessor, together with the Technical Assessors and/or experts, shall select from this list three reports. These reports have to be submitted to the IECRE Secretariat by the Applicant.

The reports shall be reviewed for compliance with the standard, as per the checklist in Annex A of this OD. A filled-out version of the checklist shall be included in the final assessment report.

3 Proficiency testing

3.1 Topics of proficiency test

The following aspects of the power performance testing shall be covered by the proficiency test and the results from multiple test laboratories shall be compared. For each entry the number of results where a comparison shall be done, documented and reported is indicated.

1) Site calibration factor for each end of each wind speed sector (multiple results)
2) Site calibration uncertainty for each wind speed sector (multiple results)
3) Filtering of data
4) Average power per bin, for each bin (around 25 to 40 results), Database A
5) Average power per bin, for each bin (around 25 to 40 results), Database B
6) AEP measured, for each Annual Average Wind Speed (7 results)
7) AEP extrapolated, for each Annual Average Wind Speed (7 results)

8) Terrain assessment on each criterion of Annex B (8 results (max slope and max terrain deviation evaluated for 4 distances))
9) Each end of the measurement sector according to Annex A (multiple results)
10) Each end of the final measurement sector (possibly reduced measurement sector including site calibration influence) (multiple results)
11) Power curve uncertainty per bin as per Annex D and E (around 25 to 40 results)
12) AEP uncertainty per Annual Average Wind Speed (7 results)
13) In situ calibration according to Annex K, for each bin to be evaluated (4 results)

3.2 Requirements

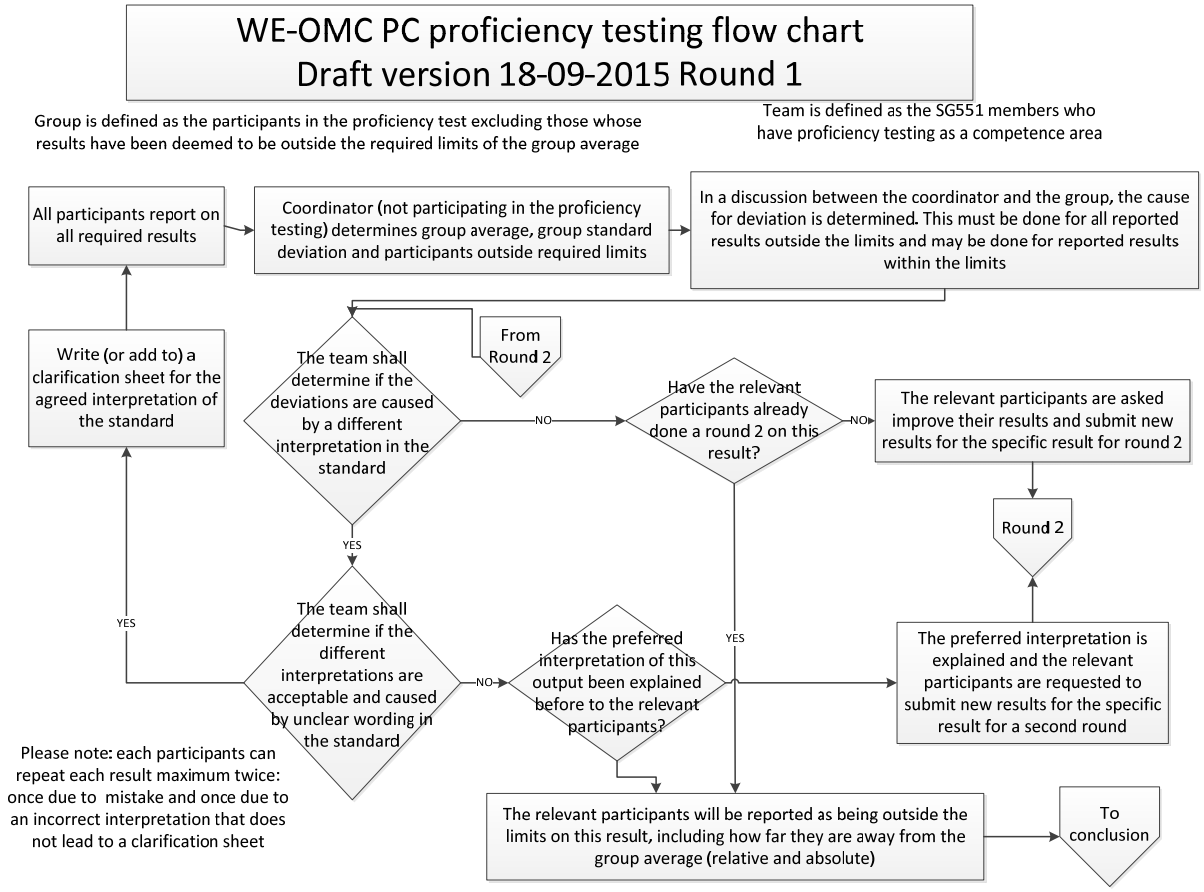
In order for the proficiency test to give reproducible results, for each of the above entries under 3.1 this OD defines a limit within which the successful Applicant must report its results.

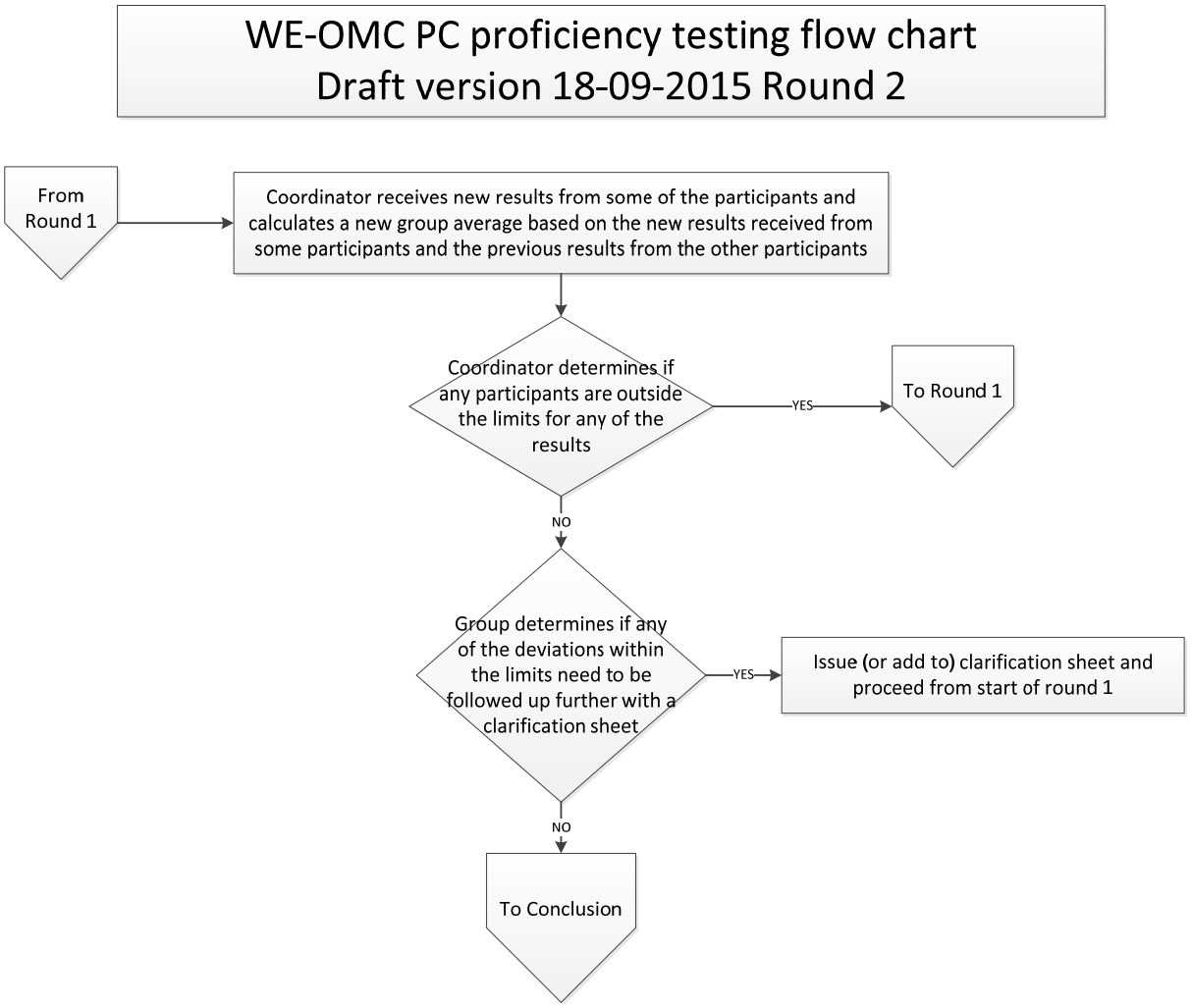
	Aspect	**Acceptable deviation from group average**
1	Site calibration factor for each end of each wind speed sector	0.1%
2	Site calibration uncertainty for each wind speed sector	1%
3	Filtering of data	Identical amounts of data points in each bin
4	Average power per bin, for each bin, Database A	0.1%
5	Average power per bin, for each bin, Database B	0.1%
6	AEP measured, for each Annual Average Wind Speed	0.1%
7	AEP extrapolated, for each Annual Average Wind Speed	0.1%
8	Terrain assessment on each criterion of Annex B	1%
9	Each end of the measurement sector according to Annex A	0.1 degree
10	Each end of the final measurement sector (possibly reduced measurement sector including site calibration influence)	0.1 degree
11	Power curve uncertainty per bin as per Annex D and E	5%
12	AEP uncertainty per Annual Average Wind Speed	10%
13	In situ calibration according to Annex K, for each bin to be evaluated	0.1%

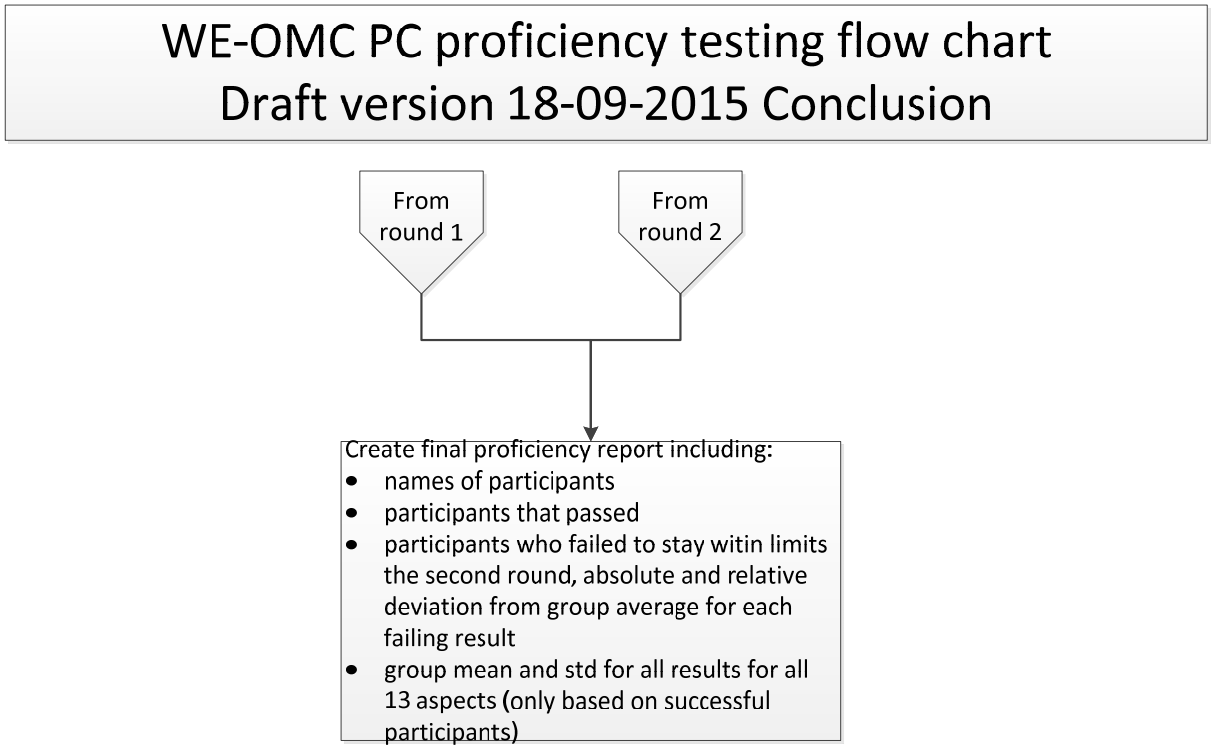
3.3 Process

The process that shall be followed for the proficiency testing is described in OD XXXXX. (Reference to OD with process description for proficiency testing, this OD does not exist yet).

A proposal for such a process (to be included in a separate OD) is:


WE-OMC PC proficiency testing flow chart
Draft version 18-09-2015 Round 1
Group is defined as the participants in the proficiency test excluding those whose results have been deemed to be outside the required limits of the group average
Team is defined as the SG551 members who have proficiency testing as a competence area
All participants report on all required results
Coordinator (not participating in the proficiency testing) determines group average, group standard deviation and participants outside required limits
In a discussion between the coordinator and the group, the cause for deviation is determined. This must be done for all reported results outside the limits and may be done for reported results within the limits
From Round 2
Write (or add to) a clarification sheet for the agreed interpretation of the standard
The team shall determine if the deviations are caused by a different interpretation in the standard
NO
Have the relevant participants already done a round 2 on this result?
NO
The relevant participants are asked improve their results and submit new results for the specific result for round 2
Round 2
YES
YES
The team shall determine if the different interpretations are acceptable and caused by unclear wording in the standard
NO
Has the preferred interpretation of this output been explained before to the relevant participants?
YES
The preferred interpretation is explained and the relevant participants are requested to submit new results for the specific result for a second round
Please note: each participants can repeat each result maximum twice: once due to mistake and once due to an incorrect interpretation that does not lead to a clarification sheet
The relevant participants will be reported as being outside the limits on this result, including how far they are away from the group average (relative and absolute)
To conclusion


WE-OMC PC proficiency testing flow chart
Draft version 18-09-2015 Round 2
From Round 1
Coordinator receives new results from some of the participants and calculates a new group average based on the new results received from some participants and the previous results from the other participants
Coordinator determines if any participants are outside the limits for any of the results
YES
To Round 1
NO
Group determines if any of the deviations within the limits need to be followed up further with a clarification sheet
YES
Issue (or add to) clarification sheet and proceed from start of round 1
NO
To Conclusion


WE-OMC PC proficiency testing flow chart
Draft version 18-09-2015 Conclusion
From round 1
From round 2
Create final proficiency report including:
• names of participants
• participants that passed
• participants who failed to stay witin limits the second round, absolute and relative deviation from group average for each failing result
• group mean and std for all results for all 13 aspects (only based on successful participants)

4 Review of internal procedures

4.1 Identification of key procedures

The following procedures should normally be checked:

– Installation of anemometers in the meteorological mast
– Installation of wind vanes in the meteorological mast
– Determination of wind vane uncertainty
– Calculation of uncertainty

Text to be added

A review of facilities where equipment is prepared for outside use may be part of the assessment.

4.2 Guidance

For the review of these procedure the following guidance is given:

text to be added.

5 Inspection of field test

As part of the assessment the assessment team shall inspect one test in the field to establish:

1) Compliance with the standard
2) Compliance with the key internal procedures as defined under section 4 of this OD
3) Identify further process or technical issues that could affect the result of the test

Annex A – Checklist

Please note that this checklist is used for reviewing reports as well as the applicant's internal procedures and may be used as well for the on-site inspection

#	Reference to section in standard	Requirement from standard	Checks & expert guidance	Reported / Inspected	Finding
	Identification and description of the specific wind turbine configuration under test (Chapter 5 – Preparation for performance tests / Reported according to 9.a & b)				
1	5: Preparation for performance test	The specific test conditions related to the power performance measurement of the wind turbine shall be well-defined and documented in the test report, as detailed in clause 9.	- Have there been specific test conditions worth mentioning, such as snow and ice (which may affect turbine and sensors), freezing weather (affecting the sensors and cup classification), strong hail - To the extent these are measured, also information regarding shear, veer and upflow is to be reported alongside turbulence		
2	5.1: wind turbine and electrical connection Reporting clause 9.a	As detailed in clause 9, the wind turbine and electrical connection shall be described and documented to identify uniquely the specific machine configuration that is tested.	- Are the wind turbine main characteristics documented according to 9.a) from 1) to 8) - Is it documented how that information is obtained (manufacturer's certificate, in-situ verification,..)? - Check that all points mentioned in 9.a have been included in the report		
3			- Is the electric measurement system documented (by drawing or electrical sketch)?		
3	5.2: test site Annex A – Assessment of obstacles at the test site Annex B – Assessment of terrain at the test site Reporting clause 9.b	The test site shall be assessed for sources of wind flow distortion	No specific guidance		
		Page 39: No significant obstacle (e.g. buildings, trees, parked wind turbines) shall exist in the measurement sector within a reasonable distance from the wind turbine and meteorological mast.	- Are there trees, buildings or parked wind turbines within a 20D distance from the turbine or meteorological mast? The report should also indicate clearly of there are no obstacles within a 20D diameter. - For any existing potential obstacles, has formula A.1 been applied and the results documented?		
		Page 42: If the terrain complies with the requirements of Table B.1, then no site calibration is required.	- Has the resolution of the digital map been defined that has been used to assess the test site? - Check how the planes have been fitted to the terrain. Check that for 'Outside the measurement sector' the line of steepest slope has been used. - Have the maximum slopes found at the test site been documented? (I.e. more documentation is expected than whether the site meets or fails to meet the requirements from Table B.1) - Have the maximum terrain variation from plane been documented? (I.e. more documentation is expected than whether the site meets or fails to meet the requirements from Table B.1)		
		Page 42: If the terrain characteristics are within an additional 50 % of the limits of the maximum slopes shown in Table B.1, then a flow model can be used to determine if a site calibration measurement can be avoided.	- Has a flow model been applied to avoid a site calibration? - What were the documented results as shown by the flow model?		
		Page 42: The flow model shall be validated for the type of terrain	- If a flow model was used, the validation report for the model for the appropriate terrain type shall be checked		
		Page 29 - Does the report contain photographs of all measurement sectors (preferably taken from the wind turbine at hub height)?	- Have the different sectors/directions clearly been indicated on the photographs?		
		Page 29 - Is a map included showing the information in 9.b.2?	No specific guidance		

#	Reference to section in standard	Requirement from standard	Checks & expert guidance	Reported / Inspected	Finding
5	5.2.1 - Location of the meteorological mast	page 14: The meteorological mast shall be positioned at a distance from the wind turbine of between 2 and 4 times the rotor diameter D of the wind turbine.	- In case of several WTG / locations were suitable for testing, is the selected one the most appropriate (from the point of view of the terrain affections, obstacles,…)? - If not, were there constraints forcing the selection of the turbine to be tested?		
			- Is the selected location of the met mast appropriate (upwind, alongside if on a ridge,…)? - If not, were there constraints forcing the selection of the tested one?		
			- Is the reported distance from the met mast to the tested WTG between 2D and 4D (or L+0,5D for vertical axis wind turbine)?		
		Page 33: The minimum distance from the wind turbine under test and the meteorological mast to neighboring and operating wind turbines shall be two rotor diameter D_n of the neighboring wind turbine or two rotor diameter of the wind turbine under test if it has a larger diameter.	No specific guidance		
6	5.2.2 - Measurement sector	The wind turbine under test and the meteorological mast shall not be influenced by neighboring wind turbines. If a neighboring turbine is operated at any time during the power performance test, its wake shall be determined and accounted for as described in this annex. If the turbine is stopped at all times during the power performance test, it shall be considered as an obstacle and accounted for as described in Clause A.2	No specific guidance		
		page 15: The measurement sector(s) shall exclude directions having significant obstacles and other wind turbines, as seen from both the wind turbine under test and the meteorological mast.	- Is the measurement sector reported? - Have all the neighbouring and operating WTG considered as obstacles been reported (location, distance Ln and rotor diameter Dn)? - Have all the excluded measurement sectors due to the wake of each of those obstacles upon the mast and the turbine bee reported? - Have all other significant obstacles clearly been reported (buildings, trees, parked WTG) and considered for the calculation of the measurement sector (location, distance Le and equivalent rotor diameter De)? - Has the influence of each of those obstacles been reported according to chapter A.2? - Have the excluded measurement sectors due to the wake of each of those obstacles upon the mast and the turbine been reported?		
		Page 15: All reasons for reducing the measurement sector shall be clearly documented.	- Has the measurement sector been reduced for any other reasons than those indicated in Annex A of the standard? If so, is this reported and documented in sufficient detail? (site calibration influence,…)?		
8	5.2.3 - Correction factors and uncertainty due to flow distortion originating from topography	page 15: The test site shall be assessed for sources of wind flow distortion due to topographical variations. The assessment shall identify whether the power curve can be measured without a required site calibration.	- Has the assessment of the test site according to Annex B been documented? - Have the analysis results and results of the terrain assessment according to Table B.1 been reported (slope and terrain variation from plane for each of the sectors)?		
			- In case that no site calibration is required, has it been documented what the applied uncertainty due to flow distortion of the test site is? If other values are used than per 5.2.3 of the standard – has objective evidence been provided for such a decision?		

#	Reference to section in standard	Requirement from standard	Checks & expert guidance	Reported / Inspected	Finding
	Test equipment (Chapter 6 – Test equipment / Reported according to 9.c)				
11	6.1 – Electric power Reporting clause 9.c	page16: The net electric power of the wind turbine shall be measured using a power measurement device (e.g. power transducer) and be based on measurement of current and voltage on each phase.	No specific guidance		
		The power measurement device shall be mounted between the wind turbine and the electrical connection to ensure that only the net active electric power (i.e. reduced by self-consumption) is measured	- Is the power measurement device mounted in such a way that it ensures the measurement only of the active electric power (i.e. reduced by self-consumption)?		
		It shall be stated whether the measurements are made on the turbine side or the network side of the transformer.	- Is it stated whether the measurements are made on the turbine side or the network side of the transformer? (drawing as per Item 2 is valid)		
12		page16: The class of the current transformers shall meet the requirements of IEC 60044-1	- What is the class of current transformers? Are they class 0.5 or better (according to IEC 61869-2)?		
		Page 16: the class of the voltage transformer, if used, shall meet the requirements of IEC 60186. They shall be class 0.5 or better.	- What is the class of voltage transformers (if used)? Are they class 0.5 or better (according to IEC 61869-3)?		
13		page16: the accuracy of the power measurement device, if it is a power transducer, shall meet the requirement of IEC 60688 and shall be class 0.5 or better	- What is the class of the power transducer? Is it class 0.5 or better (according to IEC 60688) or equivalent (if no power transducer is used)?		
14		page16: The operating range of the power measurement device shall be set to measure all positive and negative instantaneous power peaks generated by the wind turbine. All data shall be periodically reviewed during the test to ensure that the range limits of the power measurement device have not been exceeded	- How have the results of these reviews been documented?		
15		page 16: The power transducer shall be calibrated to traceable standards.	- Check the calibration certificate of the power transducer		
17	Clause 6.2: Wind speed (general and mounting requirements) Annex G – Reporting Clause 9.c	page 16: Wind speed measurements shall be made with a cup anemometer that meets the requirements in Annex I	No specific guidance		
		page 16: For power performance measurements an anemometer with a class better than 1.7A shall be used	- Required: Anemometer with class better than 1.7A (if site calibration not required)? - Recommended: Anemometer with class better than 2.5B (if site calibration required)?		
18		page 16: All reported wind speeds, and all uncertainties connected to operational characteristics shall be related to this wind speed definition	No specific guidance		

#	Reference to section in standard	Requirement from standard	Checks & expert guidance	Reported / Inspected	Finding
		page 17: The requirements given in Annex G with respect to mounting shall be used	- Has it been reported whether configuration according to clause G.2 - Fig G.1 (preferred) or clause G.3 - Fig G.2 (alternative) has been used for the mounting of top anemometer?		
		Page XX: During calibration the cup anemometer shall be mounted on a vertical tube configuration similar to the one being used during the power performance test	- Is it the anemometer mounted on a vertical tube configuration (tube diameter) similar to the one used for the calibration? - Has the tube diameter during test been documented? - Has the tube diameter during calibration been reported in the calibration report? - 'Similar' has to be interpreted in relation to the influence a different tube diameter would have on the validity of the calibration. Very small differences have (sometimes surprisingly) large influences. Any difference in tube diameter should be well documented and assessed for influence on measurement uncertainty.		
		page 17: The cup anemometer shall be mounted at hub height of +-2.5%, relative to the ground at the meteorological mast	- Is the top anemometer mounted within 2.5% of HH? How has this been determined? Would a mistake in erection of the meteorological mast have been detected?		
19	Clause 6.2: Wind speed (calibration requirements) Reporting Clause 9.c	page 16: Calibration of the cup anemometer shall be made according to the procedure of Annex F.	- Are the anemometers calibrated according to Annex F?		
		page 16: The cup anemometer shall be calibrated before and recalibrated after the measurement campaign	- Is the verification done through recalibration (calibration of the measurement campaign) or through in-situ comparison according to Annex K (alternative to recalibration)		
		The difference between the regression lines of calibration and recalibration shall be within ±0.1m/s in the range 6m/s to 12m/s.	- Has the difference between the 'before' and 'after' calibration of the anemometer been documented? - The report has to give more details than just indicate compliance with this requirement – to ensure repeatability - Is the difference between the regression lines of calibration and recalibration within ±0,1 m/s in the range 6m/s to 12 m/s? - If the difference is higher, have additional uncertainties been considered for calculations?		
20		page 16: Only the calibration before the measurement campaign shall be used for the performance test.	- Verify that only the 'before' calibration has been used for the power curve measurements		
22		page 17: As an inferior alternative to the recalibration, it shall be documented that the cup anemometer maintains its calibration over the duration of the measurement period. The procedure in Annex K should be used.	- In case that in-situ comparison according to Annex K has been used, it must be verified: - Data used coming from a narrow wind direction sector (e.g. ±20º or ±40º with the centre 90° to the boom, dependent of the measurement sector, and free of disturbances of the mast) - Wind speed range of 6 m/s to 12 m/s. - Method of bins into bins of 1 m/s based on control anemometer wind speed. - Minimum three values per bin and for maximum eight weeks - Linear regression is performed with the control anemometer as dependent variable and the primary anemometer used for the power curve measurement as independent variable		
25		page 17: Uncertainty in calibration shall be derived from Annex F.			
26		page 17: Uncertainty due to operational characteristics shall be derived from Annex I on classification of anemometry.			
27		page 17: Uncertainty due to mounting effects shall be derived from Annex G.			

#	Reference to section in standard	Requirement from standard	Checks & expert guidance	Reported / Inspected	Finding
28	6.3 - Wind direction	page 17: Wind direction should be measured with a wind vane. A wind vane used for this purpose shall be mounted on the meteorological mast on a boom, as described in Annex G.	- Mounting of the wind vane according to Clause G.5: - Between 1.5 m below the primary anemometer and within 10 % of hub height. - Mounted above the boom by a minimum of 15 times the boom diameter - Distance from the wind vane to the mast according to G.6.1 (tubular mast) or G.6.2 (lattice mast), and calculated for a disturbance lower than 1%. - Direction of sensor booms according to G.6.1 or G.6.2 dependent on the prevailing wind speed and measurement sector. - Verify that no upstream guys (or other “accessories”) are placed in the vicinity of the wind vanes The above is valid for any other wind vane used for the calculations (veer filtering,…)		
29	6.4: Air density Reporting Clause 9.c	page 17: Air density shall be derived from the measurement of air temperature and air pressure using equation (1).	- Temperature (+ humidity sensor if used): - Mounted 1.5 m below the primary anemometer and within 10m of HH? - Mounted in a radiation shield?		
30		page 17: The correction for the density effect of the air humidity shall be performed using equation (F.1).	- Is it the air density corrected by considering the effect of the relative humidity? How has this decision been made?		
31		page 17: The air temperature sensor, and the humidity sensor if used, shall be mounted within 10m of hub height to represent the sir temperature at the wind turbine rotor center.			
32		page 17: If the air pressure sensor is not mounted close to the hub height, air pressure measurements shall be corrected to the hub height according to ISO 2533.	- Pressure sensor: - Mounted close to HH? - If not, corrected according to ISO 2533? - Mounted on a waterproof box (properly vented)		
33	6.5 - Rotational speed and pitch angle	page 17: If measured, the measurements shall be reported according to Clause 9	- Have rotational speed and pitch angle been measured?		
	6.6 - Blade condition		- Have been measured and considered in calculations those variables (precipitation, icing) which may affect the power curve (not mandatory, except included in contractual clauses)		
34	6.7 - Wind turbine control system	page 17: Sufficient status signal shall be identified, verified and monitored to allow the rejection criteria of 7.4 to be applied.	- How is the status signal obtained (from the turbine’s controller, other)? - Which criteria have been applied to identify the turbine status based on the monitored signals? - Are the status sufficient to identify the required status: - On/Off: turbine fault condition, turbine manually shut down, turbine off-grid,… - Cut-out hysteresis - Curtailment		
35		page 17: The definition of each status signal shall be reported.	- Check that a clear definition of each status signal has been reported		

#	Reference to section in standard	Requirement from standard	Checks & expert guidance	Reported / Inspected	Finding
36	6.8 - Data acquisition system (documentation of test equipment) Reporting Clause 9.c	Description of the test equipment. This is valid for Power Curve and Site Calibration if applying Electric power measurement: The net electric power of the wind turbine shall be measured using a power measurement device (e.g. power transducer) and be based on measurements of current and voltage on each phase	- Identification of the sensors and data acquisition system (code-serial number, manufacturer, model)?		
		The report shall include "identification of the sensors and data acquisition system, including documentation of calibrations for the sensors, transmission lines, and data acquisition system;"	- Calibration of measurement sensors? - Verify the programming of the sensors (calibration curves) which have been used during the measurements (the ones obtained during the previous calibration)		
		The report shall include a "description of the arrangement of cup anemometers on the meteorological mast, following the requirements and descriptions in Annex G;"	- Calibration of data acquisition system channels and transmission chain?		
		The report shall include a "sketch of the arrangement of the meteorological mast showing principle dimensions of the tower and instrument mounting fixtures"	- Does the sketch provide a top view (incl. direction of the test turbine) and side view		
		page 18: A digital data acquisition system having a sampling rate per channel of at least 1 Hz shall be used to collect measurement and store pre-processed data.	No specific guidance		
37		page 18: The calibration and accuracy of the data system chain (transmission, signal conditioning and data recording) shall be verified by injecting known signals at the transducer ends and comparing these inputs against the recorded readings.	- Check calibration of field calibrator - Check documentation of signal injection: what has been injected, what has been measured and how has this been determined (through data acquisition or read-from-screen)? - Was all the signal conditioning the same as during the measurement?		
	Measurement Procedure and Derived Results (Chapters 7 an 8 / Reported according to 9.d, 9.e, 9.f, 9.g, 9.h and 9.k)				
38	7.1 - General	page 18: The measurement procedure shall be documented, as detailed in Clause 9, so that every procedural step and test condition can be reviewed and, if necessary, repeated	- Have any additional requirements and/or specifications to be considered (test plan) other than the ones in IEC 61400-12-1 (contractual terms,...), including additional rejection or filtering criteria other than those listed in 7.4 been documented - Have the measurement period, averaging time and sampling rate been documented?		
40		page 18: Test logs shall be maintained to document all important events during the power performance test	- Is a log book that records all important events during the power performance test; including a listing of all maintenance activities that occurred during the test and a listing of any special actions (such as blade washing) that were completed to ensure good performance provided? - Have those events been registered through the recorded status signals and verified? - Have all those period of data rejected due to failure of the measurement equipment been documented?		

#	Reference to section in standard	Requirement from standard	Checks & expert guidance	Reported / Inspected	Finding
41	7.2 - Wind turbine operation	page 18: During the measurement period, the wind turbine shall be in normal operational, as prescribed in the turbine operations manual, and the machine configuration may not be changed	The turbine must work in normal operation mode, but sometimes some irregularities might be detected : - Has the turbine operator reported of changes on the turbine configuration? - Has been detected any modification on the response of the turbine in terms of power performance? - Has been detected any period of curtailment,…?		
43		page 18: Normal maintenance of the turbine shall be carried out throughout the measurement period, but such work shall be noted in the test log. Any special maintenance actions, such as frequent blade washing, which ensure good performance during the test shall in particular be noted	- If maintenance works have been done, are they correctly reported in the log book? - What kind of maintenance has been done? - Has any blade washing or other special maintenance been done?		
44	7.3 - Data collection	page 18: Data shall be collected continuously at a sampling rate of 1 Hz or higher.	No specific guidance		
45		page 18: The data acquisition system shall store either sampled data or statistics of data sets as follows: - mean value; - standard deviation; - maximum value; - minimum value	No specific guidance		
46		page 18: Selected data sets shall be based on 10-min periods derived from contiguous measured data	- How has contiguous data been assured?		
47		page 18: Data shall be collected until the requirements defined in 7.6 are satisfied	No specific guidance		
48	7.4 - Data rejection	page 19: To ensure that only data obtained during normal operation of the turbine are used in the analysis, and to ensure data are not corrupted, data sets shall be excluded from the database under the following circumstances:	- Has it been clearly reported and documented what data have been rejected? - Have those conditions stated as “external conditions other than wind speed are out of the operating range of the wind turbine” been documented? The absence of such conditions should also be documented for clarity. - Have the rejected data based on the log book and status signals obtained as per 6.7 been documented? The absence of such rejected data should also be documented for clarity. - Has all data rejected due to equipment failure been documented? The absence of such rejected data should also be documented for clarity. Data rejection should preferably be documented as follows: - a list of all filter criteria applied (sufficiently detailed to allow reproduction of the filter) for each filter criterion, the number of data points in the data set before the filter is applied, after the filter is applied and how many data points have been removed by the filter criterion		
49		page 19: Any other rejection criteria shall be clearly reported.	- Are any other rejected data (and supported by reasonably documentation,…) documented? The absence of other rejected data shall also be documented		
50		page 19: The power curve shall capture the effect of hysteresis at the cut-in control algorithm, as well as the effect of parasitic losses below cut-in	- Does the measured power curve capture the cut-in hysteresis effect and parasitic losses below cut-in? => data completion requirements fulfilled for Vcut-in – 1m/s bin		

#	Reference to section in standard	Requirement from standard	Checks & expert guidance	Reported / Inspected	Finding
51		page 19: In case cut-out behavior has been reached during the measurement period, two data sets shall therefore be presented. One data set shall include all data points in the database (database A). The other data set shall exclude all data sets where the turbine has stopped generating power due to cut-out at high wind speed (database B).	- What is the cut-out wind speed for the turbine? - What is the wind speed of the bin with the highest wind speed that still has 3 data points?		
52	7.5 - Data correction	page 19: For the selected data sets wind speeds shall be corrected for flow distortion from site calibration (see 5.2) and air pressure shall be corrected if measured at a height other than close to hub height (see 6.4).	- Is it reported if correction factors obtained during a previous site calibration (if necessary) have been applied? - Is it reported if pressure correction has been applied (based on a pressure measurements at a height other than close to hub height)?		
53	7.6 - Database	page 19: After data normalization (see 8.1) the selected data sets shall be sorted using the "method of bins" procedure (see 8.2).	No specific guidance		
54		page 19: The selected data sets shall at least cover a wind speed range extending from 1 m/s below cut-in to 1.5 times the wind speed at 85% of the rated power of the wind turbine. Alternatively, the wind speed range shall extend from 1 m/s below cut-in to a wind speed at which "AEP-measured" is greater than or equal to 95% of "AEP-extrapolated" (see 8.3). The report shall state which of the two definitions has been used to determine the range of the measured power curve.	- Check that the required wind speed range has not been used as a filter criteria, i.e. data above and below the required wind speed range shall not be filtered out - Is it documented which of the completion criteria has been used for the completion of the database?: - From 1 m/s below cut-in to 1,5 times the wind speed at 85 % of the rated power. - From 1m/s below cut-in to a wind speed at which "AEP-measured" is greater than or equal to 95 % of "AEP-extrapolated".		
55		page 19: The wind speed range shall be divided into 0.5 m/s contiguous bins centered on multiples of 0.5 m/s.	- Have the data been sorted by using the method of bins (0.5 m/s wide and centred on multiples of 0,5 m/s?		
56		page 20: The database shall be considered complete when it has met the following criteria: - each bin includes a minimum of 30 min of sampled data; - the database includes a minimum of 180h of sampled data;	- In case that a single incomplete bin has been estimated by linear interpolation from the two adjacent complete bins (only if required for the completion of the test), is it reported? - In case the measurement sector has been opened for wind speeds above 1,6 times the wind speed at 85 % of rated power (in order to complete the power curve at high wind speeds), is it reported? - In case that one of the above procedures has been used in order to complete the database, has been assessed the following criteria: AEP-measured by extended procedures deviates less than 1 % from AEP-extrapolated up to the highest complete wind speed bin for the extended procedures (for the Rayleigh distribution)		

#	Reference to section in standard	Requirement from standard	Checks & expert guidance	Reported / Inspected	Finding
		Clause 8: Derived results			
58	Clause 8.1: Data normalization Reporting Clause 9.e	page 20: The selected data sets shall be normalized to two reference air densities. One shall be the sea level air density, referring to ISO standard atmosphere (1.225kg/m^3). The other shall be the average of the measured air density data at the test site during periods of valid data collection, rounded to the nearest 0.05 kg/m^3.	- is it reported whether the turbine has an active power control or a passive power control (stall-regulated)? Has every datapoint been normalized by applying the correct equation (2 or 3) depending on the control method? - Have all datasets (incl. special databases) been documented according to first three bullets of 9.e? - Does the report contain a plot of the status signals during the measurement period as per 9.5 bullet 6?		
59		page 20: For a stall-regulated wind turbine with constant pitch and constant rotational speed, data normalization shall be applied to the measured power output according to the equation (2)	No specific guidance		
60		page 21: For a wind turbine with active power control, the normalization shall be applied to the wind speed according to the equation (3)	No specific guidance		
62	8.2 - Determination of the measured power curve Reporting Clause 9.f and 9.h	page 21: In case cut-out behavior has been reached during the measurement period two power curves shall be presented. Power curve A shall be based on database A and power curve B shall be based on database B, as described in 7.4. Both power curves shall be presented as detailed in Clause 9.	- Has the power curve for air density at sea level been documented according to 9.f? - Has the power curve for site specific air density been documented according to 9.g?		
63	8.3 - Annual energy production (AEP)	page 21: A Rayleigh distribution, (…) shall be used as the reference wind speed frequency distribution.	No specific guidance		
64		page 21: AEP estimation shall be made for hub height annual average wind speeds of 4, 5, 6, 7, 8, 9, 10 and 11 m/s according to equation (6)	No specific guidance		
65		page 22: The AEP shall be calculated in two ways, one designated "AEP-measured", the other "AEP-extrapolated".	- Have all AEPs been documented according to 9.i (for sea level air density) and 9.j (for site specific air density)?		
66		page 22: If the measured power curve does not include data up to cut-out wind speed, the power curve shall be extrapolated from the maximum complete measured wind speed up to cut-out wind speed.	No specific guidance		

#	Reference to section in standard	Requirement from standard	Checks & expert guidance	Reported / Inspected	Finding
67		page 22: AEP-measured shall be obtained from the measured power curve by assuming zero power for all wind speeds above and below the range of the measured power curve.	No specific guidance		
68		page 22: AEP-extrapolated shall be obtained from the measured power curve by assuming zero power for all wind speeds below the lowest wind speed in the measured power curve and constant power for wind between the highest wind speed in the measured power curve and the cut-out wind speed. The constant power used for the extrapolated AEP shall be the power value from the bin at the highest wind speed in the measured power curve.	No specific guidance No specific guidance		
73	8.4 - Power coefficient Reporting Clause 9.k	page 22; The power coefficient C_p, of the wind turbine shall be added to the test results and presented as detailed in Clause 9. C_p shall be determined from the measured power curve according to the following equation: (8).	- Has the power coefficient been documented according to 9.k?		
		Annex C: Site calibration procedure			
		Clause C.2: Test set-up			
105	page 37, paragraph 3, line 1	Prior to the installation or after removal of the wind turbine two meteorological masts shall be erected.			
106	page 37, paragraph 3, line 4	The reference position anemometer and the wind vane shall be mounted on the meteorological mast that is also used for power performance testing.			
107	page 37, paragraph 3, line 6	The turbine position anemometer shall be mounted on a temporary mast as close as possible to the position where the turbine's hub will be or was located. This anemometer shall be within 2.5 % of hub height and the mast as close as possible to the turbine tower center-line but no more than 0.2 H from the center-line where H is the turbine hub height.			
108	page 37, paragraph 4, line 1	Sensors used in the site calibration test shall meet the requirements of Clause 6.			Also check against Clause 6.

#	Reference to section in standard	Requirement from standard	Checks & expert guidance	Reported / Inspected	Finding
109	page 37, paragraph 4, line 1	The anemometers shall be of the same type with the same operating characteristics. The anemometers shall be calibrated during the same anemometer calibration campaign.			
110	page 37, paragraph 4, line 3	The meteorological mast instrumentation should be the same for the power curve measurement as for site calibration. If this is not the case, the added uncertainty shall be taken into account.			
		Clause C.3: Data acquisition and analysis			
111	page 37, paragraph 5, line 1	Data shall be collected continuously at the same sampling rate as for the power performance test. Data sets shall be based on 10 min periods derived from contiguous measured data. The mean, standard deviation, minimum and maximum values for each 10 min period shall be derived and stored.			
112	page 37, paragraph 6, line 1	The data sets shall be sorted into wind direction bins. Each bin shall be no longer than 10^0			
113	page 37, paragraph 7, line 1	Data sets shall be rejected from the database under the following circumstances:			
114	page 38, paragraph 1, line 1	As a minimum the site calibration data set shall consist of 24 h of data for each non-excluded wind direction bin. Of these each bin shall have at least 6 h of data where winds are above 8 m/s and at least 6 h of data where winds are below 8 m/s.			
115	page 38, paragraph 2, line 1	From the site calibration database, the average of the flow correction factors due to terrain α_j (ratio of the wind speed at the wind turbine location divided by the wind speed at the meteorological mast) for each sector shall be made.			

#	Reference to section in standard	Requirement from standard	Checks & expert guidance	Reported / Inspected	Finding
		Clause C.4: Uncertainty analysis			
116	page 38, paragraph 3, line 1	Measurement uncertainty of flow correction factors shall be determined according to Annex D.			also check against Annex D.
		Clause C.5: Selection of final measurement sector.			
117	page 38, paragraph 5, line 3	The increase in measurement sector must account for the potential for the wake from an obstruction to affect the test turbine's rotor even if it does not affect an anemometer at the hub.			
		Annex D: Evaluation of uncertainty in measurement			
118	page 39, paragraph 2, line 1	The measured power curve shall be supplemented with an estimate of the uncertainty of the measurement. The estimate shall be based on ISO information publication "Guide to the expression of uncertainty measurement".			
119	page 39, paragraph 5, line 1	Table D.1 provides a minimum list of uncertainty parameters that shall be included in the uncertainty analysis.			
		Annex E: Theoretical basis for determining the uncertainty of measurement using the method of bins.			
		Clause E.3: Example			
120	page 43, paragraph 5, line 1	The example only considers the uncertainty components, which shall be included in the uncertainty analysis according to table D.1.			
		Clause E.5: Category B uncertainties			
121	page 46, paragraph 3, line 2	If the uncertainties are expressed as uncertainty limits, or have implicit, non-unity coverage factors, the standard uncertainty must be estimated or they must be properly converted into standard uncertainties.			
		Clause E.5.2: Category B uncertainty in electric power			
122	page 48, paragraph 1, line 1	If current and voltage transformers are not operated within their secondary loop operational load limits, additional uncertainties shall be added.			

#	Reference to section in standard	Requirement from standard	Checks & expert guidance	Reported / Inspected	Finding
		Clause E.5.3: Category B uncertainty in wind speed			
123	page 48, paragraph 4, line 6	If an experimental site calibration is undertaken according to Annex C, the standard uncertainty derived from the site calibration shall be used.			also check against Annex C.
124	page 49, paragraph 3, line 1	In the case where a site calibration has been undertaken, the uncertainty from the site calibration shall be included as the uncertainty of the flow distortion due to terrain U_V4,j, instead of the fixed value (2% or 3%).			
125	page 49, paragraph 5, line 2	In Clause 6, it is specified that the uncertainty shall be calculated for three wind speeds.			Also check against Clause 6.
126	page 50, paragraph 1, line 1	The uncertainty of each wind speed bin of the power curve shall be weighed with the number of data in that wind speed bin for each wind direction bin of the site calibration: (E.24)			
		Clause E.5.4: Category B uncertainty in air density			
127	page 50, paragraph 5, line 2	An uncertainty due to the correction might be considered, and the uncertainty (calibration) of the pressure sensor shall be included.			
130	page 66, paragraph 3, line 1	The anemometers shall be mounted on a round vertical tube, with the same outer diameter as used during calibration, which carries the cable to the anemometer inside.			
131	page 66, paragraph 3, line 4	The tube shall be no larger in diameter than the body of the anemometer and shall support the anemometer cups at least 0.75 m above the meteorological tower and any other flow disturbances. The bracket connecting the anemometer to the vertical tube shall be compact, smooth and symmetrical.			

#	Reference to section in standard	Requirement from standard	Checks & expert guidance	Reported / Inspected	Finding
132	page 66, paragraph 3, line 10	Other instruments must be positioned at least 1.5 m below the anemometer cups.			

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