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IECRE OPERATIONAL DOCUMENT

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

Assessment of RETLs/RECTFs for anemometer calibration

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1 Introduction

This OD covers the assessment of anemometer calibration facilities for Test Laboratories who want to get this competence area recognized under IECRE.

Specifically, this ODs covers the standard assessment as per the IECRE 02 WE-SUP. The scope of this OD is the IEC 61400-12-1 Ed2.0:2017 standard.

The full assessment is based on four elements:

– A review of three reports issued by the Test Laboratory within the last three years

– Successful participation in an anemometer calibration proficiency test

– Review of key internal procedures

– Witnessing of one anemometer calibration

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

2 Review of historic reports

In order to have three reports reviewed, the RETL/RECTF shall submit an overview of reports submitted the last three years with the IECRE logo. In case the assessment is for a candidate RETL/RECTF, or the RETL/RECTF has issued fewer than three IECRE test reports for anemometer calibrations, the assessed Test Laboratory shall submit to the IECRE Secretariat a list of reports issued that state compliance with IEC 61400-12-1 Ed2.0:2017 Annex F.

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 assessed Test Laboratory.

The reports shall be reviewed for compliance with IEC 61400-12-1 Ed2.0:2017 Annex F, 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 Review of internal procedures

3.1 Identification of key procedures

The following procedures should normally be checked:

- Wind tunnel properties
- Instrumentation and set-up
- Calibration procedure
- Processing of measured data
- Uncertainty estimation
- Reporting format

4 Witnessing of test

As part of the assessment the assessment team shall witness one test to establish:

- Compliance with the standard IEC 61400-12-1 Ed2.0:2017 Annex F

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

In the case that a witness of test is not available or the effort for the assessment is unjustifiable, the assessed RETL/RECTF together with the assessment team shall agree upon a solution on how to carry out this witness of 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 witness of the test

Item no	Reference to section in standard	Requirement in the standard (verbatim)	Guidance on assessment of requirement	Reported / Inspected	Finding	Classification (Minor/Major) (*)
Annex F: Cup anemometer calibration procedure						
Clause F.1: General requirements						
1	F.1 b)	The calibration facility shall be recognized by IECRE or accredited in accordance with ISO/IEC 17025, being the main standard for testing and calibration laboratories.	Check for IECRE recognition or accreditation according to ISO/IEC 17025			
2	F.1 c)	All transducer and measuring equipment relevant for the calibration of anemometers shall have traceable calibrations according to ISO/IEC 17025. Calibration certificates and reports shall contain all relevant traceability information.	Check for all calibration certificates.			
			Check for the references to international standards used during calibration.			
3	F.1 d)	The reference wind speed shall be measured with a pitot-static tube that shall be of NPL type with ellipsoidal head according to ISO 3966. The pitot-static tube shall be calibrated for appropriate wind speed ranges, and be documented. The reference wind speed may alternatively be	Check for calibration details of pitot tubes/LDA used.			
			Check for the defined wind speed ranges against the			

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		measured by LDA (Laser Doppler Anemometry) with well documented uncertainties.	calibration range for pitot tubes/LDA.			
4	F.1 e)	Consistency of the experimental set-up shall be verified by at least daily comparative calibrations of the facility's "quality control anemometer".	Check for details of the quality control anemometer of the calibrating institute.			
			Check for details of verification of test set-up consistency.			
5	F.1 f)	Flow quality measurement shall be verified as required in Clause F.2	Check for the measurement of flow quality in the calibration set-up report based on list F.2 (item no 8 – 16).			
6	F.1 g)	The repeatability of the calibration shall be verified.	Check for all adequate information required to repeat the calibration as stated in item no 18.			
7	F.1 h)	Anemometer calibration shall be supported by a thorough assessment of calibration uncertainty, carried out	Check for assessment of uncertainty in the anemometer			

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		in accordance with ISO Guide 98-3:2008.	calibration as stated in item no 48.			
Clause F.2: Requirements of the wind tunnel						
8	F.2 paragraph 1	The presence of the anemometer shall not substantially affect the flow field in the wind tunnel.	Check for assessment of flow distortion caused by the anemometer in the wind tunnel.			
9		The blockage ratio (BR) - defined as the ratio of the anemometer projected area, perpendicular to flow direction, (including its mounting system and projected area of a spinning rotor) to the total test section area - shall not exceed 0.05. Blockage effects shall always be accounted for according to F.4.3.	Check for the geometrical specifications of the wind tunnel and the anemometer to be calibrated			
			Check for the estimation of blockage ratio			
10	F.2 paragraph 2	It is recommended that the wind tunnel test section has a height of at least 1.0 m and a width of at least 1.0 m.	Check for wind tunnel test section dimensions			
11	F.2 paragraph 3	The flow in the cross-sectional area, where the anemometer will be located, shall be uniform. Flow uniformity should be measured using velocity sensing devices, i.e. pitot	Check for details of flow uniformity in the cross-sectional area where the			

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		tubes, hot wires or Laser Doppler Velocimetry to measure flow profiles in longitudinal, transversal and vertical direction. Over the calibration wind speed range, the maximum difference in the mean velocity between any two points inside the measurement volume shall be less than 0,2 %. The mean value shall be calculated during at least five minutes and the measurement volume shall cover the active volume of the anemometer with 50 % margin in all directions as per Figure F.1. Uniformity shall be tested over a period of at least 5 minutes for wind speeds at approximately 4 m/s, 8 m/s, 12 m/s and 16 m/s each.	anemometer will be located.			
12	F.2 paragraph 4	The stability of the flow shall be measured in the middle of the volume of which uniformity was verified. The flow can be considered stable if 10 consecutive 30 s means are within 0,5 % of their average value.	Check for the measurement of flow stability.			
13	F.2 paragraph 5	Therefore, it is useful to check the horizontal wind gradient by using two identical pitot tubes. They shall be	Check for estimation of horizontal wind gradient.			

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		placed at the exact position where the anemometer will be placed with their heads spanning approximately the area covered by the cup anemometer rotating cups. A set of measurements shall be made and the linear regression between the dynamic pressures measured by the two pitot tubes shall be calculated. The difference shall be less than 0.2% over a period of at least 5 minutes.				
			Check for details of two pitot tubes used for the purpose and verification that they are identical			
14		The influence due to the presence of the anemometer type to be calibrated (including mounting tube) on the flow speed measured by the pitot tube shall be verified to be less than ± 0,2 %.	Check for estimation of the influence of the anemometer on the reference flow speed.			
15	F.2 paragraph 6	The axial turbulence intensity in wind speed at the anemometer's position shall be below 2 %. The turbulence intensity shall include longitudinal wind speed fluctuations with frequencies of up to 10 Hz. The data for turbulence measurements shall be acquired for a duration of 60 s per wind speed at a sampling rate of at least 20 Hz. Turbulence assessment shall be performed for at least the	Check for the estimation of the axial turbulence intensity.			

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		flow speeds 7 m/s, 10 m/s and 13 m/s with a device that is suitable to measure wind speed fluctuations with a cut-off frequency of at least 20 Hz.				
16		Deviations from the above requirements shall be assessed through suitable tests and be considered in the uncertainty evaluation.	Check if deviations are considered in the uncertainty evaluation.			
17	F.2 paragraph 7	The wind tunnel calibration factor, which gives the relation between the conditions at the reference measurement position and those at the anemometer position, shall be appraised using pitot tubes for a speed range of 4 m/s to 16 m/s.	Check for the details of assessment of wind tunnel calibration factor.			
18	F.2 paragraph 8	The calibration setup shall undergo a detailed examination of the repeatability of anemometer calibration. The facility shall designate reference anemometers of representative size for use in these tests. The standard deviation and maximum deviation of the quality control anemometer output in the calibration speed range should be less than 0,2 % and 0,6 %, respectively, of the mean value.	Check for all the details required to reproduce the anemometer calibration			
			Check for details of the designated reference anemometer for the facility			

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19	F.2 paragraph 9	The facility shall prove, through proficiency testing, that its results are comparable with other anemometer calibration facilities, according to ISO 17043.	Check for details of proficiency tests.			
Clause F.3: Instrumentation and calibration set-up requirements.						
20	F.3 paragraph 1	Dedicated external signal conditioning equipment such as frequency to voltage converters, etc. shall be calibrated in isolation from the anemometer, so allowing the anemometer's calibration to be derived and reported in isolation from signal conditioning equipment.	Check for details of the signal conditioning equipment used in the test facility.			
			Check for the calibration reports of the entire listed signal conditioning equipment.			
21	F.3 paragraph 2	The resolution of the data acquisition system shall be at least 0.02 m/s. Care shall also be exercised in the case of an analogue voltage instrument, to ensure that the signal is adequately buffered to prevent its attenuation by low impedance logging equipment.	Check for details of the data acquisition system			
			Check for the resolution used in the data acquisition system			
22	F.3 paragraph 3	Therefore, during calibration, the	Check for details of mounting specifications during			

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		anemometer shall be mounted on top of a tube in order to minimize flow distortion and only one anemometer may be calibrated at a time. This tube shall be of the same diameter as the one on which the anemometer will be mounted in service in the free atmosphere. It is recommended that the vertical distance between the anemometer rotor relative to the upper and lower boundaries of the wind tunnel test section should not be less than 0,5 m.	the anemometer calibration.			
			Check for details of mounting specifications required during service.			
23		In case of a directional sensitive anemometer with respect to horizontal flow, a reference orientation has to be defined and documented and referred to during calibration.	Check for documentation of the reference orientation if applicable.			
24		The anemometer shall be positioned at the test section perpendicular to the flow field of the wind tunnel as accurate as possible. The maximum deviation of the anemometer mounting tube is 0,2°.	Check for the accuracy of the positioning of the mounting tube.			
25	F.3 paragraph 5	The pitot static tubes shall be positioned at the test section aligned with the mean flow direction. The	Check for positioning of pitot			

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		maximum misalignment allowed is 0.5°.	tube with respect to flow field.			
26	F.3 paragraph 6	During calibration, the anemometer output signal shall be examined to ensure that it is not subjected to interference or noise.	Check for quality assessment of the anemometer output signal.			
Clause F.4: Calibration procedure						
Clause F.4.1: General procedure cup and sonic anemometers						
27	F.4.1, paragraph 1	The anemometer shall run in for minimum 5 min at about 10 m/s before the calibration procedure begins. Calibration shall be performed under both rising and falling wind speed in the range of 4 m/s to 16 m/s at a calibration interval of 1 m/s or less.	Check for details of operational procedures followed during the anemometer calibration (test log)			
			Check for the range of wind speed in which the calibration was performed and the calibration interval within the defined range.			
28		If heating is switched on during calibrations, it shall be noted in the calibration certificates.	Check note in calibration certificate if applicable.			

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29	F.4.1, paragraph 2	The sampling frequency shall be 1 Hz and the sampling interval at least 30 s. This sampling interval can be increased when low resolution anemometers are calibrated.	Check for details of the sampling frequency and sampling interval.			
			Check for resolution details of the anemometer which will be calibrated.			
30		Before collecting data at each wind speed, adequate time shall be allowed for stable flow conditions to become established, see Clause F.2.	Check for details of operational procedures followed during the anemometer calibration (test log)			
Clause F.4.2: Procedure for the calibration of sonic anemometers						
40	F.4.2, paragraph 1	Sonic anemometers are designed to measure 2D or 3D wind components. For the purpose of power performance measurements sonic anemometers shall be set up for measurement of horizontal wind speed preferably internally or by post processing.	Check if horizontal wind component is measured.			
41	F.4.2, paragraph 2	During calibration the complete sonic anemometer shall be placed in the wind tunnel test section. The active part of the sonic anemometer shall	Check for positioning of the sonic anemometer			

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		be located within the test section volume.	within the test section.			
42	F.4.2, paragraph 2	The setup parameters of the sonic during its calibration shall be documented in the calibration certificate or alternatively in an annex of the calibration certificate.	Check for the setup parameters in the calibration certificate.			
43	F.4.2, paragraph 3	Status signal of the sonic anemometer (if available) shall be monitored during the calibrations. The status signal shall be used to exclude erroneous data.	Check for monitoring of the status signal.			
Clause F.4.3: Determination of the wind speed at anemometer position						
44	F.4.3 paragraph 1	Air density ρ shall be calculated on the basis of the mean wind tunnel air temperature T, relative humidity φ and barometric pressure B using equation (F.1).	Check for records of measured air temperature, pressure and relative humidity.			
			Check for estimation of air density at the time of calibration.			
45	F.4.3 paragraph 3	The influence of the correction function on the calibration results shall be assessed and included in	Check for details of estimation of influence of the correction function.			

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		the calibration facility setup report and uncertainty calculation.				
			Check for the inclusion in the uncertainty calculation.			
Clause F.5: Data analysis						
46	F.5 paragraph 1	A linear regression analysis shall be carried out on the calibration data for the estimation of the following regression parameters: offset, slope, regression coefficient, standard uncertainty. The wind speed values shall be regressed upon the anemometer outputs.	Check for the details of linear regression carried on the calibration data.			
47	F.5 paragraph 2	If the correlation coefficient, r, for the data is less than 0.99995 then it shall be checked if it is caused by anemometer non-linearity or due to other reasons.	Check for estimation of correlation coefficient r, for the calibrated data. Check for the actions taken if the coefficient is below 0.99995			

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Clause F.6: Uncertainty analysis						
48	F.6 paragraph 1	It is required that an uncertainty analysis is carried out in accordance with the ISO/IEC Guide 98:2008 comprising both category A and category B uncertainty. The magnitude of the net uncertainty shall be assessed statistically and shall take account of items a) to i) in the standard.	Check for the assessment of uncertainty in the calibrated data.			
			Check against the list of uncertainties in the estimation.			
Clause F.7: Reporting format						
49	F.7 paragraph 1	The relevant documentation shall provide information on the procedure followed and the facility used for calibrating the anemometers (report on the calibration facility setup) and on the individual anemometer calibration	Check for all the documentations necessary to understand the anemometer calibration process.			
			Check for the details of all the procedures followed during the calibration.			
			Check for details of both the facility and the calibration process in the documents.			

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50		The calibration facility setup report shall contain the information listed in the standard at F.7 items a) to o).	Check against the list of minimum requirements in the test report.			
51	F.7 paragraph 2	The calibration report of an anemometer shall as a minimum contain the information listed in the standard at F.7 items 1) to 16).	Check against the list of minimum requirements in the calibration report.			

(*) Minor and major finding are defined as:

- Minor: does not affect final results
- Major: could affect final results
- Depending on details, minor/major can be tweaked during the assessment

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