Measuring-Network of Wind Energy Institutes

20ac01

Anemometer Calibration Proficiency Test

External Report

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Participants identities managed by MEASNET Secretariat

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Preface

IEC Conformity Assessment Systems are globally recognized as giving consumers and industry more widely confidence that a device or system meets or exceeds international standards.

IECRE is the global system for renewable energy conformity assessment and was established in 2014. Stakeholders in the system, those delivering conformity assessment activities, have to meet exacting criteria before being approved to operate.

In IECRE we have a global network of testing laboratories —known as RETLs— who meet the criteria in ISO/IEC 17025 for best management and measurement practice. An essential element of 17025 compliance is the demonstration of competence through inter laboratory or proficiency testing. Specifically for an international system with mutual acceptance of test results and certifications, proficiency testing is an integral element fostering mutual trust which enable acceptance. All participants within the IECRE know and have proof that the system evaluates qualification to harmonized and aligned criteria.

IECRE has been working closely with MEASNET, who is the provider of proficiency testing in the renewables sector.

IECRE and MEASNET are delighted to publish the final report for the most recent round of Anemometer Calibration proficiency testing and to make this available to all stakeholders and interested parties.

This report is the most comprehensive overview of Anemometer Calibration evaluation ever undertaken by almost every testing organization active in the renewables sector and it is hoped demonstrates that all laboratories in IECRE have proved their competence through a thorough and independent process.

We encourage the reports use in the renewables sector and welcome any comments or feedback.

Wolfram Zeitz
IECRE Executive Secretary

Alistair Mackinnon
IECRE Chair

Alejandro Martínez
MEASNET Vice Chairman

1. Introduction & Methodology

Within the framework of the MEASNET network internal quality evaluation program, the collaboration with the IECRE organization and the consideration of proficiency testing as a service offered to its customers, an Anemometer Calibration Proficiency Test (PT) exercise was organized and performed.

This internal report is issued according to the contents described in the IECRE O.D. 551-17 [1].

1.1. Standards in Scope.

The participants performed the tasks according to the standard IEC 61400-12-1:2017 [2] and IEC 61400-50-1:2022 [3].

1.2. Methodology.

The Proficiency Test was performed in one round.

Unlike other proficiency tests, this PT is structured in one round because the analysis of the results is not expected to provide insight of the sources of deviation by itself. The search of such sources is commended to the appropriate forums (SG551 & MEASNET) which should host meetings in light of the results.

All the participants belonging to IECRE or MEASNET are considered as Type A participants, although the participants shall take the appropriate measures to avoid the bias from laboratories and / or wind tunnels that are not totally independent.

1.3. Preliminary Line Choice.

The line choice is a set of instructions handled to the participants explaining which options, among those valid and present in the standard, have to be taken in order to improve the intercomparability of the results.

Data sheets for the two anemometers were forwarded to the participants. The institutions were to use their own connectors / cables for the calibrations.

The participants were instructed to handle the anemometers with care, not modify them in any way, and not to place any kind of stickers on them.

Regarding mounting, the institutions should use their own mounting tubes for the calibration. The tube should have a circular cross section. For the Thies anemometer, the nominal outer diameter of the mounting tube should be in the range 33.4 mm to 35.0 mm. For the WindSensor anemometer, the nominal outer diameter of the mounting tube should be 25.0 mm.

2. Topics covered by the PT

2.1. General Comments

Two anemometers were be circulated among all the participants, according to a calendar agreed among them all (although it was revised several times during the PT due to delays of various types).

The anemometers to be calibrated and which results will be accounted for in the Pass and Fail Criteria were:

- Thies First Class Advanced model 4.3352.10.000, S/N 06225543
- WindSensor model P2546D-OPR, S/N 67138

The following rules were applied to those laboratories that wished to evaluate more than one wind tunnel, as well as to those that had close connections among them (i.e. shared personnel, procedures, equipment or investors):

- The involved laboratories designated a representative set of results (called “primary results”). However, the laboratories had to present results for all the facilities to be evaluated.
- Only the designated results were taken into account to calculate the PT reference wind speed.
- All the results were evaluated against the PT reference wind speed.

3. Pass / Fail Criteria

The RETLs belonging to IECRE must fulfil the following Pass and Fail Criteria in order to be part of the IECRE system. These are not mandatory for other participants.

Step 1: Assessment of anemometers integrity. After the end of the measurement campaign by all participants, the physical condition of the anemometers used will be assessed, on the responsibility of the laboratory providing the initial and final calibration (the PT conductor). In case any sign of damage, degradation, or irregular operation that could possibly have effect on the PT results, is identified on any of the anemometers used in the PT, then this anemometer must be discarded from the PT and the result obtained must not be used in the compilation of the PT results.

Step 2: For each anemometer three output values are determined, corresponding to wind speeds of about 7, 10 and 13 m/s.

Step 3: For each anemometer and for each of the three values the wind speeds according to the calibration results of the RR participants are calculated. Each wind speed is assumed to have a standard uncertainty of 1%.

Step 4: As a first estimate of the PT reference wind speed the results per anemometer and per output frequency of all institutes are averaged. The standard uncertainty of this reference wind speed is $(1/\sqrt{N}\%)$, in which N is the number of institutes that calibrated the regarded anemometer.

Step 5: Per anemometer and per output value the result of the calibration of participant institute is discarded when the deviation with respect to the estimated reference wind speed is one standard uncertainty of the difference or more. The standard uncertainty of the difference is equal to $\sqrt{1^2 + \left(\frac{1}{\sqrt{N}}\right)^2}$ % where N is the number of non-discarded results per anemometer and output value). This step is carried out several times until no more data are discarded. The measurements are discarded in the order of their deviation, the biggest deviation first.

Step 6: For each anemometer and for each output value the PT reference wind speed is defined as the average value of the non-discarded values.

Step 7: For each anemometer and for each of the three output values the difference between the wind speeds obtained with the various calibration results of the participating institutes and the PT reference wind speed is determined.

Step 8: At each approximate wind speed (7, 10 and 13 m/s) the differences obtained from each institute for all anemometers result in a series of values with an averaged value and a standard deviation. Both values should be close to zero. The sum of the absolute value of the average and the standard deviation (|AV| + stdevp) is used as a quantity that characterizes the compliance of the calibration institute with the PT reference wind speeds. (stdevp = standard deviation of the population).

Step 9: The values (|AV|+stdevp) are averaged for the approximate wind speeds (7, 10 and 13 m/s).

PASS / FAIL Criterion: The institutes with an average value of the Compliance Factor ≤ 1% comply with the IECRE requirement for anemometer calibration. As a side note, the compliant laboratories are also considered in compliance with the requirements of MEASNET regarding the proficiency tests for Anemometer Calibration.

4. Participant List

Type A participants are:

Testing Laboratory
Acoem Australasia
Ammonit Windtunnel GmbH
CRES - Center for Renewable Energy Sources and Saving
Deutsche WindGuard Wind Tunnel Services GmbH
International Wind Engineering G.P.
LAC, IDR/UPM Escuela Técnica Superior de Ingeniería Aeronáutica y del Espacio
ProfEC Ventus GmbH
SOH Wind Engineering LCC
Svend Ole Hansen ApS (associated with SOH Wind Engineering LCC)

Type B participants are:

Testing Laboratory
Anonymous laboratory 1[1]
Anonymous laboratory 2[2]
China Electric Power Research Institute CEPRI
ESTIA Consulting & Engineering S.A.
Instituto SENAI de Inovação em Energias Renováveis – ISI-ER

[1] [2] Anonymous laboratories 1 and 2 have not granted MEASNET permission to display its name on this list.

5. Proficiency Test Calendar

The following calendar describes the process of the Proficiency Test:

Preparation:

Application period deadline for Type A participants	01.10.2022
Election of coordinator & participation appeals	10.10.2022
Fees payment deadline for Type A participants	01.05.2023

Round 1:

Conductor calibration of anemometers	13.02.2023 to 08.05.2023
Participants calibration of anemometers timeframe	Begins 08.05.2023 Three weeks from reception, later changed to 2 weeks from reception due to additional participants and delays
Estimated timeframe for delivery between participants	One week
Conductor calibration of anemometers and integrity check	Originally designated period: 29.07.2024 to 12.08.2024. Due to additional participants and delays, the conductor performed integrity checks several times throughout
All participants submit results	26.08.2024 to 28.08.2024 (One Type B participant submitted results October 25, 2024)
Data analysis from coordinator	18.09.2024 to 18.10.2024
Results communication & room for non-technical corrections	18.10.2024 to 28.10.2024
Round 1 final report creation	28.10.2024 to 30.11.2024
Final results publication deadline	**30.11.2024**

6. Results provided by the participants

The designated ("primary") results of the Type A participants are shown in Table **1**. The table shows the anonymous participant ID, their Compliance Factor and whether they passed of failed the compliance criterion. The reported calibration slope and offset for the two anemometers (Thies and WindSensor) are also included for reference.

Corresponding results for Type B participants as well as non-designated ("secondary") results from Type A participants are shown in Table **2**. The participant ID is replaced by a letter to ensure that participants with more than one result are not identifiable.

Table 1. PT results for Type A participants. Submitted calibration results (slope and offset) for the two participating anemometers are included.

Participant ID	Compliance Factor	Passed / failed	Thies, S/N 6225543		WindSensor, S/N 67138	
			Slope [m/s/Hz]	Offset [m/s]	Slope [m/s/Hz]	Offset [m/s]
0788	**0.61 %**	**Passed**	0.04587	0.21919	0.61564	0.21599
2490	**0.29 %**	**Passed**	0.04596	0.24415	0.61701	0.23774
4314 *)	**0.64 %**	**Passed**	0.04560	0.22876	0.61949	0.22239
4562	**0.35 %**	**Passed**	0.04580	0.24000	0.61740	0.28000
6692	**0.33 %**	**Passed**	0.04577	0.22330	0.61867	0.24380
7471	**0.74 %**	**Passed**	0.04638	0.20191	0.62044	0.25362
9648 *)	**0.37 %**	**Passed**	0.04596	0.24200	0.61271	0.28700
9896	**0.10 %**	**Passed**	0.04584	0.23423	0.61850	0.22442

*) See remarks below.

Table 2. PT results for Type B participants as well as secondary results of type A participants. The anonymous 4-digit participant ID is replaced with letters to ensure that the number of submitted results from a single institution is not revealed.

Participant ID	Compliance factor	Passed / failed	Thies, S/N 6225543		WindSensor, S/N 67138	
			Slope [m/s/Hz]	Offset [m/s]	Slope [m/s/Hz]	Offset [m/s]
A	**0.29 %**	**Passed**	0.04606	0.22191	0.61981	0.19927
B *)	**NA**	**NA**	0.04586	0.21212	NA	NA
C	**0.31 %**	**Passed**	0.04606	0.22594	0.61828	0.22132
D	**0.55 %**	**Passed**	0.04587	0.21206	0.61589	0.21805
E	**0.33 %**	**Passed**	0.04601	0.23804	0.61916	0.21455
F	**0.65 %**	**Passed**	0.04589	0.21679	0.61518	0.21884
G	**0.91 %**	**Passed**	0.04543	0.23717	0.61862	0.17123
H	**0.16 %**	**Passed**	0.04573	0.24777	0.61869	0.22979
I	**1.03 %**	**Failed**	0.04568	0.36868	0.61100	0.37828
J	**0.18 %**	**Passed**	0.04601	0.20708	0.62117	0.17915
K *)	**4.76 %**	**Failed**	0.04430	0.18400	0.59595	0.11780

*) See remarks below.

Remarks

- Participant with ID 4314 requested that their submitted results would be changed based on an error when pasting their calibration results to the designated submission template. The participant forwarded documentation of their claim, and the error was accepted by MEASNET as a non-technical correction. The evaluation above is based on the corrected results.

- Participant with ID 9648 submitted a set of results within the original submission deadline. On September 25 the participant sent an email to MEASNET stating that those submitted results were erroneous and forwarded a corrected set of results on the same day. The error was accepted by MEASNET as a non-technical correction, and the evaluation above is based on the results submitted on September 25, 2024. The results from all the institutes were not distributed among them before October 18, 2024, and therefore MEASNET has no reason to believe that the participant had any prior knowledge of the submitted results from other participants when they submitted their corrected results.

- Participant with ID B only submitted calibration results for one of the two PT anemometers. The evaluation above is therefore marked as being Not Available (NA).

- Participant with ID K joined the PT at a late stage, and their results were not submitted by the original submission deadline. Instead, their results were forwarded to MEASNET on October 25, 2024, i.e., after the results of the all the remaining participants were distributed among those participants on October 18, 2024. For this reason, the independence of the submitted results cannot be guaranteed. However, MEASNET has no indications that the participant had any knowledge of the submitted results from other participants prior to forwarding their own results to MEASNET.

7. Summary statistics of PT participants

Table 3. PT results for all participants.

Wind Tunnel	Thies, S/N 6225543			WindSensor, S/N 67138		
	Slope [m/s/Hz]	Offset [m/s]	Wind Speed @10 m/s	Slope [m/s/Hz]	Offset [m/s]	Wind Speed @10 m/s
0788	0.04587	0.21919	9.98	0.61564	0.21599	9.94
2490	0.04596	0.24415	10.03	0.61701	0.23774	9.98
4314	0.04560	0.22876	9.94	0.61949	0.22239	10.01
4562	0.04580	0.24000	9.99	0.61740	0.28000	10.03
6692	0.04577	0.22330	9.97	0.61867	0.24380	10.02
7471	0.04638	0.20191	10.08	0.62044	0.25362	10.05
9648	0.04596	0.24200	10.03	0.61271	0.28700	9.97
9896	0.04584	0.23423	9.99	0.61850	0.22442	9.99
A	0.04606	0.22191	10.03	0.61981	0.19927	9.99
B	0.04586	0.21212	9.98	NA	NA	NA
C	0.04606	0.22594	10.03	0.61828	0.22132	9.99
D	0.04587	0.21206	9.98	0.61589	0.21805	9.95
E	0.04601	0.23804	10.03	0.61916	0.21455	10.00
F	0.04589	0.21679	9.99	0.61518	0.21884	9.94
G	0.04543	0.23717	9.91	0.61862	0.17123	9.94
H	0.04573	0.24777	9.98	0.61869	0.22979	10.00
I	0.04568	0.36868	10.09	0.61100	0.37828	10.03
J	0.04601	0.20708	10.00	0.62117	0.17915	9.99
K	0.04430	0.18400	9.61	0.59595	0.11780	9.53

For all the participants in the Proficiency Test the statistics are the following:

- For the Thies anemometer:
  - The average wind speed for a consensus value of 10 m/s is 9.98 m/s.
  - The Standard deviation at the same speed is 0.10 m/s.

- For the WindSensor anemometer:
  - The average wind speed for a consensus value of 10 m/s is 9.96 m/s.
  - The Standard deviation at the same speed is 0.11 m/s.

For the MEASNET participants in the Proficiency Test the statistics are the following:

- For the Thies anemometer:
  - The average wind speed for a consensus value of 10 m/s is 10.00 m/s.
  - The Standard deviation at the same speed is 0.04 m/s.

- For the WindSensor anemometer:

- The average wind speed for a consensus value of 10 m/s is 9.99 m/s.
- The Standard deviation at the same speed is 0.04 m/s.

For the IECRE participants in the Proficiency Test the statistics are the following:

- For the Thies anemometer:
  - The average wind speed for a consensus value of 10 m/s is 10.01 m/s.
  - The Standard deviation at the same speed is 0.04 m/s.

- For the WindSensor anemometer:
  - The average wind speed for a consensus value of 10 m/s is 9.98 m/s.
  - The Standard deviation at the same speed is 0.05 m/s.

8. IECRE Participants that passed the Proficiency Test

The following participants are either IECRE RETLs or RETL candidates and passed the PT:

Testing Laboratory
Deutsche WindGuard Wind Tunnel Services GmbH
LAC, IDR/UPM Escuela Técnica Superior de Ingeniería Aeronáutica y del Espacio
Svend Ole Hansen ApS (associated with SOH Wind Engineering LCC)

All the MEASNET participants passed the Proficiency Test.

9. References

[1] IECRE OD-551-17, Edition 1.0, IECRE, 2020-08-17

[2] IEC 61400-12-1:2017, Power performance measurements of electricity producing wind turbines.

[3] IEC 61400-50-1:2022, Wind measurement - Application of meteorological mast, nacelle and spinner mounted instruments