Measuring-Network of Wind Energy Institutes

16ld01

Loads Proficiency Test

External Report for IECRE

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Grevenbroich, November 6th 2019

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16ld01 Report

Acknowledgement

This project has been carried out in the framework of MEASNET, in close collaboration with the SG551 group of IECRE. The author wishes to recognize the collaboration of the Measnet secretariat and the SG551 convener in the development of the Proficiency Test.

Abstract

This document presents the results of the 16ld01 proficiency test organized by Measnet in collaboration with IECRE. This proficiency test is organized according to IEC 61400-13:2015.

The laboratories participating in this Proficiency test are:

Windtest grevenbroich gmbh [wtg]

Deutsche Windguard [DeWind]

Beijing CGC Certification Center Co., Ltd [CGC]

GL Garrad Hassan Iberica S.L. [GLGH Ib]

Wind- Consult[WiCo]

DTU Vindenergi [DTU]

China Electric Power Research Institute [CEPRI]

Shangai SERCAL New Energy Technology Co. [SERCAL]

ECN [ECN]

UL-DEWI [UL-DEWI]

Barlovento Recursos Naturales [Barlovento]

CRES [CRES]

Moeller Operating Engineering GmbH [MOE]

WRD GmbH [WRD]

GL Garrad Hassan Deutschland GmbH [GLGH De]

The results have been analyzed by windtest grevenbroich gmbh acting as the conductor of the proficiency test. Evaluations have been sent in within the same deadline in order to prevent the conductor from getting the results of the other institutions before having presented to the Measnet secretariat its own results.

Table of Content

1. Introduction & Methodology

Within the framework of the MEASNET network internal quality evaluation programme, the collaboration with the IECRE organization and the consideration of proficiency testing as a service offered to its customers, a loads proficiency test exercise was organized and performed.

The following institutes have participated in this proficiency test:

- Windtest grevenbroich gmbh [wtg]
- Deutsche Windguard [DeWind]
- Beijing CGC Certification Center Co., Ltd [CGC]
- GL Garrad Hassan Iberica S.L. [GLGH Ib]
- Wind- Consult[WiCo]
- DTU Vindenergi [DTU]
- China Electric Power Research Institute [CEPRI]
- Shangai SERCAL New Energy Technology Co. [SERCAL]
- ECN [ECN]
- UL-DEWI [UL-DEWI]
- Barlovento Recursos Naturales [Barlovento]
- CRES [CRES]
- Moeller Operating Engineering GmbH [MOE]
- WRD GmbH [WRD]
- GL Garrad Hassan Deutschland GmbH [GLGH De]

The evaluation results have been analysed by windtest grevenbroich gmbh according to IEC 61400-13:2015.

Generally, this proficiency test was subdivided into two topics:

1. Step by step evaluation of one database and a given rainflow count
2. Uncertainty analysis of one database (informative only)

The data was a mixture of constructed and real data, in case of real data, the data was anonymised by manipulating the individual signals. The plausibility of the constructed data should not be checked.

1.1. Databases and Pass / Fail Criteria.

The data was provided in two different file formats (FAMOS, ASCII):

01_Data_Base for step by step evaluation:

a. Capture matrix (any deviation was considered as fail result)
b. Load statistics (the limit value for deviation has been defined as ±0.5 % of median value)
c. Yaw misalignment (the limit value for deviation has been defined as ±0.5 % of median value)
d. FFT (the limit value for deviation has been defined as ±0.5 % of median value)

The results of the rainflow count and the data for the uncertainty analysis were provided as an Excel sheet: "IECRE_LPT_2016_Loads_Report_01_Data_Base_Company.xls"

From this database the following items had to be evaluated:

a. Load spectra (any deviation was considered as fail result)
b. Damage equivalent loads (R_i is the average value of the i^{th} range bin of the fatigue load spectrum) (the limit value for deviation has been defined as ±0.5 % of median value)
c. Total uncertainty (the limit value for deviation has been defined as ±0.5 % of median value)
d. Uncertainty of the BIN scatter (the limit value for deviation has been defined as ±0.5 % of median value)
e. Uncertainty of the x-axis quantity (the limit value for deviation has been defined as ±0.5 % of median value)
f. Uncertainty of BIN averaged mean values (the limit value for deviation has been defined as ±0.5 % of median value)

The data provided had to be analysed according to IEC 61400-13:2015.

No site calibration had to be done.

Since this proficiency test was divided in two phases two sets of different data were sent around. Phase 1 was for measurement institutes only, phase 2 was open for other institutions. After phase 1 a meeting was held with all participants to clarify all possibilities of different interpretations of the tasks in the guideline and in the instructions of this proficiency test.

Two clarification sheets have been developed and sent to the IEC. Both have been rejected.

2. Instructions provided to the participants

2.1. Introduction.

This proficiency test is subdivided into two topics:

1. Step by step evaluation of one database and a given rainflow count
2. Uncertainty analysis of one database (informative only)

The data provided is a mixture of constructed and real data, in case of real data; the data was anonymised by manipulating the individual signals. The plausibility of the constructed data should not be checked.

The data is provided in two different file formats (FAMOS, ASCII) and was transmitted using the Measnet FTP-server:

- 01_Data_Base for step by step evaluation:

  1. Capture matrix
  2. Load statistics
  3. Yaw misalignment
  4. FFT

The results of the rainflow count and the data for the uncertainty analysis are provided in a separate Excel sheet and were placed on the FTP-server:

- "IECRE_LPT_2016_Loads_Report_01_Data_Base_Company.xls"

  1. Load spectra
  2. Damage equivalent loads (R_i is the average value of the i^{th} range bin of the fatigue load spectrum)
  3. Total uncertainty
  4. Uncertainty of the BIN scatter
  5. Uncertainty of the x-axis quantity
  6. Uncertainty of BIN averaged mean values

The data provided had to be analyzed according to IEC 61400-13:2015.

For the analysis all signals had to be calibrated according to the calibration factors provided. The tower bottom roll and tilt moments had to be calculated.

In the following sections the characteristics of the provided data are detailed.

2.2. Wind turbine data

Table 2-1 Wind turbine characteristics

No.	Description	Value	Unit
1.	Hub height	85	m
2.	Rotor diameter	75	m
3.	Number of blades	3	-
4.	Tilt angle	0	°
5.	Cut-in wind speed	3	m/s
6.	Cut-out wind speed	22	m/s

2.3. Strain gauge data

All strain gauges were positioned according to IEC 61400-13. All strain gauges are full bridges with two parallel gauges at one side and two parallel gauges at the opposite side inside the tower.

Table 3-2 Strain gauge data

No.	Description	Value	Unit
1.	Resistance of all strain gauges	350	Ω
2.	k-factor of all strain gauges	2.14	-

2.4. Sector of evaluation

Table 4-3 Sector of evaluation

No.	Description	Value	Unit
1.	Sector of evaluation	220..300	°

2.5. Channel list

Table 5-4 Load channels

No.	Value	Channel name	Unit
1.	Tower bottom bending moment	MbTb000V	mV/V
2.	Tower bottom bending moment	MbTb090V	mV/V
3.	Blade flapwise bending moment	MbBlFlapV	mV/V

Table 5-5 Meteorological channels

No.	Value	Channel name	Unit
1.	Wind direction at 82 m	DirWndU	V
2.	Wind speed at 85 m	VWndU	V

Table 5-6 Wind turbine channels

No.	Value	Channel name	Unit
1.	Electrical power output of wind turbine	PElU	V
2.	Status WT mode	StWtModU	V
3.	Direction of the nacelle	AgYawU	V
4.	Rotor speed	NRotU	V

2.6. Calibration factors

Table 6-7 Load channels

No.	Channel name	Offset	Slope
1.	MbTb000V	-18,000 kNm	40,000 kNm/(mV/V)
2.	MbTb090V	18,000 kNm	40,000 kNm/(mV/V)
3.	MbBlFlapV	0 kNm	1 kNm/(mV/V)

Table 6-8 Strain gauge positions to geodetical north

No.	Description	Value	Unit
1.	MbTb000V	25	°
2.	MbTb090V	115	°

Table 6-9 Meteorological channels

No.	Channel name	Offset	Slope
1.	DirWndU	90 °	45 °/V
2.	VWndU	0.25 m/s	0.05 (m/s)/Hz

Table 6-10 Wind turbine channels

No.	Channel name	Offset	Slope
1.	PElU	1,200 kW	180 kW/V
2.	StWtModU	-	-
3.	AgYawU	1,980 °	-180 °/V
4.	NRotU	0 rpm	2.5 rpm/V

Table 6-11 Output values status wind turbine mode

Status channel	Signal	Status
StWTModU	5 ±0.5	grid connection
StWTModU	3.5 ±2	system Ok

Table 6-12 Output values status signals

Status channel	*Signal*	*Status*
StGrid	0	no grid connection
StGrid	1	grid connection
StSysOk	0	system not ok
StSysOk	1	system ok

2.7. Settings

2.7.1. Filtering

Filtering according to:

1. Sector of evaluation
2. Status grid connection
3. Status system ok

2.7.2. Rainflow parameters

For information only. The results of the rainflow count for further analysis can be found in the above mentioned Excel sheet.

Table 7-13 Rainflow parameters

Channel name	*Resolution [kNm]*	*Range [kNm]*
MbBlFlap	0.25	0..8 kNm

Rainflow counting is performed with full circles and residuals.

2.7.3. Material exponent

Table 7-14 Material exponent

Channel name	*Material exponent*
MbBlFlap	10

2.8. Reporting

Participants were requested to fill in the yellow cells in an Excel file named: "IECRE_LPT_2016_Loads_Report_02_Data_Base_Company.xls"

The excel files were sent to the Measnet secretariat who anonymized the results and circulated them to the Proficiency Test conductor.

2.9. Calendar

Phase 1:

Data Base 1A sent to participants	20.06.2016
Phase 1A results discussion	05.10.2016
Data Base 1B sent to participants	07.11.2016
Phase 1B results discussion	December 2016

Phase 2:

Data Base Phase 2 sent to participants	04.01.2017
Phase 2 results discussion	05.04.2017
Final report Issued	24.04.2017

Please note that the final report date corresponds to the date in which the conductor issued its report. Further discussions in IECRE on the content of public and restricted reports have led to delays in the release of a public report.

In this case the conductor performed an extension of the report to include the evaluation of entities that joined the Proficiency Test at a later stage. Provisions were taken to assure the integrity of the participation of these entities.

3. Evaluation of the results

3.1. Results of the IECRE Laboratories

Each one of the tasks listed in the first column was evaluated, giving as a result a pass (✓) or a Fail (x). The table summarizes the results of the participant laboratories.

	Institutes																	
	A	B	C	D	E	F	H	I	J	K	L	N	O	P	Q	R	S	T
Capture Matrix	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Load Statistics	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	X	✓
Yaw Misalignment	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	X
FFT	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	X
Load Spectra	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	X	✓
DEL	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	X	X
Informative only / has to be discussed																		
Uncertainites	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	X	X*	✓	✓	X*	X*	✓
Sum (excl. informative)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	X	X
Sum (incl. informative)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	X	X*	✓	✓	X*	X	X

X*: This result may be attributable to a different interpretation of the standard.

The part of the Standard related to Uncertainties was evaluated with an informative character only, and therefore the laboratories that only failed this part have been considered as Pass.

All the IECRE Testing Laboratories that participated have Passed in the Loads Proficiency Test.

3.2. Statistics for IECRE Laboratories

In order to present an overview of the *status quo* of this type of test some statistics from the results presented by the laboratories are presented below.

Loads statistics (Wind Speed 9.25 m/s)

	Maximum Tilt Moment [kNm]	*Average Tilt Moment [kNm]*	*Minimum Tilt Moment [kNm]*	*Standard Deviation of Tilt Moment [kNm]*
Average Value	27247.117	20709.526	13495.096	2951.726
Median Value	27247.110	20709.516	13495.081	2951.730
Maximum Value	27247.258	20709.689	13495.250	2951.731
Minimum Value	27247.076	20709.500	13495.080	2951.681
Standard Deviation	0.04019	0.04506	0.04397	0.01275

Note: In the elaboration of these statistics one single outlier (not from an IECRE laboratory) has been discarded

Determination of the frequencies related to tower bending

	Frequency II [Hz]	*Frequency III [Hz]*	*Frequency IV [Hz]*	*Frequency V [Hz]*
Average Value	0.29944599	0.50024352	1.00059380	1.99949037
Median Value	0.29910000	0.50048800	1.00097660	1.99900000
Maximum Value	0.30000000	0.50050000	1.00100000	2.00195310
Minimum Value	0.29900000	0.49970000	1.00000000	1.99890000
Standard Deviation	0.00046884	0.00028709	0.00050194	0.00085245

The statistics related to other topics treated in this Proficiency Test have been considered of no relevance, since they show total agreement in the results among all the participants.

4. Clarification Sheets

During this Proficiency test two Clarification Sheets were produced and circulated to the TC88 committee.

- “Calculation of the Damage Equivalent Load”, referring to Standard IEC 61400-13:2015 Subclause 10.8.
- “Handling of bin limits”, referring to Standards in the IEC 61400 series, affecting several clauses.

Both Clarification sheets have been rejected by the TC88 committee.

A third Clarification Sheet regarding the Rainflow Count was agreed among the participants, but was not presented after the rejection of the two aforementioned ones.