measnet

ANEMOMETER CALIBRATION PROCEDURE

Version 2
October 2009

List of Contents

1. INTRODUCTION

The MEASNET Anemometer Calibration Procedure is the measurement procedure, agreed upon by the MEASNET members to be mutually used and accepted. The procedure is considered to be the most internationally accepted procedure on which a common interpretation and understanding has been exercised in accordance with the MEASNET Quality Evaluation Program, based on the objective of continuously improving quality in measurements.

2. THE REFERENCE MEASUREMENT PROCEDURE

The "Reference Measurement Procedure" on which the present MEASNET Measurement Procedure is based is :

IEC 61400-12-1:2005(E) "Wind turbines - Part 12-1: Power performance measurements of electricity producing wind turbines, First edition 2005-12/ Annex F "Cup anemometer calibration procedure".

3. ADDITIONAL REQUIREMENTS

Additional to the provisions of the above mentioned Reference Measurement Procedure, the following requirements apply (the numbering of the paragraphs of the Reference Measurement Procedure is followed):

F.1 General requirements

F.1.1 Participation in MEASNET Anemometer Calibration Round Robins

The integrity of the calibration procedure shall be further verified by the successful participation of the institution to the MEASNET Anemometer Calibration Round Robins. The acceptance criteria set by MEASNET Quality Evaluation Procedure must be fulfilled

F.1.2 Pitot tubes

PItot tubes are stable mechanical systems, whose long term operational characteristics are practically unaffected under operating conditions usually prevailing in anemometer calibration facilities. For Pitot tubes compliant to the requirements of ISO 3966, calibration interval of 10 years is recommended.

F.2 Requirements of the wind tunnel

F.2.1Interference from the anemometer set up (including boom, cabling etc) to the reference position.

Interference from the anemometer to be calibrated to the measurement of the reference wind speed should be investigated, In case it is found to be significant it should be eliminated or appropriate correction factors applied. The unaccounted interference from the anemometer to the reference position shall be less than 0.2% at 10 m/sec. This will be verified by measurements of the flow at the reference position with and without the typical anemometer set up as used in calibrations.

Measurements can be made using two Pitot tubes, following a procedure similar to the one described in the Reference Measurement Procedure for checking the horizontal velocity gradient. Other measurement methods like laser or hot wire anemometry may also be used.

F.2.2 Turbulence intensity in the wind tunnel

Turbulence intensity should be less then 2% for averaging period up to 1 minute.

Turbulence components with frequency greater than 10Hz may be disregarded.

F.3 Calibration procedure.

F.3.1.Calibration of anemometer types other than cup.

The method used for the determination of the reference wind speed in the present procedure is independent of type of the anemometer to be calibrated. Therefore it can be applied for the determination of the reference wind speed for the calibration of any type of anemometer. However, when anemometers other than cup are to be calibrated the specific operational characteristics of other type anemometers (directional sensitivity, temperature effects etc) should be taken into account and where appropriate reported.

F4. Reporting format

F.4.1 Presentation of uncertainty.

The calculation of uncertainty should be made according to the requirements of the Reference Measurement Procedure.

Alternative calculation methods and / or presentations formats for the uncertainty may be used under the following requirements :

- they are explicitly required by the Accreditation Bodies
- the resulting uncertainty values are greater or equal to the values estimated by the procedure described in the “Reference Measurement Procedure”.

4. REFERENCES

IEC 61400-12-1:2005: *WTGS, Part 12 Power performance measurements techniques, Annex F: Anemometer Calibration*

Annex A
(informative)
MEASNET Anemometer Calibration Round robin rules

Annex A
(informative)

MEASNET Anemometer Calibration Round robin rules

1. Responsibilities

The MEASNET Round Robin (RR) on anemometer calibration is organized under the responsibility of the MEASNET Expert Group on Anemometer Calibration. The MEASNET Expert Group on Anemometer Calibration nominates the coordinator for each Round Robin.

2. RR Plan

A RR plan should be agreed upon and shall be documented before commencement of the scheme, and should include the following information:

a) The name and address of the provider of the RR;	MEASNET (at MEASNET legal address)
b) the name and address of the coordinator and other personnel involved in the design and operation of the scheme;	As decided by the Expert Group
c) the nature and purpose of the scheme;	RR in anemometer calibration according to MEASNET procedures
d) Reference procedures	IEC 61400-12-1:2005 MEASNET Procedure for "Anemometer calibration"
e) Expected participants (Names and addresses)	As decided by the Expert Group

Additionally to the above the RR plan should include information on the following

- Identification of anemometers to be calibrated

  This should include at least the following
  - Anemometer type and manufacturer
  - Anemometer individual identification (serial number, equipment code etc)
  - Mounting method and main dimensions. It is recommended that a common mounting boom is supplied for each anemometer and were possible is used by all institutions. Where the wind tunnel layout of an individual institution does not allow for the use of the provided common mounting boom, a different boom may be used, provided that at least the part of the boom immersed in the wind tunnel flow is identical to the "common mounting boom" provided for the RR.
  - Information about electrical connections and operating principles for each anemometer (preferably copies of the respective manufacturers manuals)

- A time schedule including the expected initial and target dates or deadlines of the scheme, and, where appropriate, the dates on which testing is to be carried out by participants;

- Outline of the statistical analysis to be used, including the determination of assigned values and any outlier detection techniques;
- a description of the data or information to be returned to participants;
- a description of the extent to which test results, and the conclusions that will be based on the outcome of the scheme are to be made public.

Special issues

- Two ore more institutions using the same wind tunnel but with different instrumentation are counted as different participants
- One institution with two or more wind tunnels will decide in advance which w/t will be used for defining the “MEASNET reference value”. The other wind tunnel(s) of the same institution will be assessed for compliance if requested, but will not be included in the estimation of the reference MEASNET value.

3. Statistical analysis of Round Robin Results

The following method should be used for the analysis of the Round Robin Results:

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 RR coordinator. In case any sign of damage, degradation, or irregular operation that could possibly have effect on the RR results, is identified on any of the anemometers used in he RR, then this anemometer must be discarded from the RR and the result obtained must not be used in the compilation of the RR results.

Step 2: For each anemometer three output frequencies 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 frequencies the wind speeds according 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 MEASNET -reference wind speed the results per anemometer and per output frequency of all institutes recognized by MEASNET for anemometer calibration are averaged. The standard uncertainty of this reference wind speed is $(1/\sqrt{N})\%$ in which *N* is the number of MEASNET institutes that calibrated the regarded anemometer.

Step 5. Per anemometer and per output frequency the results of the calibration of a MEASNET recognized 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 $\sqrt{1+(1/N)}$ (%) (Where *N* is the number of non-discarded results per anemometer and output frequency). 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 frequency the MEASNET -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 frequencies the difference between the wind speeds obtained with the various calibration results of the participating institutes and the MEASNET -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 MEASNET –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). The institutes with an average value of 1% or less comply with the MEASNET requirement for anemometer calibration uncertainty.