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Wind tunnel calibration of cup anemometers – reduced uncertainties

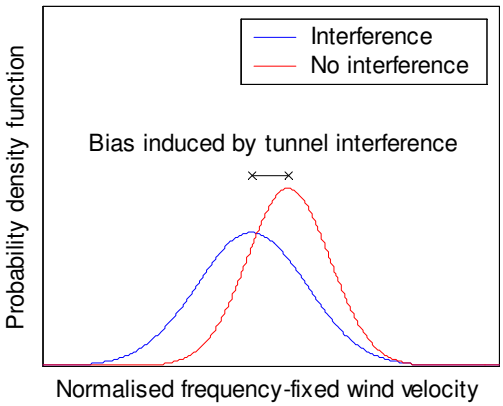
This memo describes the reduced calibration uncertainties obtained by including the influence of interference between tunnel boundaries and rotating cup anemometer rotors.

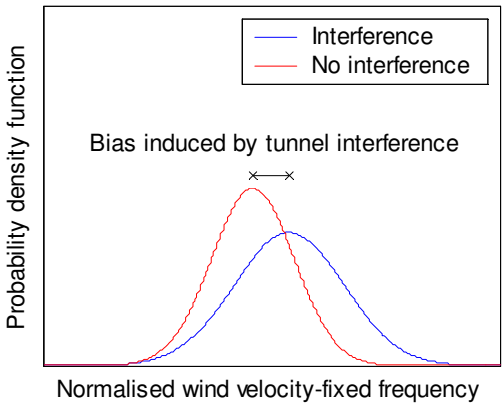
The background and documentation of the most fundamental wind tunnel interference results will be described in the paper: "Wind tunnel calibration of cup anemometers" by Ole Frost Hansen and Svend Ole Hansen. The American Wind Energy Association (AWEA) has accepted the paper for publication at the WINDPOWER 2012 Conference, taking place on June 3-6 at the Georgia World Conference Center in Atlanta. The paper will be presented on June 4 at the scientific session: Modeling and Measurement - Current Advances in the State of the Art.

The paper shows that calibration accuracy is highly dependent on the distance between rotor and tunnel boundary, and a minimum distance from rotor to tunnel boundary is crucial for avoiding interference. If this distance is too small, the tunnel boundary is sucked towards the rotor in open tunnels or a friction force is generated in closed tunnels. The interference will influence calibration results significantly for small wind tunnels with short distances from cup anemometer rotor to tunnel boundary.

The actual interference present in our Measnet approved wind tunnel setups has been determined by extensive investigations. Different distances between tunnel boundary and rotating cup anemometer rotors have been investigated in our large wind tunnel cross section with a height of 1.2 m, and the results show the influence of tunnel interference as function of distance. The figure below summarizes the main findings by probability density functions of calibration results for different cup anemometers of the same type using two tunnel setups. The influence of tunnel interference gives a bias of the average calibration results, and the reduced uncertainties of the non-biased distribution originates from increased accuracy in the day-to-day tunnel calibration.

For WindSensor P2546A cup anemometers an improved calibration procedure taking wind tunnel interference into account was put into operation on March 19, 2011. After this date the non-biased calibrations show average wind velocities that are approx. 0.4% less than previous average calibration results influenced by tunnel interference. The average bias of WindSensor P2546A calibrations carried out before March 19, 2011 may be corrected for by multiplying the slope and offset values originally informed with 0.996.





For other cup anemometers the improved calibration procedure was put into operation on April 4, 2012. Start dates and correction factors are summarized in the table below. The slope and offset determined for calibrations carried out prior to the start date given may be multiplied with the correction factor.

Cup anemometer	Start date	Correction factor
WindSensor P2546A	March 19, 2011	0.996
Vector	April 4, 2012	0.998
Thies First Class	April 4, 2012	0.998
NRG #40	April 4, 2012	1.00

The new findings show that tunnel dimensions should be larger than certain minimum requirements in order to reduce the tunnel interference to a minimum. Interference occurs in both closed and open tunnels, and its importance depends on the actual tunnel. Interference is important for closed wind tunnels with cross section dimensions of less than 1.2 m. The minimum requirements for open tunnels may be even larger.

The present Measnet procedure does not consider interference effects directly.

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