

## Abstract

Sonic anemometers are commonly employed for weather measurements of atmospheric wind speed and direction. In the wind industry, sonic anemometers are often used for turbine control and at times for resource assessment, instrument comparison studies, or even power performance measurements. Currently, there are no standards for the wind industry that are directly related to the use and testing of sonic sensors. The most common standard referenced for anemometer testing in the wind industry is the IEC 61400-12-1, which define the procedures applied by MEASNET test facilities. However, this particular standard specifies the protocols for testing cup anemometers, the preferred instrumentation for wind resource site assessments and turbine performance evaluations. The available standards for the performance testing of sonic anemometers, ASTM D 6011-96 and ISO 16622, are intended for general meteorology applications and involve a rigorous test program that evaluates the inherent three-dimensional characteristic of sonic anemometers. For sonic sensors used in research studies, wind turbine site assessment, or power performance measurements, such detailed test procedures may be necessary. For sensors used for turbine control, a more practical protocol for verifying sonic sensor wind speed output may be applicable.

## Objective

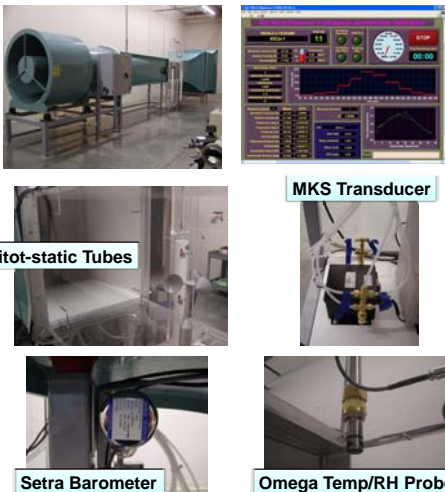
The objective of this investigation is to propose a wind speed verification protocol for sonic anemometers starting with the base test methods performed in the acceptance testing for the sonic sensor model employed for the Automated Surface Observing System (ASOS) of the United States National Weather Service (NWS). For this project, the following sonic sensors were tested in the Otech Wind Tunnel Test Facility, WT3A. Although sensor blockage was evaluated for the setup of each test, blockage corrections were NOT applied to the test data. Further study is needed in understanding the application of blockage.



## Wind Tunnel Test Facility

### OTECH Wind Tunnel Facility, WT3A

Otech Engineering, Inc. is an ISO/IEC 17025:2005 accredited laboratory. WT3A is a suction-type (Eiffel-type) wind tunnel of test section size 61.0 cm (2 ft) crosswind width x 61.0 cm (2 ft) height x 121.9 cm (4 ft) downwind length and is driven by a 30 hp (22 kW) fan motor, which can generate winds up to 45 m/s. Controls and data acquisition are performed using National Instruments hardware and LabVIEW software. All instruments used in the wind tunnel are traceable to NIST.



## General Methods

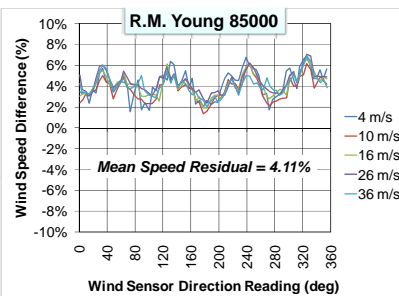
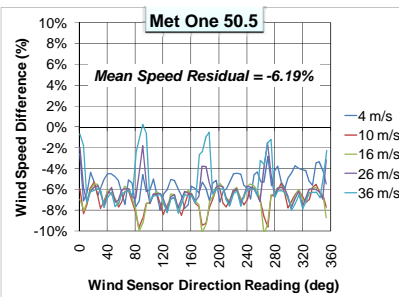
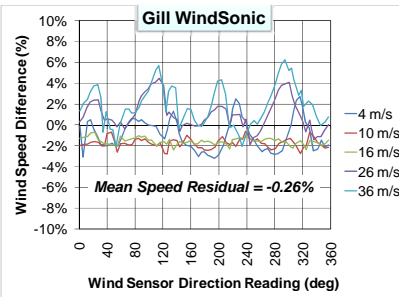
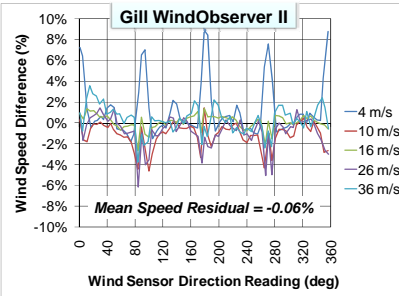
General procedures for the sonic sensor evaluation are based on methods suggested in ISO 16622 and are similar to the acceptance tests used for the sonic sensor employed for ASOS.

- Direction Test:** collect sonic wind speed measurements at five (5) wind tunnel speed settings (4, 10, 16, 26, and 36 m/s) and at direction orientations of five (5) degree increments around the entire sensor.
- Verification Test:** collect wind speed readings at the best and worst orientations for a test speed range of 4 to 26 m/s at 2 m/s increments.

Out of the two methods above, the most rigorous and lengthy is the Direction Test. Results in this paper will demonstrate that a much simpler Verification Test can provide similar results.

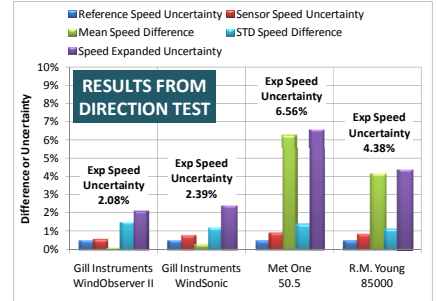
## Results from Direction Tests

With data from the Direction Tests, comparisons were made between the wind speed reading from the Pitot-static tube system and from the sonic sensor undergoing the test. According to the plots of wind speed differences below, it was determined that overall the worst wind speed readings occur at positions near 0, 90, 180, and 270 degrees. Best wind speed readings were found near 45, 135, 225, and 315 degrees. An opposite result was found only with the R.M. Young 85000 sensor.



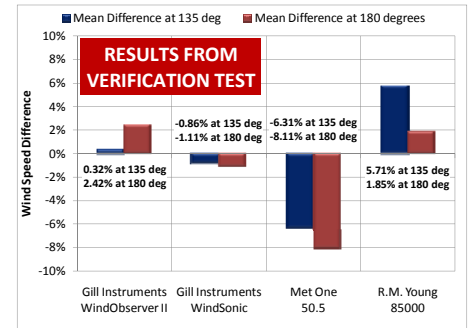
## Uncertainties from Direction Tests

Expanded uncertainties for the wind speed readings collected in the Direction Tests were based on the propagation of errors from the wind tunnel reference speed, from the sonic sensor wind speed reading, and the mean and standard deviation of the wind speed difference between the two measurements over each direction tested.



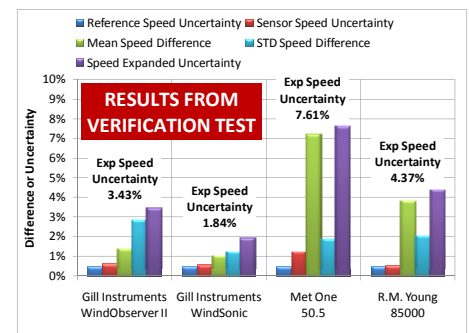
## Results from Verification Tests

Based on the evaluation of wind speed differences from the Direction Tests, calibration verifications were chosen to be performed at the critical sonic sensor rotational orientations of 135 degrees and 180 degrees.



## Uncertainties from Verification Tests

Expanded uncertainties of the Verification Test wind speed readings were calculated based on a similar method of error propagation as those done for the earlier direction tests. Overall, these uncertainties show to be comparable to those calculated for the Direction Tests.



## Conclusion

Two methods of sonic anemometer tests defined in ISO 16622 were performed: 1) a rigorous Direction Test and 2) a simplified Verification Test. Results from both methods show that the speed differences and uncertainties were overall comparable. Thus, a simple Verification Test can provide a proper performance review for sonic sensors.

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