

## Met One Instruments Introduces the Model 011 E-Class One Wind Sensor

### Overview

Applications for horizontal wind speed measurement, such as resource assessment and power performance assessment in the wind energy industry, require high accuracy as well as high performance anemometry. The Met One Instruments' (MOI) Model 011 E-Class One Wind Sensor has been designed as a "First Class" anemometer. Introduced in the middle of 2011, this wind sensor provides the following benefits:

- Performs in accordance with IEC 61400-12-1
- Optimized cost and performance
- High accuracy and exceptional linearity over wind turbine generator operation wind speed range
- Expanded linearity for wind gust measurement
- High strength polymer cup design reduces stress points for long-lasting performance
- Rugged anodized aluminum body and stainless steel bearing assembly
- Non-disposable: lifetime component serviceability
- Low power consumption
- Pulse frequency output signal (proportional to wind speed) is compatible with industry standard data loggers
- Designed and manufactured in the United States of America



The design has been tested at three wind tunnels in the United States and the initial results suggest that the design meets "Class 1" performance requirements under IEC 61400-12-1 for the horizontal component of wind speed. Full classification testing is currently underway at Deutsche WindGuard. Results are expected by the end of calendar year 2011.

### Description

The 011 E-Class One Wind Sensor has several field-proven design characteristics based on the MOI long-standing legacy anemometer product line. More specifically, the Model 010C has been manufactured for over twenty-five years and has provided field-proven performance at thousands of installations worldwide. The 011 E-Class One Wind Sensor is a mechanical anemometer with rugged clear anodized aluminum body, stainless steel shaft, stainless steel bearing assembly and high strength polycarbonate molded three cup assembly. The anemometer shaft is directly coupled to a forty slot disc optical chopper wheel. The chopper wheel rotates and interrupts the light path of an optical link forty times per revolution producing fixed amplitude pulses. These pulses are amplified and produce a frequency output that is

proportional to wind speed. The pulse output signal may be used directly with various digital counters, totalizers, and other signal processors and data loggers.

MOI made the 011 E-Class One Wind Sensor functionally robust with built-in electrical field surge protection which greatly reduces static field discharges. The 011 E-Class One Wind Sensor signal cable connects to the sensor with a military style quick connector. The sensor base diameter is 1.00 inches in diameter so it can be mounted to 1-inch ID pipe. MOI has also designed a variety of adaptors so that the sensor can mount to industry standard booms.

### *Asymmetric Cup Design*

The 011 E-Class One Wind Sensor cup design has a pending patent for the asymmetric shape to the cups which improves off-axis cosine response in accordance with IEC 61400-12-1. This optimization of dynamic response helps provide accurate horizontal wind speed measurement in flat and complex terrain environments.

### *Specifications*

#### PERFORMANCE CHARACTERISTICS

Operating Range*	0-60+ m/s
Starting Threshold*	0.19 m/s
Accuracy*	±0.1 m/s or 1% FS
Resolution	0.04 meter wind run
Temperature Range	-50°C to +85°C
Distance Constant*	3.0 m

#### ELECTRICAL CHARACTERISTICS

Power Requirements	9-27 VDC, 3 mA @ 12 VDC
Output Signal	Pulse (frequency) output (amplitude is power supply)
Output Impedance	100 ohms

#### PHYSICAL CHARACTERISTICS

Weight	0.68 kg (1.5 lbs)
Finish	Anodized aluminum body; high strength polymer cups
Mounting	PN 191 cross-arm or PN 10392 vertical pipe mount
Cabling	PN 10432-XX (specify length)

\*Specifications subject to revision upon completion of Classification testing.

### *Electrical*

Low current draw is critical for today's wind prospecting applications. The current draw of the 011 E-Class One Wind Sensor is less than 3.0 mA. The sensor is powered by a low-wattage DC power source in the 9 to 27 VDC range. It can easily be powered by a small battery source that is capable of being recharged with a small solar panel.

### *Connection to Cable and Mounting Booms*

The 011 E-Class One Wind Sensor has a simple male/female military type connector. The connector plugs are designed so they can only be connected correctly without need for determining positive and negative terminals at the tower boom. The connection is weatherproof (IP67 connector) to keep out moisture. A selection of adapters is available to allow connection to a variety of boom sizes and end posts.

### *Connection to Data Loggers*

The available user-specified length signal cable assembly easily connects to most data loggers and power supplies currently in the field. The five wire connection includes voltage in, signal out, common, shield, and internal heater positive and negative.

The 011 E-Class One Wind Sensor's digital frequency output connects directly to the pulse counter channels of industry standard loggers.

### *Bearing Protection*

Another carry over from the 010C design is the incorporation of multiple components to resist bearing contamination. An exploded view of these features is shown in Figure 1. The components include a protective dust cap that shields bearings from dust and moisture and a rotating "Slinger" to further reduce dust from entering the bearing. The result is a virtually weatherproof, dust proof assembly to increase bearing life. Bearing replacement is recommended every 12 to 24 months.

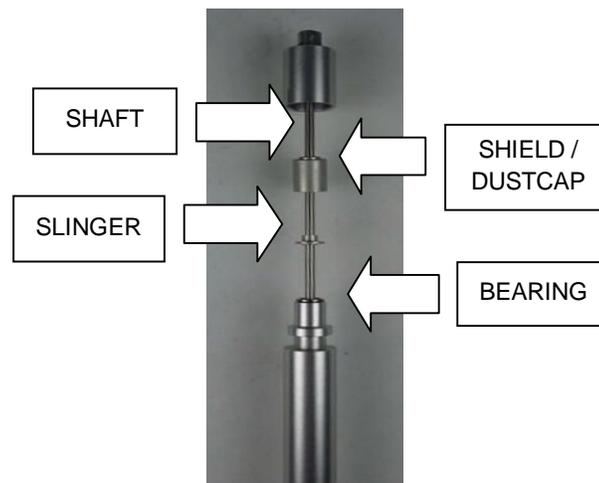


Figure 1: Exploded view of bearing assembly

### *Internal Heater Option*

Inclusion of an internal heater of 4.5 watts requires an external 12 volt 500 mA power supply. This provides positive clean aspiration through the bearings, thereby greatly increasing sensor life.

### Initial Wind Tunnel Testing

Preliminary design testing was performed in MOI's wind tunnel facility in Grants Pass, Oregon. Verification testing was conducted at the Oregon State University's Mechanical, Industrial, and Manufacturing Engineering (OSU) wind tunnel facility in Corvallis, Oregon. The results strongly indicated that the cosine response and other sensor performance criteria would be within the IEC 61400-12-1 cup classification of better than 1.7A which meets Class One measurement criteria.

Eighteen 011 E-Class One Wind Sensors were calibrated at Otech Engineering. These were used to define a consensus transfer standard for the 011 E-Class One Wind Sensor. Otech Engineering also tested one of the anemometers over an extended wind speed range with additional test points at 30, 35, 40 and 45 m/s wind speeds. These points were included to further evaluate linearity and sensor performance at higher wind speeds.

### Classification Testing by Deutsche WindGuard

IEC 61400-12-1 Annex J addresses how a cup anemometer must be tested for determining its IEC classification. MOI has contracted with Deutsche WindGuard to conduct the classification testing during the last part of 2011. Part of the classification testing includes sensor performance characterization for torque on the cup anemometer rotor, bearing friction, temperature influence, and free field comparison. Additional results will be included in future updates to this document.

### Calibration

A consensus transfer function was established over the expanded wind speed test range of 4 m/s to 26 m/s. This expanded calibration range included the MEASNET calibration wind speed test points (4 to 16 m/s, every 1 m/s), as well as an additional expanded set of calibration points from 18 to 26 m/s, every 2 m/s. The standard practice of an interleaved ramp up and down the wind speed range was followed. The consensus transfer function for the 011 E-Class One Wind Sensor over the wind speed range of 4 to 26 m/s is:  $V[\text{m/s}] = 0.0411f[\text{Hz}] + 0.19$ . The correlation coefficient, R, for each sensor's regression was in a range of 0.99998 to 0.99999. The results showed a standard error of 0.03 m/s, or < 0.1% of full scale, which is comparable with other industry standard cup anemometers.

Using the MEASNET calibration procedure, considering the wind speed test range of 4 m/s to 16 m/s, the consensus transfer function was unchanged from the expanded range. The correlation coefficient, R, for each sensor's regression was again in a range of 0.99998 to 0.99999. This indicates that the 011 E-Class One Wind Sensor exhibits excellent linearity over the MEASNET or expanded calibration range.

The 011 E-Class One Wind Sensor is available with an individual expanded (ISO 17713 1, ASTM D5096 02) or MEASNET calibration.

### Linearity

The linearity of the 011 E-Class One Wind Sensor was determined by linear regression of the wind tunnel reference wind speed against the anemometer's frequency output at each test point. The statistical slope and offset (intercept) of the population of sensors tested to arrive at the consensus transfer function showed a correlation coefficient in the range of 0.99998 to 0.99999 which illustrates a strong positive linearity. One of the eighteen wind sensors was subjected to an extended linearity test over the range of 4 to 45 m/s. The 011 E-Class One response remained highly linear ( $R=0.99994$ ) also showing that the ruggedized cup design responded well at this higher test wind speed range.

### Cosine (Off-Axis) Angular Response Tests

An 011 E-Class One Wind Sensor was tested for response to a cosine curve to evaluate the instrument response to non-horizontal, off-axis winds. Testing was conducted at the OSU's wind tunnel facility. Angular response following the IEC 61400-12-1 convention (positive values for wind flow coming from below) was conducted over a  $\pm 30$  degree wind flow angle. These tests were conducted at 5, 8 and 12 m/s. The partial results shown in Figure 2 demonstrate off-axis response comparable to other "First Class" cup anemometers.

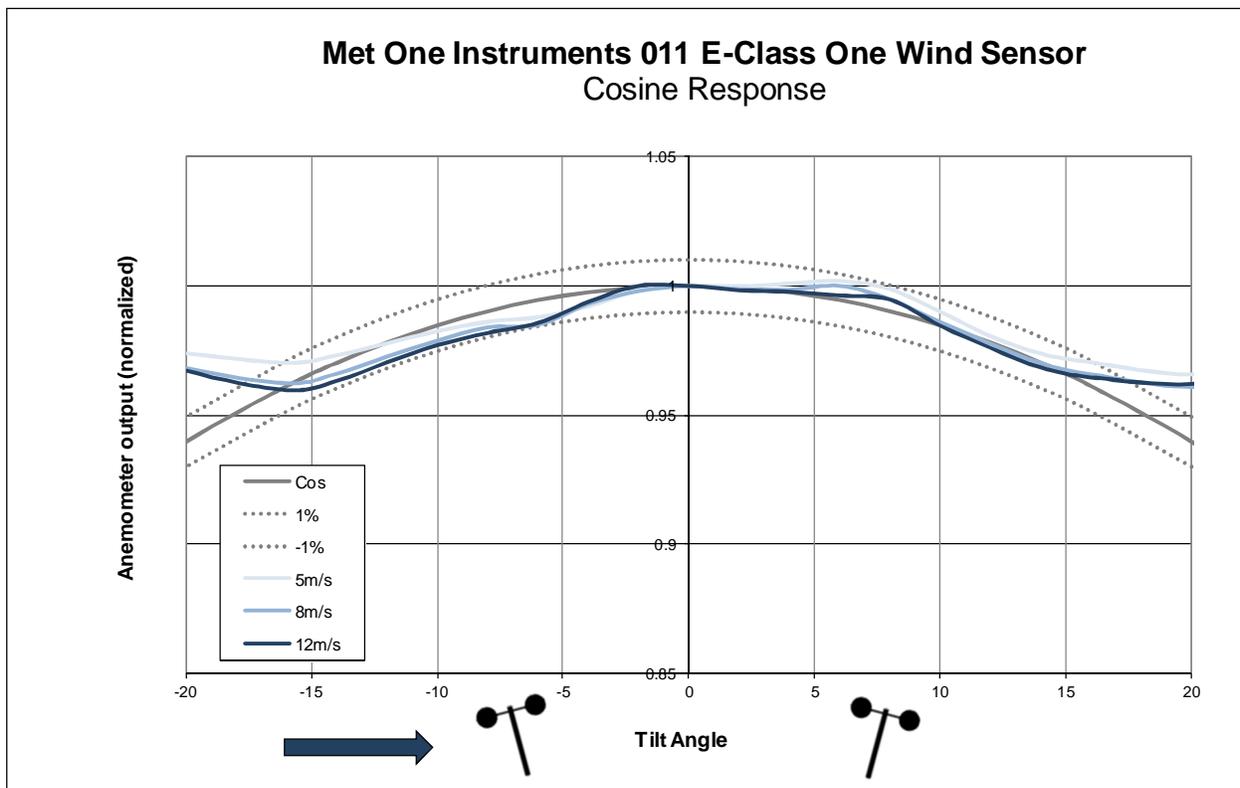


Figure 2: Cosine (off-axis) angular response

## Additional Test Parameters

Additional tests were performed to further document the anemometer specifications.

### *Distance Constant*

The distance constant measurement is important to determine the anemometer's ability to react to changes in speed. Specifically, distance constant is the distance that air flows past an anemometer while measuring the time it takes for the response to reach 63% of the desired speed. The test is performed by measuring the time for the anemometer to reach setpoint speed from a stopped position in a wind tunnel at constant speed.

A lower distance constant means that the sensor is more responsive to wind speed changes and less susceptible to "overspeeding". The distance constant test is conducted at two wind tunnel speeds within the normal operating range of the instrument such as 5 and 10 m/s.

The distance constant for the 011 E-Class One wind sensor is better than 3.0 meters. This is comparable with other First Class cup anemometers in the industry.

### *Starting Threshold*

The starting threshold, in meters/second is determined by measuring the lowest speed at which a rotating anemometer starts and continues to turn and produce a measurable signal when mounted in its normal position (ASTM D 5096-02). The resulting value is 0.19 m/s.

## Summary and Next Steps

A new Class 1 candidate wind sensor, the 011 E-Class One, was introduced by Met One Instruments, Inc. in 2011. The combination of cost and performance optimization, legacy mechanical platform, proven field installations, and manufacture in the United States, should appeal to all wind energy industry customers who are looking for an accurate, reliable, lower cost, inventory alternative.

Classification testing is underway and scheduled for completion by the end of 2011. Additional comparative field testing at demonstration sites in North America has begun. These field tests will compare the 011 E-Class One wind sensor with other Class 1 and industry standard anemometry.

This document will be updated upon completion of the IEC classification tests and as additional test data become available.

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Revised: n/a

For more information contact Met One Instruments, Inc. ([www.metone.com](http://www.metone.com))

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