

Title: Standard Operating Procedure Measurement of Wind Speed and Direction – Anemometer & Vane System		
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1. INTRODUCTION AND SCOPE

To obtain timely data for the purpose of air quality assessment, meteorological and climate trend reporting and to meet the requirements for inclusion of the data in provincial and national meteorological databases, a continuous method of measuring Wind Speed and Direction is used. This method is capable of measurement updates at a rate of once every five minutes or faster. Readings from instruments of this method enables the calculation of hourly averaged measurements of Wind Speed and Direction. Commercially available anemometer and vane Wind Speed and Direction sensors are used in the method.

This method is applicable to the measurement of Wind Speed and Direction in ambient air in the range of 160 kilometers per hour (kph) or 50 meters per second (m/s) and 0 to 360°.

This method adheres to the requirements of the current Air Monitoring Directive (AMD) drafted by Alberta Environment in 1979. In some cases the limits and specifications exceed the requirements of the current AMD and subsequent amendments. It should be considered that the current and any future amendments or drafts of the AMD will be used as the benchmark for requirements and criteria for ambient air monitoring practices conducted in the Province of Alberta. Information used to write this procedure was also taken from sources identified in the reference section.

2. PRINCIPLE OF THE METHOD

The method used to determine Wind Speed for this procedure is rotation of a vertical shaft connected to an anemometer. The anemometer is typically configured as three cups mounted to a hub. The other end of the vertical shaft is connected to a photochopper which generates an electronic signal directly proportional to wind speed. Horizontal air movement pushes on the cups of the anemometer, which causes the shaft to rotate generating an electrical signal with frequency proportional to the speed of air movement. The signal is introduced to a translator which converts the frequency to an analog signal, typically voltage. The translator can be configured from the factory to provide an output in either meters per second, kilometers per hour or miles per hour.

The method used to measure Wind Direction for this procedure is the flat plate vane which is a direct sensing method. The flat plate vane is connected via a vertical shaft to a precision wire-wound potentiometer capable of rotating through 360° as the sensing element. In operation, a reference voltage is applied across the resistance element of the potentiometer and wind direction becomes a function of voltage signal of the wiper of the potentiometer. The output signal is directly proportional to the azimuth angle. The

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wind direction sensing device must be adjusted to compensate for inclination or declination from magnetic north.

3. MEASUREMENT RANGE AND SENSITIVITY

The Wind Speed and Direction sensors used in this method are commercially available models. The measurement range of wind speed is typically 0 to 160 kilometers per hour (kph) and wind direction is 0 to 360° (degrees).

The detection limit of the wind speed and direction sensors is specified by the manufacturer. For the wind speed sensor, a threshold determination is conducted on the size and design of the anemometer used in a wind tunnel. This threshold is the amount of wind speed required to start the anemometer in motion from a calm condition. For wind direction the process is similar, however, the threshold for the vane is much lower due to the physics of the sensor configuration. Typically the thresholds are 0.8 kph for wind speed and 1.0 degrees for wind direction.

4. EQUIPMENT AND APPARATUS

The following are commercially available sensors suitable for use in this method which are currently used in the AENV Network:

Blue Sky Instruments Model 857 Wind Speed and Direction Sensor

Athabasca Research Model 540-E1 Wind Speed and Direction Sensor

Met One Model 024A and 034B

RM Young Model 5103V

5. INTERFERENCES

Interferences with measurement accuracy can be caused by improper location of the sensors relative to objects which affect airflow.

Bearing friction reduces accuracy and threshold detection. Extreme cold and ice and snow build up can cause inaccuracy of measurements or render the sensors totally unresponsive.

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6. PRECISION AND ACCURACY

The measurement precision is generally considered to be the “repeatability of the measurement”. Precision is established by the manufacturer, but confirmed during calibration checks. The accuracy of the sensor is generally considered the “deviation from true”. This means how close it is to what it should be. The benchmark of “what it should be” is provided by Alberta Environment. In calibrating the sensor, accuracy is also dependent on the accuracy of the calibration transfer standard used to calibrate the wind speed sensor and its translator. The determination of uncertainty of measurements has been done using the Type A protocol specified by the Canadian Association for Environmental Analytical Laboratories (CAEAL) to comply with the requirements of CAN-P-4D (ISO/IEC 17025).

The uncertainty of measurement estimate is the result the statistical analysis in which the root sum of squares (square root of the sum of the squares) of the variables is determined.

For Wind Speed the variables are:

Transfer standard precision	1.0 kph
Sensor precision	0.8 kph
The resultant uncertainty is	1.0 kph

For Wind Direction the variables are:

Transfer standard precision	2° (Degrees)
Sensor precision	3° (Degrees)
The resultant uncertainty is	3.6° (Degrees)

7. SITE REQUIREMENTS

Site location of the Wind Speed and Direction monitoring station should be determined according to the intended application of the monitoring data. The detailed requirements for selection of sites for monitoring ambient Wind Speed and Direction in Alberta can be found in the Air Monitoring Directive.

Wind Speed and Direction sensors are sited and operated in accordance with the guidelines outlined by the AES Guidelines for Co-operative Climatic Autostations Guide 89-1.

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8. INSTALLATION REQUIREMENTS

All the installation requirements as specified by the manufacturer in the installation procedures as well as the general requirements below must be followed.

8.1 Trees

Trees and vegetation can cause disturbance of airflow patterns which affect Wind Speed and Direction measurements. To minimize this effect, the distance between the sample inlet probe of the Wind Speed and Direction sensors and the drip line of the tree must be at least twice the height of the tree above the inlet probe or at least 10 metres away whichever is greater.

8.2 Other spacing requirements for the wind sensors such as height above ground, distance from obstructions and distance from horizontal or vertical support are as follows:

Height above ground	10 to 15 metres
Distance from support structure	> 2 metres
Distance from any air flow obstacle, i.e. buildings	> 2×height of obstacle above the sensor
Airflow obstructions	unobstructed airflow in all directions for more than 2 metres.

8.3 A data acquisition system is required to record or download the signal output from the translator.

9. OPERATIONAL REQUIREMENTS

The following table of activities must be performed when operating continuous Wind Speed and Direction sensors in the AENV network. The following documentation must be available to the operators on site: operational and maintenance manual(s), quality system documentation and station site documentation.

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**Table 2
Analyzer Operational Requirements**

Action	Time and Frequency	Procedure	Documentation	Action by
Set sensor and data system range (WS 120 kph and WD 360 °)	After installation	As per manufacturer's manual	Entry to log book	Station operator
Verification of operational parameters	Weekly	Visual Check	Entry to log book	Station operator
Sensor maintenance	As recommended by manufacturer	As per manufacturer's manual	Entry to log book and Work Order	Instrument Technician
Calibration	After installation or repair and as required thereafter Yearly	Remove sensor and translator and calibrate	Entry to log book; and Work Order	Instrument Technician

10. CALIBRATION

Calibrations of the entire wind system must be completed annually at a minimum. This procedure involves removing the sensor from the tower or mast where it is installed, verifying the mechanics are functional and completing a calibration by spinning the anemometer shaft at set frequencies, and moving the wind direction shaft to set increments throughout the 360 degrees of travel. The system manuals will provide necessary information on; corresponding wind speeds for frequency set points, system ranges, and calibration procedures. The minimum required procedure is outlined below.

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10.1 Before any hardware is disturbed, visually verify the operation of the wind speed and direction sensors by comparison to the data collected by the data system. Ensure all cables and connections from the sensors to the translators and data collection system are secure. Prior to removing the wind head from the tower, the alignment of the head must be verified. This can be completed using either a magnetic compass or the solar noon method. To use a magnetic compass, adjust the bezel of the compass to the appropriate declination depending on the co-ordinates of the sensor. Check the alignment of the crossarm to true north, not magnetic north. If it is not aligned correctly, document the deviation from true north so that collected data can be adjusted.

10.2 The following equipment is required for a wind system calibration:

Wind speed sensor calibrator – DC motor with optical feedback

Wind direction sensor calibration template.

Torque wheel

10.3 Flag the channels collecting the data for the wind speed and direction system as down for calibration. Arrange to record the data from the calibration using the data system or strip chart recorder. If the data system is used to collect the calibration data, it must be set to record in a small enough increment, typically 30 seconds or less. Also prepare a calibration form to record all parameters of the calibration. A sample form is attached below.

10.4 Verify that the starting wind speed is within the tolerance by attaching the torque wheel to the wind speed shaft. Holding the sensor horizontally with the screw on the appropriate space, the wheel should fall freely to the bottom. If it does not, the bearings should be replaced. This procedure is repeated for the wind direction shaft to ensure the bearings are within specs.

10.5 Connect the wind speed motor to the wind speed shaft using the appropriate connector. Spin the shaft at predetermined setpoints within the range of the sensor. The setpoints can be determined using the RPM vs WS tables found in the operations manual. If there are no tables available, an equation to calculate WS for RPM would be available. Each setpoint should be maintained for a length of time long enough to verify stability of the system. 5 to 10 minutes is typical.

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10.6 Connect the wind direction template to the outer housing of the wind direction sensor. Then connect the pointer to the wind direction shaft. While monitoring the data system used to collect the data in real time, align the pointer and plate so that the wind direction is reading 360 degrees and secure both in place. Then rotate the shaft and pointer to achieve predetermined set points. Each setpoint should be maintained for a length of time long enough to verify stability of the system. 5 to 10 minutes is typical

10.7 Document the results of the calibration using the appropriate calibration form.

10.8 Attach a label at a visible location on the instrument (typically the translator so that it is sheltered and will not weather) indicating the date of most recent calibration.

10.9 Return the wind head to the tower insuring the wind head is aligned to true north as described above.

11. APPLICABLE DOCUMENTS

EM-018a Met One Model 010C Wind Speed Sensor Operating Manual

EM-018b Met One Model 020C Wind Direction Sensor Operating Manual

EM-018c Environment Canada AES Guidelines for Co-operative Climatic Autostations: Guide 89-1 June 30, 1989

12. LITERATURE REFERENCES

Lodge. 1991. "Methods of Air Sampling and Analysis", 3rd edition.

"Guidance Document on Achievement Determination-Canada Wide Standards for Particulate Matter and Ozone". ISBN: 1-896997-41-4 PN 1330, October 2002, Canadian Council of Ministers of the Environment.

Quality Assurance and Quality Control Guidelines - National Air Pollution Surveillance Network Report Series No. AAQD 2004-1

Blue Sky Instrument Model 805 Air Quality Wind System 8059001 June 1995

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13. REVISION HISTORY

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14. APPROVAL



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