

National Core (NCore) and State and Local Air Monitoring Station (SLAMS) Meteorological  
Monitoring QA Plan  
Section 2.12.1  
Revision No. 1.5  
July 1, 2015  
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National Core (NCore) and State and Local Air Monitoring Station  
(SLAMS) Meteorological Monitoring QA Plan  
Section I

Electronic Calibration Branch Responsibilities

**Approval Sign-Off Sheet**

I certify that I have read and approve of the contents of this version of the "National Core (NCore) and State and Local Air Monitoring Station (SLAMS) Meteorological Monitoring QA Plan, Section I, Electronic Calibration Branch Responsibilities" with an effective date of July 1, 2015. **Sign, date and return to the Ambient Monitoring Section Chief.**

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**2.12.1 National Core (NCore) & State and Local Air Monitoring Station (SLAMS)  
Meteorological Monitoring QA Plan: ECB Responsibilities.**

**Note:** The following is a list of "significant changes" from Revision 1.4.

- 1) QA updated per QAP/SOP 2.39 "Standard Operating Procedure (SOP) for Preparing Quality Assurance Plans/SOPs".
- 2) Project and Procedures Branch updates.
- 3) State and Local Ambient Monitoring (SLAMS) meteorological monitoring requirements added.
- 4) EDAS language removed and AvTrend language added.

The U.S. EPA is currently implementing the National Ambient Air Monitoring Strategy (NAAMS). The NAAMS goals include improvement of the scientific and technical competency of the nation's air monitoring networks and increased value in protecting public health and the environment.

The North Carolina Ambient Meteorological Monitoring System must meet or exceed the requirement that meteorological data collected at all NCore stations, as stated in the Code of Federal Regulations (CFR) Chapter 40 Section 58, Appendix D.3.b. Effective January 1, 2011, two (2) meteorological calibrations are required per year at all NCore stations. The NC ambient meteorological monitoring system consists of the following:

1. Met One Model 010C Wind Speed Sensor
2. Met One Model 020C Wind Direction Sensor
3. R M Young Model 05305AQ Wind Speed/Wind Direction Sensor
4. Climatronics Model CS880-L Wind Speed/Wind Direction Sensor
5. Campbell Model HC2S3 Relative Humidity/ Temperature Sensor
6. Met One Model 083C Relative Humidity Sensor
7. Vaisala Model HMP45AC Relative Humidity/ Temperature Sensor
8. Met One Model 062 Temperature Sensor
9. Campbell Model HC2S3 Temperature Sensor
8. Apogee SU-100 UV Solar Radiation

Note: minor components are not specified but included by reference.

The ECB is responsible for ensuring that all components are compatible with the meteorological measurement devices. The ECB also performs audits and calibrations as needed. The ECB is

responsible for the performance of complete system evaluation prior to the field installation and that the system is fully functional at the completion of the installation. On an ongoing basis as needed the ECB provides equipment and instrumentation maintenance and operational support to maximize the collection of the highest quality ambient air pollution data possible in accordance with accepted and approved procedures.

**The Quality Assurance Handbook for Air Pollution Measurement Systems Vol. IV: Meteorological Measurements Version 2.0 (Final)** is designed to provide clear and concise information and guidance to the State/Local/Tribal (SLT) air pollution control agencies that operate meteorological monitoring equipment and systems. Recently, the new monitoring rule was published, which establishes the requirements for meteorological monitoring in support of National Core (NCore) and State and Local Ambient Monitoring Station (SLAMS) network for items such as ambient temperature, relative humidity, wind speed and wind direction. Other requirement items such as barometric pressure, precipitation and upper-air meteorology will not be discussed in this document.

**Note:** The meteorological monitoring for the State and Local Air Monitoring Station (SLAMS) sites will follow the NCore requirements with the exception of sensor acceptance criteria (relative humidity and ambient temperature) and calibration frequency.

### **2.12.1.1 Meteorological Monitoring Equipment**

#### **Selection and Procurement**

The Electronics and Calibration Branch (ECB) of the Ambient Monitoring Section of the Division of Air Quality (DAQ) is responsible for the evaluation and procurement of ambient pollution monitoring equipment; installation of monitoring instrumentation, samplers, and support equipment; evaluation of the on-going performance of all state operated air pollution sampling and monitoring systems; and scheduled and unscheduled system maintenance. The ECB maintains a sufficient inventory of monitoring system instrumentation, support equipment, and replacement parts to minimize the loss of ambient air monitoring data for all ambient air monitoring equipment of the Ambient Monitoring Section.

The ECB is also responsible for procuring and maintaining dedicated traceable standards for the certification of all calibrators and the independent accuracy auditing of ambient air quality monitoring systems. These standards provide a direct link to established national standards and are the foundation for the collection of the highest quality ambient air pollution data possible in accordance with current procedures and existing Federal Regulations and Guidelines. The accuracy audits performed by ECB provide an ongoing evaluation of monitoring equipment performance and site operator adherence to approved operating procedures. The ECB maintains permanent records on all standards used in the calibration and auditing of all instrumentation and

sampling equipment used in support of DAQ monitoring activities.

The ECB maintains permanent records for each meteorological site used to monitor ambient air quality in the state of NC. Each significant component of the meteorological monitoring system (wind direction sensors, wind speed sensors, temperature sensors, and relative humidity sensors) is assigned a dedicated unique (data logger) logbook. These logbook records include the complete repair records for the site instrumentation. These permanent records are updated continuously.

The ECB is also responsible for evaluating, developing, and recommending changes in equipment and operating parameters to improve the quality of data collected and procedures used in the collection of the data.

All original records (records documenting observations, i.e. calibration and audit logbook) must be legible, complete, dated, and signed by the operator and retained as part of the permanent instrument calibration record. The operator's signature on the calibration logbook form certifies that the calibration has been performed in accordance with this QA/SOP and that the information contained on the form is accurate. All records will be reviewed and verified by the ECB Supervisor and audited by Raleigh Central Office.

#### **2.12.1.1.1 MET One Model 010C Wind Speed Sensor**

The wind speed sensor uses a three-cup anemometer assembly and solid-optical link with a 40-slot chopper disk to produce a pulse output frequency proportional to the wind speed. An internal heater reduces moisture to extend bearing life. This sensor is usually used in conjunction with the 191 Cross arm Assembly. The sensor cable is connected directly to the data logger. The following table summarizes the performance and electrical specifications:

<b>PERFORMANCE CHARACTERISTICS</b>	
Maximum Operating Range	0-125 mph or 0-60 meters/sec
Starting speed	0.6 mph or 0.27 meters/sec
Calibrated range	0-100 mph or 0-50 meters/sec
Accuracy	1% or 0.15 mph
Temperature range	-50°C to +85°C
Response	Distance constant less than 5 feet of flow*
* The distance traveled by a sharp wind gust for the anemometer to reach 63% of the new wind speed value.	
<b>ELECTRICAL CHARACTERISTICS</b>	
Power requirements	12 VDC at 10 mA
Output signal	11-volt pulse
Output impedance	100 ohms maximum

### **Installation**

- a) Mount the cup assembly and secure with the allen-head setscrew and check to see that the cup assembly rotates freely.
- b) Install the sensor in the end of the Model 191 Mounting Arm (the end without the bushing).
- c) Tighten the locking setscrews. **Do not over tighten.** Apply a small amount of silicone grease to the setscrews to prevent freezing in corrosive environments.
- d) Connect the cable assembly to the keyed sensor receptacle and attach it to the mounting arm. (Refer to Met One operations manual, 010C Wind Speed Sensor Fig. 2-1).
- e) Connect the six wires on the cable from the 2 meter and 10 meter wind speed sensors to the ESC data logger. (Refer to Met One operations manual, Connections section drawing SID-1019 and SID-1021).
- f) Weather sensors are sensitive to direct or nearby lightning strikes. A well-grounded

metal rod or frame should be placed above the sensor installation. In addition, the shield on the signal cable leading to the translator must be connected to a good earth ground at the translator end and the cable route should not be vulnerable to lightning.

### **Operational Check**

- a) Spinning the anemometer cup assembly will produce output pulses (40 pulses per revolution). To verify sensor output, monitor this signal with the translator module, data logger or an oscilloscope. Spinning the anemometer hub without the cup assembly mounted and allowing it to coast to a stop will give a good indication of the threshold performance; a jerky or sudden stop indicates damaged bearings, bent drive shaft or obstruction in the light chopper.
- b) Inspect the cup assembly for loose cup arms or other damage. The cup assembly cannot change calibration unless a mechanical part has come loose or has been broken. If a cup arm is loose or broken, the calibration of the sensor may be affected.
- c) Check the internal heater operation by sliding the sensor cover down and touching the housing behind the printed circuit board. The housing should feel warmer than the adjoining metal parts. The sensor has a built-in heater that is designed to provide a raise in the internal temperature, providing a small positive pressure. This heater requires an external 12V (@500ma) power supply.

### **Maintenance, 6-12 Month Interval**

- a) At the cross arm assembly, disconnect the quick disconnect plug from the sensor (leave the cable secured to the cross arm) and remove the sensor from the cross arm assembly.
- b) Loosen the setscrew holding the cup assembly. Support the rotating hub of the sensor with one hand and pull the anemometer cup assembly free.
- c) Visually inspect the anemometer cups for cracks and breaks, and make sure each arm is securely attached to the cup assembly hub.
- d) Slide the sensor cover down to expose the light chopper disc assembly, light source and the detector and circuit board. Inspect the interior of the sensor for any signs of corrosion and dust buildup. Inspect the light-chopper for cracks and make sure all slots are free of corrosion. Inspect the signal conditioning module for cracks and corrosion around the soldered connections. Repair or replace any bad components.
- e) Apply a small amount of silicone lubricant (Dow Corning DC-33 or equivalent) to the sensor o-rings. Slide the cover up over the sensor and remove any excess lubricant.



- f) A moisture vent is located on the base of the sensor; make sure this vent is clear.
- g) Reinstall the sensor and verify proper operation and sensor output per Section 2.12.1.1.1  
**Operational Check.**

**Maintenance, 12-24 Month Interval**

- a) Recommend complete overhaul of sensor. This maintenance may be provided by the factory or in-house. Section "b)" provides instructions for maintenance of the wind speed sensor.
- b) Maintenance  
The following procedures require a relatively clean, dry work area, a source of 12 VDC power at approximately 20 mA, and an oscilloscope (DC to 10 KHz minimum range required). The following sections assume the sensor has already been removed from the tower and the cup assembly removed. Also, the appendix contains a list of parts for this sensor.
- c) Sensor Bearing Replacement (Refer to Met One operations manual 010C Wind Speed Sensor, Section, 4.4 and Table 4.2)

Disassemble the sensor and remove the old bearings by the following steps:

1. Slide the sensor cover (16) down to expose the light chopper assembly (11).
2. Loosen both special setscrews on the shaft of the light chopper assembly (11)
3. Support the light chopper assembly (10) with one hand and slowly pull the rotating hub/shaft assembly (2) out of the assembly (8).
4. Remove the shield (4) and slinger (5) from the column (8).
5. Remove the light-chopper assembly (10) from the sensor housing, being careful not to damage the slots located between the light chopper holder and the lower bearing.
6. Insert the lower end of the rotating hub/shaft assembly into the upper bearing, cock it slightly to one side and push out the lower bearing.
7. Insert a right-angle type of tool, such as an Allen wrench, into the upper bearing: cock it slightly to one side and remove the bearing.
8. Clean dirt from the bearing using a cotton swab and alcohol.

Install the new bearings and assemble the sensor as follows:

1. Install the new upper and lower bearings in the column (8). Bearings should slide easily into the bearing bores.  
Install the slinger and shield (4,5) on the column assembly. Replace the damaged or corroded parts with new parts.

3. Insert the rotating hub shaft (2) into the column assembly (8) through the shield (4), slinger and upper bearing, until it starts to protrude through the lower bearing.
  4. Support the light-chopper assembly (10) with one hand and slowly push the rotating hub shaft into it until the shaft almost bottoms.
  5. Tighten both special setscrews on the light-chopper assembly, but do not over tighten as the setscrews will damage the shaft.
  6. Rotate the sensor hub assembly (2) to ensure it turns freely and the end play is about 0.005.
  7. Hold the sensor vertically and make sure the light-chopper assembly (10) is not contacting the detector assembly (12).
  8. Apply small amount of silicone lubricant (Dow Corning DC-33 or equivalent) to the sensor O-rings and slide the cover (16) up over the sensor and remove any excess lubricant.
- d) C1200 Circuit Board Assembly Replacement (Refer to Met One operations manual 010C Wind Speed Sensor, Section 4.5, Table 4.2 and Drawing 1202)
1. Slide the sensor cover (16) down to expose the light-chopper disc assembly (10), detector assembly (12) and the circuit board (18).
  2. Remove the two screws (17) holding the circuit board assembly (18) and lift the circuit board away from the sensor housing.
  3. Note the colors of each wire and unsolder the three wires to the detector assembly from the circuit board and the three wires from the connector (19).
  4. Install new circuit board assembly by reversing the above steps and following the wire color code.
- e) Detector Assembly Replacement (Refer to Met One operations manual 010C Wind Speed Sensor, Section 4.6, Table 4.2 and Drawing 1202)
1. Slide the sensor cover (16) down to expose the light-chopper disc assembly (10), detector assembly (12) and the circuit board (18).
  2. Remove the two screws (17) holding the circuit board assembly (18) and lift the circuit board away from the sensor housing.
  3. Note the color of each wire and unsolder the three wires to the detector assembly from the circuit board (18).
  4. Remove the two screws (20) holding the detector assembly (12) and remove the assembly.
  5. Install the new detector assembly and re-assemble by reversing the above steps and following the wire color coding.
- f) Integrated Amplifier Replacement (Refer to Met One 010C Wind Speed Sensor operations manual, Section 4.6, Table 4.2 and Drawing 1202)

1. Slide the sensor cover (16) down to expose the light-chopper disc assembly (10), detector assembly (12) and the circuit board (18).
2. Carefully pry the amplifier (23) from its socket on the circuit board noting Pin 1 orientation.
3. Install replacement integrated amplifier by reversing the above steps, being sure Pin 1 is properly oriented.

**Model 010C Wind Speed Sensor Troubleshooting Chart**

Symptom	Probable Cause	Solution
No wind Speed output	Loss of supply voltage	Check translator +12V supply & connecting cables
	Faulty integrated amplifier	Replace IC amplifier
	Faulty diodes D1, D2	Replace circuit board
	Faulty detector	Replace detector
No wind speed output below 2-5 mph	Bad bearings	Replace bearings
	Faulty detector	Replace detector
Wind speed signal drops out as speed increases	Faulty detector	Faulty detector

**2.12.1.1.1a Wind Speed Calibrations**

**Calibration Frequencies**

Calibrations are required on the wind speed sensor at site startups, sensor repairs or adjustments that will affect the response or data. Also calibrations are required after any unacceptable QA audit. Bi-annual wind speed calibrations are required at all NCore sites, annually for non-NCore sites. **The audit and calibrations should be performed using different standards and different personnel.**

## **Wind Speed Calibrations Devices**

The wind speed calibration device is a Model 053 Wind Speed Calibrator. It consists of a variable speed motor, an electronic control and display module, a sensor clamp assembly to mount the motor and couplings to connect the motor to the shaft. The wind speed calibrator produces known revolutions per minute (RPM) of shaft speed to the wind speed sensor. The shaft speed in RPM's is used to calculate the wind speed in meters per second.

The wind speed starting torque device is a Model 050 Torque Gauge. It consists of a balance wheel and precision counter weights. The gauge is traceable to NIST MIL-STD-45662A specifications.

## **Calibration Procedure**

- a) The calibration begins by removing the wind speed anemometer cup assembly from the sensor. The wind speed calibrator motor drive is then positioned on the sensor to spin the wind speed sensor's shaft. Care must be exercised to properly align the wind speed calibrator motor drive directly over the shaft. This will prevent any strain to the calibrator motor or the shaft. The coupling from the calibrator motor drive to the shaft should be centered. Connect the calibrator motor drive cable to the electronic control module. The calibrator is now ready to begin the calibration.
- b) The calibration speeds to calibrate a Met One 010C wind speed sensor are 0.0, 100, 200, 400 and 800 RPM. The 0.0 RPM is produced with the control module turned off. The upscale points are generated with the control module turned on and the direction switch is set on clockwise rotation. The push wheel switches are toggled to produce the desired reading on the 4 digit LCD starting with the lowest setting first. The motor and control module should stabilize within a one-minute period to the input setting. If the readout is not within +/- 1 RPM on the control module LCD stop the audit and investigate problem. Problem is usually improper alignment of motor drive or weak control module batteries. Once the control module LCD is stable, view the data logger wind speed value. If data logger wind speed reading is stable at this point record the value. Adjust the push wheel switch for the next point and repeat measurement process. Continue the calibration until all points are generated and the wind speed response is recorded from the data logger.
- c) Turn off the control module power, disassemble the motor drive and remove the sensor clamp assembly. Remove the sensor cable from the wind speed sensor and remove the sensor from the cross arm mount.
- d) Install the 050-torque balance wheel on the wind speed sensor shaft to verify the starting torque. Screw a black nylon screw into the 2 cm position of the balance wheel. Lay the sensor in a horizontal position and hold the balance wheel level. Release the balance

wheel and watch for a downward deflection caused by the nylon screw. Rotate the wind speed sensor 90 degrees and level balance wheel. Release the balance wheel and watch for the deflection caused by the nylon screw. Repeat measurements until the sensor is tested at four evenly spaced points around the sensor's shaft. If there is no downward deflections at any test points the counter weight must be increased by 0.1 gm-cm until there is downward movement. Do not exceed 0.4 gm-cm counterweight since starting torque specifications have been exceeded. Record the highest value tested.

- e) Reinstall the wind speed sensor to the cross arm mount and reconnect the signal cable. Install the anemometer cups to the wind speed sensor. The wind speed calibration is now complete.
- f) Calculate the calibration input values from the formula given below and found on the field calibration form (see Figure 1, pg. 14). The calibration is considered acceptable if each wind speed value is within +/- 0.5 meters per second from the calibration input value. The audited sensor starting torque threshold is acceptable if all measured points are less than 0.2 grams per centimeter. If any measurements do not meet the acceptable specifications for a wind speed calibration the sensor must be evaluated by the technician. The technician will examine the sensor, make necessary repairs and recalibrate the sensor. The calibration data and recommendations will be included a calibration report.

Calibration Input Wind Speed m/sec = rpm\*0.00512

**Figure 1 Wind Speed Cal / Audit Sheet**

Wind Speed: Calibration      Audit \_\_\_\_\_

Site \_\_\_\_\_      Date \_\_\_\_\_  
Start Time \_\_\_\_\_      Stop Time \_\_\_\_\_  
Sensor Model \_\_\_\_\_      Sensor SN \_\_\_\_\_  
Torque Gauge \_\_\_\_\_      Device SN \_\_\_\_\_  
Calibration Device \_\_\_\_\_      Device SN \_\_\_\_\_

RPM	Input Speed (m/sec)	Data logger speed (m/sec)	Difference
0.0			
100.0			
200.0			
400.0			
800.0			

Measured Sensor Torque gms/cm      Specifications \_\_\_\_\_

Calibration Wind Speed meters / second =

MET One 010C sensor / RM Young 05305AQ      rpm \* 0.00512  
RM Young 18801 cross-arm       $\left( \frac{\text{RPM}}{42.55} \right) + 0.2235$

Difference = Data logger speed - input speed

Acceptable:    Yes                  No                  Auditor \_\_\_\_\_

Each single point measurement must be within  $\pm 0.25\text{m/s} \leq 5\text{m/s}$ ; 5% > 2m/s not to exceed 2.5m/s of input value for calibration to be acceptable (NCore and SLAMS)

**2.12.1.1.2 MET One Model 020C Wind Direction Sensor**

The wind direction sensor uses a lightweight airfoil vane and a micro torque potentiometer to produce an analog output proportional to the wind direction. An internal heater reduces moisture for extended bearing life. The sensor is used in conjunction with the 191 Cross arm Assembly. This sensor is connected to the data logger using the 2465 sensor cable. The following table summarizes the performance and electrical specifications:

<b>PERFORMANCE CHARACTERISTICS</b>	
Azimuth	Electrical 0 – 356° Mechanical 0 – 360°
Threshold	0.6 mph
Linearity	± 0.5% of full scale
Accuracy	± 2°
Damping Ratio	0.4 - 0.6
Delay Distance	less than 3 feet
Temperature range	-50°C to +85°C
<b>ELECTRICAL CHARACTERISTICS</b>	
Input Power (+VRef)	5VDC (max) with 5 mA current limiting
Output	Varying resistance 0-10k ohms
Maximum line length	1500 feet
Heater power requirement	12VDC at 350 mA

## Installation

- a) Install the vane assembly on the sensor (note the locator pin fits into the slot in the vane assembly hub) and tighten the setscrew. Do not over tighten. (Refer to Met One 020C Wind Direction Sensor operations manual, Section 2.1, Table 4-3, Fig. 2-1, and Drawing 2465).
- b) Check to see if the vane assembly rotates freely.
- c) Ensure the vane assembly is properly balanced and the balance counterweight is tight.
- d) Install the sensor in the Model 191 Mounting Arm with the keyed bushing. The orientation screw on the stem of the wind direction sensor will fit into the hole on the mounting bushing.
- e) The aluminum fitting has two recessed setscrews that may require tightening to further secure the sensor. Over-tightening these screws may strip out the head, making it virtually impossible to remove. Apply a small amount of silicone grease to prevent freezing in corrosive environments.
- f) Connect the cable assembly to the keyed sensor receptacle and attach it to the mounting arm.
- g) Model 020C Wind Direction Sensor Alignment (Refer to Met One operations manual 020C Wind Direction Sensor, Section 2-2, Table 4-3, Fig. 2-1 and Drawing 2465). The orientation pin located on the stem of the sensor is to be oriented so it points true south. This means that the wind direction orientation must account for the difference between magnetic and true north.
- h) Tape the sensor hub and column together so the notches on each part are exactly aligned.
- i) Loosen the two setscrews in the aluminum fitting so the sensor and mounting bushing may be rotated.
- j) Rotate the sensor so the vane (counter-weight end) points directly south. A transit located directly south or north will facilitate the alignment process. Merely rotate the sensor until the vane (counter weight and sensor column) point south.
- k) Tighten the two setscrews in the aluminum fitting and remove the orientation device. Apply a small amount of silicone grease to the screws to prevent freezing in the aluminum fitting. The sensor may now be removed and re-installed at any time without requiring orientation.
- l) Connect the five wires on the cable from the 2 meter and 10 meter wind direction sensors to the ESC data logger.(Refer to Met One operations manual 020C Connections Section, SID-1020 and SID-1022).
- m) Weather sensors are sensitive to direct or nearby lightning strikes. A well-grounded metal rod or frame should be placed above the sensor installation. In addition, the shield on the signal cable leading to the translator must be connected to a good earth ground at the translator end and the cable route should not be vulnerable to lightning.

## Operational Checkout

- a) With the sensor connected to the input, any movement of the vane in a clockwise direction (as seen from above) will result in a positive voltage output. Movement of the



sensor's output will progress up-scale until it reaches + Vref, then the output voltage will drop to 0 volts. Continued clockwise rotation will again bring the module's output voltage to +Vref and the action can be repeated. When the notch on the hub and the column of the sensor are exactly aligned, the output signal will correspond to 180° or 50% of Vref.

- b) Check the internal heater operation by sliding the sensor cover up and touching the housing. The housing should feel warmer than the adjoining metals parts.

#### **Maintenance, 6-12 Month Interval**

- a) At the cross arm assembly, disconnect the quick disconnect connector from the sensor (leave the cable secured to the cross arm). Remove the sensor from the cross arm assembly bushing. (Refer to Met One operations manual 021C Wind Direction Sensor, Section 4.2, Table 4-3, Fig. 2-1, and Drawing 2465).
- b) Support the rotating hub of the sensor with one hand and pull the vane assembly free.
- c) Visually inspect the wind vane assembly to ensure the wind vane and counterweight are securely attached to the wind vane rod, and the setscrew in the rotating hub holds the rod in place.
- d) Carefully slide the sensor cover down to expose the potentiometer assembly. Inspect the interior of the sensor for any signs of corrosion. Also, inspect the potentiometer for loose wires, cracks and corrosion.
- e) Inspect the shaft coupler for proper position. Make sure the marks on the rotating hub and the column assembly are aligned and all four special setscrews are tight.  
**NOTE:** Any time the coupler assembly is moved in relation to the shaft, the potentiometer alignment must be performed.
- f) Rotate the sensor hub assembly to make sure it turns freely and the sensor bearings are not damaged. If rotation is not free, inspect the bearings and replace if necessary.
- g) Check to ensure the potentiometer assembly is rigid in its holder.
- h) Check the sensor O-rings for cracks. Replace as necessary. Apply a small amount of silicone lubricant (Dow Corning DC-33 or equivalent) to the sensor O-rings seals. Slide the cover over the sensor and wipe off any excess lubricant.
- i) Support the rotating hub of the sensor with one hand and mount the wind vane assembly on the hub. The wind vane assembly is keyed to fit the pin on the hub. Make sure the moisture vent located on the base of the sensor is unobstructed.

- j) Re-install the sensor and verify proper operations per Section 2.12.1.1.2 **Installation and Operational Checkout**.

**Maintenance, 12-24 Month Interval**

- a) Replace sensor bearings

**Maintenance, 24-36 Month Interval**

- a) Recommend complete overhaul of the sensor. This maintenance may be provided by the factory or done in-house. Section "b)" provides instructions for maintenance of the wind direction sensor.
- b) Maintenance  
The following procedure requires a relatively clean, dry work area, a source of 5V DC power at approximately 5 mA, and a digital voltmeter. The following sections assume the sensor has already been removed from the tower and the vane assembly removed. (Refer to Met One operations manual 021C Wind Direction Sensor, Section 4.1, 4.2, 4.3, 4.4, Table 4-3, Figure 2-1, and Drawing 2465).
- c) Sensor Bearing Replacement.
1. Slide the sensor cover (14) down to expose the horizontal potentiometer assembly (9).
  2. Make sure the two lower special setscrews on the drive coupler (15) next to the potentiometer are tight. Loosen the two upper special setscrews.  
**NOTE:** Any time the coupler assembly is moved in relation to the shaft, the alignment must be performed.
  3. Slowly pull the rotating hub shaft assembly (2.7) from the column.
  4. Remove the shield (4) and slinger (5) from the column.
  5. Insert a right-angle type of tool, such as an allen wrench, into the bearing cocking it slightly to one side and remove the bearing (5). Clean any dirt from the bearing bores using a cotton swab and alcohol.
  6. Install a new upper bearing in the column assembly. The bearing should slide easily into the bearing bore. **CAUTION:** Do not lubricate Bearing. Do not force.
  7. Install the slinger (5) and the shield (4) on the column assembly. If the parts are damaged or corroded, they should be replaced.

8. Insert the rotating hub shaft assembly (2,7) into the column assembly through the shield (4), slinger (5) and the bearing (6).
  9. Support the drive coupler (15) with one hand and slowly push the rotating hub shaft (2,7) until the shaft bottoms.
  10. Recalibrate the sensor.
  11. Replace the vane assembly and place back on tower.
- d) Potentiometer replacement (Refer to Met One operations manual 020C Wind Direction Sensor, Section 4.2, 4.4, 4.6, Table 4-3, Figure 2-1, and Drawing 2465).
1. Carefully slide the sensor cover (14) down to expose the horizontal potentiometer assembly (9). Unsolder these wires to the potentiometer (note color code for re-installation).
  2. Loosen the two lower setscrews closest to the potentiometer in the drive coupler (15).
  3. Using a pencil, mark the approximate position of the right-hand potentiometer terminal on the pot support.
  4. Loosen the two setscrews on the potentiometer adapter and remove the potentiometer.
  5. Install the new potentiometer. Tighten the potentiometer into the adapter using the two screws. Tighten 3 turns after finger tight.
  6. Re-calibrate the sensor.
  7. Replace the vane assembly and install on the tower.

**Model 020C Wind Direction Sensor Troubleshooting Chart**

SYMPTOM	PROBABLE CAUSE	SOLUTION
No wind direction output	Loss of supply voltage	Check supply cables
	Faulty potentiometer	Replace potentiometer
No change in wind direction output below 2-5 mph	Bad bearings	Replace bearings

**2.12.1.1.2a Wind Direction Calibration**

**Calibration Frequencies**

Calibrations are required on the wind direction sensor at site startup and after sensor repairs or adjustments that will affect the data. Also calibrations will be required after any unacceptable Q.A. audit. Bi-annual wind direction calibrations are required for the NCore site, annually for the SLAMS sites. **Note:** The audit and calibrations should be performed using different equipment and different personnel.

**Wind Direction Calibration Devices**

A wind direction calibration device used is a Model 040 wind direction calibrator. The device is a directional wheel marked from 0.0 degrees to 360 degrees and is mounted on the wind direction sensor body near the hub. A pointer arm is then attached to the wind direction sensor's hub. The pointer is used to read the calibration direction from the directional wheel.

The wind direction starting torque device is a Model 050 Torque Gauge. It consists of a balance wheel and precision counter weights. The gauge is traceable to NIST MIL-STD-45662A specifications.

A surveyor's transit can be used to calibrate the wind direction. It will be used to set the reference hubs at 180 degrees from the wind direction sensor. The transit sighting scope will be set to a known direction by using the compass and adjusting for the magnetic declination of the site.

A wind direction calibration device is a model 042 telescopic sight orientation device. The telescopic sighting scope is used to align the 191 cross arm locking hub. The wind direction sensor when mounted into the locking hub will be oriented to 180 degrees. A reference hub of 180 degrees from the wind direction sensor must be established before the scope can be used.

## Calibration Procedure

- a) The calibration begins by finding the direction of the wind direction sensor. A transit can be used approximately 100 feet from the met tower. To avoid possible errors in the calibration secure the transit tripod firmly in the ground to prevent movement of the transit when observing the wind vane. Check and double check the transit bubble levels and horizontal scales for correct adjustments. The transit horizontal direction scales are set to true North with the compass needle set on magnetic North for the site location. The magnetic declination for the site can be obtained from a USGS office or the nearest airport. The transit compass can be read to within 0.5 degrees using a magnifier lens. With the transit referenced to true North, release the upper direction scale and sight the wind direction vane in the transit sighting scope cross hairs. The wind vane is taped to fix the vane's position once the vane is centered horizontally in the sighting scope's cross hairs. The wind direction sensor's direction value is then read from the data logger and recorded as found direction. The calibration direction is read from the transit horizontal direction scale. The reading must be corrected by adding 180 degrees if the scale reading is less than 180 degrees or subtracting 180 degrees if the scale reading is more than 180 degrees. The correction is done to correct for the reverse shooting of the wind direction vane from the transit.
- b) To calibrate the direction, a reference hub must be located 180 degrees from the wind direction sensor. The transit is used to establish this point and mark it with a stake. With the transit set to true north and the wind direction sensor located 180 degrees from the transit the reference hub point is found. The reference hub stake is set in the vertical cross hairs of the transit telescopic sight. The wind direction sensor must be in the same vertical line of the cross hairs. If not the transit is moved in an arc from the sensor until all the above conditions are satisfied. The reference hub has now been established. If the reference hub is found disturbed it must be reestablished with the transit before it can be used for calibrations.
- c) Disconnect the wind direction sensor cable from the sensor. Remove wind vane from the sensor and then remove the sensor from the cross arm hub. Insert the 042 sighting scope into the 191 cross arm hub and secure with the locking screw to the hub. The hub setscrews are loosened so the hub can be rotated. The hub is rotated until the vertical cross hairs of the sighting scope are in line with the reference hub. The cross arm hub is then locked with the hub setscrews. Recheck the alignment with the reference hub and readjust the cross arm hub if needed. When the cross hub is referenced to the reference hub the scope is removed from the cross arm hub. The wind direction sensor is inserted into the cross arm hub and set with the sensor setscrew. The wind direction sensor is now oriented to 180 degrees. The signal cable is connected to the wind direction sensor. The sensor's hub and stem alignment marks are then taped together so the sensor direction is set to 180 degrees. Observe the data logger and record the wind direction reading as the system calibration.

- d) The wind direction vane and the signal cable are then disconnected from the wind direction sensor. The sensor is then removed from the cross arm hub. The Model 040 wind direction calibrator is then set up on the sensor and the signal cable is reconnected. The wind direction sensor's hub is rotated until the wind direction response is reading 180 degrees +/- 2.0 degrees on the data logger. The hub position is then taped fixed. The directional wheel is then set to the pointer to read 180 degrees on the directional wheel. The wind direction calibrator is now setup to perform the wind direction sensor calibration. The data logger wind direction value is read and recorded for the calibration input direction of 180 degrees. The tape is then removed from the hub. The hub can now be turned using the calibrator pointer to the other calibration points of 270, 360, 10, 90 and 180 degrees located on the directional wheel. All values are read from the data logger and recorded. After all points are performed the calibrator is removed and the signal cable disconnected.
- e) Install the 050-torque balance wheel on the wind direction sensor shaft to verify the starting torque. Screw a stainless steel screw into the 4 cm and the 2 cm position of the balance wheel. Screw a black nylon screw into the 5 cm position of the balance wheel. Lay the sensor in a horizontal position and hold the balance wheel level. Release the balance wheel and watch for a downward deflection caused by the screws. Rotate the wind direction sensor 90 degrees and level the balance wheel. Release the balance wheel and watch for the deflection caused by the screws. Repeat the measurements until the sensor is tested at four evenly spaced points around the sensor's shaft. If there are no downward deflections at any test points the counter weight must be increased by 0.5 gm/cm until there is downward movement. Do not exceed 9.0gm/cm counterweight since starting torque specifications have been exceeded. Record the highest value tested
- f) Reinstall the wind direction sensor to the cross arm mount and reconnect the signal cable. Install the wind vane to the wind direction sensor. The wind direction calibration is now complete.
- g) All wind direction calibration values are recorded on the field audit form (see **Figure 2**, pg. 23). The system direction calibration performed with the transit or 042 sighting scope is acceptable if the wind direction response is within +/- 5.0 degrees from the transit's direction or +/- 5.0 degrees of the reference hub. The wind direction sensor calibration is considered acceptable if each wind direction value is within +/- 3.0 degrees from the calibration input value. The sensor starting torque threshold is acceptable if all measured points are less than 6.5 grams per centimeter. If any measurements do not meet the acceptable specifications for a wind speed calibration the sensor must be evaluated by the technician.

The electronics technician will examine the sensor, make necessary repairs and recalibrate the sensor. The calibration data and recommendations will be included in an audit report.

**Figure 2 Wind Direction Cal / Audit Sheet**

Wind Direction: Calibration \_\_\_\_ Audit \_\_\_\_

Site \_\_\_\_\_ Date \_\_\_\_\_  
Start Time \_\_\_\_\_ Stop Time \_\_\_\_\_  
Sensor Model \_\_\_\_\_ Sensor SN \_\_\_\_\_  
Torque Gauge \_\_\_\_\_ Device SN \_\_\_\_\_  
Calibration Device \_\_\_\_\_ Device SN \_\_\_\_\_  
Transit \_\_\_\_\_ Device SN \_\_\_\_\_

System Calibration Direction \_\_\_\_ Degrees System Value \_\_\_\_ Degrees

Wind Direction Sensor Calibration

Input Direction (Deg)	Data logger Direction (Deg)	Difference

Measured Sensor Torque \_\_\_\_\_ gms/cm Specifications <6.5 gms/cm

Acceptable: Yes \_\_\_ No \_\_\_ Auditor \_\_\_\_\_

The system calibration must be within +/- 5.0 degrees of calibration direction for the calibration to be acceptable (NCore and SLAMS).

Each single point sensor calibration measurements must be within +/- 3.0 degrees of input value for the calibration to be acceptable.

**2.12.1.1.3 R. M. Young Model 05305AQ Wind Speed / Wind Direction**

The Model 05305AQ sensor is sensed by a lightweight, carbon fiber thermoplastic (CFT), helicoid propeller. The wind direction sensor is a lightweight, balanced vane. The instrument body is UV stabilized plastic with stainless steel and anodized aluminum fittings. The instrument mounts on a standard 1 inch pipe.

MODEL 05305AQ Wind Speed/Wind Direction Sensor Specifications			
Wind Speed Sensor		Wind Direction Sensor	
Range	0 to 50 m/s (112 mph)	Range	360° mechanical, 355° electrical
Sensor	30.7 cm air passage per revolution	Sensor	Balanced vane
Distance Constant	2.1 m (6.9 ft) for 63% recovery	Delay Distance	1.2 m (3.9 ft) for 50% recovery
Threshold Sensitivity	0.4 m/s (0.9 mph)	Damped Natural Wavelength	4.9 m (16.1 ft)
Output Signal	50 mV per m/s	Output Signal	13.9 mV per degree

### Installation

- a) Proper placement of the instrument is very special. Eddies from trees, buildings, or other structures can greatly influence wind speed and wind direction observations. To get meaningful data for most applications, locate the instrument well above or upwind from obstructions.

Grounding the wind monitor is vitally important. Without proper grounding, static electrical charge can build up during certain atmospheric conditions and discharge through the transducers.

- b) Make the wiring connections to the ESC data logger.

### Operational Checkout

Remove the plastic nut on the propeller shaft. Install the propeller on the shaft with the serial number of the propeller facing forward (into the wind). The vane and propeller should easily rotate 360° without friction. Check vane balance by holding the instrument base so the vane surface is horizontal. It should have near neutral torque without any particular tendency to rotate. A slight imbalance will not degrade performance.

### Potentiometer Replacement

The potentiometer has a life expectancy of fifty million revolutions. As it becomes worn, the element may begin to produce noisy signals or become non-linear. When signal noise or non-linearity becomes unacceptable, replace the potentiometer.



1. REMOVE MAIN HOUSING

- a) Unscrew nose cone from main housing. Set o-ring aside for later use.
- b) Gently push main housing latch.
- c) While pushing latch, lift main housing up and remove it from vertical shaft bearing rotor.

2. UNSOLDER TRANSDUCER WIRE

- a) Slide junction box cover up, exposing circuit board.
- b) Remove screws holding circuit board.
- c) Unsolder three potentiometer wires (white, green, black), two wind speed coil wires (red, black), and earth ground wire (red) from board.

3. REMOVE POTENTIOMETER

- a) Loosen set screw on potentiometer coupling and remove it from potentiometer adjust thumbwheel.
- b) Loosen set screw on potentiometer adjust thumbwheel and remove it from potentiometer shaft.
- c) Loosen two set screws at base of transducer assembly and remove assembly from vertical shaft.
- d) Unscrew potentiometer housing from potentiometer mounting & coil assembly.
- e) Push potentiometer out of potentiometer mounting & coil assembly by applying firm but gentle pressure on potentiometer shaft.

4. INSTALL NEW POTENTIOMETER

- a) Push new potentiometer into potentiometer mounting & coil assembly.
- b) Feed potentiometer and coil wires through hole in bottom of potentiometer housing.
- c) Screw potentiometer housing onto potentiometer mounting & coil assembly. Apply a small amount of silicone sealant on threads.
- d) Gently pull transducer wires through bottom of potentiometer housing to take up any slack. Apply a small amount of silicone sealant around hole.
- e) Install transducer assembly on vertical shaft allowing 0.5 mm (0.020") clearance from vertical bearing. Tighten set screws\* at bottom of transducer assembly.
- f) Place potentiometer adjust thumbwheel on potentiometer shaft and tighten set screw\*.
- g) Place potentiometer coupling on potentiometer adjust thumbwheel. Do Not tighten set screw yet.

5. RECONNECT TRANSDUCER WIRES

- a) Using needle-nose pliers or a paper clip bent to form a small hook, gently pull transducer wires through hole in junction box.
- b) Solder wires to circuit board according to wiring diagram. Observe color code.
- c) Secure circuit board in junction box using two screws removed in step 2b. Do not overtighten.

6. REPLACE MAIN HOUSING

- a) Place main housing over vertical shaft bearing rotor. Be careful to align indexing key and channel in these two assemblies.
- b) Place main housing over vertical shaft bearing rotor until potentiometer coupling is near top of main housing.
- c) Turn potentiometer adjust thumbwheel until potentiometer coupling is oriented to engage ridge in top of main housing. Set screw on potentiometer coupling should be facing the front opening.
- d) With potentiometer coupling properly oriented, continue pushing main housing onto vertical shaft bearing rotor until main housing latch locks into position with a "click".

7. ALIGN VANE

- a) Connect excitation voltage and signal conditioning electronics to terminal strip according to wiring diagram.
- b) With mounting post held in position so junction box is facing due south, orient vane to a known angular reference. Details appear in CALIBRATION section.
- c) Reach in through front of main housing and turn potentiometer adjust thumbwheel until signal conditioning system indicates proper value.
- d) Tighten set screw\* on potentiometer coupling.

8. REPLACE NOSE CONE

- a) Screw nose cone into main housing until o-ring seal is seated. Be certain threads are properly engaged to avoid cross-threading.

**2.12.1.1.3a Wind Speed Calibrations**

Wind speed calibration is determined by propeller pitch and the output characteristics of the transducer. The calibration formula relating propeller rpm to wind speed is shown below. Standard accuracy is  $\pm 0.2$  m/s (0.4 mph). For greater accuracy, the sensor must be individually calibrated in comparison with a wind speed standard.

Wind Speed	vs	Propeller RPM	Wind Speed	vs	0-5 VDC Output
m/s	=	0.00512 x rpm	m/s	=	mV x 0.0200
knots	=	0.00995 x rpm	knots	=	mV x 0.0389
mph	=	0.01145 x rpm	mph	=	mV x 0.0447
km/h	=	0.01843 x rpm	km/h	=	mV x 0.0720

**Calibration Frequencies**

Calibrations are required on the wind speed sensor at site startups, sensor repairs or adjustments that will affect the response or data. Also calibrations are required after any unacceptable QA audit. Bi-annual wind speed calibrations are required for the NCore site, annually for the SLAMS sites. **The audit and calibrations should be performed using different equipment and different personnel.**

**Calibration Procedure** see pg. 12, **Wind Speed Cal / Audit Sheet** see pg. 14

**2.12.1.1.3b Wind Direction Calibrations**

**Calibration Frequencies**

Calibrations are required on the wind direction sensor at site startups, sensor repairs or adjustments that will affect the response or data. Also calibrations are required after any unacceptable QA audit. Bi-annual wind direction calibrations are required for the NCore site, annually for the SLAMS sites. **Note:** The audit and calibrations should be performed using different equipment and different personnel.

**Wind Direction Calibration Procedure** see pg. 20, **Wind Direction Cal / Audit Sheet** see pg.23

**2.12.1.1.4 Climatronics Model CS800-L Wind Speed / Wind Direction**

The Model CS800-L wind speed is sensed by a 3-cup anemometer coupled to a light chopper that outputs a frequency proportional to wind speed. Wind direction is sensed by a wind vane coupled to a precision low-torque potentiometer. Both sensors use stainless steel precision ball bearings for maximum life and low starting thresholds.

MODEL CS800-L Wind Speed/Wind Direction Sensor Specifications		
	<b>Wind Speed</b>	<b>Wind Direction</b>
Accuracy	0.25 mph or 1.5%	± 3°
Threshold	<1 mph	<1 mph
Distance Constant	8.0 ft of air max	8.0 ft of air max
Damping Ratio		0.4 to 0.6 at 10° displacement
Operating Range	0 – 125 mph	0 - 360° mechanical

**Installation**

**Siting**

As a rule of thumb, wind sensors should be located away from obstructions (e.g., trees or buildings) by a horizontal distance of at least ten times the height of the obstruction. If it is necessary to mount the sensors on a roof of a building, the height of the sensors above the

roof should be at least 1.5 times the height of the building.

#### **Maintenance, 1 month**

- Visually inspect the cupwheel and vane assemblies for damage
- Do a visual/audio inspection of anemometer at low speeds. Make sure the cupwheel assembly rotates freely, without any wobble. Worn bearings will often produce an audible noise.

#### **Maintenance, 3 month**

- Measure bearing torque to determine if bearings need replacement (unless bearings are being replaced on a periodic schedule). For a 1 mph starting threshold, bearing torque should not exceed 0.28 g-cm for the anemometer, and 6.0 g-cm for the vane.

#### **Maintenance, 12 month**

- Replace anemometer bearings
- Check vane linearity

#### **Maintenance, 24 month**

- Replace vane bearings

### **Troubleshooting**

#### **Wind Direction**

-99999 or random negative numbers displayed in input location

- Make sure the battery voltage is between 9.6 and 16 VDC.
- Verify the sensor is wired to the Single-Ended input channel specified by the manual.
- Make sure parameter 2 of Instruction 4 is 5.

0.0000 or slightly negative numbers displayed in input location

- Make sure the execution interval has been entered in the program table.
- Verify the sensor is wired to the excitation channel specified by parameter 4 of

Instruction 4. Parameter 6 should be 2500 for the CR10, 5000 for the 21X/CR7.

#### **Wind Speed**

Unreasonable results displayed in input location

- Inspect the sensor for damage or contamination.
- Check that the multiplier and offset in Instruction 3 are correct for the desired engineering units.

Offset only displayed in input location

- Make sure the sensor is properly wired to the 5V and G terminals on the CR10, or to the CAO port and ground on the 21X or CR7 data loggers.

#### **2.12.1.1.4a Wind Speed Calibrations**

Calibrations are required on the wind speed sensor at site startups, sensor repairs or adjustments that will affect the response or data. Also calibrations are required after any unacceptable QA

audit. Bi-annual wind speed calibrations are required at all NCore sites, annually for non-NCore sites. **The audit and calibrations should be performed using different equipment and different personnel.**

### **Wind Speed Calibrations Devices**

Accurate wind direction calibration requires a Model 18801 Vane Angle Bench Stand. Begin by connecting the instrument to a signal conditioning circuit which has some method of indicating a wind direction value. This may be a display which shows wind direction values in angular degrees or simply a voltmeter monitoring the output. Orient the base so the junction box faces due south. Visually align the vane with the crossmarkings and observe the indicator output. If the vane position and indicator do not agree within 5°, it may be necessary to adjust the potentiometer coupling inside the main housing.

It is important to note that, while the sensor mechanically rotates through 360°, the full scale wind direction signal from the signal conditioning occurs at 355°. The signal conditioning electronics must be adjusted accordingly. For example, in a circuit where 0 to 5.000 VDC represents 0° to 360°, the output must be adjusted for 4.930 VDC when the instrument is at 355° ( $355^\circ/360^\circ \times 5.000 \text{ volts} = 4.930 \text{ volts}$ ).

Wind Direction            vs        0-5 VDC Output  
Direction                =        mV x 0.072

**Wind Speed Cal / Audit Sheet** see pg. 14

### **2.12.1.1.4b Wind Direction Calibrations**

#### **Calibration Frequencies**

Calibrations are required on the wind direction sensor at site startup and after sensor repairs or adjustments that will affect the data. Also calibrations will be required after any unacceptable Q.A. audit. Bi-annual wind direction calibrations are required for the NCore site, annually for the SLAMS sites. **The audit and calibrations should be performed using different equipment and different personnel.**

#### **Wind Direction Calibration Device**

A surveyor's transit can be used to calibrate the wind direction. It will be used to set the reference hubs at 180 degrees from the wind direction sensor. The transit sighting scope will be set to a known direction by using the compass and adjusting for the magnetic declination of the site.

A wind direction calibration device used is a Climatronics linearity direction wheel disk (101965). The linearity test fixture consists of a stand, a notched calibrated dial, and one Allen

key, and a four foot length of cable. The stand has a connector and roll pin at the base, and a spring index pointer at the top. A length of cable with a connector at the end is wired into the base connector. To align the transmitter and check linearity at the site, proceed as follows:  
(NOTE: This procedure assumes a NORTH-SOUTH orientation of crossarm, with the wind direction sensor at the SOUTH end).

- 1) Visually align the vane shaft along the crossarm with the vane tail pointing toward the wind speed sensor. A reading corresponding to approximately “SOUTH” should be obtained. If not, check out the electronics and orientation of the crossarm before proceeding to Step 2.
- 2) Remove the wind direction sensor. Using the Allen key supplied, loosen the two set screws in the vane hub, and remove the vane from the shaft.
- 3) Take the connector at the end of the cable, and plug it into the crossarm where the sensor was. Plug the sensor into the fixture base making sure the slot in the sensor is aligned with the pin in the fixture.
- 4) Place the notched dial over the shaft so the index end of the pointer is in the 180° notch. Rotate the sensor cap until the dial hub fits on the stepped portion. The output reading should correspond to SOUTH.
- 5) If the reading obtained in Step 4 is correct, go to Step 6. If not, proceed as follows:
  - a) Using the Allen key, loosen the two set screws in the sensor hub.
  - b) With the index pointer still in the 180° notch, rotate the shaft until an output reading corresponds to SOUTH is obtained. Retighten the screws.
- 6) Move the pointer out of the 180° notch and rotate dial to the next notch, allowing the pointer to detent into the notch. Check the corresponding output reading. Continue above for the full 360° rotation, thus checking the linearity.  
**NOTE:** dial is calibrated so that 90=EAST, 0=NORTH, and 270=WEST.

**Wind Direction Cal / Audit Sheet** see pg.23

#### **2.12.1.1.5 Campbell Model HC2S3 Relative Humidity**

The Model HC2S3 is a rugged, accurate temperature/RH probe that is ideal for long term, unattended applications. The probe uses a Rotronic’s IN1 capacitive sensor to measure RH and a 100 ohm PRT to measure temperature. For optimum results, the HC2S3 should be recalibrated annually.

Model HC2S3 Specifications	
<b>Relative Humidity Sensor</b>	
Relative Humidity Measurement Range	0 to 100% non-condensing
RH Output Signal Range	0 to 1 VDC
Accuracy @ 20°C	±0.8% RH per year
Long Term Stability	<1% RH/year

### Installation

Sensors should be located over an open level area at least 9 m (EPA) in diameter. The surface should be covered by short grass, or where grass does not grow, the natural earth surface.

Sensors should be located at a distance of at least four times the height of any nearby obstruction, and at least 30 m (EPA) from large paved areas. Sensors should be housed in a suitable radiation shield.

Standard measurement heights:

- 1.5 m (AASC)
- 1.25 to 2.0 m (WMO)
- 2.0 m (EPA)

### Sensor Maintenance

Corroded, discolored or clogged filters should be replaced. To replace the filter, unscrew the filter from the probe and pull it straight away, being careful not to bend or damage the sensors. Before putting on the replacement filter check the alignment of the sensors with the probe, and if necessary, carefully correct the alignment before installing the filter.

The Teflon filter tip is recommended when the sensor is installed in close proximity to the ocean or other bodies of salt water. A coating of salt (mostly NaCl) may build up on the radiation shield, sensor, filter and even the sensors. A buildup of salt on the filter or sensors will delay or destroy the response to atmospheric humidity.

Long term exposure of the relative humidity sensor to certain chemicals and gases may affect the characteristics of the sensor and shorten its life. The resistance of the sensor depends strongly on the temperature and humidity conditions and the length of the pollutant influence. In general, the

HC2S3 requires minimal maintenance. The radiation shield should be kept clean and free of debris, and the sensor should be calibrated annually.

In general, the HC2S3 requires minimal maintenance. The radiation shield should be kept clean and free of debris, and the sensor should be calibrated annually.

## **Troubleshooting**

Symptom: -9999, NAN, -40°C, or 0 % relative humidity

1. Check that the sensor is wired to the correct analog input channels as specified by the measurement instructions.
2. Verify the voltage range code for the single-ended or differential measurement instruction is correct for the data logger type.
3. Verify the green power wire is connected to the 12V, SW12V, or 5V terminal. Cables longer than 3 m (10 ft) should be powered by the 12V, rather than the 5V terminal.

A voltmeter can be used to check the output voltage for temperature and relative humidity on the brown and white wires respectively (temperature °C = mV \* 0.1 – 40.0; relative humidity % = mV \* 0).

Symptom: Incorrect temperature or relative humidity

1. Verify the multiplier and offset parameters are correct for the desired units and temperature range.
2. Default settings are listed in Appendix A of the manual, which include the setting “Limit humidity output to 100%”. This setting is “disabled” for probes purchased through Campbell Scientific. For example, at -20°C the accuracy is ±2.3%, so a reading of 102.3% at 100% humidity is within the accuracy specification. Programs created by Short Cut set humidity values greater than 100% and less than 103% to 100%. Humidity values greater than 103% are left unchanged to indicate a problem with the probe or measurement.

### **2.12.1.1.5a Relative Humidity Calibration**

After saving calibration points to the memory of a probe or device, the HP23 can be used to do a humidity and temperature adjustment of up to two probes, transmitters or other devices.

Humidity and temperature adjustment are two separate processes.

- Press the MENU key and select either “Probe 1” or “Probe 2”. Press ENTER to activate the Probe 1 or Probe 2 menu item.
- When the device is a HygroClip 2 probe connected to a HF5 or HF8 transmitter (or similar device), select “Probe 1” and “Probe Sel” from the menu and press ENTER. Use the UP or DOWN arrow to select the probe to be calibrated (HF5 transmitter: be sure to select probe 1)
- Use the DOWN arrow key to select either “**Temp Adjust**” or “**Humi Adjust**” (we recommend selecting Temp Adjust first). The following steps are the same for a temperature or a humidity adjustment.
- Press ENTER to confirm and open the next sub-menu.
- Optional: with the “Acquired Points” menu item selected press ENTER and review the calibration points present in memory. This submenu allows you to delete unwanted calibration points. Press MENU when done.
- Use the DOWN arrow key to select the “**Adjust**” menu item and press ENTER to confirm.



- Press ENTER to activate the Adjust function. This function automatically erases the calibration points in memory. When done adjusting, the HP23 automatically exits the menu.

The calibration method is based on the constant water vapor pressure over a saturated salt solution and constant temperature. Chemicals used for the calibration are lithium chloride (LiCl), sodium chloride (NaCl), and potassium sulfate (K<sub>2</sub>SO<sub>4</sub>). The salt solutions create a humidity of approximately 13%, 75%, and the latter approximately 97% at 68°F (20°C). All of these chemicals are available from local suppliers. To guarantee accurate calibration, the salts must be of high purity. The HP23 Calibrator is used to calibrate the relative humidity probe.

Greenspan's Calibration Table

°C	LiCl	NaCl	K <sub>2</sub> SO <sub>4</sub>
0	11.23±0.54	75.5±0.3	98.8±1.1
5	11.26±0.47	75.7±0.3	98.5±0.9
10	11.29±0.41	75.7±0.2	98.2±0.8
15	11.30±0.35	75.6±0.2	97.9±0.6
20	11.31±0.31	75.5±0.1	97.6±0.5
25	11.30±0.27	75.3±0.1	97.3±0.5
30	11.28±0.24	75.1±0.1	97.0±0.4
35	11.25±0.22	74.9±0.1	96.7±0.4
40	11.21±0.21	74.7±0.1	96.4±0.4
45	11.16±0.21	74.5±0.2	96.1±0.4
50	11.10±0.22	74.4±0.2	95.8±0.5

The numbers on the right in each column indicate the uncertainty of the reference humidity of the salt in that temperature.

- 1) Greenspan, L.: journal of Research of the National Bureau of Standards – A physics and Chemistry Vol. 81A, No. 1 January-February, pp. 89-95

### Calibration Frequencies

Calibrations are required on the relative humidity sensor at site startup and after sensor repairs or adjustments that will affect the data. Also calibrations will be required after any unacceptable QA audit. Bi-annual relative humidity calibrations are required for the NCore site, annually for all SLAMS sites. **Note:** The audit and calibrations should be performed using different solutions and different personnel.

### Relative Humidity Calibration Procedure

Calibration devices (ER-15) are small, airtight chambers that precisely fit ROTRONIC probes. The lower part of the device consists of a screw-on lid into which the humidity standard is poured on to an absorbent textile pad. The specified humidity is generated in the calibration device after a stabilization period. Stabilization takes longer for high humidity values. The probe

can then be calibrated or adjusted by comparison with the reference value of the humidity standard.

a) The calibration of the relative humidity sensors must be done very carefully to avoid errors that can be introduced in the audit method. The calibrator must be handled carefully to prevent the solutions from spilling and damage to the sealed case. The calibrator must be kept near 23 degrees Celsius once the salt solutions are inserted. The calibrator must be allowed to stabilize to within +/- 1.0 degree C. of the ambient temperature at the site. A difference of 1 degree C can produce errors of 3 to 6 % relative humidity at the high point. The relative humidity sensor probe must be handled carefully to prevent damage to the exposed sensor element chip after the probe filter is removed. The exposed sensor element chip can be damaged or become contaminated by foreign matter.

b) To set up for the relative humidity calibration ambient temperature must be controlled ambient calibration temperature of 23 degrees C. Fill the calibration device with the appropriate lithium chloride solution. Place the calibrator in a position so the relative humidity sensor probe can be inserted into the calibrator. Read the calibrator thermometer and record the reading. Read the relative humidity value for the calibrator temperature from the calibration table. Record this value as the relative humidity calibration input. The sensor probe is then removed from the lithium chloride solution bottle. Remove the calibrator pad and wipe the calibrator. Install new pad. Fill the calibration device with the appropriate potassium sulfate solution. Let the probe and the calibrator stabilize for 30 minutes. Read the calibrator thermometer and record the reading. Read the relative humidity value for the calibrator temperature from the calibration table found on the calibrator case. Record this value as the relative humidity calibration input. Read and record the calibrator value for relative humidity. Repeat the procedure for the sodium chloride solutions. If any reading is out of calibration specifications, adjustment is required.

If all calibration readings are within calibration specifications, no sensor adjustments are required. The sensor probe is then removed from the last solution bottle. The sensor probe is then reinstalled on the sensor probe.

c) The calibration is now completed. Reinstall the sensor probe to the radiation shield. The relative humidity calibrator must be stored in a room that meets storage requirements.

#### **Calculations**

Calibration Difference = relative humidity reading (conc) - Calibration relative humidity

**Relative Humidity Cal / Audit Sheet**, see pg. 37

#### **2.12.1.1.6 Met One Model 083C Relative Humidity Sensor**

The Model 083E sensor probe represents sensitivity, accuracy, linearity and stability not encountered with conventional relative humidity sensors. It is extremely well suited for meteorological, industrial, laboratory and other demanding applications.

### Operation

The Model 083D Relative Humidity Sensor is based upon the capacitance change of a polymer thin film capacitor. A one-micron thick dielectric polymer layer absorbs water molecules through a thin metal electrode and causes capacitance change proportional to relative humidity. The thin polymer layer reacts very fast, and therefore, the response time is very short; less than five seconds to 90% of the final value of relative humidity.

The sensor responds to the full range from 0-100% relative humidity. Its response is essentially linear, with small hysteresis, and negligible temperature dependence.

### Relative Humidity

RH Sensing Element:	Thin film polymer capacitor
Range:	0 to 100% RH
Temperature Operation Range:	-50 °C to +50 °C (-58 °F to 122 °F)
Response Time:	10 sec. with 2 m/s aspiration
Accuracy:	± 2.0% from 0 to 100% RH
Temperature Coefficient:	Compensated internally
Output:	0 to 1 VDC Standard (0 to 5.0 VDC Optional)
AutoMet Auto ID:	Yes (Model 593A Only)

### Calibration Frequencies

Calibrations are required on the relative humidity sensor at site startup and after sensor repairs or adjustments that will affect the data. Also calibrations will be required after any unacceptable QA audit. Bi-annual relative humidity calibrations are required for the NCore site, annually for all SLAMS sites. **Note:** The audit and calibrations should be performed using different solutions and different personnel.

#### 2.12.1.1.6a Relative Humidity Calibration

Usually, the errors during humidity calibration are due to temperature differences. A temperature difference of  $\pm 1$  °C at +20 °C between the air in the chamber and the sensor causes an error of  $\pm 3$  %RH at 50 %RH and an error of  $\pm 3=6$  %RH at 97 %RH. The more the transportation or process temperatures differ from the temperature at the calibration site, the longer the stabilization time required. In laboratory use, the calibrator should be stored in that part of the room where the temperature is most stable. The calibrator must be kept out of direct sunlight and away from localized heat sources. If the probe/transmitter is checked against several humidity references, the checking must first be made at the dry end.

Handle the probe as little as possible. Do not hold the salt chamber or other parts of the calibrator in hand during calibration as they warm up and cause errors in the readings.

- Leave the calibrator and the probe at the calibration site for at least 30 minutes before starting the calibration in order to let the probe temperature stabilize to the room temperature.
- With lithium chloride it is not necessary to use the thermometer as the humidity reading changes only very slightly in the temperature range of +25 ...+30 °C. However, if you use it make sure that the sleeve is in the correct position and insert it into the 13.5 mm hole of the LiCl salt chamber.
- Take off the grid or filter protecting the sensor. Take care not to damage the sensor.
- Some 12 mm probes need a adapter fitting to fit into the 13.5 mm hole. Adapter fitting prevents sensor from soaking in the salt liquid. In case an adapter is needed, take off the grid or filter and replace it with the adapter fitting.
- Insert the probe into a suitable hole of the LiCl salt chamber. Press it downwards until it passes the O-rings. The shorter the time the hole stays open before inserting the probe, the shorter the stabilization time required.
- Wait until the humidity reading stabilizes; this take about 10 ...30 minutes.
- Read the salt chamber temperature from the thermometer and read the closest humidity value from the calibration table (Greenspan's Calibration table, see pg. 33).
- Adjust the dry end (DRY, offset) to correspond to the value give in the calibration table.
- Insert the thermometer into the 13.5 mm hole of the NaCl salt chamber.
- Insert the probe into a suitable hole of the NaCl (or K<sub>2</sub>SO<sub>4</sub>) salt chamber. The shorter the time the hole stays open before inserting the probe, the shorter the stabilization time required.
- Wait until the humidity reading stabilizes; this take about 10 ...30 minutes. **Note:** the high humidity solutions the risk for errors increases. Therefore, the stabilization time should be longer (approximately 20 ...40 minutes).
- Read the salt chamber temperature from the thermometer and read the closest humidity value from the calibration table (Greenspan's Calibration table, see pg. 33).
- Adjust the wet end (WET, gain) to correspond to the value given in the calibration table.

**Note:** separate solutions should be kept for audits / calibrations, and there should be a distinction from the auditor to the calibrator.

**Relative Humidity Cal / Audit Sheet**, see pg. 37



**2.17.1.1.7 MET One Model 062 Temperature**

Met One Instruments’ Temperature Sensors are precision, extended range thermistor devices that are used for the accurate measurement of ambient air temperature. They are particularly well suited for field applications, as they exhibit a very high resistance sensitivity. Problems associated with line lead length, noisy environments, and poor connections are virtually eliminated. Sensors may be interchanged without requiring system recalibration. Difference among these sensors are associated with packaging and accuracy, allowing for the precise solution to sensor selection.

Air temperature measurements are one of the simplest meteorological measurements, but accurate and representative measurements of air temperature require no less attention to quality than others. Temperature gradient measurements between two levels above ground on a tower demand greater accuracy and precision than measurements of temperature alone. Temperature gradient is commonly known as delta-temperature and is abbreviated ΔT.

High-quality, economical sensors based on electrical resistance that changes with temperature are readily available and adaptable to many data recording and display systems. The challenge is to place the sensors in suitable locations and provide proper protection from moisture, wind, and radiation energy interferences. ASTM International Standard Practice30 for atmospheric temperature measurements describes the types of shields needed to properly protect electrical sensors. Naturally ventilated shields can provide adequate protection for many simple air temperature measurements, but the additional accuracy required for ΔT measurement necessitates using mechanically aspirated shields to provide uniform airflow across the sensor in the shield.

**Model 062**

The Model 062 is a highly accurate version of the Model 060A-2. It is used in pairs for the measurement of differential temperature (DT), or singly for highly critical ambient temperature measurement.

Housing:	3/8 in (9.5 mm) OD x 6 in (152.4 mm)		
Range:	-50°C to +50°C		
Accuracy:	±0.05°C, PSD Compliant		
Linearity Deviation:	For a system	Max. error per degree	Max. error
	range of:	of differential temperature:	over range:
	-5°F to +5°F	.02°F	.05°F
	-5°C to +5°C	.02°C	.05°C
	-5°F to +10°F	.02°F	.1°F
	-5°C to +10°C	.02°C	.1°C
	-10°F to +20°F	.02°F	.2°F

Cable: 1 ft pigtails (for use with 076 or 077 Radiation Shield)

Additional length may be supplied, specify length

### **Installation and Wiring**

Temperature sensors should be mounted over a plot of open level ground at least 9 m in diameter. The ground surface should be covered with non-irrigated or un-watered short grass or, in areas where grass does not grow, natural earth. Gravel surfaces are also acceptable. The surface must not be concrete or asphalt or oil-soaked. The standard height for climatological purposes is 1.25 m to 2 m, but different heights may frequently be required in air quality studies. For general purposes, the primary temperature sensor is mounted 2 m above ground level, with the inlet facing away, and at a distance of approximately 1.5 times the tower diameter, from the tower.

The sensors should not be closer to obstructions, such as trees and buildings, than a distance equal to four times their height. They should be at least 30 m from large paved areas and not close to steep slopes, ridges, or hollows. Areas of standing water should also be avoided. Louvered instrument shelters should be oriented so that the door opens toward true north in the northern hemisphere. Motor-aspirated shields should also be oriented with the sensors toward true north in the northern hemisphere.

#### **2.12.1.1.7a Temperature Calibration**

Calibrating a temperature measurement system consists of comparing the output of the device being calibrated to a known value, and determining if the difference is within acceptable tolerance limits. Most modern temperature measuring systems do not need adjusting to match known values if all components are working properly, so acceptance is pass or fail. Improper signal cable connections or signal processing instructions are more likely sources of problems producing unacceptable results than the sensors themselves. Additional information about standardized testing for resistance temperature measuring devices is available from ASTM International.

Following manufacturer's instructions and using the on-site signal processing method ensures that the calibration is representative of the device's response. Note that some temperature probes may not be submersible. If this is the case, then follow the manufacturer's calibration procedures. A step by step description of a water-submersible temperature sensor follows.

1. The calibration test should be performed at three or more temperature levels spaced across the range of the sensor, such as 0 degrees C, 20 degrees C and 40 degrees C.
2. Prepare three test baths as stated in step 1.
3. Remove the sensor from the shield.
4. Place the probe and a NIST traceable temperature device in the water bath with the lowest point, a thermal mass in an ice slurry mixture.
5. To reduce physical stress on the sensors, the probes should be allowed to reach equilibrium with room conditions when they are removed from one thermal mass and before subjecting them to another thermal mass.

6. Record the temperature of the bath from the NIST traceable temperature device and the reading from the station temperature probe.
7. Remove the NIST traceable temperature device and station temperature probe and place them in the 20 degree C water bath. Repeat steps 6 and 7.
8. Remove the NIST traceable temperature device and station temperature probe and place them in the 40 degree C water bath. Repeat steps 6 and 7.

**Auditing**

The performance audit should consist of challenging the temperature and ΔT sensors to three test environments at 0 degrees C, ambient temperature, and 40 degrees C using a water bath compared to a NIST-traceable temperature standard. The temperature, ΔT, and NIST-traceable temperature probes are simultaneously placed in a water bath until equilibrium is reached for each desired temperature range. The temperature sensor’s response is compared to the audit transfer standard response for each test atmosphere, and the ΔT response is recorded at the same time. The recommended tolerance for an audit is the same as that for a calibration: ±0.5 degrees C for temperature and ±0.1 degrees C for ΔT.

**Ambient Temperature Cal / Audit Sheet**, see pg. 45

**2.12.1.1.8 Campbell Model HC2S3 Temperature**

The Model HC2S3 is a rugged, accurate temperature probe that is ideal for long term, unattended applications. The probe uses a Rotronic’s IN1 capacitive sensor to measure RH and a 100 ohm PRT to measure temperature. For optimum results, the HC2S3 should be recalibrated annually.

Model HC2S3 Specifications	
Temperature Sensor	
Temperature measurement Range	-50°C to +100°C
Temperature Output Signal Range	0 to 1.0 V
Accuracy @ 23°C	±0.1°C
Long Term Stability	<0.1°C/year

**Installation**

Sensors should be located over an open level area at least 9 m (EPA) in diameter. The surface should be covered by short grass, or where grass does not grow, the natural earth surface. Sensors should be located at a distance of at least four times the height of any nearby obstruction, and at least 30 m (EPA) from large paved areas. Sensors should be housed in a suitable radiation shield.

Standard measurement heights:  
1.5 m (AASC)



1.25 to 2.0 m (WMO)  
2.0 m (EPA)

### **Sensor Maintenance**

Corroded, discolored or clogged filters should be replaced. To replace the filter, unscrew the filter from the probe and pull it straight away, being careful not to bend or damage the sensors. Before putting on the replacement filter check the alignment of the sensors with the probe, and if necessary, carefully correct the alignment before installing the filter.

The Teflon filter tip is recommended when the sensor is installed in close proximity to the ocean or other bodies of salt water. A coating of salt (mostly NaCl) may build up on the radiation shield, sensor, filter and even the sensors. A buildup of salt on the filter or sensors will delay or destroy the response to atmospheric humidity.

The resistance of the sensor depends strongly on the temperature and humidity conditions and the length of the pollutant influence. In general, the HC2S3 requires minimal maintenance. The radiation shield should be kept clean and free of debris, and the sensor should be calibrated annually.

In general, the HC2S3 requires minimal maintenance. The radiation shield should be kept clean and free of debris, and the sensor should be calibrated annually.

### **Troubleshooting**

Symptom: -9999, NAN, -40°C, or 0 % relative humidity

1. Check that the sensor is wired to the correct analog input channels as specified by the measurement instructions.
2. Verify the voltage range code for the single-ended or differential measurement instruction is correct for the data logger type.
3. Verify the green power wire is connected to the 12V, SW12V, or 5V terminal. Cables longer than 3 m (10 ft) should be powered by the 12V, rather than the 5V terminal.

A voltmeter can be used to check the output voltage for temperature and relative humidity on the brown and white wires respectively (temperature °C = mV \* 0.1 – 40.0; relative humidity % = mV \* 0

Symptom: Incorrect temperature or relative humidity

1. Verify the multiplier and offset parameters are correct for the desired units and temperature range.
2. Default settings are listed in Appendix A of the manual, which include the setting “Limit humidity output to 100%”. This setting is “disabled” for probes purchased through Campbell Scientific. For example, at -20°C the accuracy is ±2.3%, so a reading of 102.3% at 100% humidity is within the accuracy specification. Programs created by Short Cut set humidity values greater than 100% and less than 103% to 100%. Humidity values greater than 103%

are left unchanged to indicate a problem with the probe or measurement.

#### **2.12.1.1.8a Temperature Calibration**

After saving calibration points to the memory of a probe or device, the HP23 can be used to do a humidity and temperature adjustment of up to two probes, transmitters or other devices.

Humidity and temperature adjustment are two separate processes.

- Press the MENU key and select either “Probe 1” or “Probe 2”. Press ENTER to activate the Probe 1 or Probe 2 menu item.
- When the device is a HygroClip 2 probe connected to a HF5 or HF8 transmitter (or similar device), select “Probe 1” and “Probe Sel” from the menu and press ENTER. Use the UP or DOWN arrow to select the probe to be calibrated (HF5 transmitter: be sure to select probe 1)
- Use the DOWN arrow key to select either “Temp Adjust” or “Humi Adjust” (we recommend selecting Temp Adjust first). The following steps are the same for a temperature or a humidity adjustment.
- Press ENTER to confirm and open the next sub-menu.
- Optional: with the “Acquired Points” menu item selected press ENTER and review the calibration points present in memory. This submenu allows you to delete unwanted calibration points. Press MENU when done.
- Use the DOWN arrow key to select the “Adjust” menu item and press ENTER to confirm.
- Press ENTER to activate the Adjust function. This function automatically erases the calibration points in memory. When done adjusting, the HP23 automatically exits the menu.

#### **Maintenance, Annually**

- a) Inspect the aspirated radiation shield screen over the intake baffle to remove insects and any other objects that can interfere with the operation of the motor. The screen can be cleaned with a brush and soap and water.
- b) Remove the fan assembly by removing the screws attaching it to the blower mount. Brush or blow off any accumulation of dust. Replace housing and return to service.

**WARNING:** Ensure the power is off before servicing. Failure to do so will result in exposure to severe electrical shock.

- c) The motor bearings are permanently lubricated and do not require normal maintenance. Bearing lubrication should be performed only by personnel familiar with motor maintenance. Lubrication is not recommended as a standard preventive maintenance measure.

#### **Operational Checkout**

- a) To verify correct wiring and as a rough test of the sensor operation, blowing on the sensor will cause the relative humidity to increase.

- b) The relative humidity sensor has been calibrated at the factory and will not change unless the sensor is damaged. To check for proper operation the output values can be compared against a local weather station. Exact correlation is not to be expected due to atmospheric and geographical variations.

### **Maintenance, 6-12 months**

The instrument should operate for extended period of time with minimum amount of care and maintenance. (Rotronic HygroPalm HP23-A Hand-Held Indicator User Guide).

- a) Replace battery
- b) Both the Pt 100 RTD temperature sensor used in the probe and associated electronics are very stable and should not require any calibration after the initial factory adjustment. Long term stability of the ROTRONIC Hygromer humidity sensor is typically better than 1 %RH per year. For maximum accuracy, calibration of the probe should be verified every 6 to 12 months. Applications where the probe is exposed to significant pollution may require more frequent verifications.
- c) Clean or replace the probe dust filter.

### **Replacement of the Sensor Element**

- a) Disconnect the power and unscrew the filter.
- b) Un-solder the old chip and solder a new one in its place.

**CAUTION:** The sensor chip is very delicate. Do not touch the chip with bare hands. Handle the chip only by gripping its lead with pliers. When soldering, hold the lead with the pliers to prevent the heat from soldering operation from damaging the chip. Do not bump the chip when reinstalling the protective grid.

- c) After replacement of the sensor element, calibrate the sensor.

**Ambient Temperature Cal / Audit Sheet**, see pg. 44

**Figure 4 Ambient / Delta Temperature Cal / Audit Sheet**

Ambient Temperature and Delta Temperature: Calibration \_\_\_\_ Audit \_\_\_\_

Site \_\_\_\_\_ Date \_\_\_\_\_  
Start Time \_\_\_\_\_ Stop Time \_\_\_\_\_  
Sensor Model 2 meters \_\_\_\_\_ Sensor SN \_\_\_\_\_  
Sensor Model 10 Meters \_\_\_\_\_ Sensor SN \_\_\_\_\_  
Calibration Device \_\_\_\_\_ Device SN \_\_\_\_\_

Input Tests Points >	0°C (32 °F)	20°C (68 °F)	40°C (104 °F)	Differential baths negative delta temperature	Differential baths positive delta temperature
RTD sensor temperature (degrees C)				na	na
2 meter level data logger temperature (degrees C)					
2 meter difference temperature (degrees C)				na	na
RTD sensor temperature (degrees C)				na	na
10 meter level temperature data logger (degrees C)					
10 meter difference temperature (degrees C)				na	na
Delta temperature data logger (degrees C)					
Sensors delta difference 10 meter - 2 meter					
Delta Temperature difference (Delta temp- sensors difference)					

Specification Temperature Verification Test Accuracy = ±0.5 °C (NCore) ±1.0 °C (SLAMS)  
between RTD and sensors.

Acceptable: Yes No Auditor \_\_\_\_\_

#### **2.12.1.1.9 SU-100 UV Solar Radiation Sensor**

Ultraviolet (UV) radiation constitutes a portion of the electromagnetic spectrum from 100 to 400 nm, and is further subdivided into three wavelength ranges: UV-A (315- 400nm), UV-B (280-315nm), and UV-C (100-280 nm). Much of the UV-B and all of the UV-C wavelengths from the sun are absorbed by the Earth's atmosphere. There are also many artificial UV light sources available that a select wavelength range or offer a broadband UV radiation source.

Most UV sensors designed for sunlight measurements are sensitive to UV radiation in the UV-A and UV-A ranges. The SU-100 UV sensors detect UV radiation from 250 to 400 nm and are calibrated in photon flux units of micromoles per square meter per second ( $\mu\text{mol m}^2\text{s}^{-1}$ ). The output can also be expressed in energy flux units of watts per square meter ( $\text{W m}^2$ , equal to Joules per second per square meter).

Typical applications of UV sensors include incoming UV radiation measurement in outdoor environments.

#### Specifications

Sensitivity: 0.20 mV per  $\mu\text{mol m}^2\text{s}^{-1}$   
0.61 mV per  $\text{W m}^2$

Calibration Factor: 5.0  $\mu\text{mol m}^2\text{s}^{-1}$  per mV (reciprocal of sensitivity)  
1.65  $\text{W m}^2$  per mV (reciprocal of sensitivity)

Calibration Uncertainty: 10%

Measurement Repeatability: <1%

Non-linearity: < 1% (up to 300  $\mu\text{mol m}^2\text{s}^{-1}$ )

Response Time: < 1 ms

Field of View: 180°

Operating Environment: -40 to 70°C  
0 to 100% relative humidity

#### Calibration Traceability:

Apogee SU-100 UV sensors are calibrated through side-by-side comparison to the mean of four Apogee model SU-100 transfer standard UV sensors under high intensity discharge metal halide lamps. The transfer standard UV sensors are calibrated through side-by-side comparison to an Apogee model PS-200 spectroradiometer under sunlight (clear sky conditions).

**Installation**

Mount the sensor to a solid surface with the nylon mounting screw provided. To accurately measure UV radiation incident on a **horizontal** surface, the sensor must be **level**. An Apogee Instruments model AL-100 leveling plate is recommended for this purpose. To facilitate mounting on a cross arm, an Apogee Instruments model AM-110 mounting bracket is recommended.

**Note: to minimize azimuth error, the sensor should be mounted with the cable pointing true north** in the northern hemisphere. Azimuth error is typically less than 1%, but it is easy to minimize by proper cable orientation.

In addition to orienting the cable to point toward the nearest pole, the sensor should be mounted such that obstructions (e.g., weather station tripod/tower or other instrumentation) do not shade the sensor. Once mounted, the green cap should be removed from the sensor. The green cap can be used as a protective covering for the sensor when it is not in use.

Make the wiring connections to the ESC data logger.

**Spectral Errors for UV Radiation Measurements with Apogee SU-100 Sensors**

Radiation Source (Error Calculated Relative to Sun, Clear Sky)	Error [%]
Sun (Clear Sky)	0.0
Sun (Cloudy Sky)	< 0.5
Reflected from Grass Canopy	< 0.5
Reflected from Deciduous Canopy	< 0.5
Reflected from Conifer Canopy	< 0.5
Reflected from Agricultural Soil	< 0.5
Reflected from Forest Soil	< 0.5
Reflected from Desert Soil	< 0.5
Reflected from Water	< 0.5
Reflected from Ice	< 0.5
Reflected from Snow	< 0.5
Cool White Fluorescent (T5)	9.0
Metal Halide	2.8
High Pressure Sodium	-1.7
Incandescent	-3.3
Mercury Arc	17.8

**Maintenance**

Moisture or debris on the sensor is a common cause of low readings. The sensor has a domed-shaped housing for improved self-cleaning from rainfall, but materials can accumulate on the photo-sensitive area (e.g., dust during periods of low rainfall, salt deposits from evaporation of sea spray or sprinkler irrigation water) and partially block

the optical path. Dust or organic deposits are best removed using water, or window cleaner and a soft cloth or cotton swab. Salt deposits should be removed with a soft cloth or cotton swab. **Never use an abrasive material or cleaner on the sensor.**

#### **2.12.1.1.9a Solar Radiation Calibration**

##### **Calibration Frequencies**

The solar radiation sensor has been calibrated at the factory. It will not change unless damaged. Verifications are required on the solar radiation sensor at site startups, sensor repairs or adjustments that will affect the response or data. Also calibrations are required after any unacceptable QA audit or when there is a greater than 10% difference in the readings (audit device / sensor). The solar radiation sensors will be recertified every three years.

##### **Audit Devices**

**The install device will be different than the audit device.** Audit results of the sensor will be recorded with the annual ozone audit. The audit / installation devices will be re-certified annually. A logbook will be generated to document the device events (e.g., re-certification, maintenance).

#### **2.12.1.2 Data Logger Channel Procedure**

Data logger time and date:

- Select the AvTrend icon, enter the username followed by the password, hit "**OK**"
- Select: "**Utilities**"
- Select: "**Link to Logger**"
- From the drop down menu locate the site to run the calibration on
- Select: "**Connect**"
- Select: "**L**" to log onto the site data logger (use site password)
- Select: "**C**", Configuration menu, <ENTER>
- Select: "**S**", Configure System Parameters, <ENTER>
- Highlight "**Logger Time**", <ENTER>
- Type in correct time in the format of: **HH:MM:SS**

##### **Disable Channel on Data Logger**

- Press {**ESC**} {**ESC**} to return to Home Menu
- Select: "**C**", configuration menu, <ENTER>
- Select: "**D**", configure data channels, <ENTER>
- Select: "**M**", mark channels down / off, <ENTER>
- Select: "**RH**", <ENTER>

### **Setting computer and PDL time/date.**

The times for the PDL and computer must be EASTERN STANDARD TIME

Sources for getting the correct time:

1. Call the ECB and ask for the NIST time.
2. Call the NIST Colorado time @ **(303) 499-7111** (long distance).
3. Correct time loaded into cell phone.
4. Correct time website, <http://tycho.usno.navy.mil/>

Check the computer time and date at the lower right hand corner of the computer screen. If the time and date are not correct; click "**START**" button, control panel, date/time or right click computer time on taskbar, select "**Adjust Date/Time**", type in changes and select "**OK**".

**Up the PDL channel:** Go to the Home Menu (by pressing {ESC} several times if needed), Press "**L**" and <ENTER> the code when it asks for the password and press <ENTER>.

- {ESC} {ESC} {ESC} to Home Menu on PDL
- Select: "**C**", Configuration Menu, <ENTER>
- Select: "**D**", Configure Data Channels, <ENTER>
- Select: "**E**", "Enable/Mark Channel Online", <ENTER>
- Use arrow key to select parameter, <ENTER>
- Highlight "**RH**" then press, <ENTER>

The following sequence is used to logout of the data logger:

- Press {ESC}{ESC} to return to Home Menu
- Use arrow ↓ key to select "**O**" or hit "**O**" key to logout

Turn off computer screen and **DO NOT** turn off the computer.

#### **2.12.1.3 Site Visits**

Whenever the ECB technicians visit a site, they will:

1. Document the date, time and reason for the visit in the site logbook.
2. Check that the site building temperature is between 20° C and 30° C.
3. Check that the building is secure. Vandalism is reported to the ECB Supervisor.
4. Check that all monitoring systems are operating within normal ranges (unless the reason for the visit is site start-up).
5. Down any channels for equipment being repaired, replaced, or audited during the repair, replacement, or audit.
6. Up any channels after equipment is repaired, replaced, or audited.



#### **2.12.1.4 Accuracy Audits**

The frequency for performing meteorology accuracy audits will be according to:

1. National Core (NCore) Meteorological Calibration and Accuracy Table (see **Table 2**, pg. 52).
2. State and Local Ambient Monitoring (SLAMS) Meteorological Calibration and Accuracy Table (see **Table 3**, pg. 53).

##### a) Meteorology System Audit

The meteorology system audit is performed to insure the meteorological instrumentation is being operated to QA specifications. The audit provides information about sensor calibration status, sensor malfunctions, repairs that may be needed and improvements to the QA plan. The audit is a valuable tool in determining the data quality of the different meteorological parameters that are measured. The audit information is recorded on the field audit forms and the equipment logbook. The date, start and stop times time are logged so the database will not include values associated with the audit.

When the audit values are more than the parameter(s) criteria, call the ECB Supervisor and inform the Chief of the situation and print out a copy of the last autocalibration. The ECB Supervisor will investigate suspicious audits to determine if there is a problem and if so, where the problem is and how to solve the problem.

If the problem is with the ECB equipment, the ECB generally fixes the audit equipment and repeats the audit. If the problem is with the site equipment, the

ECB takes appropriate action to either repair or replace the site equipment. If the problem is a major site operation problem, the ECB supervisor informs the Projects and Procedures Supervisor.

##### b) Interagency Testing

No interagency testing devices are known to be available from EPA. When such devices become available NCDAQ will participate in interagency testing.

#### **2.12.1.5 Data Acquisition**

- a) When the data logger has been shown to be polling acceptable data, the data will be automatically collected by the Statistician's computer using polling routines. The actions required by the regions are to report reasons for missing data: identify invalid data and identify data to be changed by the Statistician. The actions are to be recorded on the problem log sheet meteorological site forms for documentation purposes.

#### **Data Editing**

- a) All periods of missing or invalid data must be accounted for. Documentation

- identifying the reasons for missing or invalid data is the meteorology system checkout list.
- b) Any valid data identified by the data logger as "invalid" data (by flags) must be verified with proper documentation stating why data is valid. This documentation should state actions required correcting the problem and why data flags were set by the data logger.
  - c) The data must be exported into a spreadsheet or a database program on the PC. The data is exported with a start date and end date for the file. The data files are created monthly for each site. Monthly data files can be edited using the data base software. The edited data must have documentation to support any editing changes made to the database.
  - d) The database is edited first to satisfy the documentation generated from site operations or any questionable data. Once all editing is done the database is screened. The screening process involves comparing the data to expected values or range of values. The screening is performed manually or by macros using a PC. All data that does not pass the screening criteria must be examined to determine if the data is acceptable. The data that is determined unacceptable can be deleted from the database or marked questionable. A documentation record must be created to log deleted data and questionable data. This record provides information about gaps in the data base and quality of the database.
  - e) The data now can be transferred to AQS according to procedures. Notify the Statistician to update when the screening file is ready.
  - f) Review the quarterly data reports from AQS, make changes as needed. When data in AQS is complete and correct, prepare the quarterly data submittal letter for the signature of the Ambient Monitoring Chief.

#### **2.12.1.6 MET Parameter Shutdown Procedure**

- Select the AvTrend icon; enter the username followed by the password, hit "**OK**"
- Select: "**Utilities**"
- Select: "**Link to Logger**"
- From the drop down menu locate the site to shut down
- Select: "**Connect**", when the site has connected
- Select: "**L**", to log onto the site data logger (use site password).
- Down the associated parameter (**WS, WD, RH, etc**)
- Submit the site shutdown form.

**Table 1 Database Screening Criteria**

Wind Speed	Wind speed less than 0 m/sec or greater than 25 m/sec, does not vary more than 0.1 m/sec for 3 consecutive hours
Wind Direction	Wind direction less than 0 degrees or more than 360 degrees, does not vary more than 1 degree for 3 consecutive hours
Temperature	Does not vary more than 0.5 degrees C for 12 consecutive hours, more than 5.0 degrees C change from previous hour
Relative Humidity	Does not vary more than $\pm 7\%$ RH

**Table 2 NCore Meteorological Calibration and Accuracy Criteria**

Measurement	Verification/Calibration			Accuracy		
	Type	Acceptance Criteria	Frequency	Type	Acceptance Criteria	Frequency
Ambient Temperature	3 pt. Water Bath with NIST traceable thermistor <b>or</b> thermometer	$\pm 0.5$ °C	Semi-Annually	3 pt. Water Bath with NIST traceable thermistor <b>or</b> thermometer	$\pm 0.5$ °C	Annually
Relative Humidity	NIST-traceable Psychrometer <b>or</b> standards solution	$\pm 7\%$ RH	Semi-Annually	NIST-traceable Psychrometer <b>or</b> standards solution	$\pm 7\%$ RH	Annually
Wind Speed	NIST-traceable Synchronous Motor, CTS method	$\pm 0.25\text{m/s} \leq 5\text{m/s}$ ; 5% >2m/s not to exceed 2.5m/s	Semi-Annually	NIST-traceable Synchronous Motor	$\pm 0.25\text{m/s} \leq 5\text{m/s}$ ; 5% >2m/s not to exceed 2.5m/s	Annually
Wind Direction	Solar Noon, GPS Magnetic Compass, CTS method	$\pm 5$ degrees; includes orientation error	Semi-Annually	Solar Noon, GPS or Magnetic Compass	$\pm 5$ degrees; Includes orientation error	Annually

This method is described in detail in Section 2.72 – 2.74 of the **Quality Assurance Handbook for Air Pollution Measurement Systems Vol. IV: Meteorological Measurements Version 2.0 (Final)**.


**Table 3 State and Local Air Monitoring Station (SLAMS) Meteorological Calibration and Accuracy Criteria**



Measurement	Verification/Calibration			Accuracy		
	Type	Acceptance Criteria	Frequency	Type	Acceptance Criteria	Frequency
Ambient Temperature	3 pt. Water Bath with NIST traceable thermistor or thermometer	±1.0 °C	Annually	3 pt. Water Bath with NIST traceable thermistor <b>or</b> thermometer	±1.0 °C	Annually
Relative Humidity	NIST-traceable Psychrometer <b>or</b> standards solution	±10% RH	Annually	NIST-traceable Psychrometer <b>or</b> standards solution	±10% RH	Annually
Wind Speed	NIST-traceable Synchronous Motor, CTS method	±0.25m/s ≤5m/s; 5% >2m/s not to exceed 2.5m/s	Annually	NIST-traceable Synchronous Motor	±0.25m/s ≤5m/s; 5% >2m/s not to exceed 2.5m/s	Annually
Wind Direction	Solar Noon, GPS Magnetic Compass, CTS method	±5 degrees; includes orientation error	Annually	Solar Noon, GPS or Magnetic Compass	±5 degrees; Includes orientation error	Annually


This method is described in detail in Section 2.72 – 2.74 of the **Quality Assurance Handbook for Air Pollution Measurement Systems Vol. IV: Meteorological Measurements Version 2.0 (Final)**.


## Sign-Off Sheet


I certify that I have read, understand and agree to follow the contents of Revision 1.5 "National Core (NCore) and State and Local Ambient Monitoring Stations (SLAMS) Meteorological Monitoring QA Plan, Section I, Electronic Calibration Branch Responsibilities" with an effective date of July 1, 2015. **Sign, date and return to the Ambient Monitoring Section Chief.**

ECB Technician:  7-9-15

ECB Technician:  7-2-15  7-13-15

ECB Technician: 

ECB Technician:  6-30-15

ECB Technician:  6-30-15