This SOP is subject to
review and revision in 2015.

BAY AREA
AIR QUALITY
MANAGEMENT
DISTRICT

TECHNICAL SERVICES DIVISION

QUALITY ASSURANCE PROJECT PLAN

STANDARD OPERATING PROCEDURE

MET SOP 511

F460 WIND DIRECTION SENSOR MAINTENANCE

REVISION 511.1.00 02/24/10

Dick Duker
Digitally signed by Dick Duker
DN: CN = Dick Duker, C = US, O = BAAQMD, OU = Technical Division
Reason: I am approving this document
Date: 2010.03.29 15:48:52 -07'00'

Dick Duker, Manager
MQA Section

Mark Stoelting
Digitally signed by Mark Stoelting
DN: CN = Mark Stoelting, C = US, O = Bay Area AQMD, OU = Technical Services
Reason: I am approving this document
Date: 2010.03.29 15:48:25 -07'00'

Mark Stoelting, QA Officer
Technical Services Division

BAY AREA AIR QUALITY MANAGEMENT DISTRICT
939 ELLIS STREET
SAN FRANCISCO, CA 94109

STANDARD OPERATING PROCEDURE
BAAQMD TECHNICAL SERVICES DIVISION

CLIMATRONICS F460 WIND DIRECTION SENSOR MAINTENANCE PROCEDURES

February 24, 2010

TABLE OF CONTENTS

INTRODUCTION 2
GENERAL OPERATING PROCEDURES 2
EQUIPMENT 3
PROCEDURES
- Inspection 4
- Bearing Replacement 4
- Linearity and Hysteresis Verification 5
- Potentiometer Replacement 6
- Starting Torque Verification 7
- Set Screw Checks 7

AUTHORS, REVISIONS, AND APPROVALS 8
APPENDIX: SENSOR PLACEMENT OPTIMIZATION 9

INTRODUCTION

Climatronics' F460 Wind Direction Sensor, P/N 100076, is designed to provide low starting threshold, fast dynamic response, and high accuracy over a wide operating range under adverse environmental conditions. A counterbalanced, heavy-duty vane assembly (wind vane) S/N 101288 attached to the sensor shaft is coupled to a precision low torque potentiometer. Wind direction via vane position is converted to a proportional dc voltage by the potentiometer. The sensor is accurate to ±2° with a threshold of 0.22 m/s.

GENERAL OPERATING PROCEDURES

BAAQMD conducts two meteorological site calibrations (summer and winter) and two audits (fall and spring) annually. Wind vanes are replaced annually during summer calibrations and the sensors are replaced twice yearly during calibrations. In the field, the sensors are tested and replaced only if they are damaged or they exceed any of three specifications: 1) 6 g-cm starting torque, 2) 6° total linearity (smallest error subtracted from largest error), and 3) 2.5° hysteresis.

Once removed, the sensors and wind vanes are brought into the meteorology instrument lab and thoroughly inspected. Damaged or worn parts are repaired or replaced as necessary, set screws are replaced if the corners are rounded. If a sensor was brought into

the lab because of high non-linearity or hysteresis, a linearity test is first performed to confirm the condition of the sensor. In the lab, linearity error should be within 3° and hysteresis should be within 2.5°. Sensors that do not meet these tolerances are taken out of service until the potentiometer is replaced. If a sensor satisfies linearity and hysteresis tolerances, the bearing is replaced, the starting torque is tested with a torque wheel, and linearity/hysteresis tolerances are verified.

EQUIPMENT

1. Lab Equipment
    a. .050, 1/16, and 1/8 hex keys
    b. #1 Philips screwdriver
    c. Desktop Computer with Linearity Spreadsheet
    d. Campbell Scientific CR10 Logger with Wiring Panel
    e. Campbell Scientific CR10KD Keypad Display
    f. Climatronics F460 Wind Direction Sensor Adaptor with Break-Out Cable
    g. Climatronics 101984 Degree Fixture.
    h. Climatronics 101137 Degree Wheel.

2. Climatronics Sensor Parts
    a. 500096 Bearing
    b. 400568-3 Potentiometer
    c. MS24693-C2 Transmitter Support Screw
    d. SC6-3 Coupling Set Screw
    e. SC8-5 Cap Set Screw
    f. SC8-17 Cup/Vane Set Screw
    g. SC10-4 Base Set Screw

Figure 1: F460 Wind Direction Sensor connected to CR10 Logger and CR10KD Keypad Display

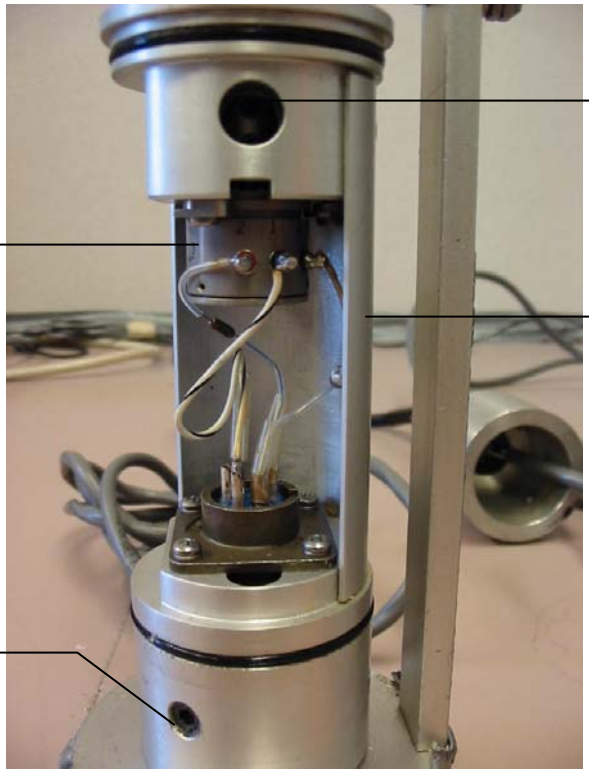


Figure 2: F460 Wind Direction Sensor Interior

PROCEDURES

A. **Inspection**

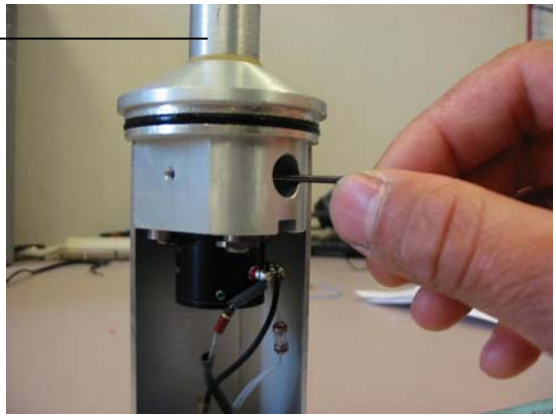
Thoroughly inspect the sensor and vane. Repair or replace damaged or worn parts as necessary. If the wind vane shaft is bent, straighten it by hand is usually sufficient. Remove and inspect the set screws. The set screws have a rubber tip to prevent damage and should be replaced if the tips are degraded or missing, or if the screw heads are rounded.

B. **Bearing Replacement**

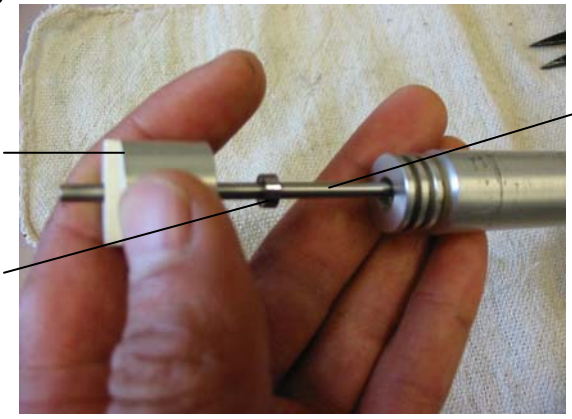
The sensor bearings should be replaced after 6 months of service.

1. Remove the sensor cover by pulling it towards the base with a slight twisting motion

2. Loosen the upper set screw in the potentiometer coupling.



3. Carefully slide the cap and shaft out through the top of the column. It may be necessary to push the bearing out from the bottom of the seats if the bearing is stuck in the column. To do so, remove the potentiometer (step D) and use a long thin rod or a shaft assembly to tap lightly all around the bearing. Discard the bearing.



4. Slide a new bearing onto the shaft, slide the shaft through the sensor column, and tighten the upper coupling set screw.

C. **Linearity and Hysteresis Verification**

Verify that the sensor linearity is within 3° and hysteresis is within 2.5°.

1. Open the linearity spreadsheet in the lab computer.

2. Connect the wind direction sensor adaptor to the CR10 wiring panel. Plug the connector at the end of the Climatronics degree fixture into the sensor adaptor.

3. Attach the sensor into the fixture base by aligning the slot in the wind direction sensor with the pin in the fixture base. Tighten the sensor base set screws against the fixture.

4. Remove the pointer bar behind the fixture column and slide it into the hole located at the top. Tighten the upper thumb screw against the pointer bar.

5. Place the degree wheel over the shaft and rotate the sensor cap until the dial hub fits on the stepped portion on the bottom of the wheel. Rotate the wheel clockwise so that the index end of the pointer bar is in the 0º notch.

6. Rotate the degree wheel clockwise in 30º increments and record each measurement in the spreadsheet until 330º is reached.

7. The same procedure must now be done in the counterclockwise direction. Rotate the degree wheel clockwise past 0º to 330º. Then rotate it counterclockwise to 0º and record the measurement.

8. Rotate the degree wheel counterclockwise from 330º in 30º increments and record the measurement in the spreadsheet until 30º is reached.

9. The maximum hysteresis and maximum normalized linearity error should be displayed at the bottom of the spreadsheet. If the normalized linearity error exceeds ±2.5° or hysteresis exceeds 2.0°, do not re-use the sensor until the potentiometer has been replaced and the sensor has been re-tested.

D. **Potentiometer Replacement**

If normalized non-linearity is within ±2.0° and hysteresis is within 2.0°, skip to step E. Otherwise, replace the potentiometer.

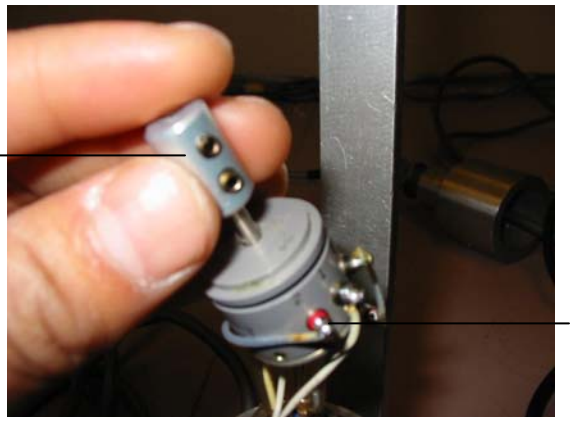
1. Remove the upper coupling set screw.

2. Free the base by removing the bottom two flat head screws from the transmitter support.

3. Loosen the three retaining clamps and remove the potentiometer from the top section.

4. Loosen the lower coupling set screw and remove the coupling.

Coupling and Set Screws



#2 Pin

5. Desolder the three pins on the old potentiometer and solder the wires onto the new potentiometer.

6. Attach the base and potentiometer assembly onto the degree fixture.

7. Turn the potentiometer shaft until the output is 0°.

8. Slide the coupling onto the new potentiometer shaft so that the set screw is aligned with the #2 pin on the potentiometer. This will ensure that access to the retaining clamps will not be blocked by the potentiometer pins when installed.

9. Attach the potentiometer to the top section by tightening the three retaining clamps. Align the #2 pin of the potentiometer to the coupling access hole.

10. Re-attach the base to the transmitter cover with the transmitter cover screws. Replace the screws if the heads are stripped.

E. **Starting Torque Verification**

Verify that the starting torque is within 5 g·cm with the RM Young torque wheel (see Met SOP 502: Wind Direction). The procedure in the field is the same as the procedure in the lab.

F. **Set Screw Checks**

Check the general condition of the cap, vane, coupler, and base set screws, and replace them as necessary. The cap and vane set screws should have sufficient rubber material at the tip to prevent damage to the shaft. Set screw heads should not be excessively rounded. Apply silicone grease to the cap set screw holes in the lab and to the vane and base set screw holes in the field after installation to prevent rust.

AUTHORS, REVISIONS, AND APPROVALS

July, 2008 (Original Version)
Author: Jiawei Toh, Air Quality Instrument Specialist II
Approved: Dick Duker, Meteorology and Quality Assurance Manager

APPENDIX A
Sensor placement Optimization

BAAQMD F460 wind direction sensor error tolerance (normalized) is 3°, and total error tolerance as specified by EPA is 5°. However, total error can exceed 5° even if a sensor's linearity error is within 3°. We are currently exploring various methods that will decrease the chance of wind direction failure. We will illustrate how the above can occur with an example:

A typical marginal sensor may have a linearly increasing error of +2.5° at 0°, +4.5° at 180°, and +6.5° at 330°. The normalized error will be -2.0° at 0°, 0° at 180°, and +2.0° at 330°. The total error is 4° and the normalized error is 2°. The "normalized center" is 180°, which means that the directional error is minimized (within ±2°) throughout the entire range *relative* to the 180° reference. That is, if we installed this sensor at a site with a 180° crossarm orientation and adjusted the sensor relative to the crossarm so that it outputs exactly 180° at "along", the directional error will be greatest at 0° (-2.5° error) and 330° (+2.5° error) – the ideal condition. If, on the other hand, this sensor was installed at a site with a 330° crossarm orientation and was adjusted to output exactly 330° at "along", the directional error would be -4.0° at 0°.

Two methods to reduce overall directional errors are being explored: sensor matching and sensor normalization.

<u>Sensor Matching</u>
After the final linearity test for each sensor, identify "neutral points" where normalized errors are small (generally less than 0.5°) from the linearity spreadsheet. Match the sensor to sites where the crossarm directional reference coincides with the sensor's neutral points.

<u>Sensor Normalization</u>
For any given crossarm directional reference, lookup the coinciding normalized error for the sensor to be installed in the linearity sheet. When aligning the sensor to the crossarm at "along", position the sensor so that it outputs the sum of the crossarm directional reference and the normalized error. For example, if the crossarm directional reference is 330° and the sensor's normalized error is +2.0° at 330°, position the sensor so that it outputs 332° at "along."