

## **Section 2.3.3**

# **Certification and Accuracy Check of Field Barometers and Thermometers**

**(Performed by the Electronics and Calibration Branch)**

**November 1, 2011**

## Approval Sign- Off Sheet

I certify that I have read and approve of the contents of this revision of the "Certification and Accuracy Check of Field Barometers and Thermometers" QAP/SOP with an effective date of November 1, 2011.

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## **2.3.3 Certification and Accuracy Check of Field Barometers and Thermometers**

This section documents the procedures for the Electronics and Calibration Branch (ECB) to verify the accuracy of thermometers and barometers used by the Regional Ambient Monitoring staff. This re-certification record will be kept in ECB's archive files located in the Calibration Room of the ECB facility. The NIST traceable working Laboratory Standard(s) (LS) are calibrated annually by their manufacturers or some other NIST certified facility capable of the work to be performed. These in-house primary reference LSs are used to verify the accuracy of the barometers/thermometers that are used in the field as a reference for checking Particulate Matter (PM) sampling systems' integral temperature and pressure units. This certification is performed on an annual basis by the ECB.

### **2.3.3.1 Barometers**

#### **2.3.3.1.1 Introduction**

Druck Model DPI 705-30a electronic digital barometers are used in the field to measure ambient barometric pressure. "Field Barometers" are used by the regional offices to 1) verify the accuracy of barometric sensors associated with particulate matter (PM) sampling systems and 2) in the calculation of monitor flow rates when using "Flow Transfer Standards (FTSs). The Mensor Model # 14500C is the LS electronic barometer and is located and maintained by the ECB. The LS barometer will be recertified at least annually by the manufacturer or some other NIST certified agency. Any other Mensor Model 14500C barometer can be used as a secondary LS if it is referenced to the primary LS. The procedure outlined below is designed to establish NIST traceability for these "Field Barometers".

#### **2.3.3.1.2 Procedure**

- A) Equipment and Materials List:
  - 1) A pressure manifold with three (3) connecting ports plus an on/off vent to atmosphere;
  - 2) NIST traceable barometric LS;
  - 3) Hand pumps and valve system for creating negative/positive pressures in the manifold; and
  - 4) Calibration/Verification Form (see Appendix A)

## B) Procedure:

There are three steps to follow: 1) Initial "Confidence" Check; 2) Recertification; and 3) Calibration. If a unit passes the criteria for the Initial Confidence Check, it will proceed to the Recertification. If the unit fails the criteria for Initial Confidence Check or the Recertification it will proceed to the Calibration step. If the unit fails the Calibration step, it will be returned to the manufacturer for service.

### **Initial Confidence Check**

1. Inspect the barometer to make sure it is in proper working order; replace or repair as needed. (Check for low battery if so equipped.)
2. All barometers are referred to by their model number, serial number, and unique ECB assigned unit number.
3. Enter the LS Serial number, the barometer's unique ECB number, and the barometer's region of origin on to the Druck Barometric Certification Form (Appendix A).
4. Setup the test:
  - a. Using rubber tubing, connect the Druck, LS and the vacuum and pressure pumps to the ports on the manifold.
  - b. Set both the LS and the Druck barometer being tested to read in mmHg.
5. Perform the "Confidence" Barometric Test:
  - a. Perform a brief "confidence test" at atmospheric pressure, a vacuum of 560 mm Hg and a pressure of 860 mm Hg to show that the unit is responding accordingly. Record the readings of the unit at each pressure against the readings of the ECB NIST certified reference (Lab Standard, LS).
  - b. At each pressure, ensure that the readings are stable for approximately 5 seconds; (Note: the LS can fluctuate with ambient changes in the lab atmosphere such as doors opening, the ventilation system turning on/off).
  - c. Record the time of the test, and ambient pressure readings for both the LS and Druck being tested onto the Calibration/Verification Form.
  - d. Compute the difference as  $\pm$  mmHg and record.

- e. If the differences are 5 mm Hg or less, proceed to the Recertification Step. If not, proceed to the Calibration Step.

### **Recertification**

1. Recertification is to be performed at atmospheric pressure only.
2. Procedure:
  - a. At this point, the Druck and LS should be connected to the manifold. Ensure that the manifold vent valve is open and vented to the atmosphere. Do not move or touch the hand pump or tubing during this acclimation or the test period.
  - b. Ensure the LS output is stable for approximately 5 seconds; (Note: the LS can fluctuate with ambient changes in the lab atmosphere such as doors opening, the ventilation system turning on/off).
  - c. Record the time of the test, and pressure readings for both the LS and Druck being tested onto the Calibration/Verification Form.
  - d. Compare the two readings. If the difference is  $\pm 5$  mm Hg or less enter "Y" for pass and if greater than  $\pm 5$  mm Hg enter "N" for fail.
  - e. If the unit "Fails" it must be recalibrated by the ECB. Proceed to the CALIBRATION procedure below. If the unit "Passes", complete the "ECB Certification Validation" form. On the form provided to the regions and on the unit itself, indicate the magnitude and direction of the deviation from the LS in mm Hg. For example, if the field unit recertification shows that it is within EPA specification ( $\pm 5$  mm Hg) but is reading high by 3 mm Hg, indicate that 3 mm Hg should be subtracted from the reading when used in the field. Return the unit to the appropriate region.

### **Calibration**

1. Ensure that the LS is set to read mm Hg. If the Druck does not read in mm Hg, simultaneously press and hold LEAK and ON/OFF

- keys to see OFF displayed momentarily and then release both keys. Then set Druck to display mm Hg.
2. On the Druck, simultaneously press and hold EQUALS, TARE and UNITS keys to see CAL displayed then release all keys. Push the TARE key to see the PIN# "1111" displayed. Use the EQUALS and LEAK keys to set the PIN# to "4321". Push the TARE key and see "2ErO" (zero) displayed. This indicates that the Druck is in the Calibrate mode.
  3. Connect the Druck, LS and vacuum hand pump to the manifold. Ensure that the manifold vent valve is closed.
  4. Perform the "Low Pressure" or ZERO calibration:
    - a. Use the vacuum hand pump to SLOWLY evacuate the manifold until the LS indicates 560.0 mmHg. It may be necessary to slightly over shoot the 560 and use the pump vernier adjustment to bring the pressure to exactly 560.0.
    - b. Ensure the LS output is stable for 5 seconds. Do not move or touch the hand pump or tubing during this acclimation or the test period.
    - c. Push the TARE key once, wait 5 seconds and see "0.0" displayed.
    - d. Use the EQUALS and UNITS keys to change the Druck display to read 560.0 exactly.
    - e. Press TARE and see F5 (full scale) displayed. Release the vacuum and ensure the manifold valve is closed for the "High Pressure" calibration.
  5. Perform the "High Pressure" or full scale calibration:
    - a. Use the pressure hand pump to SLOWLY pressurize the manifold until the LS indicates: 860.0 mmHg. It may be necessary to slightly over shoot the 860 and use the pump vernier adjustment to bring the pressure to exactly 860.0.
    - b. Ensure the LS output is stable for 5 seconds. Do not move or touch the hand pump or tubing during this acclimation or the test period.
    - c. Push the TARE key once, wait 5 seconds and see "1551.x" displayed.
    - d. Use the EQUALS and UNITS keys to change the Druck display to read 860.0 exactly.

- e. Press TARE and listen for two beeps to indicate calibration is complete.
- f. Return the manifold to ambient pressure by slowly releasing the pressure and perform a check at ambient pressure.

#### 6. Final Ambient Check

- a. At this point, the Druck and LS should be connected to the manifold. Ensure that the manifold vent valve is open and vented to the atmosphere. Do not move or touch the hand pump or tubing during this acclimation or the test period.
- b. Ensure the LS output is stable for approximately 5 seconds; (Note: the LS can fluctuate with ambient changes in the lab atmosphere such as doors opening, the ventilation system turning on/off).
- c. If the difference between the two ambient pressure readings is greater than  $\pm 5$  mmHg, repeat the calibration at 115 mm Hg and 969 mm Hg (instead of 560 and 860). If the difference is still greater than  $\pm 5$  mm Hg, the unit must be return to the factory for repair. If the difference is within  $\pm 5$  mm Hg, the calibration is complete. Proceed to the Recertification procedure.
- d. On the Druck, simultaneously press and hold LEAK and ON/OFF keys, see OFF displayed momentarily, and then release the keys. Simultaneously press and hold EQUALS, TARE and UNITS keys to see CAL displayed then release all keys. Push the TARE key to see the PIN# "1111" displayed. This will ensure that access to the calibration function has been denied.

### 2.3.3.2 Thermometers

#### 2.3.3.2.1 Introduction

"Field Thermometers" are used by the regional offices to 1) verify the accuracy of temperature sensors associated with particulate matter (PM) sampling systems and 2) in the calculation of monitor flow rates when using "Flow Transfer Standards (FTSs)". The procedure outlined below is designed to establish NIST traceability for these "Field Thermometers".

Glass thermometers will be used in all regions for the required field measurement of various temperatures associated with the operation of ambient air monitors. These thermometers may be referred to as “alcohol” (or “mineral”) thermometers to distinguish them from other devices such as battery operated digital readouts. In actuality, these “alcohol” thermometers do not contain alcohol (or mineral fluid or mercury) but contain an environmentally friendly liquid. The “Field Thermometers” will be certified by the ECB on an annual basis against National Institute of Standards and Technology (NIST) traceable test equipment which are themselves certified annually by the manufacturer. All **new** glass thermometers will be certified at 0 and 40 ° C (32 and 104 ° F) to ensure that they meet or exceed the manufacturer’s stated accuracy of  $\pm 1$  ° C (note: a thermometer that does not meet this specification will not be used). Any thermometer that has experienced a separation in the liquid column and subsequently rejoined will also be certified at 0 and 40 ° C. All thermometers returned from the regional offices that are in a useable condition (i.e. no liquid separation) will be re-certified at 0 ° C only.

All thermometers are similar (the same) in design and function and individual thermometers do not have a unique “permanent” serial number. The units are certified by ECB in a batch mode and each is assigned a unique identifier after certification and before distribution to a region. This identifier will change from year to year as there is no need to develop a history on individual units. Each unit is approximately 6 inches long, has a temperature range of -10 ° C to 50 ° C with 1 ° gradations, and a readable resolution of  $\pm 0.5$  ° C.

ECB maintains an inventory large enough to be able to provide all regions with the necessary number of thermometers to meet their needs and a large enough reserve of certified units to be able to re-supply a region prior to the annual expiration of “in-use” thermometers. Upon receipt at ECB (from either the manufacturer or from the regions) each glass thermometer is removed from its “easy-view” protective carrying case, inspected for integrity (not broken, no liquid separation) and placed in an appropriate “bin” depending on action required as described below:

<b><u>BIN Number</u></b>	<b><u>Description</u></b>
<b>1) New</b>	New units for testing at 0 and 40 ° C
<b>2) Rework</b>	Units needing some corrective action (liquid separation)
<b>3) Reusable</b>	Returned from Regions in usable condition
<b>4) Need Test-40</b>	Units for testing at 40 ° C
<b>5) Need Test -0</b>	Units for testing at 0 ° C
<b>6) Hold for Users</b>	Certified units ready for field use
<b>7) Bad</b>	Units to be removed from service

### 2.3.3.2.2 Procedure

A) Equipment and Materials list:

- 1) Dry well temperature calibrator that is NIST traceable and is certified by the manufacturer annually;
- 2) Omega Model # DP41-RTD temperature probe that is NIST traceable and is certified by the manufacturer annually. This unit is designated as the “**Lab Standard**” (**LS**) and is the reference point for all thermometer certifications;
- 3) Batch Log certification work sheet (see Appendix B);
- 4) ECB Certification Sheet (see Appendix C); and
- 5) Audible timer. This is optional and would be used as a reminder to the technician when equilibration times have expired.

B) Procedure:

The following procedure will be used for the annual certification of the thermometers. All readings should be made to the nearest half degree C (0.5° C). **To be acceptable for use in the field, each unit must be within ± 1° C of the LS at the test temperature(s).**

- 1) Power up the dry well calibrator (DWC) and allow it to warm up for a minimum of 30 minutes before use. Ensure that the DWC “shift” feature is set to zero. (The “shift” feature allows the DWC temperature to be adjusted in increments of 0.1 degrees, if needed, to more closely match the reading given by the LS.) The first temperature test point may be either 0 or 40. If the units are to be tested at both points in a given day, then, as a time saver, set the initial test temperature to 0 °C.
- 2) Insert the LS probe fully into the **top test-well hole** of the DWC and allow the readings to stabilize (approximately 30 minutes). The DWC and LS should be within ± 0.5 ° C of each other. At this point, the DWC can be finely adjusted to more closely match the LS reading by using the “shift” feature of the DWC. Record both readings on the “Batch Log” as the “Start Temp”. To ensure that the two test-well holes provide the same reading, insert the LS probe into the **bottom test-well hole** of the DWC, allow the reading to stabilize and record the values. The LS and DWC should agree to within ± 0.5° C in the top and bottom **test-well holes**. This procedure is

- the initial check of the DWC and LS. Perform this procedure at the test temperature selected (either 0 or 40).
- 3) The thermometers will be tested in a batch mode. The number of thermometers in a batch will be determined by the technician and may be nominally 1 to 25 based on time constraints and equipment availability. Remove the glass thermometers from their plastic protective cases and inspect each thermometer to ensure that it is not broken and no liquid separation has occurred in the capillary column. Also remove the identification number. Place them in the appropriate bin (#1 for New Units, #2 for Rework, #3 for Reusable or #7 for Bad). If a unit is found to have a liquid separation, put a "black" mark on the unit and place it in bin #2 as it may be possible to re-join the liquid column.
  - 4) Fully insert the first two thermometers into the top and bottom test-well holes of the DWC. Allow sufficient time for the temperature to stabilize as indicated by a constant reading on the DWC and thermometers (approximately 10 minutes). Pull each thermometer out of the DWC a distance that is sufficient to only expose enough of the scale for easy readability. Quickly determine the reading indicated by the thermometer and, on the batch log, circle the appropriate "delta" value (difference between the test temperature and the thermometer reading). If the "delta" value is within  $\pm 1^\circ$  of the test temperature, the unit passes at that test temperature. If the unit is to be tested at a second temperature (either 0 or 40), place it in either Bin #4 or Bin #5 as appropriate. If the unit is to be tested at  $0^\circ\text{C}$  only and it passes, place it in Bin #6. If the unit fails, put a red mark on the unit and place it in Bin #7.
  - 5) Insert the next two thermometers and repeat Step #4 until the batch is completed.
  - 6) Insert the LS and allow the readings to stabilize. Record the LS and DWC values on the Batch Log as "Stop Temp". The LS and DWC should agree within  $\pm 0.5^\circ\text{C}$ .
  - 7) On an as needed annual basis, the appropriate number of thermometers is removed from Bin #6 for shipment to a region. Each thermometer is placed into a plastic protective case and relabeled with a unique identification number. To make the most recently certified units more easily identified by a regional office, each unit within a group is label with a colored tag (typically red, orange or yellow) which are numbered sequentially starting with "1". Each unit will be accompanied with a "Certification Sheet" (see Appendix C).

**Appendix A****(Druck Barometric Calibration/Recertification Laboratory Form)****DRUCK BAROMETRIC RECERTIFICATION FORM**

DUT ECB #: \_\_\_\_\_ Lab Standard SN: \_\_\_\_\_

Model / Serial \_\_\_\_\_ LS Check Passed Y / N: \_\_\_\_\_

DUT Region: \_\_\_\_\_ Test Date: \_\_\_\_\_

Test	Labstd mm Hg  xxx.xx	DUT mm Hg  xxx.xx	Delta +/-  xx.xx	Max Delta Allowed  xx.x	Pass  Y/N:	Test Time  hh :mm	Date:  mm:yy	Signature
<b>Initial Amb:</b>				5.0				
<b>Low:</b> 560 mm (115 mm)				5.0				
<b>High:</b> 860mm (969 mm)				5.0				
<b>Final Amb.</b>				5.0				

**For Field Use:**

- 1) Add \_\_\_\_\_ mm Hg to Reading
- 2) Subtract \_\_\_\_\_ mm Hg from Reading

**Appendix B  
(Batch Log)**

Date: \_\_\_\_\_ Technician: \_\_\_\_\_

Start Temp: Lab Std: \_\_\_\_\_ Dry Well: \_\_\_\_\_ Stop Temp: Lab Std. \_\_\_\_\_ Dry Well: \_\_\_\_\_

+1.0 +1.0 +1.0 +1.0 +1.0 +1.0 +1.0 +1.0 +1.0 +1.0 +1.0 +1.0 +1.0 +1.0 +1.0 +1.0 +1.0 +1.0 +1.0  
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Date: \_\_\_\_\_ Technician: \_\_\_\_\_

Start Temp: Lab Std: \_\_\_\_\_ Dry Well: \_\_\_\_\_ Stop Temp: Lab Std. \_\_\_\_\_ Dry Well: \_\_\_\_\_

+1.0 +1.0 +1.0 +1.0 +1.0 +1.0 +1.0 +1.0 +1.0 +1.0 +1.0 +1.0 +1.0 +1.0 +1.0 +1.0 +1.0 +1.0 +1.0  
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Summary Statistics

Test Temp. "0" Results \_\_\_\_\_

Test Temp. "40" Results \_\_\_\_\_

The # of +1.0 Observed= _____ :% of Total _____	The # of +1.0 Observed= _____ :% of Total _____
The # of -1.0 Observed= _____ :% of Total _____	The # of -1.0 Observed= _____ :% of Total _____
The # of +0.5 Observed= _____ :% of Total _____	The # of +0.5 Observed= _____ :% of Total _____
The # of -0.5 Observed= _____ :% of Total _____	The # of -0.5 Observed= _____ :% of Total _____
The # of 0.0 Observed= _____ :% of Total _____	The # of 0.0 Observed= _____ :% of Total _____

Totals: \_\_\_\_\_

**Appendix C  
(ECB Certification Sheet)**

**ECB Certification Validation**

**Technician:** \_\_\_\_\_

**Region:** \_\_\_\_\_

**Date:** \_\_\_\_\_

**Expires:** \_\_\_\_\_

**ECB #:** \_\_\_\_\_

**Barometer:** \_\_\_\_\_

1) Add \_\_\_\_\_ mmHg

2) Subtract \_\_\_\_\_ mm Hg

**Manometer:** \_\_\_\_\_

**Thermometer:** \_\_\_\_\_

**On the above date, this unit was certified/calibrated to ECB standards and the unit is within proper operating ranges.**

**Signature:** \_\_\_\_\_