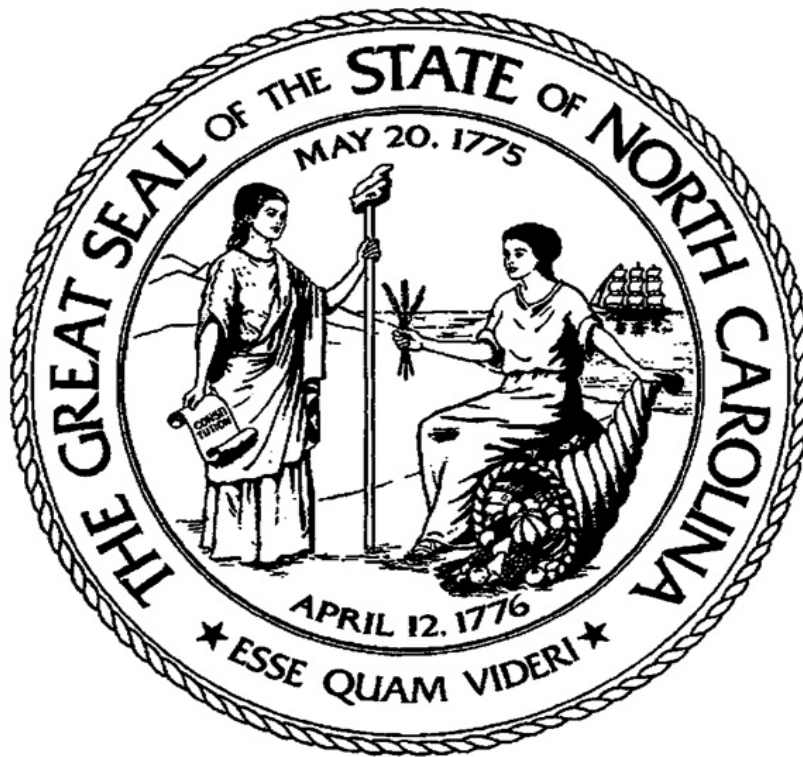


# Standard Operating Procedure DAQ-15-001.1 Verification of Ambient Monitoring Thermometers Version 0.0



Standard Operating Procedure Approval

Department of Environmental Quality

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## 1. Scope and Purpose

This document is designed for the Electronics and Calibration Branch (ECB) Technician responsible for maintaining and verifying thermometers used throughout the NC DAQ Ambient Monitoring Network. It provides routine operating procedures used to achieve uniformity and ensure highly accurate temperature measurements.

## 2. Safety and Cautions

Because of the design of temperature probes, care should be taken when handling the probes to avoid injury.

Cautions:

- DO NOT use pliers or other similar devices to squeeze the sheathing of the temperature sensor around the probe wiring harness. This could permanently damage the sensor and change the calibration coefficient.
- DO NOT use fluid to clean inside the drywell. It is important to keep the well of the calibrator clean and clear of any foreign matter.
- Avoid operating the instrument in an oily, wet, or dirty environment.
- Operating the instrument in a draft-free environment improves performance of the instrument.

## 3. Instrument Description

Different types of thermometers are used throughout the network including but not limited to: HH804 Omega, The H-B Instrument B60570-0200 Thermometers and Tetracal temperature probe. These thermometers are used to: (1) verify the accuracy of the temperature sensors samplers/monitors, (2) in calculating flow rates when using a flow transfer standard (FTS) and (3) used to verify shelter temperature criteria.

## 4. Verification of Field Thermometers

Thermometers (new or returning from the field) go through an annual verification process based against National Institute of Standards and Technology (NIST) traceable testing equipment. They are verified at 0° C, 20° C and 40 ° C to ensure that they meet or exceed the manufacturer's stated accuracy (Note: A thermometer that does not meet this specification will not be used). Certificates are issued to thermometers that meet specifications. This may be referred to as "certification of thermometers, certified thermometers or certification of verification." Thermometers are verified only, currently no calibrations of these types of thermometers are done at the ECB.

Many thermometers have unique identifiers (serial numbers); however, some do not, for example, the glass field thermometer. As a result, they will be given a "unique identifier" tag attached to the blue protective carrying case. Be careful when certifying glass field

thermometers, not to mix up different thermometers with different protective carrying cases. This is the only way to track glass field thermometers.

ECB maintains an inventory large enough to: 1) Provide all regions with the necessary number of thermometers to meet their needs, 2) re-supply a region prior to the annual expiration of “in-use” thermometers and 3) to supply replacement thermometers if needed. Upon receipt at ECB (from either the manufacturer or from the regions) each thermometer is inspected for integrity (not broken, no liquid separation, broken wires, etc.) and prepared for verification or stored until it is verified. Broken or bad units will be discarded properly or returned to the manufacturer for repair.

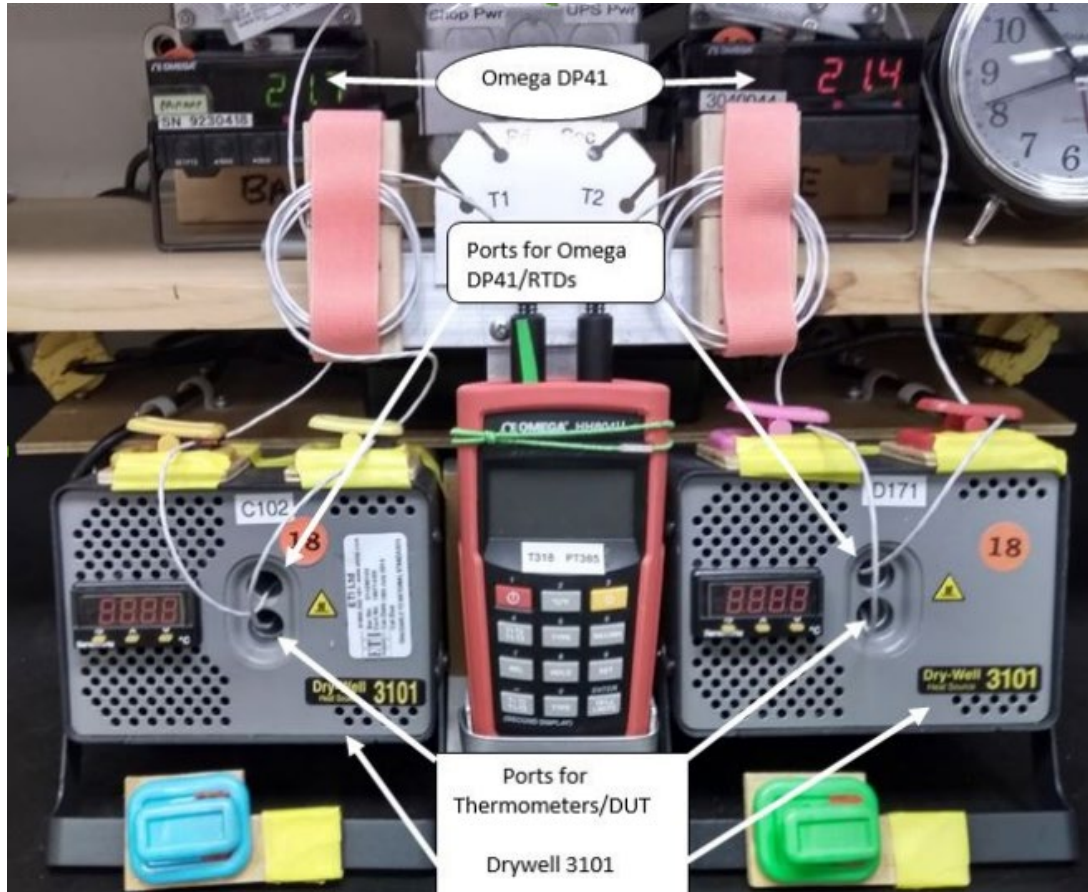
#### 5. Equipment and Materials Setup

The ECB's setup for verifications of thermometers consist of the following:

- Two ThermoWorks 3101 Drywell calibrators (DWC)
- Two Omega DP41(with resistance temperature detectors) RTD-805-Lab Standard (LS)
- E-log certification work sheet (see Appendix A) Note: Become familiar with the E-log documentation requirements before beginning the verification procedure.
- Backup-T-200 PRT Thermal X Met One temperature probe and data logger that meets the specifications to serves as a LS.

All the lab standards (LS) listed are calibrated annual by the manufacturer and kept on file at ECB. The setup below allows for 1-2 field thermometers to be verified at a time during a session.

Figure 1 Omega DP41, High performance temperature meters with two RTD-805's and two ThermoWorks Drywell calibrators with two ports



## 6. Verification Procedure

The following procedure will be used for the annual verification of the thermometers. Thermometer readings should be made according to the manufacturer specification. Resolutions of  $\pm 0.1^\circ \text{C}$  and accuracies of  $\pm 0.5^\circ \text{C}$  are acceptable for field use and each thermometer must be within  $\pm 1.0^\circ \text{C}$  of the LS at the test temperature(s).

The thermometers are tested in batch mode. The number of thermometers in a batch will be determined by the technician and may be nominally 1 to 10 based on time constraints and equipment availability. Note: If verifying field glass thermometers, 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. If a thermometer does not meet the criteria, dispose of it properly. If several glass thermometers are in a batch, organize or label them in an orderly fashion (test tube rack) to eliminate any confusion during testing.

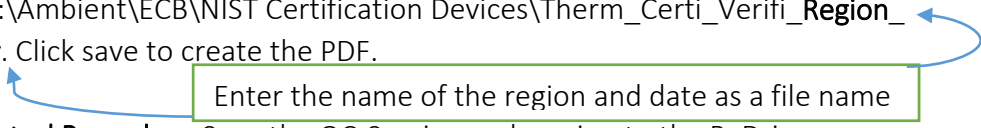
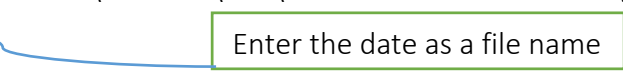
- a. Power up the dry well calibrator (DWC) and allow it to warm up for a minimum of 30 minutes before use. Ensure that the DWC “shift” feature is set to zero. The

“shift” feature allows the DWC temperature to be adjusted in increments of 0.1 ° C, if needed, to more closely match the reading given by the LS.

- b. Insert the LS probe fully into the top test-port of the DWC and allow the readings to stabilize (approximately 15-30 minutes). The DWC and LS should be within  $\pm 0.5$  ° 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. Allow the reading to stabilize and record the readings. 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 readings. The LS and DWC should agree to within  $\pm 0.5$  ° C in the top and bottom test-well holes. This procedure is the initial check of the DWC and LS. Note any abnormalities in the comment section.
- c. Leave the LS in the top test-port and insert the thermometer(s) into the bottom test-port of the DWC. Adjust the DWC to the first test point of 0° C using the up or down arrow buttons on the front of the DWC. The LS and DWC should agree within  $\pm 0.5$  ° C. Allow the reading to stabilize (approximately 10 minutes). If testing a glass thermometer, pull each thermometer out of the DWC a distance that is sufficient to only expose enough of the scale for easy readability. Quickly determine and record the reading indicated by the thermometer and readings of the LS. The e-log will indicate pass or fail after the value has been entered based on the “delta” value  $\pm 1$ ° of the test temperature. If the unit fails, try testing again and if it fails a second attempt properly dispose of the unit, troubleshoot or send to the manufacturer for repair. Carefully remove the thermometer from the DWC. Continue with the batch until the test point is completed.
- d. Adjust the DWC to the next test point of 20° C using the up or down arrow buttons on the front of the DWC. The LS and DWC should agree within  $\pm 0.5$  ° C. Repeat Step c. with the new test point, until the batch is complete at this test point.
- e. Adjust the DWC to the next test point of 40° C using the up or down arrow buttons on the front of the DWC. The LS and DWC should agree within  $\pm 0.5$  ° C. Repeat Step c. with the new test point until the batch is complete at this test point.
- f. When the batch is complete with passing result on all three test points, record the ending temperatures from the DWC ports and LS. Investigate any failed set criteria and begin troubleshooting the device under testing (DUT). Use the Omega DP41-E High Performance Process Indicator Users Guide and ThermoWorks 3101 Dry-Blockheat/Cool Source User Manual troubleshooting section to find a solution. Document findings in the comments and contact the particle matter (PM) Lead.

## 7. Documentation Handling

The following explains where e-logs and the portable document format (PDF) of the sessions are saved as well as the naming convention.

- a. **Verifications**-Save the verification session to the P: Drive as: P:\Ambient\ECB\NIST Certification Devices \Therm\_Certi\_Verifi\_Region\_mmddyyyy .
- b. Also create a PDF of the session. Click the Region tab and go to File=> Save as=> P: Drive as: P:\Ambient\ECB\NIST Certification Devices\Therm\_Certi\_Verifi\_Region\_mmddyyyy. Click save to create the PDF.  

- a. **Quality Control Procedure**-Save the QC-Semiannual session to the P: Drive as: P:\Ambient\ECB\NIST Certification Devices\ QC\_LS\_ECB\_mmddyyyy.
- b. Also create a PDF of the session. Click the QC-Semiannual tab and go to File=> Save as=> P: Drive as: P:\Ambient\ECB\NIST Certification Devices\QC\_LS\_ECB\_mmddyyyy.  


## 8. Quality Control Procedure

The following procedure will be used for the LS semi-annual multipoint (0°C, 20°C and 40°C) comparison. It is to be performed between the LS and another LS device that meets the requirements of a LS and serve as a control standard. Note: To avoid confusion in this comparison, the LS that is being tested will be referred to as lab standard device under testing (LS-DUT).

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 ° C, if needed, to more closely match the reading given by the LS.

- a. Insert the LS probe fully into the top test-port of the DWC and allow the readings to stabilize (approximately 15-30 minutes). The DWC and LS should be within  $\pm 0.5$  ° 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. Allow the reading to stabilize and record the readings. 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 readings. The LS and DWC should agree to within  $\pm 0.5$ ° C in the top and bottom test-well holes. This procedure is the initial check of the DWC and LS. Note any abnormalities in the comment section.
- b. Leave the LS in the top test-port and insert the LS-DUT (into the bottom test-port of the DWC. Adjust the DWC to the first test point of 0° C using the up or down arrow buttons on the front of the DWC. The LS and DWC should agree within  $\pm 0.5$ ° C. Allow the reading to stabilize (approximately 10 minutes). Determine and record the reading indicated by the LS-DUT and readings of the LS in the



appropriate cells on the e-log. The e-log will indicate pass or fail after the value has been entered based on the “delta” value  $\pm 0.5^{\circ}\text{C}$  of the test temperature. If the unit fails a test point, try testing again and if it fails a second attempt troubleshoot the problem. Note: Continue with the multipoint comparison even if a test point fails. This will allow for a complete data set to better diagnose a problem.

- c. Adjust the DWC to the next test point of  $20^{\circ}\text{C}$  using the up or down arrow buttons on the front of the DWC. The LS and DWC should agree within  $\pm 0.5^{\circ}\text{C}$ . Repeat Step b. with the new test point, until the comparison test point is complete.
- d. Adjust the DWC to the next test point of  $40^{\circ}\text{C}$  using the up or down arrow buttons on the front of the DWC. The LS and DWC should agree within  $\pm 0.5^{\circ}\text{C}$ . Repeat Step b. with the new test point until the comparison test point is complete.
- e. When the comparison is complete on all three test points, record the ending temperatures from the DWC ports and LS. Review the multipoint comparison and investigate any failed set criteria and begin troubleshooting. Use operator’s manuals and ThermoWorks Drywell calibrator operator’s manual troubleshooting section to find a solution to any problems encountered. Document findings in the comments and contact the PM Lead.

The acceptance criteria are  $\pm 0.5^{\circ}\text{C}$  at each point and an  $R2 \geq 0.9999$ . A calibration curve graph is included with the e-log as a visual reference. If all criteria are not met, re-run the test to confirm the result. If a failure is confirmed, consult with the PM Lead to determine if the problem is with the control standard or reference standard. If it is determined to be an issue with the control standard or the reference standard, have the device sent to a qualified vendor that utilizes NIST traceable standards for repair or re-calibration. If the comparison test meets all criteria, save the e-log following the Section 7: Documentation Handling procedure with a file name of QC\_LS\_ECB\_mmdyyy.

#### 9. List of Acronyms, Abbreviations and Glossary

Calibration – establishes a correction formula to be used to adjust or correct the display of the candidate instrument. This is determined through a comparison of the candidate instrument to a known, or reference standard.

Delta Value - Difference between the lab standard and the device under testing reading.

DUT - Device Under Testing

DWC - Dry Well Calibrator

ECB – Electronics and Calibration Branch

LS - Lab Standard

LS-DUT - Lab Standard Device Under Testing

NC DAQ – North Carolina Division of Air Quality

NIST – National Institute of Standards and Technology

PDF-Portable Document Format

PM – Particle matter

QA - Quality assurance

RTD - Resistance Temperature Detectors

R2 - Coefficient of determination

Verification – Establishes comparability of a candidate instrument to a known, or reference standard; the output of candidate instrument is not corrected based upon the results of the verification procedure.

## 10. References

Quality Assurance Guidance Document 2.12 Monitoring PM<sub>2.5</sub> in Ambient Air Using Designated Reference or Class I Equivalent Methods

U.S. EPA Quality Assurance Handbook for Air Pollution Measurement Systems Volume II Ambient Air Quality Monitoring Program

U.S. EPA Quality Assurance Handbook for Air Pollution Measurement Systems Volume IV: Meteorological Measurements

ThermoWorks 3101 Dry-Blockheat/Cool Source User Manual

Omega DP41-E High Performance Process Indicator Users Guide

## 11. Appendix: A E-log Documentation

The e-log is designed for the Technician to fill out only the blue cells. The other cells are locked to avoid errors. The Region tab and QC-semiannual tab are filled out in the same manner. Below is a description of information entered into the cells.

1. Click on the Standards tab and fill out the following information about the LS and DWC (the information on the Standards sheet is linked to both Region and QC-semiannual sheet):
  - Name of the equipment and ID (in the same cell)
  - the certification date
  - expiration date

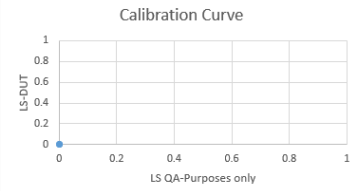
2. Click on the Region tab/QC-Semiannual to fill out the following information for the batch or QC session:

Description of Information Entered in Cells	
<b>Region</b>	<b>QC/Semiannual</b>
<b>Date</b> -Date of session	<b>Date</b> -Date of session
<b>Time</b> -Time of session	<b>Time</b> -Time of session
<b>Tech.</b> -Technician	<b>Tech.</b> -Technician
<b>Region/Branch</b> -Region/Branch (Select from the dropdown menu)	<b>Region/Branch</b> -Region/Branch (Select from the dropdown menu)-ECB
<b>Starting Room Temperature</b> -Starting Room Temperature	<b>Starting Room Temperature</b> -Starting Room Temperature
<b>Ending Room Temperature</b> - Ending Room Temperature	<b>Ending Room Temperature</b> - Ending Room Temperature
<b>Dropdown menu</b> -Select the DWC used during the test (Both can be used during a session) the certification date will populate as well as the remaining days before it expires.	<b>Dropdown menu</b> -Select the DWC used during the test (use one during QC session) the certification date will populate as well as the remaining days before it expires.
<b>Dropdown menu</b> -Select the LS (Both can be used during a thermometer session) the certification date will populate as well as the remaining days before it expires.	<b>Dropdown menu</b> -Select the LS (use one during QC session) the certification date will populate as well as the remaining days before it expires.
<b>DUT</b> - Enter the name of the thermometer(s)	<b>LS-DUT</b> - Enter the name of the LS-DUT
<b>ID</b> -Enter the ID number(s) of the thermometer(s)	<b>ID</b> -Enter the ID number(s) of the LS-DUT
<b>Initial Ck. LS</b> -The initial temperature of the LS	<b>Initial Ck. LS</b> -The initial temperature of the LS
<b>Initial Ck. DWC top port</b> - The initial temperature of the DWC top port	<b>Initial Ck. DWC top port</b> - The initial temperature of the DWC top port
<b>Initial Ck. DWC bottom port</b> - The initial temperature of the DWC bottom port	<b>Initial Ck. DWC bottom port</b> - The initial temperature of the DWC bottom port
<b>Final Ck. LS</b> -The final temperature of the LS	<b>Final Ck. LS</b> -The final temperature of the LS
<b>Final Ck. DWC top port</b> - The final temperature of the DWC top port	<b>Final Ck. DWC top port</b> - The final temperature of the DWC top port
<b>Comments</b> -Use as necessary	<b>Comments</b> -Use as necessary



Figure 4 E-log QC-Semi-annual Data Entry

v1.1 Effective Start Date 11/1/20																	
1	Date		Semi-annual Multipoint (0°C, 20°C and 40°C) Comparison														
2	Time																
3	Tech.																
4	Region/Branch																
5	Start Room temp																
6	End Room temp																
7																	
8	Dry Well Calibrator (DWC)	Shift	Cert. Date	Exp. Date	Rem. Days	Start Temp DWC	Start Temp DWC	End Temp DWC	End Temp DWC								
9																	
10	ThermoWorks-Drywell1		1/0/1900	#N/A													
11	N/A		N/A	N/A													
12	Lab Std. (LS)		Cert. Date	Exp. Date	Rem. Days	Start Temp LS top port	Start Temp LS btm port	EndTemp LS top port	End Temp LS btm port	Comments:							
13	METOne Temporary standard		1/0/1900	#N/A													
14	N/A		N/A	N/A													
15	LS-DUT	ID	LS-Set point 0C	DUT @ 0C	Diff. C	Pass/Fail	LS-Set point 20C	DUT @ 20C	Diff. C	Pass/Fail	LS-Set point 40C	DUT @ 40C	Diff. C	Pass/Fail	Slope	Inter	R2
16																	
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3. Printing Labels (Optional). Printing labels for thermometers are optional. This can be achieved by using the Mail merge wizard in Microsoft Word and using “Labels” tab in the e-log as a data source. If labels are not printed, write in the pertinent information where applicable on a preprinted label to identify thermometers without identification.

12. Revisions








# 112020\_Standard Operating Procedure for the Calibration of Thermometer


Final Audit Report

2020-11-10

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