QAM-I-118

Thermometer Calibration

Verification

Revision 14

Approval:

Laboratory Manager — Date: 6.10.20

Concurrence — Date: 6/10/2020

Effective date: 6-11-20

Renewal date: 6-30-21 for 6-10-~~20~~ 21 ~~6-30-21~~ Initials: SPM

Texas Institute for Applied Environmental Research

1. **Applicability and Purpose**
   i. This procedure applies to all thermometers used for temperature measurement data. The purpose of this procedure is to ensure proper calibration of thermometers as compared to the National Institute of Standards and Technology (NIST) acceptance criteria through the use of an NIST certified thermometer.

2. **Definitions**
   i. Type II ASTM water: deionized water, which meets the criteria, set by the American Society for Testing and Materials. Type II water has a maximum specific conductivity of 1.0 µmho/cm^2.
   ii. NIST traceable: a specific quality of standard that can be traced by documentation back to its certification source at the NIST (formerly NBS, National Bureau of Standards). This thermometer has a calibration certificate supplied by the vendor for at least a 5 point check listed for that thermometer. The LQAO files the certificate.
   iii. Correction Factor- The difference between the actual readings of the working thermometer and the NIST thermometer is Correction Factor (CF). Both the observed and the corrected temperatures are recorded. The NIST traceable thermometer may have CFs at temperatures within the readability of the working range of the laboratory thermometer that are applied to the laboratory thermometers at those temperatures.

3. **Equipment, Reagents and Standards**
   i. Hot plate, standard laboratory type
   ii. Laboratory glassware
   iii. Freezer, household or standard laboratory type
   iv. Type II ASTM water
   iv. NIST traceable thermometer; new or calibrated by vendor at least every 5 years, or when damaged or mercury is separated
   v. Laboratory thermometers
   vi. Laboratory oven
   vii. Refrigerator
   viii. Incubators
   ix. Oil
   x. Sand

4. **Procedure**

   i. Thermometer calibration is verified annually, with the exception of the NIST thermometer. The expiration date or next annual calibration due date is labeled or affixed to the thermometer and recorded in the correction factor log (I-118-1). Calibration expiration dates are checked at least monthly and noted in the Maintenance Log (E-log) as done. More frequent verification may be needed if the thermometer is jarred, the filling is separated, or other conditions arise which compromise accuracy.

   ii. The NIST thermometer will expire 5 years from the day it is received or on the expiration date indicated on the certification certificate.

   iii. Correction factors are determined for working thermometers by comparison to the NIST thermometer and are in the Elog for each thermometer. The CF is applied at any readable level.

   iv. For thermometers designed to be used at one temperature (range of less than 10°C) suspend the thermometer to be calibrated and the NIST thermometer together in a container of Type II ASTM water, oil, sand or other media.

   v. Warm or cool the container to a temperature within the working range of the thermometer.

   vi. Read and record the temperatures of both thermometers and record values in the Thermometer Correction Factor Log (Attachment 1). Ensure the thermometers are uniquely identified and match both the log and tags. Mercury thermometers are read by inverse meniscus. Red alcohol and other water-based media are read by meniscus.

   vii. The difference in the corrected NIST thermometer reading and the thermometer to be calibrated is the correction factor.

   viii. For thermometers that are not used at a single temperature (range of greater than 10°C) choose two temperatures that bracket the working range for the thermometer to be verified, within reasonable proximity to the upper and lower limit of the scale.

   ix. Suspend the thermometer to be verified and the NIST traceable thermometer together in a container of Type II ASTM water, oil, sand or other media and alternately place the container in temperature controlled climates (freezer, ice bath, oven, etc).

x. Read and record the temperatures of both thermometers and record values in the Thermometer Correction Factor Log (Attachment 1). Ensure the thermometers are uniquely identified and match both the log and tags. Mercury thermometers are read by inverse meniscus. Red alcohol and other water-based media are read by meniscus.

xi. Construct a two point line curve (provided in the log) to obtain the equation for slope, abscissa and ordinate intercept (y=mx+b). Points are based on difference between the two thermometers at the two temperature extremes of the range used. This formula is applied to all future observations to obtain correction factors. This part of the log is password locked by the LM so it cannot be changed until the next correction factor determination (annual calibration check).

xii. If the NIST calibration certificate has a CF at a temperature checked within the working range of the laboratory thermometer, apply it also. All temperature measurements using the working thermometer have the observed temperature, correction factor and corrected temperature recorded in all documentation where temperature is measured, including the Q-103-2, “Equipment Temperature Log”.

xiii. Report results to the nearest 0.1 degrees Celsius, unless the thermometer has only whole number digital readout. Normally temperature in the laboratory is not measured in Fahrenheit.

xiv. The usability criterion for thermometer calibrations is $\Delta T \leq 1$ ºC between the NIST thermometer and the working thermometer (e.g., $\Delta T=1.5$ between NIST and working thermometer means the thermometer is removed from service or discarded). Some thermometers, such as the IR thermometers, may have a correction factor of more than 1°C.

5. **<u>Quality Control and Safety Aspects</u>**

i. Thermometer calibration verification is performed in accordance with this procedure and under the guidelines established in QAM-Q-101, "Laboratory Quality Control" and QAM-S-101, "Laboratory Safety".

ii. If a thermometer is found to be out of calibration, a Corrective Action Report is completed in accordance with QAM-Q-105, "Corrective Actions".

iii. Broken thermometers are disposed of in accordance with QAM-W-101, "Disposal of Laboratory Waste". Many thermometers contain pure mercury metal, which is extremely toxic. All thermometers are handled in accordance with QAM-S-101. If mercury is spilled or released, evacuate the area and notify the Laboratory Manager or his/her designee immediately for cleanup directions with sulfur compounds and disposal as hazardous waste.

iv. The Laboratory Manager is responsible for ensuring that all thermometers used in the laboratory for data collection and generation are of acceptable quality. He/she ensures that calibration is verified and documented. Corrective actions include consultation with the Quality Assurance Officer or Project/Program Manager, if appropriate, to determine validity of data since last calibration verification.

v. Some purchased thermometers (refrigerators) may be directly NIST traceable by the manufacturer and do not need to be checked for accuracy. They are periodically checked for separation of the mercury/red alcohol medium, and disposed of or repaired when this occurs. Thermometers purchased as NIST traceable have certificates with correction factors for the temperature at which they are used on file with the Laboratory Manager and are considered good for one year from the date of receipt and **not** the date of calibration at the factory. Purchased thermometers also have NIST traceable calibration records that show calibration points that bracket the range of use.

6. **References**

i. Standard Methods for the Examination of Water and Wastewater, latest approved edition, ed. by Arnold E. Greenberg, et al., APHA, AWWA, Washington, D.C.

ii. Handbook for Analytical Quality Control in Water and Wastewater Laboratories, USEPA, EPA-600/4-79-015, March 1979.

iii. The National Environmental Laboratory Accreditation Conference Institute (TNI) standard, 2016.

7. **Attachments**
   i. Thermometer Correction Factor Log (or E-log), I-118-1
   ii. Thermometer Log (or E-log), I-118-2

Attachment 1
Example Correction Factor Log

Note: Lab thermometer must agree within 1ºC or 5% (whichever is lowest) of NIST thermometer at both temperatures to pass.

thermometer	temp 1 NIST	temp 1 obs	temp 2 NIST	temp 2 obs	CF1	CF2	**CF final**	NIST therm. ID	**Cal Due**	date 1	Date 2
C-1	11.2	11.61	31.8	31.49	-0.41	0.31	**y=-0.005x-0.3416**	T-115	**3/5/2013**	3/6/2014	3/6/2014
PM-1	10.2	10.3	33.6	33.3	-0.1	0.3	**y=-0.0043x-0.3552**	T-115	**3/5/2013**	3/6/2014	3/6/2014
T-060	39	39.1	45	45	-0.1	0	**y=0.0169x-0.7627**	T-115	**10/25/2012**	13/30/2013	2/20/2014
T-065	0.3	0	45.6	45	0.3	0.6	**y=0.0067x+0.3**	T-115	**10/25/2012**	13/30/2013	2/20/2014
T-066	0.3	0	45.6	45	0.3	0.6	**y=0.0067x+0.3**	T-115	**10/25/2012**	13/30/2013	2/20/2014
T-070	97.8	98.2	189.8	190.3	-0.4	-0.5	**y= -0.0011x-0.2934**	T-115	**10/25/2012**	10/26/2013	3/1/2014
T-072	20.2	20.2	188.6	188	0	0.6	**y= 0.0036x-0.0722**	T-115	**10/25/2012**	10/25/2013	3/1/2014
T-090	32.5	32.7	43.9	43.7	-0.2	0.2	**y=0.0364x-1.3891**	T-115	**10/25/2012**	13/30/2013	2/20/2014
T-091	29.3	29.4	45.9	45.7	-0.1	0.2	**y=0.0184x-0.6411**	T-115	**4/5/2013**	3/6/2014	4/5/2014
T-092	29.3	29.3	45.9	45.6	0	0.3	**y=0.0184x-0.5393**	T-115	**4/5/2013**	3/6/2014	4/5/2014
T-109	20.2	20	190	190.5	0.2	-0.5	**y= -0.0041x+0.2821**	T-115	**10/25/2012**	10/25/2013	3/1/2014
T-112	98.4	98	124.8	125	0.4	-0.2	**y=-0.0222x+2.5778**	T-115	**4/5/2013**	13/30/2013	4/5/2014
T-113	101.2	101.8	172.6	173.4	-0.6	-0.8	**y= -0.0028x-0.3156**	T-115	**10/25/2012**	10/26/2013	3/1/2014
T-114	100.7	100.5	172.7	173	0.2	-0.3	**y= -0.0069x+0.8931**	T-115	**10/25/2012**	10/26/2013	3/1/2014
T-117	0	0.5	50	49.5	-0.5	0.5	**y=0.02x-0.5**	factory cal	**2/12/2013**	2/14/2014	2/14/2014
T-118	0	1	50	50	-1	0	**y=0.02x-1**	factory cal	**2/12/2013**	2/14/2014	2/14/2014
T-119	0	0.5	50	49.5	-0.5	0.5	**y=0.02x-0.5**	factory cal	**2/12/2013**	2/14/2014	2/14/2014
T-120	0	0.5	50	49	-0.5	1	**y=0.03x-0.5**	factory cal	**2/12/2013**	2/14/2014	2/14/2014
T-121	0	1	50	50	-1	0	**y=0.02x-1**	factory cal	**2/12/2013**	2/14/2014	2/14/2014

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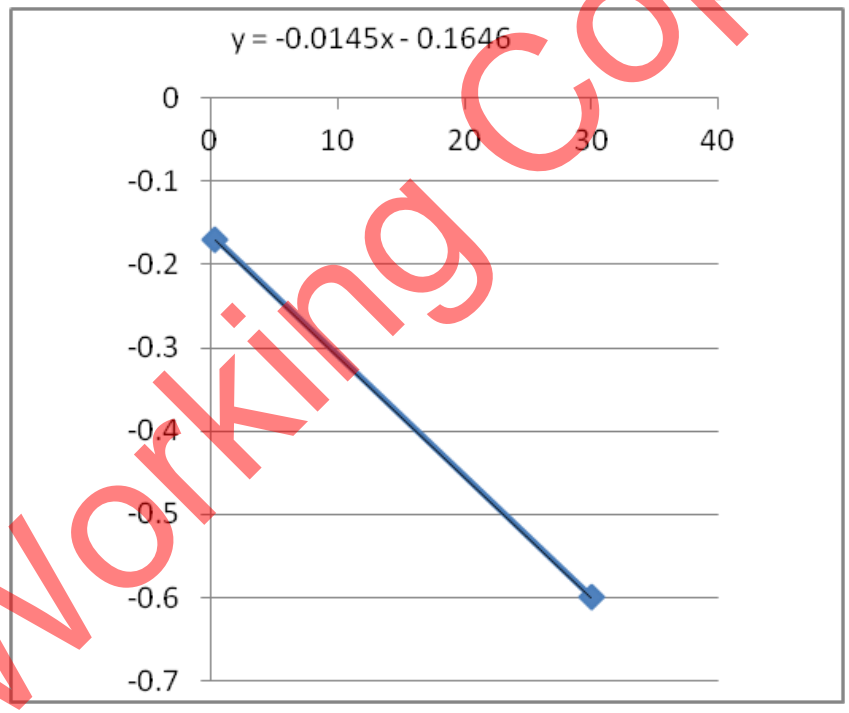
Attachment 1 (cont.)

		difference		CF	
T1/CF 1	**0.37**	**-0.17**	0.37	-0.293807	0.076193
T2/CF2	**30**	**-0.6**	30	-0.3264	29.6736



Attachment 2
Example Thermometer Log

Date in Service	ID	Manufacturer	Serial #	Cal Due	Cal Type	Use	other
3/5/2014	Duck	Fisher/MadgeTech	N70647	3/4/2013	TIAER	Data Logger	w/thermocouples
3/5/2014	Goose	Omega	TJ36-ICSS-316U-12-SMPW-M	3/4/2013	TIAER	thermocouple	w/datalog Duck
3/5/2014	Hen	Omega	TJ36-ICSS-316U-12-SMPW-M	3/4/2012	TIAER	thermocouple	w/datalog Duck
10/25/2013	T-109	not listed	not listed	10/25/2012	TIAER	general	n/a
2/22/2013	T-113	Ertco	1598	10/31/2012	TIAER	refrig/freezer	n/a
2/22/2013	T-114	Ertco	1435	10/31/2012	TIAER	refrig/freezer	n/a
11/15/2013	T-115	Ertco	3484	11/15/2012	TIAER	NIST Cal Checks	n/a
11/30/2013	T-116	Millipore	J93-523	11/30/2012	TIAER	incubator	n/a
2/28/2014	T-117	Control Company	111905985	2/12/2012	factory	refrig/freezer	n/a
2/28/2014	T-118	Control Company	111432079	2/12/2012	factory	refrig/freezer	n/a
3/1/2014	T-119	Control Company	111906007	2/12/2012	factory	refrig/freezer	n/a
3/1/2014	T-120	Control Company	111906002	2/12/2012	factory	refrig/freezer	n/a
3/1/2014	T-121	Control Company	111335210	2/12/2012	factory	refrig/freezer	n/a
3/1/2014	T-122	Control Company	111438220	2/12/2012	factory	refrig/freezer	n/a
3/1/2014	T-123	Control Company	111906006	2/12/2012	factory	refrig/freezer	n/a