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STATEWIDE STANDARD OPERATING PROCEDURE FOR THERMO FISHER SCIENTIFIC ™ MODEL 146iQ MULTI GAS CALIBRATOR

STATE OF FLORIDA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
OFFICE OF AIR MONITORING

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1.0 PURPOSE

These procedures are intended to provide operational information for the Thermo Environmental Instruments (THERMO SCIENTIFIC™) 146iQ Multi Gas Calibrator. The instructions are based on requirements in the manufacturer's instructions, EPA Quality Assurance Handbook and the state and local quality assurance plans. They are intended for use by any operator utilizing the calibrator.

2.0 SCOPE AND APPLICABILITY

The procedures outlined in this document outline the operational use and routine maintenance for the THERMO SCIENTIFIC™ 146iQ Multi Gas Calibrator. The unit is used for calibrations and routine verification of gaseous ambient air monitoring instruments including but not limited to those manufactured by Thermo Environmental Instruments, API or Teledyne for the measurement and reporting of Nitrogen Dioxide (NO2), Sulfur Dioxide (SO2) and Carbon Dioxide (CO). This document is to be used in conjunction with the manufacturer's instruction manual, which will be frequently referenced in this SOP. The operator should read and become thoroughly familiar with this SOP and the THERMO SCIENTIFIC™ 146iQ Instruction Manual before starting any operations with the calibration system.
The operator should also read and become familiar with a Zero Air System such as THERMO SCIENTIFIC™ Model 111 Zero Air System, or those made by other vendors such as Teledyne, Environics, etc. The Zero Air System is used to supply zero air to the calibrator.

Before beginning any operation described in this document, ensure that any related manuals and SOPs are also at hand.

3.0 SUMMARY OF THE METHOD

The THERMO SCIENTIFIC™ 146iQ Multi Gas Calibrator is microprocessor-driven calibrator that combines up to four calibration systems into one package: an accurate mass-controlled gas dilution system, an ozone generator, and a gas-phase titration system. The instrument can be controlled via the front panel interface or remotely using a data logger or computer.

The gas dilution system will mix the contents of a cylinder gas of known concentration with zero air. The mixing ratio is accurately measured and controlled with three precision mass flow controllers (MFC). The zero air controller range is 10 standard liters per minute (slm) full scale and the gas flow controllers range is 100 standard cubic centimeters per minute (sccm) full scale. There are two Gas MFC's included in the new 146iQ gas calibrator. The largest is a 100 sccm MFC, and the smaller is a 20 sccm MFC. The combination of these two MFC's offers the user a more reliable and accurate amount of flow at lower levels, which is necessary when calibrating trace level analyzers.

Ozone is generated by a photolytic ozone generator by exposing air to light at 185 nanometers in the zero air pathway and measured by an on-board photometer bench. The gas phase titration system (for NO2 calibrations) mixes the ozone with a known concentration of Nitric Oxide (NO) to provide a concentration of NO2. This NO2 concentration will be equal to the decrease in the concentration of NO as determined by a calibrated chemiluminescence or photolytic NO analyzer. NO gas is delivered from a gas cylinder via the gas dilution system.

4.0 DEFINITIONS AND CONVERSION FACTORS

Technical terms in this SOP are defined as they are introduced so that their meaning is made clear in context. A glossary is available in Appendix B for additional reference. This section explains some general terminology.

Calibration — Refers to the act of adjusting an instrument after comparison with a standard. When referring to the instrument software, the term "calibration" is used to indicate a procedure that would alter instrument output.

NIST — National Institute of Standards and Technology, a measurement standards laboratory

QA — Quality Assurance, an integrated system of management activities involving planning, implementation, assessment, reporting, and quality improvement to ensure that a process, item, or service is of the type and quality needed and expected by the end-user.

QC — Quality Control, the overall system of technical activities that measures the attributes and performance of a process, item, or service against defined standards to verify that they meet the specifications established by the customer; operational techniques and activities that are used to fulfill the need for quality.

SOP — Standard Operating Procedure, a document that details the method for an operation, analysis, or action with thoroughly prescribed techniques and steps to be followed. It is officially approved as the method for performing certain routine or repetitive tasks.

Table 4-1Conversion Factors

To Change	To	Multiply by
parts per million (ppm)	parts per billion (ppb)	1000
standard liters per minute (slm)	standard cubic meters per minute (sccm)	1000

Equation 4-1 Calibrator Output Concentration Calculation

$$\text{Output Concentration} = \frac{F_g}{(F_g + F_z)} \times C_g$$

Where: Output concentration = Calibrator output gas concentration in ppm.
Fg = NIST standard verified gas flow in sccm
Fz = NIST standard verified dilution (zero) air flow in sccm
Cg = Gas cylinder concentration in ppm.

5.0 HEALTH AND SAFETY PRECAUTIONS

Any pressurized gases such as Carbon Monoxide, Nitrogen Dioxide or Sulfur Dioxide should be carefully vented outside of the ambient air monitoring shelter or building to safely eliminate the chance of inhalation of these gases. Improper venting of the exhaust gases may result in displacement of oxygen from the air in the ambient air monitoring shelter or building and could lead to asphyxiation or death.

CAUTION: When lifting the calibrator, use a procedure appropriate to lifting a heavy object, such as bending at the knees while keeping your back straight and upright. Do not attempt to lift the calibrator by the cover or other external fittings.

6.0 INTERFERENCES

It should be noted that the unit is sensitive to humidity or other sources of contamination from the zero air supply. Careful attention to the quality of the zero supply is imperative to preserve the integrity of the flow controllers in this calibrator. If using the 146iQ calibrator in conjunction with a zero air generator, ensure that the generator has maintained its routine preventative maintenance program. Clean, particulate free air is very important to maintaining the longevity of mass flow controllers.

7.0 PERSONNEL QUALIFICATIONS

A basic understanding of the principles governing ambient air sampling is necessary. All field operations personnel should be familiar with environmental field measurement techniques. Those who service the calibrator in the field must be very conscientious and attentive to detail to report complete and high-quality environmental data. Installation, operation, maintenance, repair and calibration of the instrument and all support equipment should only be performed by properly trained personnel. The training will be provided by in-house personnel, state or federal agencies when available. The training documentation will be maintained by the state or local agency where the personnel operate. Persons qualified to perform calibrations and routine verification of gaseous ambient air monitoring instruments should be able to:

a) Operate the 146iQ Multi Gas Calibrator;

b) Safely handle and use the EPA Protocol Calibration Gases;

c) Calibrate, audit, and troubleshoot the 146iQ Multi Gas Calibrator; and

d) Operate the associated gaseous analyzers and dilution (zero air) system.

Operators are also required to read the manufacturer's instruction manuals supplied with the calibrator and supporting equipment to become familiar with the various controls and components prior to attempting any operation described in this procedure. The manufacturer's manuals contain useful operation, maintenance, and diagnostic information that may not be contained in this SOP.

8.0 EQUIPMENT AND SUPPLIES

A. The THERMO SCIENTIFIC™ 146iQ Multi Gas Calibrator

B. The THERMO SCIENTIFIC™ 111 Zero Air System, or other manufacturer's Zero Air System

C. EPA Protocol Calibration Gases

D. Data Logging System (For Example, ESC-8832 or ESC-8872 with Air Vision / AV Trend software); Thermo Environmental ePort Software (optional)

E. Teflon® tubing: FEP Teflon tubing (1/8th and 1/4th inch), Teflon Swagelok unions and tees.

F. 9/16th wrench and stainless steel caps

9.0 INSTALLATION, STARTUP AND REMOVAL INSTRUCTIONS

9.1 Installation

Installation of the THERMO SCIENTIFIC™ 146iQ consists of placing the calibrator on the instrument bench in close proximity to the analyzer(s) it is to be used with, connecting the zero air and gas inputs, connecting the output to the feed line that corresponds to the analyzer to be calibrated, and connecting the Ethernet cable to the data system.

WARNING The Model 146iQ is supplied with a three-wire grounding cord. Under no circumstances should this grounding system be altered.

A. Position the 146iQ unit on a level and sturdy surface, allowing easy access to both the front and rear panels.

B. Using FEP Teflon, with an outer diameter (OD) of ¼-inch and a minimum inner diameter (ID) of ⅛-inch, connect from the ZERO AIR IN port to the output of the Zero Air System unit. The zero air flow controller is capable of receiving zero air between 10 to 40 psi. The input pressure should be approximately 30 psi.

C. Connect another length of ¼-inch OD FEP Teflon line from the DUMP of the calibrator and ensure the end of the line is connected to an atmospheric dump (released outside). Repeat this procedure for the EXHAUST port. The line from the calibrator output to the sample filter and the line from the sample filter to the analyzer should be approximately the same length.

D. Connect an Ethernet cable from the 146iQ to the data logger in the same manner as the analyzers.

E. Leave the port marked as EXTERNAL SAMPLE capped. The only plumbing necessary is the zero air, the output and each of the standard gases (ports A, B, and/or C).

F. Connect an AC power cord to the nearest outlet and turn the unit on. Once the calibrator is turned on, the Power-Up and Getting Ready screens will be displayed as it is warming up. When the calibrator has warmed up, the Home screen will be displayed. Allow it to equilibrate to the temperature in the ambient air monitoring shelter for 2 to 24 hours before proceeding.
Never restrict the flow from the output of the 146iQ.

9.2 Start-Up

The Front Panel is controlled by way of touchscreen interface, which contains the following information.

A. Title Bar:

a. *Home button:* When pressed, it brings you to the Home Screen that displays Time, Date, Total Flow, and Ozone concentration.

b. *Title Text:* Displays instrument name when in the Home Screen. Displays the total flow being output when in all other screens.

c. *Operation button:* Displays operation mode ("Operation" or "Manual Operation"). Displays "Program" when a program is active.

d. *Help button:* When pressed, it brings you to the help screens.

B. User Interface:

a. *Calibration button:* Allows the user to calibrate various components of the instrument, and view calibration data.

b. *Data button:* Allows the user to view, graph, stream, and analyze data.

c. *Settings button:* Shows real-time status and alarms, also predictive diagnostics and maintenance history. Contains controls for operating the instrument, communications, and sets instrument options.

d. *Total Flow*: Displays total flow in sccm, as measured by the zero and gas flow controllers.

e. *GasX*: Displays diluted concentration of gas (from selected solenoid), diluted O_3 (from ozonator), or diluted NO_2 (from GPT), in ppm.

f. *Phot O3*: Displays concentration of ozone measured by photometer.

C. Status Bar:

a. *Back button:* When pressed, it displays the previous screen.

b. *Access Levels button:* Allows the user to set security access levels, and allows/restricts access to functionality depending on the selected access level.

c. *Health Check button:* Brings the user to the Health Check screen.

The Thermo 146iQ is based on menu-driven software. In this procedure, the operator turns on the Thermo 146iQ and observes the condition of various calibrator performance indicators to determine its operational status.

1. To set the time from the Home screen click Settings, More, Instrument Settings, Clock. Disable the Time Server, then the ability to manually change the time will be blue and not greyed out. Click on Time and manually change the time. Hit the Home button in the top left screen and return to the Home Screen.

D. Communications:

For datalogger communications start from the Home Screen, navigate to Communication Settings by pressing Settings, More, Communications.

NOTE: Consult the ambient monitoring supervisor for a reference of applicable codes and communications settings.

a. Navigate to *INSTRUMENT ID* and using the [↑ ↓] buttons click [ENTER].

Change the digits to a two digit number that must match the Modbus driver being used by the data logger that corresponds with the data logger. For example, in AirVision/AV Trend, this would be called the Device ID code. Click [ENTER] to save the changes. Click the [MENU] button to return to the *COMMUNICATION SETTINGS* screen.

b. Navigate to the *COMMUNICATION PROTOCOL* and click [ENTER]. Using the [↑ ↓] buttons, change the setting to *MODBUS* if it is not already set. Click [ENTER] to save changes. Click the [MENU] button to return to the *COMMUNICATION SETTINGS* screen.
c. Navigate to *TCP/IP SETTINGS* and click [ENTER]. Navigate to *USE DHCP* and ensure that it is *OFF*. If it is *ON*, Click [ENTER] to toggle it *OFF*, which will require the power to be cycled (restarting the calibrator). If restarting, navigate back to *TCIP/IP SETTING* using the above instructions. Navigate to the *IP ADDR* and click [ENTER]. Using the [← →] buttons and [↑ ↓] buttons, set the IP address for the calibrator to match the Modbus driver that is used by the data logger that corresponds to the calibrator. Click the [ENTER] button to save changes. Click [MENU] button to return to the *TCP/IP SETTINGS* menu.
d. Navigate to the *NETMASK* and click [ENTER]. Using the [← →] buttons and [↑ ↓] buttons, set the netmask address specific to the agency's Network or Information Technology department requirement. Click [ENTER] to save changes. Click [MENU] button to return to the TCP/IP SETTINGS menu.
e. Navigate to the *GATEWAY* and click [ENTER]. Using the [← →] buttons and [↑ ↓] buttons set the gateway address specific to the agency's Network or Information Technology department requirement. Click [ENTER] to save changes. Click the [MENU] button twice to return to the *INSTRUMENT CONTROLS* screen.
f. Navigate to *SCREEN CONTRAST* and click [ENTER]. Use the [↑ ↓] buttons to increase or decrease the contrast percentage as desired and click [ENTER] to save changes. Click the [MENU] button twice to return to the main menu.

D. Program Controls (optional)

The Program Controls Menu (accessed by selecting Programmed Events from the Settings Menu allows the operator to program the THERMO SCIENTIFIC™ 146iQ to perform calibration events at preset times and durations. However, if calibrations or periodic checks are initiated and controlled using an external data logger, this feature will not be used. If this feature is used, be sure to *DISABLE* the program after each use or set the *PROGRAM CYCLE PERIOD* for whatever interval applies to the local program. See the manufacture's instruction manual, starting on page 3-36, for information on configuring Program events.

E. Alarm Controls

The Alarm Menu (accessed by selecting Health Check button from the Home Screen) displays the current status of all parameters and allows the operator to set specific upper and lower limits on allowable parameters. Unless otherwise specified for a particular

calibrator, the **alarm limits should be left at the default values**. If there is a problem contact the QA coordinator.

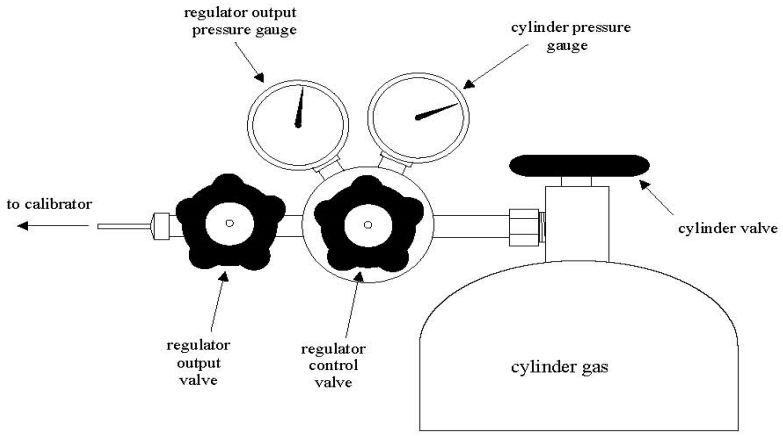
9.2.1 Cylinder Gas Connection

Before connecting cylinder gas to the calibrator, ensure dilution (zero) and gas flow controllers have been calibrated and output flows have been verified (see section 10.0). Once flow verification is complete and readings are within acceptable limits, proceed with the gas connection procedure below.

Ports that are not being used should remain plugged/capped. Use port A if using only one gas at one time. Teflon tubing should be used for gas connections and the length should be kept as short as reasonably possible. Any time the regulator is removed from the cylinder, such as at original installation or whenever the cylinder is replaced, the regulator must be purged to remove possible contaminants from the system. This is especially critical with NO since small amounts of contaminants can cause scrubbing or conversion of NO to some other compound. Migration of such contaminants back to the cylinder can change the concentration balance of the gas. The next section describes the steps to purge a regulator.

A. Purging the Cylinder Regulator

Figure 9-1 Cylinder Gas/Regulator Connection



IMPORTANT SAFETY CONCERN: Be sure to vent gas outside while purging the regulator.

To purge the cylinder regulator, a small vacuum pump and line of FEP Teflon tubing will be needed.

1. Close outer valve (regulator output valve) of the gas cylinder.
2. Open the cylinder valve to get pressure in between the cylinder valve and regulator output valve.
3. Close the cylinder valve. Hook up the gas line to the vacuum/suction side of the pump.
4. Attach a line (FEP Teflon) from output side of pump to the exhaust releasing outside into the atmosphere.
5. Plug in/turn on the pump. Now, a vacuum is being pulled on the system.
6. Slowly open the regulator output valve to pull a vacuum until a negative value is displayed on the regulator output gauge. Once a vacuum is reached, close the regulator output valve.
7. Turn off pump.
8. Open cylinder valve until a positive pressure is read on the regulator output gauge.
9. Repeat step 1-8 three times.
10. Once cylinder regulator is purged and steps 1-8 are complete, close the regulator output valve, then close the cylinder valve.

B. Assigning Gases to Calibrator Ports

To assign gas names to the ports, press Settings, and Cylinder Setup. Click on Gas Name of Gas Solenoid 1. From there, create a custom name, or choose from a list of names. Repeat this process for up to six input gases.

Connect each applicable gas to the assigned ports on the rear of the calibrator. Connect the desired gases to the relevant ports, for example using the configuration: Gas A – Sulfur Dioxide, Gas B – Nitrogen Oxide, and Gas C – Carbon Monoxide. Use a piece of 1/4" FEP Teflon tubing long enough to reach each cylinder. If the ambient air monitoring site does not sample for one of these gases, leave the respective port capped.

9.3 Removal

D. To shutdown (turn off) the calibrator, ensure that unit is not operating any manual flows or programmed events. From Home screen, click Settings, Operation and make sure Gas and Photometer say Off.

E. Ensure that the cylinders are turned off and disconnected from the calibrator, then switch the power switch to off.

F. Disconnect the zero air supply, the data cable, and power cord and ensure that all ports are capped. Store in a climate controlled location if possible.

10.0 CALIBRATION

10.1 Temperature Verification

A. The photometer bench temperature sensor needs to be verified against a NIST traceable temperature standard annually. The sensor cannot be calibrated in the software of the 146iQ. Therefore, a temperature verification will be performed.
Note: Temperature and Pressure are important components of the ozone concentration equation per 40 CFR, Part 50 Appendix D, Section 4.1.
B. Power down the unit, unplug the temp sensor from the circuit board, then unscrew the temp sensor from the top of the photometer bench. This will safely unwind the sensor's cable without possibly twisting and breaking it. Use a wrench to unscrew the fitting touching the top of the photometer bench.
C. Plug the temp sensor back into the board and power up the unit. Place a temperature standard and the sensor next to each other and allow them to equilibrate. If the sensor is more than 2º Celsius different from the standard, repair or replace the sensor. Contact Thermo for troubleshooting or purchase.

10.2 Pressure Calibration

A. The 146iQ uses a number of pressure sensors to measure upstream and downstream pressure differentials to calculate internal flows. Unlike the temperature, there is a software calibration that can be performed for the various pressure sensors. To access the table, press Calibration, Pressure Calibration. The next steps are for the individual pressure sensors to be calibrated. Locations of sensors 1-3 are as follows*:* Under the column labeled Reading, current reading of each pressure sensor. Sensor 1 is connected to the pump (vacuum) side of the photometer capillary, and in the 146iQ is the sensor on the bottom of the board. Sensor 2 is a differential pressure sensor that is connected to the 2 sides of the ozonator capillary. Sensor 3 is connected to the bench (pressure) side of the photometer capillary, and in the 146iQ is the sensor on the top of the board. The Sensor readings are only valid if their corresponding options are installed and can otherwise be ignored.
B. Atmospheric Sensor 1-3: User should expose the sensor to atmospheric pressure by disconnecting the tube attached to the sensor. Under the column labeled Reading, the user enters the current atmospheric pressure in mm Hg units. Under the column labeled Calibration, the user presses the Start button to calibrate the high point of Sensor 1 at atmospheric pressure.
C. *High Point Sensor 2:* In order to calibrate the high point of the differential pressure sensor, adjust the pressure of the pressure gauge in line with the capillary to 3 psi (~155 mm Hg). Under the column labeled Reading, the user enters the measured pressure in mm Hg units. Under the column labeled Calibration, the user presses the Start button to calibrate the high point of Sensor 2. Dial down the regulator to 3 psi. Whatever barometer ambient psi. is, add 3 to it., plug in to output of regulator. Ambient is ambient+3= ~17.75 psi. Then plug hose back into the regulator and calibrate

Atmospheric Sensor 2 at 155. Then dial the regulator back to 10 psi. For this to be an official NIST traceable pressure calibration, use a certified ported barometer that reads in psi.

D. *Low Point Sensor 2*: In order to calibrate the low point of the differential pressure sensor, disconnect the two tubes to the differential pressure sensor so that both sides of the sensor are exposed to atmospheric pressure. In this condition, the measured differential pressure should be 0 mm Hg. Under the column labeled Reading, the user enters this pressure in mm Hg units. Under the column labeled Calibration, the user presses the Start button to calibrate the low point of Sensor 2 at atmospheric pressure.

E. *Atmospheric Sensor 3*: User should expose the sensor to atmospheric pressure by disconnecting the tube attached to the sensor. Under the column labeled Reading, the user enters the current atmospheric pressure in mm Hg units. Under the column labeled Calibration, the user presses the Start button to calibrate the high point of Sensor 3 at atmospheric pressure.

10.3 Flow Controller Calibrations

Unadjusted flow verifications are to be performed before calibrating the MFC's, and/or if calibrator output is suspect. It is "best practice" to perform an unadjusted flow verification before performing any maintenance or calibration of the 146iQ to document the condition it was received.

This step must be performed before initial use and must be re-calibrated at least on an annual basis using NIST traceable flow standards for each flow controller. Have a fully charged NIST traceable flow meter for each mass flow controller ready before beginning. Be sure that the NIST standard covers the range needed for the particular flow controllers being calibrated.

10.3.1 Zero Air Calibration

Note: An unadjusted flow verification should precede a flow calibration documenting the condition of the 146iQ. Choose flow test points at 0%, 5%, 7%, 10%, 13%, 17%, 20%, 35%, 50%, 65%, 80%, 95%, and 100% of the dilution flow range, and overall gas flow range of the 146iQ. These are more test points than the software calibration table. Thus, conduct the unadjusted and adjusted flow comparisons in normal operation mode. The following steps are performed through the Calibration Menu.

A. Navigate to the Zero MFC Calibration screen from the main menu by pressing Calibration, MFC Calibration. This will display the table of the unit's MFC's. *Note: Confirm the Cal Temp. is 25^{o} C, and Cal Press. is 760 mmHg. This reflects Florida's standard temperature and pressure.*
B. Ensure zero air supply is turned on and supplying the calibrator with air through the Zero Air In port at approximately 30 psi.
C. Attach a NIST certified flow standard to the output port of the calibrator using a ¼ inch line of FEP Teflon. On the calibrator's MFC Table click on Zero MFC Points, Continue to Zero MFC Calibration, which brings up the flow table.
D. Click on Point #1's "entered Measured (sccm) cell. This opens the solenoid to begin flow control. Allow for flow to stabilize, then initiate the flow meter to read ten stable volumetric flow readings. Click Enter Measured Flow and input the average flow reading and click enter. Press the Back button to return to the dilution controller's cal table.
E. Repeat this process for the other 6 software calibration points at 20%, 35%, 50%, 65%, and 80%. As in the above step, record the average of 11 stable volumetric readings, and input the average volumetric rate from the NIST traceable flow standard for each % level and input this value into the "Enter Measured Flow".
F. When completed, turn off zero air supply and ensure that no air is being supplied to the calibrator. If continuing to perform flow controller verifications, proceed to section 10.4.

10.3.2 Gas Flow Calibration

A. Note: The calibration steps below illustrate procedures using Gas Port A on the rear of the calibrator. However, the same procedures may be followed for the calibration of ports B and C. Since the gas ports are looped together, it doesn't matter which gas inlet port is chosen when performing the gas MFC calibrations. The 146iQ has a software calibration table that can accept anywhere from 2-7 flow points. The more set points used in the table the more accurate and linear the MFC will be. It is highly recommended that the operator use all 7 flow points of the software calibration table. Each point is a correction factor used in calculating and controlling flows. These correction factors are recorded for each corresponding flow point in the form DEP 13-7-C under the Correction Factors column. The form has 13 flow points to test. Therefore, if a flow point does not have a corresponding correction factor, place N/A in that cell in the Correction Factors column.

A. Turn off the zero air supply and ensure that no air is being supplied to the calibrator before disconnecting the Zero Air In port from the back of the instrument. Using a wrench, disconnect the Zero Air Supply from the Zero Air In port input on the back of the unit and connect to the port that is marked as GAS A. Plug/Cap the Zero Air In port to ensure no leak.

B. Navigate to the Gas 1 MFC Calibration screen from the main menu by pressing Calibration, MFC Calibration. This will display the table of the unit's MFC's. *Note: Confirm the Cal Temp. is 25º C, and Cal Press. is 760 mmHg. This reflects Florida's standard temperature and pressure.*

C. Ensure zero air supply is turned on and supplying the calibrator with air through the Zero Air In port at approximately 30 psi.

D. Attach a NIST certified flow standard to the output port of the calibrator using a ¼ inch line of FEP Teflon. On the calibrator's MFC Table click on Zero MFC Points, Continue to Zero MFC Calibration, which brings up the flow table.

E. Click on Point #1's "entered Measured (sccm) cell. This opens the solenoid to begin flow control. Allow for flow to stabilize, then initiate the flow meter to read 11 stable volumetric flow readings. Click Enter Measured Flow and input the average flow reading and click enter. Press the Back button to return to the gas controller's cal table.

F. Repeat this process for the other 6 software calibration points at 20%, 35%, 50%, 65%, and 80%. As in the above step, record the average of 11 stable volumetric readings, and input the average volumetric rate from the NIST traceable flow standard for each % level and input this value into the "Enter Measured Flow"

G. When completed, turn off zero air supply and ensure that no air is being supplied to the calibrator. If continuing on to perform flow controller verifications, proceed to the next section.

H. Notify the QA personnel if any values are over 2% difference from the NIST traceable standard. % Difference = (NIST standard flow value in sccm - calibrator set flow value in sccm) / NIST standard flow value in sccm.

I. Follow the above steps for GAS 2 MFC if a second MFC is installed.

10.4 Zero Air and Gas Flow Verifications (Unadjusted Calibrations)

Unadjusted flow verifications are to be performed before calibrating the MFC's, and/or if calibrator output is suspect. It is "best practice" to perform an unadjusted flow verification before performing any maintenance or calibration of the 146iQ to document the condition it was received.

10.4.1 Determining Flow Settings

Flows should be verified at settings across the full range of the 146iQ as a whole. If the agency purchased the optional gas MFC, then this means the combined flow of possibly 2 gas MFC's. (i.e. – A 100cc + 20 cc = 120 cc's. Therefore, in the As Found and Final Flow Verifications, choose points between 0 cc and 120 cc's.) The individual flow points to be tested are as follows: 0%, 5%, 7%, 10%, 13%, 17%, 20%, 35%, 50%, 65%, 80%, 95%, and 100% of possible flow.

10.4.2 Zero Air Flow Verification

A. Ensure the zero air supply is turned on and supplying the calibrator with air through the Zero Air In port at approximately 30 psi.

B. Attach a NIST certified flow standard to the To Analyzer port and cap the Dump port of the 146iQ Calibrator.

C. From the main menu press Settings, More, Manual Operation Disabled, Manual Operation Disabled. This will turn yellow and put the 146iQ into manual mode. From here press Manual Operation Settings. This will bring up the flow settings table. The Gas Setting is defaulted to Off. Press that cell and then press Solenoid 1. The solenoid will click open. Press the back arrow and then press the Zero Flow Set Value cell. Choose zero flow, and measure with the flow meter and record this on the flow form DEP 13-7-C. After that input the next flow measurement (i.e. 5%) and press Enter. Wait for flow to stabilize. Record the flow setting and 11 stable mass flow readings from the flow standard, and the mass flow reading of the calibrator on form DEP 13-7-C, under the Dilution MFC Worksheet section. The average of the 10 stable mass flow readings will be calculated by the spreadsheet and recorded in the Unadjusted Flow Verification section of form DEP 13-7-C.

D. Repeat Step C above for each of the 13 levels of zero air flow to be verified.

E. Notify the QA personnel if any values are over 2% difference from the NIST traceable standard. % Difference = (NIST standard flow value in sccm - calibrator set flow value in sccm) / NIST standard flow value in sccm.

F. When completed, turn off zero air supply and ensure that no air is being supplied to the calibrator, and put the unit back into Operation mode.

10.4.3 Gas Flow Verification - GAS PORT A.

A. Ensure that zero air supply is off and that no air is being supplied to the calibrator before disconnecting the Zero Air In Port from the back of the calibrator. Using a wrench, disconnect the Zero Air Supply from the Zero Air In Port input on the back of the calibrator and connect to GAS A. Plug/Cap the Zero Air In port to ensure no leak.

B. Turn on zero air supply and ensure that it is now supplying approximately 30 psi of clean zero air to the calibrator's gas inlet port A. All the gas inlet ports are looped together, so it doesn't matter which port you choose.

C. Attach a NIST certified flow standard to the To Analyzer port and cap the Dump port of the 146iQ Calibrator.

D. From the main menu press Settings, More, Manual Operation Disabled, Manual Operation Disabled. This will turn yellow and put the 146iQ into manual mode. From here press Manual Operation Settings. This will bring up the flow settings table. The Gas Setting is defaulted to Off. Press that cell and then press Solenoid 1. The solenoid will click open. Press the back arrow and then press the Gas Flow Set Value cell. Choose zero flow, and measure with the flow meter and record this on the flow form DEP 13-7-C. After that input the next flow measurement (i.e. 5%) and press Enter. Wait for flow to stabilize. Record the flow setting and 11 stable mass flow readings from the flow standard, and the mass flow reading of the calibrator on form DEP 13-7-C, under the Dilution MFC Worksheet section. The average of the 10 stable mass flow readings will be calculated by the spreadsheet and recorded in the Unadjusted Flow Verification section of form DEP 13-7-C.

E. Repeat Step D above for each of the five desired/calculated level of zero air to be verified.

F. Notify the QA personnel if any values are over 2% difference from the NIST traceable standard. % Difference = (NIST standard flow value in sccm - calibrator set flow value in sccm) / NIST standard flow value in sccm.

G. When completed, turn off zero air supply and ensure that no air is being supplied to the calibrator, and put the unit back into Operation mode.

11.0 CALIBRATOR MAINTENANCE

The following maintenance and certification procedures must be completed at specified intervals and documented on the Preventive Maintenance Schedule, Form DEP 13-7-B. Table 12-1 summarizes maintenance activities and frequencies.

Any other corrective maintenance performed on the THERMO SCIENTIFIC™ 146iQ must be documented on the calibrator's Historical Maintenance Log (Form DEP 13-7-A). See the THERMO SCIENTIFIC™ 146iQ Instruction Manual for other service checks and corrective maintenance procedures.

11.1 Clean or Change Capillaries

Change or clean the capillaries at least on an annual basis, or as needed. Be sure to verify the flow both before and after changing the capillaries. Refer to Section 10.0 for Flow Verifications. To access the capillaries, follow the detailed instructions of the 146iQ manual in Section 7-23. Take a thin wire and remove any debris inside the capillaries or replace them annually.

11.2 Calibrator Interior, Cooling Fan and Screen

On an annual basis, the fan screen material should be cleaned or replaced to reduce the chance of dust or dirt getting into the calibrator.

A. Turn the calibrator off and disconnect the power cord.
B. Remove the calibrator cover and remove the fan and wire screen.
C. Clean the fan by wiping with a Kimwipe or brush.
D. Clean the screen by brushing off or replace if necessary.
E. Reinstall the fan and screen, replace the calibrator cover, and connect the power cord. Refer to page 5-1 of the manual if needed.

11.3 Leak Check

Note: The leak check procedure in the 146iQ manual is not the procedure described in the State of Florida SOP. The following procedure has been created by trained OAM personnel to accurately and reliably test the pneumatic system for leaks. Contact Standards Lab personnel for questions.

A. With the unit off, unplug all hoses going to the unit, and cap all the ports except the Exhaust port.
B. Attach a vacuum gauge that reads in inches of Mercury (inHg) to the to the Exhaust port.
C. Remove the 146iQ cover and find the "Y" connection with a short vent hose. It is attached to the photometer bench solenoid. Plug the vent hose securely. (See Figure 11-1)
D. Draw a vacuum of 10 inHg and hold the vacuum for 5 minutes. If the reading drops by more

than 0.5 inHg a leak is present in the system. Troubleshoot the leak and fix it.

Figure 11-1 Leak Check

12.0 QUALITY ASSURANCE AND QUALITY CONTROL

12.1 Quality Control Tasks for the THERMO SCIENTIFIC™ 146iQ Multi Gas Calibrator

A. The THERMO SCIENTIFIC™ 146iQ gas calibrator is limited by its flow controllers. Both zero air supply and gas flow controllers must be verified annually by performing the calibration procedure in the service menu (Section 10.3) as well as performing a flow verification of each flow controller at user specified flow rates evenly spaced across the flow range.

B. Each portion of the flow controller calibration and verification procedures must be performed with a NIST certified flow meter.

C. The photometer bench temperature must be verified on an annual basis using a NIST certified thermometer capable of recording to 0.01 degrees Celsius (see Section 10.1)

D. The capillaries must be changed or cleaned on an annual basis or more frequently if a clog or blockage occurs (See Section 11.1).

E. The calibrator should be maintained in a clean and temperature-controlled environment and the cooling fan and dust screen be cleaned on at least an annual basis (See Section 11.2).

Table 12-1 Frequency of QA/QC and Preventive Maintenance Tasks

Task	Frequency (at minimum)	SOP Section
Unit Status Check: Check for Alarms and contact QA coordinator if found.	Each Use	9.2E
Verify Calibrator time against site time reference. Report to QA Coordinator if not within ± 1 minute.	Each Use	9.2
Verify calibrator ambient temperature sensor to 1°C	Annually	10.1
Calibrate and Verify Zero-Air Flow Controller. Report to QA Coordinator if not within 2%.	Annually	10.3
Calibrate and Verify Gas Flow Controller. Report to QA Coordinator if not within 2%.	Annually	10.3
Maintenance: Clean calibrator interior, cooling fan, and screen	Annually	11.2
Maintenance: Change or clean capillaries	Annually	11.1
Calibrate or verify calibrator pressure sensors within 10 mmHg.	Annually	10.2

12.2 Quality Control Procedures for Ambient Monitoring Analyzers using the Calibrator

The calibrator may be used in either Manual or Operation modes for performing quality

checks and calibrations on a variety of ambient monitoring analyzers. The instructions below provide specific guidance for using the calibrator to generate gas concentrations required for the quality checks and calibrations. Refer to the applicable analyzer SOP for general quality check procedures, sampling system connections, and required gas concentrations.

12.2.1 Generating Concentrations using the Calibrator

The 146iQ has four separate procedure below detailing how to manually enter flows to generate calibrator gas outputs. In Manual Mode, you calculate the flows necessary for the desired concentrations. In Operation Mode, you input the concentration and the unit chooses the flows. For details on programming the calibrator to automatically run programmed events, see the manufacturer's instruction manual.

Also, before creating pollutant concentrations, appropriately plumb the output ports for the analyzer(s) to receive sample gases.

A. Manual Mode

1. Ensure the calibrator, if it was off, has warmed up at least one hour prior to use. Turn the zero-air system on and ensure it is supplying a pressure of 30 psi to the calibrator.
2. The 146iQ boots up into Operation Mode. To change to Manual press Settings, More, Manual Operation Disabled, then click Manual Operation Disabled. It will toggle to Manual Operation Enabled. To return to Operation Mode, follow these same steps and disable Manual Operation Mode.
3. To create gas concentrations, press Settings, Manual Operation. This will display the Manual Mode screen. Press the Gas Setting, then choose the Solenoid desired.
4. After calculating the flows necessary for the concentration of sample gas needed, press Set Value for Gas Flow, enter the flow, and then press Set Value for Zero Flow. Enter that value. This will instruct the 146iQ to produce this flow combination. It will then calculate the pollutant concentration in ppm that is flowing from the unit to the analyzer.
5. Repeat step 4 to change sample gas concentrations.
6. When finished turn off gas flow by pressing Gas Setting and choosing Off.

B. Operation Mode

1. In this mode the 146iQ will choose the flows to create the gas concentration desired. This could be a combination of flows from both Gas MFC's. That is why it's important to perform a 146iQ flow verification (Section 10.4) at the combined flow of the 2 gas MFC's if the second one is installed.
2. When performing a QC check or analyzer calibration the Operation Mode allows 6 "Span Points". You can set each Span Point to whatever ppm concentration you desire. To do this select Settings, Gas Setup, and the Gas Solenoid with the pollutant desired.
3. Click Setpoint for Span 1 Concentration. Enter desired concentration in ppm. And press Enter. Then click on Setpoint for Span 1 Total Flow and choose the maximum combined gas and zero air flow for the span event.
4. To initiate the event you just created, at the Home screen press Settings, Operation, Gas Setting, choose Solenoid 1, enter. This opens the gas solenoid with the gas desired. Then click Zero / Span Setting. Choose the event you created (i.e. – Span 1). Press the Back button and the Zero / Span Set Value will be the ppm concentration and flows the 146iQ is controlling to deliver that pollutant concentration.

5. Repeat Steps 2 & 3 to set the other span points to create the desired QC check points for your agency.

C. Gas Phase Titration (GPT)

1. Ensure the calibrator is generating and supplying the analyzer sampling system with zero air, as detailed in the previous section. Attach the line from the output of the gas cylinder regulator to the applicable port (A, B, or C) on the rear of the calibrator. Use a wrench to ensure the connection is secure.
2. Open the gas cylinder valve and ensure there is the regulator output pressure gauge reads approximately 25 psi. Then, open the regulator output valve.
3. If the zero flow setting to generate the gas concentration required is different from the zero air set previously, the ZFLOW setting will have to be adjusted. From the Operation Mode screen on the calibrator, use the [↑ ↓] buttons to move the cursor next to "Gas A ZFlow". Enter the zero air flow determined from the gas concentration calculations and press [ENTER] to generate dilution air.
4. Use the [↑ ↓] buttons to move the cursor next to "Manual GFlow" and input the gas flow settings required. Click [ENTER] to initiate generation of calibrator gas output, in concentrations calculated in section 10.3.1.

D. Photometer Ozone Operations

1. After use, adjust GFLOW settings to zero. On the gas cylinder, close the regulator output valve first, then the gas cylinder valve. Disconnect the line from the regulator output from the rear port calibrator and cap the port.
2. Allow the analyzer to receive zero air until the calibration gas is flushed out through the sampling system. When complete, disconnect the calibrator output line from the sample feed/output manifold and adjust ZFLOW settings to zero.
3. Click [MENU] to access the Main Menu. Navigate to FLOW MODES and click [ENTER]. Navigate to STANDBY MODE and click [ENTER].
4. Disable the zero air system (instrument may be left ON, but disabled, depending on zero air operating procedures).
5. Leave the calibrator turned ON, in Standby Mode, for future routine use.

E. Gas Phase Titration for Generation of NO2 Gas

1. Follow the steps of section 12.2.1A-12.2.1C above using Nitric Oxide gas attached to the gas cylinder inlet port.
2. From the Operation Mode screen, use the [↑ ↓] buttons to move the cursor next to "OZONE MAN" and enter a percentage value (0-100). Change the ozone percentage for each NO2 point desired.
3. After the Gas Phase Titration is complete, set the OZONE MAN to zero, and follow instructions in step 12.2.1D to finish operation of the calibrator.

13.0 DATA ACQUISITION AND RECORDS MANAGEMENT

13.1 Data Acquisition

All preventative maintenance, calibrations or verifications must be recorded on the Preventative Maintenance Schedule (Form DEP 13-7-B), either paper or electronic form. The form is designed to record completed maintenance tasks for multiple days, as long as space permits.

In addition, the Calibrator Historical Maintenance Record (Form DEP 13-7-A) must be used to document placing the calibrator in service, taking the calibrator out of service or any major repairs or changes to the calibrator (i.e., circuit board or flow controller replacement).

If using the paper form, pen should be used to record the site check data, comments, and required signatures. To make corrections, the incorrect information should be struck with a single line, so the original data is still legible. Corrections must be initialed and dated by the person making the correction.

13.2 Records Management

The Preventive Maintenance Schedule (DEP-13-7-B), and Historical Maintenance Log (DEP 13-7-A) should be displayed and made available at each site, either by hardcopy or electronically. Air monitoring operators shall submit completed records to the QA coordinator for verification and storage, and a new log sheet should be made available for future use. The form is determined as complete once the form is filled completely, and/or at the start of each calendar year.

If using any form electronically, ensure the document is not lock-protected until fully completed and verified by QA personnel. Electronic copies of the form, either active or archived, should be accessed and stored in the agency's shared drive to reduce the occurrence and confusion of duplicitous or non-concurrent copies. Consult the ambient supervisor and the Data Handling and Validation SOP for the specific electronic record management guidance.

14.0 REFERENCES

Model 146iQ Instruction Manual: Multi-Gas Calibrator, April 2020, Thermo Fisher Scientific Instruments, Inc. Franklin, MA.

Statewide Standard Operating Procedure for Air Monitoring Data Handling and Data Validation (DEP 18-27), *Revision 1*, December 2019. Florida Department of Environmental Protection, Tallahassee, FL.

15.0 APPENDIX A: FORMS

- Form DEP 13-7-A
- Form DEP 13-7-B
- Form DEP 13-7-C
- Form DEP 13-7-D

15.1 FORM DEP 13-7-A: Historical Maintenance Record

DEP 13-7
REV. NO. 0: December 2020
Effective: 06-2021

Form DEP 13-7-A: HISTORICAL MAINTENANCE RECORD

EQUIPMENT: Thermo Scientific 146iQ Multi-Gas Calibrator

S/N: _____ PROPERTY No.: _____

Date	Maintenance	Signature

Verified By: _____ Date: _____

FORM DEP 13-7-A INSTRUCTIONS

To complete Form DEP 13-7-A, the information to the following listed items will be required:

- Serial No. – Fill in the full serial number assigned to the instrument by the manufacturer.
- Property No. – Fill in the fixed asset tracking number also called the property number. This is the number usually assigned by the state or local agency by their Comptroller if the asset is tracked by the agencies comptroller's office. If not, enter "NA" in this pace.
- Date – Fill in the current date that the maintenance is occurring. Fill out the date in this format: MM/DD/YY.
- Maintenance – Fill in a brief description of any major maintenance. This must not include routine calibrations or verifications but must include physical maintenance such as capillary changes, or any replacement parts.
- Signature – The operator must sign each line item independently.

15.2 FORM DEP 13-7-B: Preventative Maintenance Schedule

DEP 13-7
REV. NO. 0: December 2020
Effective: 06-2021

Form DEP 13-7-B: Preventative Maintenance Schedule

CALIBRATOR: Thermo 146iQ S/N: _____ PROPERTY No.: _____

Maintenance Task	Frequency (At Minimum)	SOP Ref.	Date Due	Date Perf.	Oper. Initial	Date Due	Date Perf.	Oper. Initial	Date Due	Date Perf.	Oper. Initial	Date Due	Date Perf.	Oper. Initial
Verify Zero-Air Flow Controller	Annually	10.4.2												
Verify Gas Controller	Annually	10.4.3												
Clean calibrator interior, cooling fan, and screen	Annually	11.2												
Verify calibrator temperature	Annually	10.1												
Verify/Calibrate Pressure Senso	Annually	10.2												
Leak Check	Annually	11.3												
Clean or change capillaries	Annually	11.1												

Comments:	Signature:

Verified By: _____ Date: _____

FORM DEP 13-7-B INSTRUCTIONS

To complete Form DEP-137x-B, input the following information:

- Serial No. – Fill in the full serial number assigned to the instrument by the manufacturer.
- Property No. – Fill in the fixed asset tracking number also called the property number. This is the number usually assigned by the state or local agency by their Comptroller if the asset is tracked by the agencies comptroller's office. If not, enter "NA" in this pace.
- Due Date – Fill in the due date of the corresponding maintenance item in the following format: 03/15/16.
- Date Perf. – Fill in the date that the corresponding maintenance was performed.
- Oper. Init. – This space is filled in by the operator performing the corresponding maintenance.

15.3 FORM DEP 13-7-C: Flow Controller Verification Form

DEP 13-7
Revision No. 0
Date: December 2021
Effective Date: 06-2021

Thermo Model 146iQ Multi-Gas Calibrator Verification Report

GAS MFC VERIFICATION REPORT DEP 13-7-C

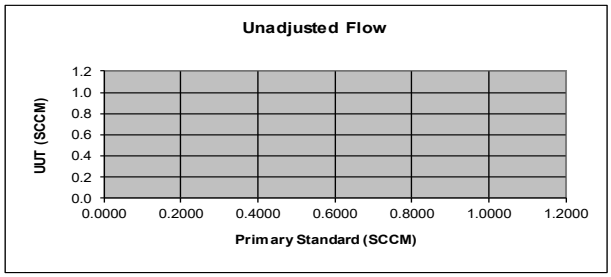
Agency	DUT Model	DUT Manufacturer	MFC Model	MFC Range (sccm)	MFC Serial Number
DUT Serial Number		**Flow Range (sccm)**	**MFC Model**	**MFC Range (sccm)**	**MFC Serial Number**

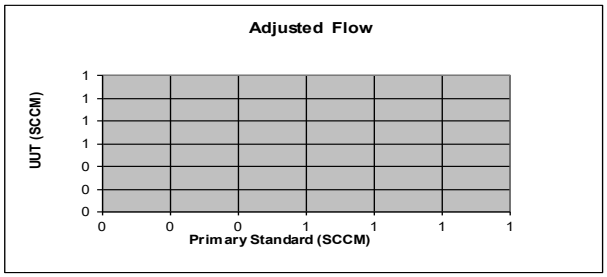
Primary Standards

Model #	Serial Number	Description	Range	Certification Date

Multi-gas Calibrator Gas Flow

	Unadjusted Verification				Adjusted Verification			
Target SCCM	Primary Standard Reading SCCM	GAS A Indicated SCCM	% Deviation	Correction Factors	Primary Standard Reading SCCM	GAS A Indicated SCCM	% Deviation	Correction Factors
0.0			N/A				N/A	





SLOPE	
INTERCEPT	
CORRELATION	

SLOPE	
INTERCEPT	
CORRELATION	

Ambient Temperature: ° C

Barometric Pressure: mmHg

Verification Date:

Due Date:

Comments:

Calibration Gas:

Verified By:

Reviewed By:

DEP 13-7
Revision No. 0
Date: December 2021
Effective Date: 06-2021

Thermo Model 146iQ Multi-Gas Calibrator Verification Report

DILUTION MFC VERIFICATION REPORT
DEP 13-7-C

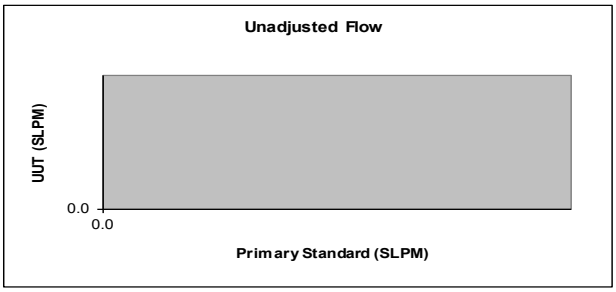
Agency	DUT Model	DUT Manufacturer	Mass Flow Controller Model	MFC Serial Number
DUT Serial Number		**Flow Range (SLPM)**		

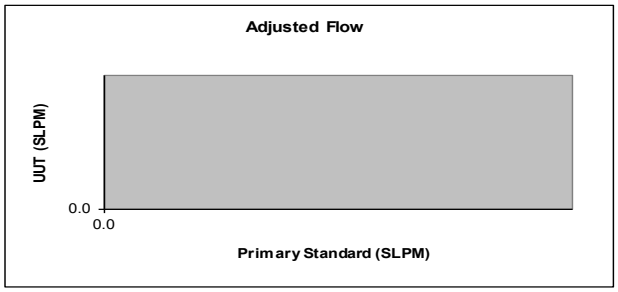
Primary Standards

Model #	Serial Number	Description	Range	Certification Date

Multi-gas Calibrator Zero Air Flow

	Unadjusted Verification				Adjusted Verification			
Target SLPM	Primary Standard Reading SLPM	GAS A Indicated SLPM	%Deviation	Correction Factors	Primary Standard Reading SLPM	GAS A Indicated SLPM	%Deviation	Correction Factors
0.0			N/A				N/A	





SLOPE	
INTERCEPT	
CORRELATION	

SLOPE	
INTERCEPT	
CORRELATION	

Ambient Temperature: ° C

Barometric Pressure: mmHg

Verification Date:

Due Date:

Comments:

Calibration Gas:

Verified By:

Reviewed By:

FORM DEP 13-7-C INSTRUCTIONS

Form DEP 13-7-C is used for both calibrations, which are electronic adjustments of the flow controllers as well as for verifications, which are not adjusted. To complete Form DEP 13-7-C, the information to the following listed items will be required:

- Agency – Input who the calibrator belongs to.
- DUT (Device Under Test) Model – Input the model of the calibrator (i.e. – 146iQ)
- DUT Manufacturer – Input the manufacturer of the calibrator.
- MFC (Mass Flow Controller) Model – Input the model I.D. of the mass flow controller.
- MFC Serial Number – Input the controller specific identification number.
- DUT Serial Number – Input the serial number of the multi-gas calibrator.
- Flow Range – Input the total flow range of the dilution or gas flow.
- Primary Standards – Input the required information for each flow standard used during the verification / calibration process.
- Calibration Gas – Input the source of gas used (i.e. – Compressed Gas Cylinder, Zero Air Generator, etc.)
- Flow settings – Refer to Section 10 for the flow settings.
- Correction Factors – Refer to the calibrator's software calibration table to input the correction factor for each test point. If there is not a corresponding correction factor for a specific test point then put N/A in the cell.
- Slope/Intercept/Correlation Coeff. – The verification form is electronically saved as an Excel document which will automatically calculate the slope, intercept, and correlation coefficient based on the 13 flow points tested.
- If there is no specific information to be placed in a cell, the type in N/A.

15.4 FORM DEP 13-7-D: Temperature Calibration Form

DEP 13-7
REV. No. 0: December 2020
Effective Date: 06-2021

Form DEP 13-7-D: Temperature and Pressure Verification Form

Make / Model:	S/N:	PROPERTY No.:
Reference Pressure Sensor:	S/N:	CERT. DATE:
Reference Temp Sensor:	S/N:	CERT. DATE:

Temperature Reading	Ref. Temp Sensor (°C)	Calibrator Temp Sensor (°C)	Difference (Limit ± 2.0 °C)
Unadjusted			

Pressure Reading		Ref. Pressure Sensor (°C)	Calibrator Pressure Sensor (°C)	Difference (Limit ± 5 mmHg)
Atmospheric Sensor 1	Unadjusted			
	Adjusted			
Atmospheric Sensor 2	Unadjusted			
	Adjusted			
Atmospheric Sensor 3	Unadjusted			
	Adjusted			
Low Point Sensor 2	Unadjusted			
	Adjusted			
Pressure Reading		Ref. Pressure Sensor (p.s.i.)	Calibrator Pressure Sensor (p.s.i.	Difference (Limit ± 0.5 p.s.i.)
High Point Sensor 2	Unadjusted			
	Adjusted			

Performed By: Date:

Verified By: Date:

FORM DEP 13-7-D INSTRUCTIONS

To complete Form DEP-13-7-B, input the following information:

- Serial No. – Fill in the full serial number assigned to the instrument by the manufacturer.
- Property No. – Fill in the fixed asset tracking number also called the property number. This is the number usually assigned by the state or local agency by their Comptroller if the asset is tracked by the agencies comptroller's office. If not, enter "NA" in this pace.
- Reference Temp Sensor – Fill in the make, model, S/N, and certification date of the Thermometer.
- Reference Pressure Sensor – Fill in the make, model, S/N, and certification date of the Pressure Sensor.

For the body of the form, provide the following information:

- For the photometer bench temperature, input the 146iQ's reading, and the certified temp sensor's reading. If they are greater than 2 degrees apart, replace the photometer bench temperature sensor, and re-test.

- For the pressure sensors, follow the directions to compare the sensor readings versus a certified pressure standard. If the pressure sensor is more than 5 mmHg different, then calibrate the unit and put the final pressure comparison in the adjusted column.

16.0 GLOSSARY

CO	Carbon Dioxide
FEP	Fluorinated ethylene propylene, a coating used on Teflon tubing. EPA has specified borosilicate glass or FEP Teflon® as the only acceptable probe materials for delivering test atmospheres in the determination of reference or equivalent methods.
MFC	Mass Flow Controller. The calibrator has two mass flow controllers which must be calibrated separately.
mmHg	Millimeters of Mercury, a standard pressure term, equivalent to 1 torr, or 1/760 of standard atmospheric pressure
NIST	National Institute of Standards and Technology, a measurement standards laboratory
NO	Nitric Oxide
OD	Outside diameter, used for specifying sample line width.
ppb	Parts per billion, a measurement of gas concentration
ppm	Parts per million, a measurement of gas concentration
PSI	pounds per square inch of pressure
QA	Quality Assurance, an integrated system of management activities involving planning, implementation, assessment, reporting, and quality improvement to ensure that a process, item, or service is of the type and quality needed and expected by the end-user.
QC	Quality Control, the overall system of technical activities that measures the attributes and performance of a process, item, or service against defined standards to verify that they meet the specifications established by the customer; operational techniques and activities that are used to fulfill the need for quality.
sccm	Standard cubic centimeters per minute, a flow measurement term
slm	Standard liter per minute, a flow measurement term
SO2	Sulfur Dioxide
SOP	Standard Operating Procedure, a document that details the method for an operation, analysis, or action with thoroughly prescribed techniques and steps to be followed. It is officially approved as the method for performing certain routine or repetitive tasks.