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DAQ-04-001.2 Standard Operating Procedure (SOP)  
Model 48i Trace Level Carbon Monoxide (CO-*tle*) Monitoring System  
Operator Responsibilities

Revision 7.0



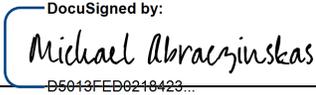
1.0 Approval Sign Off-Sheet

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I certify that I have read and approve of the contents of the Model 48i Trace Level-Enhanced Analyzer (CO-tle) Monitoring System, Standard Operating Procedure, Operator Responsibilities, with an effective date of April 1, 2022.

**Director, Air Quality Division**

Michael Abraczinskas

Signature:  Date: 3/25/2022

**Ambient Monitoring Section Chief**

Patrick Butler, Section Chief

Signature:  Date: 3/25/2022

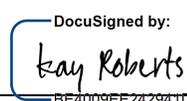
**Projects and Procedures Branch Supervisor**

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Signature:  Date: 3/25/2022

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Signature:  Date: 3/25/2022

This document, and any revision hereto, is intended solely as a reference guide to assist operators in the setup, calibration, operation, and the collection of data related to the North Carolina Division of Air Quality’s Ambient Monitoring Program. This document is intended as a supplement to, and not a substitute for, the education, training and experience required for the efficient operation of ambient air quality monitoring equipment and the collection of scientifically valid data. If an event affecting CO monitoring is outside the purview of this SOP, contact the Electronics and Calibration Branch and the Raleigh Central Office for guidance.

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## 2.0 Scope and Purpose

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The U.S. Environmental Protection Agency (EPA) has determined carbon monoxide (CO), a colorless, tasteless, highly poisonous, and odorless gas that can be lethal in high concentrations, a health and environmental concern. CO originates from the partial oxidation of hydrocarbon fuels and coke. CO affects the oxygen carrying capacity of the blood. CO can diffuse through the alveolar walls of the lungs and compete with oxygen for one of the four iron sites in the hemoglobin molecule. The affinity of the iron site for CO is approximately 210 times greater than oxygen. Low levels of CO can cause a number of symptoms including a headache, mental dullness, dizziness, weakness, nausea, vomiting and loss of muscular control. In extreme cases, collapse, unconsciousness and death can occur. For this reason, The Clean Air Act of 1970 set the National Ambient Air Quality Standards (NAAQS), through which concentrations of carbon monoxide are limited to ensure public safety.

Besides being one of the “Health and Welfare” based Criteria Pollutants required to be monitored by each State as a means of tracking progress in improving and maintaining ambient air quality, CO is also a precursor to ozone and particulate matter. The Division of Air Quality of the Department of Environmental Quality (DEQ) determines the ground level concentration of ambient air ozone and fine particulate matter throughout North Carolina as required by the 1970 Clean Air Act and the subsequent Amendments thereto. In short, the Clean Air Act established ambient air quality as a natural resource that must be protected. The EPA has designated the responsibility to administer and assist in the nationwide program to protect and improve air quality and each state is assigned the direct responsibility for assuring air quality within its borders.

In support of the monitoring requirements, the State of North Carolina operates Trace Level Carbon Monoxide (*CO-tle*) monitors at two sites in the state for the purpose of monitoring the ambient CO exposure of the general population. In order to collect accurate, meaningful data the monitors must be operated in a consistent manner. The goal of this document is to establish a continuous, verifiable and defensible set of procedures and a means to record events and activities with regard to the site and the instrument as required by the EPA, 40-CFR 50, 53, and 58.

All original records (electronic logbook, site logbook, etc.) must be legible, complete, dated and signed or initialed by the operator and retained as a part of the permanent monitor record. The operator’s name and/or initials presented on the e-log will certify that the activities indicated have been performed in accordance with this SOP and that the information contained on the form is accurate (See NCDAQ NCore or Near-Road Quality Assurance Project Plan (QAPP) for examples of e-log and forms). All records will be reviewed and verified by the Regional Ambient Monitoring Coordinators (RAMCs) and validated and audited by the responsible chemist at the North Carolina Division of Air Quality (DAQ).

## 3.0 Equipment Checks

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The significant instrumentation and equipment at each DAQ carbon monoxide monitoring site includes:

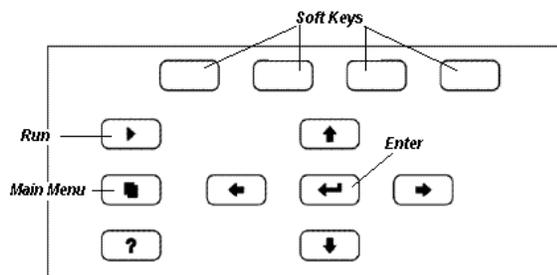
- Thermo Environmental Instruments (TEI) Model 48*i* CO-*tle* Analyzer
- TEI 146*i* Calibrator or Teledyne-API T700U Dynamic Gas Calibrator
- Teledyne – API 701 Zero Air Generator
- Data management system (e.g. Envidas/Envista)

- Certified Primary “CO” gas cylinder
- Ethernet / Modem connectivity
- Uninterruptible Power Supply (UPS)
- Dedicated Windows compatible site personal computer (PC)

Also included are HoBo back-up temperature sensors (shelter temperature), air conditioners, heaters, and other minor components not specified.

### 3.1 Model 48i Trace Level Carbon Monoxide (CO-tle) Operational Check

Verify and record (e-log, Logbook Tab) the 48i instrument settings using the buttons on the front of the instrument panel and check for instrument alarms. Instrument settings should be:



Diagnostic Checks for 48i TLE monitor can be easily accessed from the soft keys on the instrument panel or through the main menu. See [Appendix D](#) for the Thermo Model 48i Analyzer menu flowchart.

Temperatures	Internal: 38 – 43 degrees Celsius (°C)
	Bench: 40 °C – 59 °C
Pressure	250 to 1000 millimeters mercury (mm Hg)
Flow	0.3 to 1.5 liters per minute (LPM)
Sample / Ref Ratio	0.9 to 1.20
AGC Intensity	150,000 to 300,000
Motor Speed	99.9% - 100.1%
Filter Wheel Purge Flow	Regulator Set to 15 pounds per square inch gauge (psig)
Averaging Time	120 Seconds

### 3.2 Residence Time Check

The EPA has a maximum sample line residence acceptance criteria of 20 seconds. The table below illustrates sample line (5/32 inner diameter, or ID) residence time at 1.0 and 1.5 LPM flow rates for various lengths of sample tubing. Residence time is calculated in the e-log, Logbook tab.

Sample Tubing (meters)	Residence Time (Seconds at Flow Rates)	
	Flow Rate = 1.0 LPM	Flow Rate = 1.5 LPM
5	3.7	2.5
10	7.5	5
15	11.2	7.5
20	14.9	10

**NOTE:** At a Flow Rate of 1.0 LPM the maximum sample tubing length is 26 meters  
At a Flow Rate of 1.5 LPM the maximum sample tubing length is 40 meters

### 3.3 Calibrator Check

Calibrator certification is valid for 365 days and the calibration and/or expiration date(s) should be indicated on a label located on the front panel of the instrument.

Verify that the calibrator has the correct cylinder concentration stored in memory. Cylinder concentration can be accessed from the instrument panel through the following steps: (On the front panel of the instrument the ↵ key indicates <Enter>).

146i Calibrator	Main Menu<Enter> Gas Setup <Enter> GasB (COTB) <Enter> Tank Conc <Enter> Return to Run
T700U Calibrator	“SETUP” “GAS” “CYL” “PRT2” (press exit until STANDBY status is displayed)

NOTE: On the 146i Calibrator panel the labels for ZERO to SPAN6 and corresponding concentrations are not the same labels used in the Envidas software. The SPANs to complete procedures in this SOP are those programmed into the Envidas software at the site. See [Appendix C](#) for Envidas Phase versus Calibrator Display.

### 3.4 Calibration Gas Cylinder Check

Verify that the calibration gas cylinder and calibrator are in certification and document certification dates in the e-log, Logbook tab. Calibration gas cylinders at a concentration of approximately 190.0 parts per million (ppm) are certified for eight years from the original date of the manufacturer’s certification. If the calibration gas cylinder pressure is **less than 500 psig**, the Electronics and Calibration Branch (ECB) should be notified, and a new cylinder requested. The delivery of a new calibration gas cylinder or calibrator must be coordinated with the Regional Office and ECB.

**NOTE:** A gas cylinder of ~190-ppm carbon monoxide is used as the calibration standard. CO is an odorless, colorless, poisonous gas. **Breathing high concentrations of CO can be lethal in minutes. Low concentrations over time can be dangerous as well. Early symptoms of carbon monoxide poisoning include headache, dizziness, weakness, nausea, vomiting, sleepiness, and confusion.**

### 3.5 Model 701 Zero Air Generator Check

Verify that the delivery pressure is set to  $30 \pm 2$  psig. If the delivery pressure is outside of the  $\pm 2$  psig range, adjust the pressure using the pressure adjust control knob. Document in the e-log, Logbook tab. As the expiration date of the Model 701 Zero Air Generator approaches, contact the ECB to make arrangements for new materials, and verification/certification if required.

### 3.6 Monitor Particulate Filter and Leak Check

The monitor particulate filter must be **replaced prior to a calibration and at a minimum of every 28 days**. A leak check is **required** prior to and immediately after changing the particulate filter. It is recommended to use gloves or tweezers to avoid contamination of the particulate filter. See [Appendix A](#) for detailed instructions regarding filter change and leak check procedures. Record filter change and leak check pass/fail in the e-log, Logbook tab.

## 4.0 Site Visit and Checks

Operators are required to visit the site at least once every 14 days. Upon arrival at the site, observe the outside of the shelter and probe inlet, looking for vandalism or security breaches. If there is evidence of vandalism the operator should contact the appropriate law enforcement department (generally this is the city police department if the monitor is within city limits or the county’s sheriff’s department if outside city limits) as well

as the RAMC, the Raleigh Central Office (RCO), and the ECB of DAQ. Verify that the probe inlet and screen are in place and that the sample line is not blocked by insects or other debris. Check the data acquisition system (DAS) (Envidas) for appropriate date/time and concentration readings. Document all observations and actions in the e-log, Logbook tab. The RAMC and a member of the Projects and Procedures Branch (PPB) should review the data generated during any “out-of-control” period to determine if the data should be flagged or invalidated.

#### 4.1 Shelter Temperature Check

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The shelter temperature sensor (Comet Temperature Probe connected to Site PC and reported via Envidas) must be compared to a National Institute of Standards and Technology (NIST) traceable thermometer, likewise the back-up temperature logger (HoBo) must be compared to the NIST traceable thermometer. If the NIST traceable thermometer was brought to the site, allow sufficient time for the reading to stabilize.

Observe and record the internal temperature of the building in °C displayed by the Comet Temperature Probe and the HoBo. Compare to the NIST traceable thermometer and, record values of all three in the e-log Logbook tab. If either of the shelter temperature sensors is reading greater than  $\pm 2$  °C of the reference (NIST), contact the ECB.

**NOTE:** The Comet and the HoBo do not have to agree in temperature, *but both must be* within  $\pm 2$  °C of the NIST thermometer. The HoBo temperature data will need to be exported at least once every 30 days for the logger; refer to RCO Guidance Documents under the Documents section on DAQ’s Ambient Monitoring SharePoint page for instructions. The exported temperature data file name should include specific naming parameters such as site, parameter and date. For example, “MQ 20190201to15 ST.xls” would be Millbrook Shelter Temperature between 01 Feb and 15 Feb 2019.

The exported data are considered site files and kept in accordance with Section 8.0 Quality Assurance and Data Handling of this SOP. HoBo temperature data may be imported into Envista Air Resources Manager (ARM) when needed as backup; refer to RCO Guidance Documents under the Documents section on DAQ’s Ambient Monitoring SharePoint page for instructions.

Adjust the site thermostat as necessary to maintain the shelter temperature within 20 °C to 30 °C range. If the temperature cannot be stabilized and controlled within this range, notify the Regional Chemist and the ECB that corrective action is required. Document in the e-log, Logbook tab.

#### 4.2 Electrical Power and Sample Line Check

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Observe the monitor, calibrator, PC and data management system for indications of a power failure, and if needed, correct the cause. If the monitor or calibrator lost power, allow an equilibration period of at least 60 minutes for the instrument to stabilize after being powered up. Visually inspect the sample line tubing, especially at any bends, to ensure that it has not kinked, crimped, cut, or to ensure that insects have not nested in the lines. Particulate matter and/or moisture may also collect in the sample line leading to the instrument. Ensure that the sample line is being heated and slightly warm to the touch. The ECB is required to replace the sample line every two years and will perform a sample line integrity check at their yearly audit (Reference Section I (SOP 2.36.1): ECB Responsibilities for details). Record all events in the e-log, Logbook tab.

#### 4.3 Time and Date Check

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The time displayed via the PC / Envidas site PC, and the monitor must be EASTERN STANDARD TIME and be synchronized to NIST time ( $\pm 1$  minute). Time Synchronization on the monitor and site PC is an automated

process that occurs once per day and was programmed during Envidas installation on the site PC. If the times for either the monitor or site PC are not within 1 minute of NIST time, call the ECB and they will assist with correcting the problem.

Record the time displayed on the site PC, and monitor (Instrument Controls – Date and Time) as compared to NIST time on the e-log created for the site visit, Logbook Tab.

Sources for getting the correct time:

- Call the ECB lab and ask for the NIST time
- Call the NIST Colorado time at (303) 499-7111
- Correct time loaded into cell phone (Eastern Standard Time)

Correct time website, <http://nist.time.gov>

**NOTE:** The HoBo logs a start-time at each launch and starts a timer/clock. Launching is required after battery replacement and should be performed at least once every 30 days to synch time with the site PC and to export and save the monthly HoBo logger data. (Refer to “Exporting Data from HoBo Temperature Data Logger” in the RCO Guidance Documents folder under the Documents section of DAQ’s Ambient Monitoring SharePoint page for instructions).

#### 4.4 Computer Check

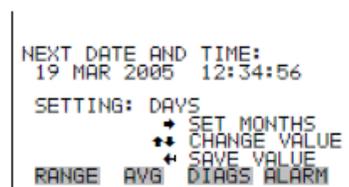
At least once every 30 days, the site PC should be restarted. This will ensure that network updates from the North Carolina Department of Information Technology (DIT) take effect without a prolonged interruption of service. Operators should also contact the ECB if the site PC behaves unusually or if a piece of computer equipment needs to be replaced such as a router, PC tower, computer mouse, etc.

**NOTE:** DIT will have to be contacted if unable to log on to the site PC.

#### 4.5 Advance The ZERO/SPAN (AutoZero) Run-Time

On the 48i CO-tle Monitor Panel

Set the next scheduled “Zero/Span Check” routine forward 4 or 8 hours (from the Main Menu  scroll down using the ↓ key to select **Calibration** ←<Enter> followed by **Zero/Span Check >Next Time** ←<Enter> press ←<Enter> to edit. The default ‘Days’ will be displayed, using the → scroll to select TIME and adjust the hours using the ↑ as needed followed by ←<Enter>. An example of Zero/Span Check scheduled run-times are: 02:46, 04:46, 06:46, 08:46, 10:46, 12:46, 14:46, 16:46, 18:46, 20:46 and 22:46)



The Zero/Span Check routine should be advanced prior to any calibration, verification or manual performance check.

## 5.0 Detailed Procedures

**A Calibration followed by a Multi-point Verification is required:**

- During site start-up or installation of the monitor
- Whenever the monitor is without power for 72-hours or longer (e.g., extended power outages caused by inclement weather)
- If the monitor is replaced or undergoes major repairs or maintenance
- When the results of the automated Precision-Zero-Span (PZS) falls outside the warning limits for 2 or more consecutive days and results of a manually initiated One-Point Quality Control Check of the monitor are outside the range of acceptable criteria.

#### Criteria for PZS's

	Zero	Span	Precision (Span 1)
Concentration (parts per billion, or ppb)	0	4000	500
Control Limit ( $\pm$ )	< $\pm$ 30.0 ppb	< $\pm$ 10.1 %	< $\pm$ 10.1 %
Warning Limit ( $\pm$ )	< $\pm$ 41.0 ppb	$\pm$ 5%	$\pm$ 7%

- When a manual One-Point Quality Control Check fails, the Operator should evaluate and document the cause of the failure and take action accordingly ([See Section 9](#))
- When the CO Background exceeds a value of 9500 ppb. (The CO Background approaching or exceeding 9500 ppb may be an indication that the PreAmp and Sample/Reference adjustment is needed to reset the background value. This procedure is best completed by ECB personnel or site operators who have multiple years of experience calibrating the monitor.

A multi-point calibration ([Section 5.2](#)) or multi-point verification ([Section 5.3](#)) is required once every 365 days and 1/ calendar year regardless of monitor performance.

Unlike Ozone, SO<sub>2</sub> and NO<sub>y</sub> instruments which only set the high-span (80% level) *all three span points* SPAN (4000 ppb), SPAN2 (2000 ppb), and SPAN3 (300 ppb) are set for the CO-*t/e* monitor.

NOTE: A One-Point Quality Control Check (QC Check) ([Section 5.4](#)) of the precision point (500 ppb) is required, followed by a leak check (see [Appendix A](#)), filter replacement and leak check prior to *any* calibration. If the monitor has failed the operator should forgo the check by documenting the cause of the failure in the comments section of the *e-log, Logbook tab* and proceeding to the calibration.

#### Multi-point Verification ([Section 5.3](#)) Requirements:

The purpose of a multi-point verification is to correlate the output of a monitoring system with known traceable concentrations of CO to demonstrate the linearity of the monitor response.

- A multi-point verification *is required* as a part of any calibration procedure to assess the overall success of the calibration.
- Within 182 days of the most recent calibration / verification if continuous zero/span performed daily regardless of monitor performance.

Complete the required Equipment Checks ([See Section 3](#)) and Site Visit and Checks ([See Section 4](#)) as specified in this SOP prior to any Calibration or Multi-point verification.

#### One-Point Quality Control (QC) Check ([Section 5.4](#)) Requirements

- At least every 14 days or less and should include the 1-Point QC Check (500 ppb).

- Prior to any required calibration (see calibration requirements)
- When the automated PZS fails **any** of the three points on the morning immediately following installation of a new calibration cylinder or calibrator. The operator *should investigate* to identify a cause for the failure and decide if the monitor is operating within the range, determine if the calibration cylinder or calibrator is suspect, or if a calibration followed by a multi-point verification is needed.
- During all manual performance checks the 1-Point QC check (500 ppb) must be included and is reported to AQS. (40 CFR Part 58, Appendix A, Section 3.2)

Complete the required Equipment Checks (*See Section 3*) and Site Visit and Checks (*See Section 4*) as specified in this SOP prior to any manual performance check.

### 5.1 Pre-Calibration Procedure

On the 48i CO-tle Monitor Panel

Record the as found “**Calibration Factors**” for **BKG** and **COEF**. (Main menu – “**Calibration Factors**” – record – return to Main Menu)

```

CALIBRATION FACTORS:
>BKG          0.0
COEF          1.000
RESET USER CAL DEFAULTS

RANGE  AVG  DIAGS  ALARM

```

On the 48i CO-tle Monitor Panel

Turn “**Service Mode**” **ON** (“Instrument Controls” – “Service Mode” – on/off press <Enter>) (*Note: A wrench will be displayed on the monitor panel while in Service Mode*)

```

SERVICE MODE:
CURRENTLY:           OFF
SET TO:              ON ?

+ TOGGLE VALUE

RANGE  AVG  DIAGS  ALARM

```

On the 48i CO-tle Monitor Panel

Display and **Record** the **as-found** Calibration Coefficients stored in the monitor (Main menu – Service (select), Multipoint Cal (select) Coefficients (select) Record the as found “**Calibration Coefficients**” for Coeff-1, Coeff-2, Coeff-3 (“Service” – “Multi-Point Calibration” – “Coefficient” – **Reset or Default the Coefficients**)

```

MULTI-POINT CAL:
>CALIBRATE POINT 1
CALIBRATE POINT 2
CALIBRATE POINT 3
COEFFICIENT
DEFAULT COEFFICIENTS

RANGE  AVG  DIAGS  ALARM

```

```

COEFFICIENTS:
1: 1.000000
2: 1.000000
3: 1.000000

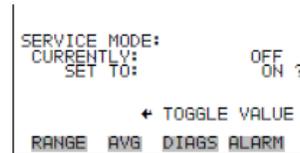
+ RECALCULATE?

RANGE  AVG  DIAGS  ALARM

```

### On the 48i CO-t/e Monitor Panel

Turn **“Service Mode” OFF** (“Instrument Controls” – “Service Mode” – on/off press <Enter>) Press  three times to return to the instrument main menu. (Section 4.10 of Manual) *(Note: **DAS commands will not be initiated when Service Mode is ON**)*



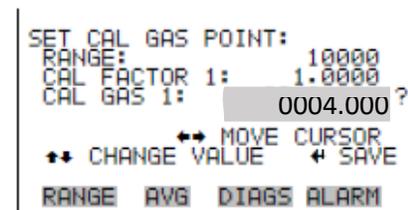
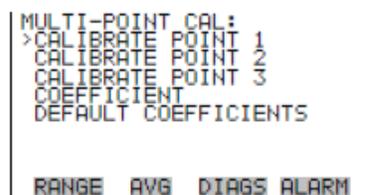
## 5.2 Calibration Procedure (Multi-Point)

### 5.2.1 Initiate SPAN ZERO (0 ppb)

- Using the “Phase from Sequence” menu
  - Select “COTMAN”
  - Select “ZERO”
  - Select “Start”
- Create a Viewer Dynamic Chart for capture of all the calibration points during the calibration procedure. Edit the chart axis to 60 minutes to capture all 4 calibration points generated.
- Allow time for values to stabilize (approximately 10 minutes).
- Record on the *Calibration Graph tab*, the *updated* 5-minute average concentration value generated by the Calibrator using Envidas (Viewer Dynamic Tab) or as displayed on the calibrator panel.
- Abort SPAN ZERO

### 5.2.2 Initiate SPAN (4000 ppb)

- Using the “Phase from Sequence” menu
  - Select “COTMAN”
  - Select “SPAN”
  - Select “Start”
- Set monitor to “Service Mode” while SPAN is being run**
- Allow time for values to stabilize (approximately 10 minutes)
- Record on the *Calibration Graph tab*, the *updated* 5-minute average concentration value generated by the Calibrator using Envidas (Viewer Dynamic Tab) or as displayed on the calibrator panel.
- Start MultiPoint Cal** (“Service” – “Multi-Point Cal” – “Calibrate Point 1” – from “Set Cal Gas Point” menu use the arrow keys to adjust “Cal Gas 1” to the actual concentration generated by the calibrator. *(Front Panel of Calibrator or as displayed on DAS)* Press  $\leftarrow$ <Enter> to save.
- Abort SPAN.



### 5.2.3 Initiate SPAN2 (2000 ppb)

- Using the “Phase from Sequence” menu

- Select “COTMAN”
  - Select “SPAN2”
  - Select “Start”
2. Allow time for values to stabilize (approximately 10 Minutes)
  3. Record on the *Calibration Graph tab*, the *updated* 5-minute average concentration value generated by the Calibrator using Envidas (Viewer Dynamic Tab) or as displayed on the calibrator panel.
  4. Continue, **MultiPoint Cal** (“Service” – “Multi-Point Cal” – “Calibrate Point 2” – from “Set Cal Gas Point” menu use the arrow keys to adjust “Cal Gas 2” to the actual concentration generated by the calibrator. (*Front Panel of Calibrator or as displayed on DAS*) Press  $\leftarrow$  <Enter> to save.
  5. Abort SPAN2.

#### 5.2.4 Initiate SPAN3 (300 ppb)

1. Using the “Phase from Sequence” menu
  - Select “COTMAN”
  - Select “SPAN3”
  - Select “Start”
2. Allow time for values to stabilize (approximately 10 Minutes)
3. Record on the *Calibration Graph tab*, the *updated* 5-minute average concentration value generated by the Calibrator using Envidas (Viewer Dynamic Tab) or as displayed on the calibrator panel.
4. Continue, **MultiPoint Cal** (“Service” – “Multi-Point Cal” – “Calibrate Point 3” – from “Set Cal Gas Point” menu use the arrow keys to adjust “Cal Gas 3” to the actual concentration generated by the calibrator. (*Front Panel of Calibrator or as displayed on DAS*) Press  $\leftarrow$  <Enter> to save.
5. Abort SPAN3.

### On the 48i CO-t/e Monitor Panel

#### 5.2.4 Calculate and Record

1. **Calculate** the new calibration curve values. From the “Main Menu” – “Service” – “Multi-Point Cal” – “Coefficients” – “RECALCULATE” by pressing  $\leftarrow$  <Enter>). Record the new Coefficients for calibration points 1, 2, and 3. (*e-log, Calibration Graph tab*) **If problems arise during the recalculation process STOP the linearity of the monitor is suspect, note any error messages displayed then contact ECB for guidance before proceeding further.**
2. **Record** the new, “as left” calibration factors (*e-log, Calibration Graph tab*). From the “Main Menu” – “Calibration Factors” – record “BKG” and “COEF” – return to Main Menu
3. Return the monitor to normal operating conditions **“Service Mode” OFF** (“Instrument Controls” – “Service Mode” – On/Off press  $\leftarrow$  <Enter>)
4. Copy and paste the graph created during the multi-point calibration procedure, including all points generated (0 – 4000 – 2000 – 300) during the calibration in the e-log (*e-log, Calibration Graph tab*).

### 5.3 Multi-Point Verification

1. Initiate a series of SPAN Point checks to confirm the calibration, allowing the monitor readings to stabilize (approximately 10 minutes for each point). Create a Viewer Dynamic Charts to capture the span points during the multi-point verification. Include the graphs in the e-log. (*Span Graphs tab*)

2. Record five stable 1-minute readings from both the calibrator and the monitor *along with* the Gas and DIL Gas flows (*e-log, Multi-Point Verification tab*).
3. Abort the point once the series of stable readings have been recorded.

Continue the series of SPAN Point checks using the Phase from Sequence commands until all five points are complete. The points run for the multi-point verification should include:

- a. SPAN Zero (0 ppb)
- b. SPAN 4 (1000 ppb)
- c. SPAN2 (2000 ppb)
- d. SPAN 5 (3000 ppb)
- e. SPAN (4000 ppb)

allowing the monitor readings to stabilize (approximately 10 minutes for each point) then recording five stable 1-minute readings, along with the concentration value generated by the calibrator (either from the Calibrator Display or Envidas, as well as the CAL Gas and DIL Gas flows for each SPAN point (*e-log, Multi-Point Verification tab*).

#### Multi-Point Verification Acceptance Criteria

A multi-point verification is complete when the five span points (including ZERO) have been run, and the values for all points are within the acceptance criteria listed in the table below. The criteria for all points of the multi-point verification are  $< \pm 2.1\%$  or  $\leq \pm 30$  ppb difference of the best-fit straight line, whichever is greater. It is recommended the slope be  $1 \pm .05$ . If any of the points are greater than the acceptance criteria, the calibration is unacceptable. If the calibration is unacceptable contact ECB for guidance.

Multi-Point Verification	Nominal Calibrator Concentration (146i or T700U)	Acceptance Criteria (Nominal difference)
ZERO	0.0	$\leq \pm 30.0$ ppb
SPAN	4000 ppb	$< \pm 2.1\%$ <i>or</i> 30 ppb
SPAN 5	3000 ppb	$< \pm 2.1\%$ <i>or</i> 30 ppb
SPAN 2	2000 ppb	$< \pm 2.1\%$ <i>or</i> 30 ppb
SPAN 4	1000 ppb	$< \pm 2.1\%$ <i>or</i> 30 ppb

If the multi-point verification is acceptable:

- If using a T700 Calibrator, initiate a PURGE sequence using Envidas Viewer (Operational Tab, select CO Purge, Schedule Sequence, Start in 0 minutes, INIT).
- If using a 46i Calibrator, Initiate SPAN ZERO for approximately 10 minutes to purge the system.
- Confirm the next scheduled “Zero/Span Check” routine is set to run at the next available time (The Auto-Zero schedule is set by ECB to every 2 hour intervals beginning at minute 46 and should not be altered other than to advance ‘Next Time.’ Scheduled run-times are: 02:46, 04:46, 06:46, 08:46, 10:46, 12:46, 14:46, 16:46, 18:46, 20:46 and 22:46). (  Calibration  $\leftarrow$  Zero/Span Check  $\leftarrow$  Confirm ‘NextTime’ – Press the Run key  $\rightarrow$  to exit).
- Verify the monitor is in “Sample” mode and the Calibrator is in “Standby” mode.
- Save appropriate e-logs, graphs of each multi-point verification point along with CO Purge or SPAN ZERO completed at the end of the calibration procedure, and all minute data. Include Span graphs (*Span Graphs tab*) and minute data (*Minute Data tab*) in the e-log.
- Reset all Flags and Log OFF of Envidas/site computer prior to leaving the site.

## 5.4 Manual Performance Check (Zero – Precision – Mid-Span – Full Span)

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### 5.4.1 Initiate SPAN ZERO (0 ppb)

1. Using the “Phase from Sequence” menu
  - Select “COTMAN”
  - Select “ZERO”
  - Select “Start”
2. Create a Viewer Dynamic Chart to capture the span point during the manual performance check. Allow time for values to stabilize (approximately 10 Minutes). Include the graph in the e-log. (*Span Graphs tab*)
3. Using Envidas Reporter record the time and five stable 1-minute “COT” and calibrator values in the e-log (*Manual Check tab*) along with CAL Gas and DIL Gas flows. Abort SPAN ZERO.

### 5.4.2 Initiate SPAN1 (500 ppb - Precision)

1. Using the “Phase from Sequence” menu
  - Select “COTMAN”
  - Select “SPAN1”
  - Select “Start”
2. Create a Viewer Dynamic Chart to capture the span point during the manual performance check. Allow time for values to stabilize (approximately 10 Minutes). Include the graph in the e-log. (*Span Graphs tab*)
3. Using Envidas Reporter record the time and five stable 1-minute “COT” and calibrator values in the e-log (*Manual Check tab*) along with CAL Gas and DIL Gas flows. Abort SPAN1.

### 5.4.3 Initiate SPAN2 (2000 ppb – Mid-Span)

1. Using the “Phase from Sequence” menu
  - Select “COTMAN”
  - Select “SPAN2”
  - Select “Start”
2. Create a Viewer Dynamic Chart to capture the span point during the manual performance check. Allow time for values to stabilize (approximately 10 Minutes). Include the graph in the e-log. (*Span Graphs tab*)
3. Using Envidas Reporter record the time and five stable 1-minute “COT” and calibrator values in the e-log (*Manual Check tab*) along with CAL Gas and DIL Gas flows. Abort SPAN2.

### 5.4.4 Initiate SPAN (4000 ppb – Full Span)

1. Using the “Phase from Sequence” menu
  - Select “COTMAN”
  - Select “SPAN”
  - Select “Start”
2. Create a Viewer Dynamic Chart to capture the span point during the manual performance check. Allow time for values to stabilize (approximately 10 Minutes). Include the graph in the e-log. (*Span Graphs tab*)
3. Using Envidas Reporter record the time and five stable 1-minute “COT” and calibrator values in the e-log (*Manual Check tab*) along with CAL Gas and DIL Gas flows. Abort SPAN.

## Manual Performance Check Criteria

The manual performance check is complete when the four points including ZERO have been completed, and the values for all points of the manual performance check are within the acceptance criteria listed in the table below.

Manual Performance Check	Nominal Calibrator Concentration (146i or T700U)	Acceptance Criteria (Nominal difference)
ZERO	0.0	< ± 41.0 ppb
SPAN 1	500 ppb	± 7.0 % (35 ppb)
SPAN 2	2000 ppb	± 5.0 % (100 ppb)
SPAN	4000 ppb	± 5.0 % (200 ppb)

- If using a T700 Calibrator, initiate a PURGE sequence using Envidas Viewer (Operational Tab – select CO Purge – Schedule Sequence – Start in 0 minutes – INIT).
- If using a 146i Calibrator, Initiate SPAN ZERO for approximately 10 minutes to purge the system.
- Confirm the next scheduled “Zero/Span Check” routine is set to run at the next available time (The Auto-Zero schedule is set by ECB to every 2-hour intervals beginning at minute 46 and should not be altered other than to advance ‘Next Time.’ Scheduled run-times are: 02:46, 04:46, 06:46, 08:46, 10:46, 12:46, 14:46, 16:46, 18:46, 20:46 and 22:46). (  Calibration ← Zero/Span Check ← Confirm ‘NextTime’ – Press the Run key  to exit)
- Verify the monitor is in “Sample” mode and the Calibrator is in “Standby” mode.
- Save appropriate e-logs, graphs, and minute data (including CO Purge or SPAN ZERO completed at the end of the manual performance check). Include graphs (*Span Graphs tab*) and minute data (*Minute Data tab*) in the e-log.
- Reset all Flags and Log OFF of Envidas/site computer prior to leaving the site.

### 5.5 Leak Check and Filter Change

Once the manual performance check is completed, check the e-log to determine if the particulate filter needs to be changed (every 28 days) If the filter needs to be changed, perform a leak check (both pathways) then change the particulate filter and perform another leak check (both pathways). See [Appendix A](#) for detailed instructions for leak checks and changing the particulate filter.

## 6.0 Logbook Submittal – Data Review

### 6.1 Logbook Submittal

The CO Logbook (e-log) is used for evaluating the success/failure of the operation of the CO monitor and is an essential record for determining the quality of the CO data reported.

1. The Site Operator must complete the CO e-log to document the purpose of any site visit, the observations and findings during the site visit, and the evaluation of the performance of the CO monitoring system for each site visit.
2. Within three business days after the site operator making the site visit returns to the regional office, the person must transfer the electronic logbook to the local area network (LAN) or SharePoint site, storing it in the appropriate folder established for that regional office and communicate to the RAMC that the logbook is available for review. If the operator reviews the electronic logbook after returning to the office and

identifies that an entry error occurred, the operator must correct the error by making a note in the comments section and date and initial the note.

3. The RAMC or designee should review the electronic logbooks as soon as reasonably possible as they become available but must review the electronic logbooks at least twice a month and at intervals not to exceed 15 business days. The RAMC and the site operator should discuss any discrepancies, errors, concerns or questions prior to the next site visit after the review is completed. The RAMCs must type their name and date of review in the electronic logbook in the space provided (or in the notes section, if a space is not provided) before submitting the electronic logbook to the RCO. If a problem is noted during the RAMC review, the RAMC should not make any changes to the electronic logbook other than to note the problems that were identified in the comments section of the electronic logbook, initialing and dating any entries made. The RAMC should also bring any problem that impacts the validity of the data collected to the attention of the assigned RCO Chemist by either a phone call or an e-mail depending upon the urgency and severity of the problem within a time period of 5 business days.
4. All electronic logbooks must be submitted to the RCO via the RCO group drive on a monthly basis, as soon as possible after the end of each month but no later than 15 business days from the start of each month. When RAMCs cannot meet this established time schedule because of extenuating circumstances, they should contact the appropriate RCO staff members with full explanations of reason(s) for the delays and make other arrangements or establish an alternate schedule.
5. The PPB Chemist must review the elogs submitted for completeness and adherence to operating procedures.

## 6.2 Data Review

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Each business day, the RCO statistician initiates a data review by providing a raw data report (in a spreadsheet format) to each Regional Office. (Reference DAQ-15-005.5 Data Validation for Continuous Gaseous Monitors and Meteorological Data: Raleigh Central Office Responsibilities.) The RCO may request the Regional Office to send additional data that are needed beyond what the RCO requires for verifying any missing data supplied by the Regional Office. These data can be retrieved from the "site monitor" as needed. (Refer to RCO Guidance Documents under the Documents section on DAQ's Ambient Monitoring SharePoint page for instructions.)

## 7.0 File Management

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Field operators must have a site PC or laptop to generate the Logbook (e-log) files from a Microsoft Excel template file. These e-logs are provided by the RCO and updated periodically. The file naming protocol is provided below. **A formalized file naming convention has been established through consensus of the regions and the RCO and should be used by all regions.**

### 7.1 Opening, Naming and Storing the Site Files

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The e-log template file used at the site should be stored on the PC used for field operations by the site operator or field technician; see [Appendix F](#) of this SOP for an example of the e-log. E-logs can also be found in DAQ's Internet-Based Enterprise Application Management system (IBEAM). To access the file, open the e-log template file using Excel. Every time a new e-log is completed using the template it must be renamed and saved as a separate and complete logbook (all sheets, i.e., tabs, saved) to preserve the record. Do NOT copy over a previously completed e-log. Refer to the Logbook file naming convention "Policy Memorandum" dated January 1, 2011 located in the DAQ IBEAM module (summarized below).

1. Open the appropriate Logbook e-log template file using Excel.

2. Left click the “file” toolbar icon, scroll down to “save as” and left click. Every time a new e-log is filled out using the template, it must be renamed and saved as a separate and complete workbook (all sheets, i.e., tabs saved) to preserve the record. **Do not copy over previously completed e-logs.**
3. Under file name (highlighted) change the Logbook file name using the following format: Site ID COTL Date Activity. For example, “MQ COTL 20180601 AX.xls” is a Manual (Precision) Check at Millbrook on June 01, 2018.
4. Change save location to operator’s choice of folders.
5. Left click “save.”
6. Find the tab needed for the task involved. The first tab selected should be the Logbook. Fill in information as indicated.
7. Open other tabs as needed and fill in information as indicated.
8. Save the Logbook (e-log) periodically and when finished entering data.

## 8.0 Quality Assurance & Data Handling

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### 8.1 Files and Electronic Logbook Procedures

All site files, elogs or other supporting documents generated in the field will be stored on dedicated server space in the Regional Office in a folder named for the official site operations file. These files should be transferred to the Official File on a frequent and regular schedule as established by the Region. This is necessary to prevent the potential loss of such files from the field PC and to maintain a “paper trail” for providing defensible data. This also makes the data easily available for review by the RAMC and transfer to the RCO group drive for review by the RCO. The files on the site/operator PC can be copied and transferred to the common hard drive via email or flash drive for storage in the official file folder.

The site files should be transferred every three business days and backed up monthly. This serves as a backup system in the event the official PC fails, is removed, or the site files are damaged. These files will be retained for a minimum of five years. When the need arises to review a file for data validation or site operations the official folder is used, or a hardcopy is created from this file. For details on data validation procedures, please reference DAQ-15-005.5 Data Validation for Continuous Gaseous Monitors and Meteorological Data: Raleigh Central Office Responsibilities. The validation checks that will be done are:

1. Providing proper null codes indicating calibrations, audits, etc.
2. Providing missing valid data
3. Documenting any invalid data as to reason with proper null code
4. Identifying any data that may be associated with exceptional events.

The assigned RCO chemist will review all logbooks within 15 business days of receipt at the RCO. The RCO chemist will provide appropriate feedback of his or her electronic logbook review to the RAMC. This feedback should include an evaluation of any impact or potential impact on the validity of the data collected, how well the QAPPs and SOPs are being followed, as well as an evaluation of how well the logbook is completed. If any corrective actions are needed, the RAMC will brief the site operator of them within five (5) business days of the receipt of the RCO chemist review comments and document the briefing on the review hard copy received from the RCO chemist. The RCO feedback may be accomplished by e-mail or other appropriate means, including follow-up conference call, depending upon the urgency and severity of the identified situation but must occur within 15 business days of receiving the electronic logbook.

The RCO chemist will maintain a copy of each monthly logbook review for use in preparing the quarterly and annual data quality audit reports.

## 8.2 Monthly Validation

Preliminary validation is completed by the Regional Operator. The operator must account for all missing or invalid data by identifying the reasons for missing or invalid data within Envista using proper flags and null codes while performing maintenance or shortly thereafter. The operator must review the previous month of data and add any flags or void codes to the Status column as necessary. For each changed status, a comment must be entered with a description of why the status was changed.

The RAMC will perform the second level review of the month of data, adding any additional void codes and comments, and requesting additional information from the operator as necessary. If required, the RAMC can send data back to the Regional Operator for additional comments or to correct any codes. When possible, the data will be validated within 15 workdays from the end of the collection month.

The RCO Chemist performs the final validation of the one-month period of data. Void codes and comments should all be added, and the RCO Chemist can send the data back to the previous reviewer. (See DAQ-15-005.5 Standard Operating Procedure (SOP) Data Validation for Continuous Gaseous Monitors and Meteorological Data Raleigh Central Office Responsibilities.) Final validation of the data should be complete within 30 days of the end of the collection month. Once the data has been approved and has had the "final validation" label applied by the RCO Chemist, it is automatically entered into a queue within Envista ARM. The Database Manager will send all approved data to AQS automatically on a regularly scheduled basis.

In some cases, "valid" data that are judged to be out of the ordinary are retained and an information flag is added in AQS by the RCO. An example would be high concentration values resulting from an exceptional event. EPA has recently begun applying stricter standards for what it will accept as an exceptional event. In any case where the Region wishes for data to be considered "exceptional," the Region should gather sufficient documentation to support the claim in accordance with a policy memorandum from the RCO dated June 29, 2007. Unusually high concentration values that may be the result of an exceptional event must be noted as such on the AQS monthly data summary reports, but not deleted. Any exceptional event will be flagged in AQS by the RCO using the appropriate qualifier code. The fully validated file data are then uploaded into AQS by the RCO.

A list of EPA-AQS Null Codes that are commonly used during data validation on the AQS monthly summary report are listed in the following table. (Partial List).

CODE	AQS Description	When to Use
AE	Shelter Temperature outside Limits	Temperature Outside 20 – 30 °C
AN	Machine or Equipment Malfunction	Machine Malfunction
AS	Poor Quality Assurance Results	N/A
AV	Power Failure	Power Failure
AZ	QC Audit (ECB Lab)	ECB Performance Audit
BA	Maintenance and Routine Repairs (including filter changes)	Maintenance/Routine Repairs
BC	Multi-point Calibration	Multi-point Calibration
BF	Auto Calibration	Precision-Zero-Span
AX	Precision/Zero/Span	Precision Check
BJ	Operator Error	Operator Error
BK	Site Computer/Data Logger Down	Site Computer/Data Logger Down
QV	Multi-point Calibration Verification	Multi-point Verification

## 9.0 Troubleshooting and Corrective Actions

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The table below provides general troubleshooting information and the checks that should be performed. For a more detailed list see Section 6.0 of the Operating Manual.

Problem	Corrective Action
Auto-Zero does not run	Check that monitor is in <i>Sample</i> mode
Monitor does not respond to any Phase Activation using Envidas Software	Check that <i>Service</i> is OFF and front panel of monitor is in <i>SPAN</i> mode
Calibrator initiates Span routine then immediately shuts down	Sample/Vent solenoid not operating properly. Check for recent software updates, contact ECB to replace and test Sample/Vent solenoid
Error message when recalculating coefficients during multi-point calibration	Response of monitor not linearized – contact ECB – possible Sample/Reference adjustment needed, or monitor should be replaced.
Manually activated phases do not initiate and/or terminate properly on the calibrator	Check that the “ADAM” unit is operational and that vent solenoids are being open and closed as needed.
Leak check (Sample or Span) takes longer than 3 minutes to reach 250 mm mercury (Hg)	Suspect internal leak – contact ECB for guidance.
Overnight PZS fails after calibration cylinder replacement	Was the correct calibrator cylinder concentration entered into the calibrator? Are all tank valves turned on?
Overnight PZS fails after calibrator replacement	Is the calibrator cylinder concentration correct? Are the correct SPAN points set in the calibrator?

## 10.0 Revision History

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### Revision 7.0

1. Updated Revision Number and Cover Page Header
2. Added reference to DAQ-15-005.5 in Section 8.2
3. Added conditional formatting to elog per Operator’s requests

#### Revision 6.0

1. Updated Revision Number and SOP formatting
2. Added additional Section 4.4 Computer Care
3. Updated PZS criteria to comply with current EPA requirements
4. Change calibration frequency schedule
5. Updated Section 6.1 Logbook Submittal to current policies / procedures
6. Updated Section 8.0 Quality Assurance and Data Handling to current policies / procedures
7. Corrected elog for Precision criteria
8. Updated Glossary of Terms ([Appendix E](#)) included
9. Removed reference to Regional Office Polling and Data Review SOP (2.8.3)
10. Removed reference to Data Review & Validation QA Plan for Continuous Gaseous & Non-Speciated Particulate Monitors SOP (2.41.4)

## 11.0 References

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1. QA Handbook for Air Pollution Measurement Systems: "Volume II: Ambient Air Quality Monitoring Program"

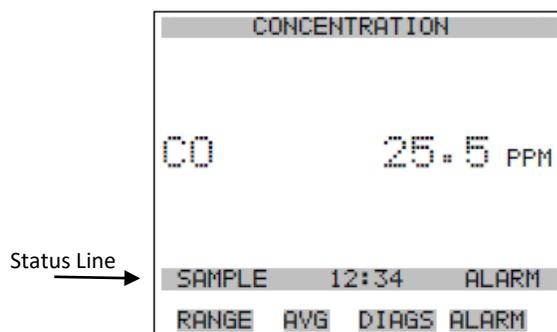
## Appendix A: Detailed Leak Check – Filter Change – Leak Check Procedure

The monitor in-line filter must be changed at least every 28 days, and before every calibration. A *leak check* is required prior to any filter change, completing both the “sample leak check” and “span leak check”.

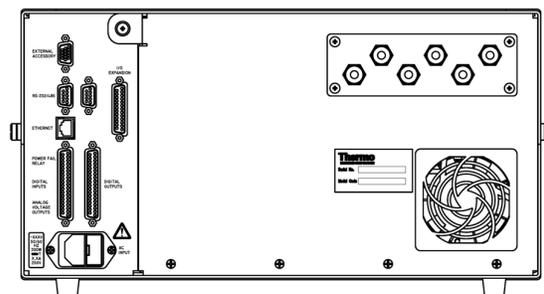
### Leak Check - Sample Route through Solenoid:

- 1) With the monitor in “Sample” mode
- 2) From the “Main Menu” (“Diagnostics” “Pressure” ↵<Enter>)
- 3) Disconnect the sample inlet probe line at the filter and cap with a Teflon cap/plug.
- 4) Observe the pressure drop to 250 mmHg with less than 3 minutes passing.
- 5) Release the vacuum on the inlet and proceed to the “span leak check”

Model 48i Front Display Panel



Model 48i Rear Panel



### Leak Check - Span through Solenoid:

- 6) On the monitor front panel, press the <Run> button  until “SAMPLE” changes to “SPAN” in the status line.
- 7) From the “Main Menu” (“Diagnostics” “Pressure” ↵<Enter>)
- 8) Disconnect the span line and cap with a steel or brass cap, re-cap the sample inlet probe line at the filter with a Teflon cap/plug.
- 9) Observe the pressure drop to 250 mmHg with less than 3 minutes passing.
- 10) Remove both caps, releasing the vacuum, reconnect the respective lines.
- 11) Disassemble the filter housing using the specific filter holder wrenches. Replace existing filter with a clean unused filter taking care to not touch the surface. Re-assemble the filter housing and run the “sample leak check” and “span leak check”. (Repeat steps 1 – 9)
- 12) On the monitor front panel, press the <Run> button  until “SAMPLE” appears on the status line.

**NOTE:** Leak checks taking greater than 2 minutes 45 seconds to reach 250 mm Hg could be an indication of a leak at the filter holder or possibly an internal leak. Disassemble and Re-assemble the filter housing and repeat the leak checks. If the leak check still takes greater than 3 minutes, call ECB for guidance and to determine if the pump or a pump diaphragm replacement is needed.

## Appendix B: Thermo Model 48i Time Settings Checks

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### *Check monitor averaging time*

- Main Menu
- Averaging Time – set to 120 seconds

### *Check Calibration / Zero Span Check run times*

- Next Time – even hours at minute 46
- Period Hr – 2
- Zero Duration Min –13 minutes
- Span Duration Min – 0
- Purge Duration Min – 0
- Zero / Span Avg Sec – 300
- Zero / Cal Reset – ON
- Zero / Span Reset – OFF
- Zero / Span Ratio – 1

## Appendix C: Envidas Phase versus Calibrator Display

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### Millbrook

Envidas Phase	Concentration (ppb)	Dilution Flow (cc/min)	Gas Flow (cc/min)	146i Calibrator Display
ZERO	0	2000	0.0	ZERO
SPAN	4000	1471	28.85	SPAN1
SPAN 1	500	3990	9.62	SPAN3
SPAN 2	2000	1981	19.23	SPAN2
SPAN 3	300	7988	11.54	SPAN4
SPAN 4	1000	5974	28.85	SPAN6
SPAN 5	3000	1971	28.85	SPAN5

### Triple Oak

Envidas Phase	Concentration (ppb)	Dilution Flow	Gas Flow	T700 Calibrator Display
ZERO	0	2000	0.0	SPN0
SPAN	4000	1470	30.3	SPN
SPAN 1	500	3990	10.1	SPN1
SPAN 2	2000	1980	20.2	SPN2
SPAN 3	300	3994	5.9	SPN3
SPAN 4	1000	5970	30.3	SPN4
SPAN 5	3000	1970	30.3	SPN5

Appendix D: Thermo Model 48i Analyzer menu flowchart



## Appendix E: Glossary of Terms <sup>[1]</sup>

[1] September 4, 2020 Revision

**Acceptance criteria** – is the pollutant-specific criteria that must be met to collect valid data specified by the United States Environmental Protection Agency in their validation templates, included as Appendix D to the United States Environmental Protection Agency Quality Assurance Handbook.

**Calibration** – is the act of changing or setting values in a monitor.

- *Gaseous Monitor Calibration* – is the act of setting response values stored in a monitor while running a series of challenge concentrations. A calibration for a monitor is accomplished by pressing a button to change the values stored in the monitor for each challenge concentration. For carbon monoxide a calibration involves running three upscale points to set or reset the coefficients. For all other gaseous monitors the challenge concentrations include zero and at least one span point.
- *Particulate Matter Calibration* - For low volume particulate matter monitors a calibration is the changing or resetting of the span and offset using three flow points bracketing the desired flow point. For PM monitors the temperature and pressure calibration is changing or resetting a slope using a one-point measurement. The temperature and pressure calibration must be completed before the flow calibration.

**Calibration Criteria** – are pollutant-specific limits established by the Division of Air Quality that a calibration must meet to pass and be used to collect valid data. The calibration criteria may be equal to or more stringent than the EPA acceptance criteria.

**Control Limits** – are limits established by the United States Environmental Protection Agency and published in the Code of Federal Regulations at 40 CFR Part 58 Appendix A. These limits may not be exceeded. They are listed as acceptance criteria in the Environmental Protection Agency validation tables in Appendix D to the United States Environmental Protection Agency Quality Assurance Handbook and North Carolina Division of Air Quality validation tables in the North Carolina Division of Air Quality quality assurance project plans. The precision, zero and span for gaseous monitors or flow rate verification for particulate matter monitors must be within the control limits for the collected data to be valid. Data collected when the precision, zero and span or flow rate verifications are outside of the control limits will be invalidated and replaced with a null code.

**Electronics and Calibration Branch Performance Evaluation** – is a check performed by the Electronics and Calibration Branch electronics technicians to confirm the correct operation of an instrument. At a minimum it involves challenging the instrument with a zero and three upscale points. One of the upscale points must be at the detection limit of the instrument. Another upscale point is either at the level of the national ambient air quality standard or at the level of the highest measured values. The Electronics and Calibration Branch electronics technicians must perform an Electronics and Calibration Branch performance evaluation on each instrument at least once every 365 days and at least once every calendar year.

**Flowrate Audit** - is a measurement of flow, ambient pressure and ambient temperature to ensure correct operation of the monitor, performed by someone other than the operator using a certified flow standard different from that used to calibrate or verify the monitor.

**Flowrate Verification** – is a measurement of flow, ambient pressure and ambient temperature by the operator to ensure correct operation of the monitor.

**Functionality Test** – is a test of the monitor, calibrator, cylinder, or zero air supply conducted by an ECB electronics technician, either remotely or on site, to evaluate whether the system is performing as expected. It may include running a zero and span or multiple points. Since functionality tests involving the running of points do not necessarily run the points long enough for them to stabilize and are not necessarily recorded in an elog, results of functionality tests are not reported to AQS. Functionality tests, alone, cannot be used as weight of evidence to demonstrate that the monitor is functioning properly.

**Installation** – is when a monitor is both taken to a site and plugged in. A leak check followed by a calibration is required on installation and before data reporting.

**Manual Performance Checks** – are any performance checks completed by the regional operator to evaluate the instrument and its performance. A manual performance check could be a precision, zero, span or just a zero and a span or just a one-point quality control check. It could be performed remotely or on-site. It includes manual 14-day one-point quality control checks performed at the site.

**Moving** – for a gaseous monitor, is removing the monitor from the monitoring shelter.

**Multi-point Verification** – is the check that the operator performs after completing a calibration on a gaseous monitor. It includes running a zero, span and two (for sulfur dioxide) or three intermediate, equally spaced concentrations to verify the linearity of the calibration and assess the overall success of the calibration. A multi-point verification may be used instead of a calibration for carbon monoxide and other pollutants, when allowed by an SOP, for the calibration required once every 365 days or when calibrators and cylinders are replaced.

**National Performance Audit Program Performance Evaluation** – is a performance check completed by United States Environmental Protection Agency contractors to confirm the correct operation of an instrument. It involves challenging the instrument with a zero and several upscale points.

**One-Point Quality Control Check** – is a check performed at least once every two weeks on each gaseous monitor. It must fall within the range of 0.5 to 5 parts per million for carbon monoxide and 5 to 80 ppb for all other gaseous pollutants. Any check that meets the requirements of a one-point quality control check must be reported to the Air Quality System.

**Precision, zero, span or PZS** – is the automated scheduled check that runs each night to measure drift in the zero, span and one-point-quality control check also known as the precision point.

- *Failed PZS* – is a check where all of the calibration equipment worked properly to provide the desired gas at the desired concentration, but the instrument failed to read the concentration within the EPA-established control limits. [Note that the action or warning limits are stricter than the control limits.] For SO<sub>2</sub> and O<sub>3</sub> the data for a failed PZS are reported to AQS. The data are invalidated back to the last passing PZS. The operator is required to take corrective action. Valid data cannot be reported until the problem is corrected, or the instrument is recalibrated.
- *Invalid PZS* – is a check where one or more components of the calibration system (solenoid, zero air generator, gas cylinder, ozone generator, mass flow controllers, etc.) used to produce the challenge concentration failed for some reason. As a result, the system failed to provide the desired gas at the desired concentration. The operator is required to take action within two working days to identify and document the cause of an invalid PZS. The invalid PZS for ozone and sulfur dioxide is reported to the Air Quality System with a null code that describes the reason the PZS failed. Because the PZS is invalid,

no data are invalidated as long as the calibration system is fixed and a passed PZS runs within 14 days. If the operator fails to act within the prescribed timeframe, the data may be flagged with a "6" for not following the standard operating procedure.

- *Passed PZS* – is a check where all of the calibration equipment worked properly to provide the desired gas at the desired concentration and the instrument successfully measured the concentration within the EPA-established control limits. For sulfur dioxide and ozone the data for a passed PZS are reported to AQS. The operator is only required to take corrective action if the check is outside of the EPA Region 4 recommended warning limits for two consecutive days.
- *Valid PZS* – is a check where all of the calibration equipment (solenoid, zero air generator, gas cylinder, ozone generator, mass flow controllers, etc.) used to produce the challenge concentration worked properly to provide the desired gas at the desired concentration. A valid PZS is necessary to have either a passed PZS or a failed PZS. A valid PZS refers only to the status of the equipment used to produce the challenge concentration and not the monitor that measures the challenge concentration.

**Shut down** – is when the monitor is no longer collecting reportable data.

**Start up** – is when the monitor is now collecting reportable data.

**Systems Test** – is a test of the monitor, calibrator, cylinder, zero air supply, or other support equipment conducted by an operator, either remotely or on site, to evaluate whether the system is performing as expected. It may include, but is not limited to, running a zero and span or multiple points. Since systems tests involving the running of points do not necessarily run the points long enough for them to stabilize, results of systems tests are not reported to AQS. Systems tests must be recorded in an elog and, alone, cannot be used as weight of evidence to demonstrate that the monitor is functioning properly.

**Warning Limits** – are limits recommended by the United States Environmental Protection Agency Region 4 and adopted by the North Carolina Division of Air Quality, which are stricter or tighter than the United States Environmental Protection Agency established control limits. The North Carolina Division of Air Quality has put them into place to minimize data loss. When the precision, zero and span for gaseous monitors or flow rate verification for particulate matter monitors are outside of the warning limits, the operator must take corrective action to identify the cause. If the cause is normal drift, the operator will recalibrate the instrument. If the cause is more serious, the instrument may be replaced or repaired and then recalibrated. Action must be taken but the data remain valid as long as the precision, zero and span or flow rate verification remains within the control limits. Data may be flagged with a "6" for not following the standard operating procedure if the operator fails to act within the timeframe prescribed by the standard operating procedure.

**Weight of evidence** – is documentation and verifiable proof that the monitor or calibration system was either working properly or failed in some manner. To demonstrate the system was working properly, the weight of evidence should thoroughly document that whatever occurred at the time had no effect on the data or did not compromise the quality or validity of the data collected. To be acceptable for use as weight of evidence, any points ran must be run by the regional office staff, must be documented in an elog, and must at a minimum include a precision point, zero point and span point. Whenever points are run to provide weight of evidence that the monitor is functioning properly, they must be reported to AQS.

## Appendix F: Guidance for Useful Logbook Documentation

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EPA has been providing guidance on record keeping requirements for QA/QC programs. In particular, EPA has discussed the role that logbooks play in providing proof that QAPPs and SOPs are being followed. According to EPA, logbooks should, at a minimum, provide the following to be a useful tool for documenting the operations conducted at a monitoring site:

1. Purpose – Define the purpose of this site visit. Tell why you are there. Is it to replace a filter? Did you note something in the previous data download that is indicating a problem? Are you experiencing data drops and want to see if anything is wrong? In a couple of sentences, tell what you intend to do. Don't say routine maintenance, say instead: "noted fluctuations in flow while reviewing the 5-minute average data". Be specific.
2. Appearance – Tell how you found the site. If the site was secure, say so. If you noted a problem, or a changed condition, then document it in a couple of sentences: "construction has taken place in the vacant lot next to the site since my last visit".
3. Action – Tell what you did. In a few short sentences describe the actions you took at the site: "cleaned the PM10 head and replaced one of the two gaskets". In particular, you might want to document any site computer updates that were run. Just things like that.
4. Results – Were you successful? Did you accomplish your goals? If so, then say so: "completed the monthly and quarterly maintenance and returned the monitor to "Wait" mode". If not, then say so: "failed as-left leak check, contacted ECB".
5. Response – Is the equipment operating within specifications set in SOP? If so, then great, note that fact in the logbook and you are done. If not, then what did you do? If something is wrong then reach out for help and document it: "contacted \_\_\_\_\_ at ECB, it was recommended \_\_\_\_\_."
6. Reviewers should add their comments: "reviewed above, approved operator action." Or: "upon review noted deviation from SOP".



Example of Logbook Tab

<b>CO -t/e Logbook</b> <small>Revision 7.0 (April 1, 2022)</small>											
Site: <input style="width: 80%;" type="text"/>	Time: <input style="width: 80%;" type="text"/>	Date: <input style="width: 80%;" type="text"/>	Operator: <input style="width: 80%;" type="text"/>								
Channel Down: <input style="width: 80%;" type="text"/>	Channel Up: <input style="width: 80%;" type="text"/>	Log Off Site Computer? <input style="width: 80%;" type="text"/>									
<b>Routine Site Inspection</b>  Building Secure (Y/N) <input style="width: 80%;" type="text"/> Sampling Probe Intact (Y/N) <input style="width: 80%;" type="text"/> Building Power On (Y/N) <input style="width: 80%;" type="text"/>	<b>Building Temperature °C</b> NIST Thermometer Serial No: <input style="width: 80%;" type="text"/> Expiration Date: <input style="width: 80%;" type="text"/> NIST: <input style="width: 80%;" type="text"/> (± 2 °C of NIST?) Comet: <input style="width: 80%;" type="text"/> <span style="color: red; font-weight: bold;">OK</span> HoBo: <input style="width: 80%;" type="text"/> <span style="color: red; font-weight: bold;">OK</span> HoBo Battery > 1 bar? <input style="width: 80%;" type="text"/> Yes	<b>Computer / Monitor Time</b> <table style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="width: 50%; text-align: center;">Date (mm/dd/yy)</th> <th style="width: 50%; text-align: center;">Time (hh:mm)</th> </tr> </thead> <tbody> <tr> <td>NIST: <input style="width: 80%;" type="text"/></td> <td><input style="width: 80%;" type="text"/></td> </tr> <tr> <td>Analyzer: <input style="width: 80%;" type="text"/></td> <td><input style="width: 80%;" type="text"/></td> </tr> <tr> <td>Site Computer: <input style="width: 80%;" type="text"/></td> <td><input style="width: 80%;" type="text"/></td> </tr> </tbody> </table> <p style="font-size: small; text-align: right;">All must be within ± 1 min. of NIST</p> Site Computer Restarted this Month? <input style="width: 80%;" type="text"/>		Date (mm/dd/yy)	Time (hh:mm)	NIST: <input style="width: 80%;" type="text"/>	<input style="width: 80%;" type="text"/>	Analyzer: <input style="width: 80%;" type="text"/>	<input style="width: 80%;" type="text"/>	Site Computer: <input style="width: 80%;" type="text"/>	<input style="width: 80%;" type="text"/>
Date (mm/dd/yy)	Time (hh:mm)										
NIST: <input style="width: 80%;" type="text"/>	<input style="width: 80%;" type="text"/>										
Analyzer: <input style="width: 80%;" type="text"/>	<input style="width: 80%;" type="text"/>										
Site Computer: <input style="width: 80%;" type="text"/>	<input style="width: 80%;" type="text"/>										
<b>Cylinder Number (&gt;500 psig)</b> <input style="width: 80%;" type="text"/> Cylinder Concentration (ppm) <input style="width: 80%;" type="text"/> Cylinder Expiration Date <input style="width: 80%;" type="text"/> Days Remaining <span style="background-color: red; color: white; padding: 2px;">0</span>	Cylinder Pressure (psig): <input style="width: 80%; background-color: #f8d7da;" type="text"/> Cylinder Delivery Pressure (psig): <input style="width: 80%;" type="text"/>	<b>Teledyne 701 Zero Air Serial No. / ID</b> <input style="width: 80%;" type="text"/> Delivery Air Pressure (psig): <input style="width: 80%;" type="text"/> Expiration Date: <input style="width: 80%;" type="text"/> Days Remaining <span style="background-color: red; color: white; padding: 2px;">0</span>									
<b>TEI Model 48i-TLE CO Analyzer Serial No. / ID</b> <input style="width: 80%;" type="text"/> Range @ 5 ppm? (Y/N) <input style="width: 80%;" type="text"/> Temp - Bench (40-59°C) <input style="width: 80%; background-color: #f8d7da;" type="text"/> Temp - Internal (38-43°C) <input style="width: 80%; background-color: #f8d7da;" type="text"/>	Pressure (250-1000mm Hg) <input style="width: 80%; background-color: #f8d7da;" type="text"/> Flow Setting (0.3-1.5 LPM): <input style="width: 80%; background-color: #f8d7da;" type="text"/> Sample/Ref Ratio (0.9 - 1.20): <input style="width: 80%; background-color: #f8d7da;" type="text"/>	Averaging Time (120 sec) <input style="width: 80%; background-color: #f8d7da;" type="text"/> AGC Intensity (150,000-300,000 Hz): <input style="width: 80%; background-color: #f8d7da;" type="text"/> Motor Speed (99.9% - 100.1%) <input style="width: 80%; background-color: #f8d7da;" type="text"/> Alarms (Y/N) <input style="width: 80%; background-color: #f8d7da;" type="text"/>									
<b>Calibrator</b> Thermo 146i Serial No. / ID <input style="width: 80%;" type="text"/> Exp. Date <input style="width: 80%;" type="text"/> Internal Temp. (18.5 to 47°C) <input style="width: 80%;" type="text"/> Days Remaining <span style="background-color: red; color: white; padding: 2px;">0</span> Alarms? (Y/N) <input style="width: 80%;" type="text"/>	API T700U Serial No. / ID <input style="width: 80%;" type="text"/> Exp. Date <input style="width: 80%;" type="text"/> Box Temp. (shelter ± 7°C) <input style="width: 80%; background-color: #f8d7da; color: red; font-weight: bold;"/> Ok Days Remaining <span style="background-color: red; color: white; padding: 2px;">0</span> Alarms? (Y/N) <input style="width: 80%;" type="text"/>	<b>Analyzer Filter: Date Changed</b> <input style="width: 80%;" type="text"/> Leak Check Sample (pre-filter change): <input style="width: 80%;" type="text"/> Leak Check Span (pre-filter change): <input style="width: 80%;" type="text"/> Leak Check Sample (post-filter change): <input style="width: 80%;" type="text"/> Leak Check Span (post-filter change): <input style="width: 80%;" type="text"/> Calibrator Cooling Fan Filter Cleaned <input style="width: 80%;" type="text"/> <small>(Thermo Calibrator Only)</small>									
<b>Sample Flow and Sample Line Residence Time Evaluation</b> Sample Line Length (meters) <input style="width: 80%;" type="text"/> Sample Line Residence Time (sec) <input style="width: 80%;" type="text"/> Sample Line Residence Time (≤ 20 Sec) <input style="width: 80%;" type="text"/> <small>(See site logbook for most recent sample line length)</small>											
Hobo Temperature Downloaded <input style="width: 80%;" type="text"/>		Date Range <input style="width: 80%;" type="text"/>									
<b>NOTES:</b>											
<b>NOTES: Regional Chemist</b>											
<b>NOTES: Central Office Chemist</b>											
RCO Review by: <input style="width: 80%;" type="text"/>	Review Date: <input style="width: 80%;" type="text"/>										

Example of Manual Check Tab

CO-t/e Manual Check											
Revision 7.0 (April 1, 2022)											
Site: 0		Time: 0:00		Date: 01/00/00		Operator: 0					
Cylinder Concentration (ppm) 0.0				Calibration Factors As Found							
				Background PPM:				CO Coefficient:			
<b>SPAN ZERO</b> 0 ppb			<b>SPAN</b> 4000 ppb			<b>SPAN 2</b> 2000 ppb			<b>SPAN 1</b> 500 ppb		
CAL Gas (SCCM)	DIL Gas (SCCM)	Calibrator (CO)	CAL Gas (SCCM)	DIL Gas (SCCM)	Calibrator (LPM)	CAL Gas (SCCM)	DIL Gas (SCCM)	Calibrator (CO)	CAL Gas (SCCM)	DIL Gas (SCCM)	Calibrator (CO)
		#DIV/0!			#DIV/0!			#DIV/0!	9.59	3988.00	0.00
<b>ZERO</b>			<b>SPAN</b>			<b>SPAN 2</b>			<b>SPAN 1</b>		
Time HH:mm	COT Analyzer	Calibrator (Actual)	Time HH:mm	COT Analyzer	Calibrator (Actual)	Time HH:mm	COT Analyzer	Calibrator (Actual)	Time HH:mm	COT Analyzer	Calibrator (Actual)
Avg ppb	#DIV/0!	#DIV/0!	Avg ppb	#DIV/0!	#DIV/0!	Avg ppb	#DIV/0!	#DIV/0!	Avg ppb	#DIV/0!	#DIV/0!
Act. Diff	#DIV/0!		Act. Diff	#DIV/0!		Act. Diff	#DIV/0!		Act. Diff	#DIV/0!	
			% Diff	#DIV/0!		% Diff	#DIV/0!		% Diff	#DIV/0!	
Acceptable: [diff ± 60 ppb] #DIV/0!			Acceptable: [diff ± 5 %] #DIV/0!			Acceptable: [diff ± 5 %] #DIV/0!			Acceptable: [diff ± 7 %] #DIV/0!		
NOTES:											





Example of Calibration Verification Tab

CO <sub>2</sub> e Multi-Point Verification											
Revision 7.0 (April 1, 2022)											
Site: 0		Time: 0:00		Date: 01/00/00		Operator: 0					
Cylinder Concentration (ppm): 0.0			SPAN (ppb)		CAL Gas		DIL Gas		Calibrator (CO) (Calculated)		
Slope: #DIV/0!			SPAN ZERO 0						#DIV/0!		
Intercept: #DIV/0!			SPAN 4 1000						#DIV/0!		
R: #DIV/0!			SPAN 2 2000						#DIV/0!		
			SPAN 5 3000						#DIV/0!		
			SPAN 4000						#DIV/0!		
						Calibration Factors					
						As Found			Post Calibration		
Background PPM						0.000			Background PPM 0.00		
Coefficient 1						0.00000			Coefficient 1 0.0000		
Coefficient 2						0.00000			Coefficient 2 0.0000		
Coefficient 3						0.00000			Coefficient 3 0.0000		
ZERO			SPAN 4		SPAN 2		SPAN 5		SPAN		
Time HH:mm			Time HH:mm		Time HH:mm		Time HH:mm		Time HH:mm		
Analyzer COT			Analyzer COT		Analyzer COT		Analyzer COT		Analyzer COT		
Calibrator 146i / T700U			Calibrator (Actual)		Calibrator (Actual)		Calibrator (Actual)		Calibrator (Actual)		
Avg ppb			Avg ppb		Avg ppb		Avg ppb		Avg ppb		
[diff ± 30 ppb]			[diff ± 30 ppb or 2%]		[diff ± 30 ppb or 2%]		[diff ± 30 ppb or 2%]		[diff ± 30 ppb or 2%]		
Acceptable: Yes			Acceptable: #DIV/0!		Acceptable: #DIV/0!		Acceptable: #DIV/0!		Acceptable: #DIV/0!		
NOTES:											

Example of Regression Tab

**CO-t/e Regression**  
 Revision 7.0 (April 1, 2022)

Acceptance Criteria: all points within D8% of best fit straight line

**Instructions**

- 1) Place in the acceptable percentage (2% is current validation criteria) in D8
- 2) Select the calibration scale. This does not need to be the FEM approved scale of the instrument (e.g., 500 ppb or 1000 ppb) in D9. It should be the high cal value. The point difference acceptance value in field D8 will be calculated for the values entered in D8 and D9
- 3) Calibration values (X) in Row 21 are linked to the Calibrator minute values entered on the Calibration Verification Tab
- 4) Instrument values (Y) are linked to the Analyzer minute values entered on the Calibration Verification Tab.
- 5) The remainder of the worksheet should automatically calculate the results.
- 6) Any **point result** > the point difference acceptance criteria in D10 will turn the boxes and font in rows 30 red. Any **percent difference** > the value in D8 will turn the boxes and font in rows 31 red.
- 7) The percent difference estimates are measured using the best fit conc. values (row 29) and the average of the instrument avg. values (row 27) for each concentration.

What percentage is acceptable?	2%
Calibration Scale	4000
Point Difference Acceptance Value	30
Slope Acceptance Criteria	0.95 - 1.05

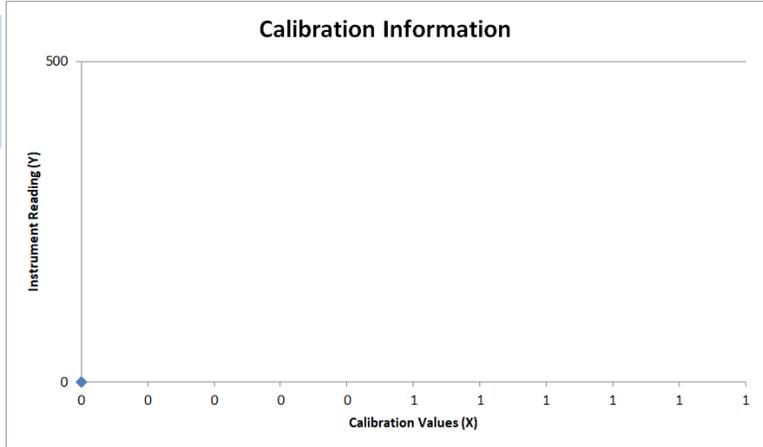
Only values on sheet that can be changed are in gray, above

	Zero Concentration 1	SPAN 4 (~1000 ppb) Concentration 2	SPAN 2 (~2000 ppb) Concentration 3	SPAN 5 (~3000 ppb) Concentration 4	SPAN (~4000 ppb) Concentration 5
Calibrator Value (X)	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
Instrument Value (Y)	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00
Average	0.00	0.00	0.00	0.00	0.00

Best Fit Concentration	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
Point Difference (Best fit - Average) absolute value	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
Percent Difference (Best fit Conc vs. Avg Y values)	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!

r	slope (m <sub>i</sub> )	intcpt (I <sub>i</sub> )	lin reg
#DIV/0!	#DIV/0!	#DIV/0!	#VALUE!

(Calibrator) X	(Monitor) Y
#DIV/0!	0.00



Example of Calibration Graph Tab

CO- <i>t/e</i> Calibration Graph			
Revision 7.0 (April 1, 2022)			
Site:	0	Time:	0:00
Date:	01/00/00	Operator:	0
<b>As Found Calibration Factors</b>		<b>Span (ppb)</b>	<b>Concentration Value Entered in Monitor</b>
Background PPM		SPAN ZERO	0
Coefficient 1		SPAN	4000
Coefficient 2		SPAN 2	2000
Coefficient 3		SPAN 3	300
<b>Post Calibration Calibration Factors</b>			
Background PPM			
Coefficient 1			
Coefficient 2			
Coefficient 3			
<b>Copy and Paste Calibration Graph below:</b>			
NOTES:			