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DAQ-08-001.2 Standard Operating Procedure (SOP) MODEL T500U NITROGEN DIOXIDE (NO₂) MONITORING SYSTEM OPERATOR RESPONSIBILITIES

Revision 2.0



1.0 APPROVAL SIGN-OFF SHEET

I certify that I have read and approve of the contents of the Model T500U Nitrogen Dioxide (NO₂) Monitoring System, Section II, Operator Standard Operating Procedure with an effective date of June 17, 2022.

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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 nitrogen dioxide (NO₂) monitoring is outside the purview of this Standard Operating Procedure, contact the Electronics and Calibration Branch and the Raleigh Central Office for guidance.

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2.0 SCOPE AND PURPOSE

On February 9, 2010, the United States Environmental Protection Agency (US EPA or EPA) finalized new minimum monitoring requirements for the nitrogen dioxide (NO₂) monitoring network in support of a 1-hour NO₂ National Ambient Air Quality Standard (NAAQS). The 2010 NO₂ regulations, as modified in 2016, require state and local air monitoring agencies to install NO₂ monitoring stations at locations where peak hourly NO₂ concentrations are expected to occur such as in large urban areas or within the near-road environment in large urban areas.

On Oct. 26, 2015, in addition to establishing a revised NAAQS for ozone, the EPA also finalized revisions to the photochemical assessment monitoring station, or PAMS, network requirements. The 2015 revisions to the PAMS monitoring requirements significantly changed the program and imposed for the first time PAMS ambient monitoring requirements at National Core, or NCore, sites in ozone attainment areas. These PAMS monitoring requirements call for the state and local air monitoring agencies to install true NO₂ monitors at PAMS stations at NCore sites in urban areas with over one million people.

The purpose of this standard operating procedure (SOP) is to describe the analysis of “true” NO₂ by cavity attenuated phase shift (CAPS) spectroscopy instruments for the EPA Photochemical Assessment Monitoring Stations (PAMS) networks. The Model T500U CAPS NO₂ Monitor provides a direct measurement of NO₂ utilizing CAPS spectroscopy. This technique has many advantages over chemiluminescence, eliminating nearly all of the maintenance items and producing an extremely accurate and fast response measurement of NO₂. The Model T500U possesses the US EPA Federal Equivalent Method (FEM) designation (EQNA-0514-212).

In support of the PAMS requirements, the State of North Carolina Division of Air Quality (DAQ) operates CAPS monitors for the purpose of monitoring the ambient NO₂ exposure of the general population, determining the effect of nitrogen compounds on ozone formation, and measuring background concentrations of NO₂ in the ambient air. 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 US EPA in 40 Code of Federal Regulations (CFR) Parts 50, 53, and 58.

This SOP describes the real-time, continuous measurement of “true NO₂” by sampling ambient air with an instrument approved as an EPA Federal Equivalency Method. The instrument response at the detector corresponds to the analyte concentration as determined by a multi-point calibration curve.

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 elog will certify that the activities indicated have been performed in accordance with this SOP and that the information contained on the form is accurate. All records will be reviewed and verified by the Regional Ambient Monitoring Coordinators (RAMCs) and validated and audited by the responsible chemists at the DAQ.

3.0 EQUIPMENT CHECKS

The significant instrumentation and equipment at each DAQ NO₂ monitoring site includes:

- Teledyne Model T500U NO₂ Monitor
- Teledyne – Advanced Pollution Instrumentation (API) T700U Dilution Gas Calibrator
- Teledyne – API 701 Zero Air Generator
- EPA Protocol nitrogen oxide (NO) gas cylinder
- Data management system (e.g. Envivas Ultimate/ Envista Air Resources Manager [ARM])
- Ethernet / modem connectivity

- Uninterruptible Power Supply
- 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.

In general, the T500U NO₂ monitoring system consists of the following components:

- **Pneumatic System:** This portion of the monitoring system consists of a sample inlet incorporating a heated sample inlet line, dilution calibrator, zero air generator and internal sample pump, all being used in conjunction to supply gaseous samples to the monitor inlet.
- **Analytical System:** This portion of the monitoring system uses a CAPS spectrometer and operates as an optical absorption spectrometer. The front panel of the T500U is pictured below.



Figure 1 CAPS T500U Home Screen

- **Electronic Hardware:** This portion of the monitoring system consists of the electronic components that control the monitor and process the signals.

3.1 Teledyne Model T500U NO₂ Operational Check

Verify and document (*in the elog*) the T500U monitor settings using the Dashboard screen on the front of the instrument panel as pictured below.

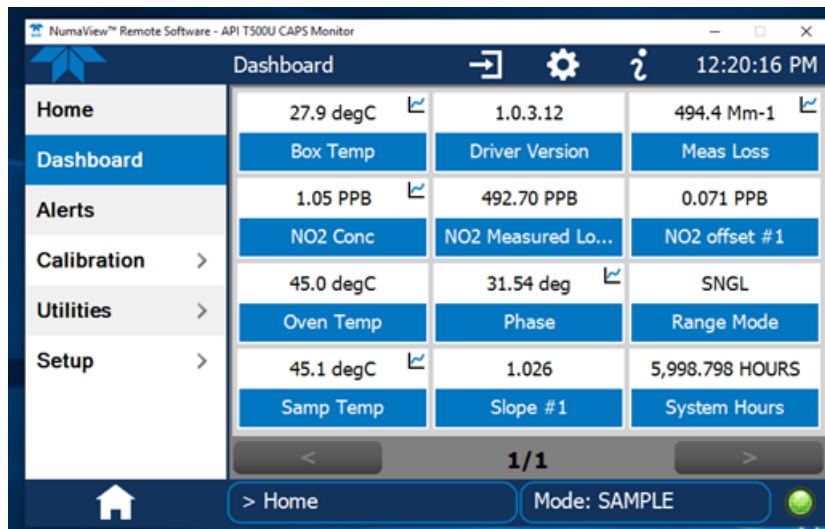


Figure 2 CAPS T500U Dashboard Screen

Instrument setting parameters while generating zero gas should be:

| Parameter | Expected Value |
|---------------------------------------------|-----------------------------------------------------|
| Instrument Range/Concentration Units | 200 PPB |
| Sample Pressure (In Hg-A) | 26 – 29 In Hg |
| AREF_L (Mm-1) | < 650 Mm-1 ^[1] with Zero Air |
| Box Temperature (degrees Celsius [°C]) | Ambient ± 5.0 °C |
| Oven Temperature (°C) | 45 ± 1 °C |
| Phase (degree of angle) | > 25 degrees with Zero Air |
| NO ₂ Measured Loss with Zero Air | 400 – 800 = Mm-1 ^[2] |
| NO ₂ Measured Loss with Span Gas | 400 – 1800 Mm-1 0 – 1000 parts per billion (ppb) |
| Range Mode | SNGL (i.e., single) |
| Slope #1 | -0.8 to 1.2, optimal is 1.000 |
| NO ₂ Offset #1 | ± 10.0 PPB, optimal is 0.0 ppb |

^[1] Mm-1: Unit of measurement to express light absorption, expressed in MEGA (10⁶) per meter

^[2] Mm-1: Unit of measurement to express light absorption, expressed in ppb for NO₂

3.2 Leak Check

A leak check should be completed monthly during a site visit. Obtain a leak checker device that has a small pump, shut-off valve, and pressure gauge to create an over-pressure condition, less than or equal to 10 pounds per square inch gauge (psig) (5 psig is recommended when performing a leak check). Results of the leak check should be documented (*in the elog*) and in the site logbook monthly for future reference by ECB technicians or other site operators. Notify ECB immediately if a leak check failure occurs. See Appendix F or Section 5.6.5 of the [manual](#) for step-by-step instructions for completing the leak check.

3.3 Sample Flow Check

A sample flow check should be completed monthly during a site visit. Sample flow checks are useful for monitoring the actual flow of the instrument and calculating the residence time.

1. Connect power to the Alicat mass flow meter being used and allow the instrument to stabilize (~ 5 minutes).
2. Using the Alicat mass flow meter with inlet and outlet capped, perform an initial flow tare by pressing the button labeled "TARE" for approximately 5 seconds. This action tares the flow meter and provides the mass flow meter a reference point for zero flow. (Appendix H provides the manufacturer's instructions for taring the device.)
3. Disconnect the sample line IN at the back of the monitor.
4. When the Alicat TARE is stable, remove the cap and connect the Alicat to the monitor at the sample IN port, observing the correct flow direction.
5. The measured sample flow should be between 810 – 990 cubic centimeters per minute (cc/min) and documented (*in the elog*) and in the site logbook monthly for future reference by ECB technicians or other site operators.
6. Once the sample flow has been measured, disconnect the Alicat mass flow meter and reconnect the sample line at the sample line IN port.

Notify ECB immediately if the sample flow is outside the acceptable range. A decreasing sample flow may point to slowly clogging pneumatic paths, most likely the sample flow restrictor or the sample filter. See Appendix G or Section 5.6.5.2 of the [manual](#) for step-by-step instructions for completing the sample flow check.

3.4 Teledyne API 700U Dilution Gas Calibrator Operational Check

The most common and/or serious instrument failures will result in a warning message being displayed on the front panel of the instrument. The T700U will alert the user that a Warning Message is active by flashing the "FAULT" light emitting diode (LED) and displaying the warning message in the parameter field. The "MSG" button displays if there is more than one warning in the queue or if the instrument is placed in the "TEST" menu and messages have not been cleared. To view or clear the various warning messages, see Figure 2.

- Verify the calibrator is in the "STANDBY" mode, if not press "STBY" or ABORT in Phase being run by the EnviDas Ultimate software.
- Press "TEST" to view warning message in the parameter field.
- Press "CLR" to clear the warning.

NOTE: If the T700U reads "REGULATOR PRES WARN" after the ZERO/SPAN is generated, verify the "CAL PRESS" and "DIL PRESS" are 25-30 psig while performing SPAN 1 by scrolling through the "<TST or TST>" buttons.

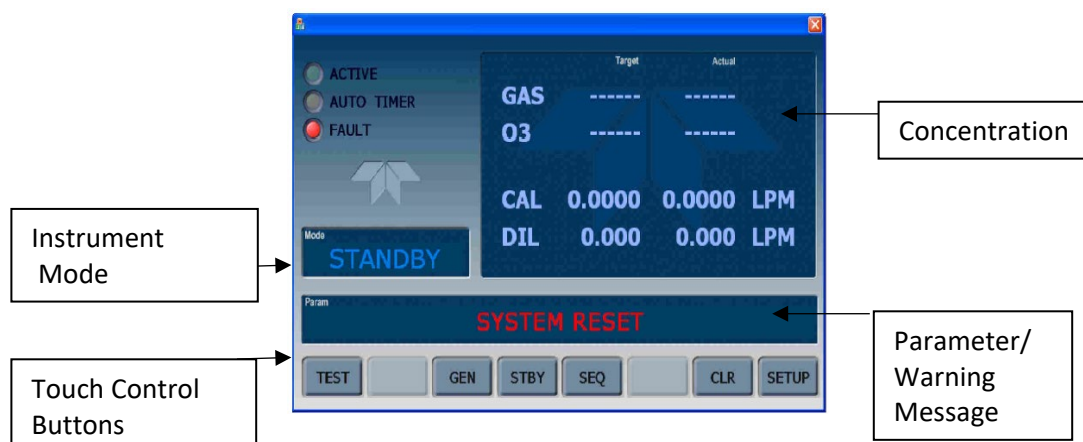


Figure 3 T700U Main Menu Screen

3.5 Calibration Gas Cylinder and Calibrator Check

Verify that the calibration gas cylinder and/or calibrator are in certification and document certification dates in the *elog*. Calibration gas cylinders at a concentration of approximately 10.0 parts per million are certified for three 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 calibration cylinder requested. The delivery of a new calibration gas cylinder or a calibrator must be coordinated with the Region.

Calibrator certification is valid for *365 days* and the calibration date 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 (See Section 3.4, Figure 3):

1. Make sure the calibrator is in the "STANDBY" mode (if not, press "STBY")
2. Press the following key in the order given: "SETUP" "GAS" "CYL" "PRT1"
3. Verify the concentration entered corresponds to the calibration cylinder.
4. Press "EXIT" "EXIT" "EXIT" "EXIT" (until "STANDBY" mode is reached)
5. Verify the gas cylinder outlet pressure is set to 30 psi and cylinder valve and regulator valve are fully open.

3.6 Model 701 Zero Air Generator Check

Verify that the delivery pressure is set to 30 ± 2 psig. If the delivery pressure is outside of the ± 2 psig range, adjust the pressure using the pressure adjust control knob. Document in the *elog*. As the expiration date of the Model 701 Zero Air Generator approaches, contact the ECB to make arrangements for a recently serviced Zero Air Generator to be placed in service at the site.

3.7 Monitor Filters

The T500U operates with an internal in-line sample filter along with an Auto Reference (AREF) filter assembly (backup particle filter and charcoal filter, which is an NO₂ gas scrubber). The manufacturer recommends these filters be changed annually or more frequently if needed. If the AREF is observed to be increasing significantly or approaching values near 1100 Mm-1, ECB should be notified as this is an indicator that the monitor requires maintenance. Annual filter changes should be scheduled with and completed by ECB personnel.

4.0 SITE CHECKS

4.1 Site Visit

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 DAS for appropriate date/time and concentration readings. Document all observations and actions in the *elog*. 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.

4.2 Shelter Temperature

The shelter temperature sensor (Comet Temperature Probe connected to Site Computer and reported via Envidas Ultimate) 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 elog. If either of the shelter temperature sensors is reading greater than ± 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 ± 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, "TO 20120201to15 ST.xls" would be Triple Oak Shelter Temperature between 01 Feb and 15 Feb 2020. 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 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 20.0 °C to 30.0 °C range, if needed for other monitors or 5.0 °C to 40.0 °C if the CAPS is in its own shelter. It is best to keep the shelter temperature closer to 30 °C to minimize condensation in the probe line. If the temperature cannot be stabilized and controlled within this range, notify the RAMC and the ECB that corrective action is required. Document in the elog.

The shelter temperature should remain fairly constant and not vary more than ± 2 °C standard deviation over any 24-hour period. The statistician at the RCO keeps track of this statistic and flags data accordingly.

4.3 Electrical Power and Sample Line Check

Observe the monitor, calibrator, computer 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. Record all events in the elog.

4.4 Time and Date Check

The time displayed via the PC / Envidas Ultimate site computer, and the monitor must be EASTERN STANDARD TIME and be synchronized to NIST time (± 1 minute). Time Synchronization of the site computer is an automated process that is initiated by the Department of information Technology (DIT) on a pre-determined schedule. Time synchronization of the monitor occurs once per 24 hours using a Network Time Protocol (NTP) Server and must be within ± 1 minute of NIST time.

NOTE: The HOBO data logger time is set when the device is launched. Launching is required after battery replacement and should be performed at least once every 30 days to synch time with the site computer 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).

If the times for either the monitor or site computer 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 computer, and monitor (Instrument Controls – Date and Time) as compared to NIST time on the elog created for the site visit.

Sources for getting the correct time:

- Call the ECB lab and ask for the NIST time
- Correct time website, <http://nist.time.gov>

5.0 DETAILED PROCEDURES

Calibration (Section 5.1) Requirements - A Calibration followed by a Multi-point Verification is required:

- During the site start-up / installation
- Whenever the system’s operation is interrupted for more than 72 hours without power or offline (such as hurricanes) or major repairs/maintenance.
- When the monitor undergoes major repairs or maintenance at the site
- When the SPAN drift on the nightly Precision-Zero-Span (PZS) check or One-Point Quality Control Check (QC Check) (on site or remote) is $> \pm 10\%$ of the target for any SPAN or SPAN 1 for two consecutive days (Table 3).
- When the zero drift on the nightly PZS or calibration check (on site or remote) is greater than or equal to ± 1.0 ppb for two consecutive days.

Criteria for PZS’s

| | Zero | Span | Precision (Span 1) |
|-------------------------|-----------------|------------|--------------------|
| Concentration (ppb) | 0 | 180 | 20 |
| Control Limit (\pm) | $< \pm 5.0$ ppb | $\pm 15\%$ | $\pm 15\%$ |
| Warning Limit (\pm) | $< \pm 1.0$ ppb | $\pm 10\%$ | $\pm 10\%$ |

- Once every 365 days and 1 per calendar year if continuous zero/span performed daily, regardless of monitor performance.

NOTE: A QC Check (Section 5.3) which includes the Precision Point (20 ppb) *is required* prior to any Calibration / Verification. This can be accomplished by completing the PZS sequence prior to a calibration / verification.

Calibration of the CAPS monitor consists of a three-step process:

1. Calibrate the ZERO using dry instrument grade air.
2. Calibrate the NO₂ by an automated gas phase titration (Gas Phase Titration Pre-Set (GPTPS) / Gas Phase Titration (GPT)) using an EPA Protocol NO gas cylinder balanced with nitrogen, leaving a remainder of NO gas generated from the calibrator.
3. Linear verification (0 and 4 upscale points), in the order given.

NOTE: If the monitor has malfunctioned the operator should forgo the QC Check by documenting the malfunction in the comments section of the *elog* and proceeding to the calibration / verification. Data will need to be invalidated back to the last passing QC Check.

Multi-Point Verification (Section 5.2) Requirements

The purpose of a multi-point verification is to correlate the output of a monitoring system with known traceable concentrations of NO₂ to demonstrate the linearity of the monitor response.

- A multi-point verification *is required* as a part of any calibration procedure.
- Within 182 days of the most recent calibration / verification, regardless of monitor performance.

NOTE: The points run for the Multi-Point Verification are: 0 ppb, 180 ppb, 135 ppb, 90 ppb, and 45 ppb.

One-Point Quality Control (QC) Check (Section 5.3) Requirements

The QC Check is to periodically verify that the monitor's calibration has not drifted out of optimal range.

- At least every 14 days or less (40 CFR Part 58, Appendix A, Section 3.2.1)
- As part of a QC Check, perform a Zero, and two (2) titration checks which include a Precision point check and a Span.
- The precision point (20 ppb) must be included during all manual QC Checks and is reported to AQS. (40 CFR Part 58, Appendix A, Section 3.2).
- Complete the required Equipment Checks and Site Checks as specified in [Section 3.0](#) and [Section 4.0](#) of this SOP prior to a QC Check.

NOTE: Regardless of which detailed procedure listed above is being completed, the status of the NO₂ channel should be set using the site computer so that no data is reported during the time the procedure is being completed. (*Refer to "Marking Channels Up or Down" in the RCO Guidance Documents folder under the Documents section of DAQ's Ambient Monitoring SharePoint page for instructions*).

5.1 Calibration

1. Using the [CAPSPZS](#) Phase from Sequence menu
 - a. Select [ZERO](#)
 - b. Select the length of time (1 hour is the default) and select [Start](#).
2. Open [NumaView](#) Remote Software application to display the NO₂ Concentration and Stability (Stab). (*NOTE: Stability is the standard deviation of concentration readings. Data points are recorded every ten seconds. The calculation uses the last 25 data points.*)
 - a. Using the [NumaView](#) screen select [HOME](#) > [Calibration](#) > [ZERO](#) button.
 - b. When the measured NO₂ value displayed on the monitor is less than 0.10 ppb and the stability has reached 0.5 ppb or less, Press [ZERO](#) – (Cal Result Success message will pop up) allow additional time if needed for the instrument to stabilize, *until NO₂ Stab <0.100 ppb*.
 - c. Using Envidas Reporter, record the updated five-minute average reading from the monitor (*elog, Calib & Verification Tab, Cell G8*). **NOTE: The measured zero must be $\leq \pm 1.5$ ppb.**
3. Abort [ZERO](#)
4. Using the [CAPSPZS](#) Phase from Sequence menu
 - a. Select [SPAN2](#) (GPTPS for the SPAN point)
 - b. Select the length of time (it is recommended to set the time to 1 hour) and select [Start](#).

- c. Keep the T700U in GPTPS mode until the “ACT” value for ozone (O₃) is within 1 ppb of the target value entered (Active LED not flashing + 5 minutes, ~10 min) (NOTE: During the GPTPS the NO₂ concentration value displayed by the monitor will be < 5 ppb)
5. Abort SPAN2 and initiate SPAN
 - a. Select the length of time (it is recommended to set the time to a minimum of 1 hour)
 - b. Allow instrument to stabilize until NO₂ STB < 0.500 ppb.
 - c. Using the *NumaView* screen select *HOME* > *Calibration* > *SPAN button*, press *Span Target* to verify the target span value is in agreement with the T700U_ACTO3 value generated by the calibrator during SPAN2.
 - d. When the stability has reached <0.500 ppb press the *SPAN button* (Cal Result SUCCESS will appear, click OK) Allow additional time for the instrument to stabilize, until NO₂ Stab is <0.500 ppb.
6. Using *Reporter*, record the updated 5-minute average reading from the monitor (*eLog*, *Calib* & *Verification Tab*, *Cell G9*). **NOTE: The measured “NO₂” Span should be ± 2% of the expected value.**

5.2 Multi-Point Verification (2 hours 20 minutes)

1. Using the “Phase from Sequence” menu
 - a. Select CAPSVER T500U from the pop-up menu then select Schedule Sequence when the window Initiate Session At appears, enter the value 0 minute and APPLY to start the sequence on the zero second. (CAPSVER T500U Sequence is preset to run for approximately 180 minutes)
 - b. Create a Viewer Dynamic Chart to capture each span point during the multi-point verification. Include the graphs in the *eLog* (*Span Graphs Tab*).
 - c. Using the *Envidas Reporter* (*Reporter*), record the last five 1-minute T700U_ACTCONC values generated during Span Zero portion of the sequence and the last five 1-minute NO₂_T500U values during the ZERO portion of the sequence
 - d. Using *Reporter*, record the last five 1-minute readings prior to a change in Status for each Span point run along with the last T700U_ACTO3 minute average value recorded during the GPTPS for each Span point (*eLog*, *Calib* & *Verification Tab*).

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 ± 1.5 ppb difference of the best-fit straight line, whichever is greater. It is recommended the slope be 1 ± 0.05 . If any of the points are greater than the acceptance criteria, the calibration is unacceptable. If the calibration is unacceptable contact ECB for guidance. (See *Appendix B* for details of the relationship of the GPTPS and GPT phases used in creating the various span point used in the multi-point verification.)

| Multi-Point Verification | Nominal Calibrator Concentration (T700U) | Acceptance Criteria (Nominal difference as compared to the best-fit line) |
|--------------------------|------------------------------------------|---------------------------------------------------------------------------|
| ZERO | 0.0 | $\leq \pm 1.5$ ppb |
| SPAN | 180 ppb | $< \pm 2.1\%$ or $\leq \pm 1.5$ ppb |
| SPAN 4 | 135 ppb | $< \pm 2.1\%$ or $\leq \pm 1.5$ ppb |
| SPAN 6 | 90 ppb | $< \pm 2.1\%$ or $\leq \pm 1.5$ ppb |
| SPAN 8 | 45 ppb | $< \pm 2.1\%$ or $\leq \pm 1.5$ ppb |

2. If the multi-point verification is acceptable, enable channels using *Envidas Ultimate* and logout.

- a. Set the monitor channel for NO₂ Reset Flags. (Refer to “Marking Channels Up or Down” in the RCO Guidance Documents folder under the Documents section of DAQ’s Ambient Monitoring SharePoint page for instructions).
- b. Once the Channel has been reset, observe that the Status is OK and that Raw, Instant and 1-minute values are changing. (The channel should no longer be highlighted blue)
- c. Using Envidas Reporter generate an Excel spreadsheet which includes minute data generated during the Calibration Procedure. (Approximately 5-minutes prior to and after the completion of the multi-point verification is ideal.) Copy the Excel spreadsheet and paste the values into the elog using the Minute Data tab provided (elog, Minute Data Tab).
- d. Verify the monitor is in “Sample” mode and the Calibrator is in “Standby” mode.
- e. Logout of Envidas Viewer and Reporter.

5.3 One-Point QC Check (PZS) (1 hour 20 minutes)

1. Using the “Sequence” menu
 - a. Select CAPSPZS, from the pop-up menu then select Schedule Sequence when the window Initiate Session At appears, enter the value 0 minute and APPLY to start the sequence on the zero second. (CAPSPZS Sequence is preset to run for approximately 80 minutes)
 - b. Press Start (A countdown window will appear that indicates the time in minutes and seconds before the sequence will begin).
 - c. CAPSPZS consists of the following Phases:
 - i. a ZERO
 - ii. a GPTPS (SPAN 9) and GPT (SPAN 1) for the Precision point
 - iii. a GPTPS (SPAN 2) and GPT (SPAN) for the SPAN point
 - d. Using the Envidas Reporter (Reporter), record the last five 1-minute T700U_ACTCONC values generated during Span Zero portion of the sequence and the last five 1-minute NO₂_T500U values during the ZERO portion of the sequence (elog, QC Check Tab).
 - e. Using the Reporter, record the last 1-minute T700U_ACTO3 value generated during the GPTPS (Span 9) portion of the sequence and the last five 1-minute NO₂_T500U (GPT) values generated during the SPAN 1 portion of the sequence (elog, QC Check Tab).
 - f. Likewise using Reporter, record the last 1-minute T700U_ACTO3 value generated during the GPTPS (Span 2) portion of the sequence and the last five 1-minute NO₂_T500U (GPT) values generated during the SPAN portion of the sequence (elog, QC Check Tab).

Review the NO₂ One-Point QC Check results. Acceptance Criteria for each Point are:

| Point (Nominal) | NO ₂ Conc. | Acceptance Criteria |
|-----------------|-----------------------|---------------------|
| ZERO | 0.0 ppb | ± 1.0 ppb |
| SPAN 1 (10-20%) | 20 ppb | ± 10% |
| SPAN (80-90%) | 180 ppb | ± 10% |

If any of the points are outside the One-Point QC check tolerance for the full-scale range, the QC Check is unacceptable. If the QC Check is unacceptable after two (2) tries, document the failure, contact ECB for guidance. A multi-point calibration followed by the verification sequence will be required prior to data collection should the One-Point QC check continue to fail the acceptance criteria.

2. If the calibration verification is acceptable, enable channels using Envidas Ultimate and logout.

- a. Set the monitor channel for NO₂ *Reset Flags*. (Refer to “Marking Channels Up or Down” in the RCO Guidance Documents folder under the Documents section of DAQ’s Ambient Monitoring SharePoint page for instructions).
- b. Once the channel has been reset, observe that the Status is OK and that Raw, Instant and 1-minute values are changing. (The channel should no longer be highlighted blue)
- c. Using Envidas Reporter generate an Excel spreadsheet which includes minute data generated during the Calibration Procedure. (Approximately 5-minutes prior to and after the completion of the Calibration Procedure is ideal.) Copy the Excel spreadsheet and paste the values into the elog using the Minute Data tab provided (*elog, Minute Data Tab*).
- d. Verify the monitor is in “Sample” mode and the Calibrator is in “Standby” mode.
- e. Logout of Envidas Ultimate Viewer and Reporter.

6.0 LOGBOOK SUBMITTAL – DATA REVIEW

6.1 Logbook Submittal

The NO₂ Logbook (elog) serves as the transfer record and document for evaluating the success/failure of the operation of the CAPS NO₂ monitor and is an essential record for determining the quality of the NO₂ data reported.

1. The **Site Operator** must complete the NO₂ elog to document the purpose of any site visit, the observations and findings during the site visit, and the evaluation of the performance of the NO₂ monitoring system for each site visit.
2. The site operator must submit the NO₂ Logbook (elog) to the RAMC or designee for review and document as soon as reasonably possible after the site visit and at a minimum by the end of each month. Additionally, a site logbook page should be annotated with any site visit, (i.e., shutting down for approaching weather, start-ups and shutdowns, etc.). Each site visit should provide an elog and an entry in the site logbook stating, at a minimum, a purpose for the visit.
3. The **RAMC** or designee must review site operator monthly submitted NO₂ elogs for each site in the region and evaluate each elog for completeness and operator adherence to operating procedures. The RAMC must also consider and compare all NO₂ elogs submitted for all NO₂ sites in the region and determine if a pattern of operation is negatively impacting the NO₂ sites in that region. 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. 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.
4. Following the review, the RAMC must initial and submit each NO₂ logbook to the RCO chemist for review.
5. The **RCO Chemist** must review the logbooks submitted by each region for all NO₂ sites for completeness and adherence to operating procedures. The RCO chemist must also review the logbook submitted from each site and from all regions to determine if there is a procedure or pattern of operation that may be negatively impacting the overall operation of the NO₂ monitoring network and the quality of the NO₂ data reported.
6. All electronic logbooks must be submitted to the RCO via the p-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.

7. The RCO Chemist must review the elogs submitted for completeness and adherence to operating procedures.

6.2 Data Retrieval and End Processing

Each business day, the RCO statistician initiates a data review by providing a raw data report (in a spreadsheet format) to each Regional Office. (RO) (Reference [DAQ-15-005.5 Data Verification and Validation for Continuous Gaseous Monitors, Revision 2.0, May 1, 2022](#)). The RCO may request the RO to send additional data that are needed beyond what the RCO requires for verifying any missing data supplied by the RO. 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

Field operators must have a PC (or laptop) to generate the Logbook (elog) files from a Microsoft Excel template file. These elogs 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

The elog 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 A of this SOP for an example of the elog. Elogs can also be found in IBEAM or on SharePoint. To access the file, open the elog template file using Excel. Every time a new elog 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 elog. *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 elog template file using Excel
2. Left click the “file” toolbar icon, scroll down to “save as” and left click. Every time a new elog 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 elogs.**
3. Under file name (highlighted) change the Logbook file name using the following format: Site ID COTL Date Activity. For example, “TO NO2 20200601 AX.xls” is a Calibration (Precision) Check at Triple Oak on June 01, 2020.
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 (elog) periodically and when finished entering data.

8.0 FILE QUALITY ASSURANCE AND DATA HANDLING

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 RO 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 RO. This is necessary to prevent the potential loss of such files from the field computer 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 Verification and Validation for Continuous Gaseous Monitors, Revision 2.0, May 1, 2022](#). 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; and
4. Identifying any data that may be associated with exceptional events.

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 ARM 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 20 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. Final validation of the data should be complete within 40 days of the end of the collection month. Once the data have been approved and have had the "final validation" label applied by the RCO Chemist, the data are 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 RO wishes for data to be considered "exceptional," the RO 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 exception 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 Null Codes that are routinely used during data validation on the AQS monthly summary report are listed below. (Partial List).

Commonly Used EPA-AQS Null Value Codes (partial list)

| Null Code | Null Code Description |
|-----------|------------------------------------------------------------|
| AE | Shelter Temperature outside Limits |
| AN | Machine or Equipment Malfunction |
| AS | Poor Quality Assurance Results |
| AT | Calibration (by ECB Lab) |
| AV | Power Failure |
| AZ | QC (ECB Lab) |
| BA | Maintenance and Routine Repairs (including filter changes) |
| BC | Multi-point Calibration |
| BF | Auto Calibration |
| AX | Precision/Zero/Span |
| BJ | Operator Error |
| BK | Site Computer/Data Logger Down |
| BL | QA Audit (EPA performance audit) |
| QV | Multi-point Calibration Verification |

9.0 TROUBLESHOOTING AND CORRECTIVE ACTIONS

Presently, DAQ has minimal history regarding troubleshooting and corrective actions using the T500U. Refer to [Model T500U CAPS NO2 Analyzer with NumaView Software](#). Section 5.0 contains a variety of methods for identifying the source of performance problems with the monitor.

| Problem | Corrective Action |
|--------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------|
| Overnight PZS fails after cylinder replacement | Was the correct cylinder concentration entered into the calibrator? Are all tank valves turned ON? |
| Overnight PZS fails after calibrator replacement | Is the cylinder concentration entered into the calibrator correct? Are the correct SPAN points set in the calibrator? |
| Regulator Pressure Warning | Check the ZAG for correct output pressure (30 psig) |
| Sample flow < 810 cc/min | Check for kinks or leaks in tubing. Check sample flow restrictor Is the pneumatic path clogged? |

10.0 REVISION HISTORY

1. Changed temperature range to 5.0 to 40.0 °C
2. Added leak check requirement
3. Added sample flow check requirement
4. Added Appendices F (Performing a Leak Check)
5. Added Appendices G (Performing a Sample Flow Check)
6. Added Appendices H (Tare Instructions for Alicat Mass Flow Meter)

11.0 REFERENCES

1. [Model T500U CAPS NO2 Operation Manual](#)
2. [NumaView™ Software Addendum to T-Series Analyzer Manual](#)
3. [Model T500U CAPS NO2 Analyzer with NumaView Software](#)
4. [Alicat Mass Flow Meter Manual](#)

12.0 APPENDICES

1. Appendix A Example of e-log
2. Appendix B GTPS and GPT Documentation
3. Appendix C Example of Data Points to be included in e-log
4. Appendix D Glossary of Terms
5. Appendix E Guidance for Useful Logbook Documentation
6. Appendix F Performing a Leak Check
7. Appendix G Performing a Sample Flow check
8. Appendix H Tare Instruction for Alicat Mass Flow Meter

Example of Logbook Tab

| CAPS NO ₂ Logbook | | | | | |
|--------------------------------------------------------------------------|------------------------------------------------------|---------------------------------------------------------|-----------------------------------------------|------------------------------------------------------------------------------------------|--|
| Revision 3.0 (June 24, 2022) | | | | | |
| Site: <input type="text"/> | Time: <input type="text"/> | Date: <input type="text"/> | Operator: <input type="text"/> | | |
| Channel Down Time: <input type="text"/> | | Channel Up Time: <input type="text"/> | | Log Off Site Computer? <input type="text"/> | |
| Routine Site Inspection | | Building Temperature °C (5.0 - 40.0 °C) | | Computer / Monitor Time | |
| Building Secure (Y/N) | Yes | NIST Thermometer Serial No: | Expiration Date: | Date (mm/dd/yy) Time (hh:mm) | |
| Sampling Probe Intact (Y/N) | Yes | NIST: | (± 2 °C of NIST?) | NIST: | |
| Building Power On (Y/N) | Yes | Comet: | OK | Analyzer: | |
| | | HoBo: | OK | Site Computer: | |
| Site Computer Restarted this Month? <input type="text"/> | | HoBo Battery > 1 bar? <input type="text"/> | | | |
| EPA Protocol NO Gas Cylinder | | | | | |
| Cylinder ID <input type="text"/> | | Cylinder Pressure (psig): <input type="text"/> | | Days Remaining 0 | |
| Cylinder Nitric Oxide Certified Concentration (ppm) <input type="text"/> | | Cylinder Delivery Pressure (psig): <input type="text"/> | | | |
| Cylinder Expiration Date <input type="text"/> | | | | | |
| Monitor | | | | | |
| Teledyne NO2 Model T500U Analyzer Serial No. / ID <input type="text"/> | | | Alarms (Y/N) <input type="text"/> | | |
| | | | (*Record these values while running Zero Air) | | |
| Box Temperature (ambient ± 5°C) <input type="text"/> | Driver Version <input type="text"/> | *Measured Loss (Mm-1) <input type="text"/> | | | |
| NO2 Concentration <input type="text"/> | *NO2 Measured Loss (ppb) <input type="text"/> | NO2 Offset # 1 <input type="text"/> | | | |
| Oven Temperature (45 ± 1 °C) <input type="text"/> | *Phase (Degree of Angle) <input type="text"/> | Range Mode <input type="text"/> | | | |
| Sample Temperature (45 ± 3 °C) <input type="text"/> | Slope # 1 (1.0 ± 0.2) <input type="text"/> | System Hours <input type="text"/> | | | |
| Leak Check | | | | | |
| Leak Check Pressure (psi) <input type="text"/> | | Sample Flow Check | | Residence Time (seconds) <input type="text"/> | |
| Pass/Fail <input type="text"/> | Sample Flow (liters per minute) <input type="text"/> | Residence Time < 20 seconds <input type="text"/> | | #DIV/0! <input type="text"/> | |
| Calibrator | | | | | |
| API T700U Serial No. / ID <input type="text"/> | | Exp. Date <input type="text"/> | | Days Remaining 0 | |
| | | Box Temp. (shelter ± 7 °C) <input type="text"/> | | Alarms? (Y/N) <input type="text"/> | |
| Teledyne Zero Air Generator | | | | | |
| Model 701 Serial No. / ID <input type="text"/> | | Expiration Date: <input type="text"/> | | Days Remaining 0 | |
| Delivery Air Pressure (psig): <input type="text"/> | | | | | |
| HOBO | | | | | |
| HOBO Temperature Downloaded <input type="text"/> | | Date Range <input type="text"/> | | | |
| NOTES: Operator: | | | | | |
| | | | | | |
| NOTES: Ambient Monitoring Coordinator: | | | | | |
| | | | | | |
| NOTES: Projects and Procedures Branch (PPB) Chemist | | | | | |
| | | | | | |
| PPB Chemist Review by: <input type="text"/> | | Review Date: <input type="text"/> | | | |

Example of QC Check Tab

| CAPS NO ₂ PZS | | | | | | | | | | | |
|--------------------------------------------------|--|-------------------------|---------------|--|-------------------------|----------------|---------------|--|-------------------------|------------|--|
| Revision 3.0 (June 24, 2022) | | | | | | | | | | | |
| Site: 0 | | | Time: 0:00 | | | Date: 1/0/1900 | | | | | |
| EPA Protocol NO Cylinder Concentration (ppm) 0.0 | | | | | Operator: 0 | | | | | | |
| ZERO Air Generator (ZAG) | | | SPAN 9 | | 20 ppb | | SPAN 2 | | | 180 ppb | |
| ZAG (psi) | | | Time HH:mm | | T700_ACTO3 | | Time HH:mm | | | T700_ACTO3 | |
| | | | | | | | | | | | |
| ZERO | | | SPAN 1 | | SPAN | | | | | | |
| Time HH:mm | | NO ₂ Monitor | Time HH:mm | | NO ₂ Monitor | | Time HH:mm | | NO ₂ Monitor | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
| Avg ppb | | #DIV/0! | Avg ppb | | #DIV/0! | | Avg ppb | | #DIV/0! | | |
| Act. Diff | | #DIV/0! | Act. Diff | | #DIV/0! | | Act. Diff | | #DIV/0! | | |
| | | | % Diff | | #DIV/0! | | % Diff | | #DIV/0! | | |
| Acceptable: | | [diff ± 1.0 ppb] | Acceptable: | | [diff ± 10 %] | | Acceptable: | | [diff ± 10 %] | | |
| | | #DIV/0! | | | #DIV/0! | | | | #DIV/0! | | |
| NOTES: | | | | | | | | | | | |

Example of Calib and Verification Tab

| CAPS NO ₂ Calibration and Verification | | | | | | | | | |
|-------------------------------------------------------------------------------|--|----------------|---------------------------------------------------------------------------------|------------|---------------------------------------------------------------------------------|-------------|---------------------------------------------------------------------------------|------------------------------------------|---------------------------------------------------------------------------------|
| Revision 3.0 (June 24, 2022) | | | | | | | | | |
| Site: 0 | | Date: 1/0/1900 | | Time: 0:00 | | Operator: 0 | | | |
| Monitor As Found Factors | | | Span (ppb) Monitor Value | | Monitor As Left Factors | | | Verification Regression | |
| Slope # 1 ^[1] | | | ZERO (0.0 ppb) | | Slope # 1 ^[2] | | | Regression Slope: ^[2] #VALUE! | |
| NO2 Offset # 1 | | | SPAN (180 ppb) | | NO2 Offset # 1 | | | Regression Intercept: #DIV/0! | |
| | | | | | | | | R: #DIV/0! | |
| Cylinder Concentration (ppm): 0.0 | | | | | | | | | |
| ZERO | | | SPAN 2 (180 ppb) | | SPAN 3 (135 ppb) | | SPAN 5 (90 ppb) | | SPAN 7 (45 ppb) |
| Time HH:mm NO ₂ Monitor T700_ACTCONC Calibrator | | | Time HH:mm T700_ACTO3 | | Time HH:mm T700_ACTO3 | | Time HH:mm T700_ACTO3 | | Time HH:mm 45 |
| | | | | | | | | | |
| | | | SPAN (180 ppb) | | SPAN 4 (135 ppb) | | SPAN 6 (90 ppb) | | SPAN 8 (45 ppb) |
| Time HH:mm NO ₂ Monitor | | | Time HH:mm NO ₂ Monitor | | Time HH:mm NO ₂ Monitor | | Time HH:mm NO ₂ Monitor | | Time HH:mm NO ₂ Monitor |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| Avg ppb #DIV/0! #DIV/0! | | | Avg ppb #DIV/0! | | Avg ppb #DIV/0! | | Avg ppb #DIV/0! | | Avg ppb #DIV/0! |
| | | | [diff ± 1.5 ppb or 2.0%] | | [diff ± 1.5 ppb or 2.0%] | | [diff ± 1.5 ppb or 2.0%] | | [diff ± 1.5 ppb or 2.0%] |
| Acceptable: Yes | | | Acceptable: #DIV/0! | | Acceptable: #DIV/0! | | Acceptable: #DIV/0! | | Acceptable: #DIV/0! |
| [1] Slope #1 refers to the slope of the T500U | | | | | [2] Regression Slope is generated when the Multi-point Verification is complete | | | | |
| NOTES: | | | | | | | | | |
| | | | | | | | | | |

Example of Regression Tab

CAPS NO₂ Regression
 Revision 3.0 (June 24, 2022)

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

| | |
|-------------------------------------------------------------|---------------------|
| | Instructions |
| What percentage is acceptable? | 2% |
| Calibration Scale | 200 |
| Point Difference Acceptance Value | 1.5 |
| Slope Acceptance Criteria | 0.95 - 1.05 |
| Only values on sheet that can be changed are in gray, above | |

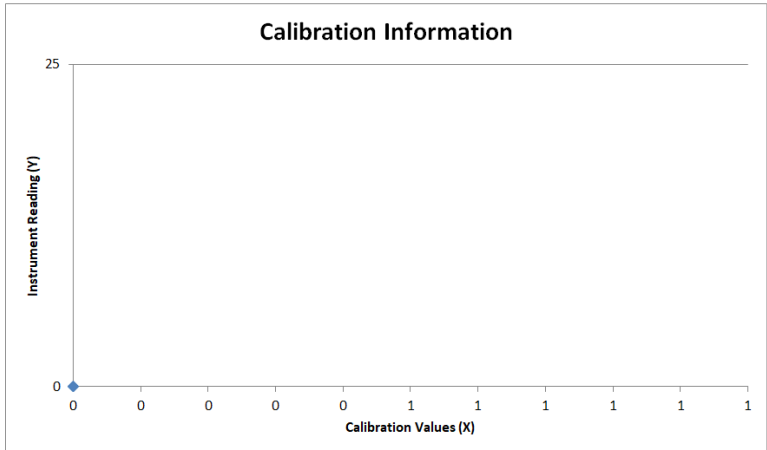
- 1) Place in the acceptable percentage (2% is current validation criteria) in D8
- 2) Select the calibration scale. This does not need to be the FEM approved scale of the instrument (e.g., 500 ppb or 1000 ppb) in D9. It should be the high cal value. The point difference acceptance value in field D8 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 D8 will turn the boxes and font in rows 29 red. Any percent difference > the value in D8 will turn the boxes and font in rows 29 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.

| | Zero Concentration 1 | SPAN 8 (~45 ppb) Concentration 2 | SPAN 6 (~90 ppb) Concentration 3 | SPAN 4 (~135 ppb) Concentration 4 | SPAN (~180 ppb) Concentration 5 |
|-------------------------|-------------------------|-------------------------------------|-------------------------------------|--------------------------------------|------------------------------------|
| Calibrator Value (X) | #DIV/0! | 0.0 | 0.0 | 0.0 | 0.0 |
| Instrument Value (Y) | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Average | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |

| 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 ₁) | intcpt (I ₁) | lin reg |
|---------|-------------------------|--------------------------|---------|
| #DIV/0! | #DIV/0! | #DIV/0! | #VALUE! |

| (Calibrator) X | (Monitor) Y |
|-------------------|----------------|
| #DIV/0! | 0.0 |
| 0.0 | 0.0 |
| 0.0 | 0.0 |
| 0.0 | 0.0 |
| 0.0 | 0.0 |



Appendix B GPTPS and GPT Documentation

The NO₂ relationship between GPTPS (Gas Phase Titration Pre-Set) and GPT (Gas Phase Titration) and concentrations are listed in the table below.

| GPTPS | GPT | Nominal Concentration (T700U) |
|--------|--------|-------------------------------|
| ZERO | ZERO | 0.0 ppb |
| SPAN 2 | SPAN | 180 ppb |
| SPAN 3 | SPAN 4 | 135 ppb |
| SPAN 5 | SPAN 6 | 90 ppb |
| SPAN 7 | SPAN 8 | 45 ppb |
| SPAN 9 | SPAN 1 | 20 ppb |

Appendix C Example of Data Points to be included in elog


Example of data to record on elog for ZERO

| | A | B | C | D | E | F |
|----|----------------------------------------------------------------------|---------------|--------|-----------|--------|---|
| 1 | Site Millbrook Period: 5/18/2020 9:14 AM-5/18/2020 9:32 AM Type: AVG | | | | | |
| 2 | | | | | | |
| 3 | Date & Time | T700U_ACTCONC | Status | NO2_T500U | Status | |
| 4 | | PPB | | PPB | | |
| 5 | 5/18/2020 9:14 AM | --- | NoData | 2.3 | Ok | |
| 6 | 5/18/2020 9:15 AM | --- | NoData | 2.2 | Ok | |
| 7 | 5/18/2020 9:16 AM | 0 | Ok | 2.5 | Zero | |
| 8 | 5/18/2020 9:17 AM | 0 | Ok | 0.5 | Zero | |
| 9 | 5/18/2020 9:18 AM | 0 | Ok | 0.2 | Zero | |
| 10 | 5/18/2020 9:19 AM | 0 | Ok | 0.1 | Zero | |
| 11 | 5/18/2020 9:20 AM | 0 | Ok | 0.1 | Zero | |
| 12 | 5/18/2020 9:21 AM | 0 | Ok | 0.1 | Zero | |
| 13 | 5/18/2020 9:22 AM | 0 | Ok | 0.1 | Zero | |
| 14 | 5/18/2020 9:23 AM | 0 | Ok | 0.1 | Zero | |
| 15 | 5/18/2020 9:24 AM | 0 | Ok | 0.1 | Zero | |
| 16 | 5/18/2020 9:25 AM | 0 | Ok | 0.1 | Zero | |
| 17 | 5/18/2020 9:26 AM | 0 | Ok | 0.1 | Zero | |
| 18 | 5/18/2020 9:27 AM | 0 | Ok | 0.1 | Zero | |
| 19 | 5/18/2020 9:28 AM | 0 | Ok | 0.1 | Zero | |
| 20 | 5/18/2020 9:29 AM | 0 | Ok | 0.1 | Zero | |
| 21 | 5/18/2020 9:30 AM | 0 | Ok | 0.1 | Zero | |
| 22 | 5/18/2020 9:31 AM | 296.1 | Ok | 33.3 | Span2 | |
| 23 | 5/18/2020 9:32 AM | 200.7 | Ok | 20.6 | Span2 | |
| 24 | Minimum | 0 | | 2.2 | | |
| 25 | MinDate | 09:16 AM | | 09:15 AM | | |
| 26 | Maximum | 296.1 | | 2.3 | | |
| 27 | MaxDate | 09:31 AM | | 09:14 AM | | |
| 28 | Avg | 29.2 | | 2.3 | | |
| 29 | Num | 17 | | 2 | | |
| 30 | Data[%] | 89 | | 11 | | |
| 31 | STD | 84.2 | | 0.1 | | |
| 32 | | | | | | |

Example of data to record on elog for SPAN

| | A | B | C | D | E |
|-----|----------------------------------------------------------------------|-------------|--------|-----------|--------|
| 1 | Site Millbrook Period: 5/18/2020 8:00 AM-5/18/2020 11:00 AM Type: AV | | | | |
| 2 | | | | | |
| 3 | Date & Time | T700U_ACTO3 | Status | NO2_T500U | Status |
| 4 | | PPB | | PPB | |
| 104 | 5/18/2020 9:39 AM | 180 | Span2 | 1.2 | Span2 |
| 105 | 5/18/2020 9:40 AM | 180 | Span2 | 1.1 | Span2 |
| 106 | 5/18/2020 9:41 AM | 179.9 | Span2 | 2.7 | Span |
| 107 | 5/18/2020 9:42 AM | --- | NoData | 22.7 | Span |
| 108 | 5/18/2020 9:43 AM | --- | NoData | 79.9 | Span |
| 109 | 5/18/2020 9:44 AM | --- | NoData | 115.4 | Span |
| 110 | 5/18/2020 9:45 AM | --- | NoData | 142.4 | Span |
| 111 | 5/18/2020 9:46 AM | --- | NoData | 156.5 | Span |
| 112 | 5/18/2020 9:47 AM | --- | NoData | 167.8 | Span |
| 113 | 5/18/2020 9:48 AM | --- | NoData | 173.2 | Span |
| 114 | 5/18/2020 9:49 AM | --- | NoData | 174.7 | Span |
| 115 | 5/18/2020 9:50 AM | --- | NoData | 175.2 | Span |
| 116 | 5/18/2020 9:51 AM | --- | NoData | 175.5 | Span |
| 117 | 5/18/2020 9:52 AM | --- | NoData | 175.6 | Span |
| 118 | 5/18/2020 9:53 AM | --- | NoData | 175.8 | Span |
| 119 | 5/18/2020 9:54 AM | --- | NoData | 175.9 | Span |
| 120 | 5/18/2020 9:55 AM | --- | NoData | 176 | Span |
| 121 | 5/18/2020 9:56 AM | --- | NoData | 175.9 | Span |
| 122 | 5/18/2020 9:57 AM | --- | NoData | 175.9 | Span |
| 123 | 5/18/2020 9:58 AM | --- | NoData | 175.9 | Span |
| 124 | 5/18/2020 9:59 AM | --- | NoData | 176 | Span |
| 125 | 5/18/2020 10:00 AM | --- | NoData | 176.1 | Span |
| 126 | 5/18/2020 10:01 AM | 6 | Span9 | 182.6 | Calib |
| 127 | 5/18/2020 10:02 AM | 19.4 | Span9 | 7.7 | Span9 |

Example of data to record on elog for SPAN 1

| | A | B | C | D | E | F |
|-----|----------------------------------------------------------------------|-------------|--------|-----------|--------|---------------------------------------------------------------------------------------|
| 1 | Site Millbrook Period: 5/18/2020 8:00 AM-5/18/2020 5:00 PM Type: AVG | | | | | |
| 2 | | | | | | |
| 3 | Date & Time | T700U_ACTO3 | Status | NO2_T500U | Status | |
| 4 | | PPB | | PPB | | |
| 130 | 5/18/2020 10:05 AM | 20 | Span9 | 0.8 | Span9 | |
| 131 | 5/18/2020 10:06 AM | 20.1 | Span9 | 0.5 | Span9 | |
| 132 | 5/18/2020 10:07 AM | 20 | Span9 | 0.3 | Span9 | |
| 133 | 5/18/2020 10:08 AM | 19.9 | Span9 | 0.3 | Span9 | |
| 134 | 5/18/2020 10:09 AM | 19.9 | Span9 | 0.2 | Span9 | |
| 135 | 5/18/2020 10:10 AM | 20 | Span9 | 0.2 | Span9 | |
| 136 | 5/18/2020 10:11 AM | 20 | Span9 | 0.2 | Span1 | |
| 137 | 5/18/2020 10:12 AM | --- | NoData | 0.1 | Span1 | |
| 138 | 5/18/2020 10:13 AM | --- | NoData | 0.9 | Span1 | |
| 139 | 5/18/2020 10:14 AM | --- | NoData | 4.2 | Span1 | |
| 140 | 5/18/2020 10:15 AM | --- | NoData | 7.9 | Span1 | |
| 141 | 5/18/2020 10:16 AM | --- | NoData | 11.2 | Span1 | |
| 142 | 5/18/2020 10:17 AM | --- | NoData | 13.8 | Span1 | |
| 143 | 5/18/2020 10:18 AM | --- | NoData | 15.9 | Span1 | |
| 144 | 5/18/2020 10:19 AM | --- | NoData | 17.5 | Span1 | |
| 145 | 5/18/2020 10:20 AM | --- | NoData | 18.5 | Span1 | |
| 146 | 5/18/2020 10:21 AM | --- | NoData | 19.1 | Span1 | |
| 147 | 5/18/2020 10:22 AM | --- | NoData | 19.4 | Span1 | |
| 148 | 5/18/2020 10:23 AM | --- | NoData | 19.6 | Span1 | |
| 149 | 5/18/2020 10:24 AM | --- | NoData | 19.8 | Span1 | |
| 150 | 5/18/2020 10:25 AM | --- | NoData | 19.9 | Span1 | |
| 151 | 5/18/2020 10:26 AM | --- | NoData | 20 | Span1 | |
| 152 | 5/18/2020 10:27 AM | --- | NoData | 20 | Span1 | |
| 153 | 5/18/2020 10:28 AM | --- | NoData | 20.1 | Span1 | |
| 154 | 5/18/2020 10:29 AM | --- | NoData | 20.1 | Span1 | |
| 155 | 5/18/2020 10:30 AM | --- | NoData | 20.1 | Span1 | |
| 156 | 5/18/2020 10:31 AM | --- | NoData | 20.1 | Purge |  |
| 157 | 5/18/2020 10:32 AM | --- | NoData | 20.1 | Purge | |

Appendix D Glossary of Terms ^[1]

[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 e-log, 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 SO₂ and O₃ 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 RO 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 E Guidance for Useful Logbook Documentation

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 Scott at ECB, he will be here presently with a new FRM."
6. Reviewers should add their comments: "reviewed above, approved operator action." Or: "upon review noted deviation from SOP".

Appendix F Performing a Leak Check

5.6.5. CHECKING FOR PNEUMATIC LEAKS

This section covers a simple leak check and a detailed leak check.



CAUTION - TECHNICAL INFORMATION

Do not exceed 15 psi when pressurizing the system during either Simple or Detailed checks.

5.6.5.1. DETAILED PRESSURE LEAK CHECK

Obtain a leak checker that contains a small pump, shut-off valve, and pressure gauge to create both over-pressure and vacuum. Alternatively, a tank of pressurized gas, with the two-stage regulator adjusted to ≤ 10 psi, a shutoff valve and a pressure gauge may be used.

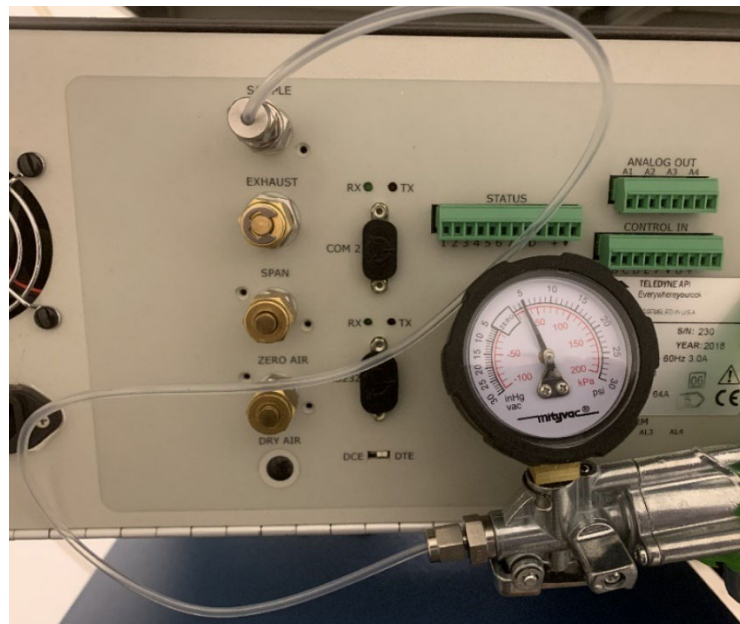
ATTENTION

COULD DAMAGE INSTRUMENT AND VOID WARRANTY

Once tube fittings have been wetted with soap solution under a pressurized system, do not apply or reapply vacuum as this will cause soap solution to be sucked into the instrument, contaminating inside surfaces.

1. Turn OFF power to the instrument and remove the instrument cover.
2. Install a leak checker on the sample inlet at the rear panel.
3. Cap rear panel ports and cap the pump port.
 - If zero/span valves are installed, disconnect the tubing from the zero and span gas ports and cap the ports (Figure 2-2).
4. Pressurize the instrument with the leak checker, allowing enough time to fully pressurize the instrument.
 - Do not exceed 10 psi pressure.

NOTE: If the leak check fails notify ECB immediately



Rear of Analyzer during Leak Check

5. The leak-down rate of the indicated pressure should be less than 1 psi in 5 minutes after the pressure is turned off.
6. If the leak check passes, reconnect the sample line and pump lines and replace the cover. Restart the analyzer.



Rear of Analyzer before and after Leak check

Appendix G Performing a Sample Flow Check

5.6.5.2. PERFORMING A SAMPLE FLOW CHECK

Important**IMPACT ON READINGS OR DATA**

Use an external calibrated flow meter capable of measuring flows between 0 and 1000 cm³/min to measure the gas flow rate through the analyzer.

Sample flow checks are useful for monitoring the actual flow of the instrument. A decreasing sample flow may point to slowly clogging pneumatic paths, most likely the sample flow restrictor or the sample filter. To perform a sample flow check:

1. Disconnect the sample inlet tubing from the rear panel SAMPLE port.
2. Attach the outlet port of a flow meter to the sample inlet port on the rear panel.
 - Ensure that the inlet to the flow meter is at atmospheric pressure.
3. Check that the sample flow measured with the external flow meter is within specification.
4. If sample flow is out of specification, call ECB.

Appendix H Tare Instructions for Alicat Mass Flow Meter

M Series Mass Flow Meter Operation

The M Series Mass Flow Meter provides a multitude of useful flow data in one simple, rugged device. The M Series can have several screen "modes" depending on how the device is ordered. All M Series meters have a default Main Mode, Select Menu Mode, a Gas Select Mode (the Gas Select Mode may not be available on meters calibrated for a custom gas or blend), a Communication Select Mode, Manufacturer Data Mode and a Miscellaneous Mode. In addition, your device may have been ordered with the optional Totalizing Mode (page 38). The device defaults to Main Mode as soon as power is applied to the meter.

Main Mode

The main mode screen defaults on power up with the mass flow on the primary display. The following parameters are displayed in the main mode as shown in Figure 6:

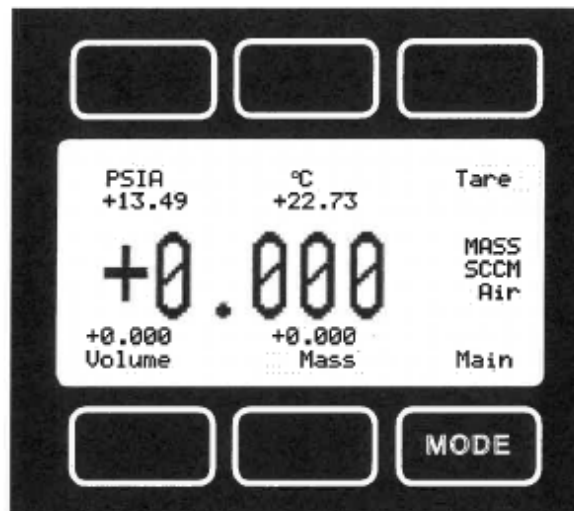


Figure 6. Main Mode Display, M Series Flow Meter

The "MODE" button in the lower right hand corner toggles the display between the Main display and the Select Menu display.

Tare – Pushing the dynamically labeled "Tare" button in the upper right hand corner tares the flow meter and provides it with a reference point for zero flow. This is a simple but important step in obtaining accurate measurements. It is good practice to "zero" the flow meter each time it is powered up. If the flow reading varies significantly from zero after an initial tare, give the unit a minute or so to warm up and re-zero it.

If possible, zero the unit near the expected operating pressure by positively blocking the flow downstream of the flow meter prior to pushing the "Tare" button. Zeroing the unit while there is any flow will directly affect the accuracy by providing a false zero point. If in doubt about whether a zero flow condition exists, remove the unit from the line and positively block both ports before pressing the "Tare" button. If the unit reads a significant negative value when removed from the line and blocked, it is a good indication that it was given a false zero. It is better to zero the unit at atmospheric pressure and a confirmed no flow conditions than to give it a false zero under line pressure.