

STANDARD OPERATING PROCEDURES

ENVIRONICS SERIES 9100

**COMPUTERIZED AMBIENT MONITORING CALIBRATION
SYSTEM**

Version 0.01

Draft



Section 1.1 Acknowledgments

This Standard Operating Procedure (SOP) for the Environics Series 9100 Computerized Ambient Monitoring Calibration System is the product of EPA's Office of Air Quality, Planning and Standards. The following individuals are acknowledged for their contributions.

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2.0 Table of Contents

Section	Page
1.0 Title Page	1
1.1 Acknowledgements	2
2.0 Table of Contents	3
2.1 List of Figures	3
3.0 Scope and Procedures	4
3.1 Scope and Applicability	4
3.2 Summary of Method	4
3.2.1 Summary of Specific Procedures	4
3.2.2 Summary of Analyzer Operation	4
3.3 Definitions	5
3.4 Health and Safety Warnings	6
3.5 Cautions	6
3.6 Interferences	6
3.7 Personnel Qualifications	7
3.8 Equipment and Supplies	7
3.9 Procedures	9
3.9.1 Start-up	9
3.9.1.1 Unpack the Instrument	9
3.9.1.2 Warm-up	10
3.9.1.3 Leak Check	10
3.9.1.4 Flow Verification	11
3.9.2 Identifying Calibrator Ports to Standards	12
3.9.3 Calibrations – Multi-point	11
3.9.3.1 Determination of Concentrations for Multi-Point Calibration	13
3.9.3.2 Performing the Multi-Point Calibration	15
3.9.4 Verifications – Zero, Span and One-point Quality Checks	15
3.9.4.1 Set-up a Sequence	16
3.9.4.2 Set-up Timer Control	17
3.9.4.3 Run a Timer Control	17
3.9.4.4 Zero, Span and One-Point Quality Checks	17
3.9.4.5 Calibrator Automation	18
4.0 Quality Assurance and Quality Control	18
5.0 References	19

List of Figures

Figure Name and Number	Page
Figure 1.0 Flow Diagram: Environics 9100	5
Figure 2.0 Sampling System Set-up	7
Figure 3.0 Calibration Graph of Environics 9100 Mass Flow Controller	12

List of Tables

Table Name and Number	Page
Table 1.0 Proposed Audit Level Concentrations	15
Table 2.0 MQO Table for Calibrator	19

3.0 Scope and Procedures

3.1 Scope and Applicability

This Standard Operating Procedure (SOP) is applicable for the Environics Series 9100 Computerized Ambient Monitoring Calibration System integrated with several ambient air monitoring analyzers. The SOP outlines the steps to run calibrations and verifications either automatically through programming sequences or through manual commands.

3.2 Summary of Method

3.2.1 Summary of Specific Procedures

This SOP will use the following methods to unpack, check and set-up, and execute a multi-point calibration, and daily zero, span and one point QC checks.

- 3.9.1.1 Unpack the Instrument
- 3.9.1.2 Warm up the Environics
- 3.9.1.3 Leak check the Environics
- 3.9.1.4 Flow Verification
- 3.9.2 Assign the Calibrator Ports to the Gaseous Standards
- 3.9.3 Multi-point Calibrations
- 3.9.4 Verifications: Zero, Span and One Point Quality Checks
 - 3.9.4.1 Setting up a Sequence
 - 3.9.4.2 Setting up a Timer Control
 - 3.9.4.3 Running the Timer Control
 - 3.9.4.4 Zero, Span, and One-Point Quality Checks
 - 3.9.4.5 Calibrator Automation

3.2.2 Summary of Analyzer Operation *Refer to the Flow Diagram, Figure 1.*

In the Environics 9100 Calibrator, Port 1 is connected to mass flow controller (MFC) 1. Port 1 is used for Zero Air. MFC 2 can choose any of the remaining available ports. When nitrogen dioxide (NO₂) is required pollutant, ozone flows into the reaction chamber along with gases from the other ports except 1. It is here that ozone reacts with the gas. The resultant gas is then sent to the Mixing Chamber and is diluted with zero air from Port 1 before exiting the calibrator and sent to the appropriate analyzer. If diluting gases for CO and SO₂, this process is by-passed.

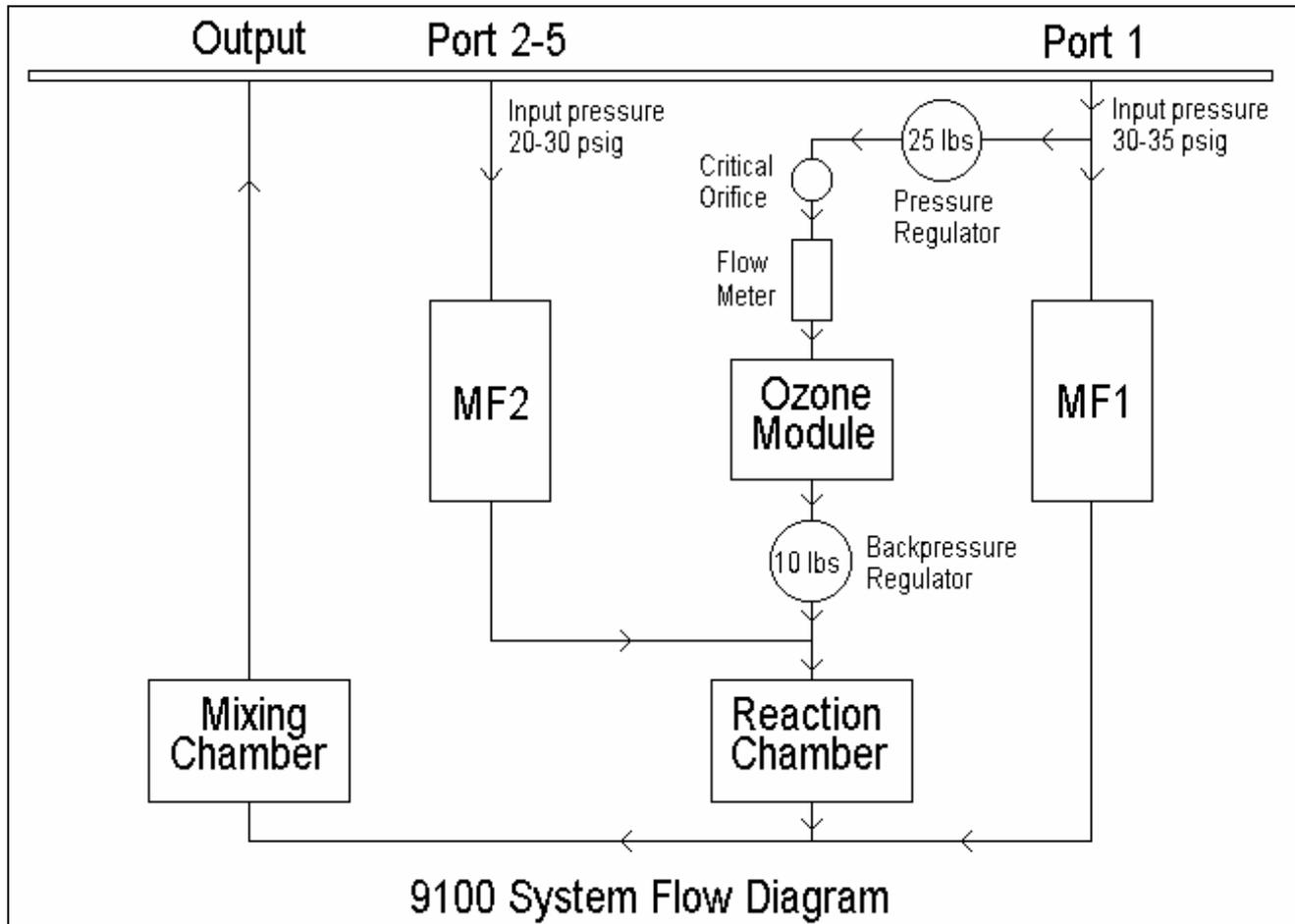


Figure 1.0 Flow Diagram: Envionics 9100

3.3 Definitions

MFC	Mass Flow Controller
Sccm	Standard Cubic Centimeter per minute
DAS	Digital Acquisition System
Span Check	a one point verification of the monitoring system challenging an analyzer with a known concentration of gas and measuring the analyzer response. Span checks are the highest concentration test point approximately 80 to 90% of full scale range.
One Point Quality Check	a one point verification of the analyzer made by challenging the concentrations. This verification should be of pre-determined acceptable quality. A response outside the limits initiates a series of actions to determine data quality.

3.4 Health and Safety Warnings

1. Some gases can be explosive or otherwise reactive when blended. Users must check gas compatibility before blending. Please consult a gas handbook, a specialty gas manufacturer or other competent source for information about gas compatibility. Failure to observe these precautions may result in damage to the instrument, serious injury or death.
2. Pressurized cylinders are extremely dangerous if improperly handled. Proper regulators, use of safety caps and proper restraints are mandatory. Avoid cross contamination when attaching regulators or making manifold connections. Always consult your gas supplier for proper safety procedures. Failure to observe these precautions may result in serious injury or death.
3. Rules and regulations regarding the transportation of gas cylinders are governed by the Department of Transportation. Each agency should familiarize themselves with these regulations and follow them when involved in transporting gas cylinders. Failure to follow these precautions may result in serious injury or death.
4. Secure Material Safety Data Sheets (MSDS) for all gases and keep in specially designated binder in any easily accessible location.
5. Power to the unit should be disconnected before working on it to prevent injury or electrical shock.
6. If it is necessary to work on the inside of the unit with power connected, extreme caution should be taken. Failure to do so can result in injury or electrical shock.
7. Because the electronic circuit boards contain static sensitive components, always use static discharge equipment when working on the unit and handling circuit boards.
8. A line should be run to the outside or a fume hood, whichever is more readily available, to vent the outflow of gases from the entire system: Environics 9100, the Zero Air Generator, and the analyzers. This should be done to prevent the possibility of a build-up of gases in a closed room/monitoring station and the potential for gaseous poisoning to the unaware station operator.

3.5 Cautions

1. The Environics 9100 operates at a line voltage between 100-120 VAC (optional 220-240 VAC). Operating at an incorrect line voltage will damage the instrument and void the manufacturer's warranty.
2. Because the RS-232 ports and the parallel printer port are especially susceptible to damage if the unit is powered ON while any computer or printer equipment is being connected or disconnected, the unit must be powered OFF before connecting or disconnecting any cables, wiring harnesses or other sources of potential electrical impulses.

3. If routine maintenance is performed, prior to putting the unit back into service check the following items:

- Inspect the power cord and internal wiring
- Check all fittings for tightness and leak check if possible
- Clean circuit boards using a vacuum or air gun to remove dust
- Check all tubing for splits, kinks, or cuts

3.6 Interferences

The calibrator as well as the zero air supply and any gaseous cylinders should be stored and operated in a temperature and humidity controlled shelter as extremes of either can effect the final concentration. Condensation of humidity in the sampling and associated lines can also dilute the concentration of gases delivered to the analyzers.

3.7 Personnel Qualifications

Persons setting up and operating this system should have an understanding of gaseous systems and/or a good background in chemistry, physics, and the scientific process. For someone unfamiliar with gaseous systems and/or setting up analyzers and related equipment at a monitoring site, an instructional course would be beneficial. Other sources of instruction include any US EPA guidance documents and training with other experienced personnel.

3.8 Equipment and Supplies

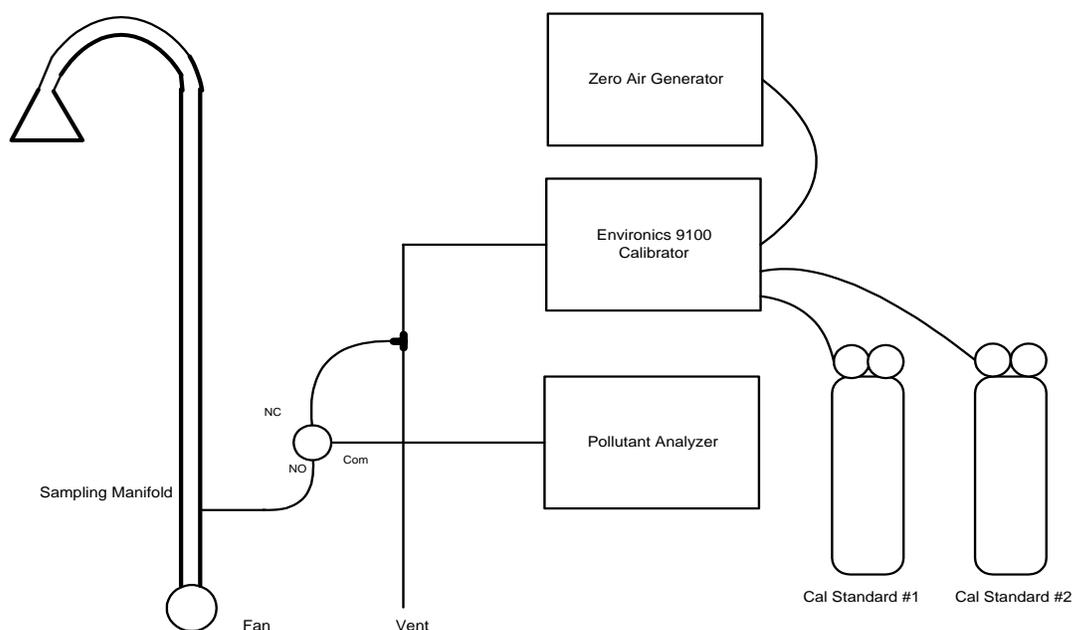


Figure 2.0: Sampling System Set-up

Enviroics Series 9100: used to blend gases to desired concentration to run check calibration of ambient air analyzers through not only a calibration of each but also through the daily zero, span, and one point quality checks.

Zero Air Source: For this study, an API Model 701 Zero Air Generator is used. Carbon monoxide and hydrocarbon scrubbers are available as an option when purchasing. For precursor gas applications, the CO scrubber is required. Please see the manual for a recommended maintenance schedule on the unit. The purpose of the zero air source is to dilute the gases to achieve the desired final concentration of gaseous pollutants in question. Zero Air should be filtered before entering the calibrator to ensure it is free of any particulate contaminants. A cylinder of zero air may also be used. However, the latter may not be cost effective or practical for monitoring organizations given the frequency of use of the zero air supply. It is also imperative for the monitoring organization to verify/recertify their zero air supply annually using an independent zero air source. The independent source should be of a higher quality than what is routinely used. Most high purity cylinder air sources are not of the quality needed as an independent source. High quality cylinders can be used, but they require external scrubbers for the precursor gases of interest.

It is not recommended that the API 701 be used to generate air at a flow rate greater than 10 LPM. The internal CO scrubber is not as efficient at the higher flow rates (e.g., 20 LPM); therefore, caution should be taken when exceeding 10 LPM. Decreased scrubber efficiency presents itself as an increased CO analyzer baseline. An external Hopcalite or Carulite scrubber can be added to the API 701 to remove any CO not eliminated by the scrubber at higher flow rates. CO scrubbers can fail. The manual recommends replacement on an annual schedule depending on CO levels in the source air.

It is also recommended that ambient air, not air from the inside of the monitoring station, is used as a source for the API zero air generator.

Reagents and Standards: Gas Cylinders are used as the source of the target pollutant concentration. Cylinders used should be of the highest purity available, specifically for multi-point calibrations and performance evaluations. All gases used should be either NIST traceable or EPA Protocol Gases having acceptance criteria of 2%. Three different gas cylinders were used in the initial testing project. The concentrations used to obtain the desired blend for the routine span and precision checks follow:

Concentration of gases, cylinder one:

- | | | |
|-------------------|--------------------------------------------------------|---------------------|
| • NO | 50 ppm nominal in N ₂ balance @ 2000 psig | Tolerance: ± 1% EPA |
| • CO | 5000 ppm nominal in N ₂ balance @ 2000 psig | Tolerance: ± 1% EPA |
| • NO _x | 50 ppm nominal in N ₂ balance @ 2000 psig | |
| • NO ₂ | <0.2 ppm in N ₂ balance @ 2000 psig | |
| • SO ₂ | 50 ppm nominal in N ₂ balance @ 2000 psig | Tolerance: ±1% EPA |

Concentration of gases used in cylinder two:

- CO 350 ppm nominal in N₂ balance @ 2000 psig Tolerance ± 1% EPA
- NO 10 ppm nominal in N₂ balance @ 2000 psig Tolerance ± 1% EPA
- NO₂ <0.05 ppm in N₂ balance @ 2000 psig
- NO_x 10 ppm nominal in N₂ balance @ 2000 psig
- SO₂ 10 ppm nominal in N₂ balance @ 2000 psig Tolerance ± 1% EPA

Cylinder three (span and precision checks)

- CO 60 ppm nominal

Targeted concentrations of the span and precision checks:

Pollutant	Range	Span	Precision Check
CO	5000 ppb	4000 ppb	250-500 ppb
SO ₂	100 ppb	80 ppb	20 ppb
NO _y	100 ppb	80 ppb	20 ppb

Data Acquisition, Storage and Communication Package: A data acquisition package is necessary to retrieve the data from a remote site and store it for further analysis. Two data acquisition systems were used in this project: Environmental Data Acquisition System (EDAS) for Windows both models 8816 and 8832, Environmental Services Corporation and Envidas, by Envotech. For further information, please refer to the Data Management SOP.

3.9 Procedures

3.9.1 Start-up

3.9.1.1 Unpack the instrument

1. Remove the unit from the shipping container and inspect for damages.
2. Note any damage to the shipping case and report to freight carrier immediately.
3. Removing the screws on each side of the top removes the top cover.
4. Inspect the interior of the calibrator for any loose parts or visible damage.
5. Check for any loose circuit boards. If loose, press down to reseat them before connecting the power.
6. Report any instrument damage to Environics or the local distributor.
7. If no damage is found, replace the cover and screws.

The above procedure should be done upon immediate receipt of the instrument or can be moved to the location the calibrator will be sited and then inspected for damage. However, do not wait too long to do the inspection to ensure validation of the warranty period. Please refer to inside the front cover of the manual for specifics on the warranty period and specific coverage.

3.9.1.2 Warm-up

When bringing zero air supply and calibrator together for initial checks, suggested warm up time is 24 hours. If moving to sampling location after initial checks, suggested warm up time would be 3-4 hours.

1. Set-up Calibrator in place and connect zero air supply to Port 1.
Note: Pressure of zero air supply should be between 30-35 PSI
2. Secure the appropriate electrical power supply to the Environics and switch to the “ON” position
3. Allow calibrator and zero air supply to warm-up and stabilize before proceeding.

3.9.1.3 Leak Check *Refer to Section 5.14 in the Environics Manual for further information on the Leak Check*

A leak check of the calibrator should be performed before beginning other work. A leak in the calibrator will result an incorrect dilution of gases delivered to analyzers yielding incorrect calibration and verifications of concentrations by the analyzer(s). It is strongly recommended to perform the leak check even if the calibrator is brand new. This ensures integrity of the system and prevents aggravation to the operator.

1. Set the pressure of the zero air supply to 10 PSI
2. At the READY screen, press the MORE key (F8) in the lower right hand corner of the screen. This will take you to the second screen.
3. Once on the second screen, press the LEAK CHECK key (F7)
4. Adjust the PSI reading on the external pressure gage on the front of the zero air supply source as necessary.

- Note:** The PSI should NOT be above 13. A PSI over 13 will activate the pressure safety.
5. Press the START key (F1) on the front panel.
6. Allow the Environics to run through the leak test cycle. The factory acceptance criterion for a leak check is less than 3 sccm.

Automatic sequence of events during the LEAK CHECK cycle:

1. Acquire atmospheric pressure (approximately 59 seconds)
2. Pressurize system - calibrator and zero air supply (approximately 89 seconds)
3. Shut down solenoids in calibrator – actual leak check of the calibrator and zero air supply

Note: The test may be cancelled at any time by pressing any key.

7. Once the LEAK CHECK is complete, the Environics will display the results. If less than 3 sccm, the results are acceptable.
8. Record results in appropriate lab notebook
9. Press the EXIT (F8) key located in the lower right hand corner of the screen.
10. Adjust the zero air supply to read 30 PSI on the external pressure gage

3.9.1.4 Flow Verification

Although the mass flow controllers have been factory set, it is strongly recommended to verify the flows through the calibrator using a NIST traceable source. This ensures accuracy as the flow measurement standard must be more accurate than the specified flow accuracy of the MFC. For this study, a BIOS Dry-Cal device was used. Flow devices must be certified annually. Flow checks should be verified at the start-up of the sampling system. Additional verifications should be performed annually or when the gaseous pollutant flow is questioned.

To complete flow verification of Port 1, zero air, and Port 2, cylinder gases, a BIOS Dry-Cal device was used. If another type of flow device is used, these procedures may differ. Consult the manual that accompanies that device for specific instructions.

1. Attach the appropriate BIOS cell to the base of the dry-cal.
2. Attach tubing to the exhaust end of the dry-cal.
3. Attach the calibration output tubing to the dry-cal. **Note:** the tubing from the calibrator output may not be the correct size to connect to the input of the dry-cal. Therefore, it may be necessary to have a small adapter/connector between two different sizes of tubing.
4. Turn on dry-cal
5. From the READY screen on the front panel of the Enviroics calibrator, press the CONC MODE (F1) soft key
6. When the Concentration Mode Screen appears, move cursor using the arrow keys on the soft key pad to Port 1.
7. Enter Port 1 and the cursor will move to the Target Gas area
8. Once in the Target Gas area, the concentration should be 0 for all gases. If not, change to 0 in those pollutant concentration fields as needed using the numeric key pad and the arrow keys.
9. After work in Target Gas area is complete, cursor should be in Total Flow area. If not move cursor to that area and enter total flow desired: 5.0 SLPM.
10. Move the cursor to another field using the arrow keys. This will update and confirm on the screen the current requested information.
11. Press START (F1) on the soft key pad at the bottom of the screen. This initiates the calibrator to open the appropriate solenoids and start the air flow through the calibrator.
12. Observing the display on the dry cal and the front of the calibrator, begin to record the actual readings from the dry cal when the flows are constant on both. It is recommended to record eight to ten readings.
13. After the readings are completed for a specific flow, select STOP (F) on the bottom of the front panel of the calibrator, repeat steps 9-12. Five or more Target Flows up to 20 LPM should be used to create a line.
14. When completed with Port 1, EXIT (F8) to the READY screen and switch to the cell for low flows on the dry cal device. The flow of Port 2 will now be verified.
15. At the READY screen, select the FLOW MODE (F2) at the bottom of the screen.
16. Cursor should appear at Port 1. Move to Target Flow area and enter 0 SLPM.
17. Move cursor to Port 2 and enter desired SCCM: 90.
18. Move the cursor to another field using the arrow keys. This will update and confirm on the screen the current requested information.
19. Turn on dry-cal

20. Select the START key (F1) on the soft key pad at the bottom of the screen. This initiates the calibrator to open the appropriate solenoids and start the air flow through the calibrator.
21. Observing the display on the dry cal and the front of the calibrator, begin to record the actual readings from the dry cal when the flows are constant on both. It is recommended to record eight to ten readings.
22. After the readings are completed for a specific flow, select EXIT (F8) on the bottom of the front panel of the calibrator, repeat steps 17, 18, and 20. Five or more Target Flows down to 10 SCCM should be used to create a line.
23. When completed with Port 2, EXIT (F8) to the READY screen.
24. Turn off dry-cal, disconnect tubing, and replace all tubing to original set-up as necessary.
25. Average each of the flow points.
26. Perform a linear regression analysis and plot the actual vs. target concentration flows.

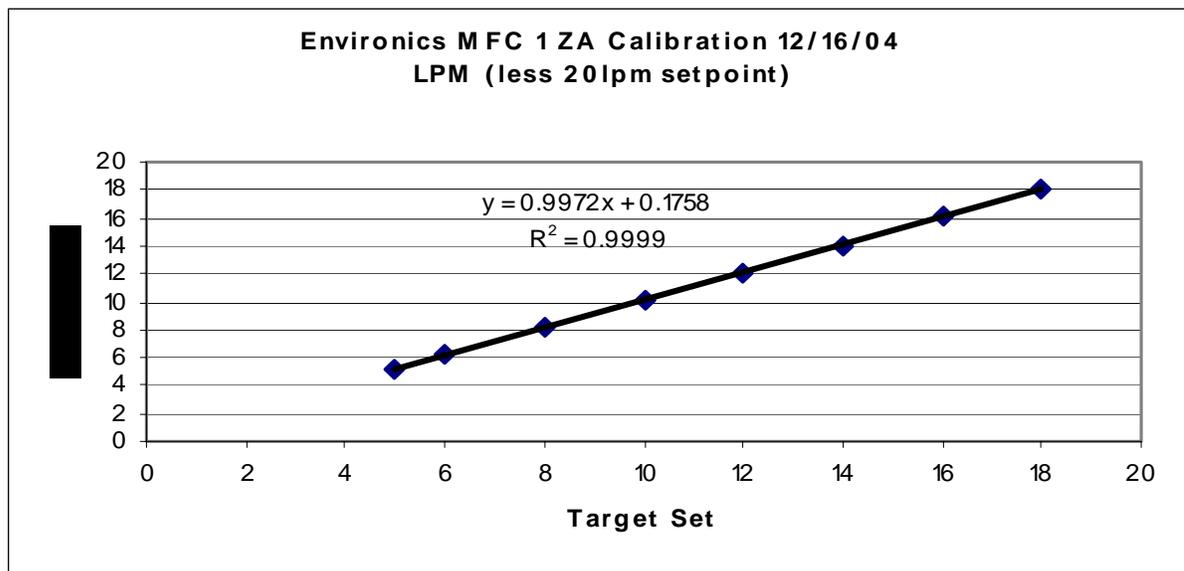


Figure 3: Calibration Graph of Enviroics 9100 Mass Flow Controller

3.9.2 IDENTIFYING THE CALIBRATOR PORTS TO THE GASEOUS STANDARDS

Refer to Section 5.8 in the Enviroics Series 9100 Manual

The purpose of this section is to assign gaseous cylinders to a specific port located on the rear of the Enviroics 9100 Calibrator.

1. From the **READY SCREEN**, select **MAINTAIN PORTS (F6)**
2. Using the soft number key pad on the right front screen, choose the desired gas port to be configured. Once a port number is selected, the cursor will appear in front of the word **BALANCE**
3. Using the Right Arrow key, move to the Gas ID column. Lines 1 will be used to name the **BALANCE** of the gas in the cylinder. Lines 2-6 will be used to name the individual gases in that cylinder.
4. Enter the first gas to be configured on line 2

- Note:** If it is intended to use nitric oxide to perform a Gas Phase Titration, “NO” must be used as the GAS ID. The system will compute the NO₂ while running. System recognizes NO only for this process.
4. Use the “Exit” key to return to the CGC area or use the “Up and/or Down” keys to move to a different CGC field.
 5. Enter the CGC for each GAS ID

Note: The cylinder concentration can either be entered as parts per million (ppm) or percent (%). Percent of a concentration is more typically used for higher blending higher concentration of gases.

Note: Concentrations of up to five (5) gases may be added for one multi blend gas cylinder. Beneath the CGC, the first cell is labeled **BALANCE**. If using a multi blend gas and contains nitric oxide (NO), this must be the first gas entered.
 6. Repeat steps 2-4 for all gases to be entered for that cylinder
 7. Press CYL ID (F6), to move to cylinder ID field and enter a name for that cylinder.
Suggestion: use the cylinder number listed on the cylinder tag
 8. After completing set-up for a desired port, press EXIT (F8) to select a different port. Press EXIT(F8) again to go to the Main Menu.

3.9.3 CALIBRATIONS – Multi-point

Running a multipoint calibration, a zero point and three separate concentrations are to be run to determine linearity of the instrument. The proposed audit ranges concentrations found in 40 CFR Part 58 Appendix A Section 3.2.2 combined with actual ambient concentrations observed would serve as a guideline of concentrations to choose for a multi-point calibration. The recommended sequence when performing the multi-point calibration is to perform a zero first, making any necessary adjustments to the zero, then move to the highest concentration working backwards ending with the low concentration and a final zero. Performing the points in this order more completely coats the exposed surfaces allowing for a more stable concentration. An added benefit to performing the concentration points in this sequence is the time savings element.

3.9.3.1 Determination of Concentrations for the Multi-point Calibration

Before performing the actual multi-point calibration, calculate the desired concentration of each point based upon the gas cylinder concentrations and gas flow. A recommendation: calculate these values before purchasing your pollutant gas standards to ensure having the desired concentrations when ready to perform the multi-point calibration.

Based on the flow verification of the mass flow controllers in the calibrator performed earlier, use the actual flow of the zero air and gases in the multi-blend cylinder to calculate what concentrations are needed for each pollutant for the multi-point calibration. Refer to Example #1 as you follow the step by step process.

1. Determine the range of the each pollutant, example CO is 0-5000 ppb

2. Next, determine 10 and 90 percent of the range, 500 and 4500 ppb respectively. By solving for the minimum and maximum concentrations, you will be able to determine what concentration of pollutant gas cylinder(s) is needed.

Note: It will be necessary to determine your total air flow needed through your system. This will be based on the set-up of the entire sampling system including manifold.

3. Using the following equation and referring to **Example #1**, Steps 2 & 3, determine what flow is needed to generate these concentrations.

$$\frac{\text{Concentration of pollutant in cylinder} \times \text{pollutant flow}}{\text{Total flow through system: pollutant flow} + \text{zero air flow}} = \text{desired concentration}$$

4. In this example, make the pollutant flow, the unknown value and solve the equation for it.
5. Once the 10 and 90 percent of range have been determined, solve for several more concentration values between those two.

Example #1 – Calculations for actual one point quality checks

Actual flow of gases through the system:

Zero air: 6.843 = 6.999.6 ccm; gaseous concentrations: 100 ccm = 98.05 ccm, 16.73 ccm = 13.63 ccm

Step 1: Zero air is run through the system to flush out any sample air before beginning the precision check

Step 2: Zero air is mixed with a gas containing

X concentration of CO at a flow of 100 ccm:

10.07 ppm of CO resulting concentration of CO: 139.1 ppb
[10.07 ppm x 98.05/ (98.05 + 6999.6)] x 1000 = 139.1 ppb

X concentration of SO₂ at a flow of 100 ccm:

13.13 ppm of SO₂ resulting concentration of SO₂: 181.4 ppb
[13.13 ppm x 98.05/ (98.05 + 6999.6)] x 1000 = 181.4 ppb - Over Range

X concentration of NO at a flow of 100 ccm:

10.26 ppm of NO resulting concentration of NO: 141.7 ppb
[10.26 x 98.05/ (98.05 + 6999.6)] x 1000 = 141.7 ppb - Over Range

Step 3: Zero air is mixed with a gas containing 13.13 ppm SO₂ , 10.26 ppm NO, and 10.07 ppm CO resulting in 25.5 ppb of SO₂ , 19.9 ppb NO, and 19.6 ppb.

X concentration of CO at a flow of 16.73 ccm:

10.07 ppm of CO resulting concentration of CO: 19.6 ppb
[10.07 ppm x 13.63./ (13.63 + 6999.6)] x 1000 = 19.6 ppb - Under Range

X concentration of SO₂ at a flow of 16.73 ccm

13.13 ppm of SO₂ resulting concentration of SO₂: 25.5
[13.13 ppm x 13.63/ (13.63+ 6999.6)] x 1000 = 25.5 ppb

X concentration of NO at a flow of 16.73 ccm
 10.26 ppm of NO resulting concentration of NO: 19.9 ppb
 $[10.26 \text{ ppm} \times 13.63 / (13.63 + 6999.6)] \times 1000 = 19.9 \text{ ppb}$

Step 4: Zero air only is run through the system

Audit Level	Concentration Range, PPM			
	O ₃	SO ₂ ,	NO ₂	CO
1.....	0.02-0.05	0.0003-0.005	0.0002-0.002	0.08-0.10
2.....	0.06-0.10	0.006-0.01	0.003-0.005	0.50-1.00
3.....	0.11-0.20	0.02-0.10	0.006-0.10	1.50-4.00
4.....	0.21-0.30	0.11-0.40	0.11-0.30	5-15
5.....	0.31-0.90	0.41-0.90	0.31-0.60	20-50

Table 1.0 Proposed Audit Levels, 40 CFR, Part 58 Appendix A, Section 3.2.2

Example concentrations used for Multipoint Calibration

CO	SO ₂	NO/NO _y
421 ppb	8.69 ppb	12.54 ppb
855 ppb	18.57 ppb	28.6 ppb
1078 ppb	40.56 ppb	50.04 ppb
2660 ppb	59.98 ppb	71.3 ppb
2990 ppb	82.5 ppb	92.28 ppb
3534 ppb	93.0 ppb	
4081 ppb		

3.9.3.2 Performing the Multi-point Calibration

1. From the READY screen, select **Concentration Mode** screen. This goes into the MANUAL Mode of Calibrations. Calibrations will occur for each analyzer and each point at a time. The cursor will appear at the first TARGET GAS concentration.
2. Enter the desired gas concentration in the TARGET GAS area by moving the cursor using the arrows.
3. Using the arrow keys, move to the TOTAL FLOW area and enter the flow, 10 LPM
4. Using the arrow keys, cursor to the OZONE area and enter desired concentration if applicable for the pollutant needed for NO₂
5. Press START. This will initiate the blending of the gases to the analyzer.
6. Allow the analyzer to stabilize.
7. Once stable, wait ten minutes, record the reading for that concentration.
8. Continue to the next concentration level repeating steps 1 through 5.
9. The above steps can be automated by programming each step into a Sequence and assigning a designated time to *Run*.

3.9.4 VERIFICATIONS – Zero, Span and One Point Quality Checks

These steps will assess and confirm the upper range of the multi-point calibration, the zero base line and the ambient working range of the instrument. The one point quality checks will determine both precision and bias of the analyzers.

This step may be either automated to occur as directed or manually. If performing a manual operation, follow the same procedure in *Section 3.9.3.2 Performing the Multi-Point Calibrations*. To operate in AUTOMATIC Mode, it is first necessary to program the **Sequences** and name the **Programs**.

3.9.4.1 SET-UP A SEQUENCE *Refer to Section 5.6.1 in the Enviroics Series 9100 Manual*

In this step, the steps necessary to automate the zero and span check will be set up. Below is an automated **Sequence** used in the project. Refer to **Example # 1** for a detailed explanation of each step.

Zero									
	Run Time	Mode	Port	Air Flow (ccm)	Gas (ccm)	Total	O₃	Gas ID	Conc.
1.	10 (min)	Conc.	2	6.843	0.0	6.843	0.0	NO	0.0
2.	20	Conc.	2	6.843	100	6.943	0.0	NO	0.142
3.	20	Conc.	2	6.843	16.73	6.8597	0.0	NO	0.025
4.	10	Conc.	2	6.843	0.0	6.843	0.0	NO	0.0

1. From the **READY**, select **Program Mode (F4)**
2. Once in **Program Mode**, select **Sequence (F2)**
3. At the blank screen, the cursor is in the **RUNTIME** column
4. Enter the desired run time for the first step Refer to Row 1 - 10 minutes
 Note: If “0” is entered, the step will be skipped and not displayed.
 Valid run times are 1 to 60 minutes.
 Twenty lines (20) are available for programming one **SEQUENCE**
5. Move the cursor to the **MODE** column. Using the function keys, choose the appropriate **MODE**
 Note: For zero, span, and precision checks use **Concentration (CONC) Mode**
6. Move the cursor to the **PORT** column; enter the desired span gas port which has been established in section 3.9.2 (In this case, it is not necessary to use Port 1. Using Port 2 and telling it not to send any gas from port 2 serves the same purpose as using Port 1 only)
7. Move to the **Total Flow** column and enter the desired flow.
8. Move to the **Gas ID** column; when at this column, the GAS ID should default to those provided in section 3.9.2
 Note: **Gas ID** number refers to the order of gases entered in the **MAINTAIN PORTS** screen.
9. Move to **CONC** column; enter desired concentration for that gas. Enter concentration in ppm.

Note: Moving cursor from column to column initiates a check to determine if the value entered is legal. If the value is not possible, an Error message is displayed at the bottom of the screen.

Note: When using the **CONC MODE**, the calibrator will automatically calculate the amount of gas needed to produce the required concentration. It is considered Good Laboratory Practice to check to determine calculations are correct. This can be a random check on one or more of the calculations.

10. Follow steps 3-9 for additional rows in the **Sequence**. Example 1 has four rows: zero, one point quality check - CO; one point quality check – NO and SO₂, and a zero.
11. After entering all steps in a specific sequence, **SAVE (F2)** the **Sequence** in the Register. Use the function keys to type the name of the **Sequence**. We'll call **Example # 1** PC-1 and saved as sequence line number 01
12. When the **SAVE** is complete, press EXIT (F8) to return to the **Program Mode**
13. Pressing EXIT again, returns to the **READY** screen.

3.9.4.2 SET-UP TIMER CONTROL (TIMER CTL) *Section 5.6.2 in the Enviroics Series 9100 Manual*

This is used to automate a number of sequences which allow for automating zero, span and one-point quality checks.

1. If this is the first set-up and no previous **Timer CTL** are stored in the register, the cursor will be in the Sequence line and it will be necessary to enter the desired sequence for the specific day(s) and time (s) the **Timer CTL**
 1. From the **Main Menu**, select **Program Mode**
 2. From **Program Mode**, select **TIMER CTL**
 3. Go to the day you want a specific **Sequence** to Run.
 4. Select the **Sequence**, 01, to be run.
 5. Enter the time to start the **Sequence**. Once the time is entered, the system will display the duration of the **Sequence** and calculate the end time.

Note: Time is based on a 24 hour clock with 12:00 being noon and 24:00 being midnight. Entering 0:00 will cause the **Sequence** to be skipped and will not be displayed; therefore must enter time as low as 00:01

Note: Three sequences per day may be entered for each day of the week.

6. Once the desired sequences are in the desired order, press the **SAVE (F2)** key.
7. Enter the desired register number. A name may also be entered.
8. Press EXIT (F8)

3.9.4.3 RUN TIMER CTL

1. If a program has been previously saved press the **RECALL (F3)** key to bring the program to the screen

2. Press the START (F1) key.

Note: The day and time of the next sequence will be displayed in the lower right hand corner of the screen.

3.9.4.4 Zero, Span, and One-Point Quality Checks

1. At the Concentration Mode, Manual Operation screen, enter the TARGET GAS concentration for the desired gas. The system will determine the actual flows for each port to achieve the requested gas concentration(s). Remember: Port 1 is Zero Gas.

2. Once the TARGET GAS concentrations have been set for the desired gas, press the START (F1) key, to begin the operation.

Note: A similar process is to go to the FLOW MODE and enter the desired flow. The Envionics will calculate the actual concentration based on the flow.

If the desire is to automate the zero, span and one point quality checks, set-up a **Sequence** and SAVE the sequence. Then to Run the **Sequence**, go to Timer Control and set the desired time to run your **Sequence**. Below is an example of a **Sequence** set-up for *Precision Checks* used in the testing program. Refer to previous sections 3.9.4.2 and 3.9.4.3. Note: A tri-blend standard was used in the testing process. An example of the gases used and the concentrations are found on pages 8 and 9.

3.9.4.5 Calibrator Automation

A Data Acquisition System can control the running of a programmed sequence. To use this function, the Envionics calibrator must have the optional status board. The INPUTS option provides the ability to trigger various actions within the system. The OUTPUTS option will signal external devices when certain operating conditions occur. In order for the data acquisition system to run the calibrator, the INPUTS option is needed.

1. Using the key pad, press the STATUS SETUP – INPUT soft key at the **Main Menu** screen.
2. At the INPUT screen add the desired function(s), **Sequence**, **Timer Control**, etc to be run in the Status Line. The desired function(s) can be chosen from the soft keys at the bottom of the screen.
3. When the desired function(s) have been entered, select the EXIT soft key returning to the **Main Menu** and the READY mode.

Note: the calibrator must be in the READY mode for the automation to occur

For further detailed information on communications between the data acquisition system, calibrator and analyzers, refer to the Data Acquisition SOP.

4.0 Quality Control and Quality Assurance

After confirming the flows through the calibrator, a multi-point calibration for each analyzer should be performed. A different certified gas cylinder should be used other than the cylinder used for span and precision check gas.

Operating the MFC below 10% of its rated full-scale flow may result in flow inaccuracies.

The system may produce gas blends that fall outside the accuracy specifications of the system if the gas pressures do not stay within the ranges specified for each gas port. The operator of the system should not be the same person who performs the multi-point calibrations, but in the case of the Trace Gas Analyzers, it could be.

MQO Table for Environics 9100 Calibrator			
Criteria	Acceptable Range	Minimum Frequency	Reference
Mass Flow Controllers			
Zero Air Source			

5.0 References

1.40 CFR Part 58, Appendix A

2. Environics Series 9100 Computerized Ambient Monitoring Calibration System, Operating Manual, Revision 6, October 1999