

Teledyne Model 701 Zero Air Generator
Certification and Verification for NCore Monitoring

Section I

Electronic Calibration Branch (ECB) Responsibilities

Effective June 2018

Approval Sign-Off Sheet

I certify that I have read and approve of the contents of this revision of the "Teledyne Model 701 Zero Air Generator Certification and Verification for NCore Monitoring, Section I, Electronic Calibration Branch (ECB) Responsibilities" with an effective date of 01-Oct-2018.

Central Office

Kay Roberts, Environmental Chemist

Signature: K. Roberts Date: 13 Sep. 2018

Electronics and Calibrations Branch

Mark Yirka, Electronics Tech III

Signature: Mark Yirka Date: 9-21-18

Electronics and Calibrations Branch Supervisor

Derrick House

Signature: Derrick House Date: 9-24-18

Projects and Procedures Branch Supervisor

Joette Steger

Signature: Joette Steger Date: 9-26-2018

Ambient Monitoring Section Chief

Patrick Butler

Signature: Patrick Butler Date: 9-26-18

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2.3.5 Teledyne Model 701 Zero Air Generator General Background Information

The Teledyne Model 701 Zero Air Generator (ZAG) is a convenient system for the generation of pollutant free zero air for High-Sensitivity Trace Level Carbon Monoxide (CO-TLE), Trace Level Sulfur Dioxide (SO₂-TLE) and Trace Level Total Reactive Oxides of Nitrogen (NO_y-TLE) analyzers and an excellent source of clean, dry air for use by dilution calibrators. The Model 701 is certified to produce zero air that meets ISO 8573.1 Class 3 Compressed Air Standards.

The basic Model 701 ZAG includes an oil and diaphragm-free pump plus scrubbers to remove sulfur dioxide (SO₂), reactive oxides of nitrogen (NO_y), nitrogen dioxide (NO₂), ozone (O₃), and hydrogen sulfide (H₂S). Optional high-performance scrubbers are available to remove CO and hydrocarbons. The Division of Air Quality (DAQ) uses these optional scrubbers at the NCore and near-road sites where CO monitors are operated. The regenerative and heatless dryer:

- Removes water;
- Can produce up to 15 standard liters per minute (SLPM) of zero air with a dew point of less than -20 °C, independent of the inlet dew point; and
- Assists in the removal of other gases, greatly increasing the life of the chemical scrubbers.

Inlet air is pulled into the pump and routed through a pre-cooler and water trap to remove moisture. The air then passes through a regenerative dryer for final drying and then to the storage tank. Tank pressure is monitored and maintained at a preset level by cycling the pump automatically as needed, thereby extending both the pump and scrubber life. Outlet air then passes through a filter to assure delivery of a clean, dry, analytical zero air supply.

DAQ uses Teledyne Model 701 ZAGs at multiple sites as a pure air generation device for High Sensitivity CO-TLE, SO₂-TLE and NO_y-TLE continuous monitors.

Model 701 ZAG Features include:

- Regenerative, heatless dryer for maintenance-free water removal independent of inlet dewpoint
- Long-lived scrubbers for SO₂, NO_y, NO₂ and O₃
- Automatic water drain
- Automatic pump control based on flow demand
- Zero air for Ozone Generators

2.3.5.1 Overview of Operation

The Model 701 draws air through the rear panel bulkhead union and inlet filter into the built-in compressor. The compressor is a single-cylinder oscillating piston type driven by a split capacitor alternating current, or AC, motor. The compressor is dry; that is, there are no lubricants which can contaminate the compressed air. The pistons are sealed by flexible tetrafluoroethylene (TFE), piston rings, and after a short conditioning period to seat the rings, should last for years. There are

no diaphragms. The compressed, ambient air then passes through a fan cooled heat exchanger to reduce the heat of compression. This cooled, moist, high pressure air then passes through a coalescing filter, or water trap, which removes the excess moisture. The separated moisture condenses in the bottom of the coalescing filter and is automatically removed by a solenoid drain valve which expels the water through a rear panel bulkhead union (drain).

The partially dried air passes a pressure relief valve, set to open at 90 pounds per square inch gauge, or psig, and enters the regenerative dryer. The regenerative dryer removes any remaining water and a portion of other trace contaminants. The operation of the pressure relief valve can be loud but this is a normal part of the operation of the Model 701.

The now dried zero air then passes through a check-valve into the surge, or pressure, tank where it is stored until needed. As the pressure in the surge tank reaches its preset "high" value, a switch turns OFF the compressor. When the pressure in the surge tank falls to its preset "low" value, the switch turns the compressor back on to begin the process again. Thus, when air demand is low, the compressor is turned OFF and the air stored in the surge tank fulfills the demand. The pressure in the tank varies from approximately 35 psig to approximately 80 psig depending on the demand. A pressure regulator mounted on the unit's front panel regulates zero air delivery pressure and flow rates. This regulator is typically set for 30psig and can be monitored by a pressure gauge on the front of the unit.

For a final clean-up, the dry, regulated air enters specific scrubbers:

For NO compounds: the NO scrubber where residual NO is oxidized to NO₂, then absorbed the activated charcoal scrubber where the NO₂ is absorbed.

For Residual Organics and Fine Particulates: the charcoal scrubber where zero air passes through a fine particulate filter and leaves the Model 701 through the rear panel bulkhead.

For CO: the CO scrubber where zero air is passed through a canister of carulite and silica gel along with a Palladium scrubber (Pd)), to catalytically oxidize CO to CO₂.

Figure A on page 11 depicts one of several ways the additional dry scrubbers may be arranged. When air usage is high (5 – 20 SLPM), the compressor may run continuously. Likewise, when air usage is low, the pressure sensor switch turns the compressor OFF until the storage tank pressure drops below the lower set point, then the pressure sensor switch turns the compressor ON again.

2.3.5.2 Routine Maintenance

The Model 701 ZAG has been designed with ease of maintenance as an important criterion. Components and sub-assemblies have been selected for high performance, excellent stability, and long life. The exact lifetime of the scrubbing materials is dependent upon flow, pressure and level of contaminants. For most applications, the following recommendations should be followed by

the Site Operator or the Electronics and Calibration Branch (ECB) and documented in the instrument logbook or file.

Monthly (to be completed by Site Operator)

- Examine the Tubing - during use, the compressor may vibrate causing some parts of the TFE tubing to abrade against nearby objects. This is most likely to occur with the tubing directly attached to the compressor. Replace any section of tubing that appears to be heavily abraded.

Annually (to be completed by ECB personnel)

- Replace the site Model 701 ZAG with a recently serviced (fresh chemicals) Model 701 ZAG which should be certified at the site when placed into service.

NOTE: Model 701 ZAG should be verified every 6 months and replaced annually. The procedures for verification and certification are found in section 2.3.5.4.

For all NCore Sites, if the site Model 701 Zero Air Generator is being replaced, a “closing” site zero air generator verification and a certification using a “recently serviced” zero air generator will need to be completed.

2.3.5.3 Model 701 ZAG Operation

1. Power ON the generator; the front panel power indicator should light up and the cooling fan should start. Allow a few seconds for the control board to measure local line frequency.
2. Adjust the pressure regulator on the Model 701 front panel to the desired pressure – typically the pressure is set to 30 psig.

2.3.5.3.1 High Sensitivity / Trace Level Carbon Monoxide Measurements

Zero air is required for the calibration of high sensitivity CO analyzers. This air must contain no detectable CO (i.e., CO content must be at or near the Lower Detectable Limit (LDL) of the CO analyzer) and must be free of particulate matter. Suitable zero air may be supplied from compressed gas cylinders of purified air, with the use of additional external CO scrubbers (e.g. carulite and/or palladium) to remove residual CO in the commercial product. It may be difficult to reduce CO levels to 45 ppb or less, unless a palladium scrubber is used.

2.3.5.3.2 High Sensitivity/Trace Level Sulfur Dioxide Measurements

Zero air is required for the calibration of high sensitivity SO₂ monitoring instruments. This air must contain no detectable SO₂ (i.e., SO₂ content must be at or near the Lower Detectable Limit (LDL) of the SO₂ analyzer) and be free of particulate matter.

2.3.5.3.3 High Sensitivity/Trace Level Total Reactive Oxides of Nitrogen Measurements

Zero air is required for the calibration of high sensitivity NO_y instruments. This air must contain no detectable NO_y species (i.e., NO_y content must be at or near the Lower Detectable Limit (LDL) of the analyzer) and must be free of particulate matter.

NOTE: It is expensive and impractical to maintain a sufficient supply of zero air cylinders to operate high sensitivity CO, SO₂ and NO_y analyzers continuously. To verify, and/or certify, the air produced by zero-air generators used for high sensitivity/trace level instruments is free of contaminants, a comparison should be done at least every 6 months by ECB staff. Results from verification and/or certification procedures should be recorded using an AQ 121C form and a copy should be kept with the zero air generator records which are maintained at ECB.

2.3.5.4 NCore Zero Air Generator Verification/Certification Requirements

1. On the 48i TLE analyzer panel main menu, choose **Calibration > “Zero/Span Check” > Next Time** and set the Zero/Span Check routine forward 4 or 8 hours (scheduled run-times are: 01:46, 05:46, 09:46, 13:46, 17:46, and 21:46).
2. Using Envidas Ultimate VIEWER select **ToMaintain** for each data channel being used during Verification and/or Certification (Refer to “Marking Channels Up or Down” in the RCO Guidance Documents folder under the Documents section of NC DAQ’s Ambient Monitoring SharePoint page for instructions). This procedure should be completed for each High Sensitivity/Trace Level analyzer being verified or certified (see Section 2.3.5.4.1 and Section 2.3.5.4.2). (Data channels can be set **ToMaintain** sequentially as being verified and/or certified or all at the same time for the duration of this procedure.)
3. Using Envidas REPORTER on the site computer, configure the data acquisition system to display real time data (Refer to “Displaying Real Time Graph and Minute Data” in the RCO Guidance Documents folder under the Documents section of NC DAQ’s Ambient Monitoring SharePoint page for instructions).

2.3.5.4.1 Verification Procedure (*Every 6 Months*)

1. Using the Model 701 ZAG at the site, sequentially initiate the onsite calibrator to deliver zero air by activating Phase Zero for 30 minutes for each type of trace level instrument (e.g. COT, SO₂T, NOT, NO_yT). This procedure can be initiated remotely and completed prior to arriving at the site. The test (ZERO) is typically performed at the same flow rate used during calibrations and overnight checks. Record the average of the last 5 minutes of Phase Zero values generated during the verification procedure on the AQ 121C form.
2. At the site, connect an “Ultra-Pure zero air cylinder” to the calibrator to deliver Ultra-Pure zero air to each type of trace level instrument for a time sufficient to allow the readings to stabilize. This test (ZERO) is typically performed at the same flow rate used for calibration

and overnight checks. Manually initiate Phase Zero for 30 minutes. Using EnVidas Reporter to display the minute data. Electronically save the average of the last 5 minutes for inclusion on the AQ 121C form to document the verification procedure.

NOTE: Additional carulite and palladium scrubbers are attached to the outlet of the “Ultra-Pure zero air cylinder” during ZAG Verification/Calibration to aid in the removal of residual CO in the commercial product.

3. Acceptable Verification values are calculated on the AQ 121C form as the *Absolute Value of Difference* between the to be verified site 701 ZAG readings and the “Ultra-Pure zero air cylinder” instrument response averages, for each individual analyzer.
4. If the on-site Model 701 ZAG values meet the Verification Zero Criteria values obtained using the Ultra-Pure cylinder, then the Model 701 ZAG is capable of producing air of sufficient cleanliness and is suitable for use with High Sensitivity / Trace Level Monitors.
5. Document Verification procedure (Date and Personnel) on ZAG front panel, in the site logbook, and ECB Logbook for Model 701 ZAG.

The Verification criteria for each monitor is listed in the table below:

	Verification Zero Criteria
Model 48i TLE CO	± 35 ppb ^[1]
Model 43i TLE SO ₂	± 1.0 ppb ^[1]
Model 42i TLE NOyT/NOT	± 0.2 ppb ^[2]

^[1] NC DAQ QAPP Revision 2.1, September 1, 2016

^[2] EPA-454/R-05-003 Technical Assistance Document (TAD) MDL for Precursor Gas Measurements in the NCore Multi-Pollutant Monitoring Network, Version 4, September 2005

6. If the verification is acceptable and certification of a replacement ZAG is not necessary:
 - a) Reconnect the zero-air generator to the calibrator
 - b) Confirm the next scheduled “**Zero/Span Check**” routine for the CO analyzer is set to run at the next available time (scheduled run-times are: 01:46, 05:46, 09:46, 13:46, 17:46, and 21:46). (On the 48i TLE analyzer panel main menu, choose **Calibration > “Zero/Span Check” > Next Time**)
 - c) Using Envidas Viewer, select ResetFlag for all channels previously marked ToMaintain
 - d) Confirm the status of all analyzers verified to be “OK” using the site DAS
 - e) Save all applicable data and graphs to document verification procedure and complete AQ 121C form.
7. If certification of a replacement ZAG is necessary, continue with certification procedure.

2.3.5.4.2 Certification Procedure (*Annually*)

1. Using a recently serviced or replacement Model 701 ZAG, connect the generator to the calibrator to deliver zero air by activating Phase Zero for each type of trace level instrument (e.g. CO, SO₂, NO_x, NO_yT) for a time sufficient to allow the readings to stabilize. This test (ZERO) is typically performed at the same flow rate used during calibrations and overnight checks. Allow the instrument to activate Phase Zero for 30 minutes. Using EnVidas Reporter to display the minute data, electronically save the average of the last 5 minutes for inclusion on the AQ 121C form to document the certification procedure.
2. Using the zero values collected during the verification procedure while running the “Ultra-Pure zero air cylinder” (See 2.3.5.4.1), calculate the *Absolute Value of Difference* between the averaged values for the Ultra-Pure zero air cylinder and the Model 701 ZAG being certified using the AQ 121C spreadsheet.
3. Acceptable Certification values are calculated as the *Absolute Value of Difference* between the *to be certified* site 701 ZAG readings and the UHP cylinder instrument response averages, for each individual analyzer.
4. If the Model 701 ZAG values are less than or equal to the values obtained using the Ultra-Pure cylinder, then the Model 701 ZAG is capable of producing air of sufficient cleanliness and is suitable for use with High Sensitivity / Trace Level Monitors.
5. Document Certification procedure (Date and Personnel) on ZAG front panel, in the site logbook, and ECB Logbook for Model 701 ZAG.

The Certification criteria for each monitor is listed in the table below:

	Certification Zero Criteria
Model 48i TLE CO	± 35 ppb ^[1]
Model 43i TLE SO ₂	± 1.0 ppb ^[1]
Model 42i TLE NO _y T/NOT	± 0.2 ppb ^[2]

^[1] NC DAQ QAPP Revision 2.1, September 1, 2016

^[2] EPA-454/R-05-003 Technical Assistance Document (TAD) MDL for Precursor Gas Measurements in the NCore Multi-Pollutant Monitoring Network, Version 4, September 2005

6. When certification is completed and acceptable:
 - a) Confirm the next scheduled “**Zero/Span Check**” routine for the CO analyzer is set to run at the next available time (scheduled run-times are: 01:46, 05:46, 09:46, 13:46, 17:46, and 21:46). (On the 48i TLE analyzer panel main menu, choose **Calibration > “Zero/Span Check” > Next Time**)
 - b) Using Envidas Viewer, select ResetFlag for all channels previously marked ToMaintain
 - c) Confirm the status of all analyzers verified to be “OK” using the DAS

- d) Save all applicable data and graphs to document verification / certification procedure(s) and complete AQ 121C form.

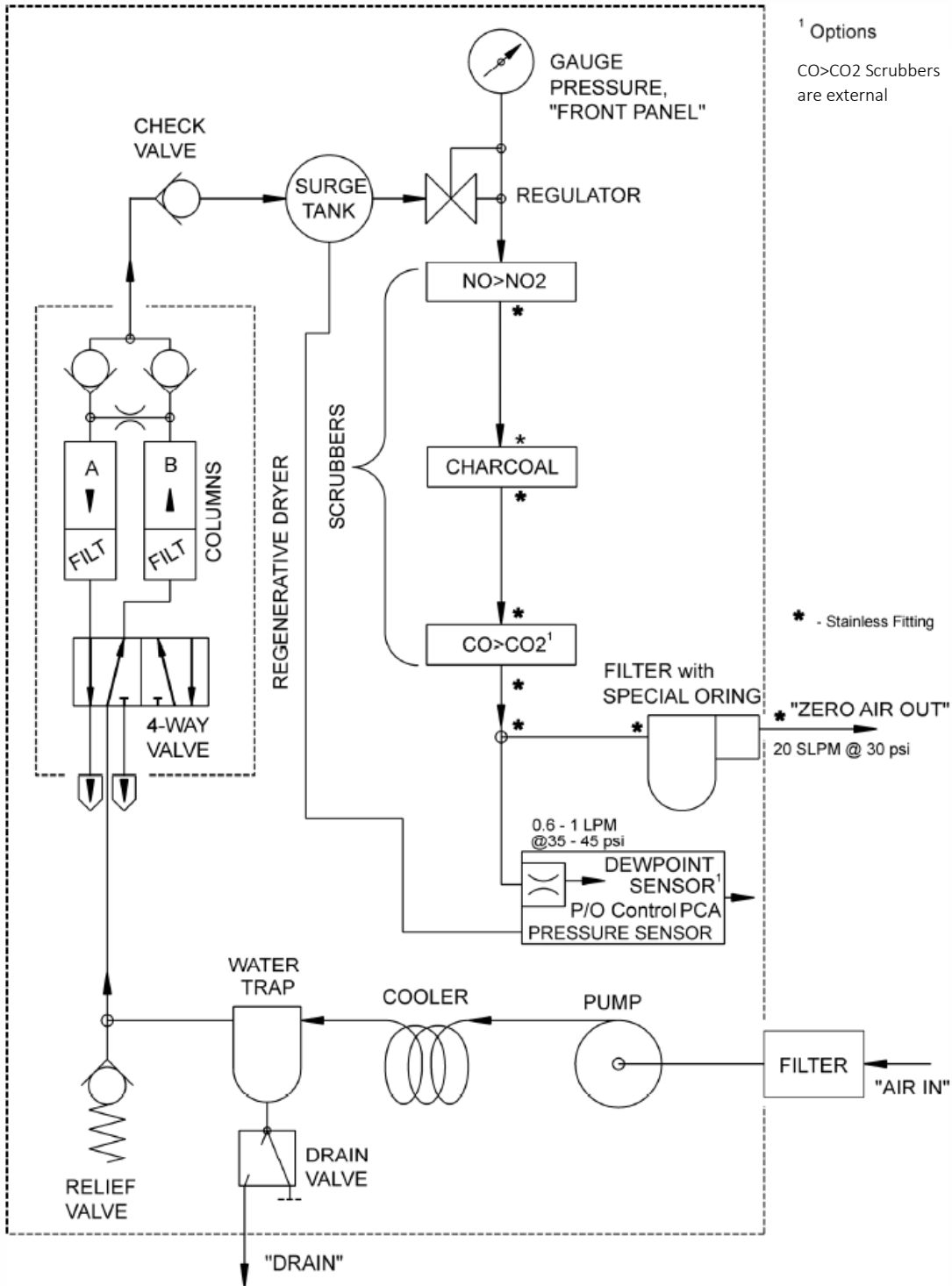
2.3.5.5 Records and Procedures

1. The Electronics and Calibration Branch (ECB) assigns a dedicated logbook to each significant component of the NCore ambient monitoring system (calibrators and analyzers). Model 701 Zero Air Generators should be certified by the ECB prior to use and verified after being in service for 6 months. The AQ 121C form is used to document the procedure, and is then reviewed by the ECB Supervisor and forwarded to the Environmental Supervisor of the Policies and Procedures Branch for final review and archive.
2. Logbook records for the NCore ambient air monitoring systems (calibrators, analyzers, zero air generators) will include complete repair records for instrumentation used at sites. All raw data generated during verification / certification procedures will be maintained on file at ECB.
3. All Verification and/or Certification Procedures should be recorded:
 - a. In the Site Logbook
 - b. On Front Panel of the ZAG
 - c. In ECB ZAG Instrument Logbook

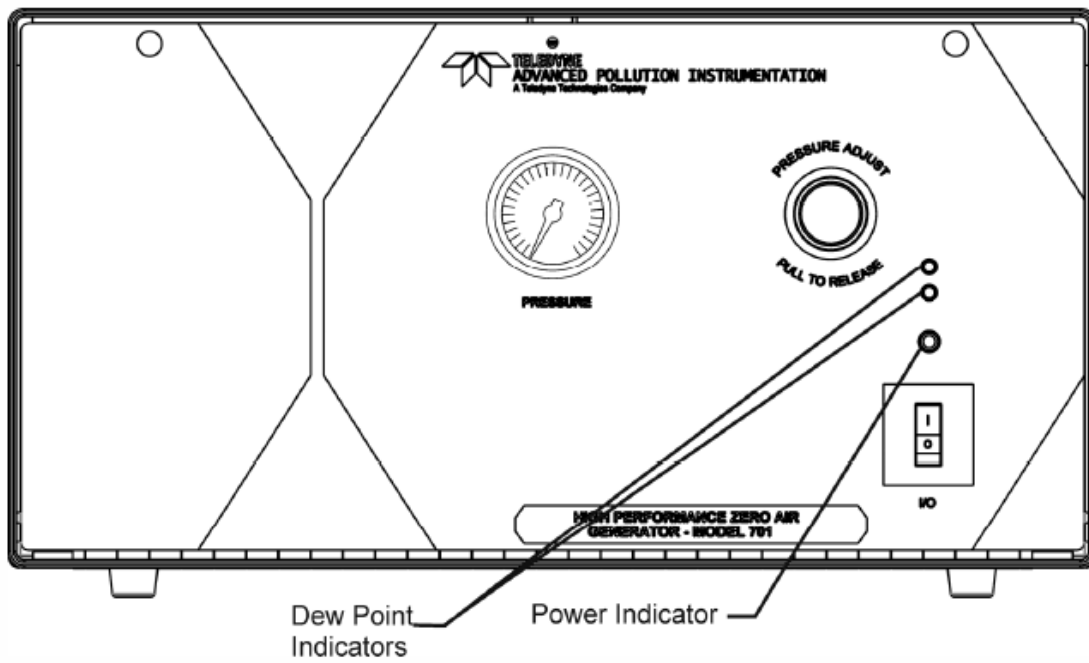
2.3.5.6 Revision History

1. Modified Title
2. Removed details for replacing CO-CO₂, Charcoal, Carulite and/or No-NO₂ scrubber at site.
3. Added instructions for advancing 48i TLE "Zero/Span Check"
4. Updated acceptance criteria for each trace level monitor
5. Added Records and Procedures Section to include current procedures
6. Moved instrument diagrams to Appendix A and Appendix B
7. Added location of RCO Guidance Documents for using new DAS (e.g. Marking Channels Up or Down in Envidas, Displaying Real Time Graph and Minute Data in Envidas) All references to AVTrend removed.
8. Added Appendix C, Example of AQ 121C Form

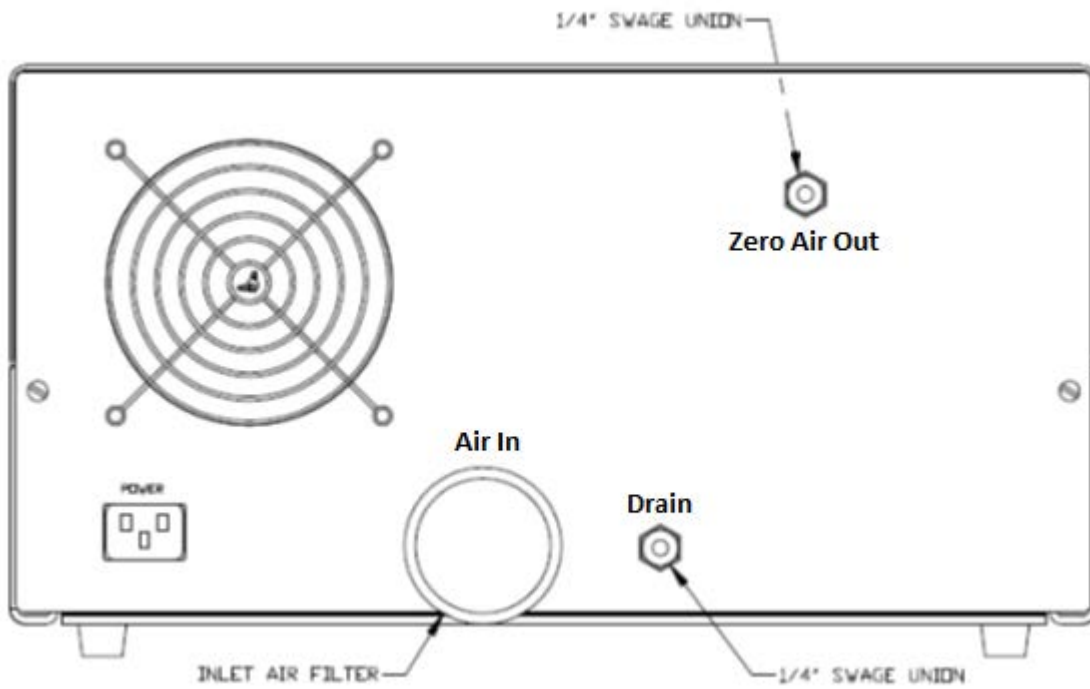
Appendix A Example of Model 701 Zero Air Generator Flow Diagram



Appendix B Model 701 Zero Air Generator Front and Rear Views



Front View



Rear View

Appendix C Example of AQ 121C Form

MODEL 701 ZERO AIR VERIFICATION and CERTIFICATION

REGIONAL SUPERVISOR				REGIONAL CHEMIST			
STATION #	37-183-0014	SITE:	Millbrook	REG:	RARO	QTR:	YR:
AUDIT CYL TYPE:		UHP	AUDIT CYL SN:		AUDIT CYL EXP. DATE:		N/A
SITE 701 ZAP TBV #		Model 701	701 ZAP TBV SN:		NEXT TBV DATE		TBR DATE
TBR 701 ZAP TBC #		Model 701	701 ZAP TBC SN:		NEXT TBV DATE		TBR DATE
AUDITORS:				REVIEWED BY:			
TBC= TO BE CERTIFIED				DATE PERFORMED:			
TBR= TO BE RENEWED (Replaced unit or scrubber chemicals renewed)							
TBV= TO BE VERIFIED							

701 ZERO AIR VERIFICATION

		COT=	2000 SCCM	DATE PERFORMED:	DATE	START	END
CALIBRATOR AUDIT FLOW TBV MODEL 701		SO2T=	2000 SCCM	DATE PERFORMED:			
		NOT / NOYT=	6000 SCCM	DATE PERFORMED:			

		COT=	2000 SCCM	DATE PERFORMED:	DATE	START	END
CALIBRATOR AUDIT FLOW UHP CYL.		SO2T=	2000 SCCM	DATE PERFORMED:			
		NOT / NOYT=	6000 SCCM	DATE PERFORMED:			

POINT	Site 701 ZAP To Be Verified 30 Min Run/5 Min Avg				UHP Cylinder Response 30 Min Run/5Min Avg			
	COT ZERO READING (ppb)	SO2T ZERO READING (ppb)	NOT ZERO READING (ppb)	NOYT ZERO READING (ppb)	COT ZERO READING (ppb)	SO2T ZERO READING (ppb)	NOT ZERO READING (ppb)	NOYT ZERO READING (ppb)

Zero Criteria	
Model 48i TLE COT	± 35.000 ppb
Model 43i TLE SO2T	± 2.000 ppb
Model 42i TLE NOT	± 0.200 ppb
Model 42i TLE NOYT	± 0.200 ppb

Absolute Value of Diff.		UNITS	Passed/Fail
Model 48i TLE COT	0.000	ppb	PASSED
Model 43i TLE SO2T	0.000	ppb	PASSED
Model 42i TLE NOT	0.000	ppb	PASSED
Model 42i TLE NOYT	0.000	ppb	PASSED

701 ZERO AIR CERTIFICATION

		COT=	2000 SCCM	DATE PERFORMED:	DATE	START	END
CALIBRATOR AUDIT FLOW TBC MODEL 701		SO2T=	2000 SCCM	DATE PERFORMED:			
		NOT / NOYT=	6000 SCCM	DATE PERFORMED:			

		COT=	2000 SCCM	DATE PERFORMED:	DATE	START	END
CALIBRATOR AUDIT FLOW UHP CYL.		SO2T=	2000 SCCM	DATE PERFORMED:			
		NOT / NOYT=	6000 SCCM	DATE PERFORMED:			

POINT	Site 701 ZAP To Be Certified 30 Min Run/5 Min Avg				UHP Cylinder Response 30 Min Run/5Min Avg			
	COT ZERO READING (ppb)	SO2T ZERO READING (ppb)	NOT ZERO READING (ppb)	NOYT ZERO READING (ppb)	COT ZERO READING (ppb)	SO2T ZERO READING (ppb)	NOT ZERO READING (ppb)	NOYT ZERO READING (ppb)

Zero Criteria	
Model 48i TLE COT	± 35.000 ppb
Model 43i TLE SO2T	± 2.000 ppb
Model 42i TLE NOT	± 0.200 ppb
Model 42i TLE NOYT	± 0.200 ppb

Absolute Value of Diff.		UNITS	Passed/Fail
Model 48i TLE COT	0.000	ppb	PASSED
Model 43i TLE SO2T	0.000	ppb	PASSED
Model 42i TLE NOT	0.000	ppb	PASSED
Model 42i TLE NOYT	0.000	ppb	PASSED

AUDITOR REMARKS:

AUDIT RESULTS: GOOD _____ NOT ACCEPTABLE _____ INDICATE ACTION TAKEN BELOW:
ADDITIONAL OPERATIONAL CHECKS (SPECIFY): _____
PREVENTIVE ACTION (DESCRIBE) _____
REMARKS: _____
EVAL. DATE: _____ EVALUATOR: _____