

**STANDARD OPERATING PROCEDURE (SOP)  
FOR THE THROUGH-THE-PROBE (TTP)  
NATIONAL PERFORMANCE AUDIT PROGRAM  
(NPAP)  
VERSION 2.0**

National Performance Audit Program (NPAP)  
Office of Air Quality Planning and Standards  
U.S. Environmental Protection Agency  
Research Triangle Park, NC 27709

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## ACRONYMS

AMTIC	Ambient Monitoring Technology Information Center, Website on the EPA TTN
AQS	Air Quality System
BOA	back of the analyzer
CASTNET	Clean Air Status and Trends Network
ccm	cubic centimeter per minute
CFR	Code of Federal Regulations
CO	carbon monoxide
DAS	data acquisition system
EPA	Environmental Protection Agency
ESAT	environmental services assistance team
FEP	fluorinated ethylene propylene
FS	field scientist
GPS	global positioning system
GPT	gas phase titration
ID	inner diameter
LPM	liter(s) per minute
MFC	mass flow controller
NAAQS	National Ambient Air Quality Standards
NCore	National Core Multipollutant Monitoring Network
NIST	National Institute of Standards and Technology
NO	nitric oxide
NO <sub>2</sub>	nitrogen dioxide
NO <sub>x</sub>	oxides of nitrogen – sum of NO <sub>2</sub> and NO
NPAP	National Performance Audit Program
O <sub>3</sub>	ozone
OAQPS	Office of Air Quality Planning and Standards
OD	outer diameter
Pd	palladium
PEAT	Performance Evaluation AQS Tool
ppm	part per million
PQAO	primary quality assurance organization
psig	pounds per square inch gauge
PTFE	polytetrafluoroethylene
QA	quality assurance
QAPP	quality assurance project plan
QC	quality control
RTP	Research Triangle Park, North Carolina
SIP	state implementation plan
SLAMS	State and Local Air Monitoring Station
SO <sub>2</sub>	sulfur dioxide
SOP	standard operating procedure
SRP	standard reference photometer

TTP through the probe  
UPS uninterruptible power supply  
ZAG zero air generator

## 1.0 Introduction

### 1.1 Purpose of Document

The purpose of this Standard Operating Procedure (SOP) is to detail and standardize the methods and procedures performed by field scientists (FSs) and Environmental Protection Agency (EPA) Regional National Performance Audit Program (NPAP) Leads for conducting through-the-probe (TTP) gas audits of criteria pollutant gases including ozone (O<sub>3</sub>), carbon monoxide (CO), sulfur dioxide (SO<sub>2</sub>), and nitrogen oxides (NO<sub>x</sub>) under the NPAP. This SOP is a resource for training new FSs and as an in-field reference for experienced FSs. This SOP also serves as a reference for self-implementing PQAQO TTP audit programs.

Due to variability in equipment inventories among the EPA Regional Offices, procedures described in this SOP are agnostic to instrument manufacturer and model but are common to the specific instrument purpose (e.g., CO analyzer). Deviations (whether already occurred or planned) from the procedures in this document can compromise the goals and integrity of the NPAP. Deviations, when planned or unplanned, are to be reported in writing and submitted to the appropriate NPAP EPA Regional Lead and to the Office of Air Quality and Planning and Standards (OAQPS) NPAP Lead. Potential modifications to this SOP shall be proposed in writing to the OAQPS NPAP Lead who will consider the modifications for the next revision.

This document follows the format for technical SOPs outlined in EPA's *Guidance for Preparing Standard Operating Procedures (SOPs)*, EPA QA/G-6, EPA/600B-07/001, April 2007.

### 1.2 NPAP Definition and Regulatory Requirement

Air quality monitoring agencies operating monitoring sites in the state and local air monitoring stations (SLAMS), National Core Network (NCore), Tribal, Special Purpose Monitor (SPM), National Park Service (NPS), and Clean Air Status and Trends Network (CASTNET) monitoring networks measure ambient air concentrations of criteria pollutant gases: SO<sub>2</sub>, NO<sub>x</sub>, O<sub>3</sub>, and CO. Measured concentrations of these gaseous criteria pollutants in the local ambient air are compared to the National Ambient Air Quality Standards (NAAQS) for each pollutant to determine whether the air at the site meets the NAAQS for each pollutant. The NPAP is a quality assurance (QA) program for the criteria monitoring networks to evaluate the proficiency of site operators and monitoring instruments per [40 CFR Part 58 Appendix A Section 3.1.3](#).

The primary goal of the NPAP is to ensure that measured concentration data reported by SLAMS, NCore, Tribal network, SPM, NPS, and CASTNET monitoring sites are within acceptable measurement tolerances. Secondary goals of the NPAP are to assist monitoring organizations in identifying and correcting problems and to drive data consistency and comparability across monitoring sites in these networks.

Primary Quality Assurance Organizations (PQAOs) that elect to self-implement a criteria pollutant gas audit program should incorporate the NPAP and utilize this document in implementing the program. The requirements for self-implementation are listed in [40 CFR Part 58 Appendix A Section 3.1.3.4](#) and within the NPAP QAPP (available at the following URL on EPA's AMTIC: <https://www.epa.gov/amtic/national-performance-audit-program-npap-gaseous-monitoring>) Section A7.1.



### 1.3 NPAP Training and Certification

Training requirements for NPAP FSs and EPA Region Leads are detailed in NPAP QAPP Section A7. Documentation and training materials pertinent to conducting NPAP activities are included in the following subsections.

#### 1.3.1 Training Documents

Prior to conducting TTP NPAP audits, FSs should be familiar with the documents listed in Table 1-1 and have documented the date reading of these documents was completed. The documents are listed in order of decreasing detail for conducting the NPAP, where 1 indicates the most detailed and 4 indicates the least detailed.

**Table 1-1. Training Documents**

Document <sup>1</sup>	Detail Level
SOP for the EPA TTP NPAP (this document)	1
Quality Assurance Project Plan (QAPP) for the NPAP: <a href="https://www.epa.gov/system/files/documents/2021-09/npap-qapp_revision-6_epa-454_b-19-012_september-14-final_0.pdf">https://www.epa.gov/system/files/documents/2021-09/npap-qapp_revision-6_epa-454_b-19-012_september-14-final_0.pdf</a>	1
Instrument Manuals for NPAP equipment (CO analyzer, gas calibrator, etc.)	1
QA Handbook Vol. II: <a href="https://www.epa.gov/sites/default/files/2020-10/documents/final_handbook_document_1_17.pdf">https://www.epa.gov/sites/default/files/2020-10/documents/final_handbook_document_1_17.pdf</a>	2
NPAP Adequacy/Independence Criteria Memo (July 2018) <sup>2</sup> <a href="https://www.epa.gov/sites/production/files/2020-10/documents/npapadequacy072408.pdf">https://www.epa.gov/sites/production/files/2020-10/documents/npapadequacy072408.pdf</a>	2
NAAQS Criteria Pollutant Gases Data Quality Objective Process ( <a href="https://www3.epa.gov/ttnamti1/files/ambient/pm25/qa/vol2sec03.pdf">https://www3.epa.gov/ttnamti1/files/ambient/pm25/qa/vol2sec03.pdf</a> )	3
40 CFR Part 50, Appendices A, C, D, and F	4
40 CFR Part 58, Appendix A	4
Transfer Standards for Calibration of Air Monitoring Analyzers for Ozone – Technical Assistance Document 2003 version ( <a href="https://nepis.epa.gov/Exe/ZyPDF.cgi/P10103FQ.PDF?Dockey=P10103FQ.PDF">https://nepis.epa.gov/Exe/ZyPDF.cgi/P10103FQ.PDF?Dockey=P10103FQ.PDF</a> ) <sup>2</sup>	4
Technical Assistance Document for Precursor Gas Measurements in the NCore Multi-pollutant Monitoring Network (version 4 - 10/25/2005 EPA-454/R-05-003 Sept 2005 <a href="https://nepis.epa.gov/Exe/ZyPDF.cgi/P100ACLX.PDF?Dockey=P100ACLX.PDF">https://nepis.epa.gov/Exe/ZyPDF.cgi/P100ACLX.PDF?Dockey=P100ACLX.PDF</a> )	4

<sup>1</sup> Links were current as of publication of this document in January 2022.

<sup>2</sup> Document required only for self-implementing PQAOs

### 1.4 Summary of the NPAP

To evaluate the proficiency of an air monitoring station to measure the gaseous criteria pollutants, the NPAP FS generates a known concentration of test gas on site and delivers the gas TTP to the monitoring station; the concentration of the test gas is blind to the station operator. The FS will notify the station operator when the test gas concentration is stable, then the operator will report the measured gas concentration to the FS once their measurement is sufficiently concentration stable. The concentration reported by the station operator is then compared to the known standard concentration. This process is repeated across a range of concentrations prescribed in [40 CFR Part 58 Appendix A Section 3.1.2.1](#) and a percent difference or absolute concentration difference calculated and assessed for each concentration level.

By use of the TTP method, the entire flow path of the ambient air sample from the sample inlet probe through the analyzer can be challenged.

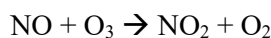
## 2.0 NPAP Audit System and Support Applications

### 2.1 NPAP Methodology

The NPAP is a QA program that directly and independently assesses the performance of criteria pollutant gas measurement systems and, by extension, the quality of data reported by the associated monitoring network. Such assessments permit identification of systematic issues (e.g., calibration biases, data transformation errors, and measurement biases) in the concentration ranges typically measured in ambient air. The TTP audit consists of three general steps:

- Generating standardized test gas using calibrated instruments with criteria pollutant concentrations known to the FS and blind to the monitoring station operator,
- Delivering the standardized test gas to the monitoring station sample inlet probe used for routine air monitoring operations,
- Comparing the air monitoring station's measurement against the known concentration of the standardized test gas generated by the NPAP FS.

The NPAP provides the following four criteria pollutant gases through the probe: carbon monoxide (CO), sulfur dioxide (SO<sub>2</sub>), ozone (O<sub>3</sub>) and oxides of nitrogen (NO and NO<sub>2</sub>). CO, SO<sub>2</sub>, and NO are sourced from a certified multi-component gas cylinder (the multiblend cylinder) and diluted to desired audit concentrations with a calibrated gas dilution system (gas calibrator). O<sub>3</sub> is generated on site with a standardized O<sub>3</sub> generator, as this gas is not stable in high pressure cylinders. NO<sub>2</sub> is generated on site with the gas phase titration (GPT) of nitric oxide (NO) gas from the multi-component gas cylinder with O<sub>3</sub> from the ozone generator per the following reaction:



GPT is employed to provide NO<sub>2</sub> to avoid losses observed when diluting NO<sub>2</sub> directly from a compressed gas cylinder. NO is sourced from the multi-component gas cylinder and O<sub>3</sub> created on site with the O<sub>3</sub> generator and these reactants are mixed in the gas dilution system. Excess NO is required to ensure the reaction above completes to the right with O<sub>3</sub> as the limiting factor for which each mole of O<sub>3</sub> introduced results in one mole of NO<sub>2</sub>.

Standardization of the test gas provided to the monitoring station during a TTP audit is accomplished in several ways depending on the equipment employed. These include measurement verification audits (MVAs), flow-based audits (FBAs), and station feedback audits (SFAs). Note that nitrogen oxides (NO and NO<sub>2</sub>) audits are SFAs and can be performed by either MVA or FBA.

At the time of this document's publication, EPA OAQPS was developing a procedure for conducting TTP audits for NO<sub>2</sub> employing dilution of NO<sub>2</sub> sourced from a high pressure standard cylinder in lieu of employing GPT. However, there remain uncertainty on the stability of the concentration of NO<sub>2</sub> in the standard cylinder as well as the potential reactive loss of NO<sub>2</sub> throughout the audit gas delivery flow path. Additionally, the standard dilution procedure intends to eliminate the need for the NO measurement channel at the monitoring station, which will permit the audit of direct reading "true NO<sub>2</sub>" instruments, which increasingly common and required as part of the EPA Photochemical Assessment Monitoring

Stations (PAMS) network. EPA expects to have an updated NO<sub>2</sub>-specific audit procedure detailed in future versions of this SOP.

#### 2.1.1 Measured Verification Audits

MVAs apply to CO, SO<sub>2</sub>, and O<sub>3</sub> audits whereby the concentration of the test gas is actively measured during audit conduct by an onboard analyzer the FS operates.

Standardization of the CO test gas is achieved by measuring the diluted concentration with a CO analyzer that is calibrated each day of use against a certified gas standard from an independent high-pressure cylinder. Standardization of the SO<sub>2</sub> test gas is achieved by calculating the relative concentration of SO<sub>2</sub> to CO in the multi-component gas cylinder. Standardization of the NO<sub>2</sub> test gas is achieved by using a certified ozone generator to introduce a standardized concentration of O<sub>3</sub> to the GPT reaction as described above and the concentration of NO<sub>2</sub> determined from the NO remaining after GPT as measured by the monitoring station NO analyzer after correction with a linear regression standardized with the NPAP delivered challenge concentrations. These standardization methods allow NPAP TTP audits to be performed without the need for inclusion of additional measurement equipment in the NPAP audit configuration, such as NO<sub>2</sub> and SO<sub>2</sub> analyzers, for verifying the audit gas concentrations.

#### 2.1.2 Flow-Based Audits

The FBA process is detailed in Appendix C. FBAs are typically performed when the monitoring station undergoing assessment is located where it is difficult or impossible to transport a full MVA system to the site, such as for sites requiring air or water travel to access. In such cases, the audit equipment rig is pared down and includes only the equipment needed that can be transported within protective shipment cases. FBAs apply only to SO<sub>2</sub> and CO, as these gases can be accurately diluted and metered to the monitoring station inlet. The SO<sub>2</sub> and CO standard gases in the multiblend cylinder are diluted with the gas calibrator for which the flow rates of each flow rate setting are measured prior to the audit (on the day of the audit) and at the conclusion of the audit. These flow rate measurements are then input into the calculation to determine the provided concentration. The FBA convention eliminates the need for transporting: the CO analyzer and the high CO, low CO, and ultrapure air compressed gas cylinders. The FBA also eliminates the need for long (e.g., 48 hours) warm-up of the CO analyzer and the zero concentration drift of the CO analyzer. Note that the OAQPS NPAP Lead will approve FSs on a case-by-case basis for conducting FBAs.

#### 2.1.3 Station Feedback Audits

SFAs are performed for NO<sub>2</sub> audits and require the monitoring station undergoing audit to provide NO measurements as inputs for calculating the provided audit concentration of NO<sub>2</sub>. The SFA cannot be performed on monitoring stations that do not comprise a nitrogen oxides monitor with an NO measurement channel. The FS provides a zero (zero air without standard gas) and several known concentrations of NO standard gas minimally covering audit concentration Levels 1 through 5 to the monitoring station and records the station NO readings to establish a linear regression for the station NO response. NO<sub>2</sub> standard gas is produced within the gas calibrator by reaction via GPT of the standard NO gas with O<sub>3</sub> generated within the gas calibrator. While excess NO is provided for the GPT to ensure complete reaction of O<sub>3</sub> to NO<sub>2</sub>, this complete reaction is not assumed and requires the station NO measurements to compensate for incomplete reaction and/or reactive loss of NO or NO<sub>2</sub> occurring during gas delivery. The resulting NO linear regression is then employed to calculate the concentrations of: NO, remaining NO after GPT, NO<sub>2</sub>, and NO<sub>x</sub> provided to the monitoring station.

## 2.2 NPAP Audit System

### 2.2.1 Audit System Overview

The NPAP is conducted in all 50 US states at air monitoring stations reporting gaseous criteria pollutant concentrations for the purposes of NAAQS attainment. NPAP audit system configurations need flexibility to deal with the unique conditions of each station, which may vary from sparsely populated national parks to densely populated urban areas. In order to maintain this flexibility, the equipment and configurations employed are tailored to meet the needs of each Region. For Regions with states within the continental US, vehicle-based audit systems may be the most convenient. In Regions with remote monitoring sites that are difficult or impossible to reach by land, FSs and their equipment may need to travel by air or water; in such cases, these Regions may employ modular case-based systems.

Typical audit system configurations for MVAs will be discussed in the following subsections. Variations to these configurations are permitted with approval from the OAQPS NPAP Lead.

#### 2.2.1.1 Vehicle-Based Audit System Configurations

In Regions for which air travel is not required to reasonably access monitoring sites, a vehicle-based audit system may suffice and may be configured and installed within recreational vehicles, cargo vans/box trucks, truck/trailer combinations. Vehicle-based configurations have the advantage of permitting the FS to begin instrument warm up and conditioning during travel to the site, reducing the time needed onsite. However, vehicle-based mobile laboratories require larger vehicles that may incur difficulty maneuvering in tight spaces or accessing monitoring stations with limited accessibility such as those located on a steep mountainside or accessible only by narrow dirt roads.

Note that for vehicle-based configurations, FSs may require additional driving certifications which may include, but may not be limited to, undergoing a Department of Transportation Medical Exam for Commercial Motor Vehicle Certification and acquiring a commercial driver's license (CDL) endorsement.

#### 2.2.1.2 Case-Based Audit System Configurations

For case-based audit system configurations, instruments and equipment are installed into racks within protective shipment cases. FSs may ship the equipment cases to a nearby airport or seaport and transport the equipment to the site in a cargo van or other suitable vehicle. While this configuration permits flexibility for equipment transport, electrical power is not typically available to permit the FS to warm up the instruments prior to arrival at the site.

#### 2.2.1.3 Equipment Complement

The equipment and supplies required for successful NPAP audits generally fall into three categories: audit system, support equipment, and consumables. The items included in Tables 2-1, 2-2, and 2-3 represent the minimum recommended components for the audit system, support equipment, and consumables, respectively, to include in the complement for conducting NPAP audits. These lists are not exhaustive; the FS and NPAP Regional Lead should adjust as needed.

**Table 2-1. Audit System Components**

Item Description	Typical Part Number (PN) or Model and Manufacturer
Data acquisition system (DAS) software	Envidas Ultimate DR DAS
Windows XP, 7, 8, or 10 laptop/tablet personal computer with PEAT software and capability to prepare PDFs of the audit report	Numerous models available – Microsoft Surface tablets have performed well in this role
Printer compatible with the laptop or tablet computer (optional if printed reports are not to be prepared) – note that laser printers typically do not suffer from clogging of print heads as occurs with inkjet printers	Numerous models available
Zero air generator (ZAG)	Teledyne API 701H or equivalent
Gas dilution calibrator capable of GPT with three mass flow controllers (MFCs): 2 to 20 liters per minute (LPM), 10 to 100 cubic centimeter per minute (ccm), and 1 to 10 ccm, equipped with ozone generator capable of generating 5 to 400 ppb ozone at 16 LPM with concentration accuracy $\pm 2\%$	EnviroNics 9100, Teledyne T700U, or equivalent
Ozone analyzer range: 0.05 to 200 part per million (ppm) lower detectable limit: 0.001 ppm	Thermo 49i or equivalent
CO analyzer range: 1 to 100 ppm (working range is typically 0.02 to 5 ppm) lower detectable limit: 0.04 ppm	Thermo 48i or equivalent
Reel for polytetrafluoroethylene (PTFE) Teflon® hose with braided stainless-steel shroud	Various models available from American Reeling Devices
Delivery hose, 3/8-inch inner diameter (ID) polytetrafluoroethylene (PTFE) with outer braided stainless-steel shroud, ~150-ft length, 1/2-inch outer diameter (OD), 3/8-inch compression fitting connections	Swagelok SS-XT6TA6TA6-1800
316 Stainless Steel Nut and Ferrule Set (1 Nut/1 Front Ferrule/1 Back Ferrule) for 3/8-inch tube fitting	Swagelok SS-600-NFSET
Stainless Steel Swagelok Tube Fitting, Male Connector, 1/2-inch Tube OD x 1/2-inch Male NPT (National Pipe Thread Taper)	Swagelok SS-810-1-8
Stainless Steel Swagelok Tube Fitting, Male Tube Adapter, 1/2-in. Tube OD x 1/2-in. Male NPT	Swagelok SS-8-TA-1-8

**Table 2-1. Audit System Components (continued)**

Item Description	Typical Part Number (PN) or Model and Manufacturer
Stainless Steel Swagelok Tube Fitting, Union Elbow, ½-in. Tube OD	Swagelok SS-810-9
Manual toggle valve, ¼-in tube fittings	Swagelok SS-1GS4
PTFE plug for ¼-inch Swagelok tube fitting	Swagelok T-400-P
PTFE Swagelok tube fitting, union, ¼-inch tube OD	Swagelok T-400-6
PTFE Swagelok tube fitting, reducing union, 3/8-inch x ¼-inch tube OD	Swagelok T-600-6-4
PTFE Swagelok tube fitting, reducing union, ¼-inch x 1/8 inch tube OD	Swagelok T-400-6-2
PTFE plug for 1/8-inch Swagelok tube fitting	Swagelok T-200-P
FEP Teflon® tubing - ¼-inch O.D. - 1/8-inch I.D. - 1/16-inch wall thickness	Cole Parmer EW-06450-05
FEP Teflon® tubing - ½-inch O.D. - 3/8-inch I.D. - 1/16-inch wall thickness	Cole Parmer EW-06450-09
PTFE Swagelok tube fitting, union tee, ¼-inch tube OD	Swagelok T-400-3
FEP Teflon® bag, approximately 12” x 12”	American Durafilm Duralok 3 mil, or equivalent
316/316L stainless steel seamless tubing, ¼-inch OD x 0.035-inch wall thickness x 20 ft	Swagelok SS-T4-S-035-20
316 stainless steel nut and ferrule set (1 nut/1 front ferrule/1 back ferrule) for ¼-inch tube fitting	Swagelok SS-400-NFSET
316 stainless steel Swagelok tube fitting, male elbow, 1/8-inch tube OD x ¼-inch male NPT	Swagelok SS-200-2-4
316 stainless steel plug for ¼-inch Swagelok tube fitting	Swagelok SS-400-P

**Table 2-1. Audit System Components (continued)**

Item Description	Typical Part Number (PN) or Model and Manufacturer
Multiblend gas cylinder with concentrations of National Institute of Standards and Technology (NIST)-traceable EPA protocol gases in the following ranges: CO: 425 to 575 ppm SO <sub>2</sub> : 13 to 20 ppm NO: 25 to 35 ppm	Appropriate AA-PGVP compliant gas vendor
High concentration CO gas cylinder with a concentration of NIST-traceable EPA protocol gas at 3.5 to 6.5 ppm CO	Appropriate AA-PGVP compliant gas vendor
Low concentration CO gas cylinder with a concentration of NIST-traceable EPA protocol gas at 0.3 to 1.2 ppm CO	Appropriate AA-PGVP compliant gas vendor
Palladium (Pd) scrubber <sup>a</sup> : <ul style="list-style-type: none"> <li>- refillable hydrocarbon trap</li> <li>- palladium on 1/8-inch alumina pellets, 0.5% Pd</li> <li>- fiberglass wool</li> </ul>	Restek PN 22013  Acros Organics PN 195082500  Corning PN 3950
Multiblend gas cylinder regulator Outlet pressure: 0 to 50 pounds per square inch (psig) Inlet gauge: 0 to 4000 psig 316L Stainless Steel CGA 660	CONCOA 408-1031-660 or equivalent
CO gas cylinder regulator Outlet pressure: 0 to 50 psig Inlet gauge: 0 to 4000 psig Brass CGA 590	CONCOA 332-2391-01-590 or equivalent
Clam shell regulator cover - 11 threads per inch	Griffan Inc. GT-11
Clam shell regulator cover - 7 threads per inch	Griffan Inc. GT-7
Delivery manifold borosilicate glass or PTFE Teflon® 3 ports minimum	Custom manufactured
Calibration/verification manifold borosilicate glass or PTFE 4 ports minimum	Custom manufactured
Needle valves for NPAP system vents	Parker 4Z-VLK-SS (preferred) or 4Z-V4LN-SS
316L stainless steel Swagelok tube fitting, union tee, 1/4-inch tube OD	Swagelok 316L-400-3

**Table 2-1. Audit System Components (continued)**

Item Description	Typical Part Number (PN) or Model and Manufacturer
Two rotameters to measure NPAP system vent flow, measurement range 0 to 1.0 LPM	Dwyer VFA-21
manual solenoid valves, 2-way, normally closed, PTFE seal material, 1/4-inch pipe size	Swagelok SS-DLS4
3-way manual valves	Swagelok SS-43GXS4

<sup>a</sup>. Instructions for assembling the palladium scrubber can be found in Appendix A.

**Table 2-2. Support Equipment**

Item Description
Generator or battery power supply with sufficient wattage capacity to power the necessary support equipment <sup>a</sup>
Uninterruptible power supply (UPS) with alternating current (AC) power conditioner capable of powering a gas calibrator, CO and O <sub>3</sub> analyzer, and PC <sup>a</sup>
Air conditioner capable of maintaining required temperature range and minimizing temperature fluctuation within the FS mobile laboratory <sup>a</sup>
Thermometer to monitor FS mobile laboratory temperature <sup>a</sup>
Toolbox with a variety of standard hand tools: e.g., screwdrivers, adjustable wrenches, pliers
ladder, aluminum construction recommended, minimum 20-ft, A-frame/extension combination
rope, 300 lb. weight capacity, ≥ 75-ft
heavy-duty, grounded, weatherproof electrical extension cords with multiple outlets, ≥ 25-ft, 10A, quantity 2

<sup>a</sup>. Items applicable to vehicle-based audit systems.



**Table 2-3. Consumables**

Item Description
zero air generator maintenance supplies: - Purafil™ - activated carbon - particulate filter - molecular sieve - CO scrubber - dryer
engine oil <sup>a</sup>
generator engine oil <sup>a</sup>
engine coolant <sup>a</sup>
generator coolant <sup>a</sup>
lint-free laboratory wipes
first-aid kit
fire extinguisher
insect repellent

<sup>a</sup> Items applicable only to vehicle-based audit systems.

## 2.2.2 Audit System Equipment

The NPAP TTP audits are typically categorized as an ozone audit (involves only ozone) or a blended gas audit (CO, SO<sub>2</sub>, and/or NO/NO<sub>2</sub>/NO<sub>x</sub>). Equipment required for each is discussed below.

The NPAP interprets requirement for calibration, certification, and verification such that quarterly and annual events cannot exceed recurrence beyond 3 months and 12 months, respectively. For example, if a flow rate calibration verification for an instrument with a quarterly frequency requirement was verified on January 01, 2016 and again on April 02, 2016, the instrument had an expired flow rate calibration for 1 day. Therefore, quarterly and annual requirements indicate that the event must have occurred within the previous 3 or 12 months, respectively.

### 2.2.2.1 Ozone Audit Equipment

Ozone audits are generally the simplest TTP audit to perform and require the least amount of equipment. A functional equipment setup to conduct an ozone audit minimally requires:

- DAS
- Windows compatible laptop/tablet with PEAT software
- ZAG
- Gas calibrator with onboard ozone generator
- Calibrated ozone analyzer (certified as a Level 2 ozone standard)
- Glass or PTFE Teflon® manifolds for calibration/verification and delivery
- Various valves, solenoids, vents, and Teflon® tees for NPAP system plumbing
- Conditioned Teflon® delivery line
- Various Teflon® connectors to connect to the monitoring site sample inlet

Note that using an ozone primary standard photometer (such as the Thermo 49i-PS ozone generator) to generate the test gas eliminates the need for a gas calibrator; however, the ozone generator selected must be able to generate sufficient flows (e.g., 16 L/minute).

#### 2.2.2.2 Blended Gas Audit Equipment

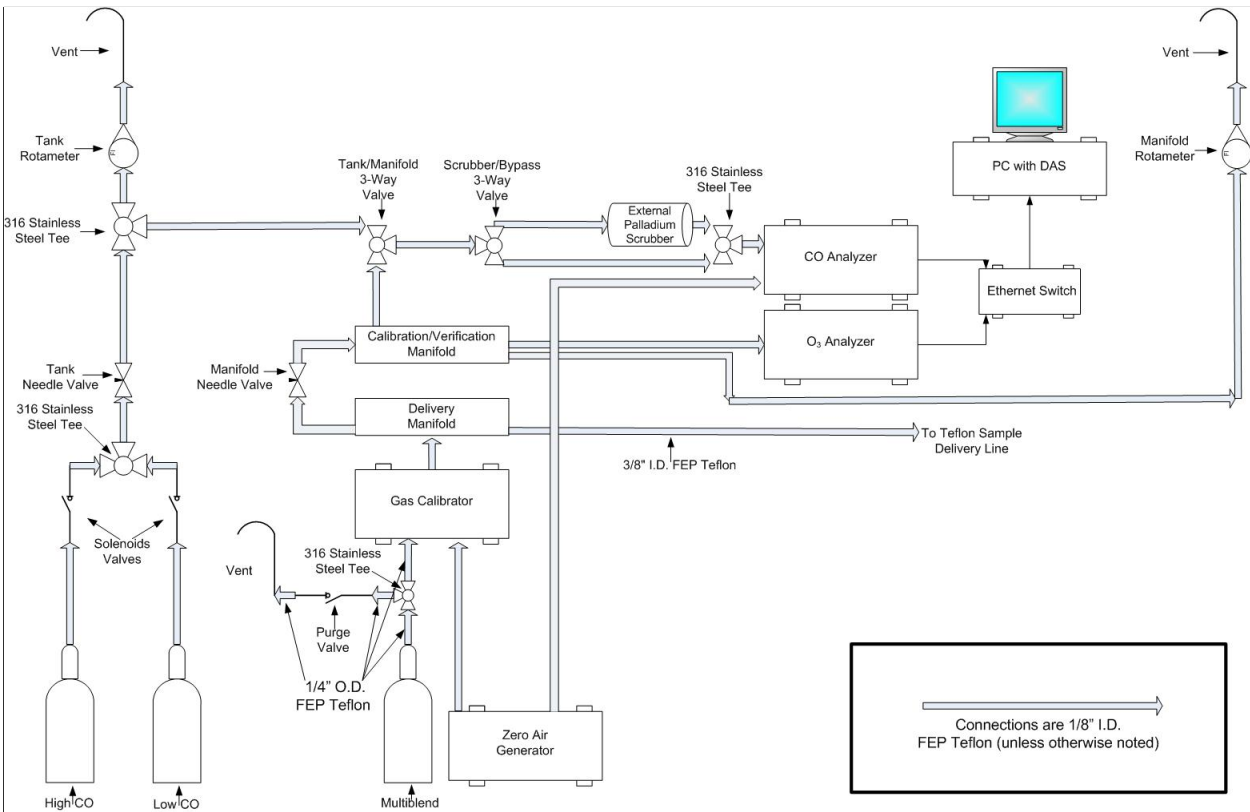
A functional equipment setup to conduct a blended gas audit by MVA minimally requires:

- DAS
- Windows compatible laptop/tablet with PEAT software
- ZAG
- Gas calibrator with an onboard ozone generator and capable of GPT
- Glass or PTFE Teflon® manifolds for calibration/verification and delivery
- Various valves, solenoids, vents, cylinder regulators, and Teflon® tees for NPAP system plumbing
- CO analyzer
- Conditioned Teflon® delivery line
- Various Teflon® connectors to connect to the monitoring site sample inlet
- Multiblend gas cylinder containing certified concentrations of CO, SO<sub>2</sub>, and NO
- High concentration CO standard gas cylinder: ~3.5 to 6.5 ppm
- Low concentration CO standard gas cylinder: ~ 0.3 to 1.2 ppm
- Palladium scrubber or ultrapure zero air cylinder

#### 2.2.3 Equipment Configuration and Construction

The sensitivity of the employed ambient air monitoring instruments to excess pressure requires adequate venting to ensure the instruments do not experience overpressure conditions (refer to the plumbing schematic in Figure 2-1). The flow diagram in Figure 2-1 applies to vehicle-based or case-based configurations. For simplification, analyzer exhausts are not depicted in the plumbing schematic.

Per Section 9 of [40 CFR Part 58 Appendix E](#), materials for measurement and delivery of test gases for SO<sub>2</sub>, NO<sub>2</sub>, and ozone may consist of only FEP Teflon®, borosilicate glass, or their equivalent. In practice, the composition of materials contacting gases delivered to the station inlet should consist only of FEP Teflon® or borosilicate glass. Special consideration must be given for materials other than these if installed in the audit system to ensure they do not come in to contact with generated test gases. As much as possible, connections and lines for delivering gases containing O<sub>3</sub>, NO/NO<sub>2</sub>/NO<sub>x</sub>, and/or SO<sub>2</sub> should avoid the use of incompatible materials and consist of only FEP Teflon® or borosilicate glass. This is difficult to achieve in practice as wetted surfaces of interior flow paths of gas calibrators and MFCs typically include some stainless steel. Wetted surfaces contacting only CO or zero air (nominally non-reactive gases) may be constructed of stainless steel.



**Figure 2-1. NPAP TTP Plumbing Schematic**

## 2.3 Air Quality System (AQS) and PEAT Support Applications

### 2.3.1 Performance Evaluation Audit Tool (PEAT) Application

The Performance Evaluation Audit Tool (PEAT) application is a software tool that facilitates performance of NPAP audits. EPA developed PEAT to streamline the audit preparation, documentation, performance, and reporting of NPAP audits. Audits are scheduled within PEAT, the performance and activities are documented within PEAT, and PEAT facilitates the upload of audit results directly to EPA's Air Quality System (AQS) database. PEAT verifies site data related to instrumentation (method codes, etc.) against AQS and business rules to ensure data submitted by PEAT will be accepted by AQS. PEAT was designed to automatically query AQS when the host PC is connected to the internet to ensure that monitoring site data queried from AQS are current. Additionally, PEAT automatically queries for software version upgrades and updates and applies these when available to ensure that FSs have current information and up-to-date software. EPA revises PEAT as needed when bugs are reported or when enhancements are completed. EPA encourages users to report PEAT software bugs, errors, and suggested enhancements to the OAQPS NPAP Lead. PEAT was built using a universal model and will run on either the 32-bit version or the 64-bit version of Windows XP, Windows 7, Windows 8, and Windows 10.

The functionality in PEAT is divided into three main categories:

- Pre-Audit Tasks

- Refresh PEAT Data from AQS – Updates the most recent list of audit agencies, NPAP audit level designations, PEAT user list, monitoring site location, monitor information, etc.
- Prepare and Certify Equipment – Allows users to update the audit equipment calibration/calibration verification and certification dates and values.
- Conduct Ozone Line Loss Test – Allows users to enter information from the most recent ozone line loss determination (this procedure is described in Appendix B).
- Confirm Monitor Information – Auditors query AQS for the latitude and longitude coordinates of the monitoring site and the Manufacturer, Model #, Method Code, and Calibration Date of the criteria pollutant gas monitors at the site. This report is sent to the site operator to verify the information is correct and to ensure the FS arrives at the proper site for the audit. If discrepancies to the monitor information are found, users can correct this information in PEAT.
- Audit Tasks
  - Schedule Audits – Allows Regional NPAP Leads (or designees) to assign an anticipated audit date to all sites assigned to the FS. The use of this feature is optional.
  - NEW Audit – Select Site / Audit Type – Users select a site and assign an audit type (ozone, blended gas, or both) which allows users to use the following three functions:
    - Confirm Monitor Information – While at the site before conducting the audit, auditors verify the GPS coordinates of the site and Manufacturer, Model #, Method Code, and Calibration Date of the criteria pollutant gas monitors at the site. If discrepancies are found, FSs can correct this information in PEAT.
    - Conduct Ozone Gas Audit – Users enter the target ozone concentrations, FS measured ozone concentrations, and corresponding monitoring site measured concentrations of ozone.
    - Conduct Blended Gas Audit – Users enter the pre-audit CO analyzer calibration information, blended gas target concentrations, FS measured CO concentrations, corresponding monitoring site measured concentrations of the gases undergoing audit, and post-audit CO analyzer calibration (drift assessment) information.
- Post Audit Tasks
  - Reports – Creates an electronic or printed report which summarizes the preliminary results of the audit for each audited gas parameter.
  - Send Monitor Changes to Agency – Creates a report and AQS transaction file which can be emailed to the site operator if the site coordinates or manufacturer and model of the on-site analyzers differ from those stored in AQS.
  - Upload QA Data to AQS – Data from the completed audit are uploaded to a staging area before input to AQS. Note that data for audits for which all site measured values are within acceptance criteria are uploaded automatically to AQS within 7 days. Data for audits for which any one site measured value fails acceptance criteria are automatically uploaded to AQS within 30 days.
  - Select Print Completed/In Progress Audits to Review – Generates a list of all audits that are in progress or completed. Selecting “in progress” audits from this list will re-enable the “Confirm Monitor Information”, “Conduct ozone Gas Audit”, and “Conduct Blended Gas Audit” functions and all “Post Audit Tasks” functions.

### 2.3.3 AQS NPAP Applications

The AQS database contains ambient air pollution data collected by EPA and State, Local, and Tribal (SLT) air monitoring agencies from thousands of monitors. AQS also contains meteorological data, descriptive information about each monitoring station (including its geographic location, responsible PQA/O, instruments on site, etc.), and data QA/QC information.

AQS data are used to assess air quality, assist in NAAQS attainment/non-attainment designations, evaluate State Implementation Plans (SIPs) for non-attainment areas, perform modeling for permit review analysis, and other air quality management functions. AQS information is also used to prepare reports for Congress as mandated by the Clean Air Act (<https://www.epa.gov/clean-air-act-overview>).

EPA NPAP Regional Leads use AQS to select sites to be audited by FSs and to generate metadata reports which include site GPS coordinates, parameter codes (criteria pollutant gas identifier) and associated method codes (monitor manufacturer and model). AQS is also the final repository for the audit data generated by the NPAP and provides Regional NPAP Leads the ability to review and, if necessary, modify audit data submitted by FSs. EPA has recently developed data visualization tools through Qlik Sense that pulls data from AQS for EPA staff to assess compliance with the measurement quality objectives (MQOs).

## 3.0 Audit Scheduling

### 3.1 Scheduling NPAP Audits

EPA Regional NPAP Leads, or designee, complete a list of sites to be audited for the coming calendar year following QAPP Section A5.2. The sites and number of sites selected for audit will be based on the required frequency of audits for given sites in the Region.

FSs, separately or in coordination with the EPA Regional NPAP Lead, will develop an audit schedule based on the list of sites selected to be audited in the coming calendar year. The audit schedule should consider the need for conducting Performance Evaluation Program audits concurrently with the NPAP audits.

The EPA Regional NPAP Lead will select the audits to conduct for the calendar year, will generate the list within AQS, and will communicate the list to the FSs who will conduct the audits. The FS may then schedule the audits in PEAT. Note that scheduling audits via PEAT is optional, but this functionality is provided as a convenient way to schedule audits and the associated trips. Furthermore, if the FS expects a site is to be audited during the calendar year but that site does not appear when attempting to schedule an audit in PEAT, then the NPAP Regional Lead should be notified.

The FS then communicates with the monitoring site staff approximately 30 days prior to the audit and again approximately 1 week prior to the audit according to QAPP Section A5.2.4. The FS will distribute a site report to the monitoring site staff approximately 30 days prior to the audit to verify the details maintained within AQS. Communication between the FS and monitoring site staff provides opportunity for adjustment in the schedule and changes in conditions (e.g., monitors offline) at the monitoring site.

## **4.0 Audit Equipment Preparation, Calibration, Certification, and Maintenance**

### **4.1 Standard Material and Instrument Calibration**

The NPAP relies on a strictly enforced QC program that ensures calibration and maintenance of equipment (MFCs, ozone generators, CO analyzers, etc.) are performed at designated intervals, standards are traceable to NIST, and that strict tolerance limits are followed.

Devices and materials utilized in generating, metering, or measuring standard gases are to be certified or the bias determined against a NIST-traceable standard or device prior to use unless such is not available or applicable. For such components for which there is no traceable standard (e.g., the TTP gas delivery line), the performance (bias) of the component must be characterized by measurement with an instrument calibrated against a NIST-traceable standard. Each device or material has a prescribed certification timeframe during which the device or material may be utilized, after which the device or material will require verification, adjustment (calibration), or redetermination of the bias (certification), or replacement with a comparable device or material such that only devices or materials that are within their certification period are employed for conducting NPAP audits. These timeframes are specified in Table 4-1.

Audit devices include gas dilution blending calibrators with an ozone generator, zero (acceptably pollutant-free) air generators, and gas analyzers (CO analyzer and ozone photometer). This section describes the calibration (standardization and verification of calibration) of instruments, devices, and performance specifications for each device or material.

Documentation of the certification, such as a certificate of analysis (COA) or similar, will be maintained and will detail the certified concentration(s) and associated expiration date. To ensure that NPAP auditors do not use an expired gas cylinder or need to postpone/cancel audit trips due to an expired gas cylinder, PEAT tracks certification dates on gas cylinders and will periodically remind users when the expiration date is approaching. It is not acceptable to utilize standards or instruments that have expired certifications or do not have valid calibration or calibration verification within the required period.

FSs are recommended to not use high pressure cylinders when pressures fall below 400 psi as low cylinder pressures cause erratic behavior in the gas calibrator. FS should not use cylinders when pressures fall below 200 psi as this will not permit analysis (for recertification) of the cylinder upon retirement.

FSs are encouraged to address material certifications and equipment calibrations during the off-season (i.e., December through January) for frequencies listed in Table 4-1 of  $\geq 6$  months.

**Table 4-1. NPAP Standard Materials and Instrument Certification and Calibration Requirements**

Device or Material	Certification or Verification Frequency	Certification or Verification Standard	Specification
Multiblend certified gas cylinder (CO, NO, and SO <sub>2</sub> )	Verification not to exceed 12 months	Against first generation NIST standard gases by gas manufacturer or verification labs in Regions 4 or 7, or other certified gas analysis laboratory compliant with EPA AA-PGVP	Within ±3% of the original certified concentration from manufacturer and within ±2% of the previous verification value
High CO gas cylinder (~3.5 - 6.5 ppm)	Verification not to exceed 12 months	Against first generation NIST standard gases by gas manufacturer or certification labs in Regions 4 or 7, or other certified gas analysis laboratory compliant with EPA AA-PGVP	Within ±3% of the original certified concentration from manufacturer and within ±2% of the previous verification value
Low CO gas cylinder (~0.3 to 1.2 ppm)	Verification not to exceed 12 months	Against first generation NIST standard gases by gas manufacturer or certification labs in Regions 4 or 7, or other certified gas analysis laboratory compliant with EPA AA-PGVP	Within ±3% of the original certified concentration from manufacturer and within ±2% of the previous verification value
Ultra-pure zero air (high pressure cylinder)	Expiration or retest date not specified	Examination of certificate of analysis (COA)	COA must show: total hydrocarbons (THC) ≤ 0.01 ppm, CO ≤ 0.01 ppm, oxides of nitrogen ≤ 0.001 ppm, and SO <sub>2</sub> ≤ 0.001 ppm
ZAG output	Performance verified with each audit performed	Compared to zero air source scrubbed by an external Pd scrubber or to ultra-pure zero air from a high pressure cylinder	CO response in the zero air from the ZAG must not be ≥ 0.02 ppm greater than the ultra-pure zero air or zero air scrubbed through an external palladium scrubber

Ozone primary standard (Level 2 ozone standard)	Calibration established or verified within the previous three months	Against a Level 1 ozone standard (SRP)	Within $\pm 3\%$ of slope and within $\pm 3$ parts per billion (ppb) of the intercept of the SRP
CO analyzer	Calibration established each day of use for TTP audits  Calibration verified prior to and immediately following each audit	Calibration established with High CO gas cylinder and zero air  Calibration verified against the Low CO gas cylinder	Calibration verification against Low CO must be within $\pm 3\%$ of Low CO certified concentration
Calibrator: gas dilution system, gas phase titrator, and ozone generator	Ozone generator calibration established or verified quarterly	Against a Level 1 (SRP) or Level 2 ozone standard	Within $\pm 5\%$ of the selected standard at each concentration representing Levels 2 through 6
	Mass flow controller (MFC) calibration established (adjusted) within the previous three months and verified immediately after calibration and the day of each audit (strongly recommended). <b>Note: this is required for performing flow-based audits.</b>	Against a certified reference flow transfer standard  Calibration is performed at 10 flow rates spanning 10 to 90% of the flow rate range  Verification is performed at 3 flow rates spanning 10 to 90% of the flow rate range	Calibration verification must show indicated flow rate is within $\pm 2\%$ of the flow transfer standard reading for each tested flow rate
Flow transfer standard	Annually by a qualified NIST-traceable metrology laboratory	Calibration verified or established against a NIST-traceably certified flow standard	Within $\pm 1\%$ of the NIST-traceably certified standard across the flow range
Ozone line loss test	Quarterly challenge the following concentration points: 0.200, 0.125, 0.050, and 0.010 ppm	Ozone evaluated upstream of and from effluent of PTFE delivery line	Ozone loss at each concentration level must be $\leq 2.5$ ppb
Environmental conditions temperature probe	Temperature probe calibration verified within the previous 12 months	Readings verified against a NIST-traceably certified thermometer at minimally one temperature between 20 to 30°C	Within $\pm 2^\circ\text{C}$ of the certified thermometer reading(s). If outside this criterion, adjust probe response to match certified thermometer



## 4.2 Safety Precautions

The CO concentration in the multi-blend cylinder is sufficient to potentially create dangerous conditions for FSs when conducting audits. A household carbon monoxide detector is required for all audit configurations (whether a mobile laboratory or case-based configuration). The CO detector must be tested to ensure proper operation before each audit and when changing regulators on a cylinder and/or manipulating plumbing. When potentially venting standard gas containing CO, conduct these , ensure there these activities are conducted in a well-ventilated area.

FSs and staff handling compressed gases must be aware of the hazards in handling compressed gas cylinders and will employ safe practices. High pressure cylinders must be properly secured within vehicles and trailers and must have clamshell-type valve protectors installed and secured prior to transporting cylinders.

To prevent personal injury, personnel must heed warnings associated with the transport and operation of NPAP equipment and vehicles (trucks, vans, trailers, etc.) and any supporting equipment and supplies. NPAP personnel that operate a tow trailer must review the operation/safety manuals for tow equipment, including the sway control device.

FSs should follow ladder safety guidance to maintain three points of contact at all times. Additionally ladder safety information is available from the American Ladder Institute:

<https://www.americanladderinstitute.org/page/BasicLadderSafety>

## 4.3 Certification of Standards and Maintenance and Calibration of Scientific Equipment

Certification, calibration, calibration verification, and maintenance records are to be maintained for scientific equipment and standard materials employed in the NPAP as described in NPAP QAPP Section A8 and must be maintained per Section B10. The following subsections detail procedures and their frequencies for standard, device, and equipment calibration, calibration verification, certification, characterization, maintenance, and contamination minimization.

### 4.3.1 Zero Air Generator

#### 4.3.1.1 ZAG Maintenance

The scrubber consumables within the zero air generator should be replaced annually and the unit serviced as recommended by the manufacturer. Consumables to replace during the annual maintenance minimally include the activated carbon (charcoal), Purafil™, and particulate filter, and may include the molecular sieve if there was evidence of degraded performance. If produced zero air indicates contamination or dewpoint failures in between regular maintenance, it may be necessary to replace the CO scrubber and/or dryer. Following maintenance, the ZAG should be powered on, a leak check performed, and the ZAG run (e.g., in maintenance mode) for several days to condition replaced materials.

**Table 4-2. Zero Air Generator Maintenance Frequency**

Component	Replacement/Maintenance Frequency
Activated Carbon	Annual
Purafil™	Annual
Particulate Filter	Annual
Molecular Sieve	As Needed
CO Scrubber	As Needed
Dryer	As Needed

#### 4.3.1.2 ZAG Performance Verification

The ZAG performance is verified with each multi-blend MVA by analyzing the CO levels in the ZAG output and subsequently measuring CO levels in either (1) the ZAG output routed through a Pd scrubber or (2) ultrapure zero air from a high pressure cylinder. The untreated ZAG output must show a CO concentration no more than 0.020 ppm higher than the Pd-scrubbed ZAG or cylinder ultrapure zero air to verify proper ZAG performance. Note that if properly functioning, the Pd-scrubbed ZAG output CO level is not expected to be appreciably lower. Further, the CO levels measured in ultra-pure zero from a higher pressure cylinder are typically higher than those measured from the ZAG.

#### 4.3.2 Ozone Analyzer (Level 2 Standard)

The ozone analyzer (Level 2 ozone standard) calibration is to be verified against an SRP every three months at 6 concentration levels spanning the range of use, typically 5 to 250 ppb. The analyzer response linear regression must be within  $\pm 3\%$  of the slope and within  $\pm 3$  ppb of the intercept of the SRP. If the analyzer fails this criterion, the ozone analyzer calibration slope and intercept must be re-established (note this recalibration will only be performed by trained SRP operators).

The procedure for calibrating a Level 2 standard against an SRP can be found at the following link on Ambient Monitoring Technology Information Center (AMTIC): <https://www.epa.gov/amtic/ozone-standard-reference-photometer-program-srp>

#### 4.3.3 Carbon Monoxide Analyzer

The CO analyzer calibration is standardized with each multi-blend audit by introducing a high concentration of CO (~3.5 to 6.5 ppm) to set the span point and with zero air to set the zero point. The CO analyzer calibration is then immediately verified by analyzing the low concentration (~0.3 to 1.2 ppm) CO standard, which must be within  $\pm 3\%$  of the certified concentration.

#### 4.3.4 Gas Dilution Calibrator

##### 4.3.4.1 Mass Flow Controller Calibration and Verification

The gas dilution calibrator MFCs must be calibrated (adjusted) quarterly (within the previous three months) and the calibration must be verified immediately after calibration. When performing FBAs, the MFCs calibrations must be verified the day of each audit by comparison to a certified flow transfer standard and such flow rate calibration verification is strongly recommended for MVAs. For MVAs, the MFC calibration and verification will decrease the likelihood that gross errors in gas dilutions will occur.

For MFC calibration verification, each MFC is tested at 3 flow rates spanning 10 to 90% of the flow rate range (e.g., for a 50 sccm MFC, test at 5, 15, and 45 sccm) and the flow measured with the flow transfer standard must be within  $\pm 2\%$  of the flow setting or else calibration is necessary. Refer to the gas calibrator manual for the MFC calibration procedure. Alternatively, the FS may measure flows at the MFC flow settings intended for use for the FBA on that day and input the measured flows at the respective settings for calculating the challenged concentrations.

OAQPS typically maintains flow transfer standards that can be loaned to Regions without ready access to certified flow transfer standards.

##### 4.3.4.2 Ozone Generator Calibration and Verification

The calibration of the gas dilution calibrator ozone generator is to be verified quarterly (within the previous three months) against a Level 2 ozone standard (ozone analyzer [note – comparison against a Level 1 [SRP] standard is also acceptable; however, this is typically not practical as a Level 2 analyzer is still needed to measure the ozone generator output]) at a minimum of five concentration levels with each level representing audit Levels 2 through 6. The ozone measured with the Level 2 standard must be within  $\pm 5\%$  of the intended concentration or the ozone generator must be recalibrated (adjusted). Refer to the gas calibrator manual for the ozone generator calibration procedure.

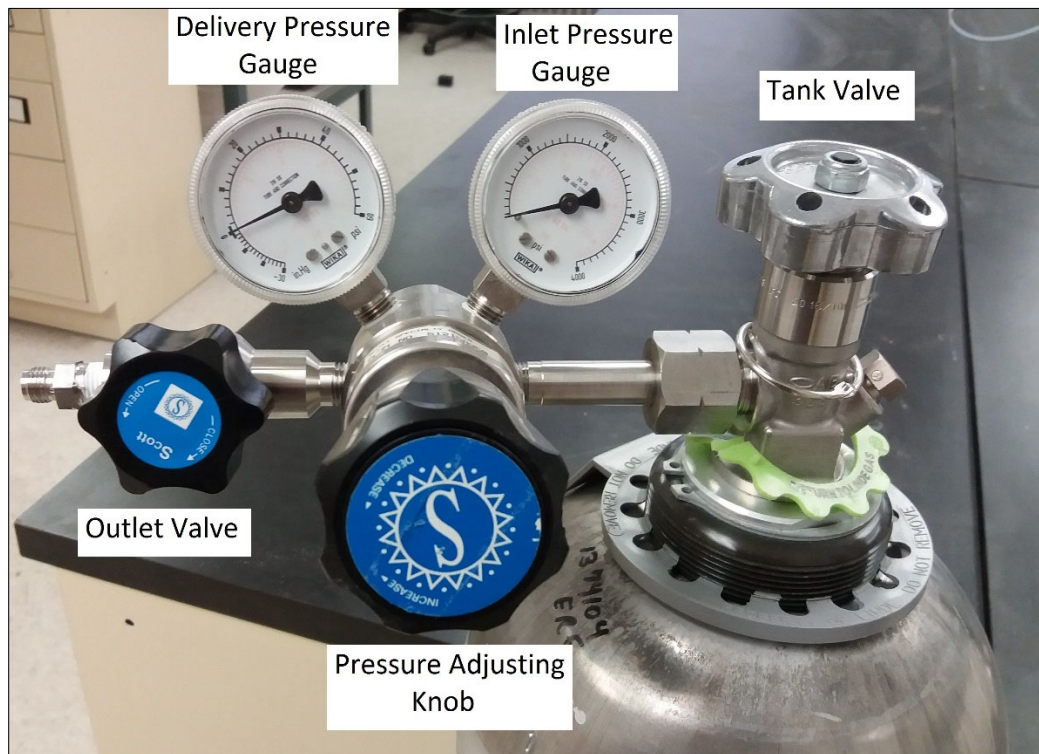
#### 4.3.5 Gas Cylinder Regulators

In addition to following all safety precautions when working with compressed gas cylinders, regulator installation should be performed carefully to prevent ambient air in detached regulators from backflowing into gas cylinders, contaminating the cylinder. Entrainment of ambient air into a standard cylinders will change the certified concentrations of the standard gases, resulting in errors in conducting audits.

If it is suspected that a cylinder has become contaminated, the FS should procure a replacement cylinder as soon as possible and have the suspect cylinder recertified (refer to Sections 4.3.6 and 4.3.7).

To attach and purge a regulator, perform the following steps and refer to Figure 4-1.

*Due to the potentially dangerous concentrations of criteria gas pollutants in the cylinders, always purge regulators in a well-ventilated area with a vent line (>10 feet in length) so that the vented gas is a safe distance away from people and animals.*



**Figure 4-1. Compressed Gas Regulator**

1. Attach the clamshell valve cover to the cylinder.
2. Ensure the regulator outlet valve and tank valve are closed.
3. Attach the regulator to the cylinder and hand tighten the regulator connection, avoiding cross-threading.
4. Securely tighten the regulator connection with a wrench.
5. Turn the pressure adjusting knob to minimize output pressure until the knob turns freely (counterclockwise in Figure 4-1).
6. Fully open the regulator outlet valve.
7. Slowly fully open the tank valve (gas will emit from the regulator) and quickly close the tank valve.
8. Close the regulator outlet valve.
9. Wait approximately 1 minute (to allow cylinder gas to permeate the voids and seals within the regulator to passivate the interior wetted surfaces of the regulator).
10. Repeat steps 6 through 8 two more times.
11. Connect gas routing plumbing to the regulator outlet and adjust the output pressure accordingly (follow pressure guidance for the gas calibrator and/or CO analyzer).

The following practices will minimize the entrainment of ambient air into the regulator and cylinder:

When both the regulator outlet valve and the tank valve are open, always close the tank valve first to ensure contaminated air within the regulator cannot backflow into the tank.

When both the outlet valve and the tank valve are closed, open the regulator outlet valve first to ensure contaminated gas within the regulator is purged and cannot ever backflow into the tank.

#### 4.3.6 Carbon Monoxide Calibration Standard Gas Cylinders

The CO concentrations in the low and high CO standard cylinders must have been certified/recertified within the previous 12 months against first generation NIST standard gases. This can be performed by a properly qualified gas vendor (compliant with AA-PGVP requirements) or by the Region 7 verification laboratory. For recertification, the concentration of each gas measured by the certification laboratory from must be within  $\pm 3\%$  of original concentration from the manufacturer and within  $\pm 2\%$  of the most recent recertification value. Any cylinder which fails these criteria cannot be employed in the NPAP.

#### 4.3.7 Multi-blend Gas Cylinder

The concentrations of CO, NO, and SO<sub>2</sub> in the multi-blend tank must have been certified/recertified within the previous 12 months against first generation NIST standard gases. This can be performed by an AA-PGVP-compliant gas vendor (e.g., the gas manufacturer) or by the certification lab in Region 7. For recertification, the measured concentration of each gas must be within  $\pm 3\%$  of original certified concentration from the manufacturer and within  $\pm 2\%$  of the most recent recertification value. Any cylinder which fails these criteria cannot be employed in the NPAP.

#### 4.3.8 External Palladium CO Scrubber

The palladium scrubber is intended to replace the ultrapure zero air gas cylinder for verifying the performance of the ZAG when performing MVAs. Once assembled, the Pd scrubber does not contain consumable material and should last the lifetime of the audit equipment assembly. For Regions desiring a Pd scrubber, these can be requested from the NPAP OAQPS Lead. The assembled Pd scrubber is plumbed into the NPAP audit system according to the recommended plumbing schematic in Figure 2-1. A detailed procedure for assembling a suitable Pd scrubber is included in Appendix A.

#### 4.3.9 Ultrapure Zero Air Cylinder

The ultrapure zero air cylinder is not required if the audit system is equipped with an external palladium scrubber described in 4.3.8. There is no recertification period for the ultrapure zero air cylinder.

#### 4.3.10 Teflon® Gas Delivery Hose

New PTFE Teflon® gas delivery hoses must be cleaned to remove manufacturing residues and conditioned, “burned-in,” prior to use. Even with proper cleaning and preparation, the delivery hose will scrub some amount of ozone from the delivered gas, therefore the cleaning and conditioning is intended to minimize this scrubbing. To demonstrate that the delivery hose performance does not unacceptably scrub ozone from the produced challenge gases, the delivery hose must go through an ozone line loss test prior to use. The delivery hose must have been subject to such a line loss test within the previous three months prior to performing a TTP ozone audit.

For new hoses, the hose is flushed with tap and deionized water, dried by flushing with dry zero air, and subsequently conditioned with ozone to eliminate potential reactive sites within the hose flow path.

Clean and condition a new PTFE delivery hose as follows:

1. Flush the hose with tap water for  $\geq 1$  minute.
2. Rinse the hose with deionized water for  $\geq 15$  seconds.
3. Dry the hose with zero air for  $\geq 12$  hours.
4. Condition the hose with  $\sim 500$  ppb ozone @ 3 LPM for  $\geq 24$  hours.
5. Condition the hose with  $\sim 100$  ppb ozone @ 3 LPM for an additional  $\geq 48$  hours.
6. Condition the hose with  $\sim 200$  ppb  $\text{SO}_2$  @ 3 LPM for  $\geq 1$  hour.
7. Cap the conditioned delivery hose until an ozone line loss test can be performed.

The conditioned delivery hose is now ready for the ozone line loss test, which is to be performed quarterly when the hose is in use for conducting TTP audits.

The ozone line loss test verifies that the delivery hose does not result in loss of more than 2.5 ppb at any of four concentration levels spanning 10 to 200 ppb. Refer to Appendix B for the ozone line loss procedure (note this procedure and acceptance criteria were revised to ensure losses at lower ozone concentrations [i.e., those  $\leq 20$  ppb] are acceptably low).

#### 4.3.11 Data Acquisition System

The NPAP has specified that Envidas Ultimate software serve as the DAS. This DAS is computer-based and does not require a separate discrete data logger. Users can display readouts and annotate readings within the software via the computer interface. The Envidas Ultimate software can be acquired by request from the OAQPS Program Lead and should be installed following the vendor’s specifications.

#### 4.3.12 PEAT Software and Tablet or Laptop Personal Computer

A Windows-compatible (refer to Table 2-1) tablet or laptop PC is required for installation of the PEAT software. For proper operation, prior to audit trips, FSs and/or NPAP Regional Leads should check for and install available updates to the operating system, antivirus software, and PEAT software on the tablet and laptop personal computers. Updates may also be installed during audit trips such as when connected to the internet at hotels.

## 4.4 Audit Transport Vehicle and Supporting Equipment

FSs should maintain logbooks for the audit equipment transport vehicle and support equipment that requires periodic maintenance. This recordkeeping is especially important when multiple FSs share equipment to ensure that maintenance schedules are followed. Equipment logs should be kept with the equipment covered.

Maintenance activities for the audit transport vehicle and supporting equipment described in the following subsections are typical and should not be considered an exhaustive list. Each Region's complement of transport equipment will be unique to the Region, therefore FSs and/or NPAP Regional Leads are encouraged to specify maintenance and associated frequencies as the unique procedures and maintenance frequencies are outside the scope of this SOP.

### 4.4.1 General Vehicle Maintenance

Due to the potential for liability, FSs should not perform maintenance on the NPAP vehicle and it should be performed only by certified mechanics. The odometer reading and date should be recorded for any routine periodic maintenance performed, including, but not limited to:

- engine oil and filter change
- coolant flush and replacement
- air filter change
- tune up
- fuel filter replacement
- tire rotation or replacement
- suspension adjustment and/or alignment

### 4.4.2 Electrical Generator

Electrical generators should be properly maintained to ensure trouble-free operation. FSs should check the oil level before each use and add oil as needed. Long periods of inactivity can degrade generator performance, therefore generators should be run monthly for approximately 30 minutes to keep the components well-lubricated and prevent oxidation of electrical contacts. Addition of fuel stabilizer when refueling will reduce the likelihood of fuel system varnish build-up. Record maintenance (routine or non-routine) in the logbook, including, but not limited to:

- oil and oil filter change
- coolant flush and replacement
- air filter change
- tune up
- general inspection by a certified generator technician
- fuel filter replacement

### 4.4.3 HVAC System

For mobile laboratory-type systems (recreational vehicle, trailers, etc.) the equipment installed requires an HVAC system to maintain the required operable temperature range for NPAP measurement instruments of 20 to 30°C (68 to 86°F). Additionally, fluctuations within this range may result in measurement response instability and drift, therefore fluctuations should be minimized to the extent possible. The HVAC system should be serviced if it cannot maintain the temperature within this range.

#### 4.4.4 Trailer Maintenance

FSs operating trailer-based configurations should complete the form in Table 4-2 prior to each audit trip and indicate whether each item is satisfactory or unsatisfactory and add notes where needed.

Unsatisfactory items must be remedied before the trailer can be towed. The odometer reading and date the maintenance is performed should be recorded, including, but not limited to:

- tire rotation for the trailer
- turn signal and brake light check

**Table 4-2. Trailer-Based Safety Checklist**

Region: \_\_\_\_\_

Reviewer: \_\_\_\_\_

Date: \_\_\_\_\_

		SAT.	UNSAT.	NOTES
<b>Tow Vehicle</b>	1. The tow vehicle has enough power and braking capacity to safely tow the trailer load.			
	2. The tow vehicle has received regular preventative maintenance work. Record odometer reading under NOTES.			
	3. The tow vehicle has adequate fuel, battery power, oil, and engine coolant.			
	4. The tow vehicle tires are properly inflated and balanced; tires do not show excessive wear or damage.			
	5. The wheel fasteners (lug nuts) are present, tight, and free of rust.			
	6. Wheel rims are free from damage.			
	7. Tow vehicle is level when attached to the loaded trailer.			
	8. All lights (dash lights, head lights, tail lights, clearance lights, brake lights, directional signals, hazard light, high beams, reflectors) are in proper working order.			
	9. Weight is properly distributed between the trailer and the tow vehicle.			
	10. All brakes are in proper working order.			
	11. Side view mirrors provide an unobstructed rear view on both sides of the vehicle.			
<b>Hitching Apparatus</b>	1. The receiver is properly and securely mounted to the tow vehicle.			
	2. The receiver, draw bar, hitch ball, coupler, sway control device, spring bars, safety chains, and power connection wiring are all functional and compatible with the tow vehicle and trailer.			
	3. The power and brake control connections between the trailer and tow vehicle are compatible, provide enough slack for turning, are in good working order and are of proper length for brake to be activated if the trailer separates from the hitch.			
	4. The landing gear (trailer jack) is functional.			
	5. The hitch ball and coupler are the same size. When attached, the ball is firmly seated in the coupler, and the latching mechanism is locked.			



## 5.0 NPAP Audit Procedures

### 5.1 General Audit Considerations

The goal of the NPAP is to objectively characterize the performance of the ambient air monitoring equipment at the site in as-is condition and is not to facilitate or encourage a passing audit. Audit outcomes reflect on the quality of the concentration data reported by the site, thus data reported recently by the site before a failing audit will be reviewed to evaluate the impact of the measurement excursion from the certified test gas concentrations. FSs perform audits on ambient air monitoring stations as-is and may not permit the monitoring site operator or others to make adjustments to the station analyzer calibration or measurement equipment (e.g., fix loose intake connections). While problems with the site operation or configuration may be obvious prior to or during conducting the audit, FSs may not suggest corrective action (such as cleaning dirty inlets) before the audit has been completed, as this compromises the primary goal of the NPAP. FSs are responsible for making an unbiased assessment of an air monitoring station's ability to measure criteria pollutant concentrations.

The Regional NPAP Lead has sole discretion as to whether the FS can offer suggestions on corrective actions to the site operator to improve performance once the audit is complete; however, such suggestions cannot be made until the audit is concluded. Such suggestions are not required, and in fact, may not be permitted by the Regional NPAP Lead. Further, FSs do not have the responsibility or authority to prescribe official corrective actions. Due to potential liability and the impact it may have on the monitoring agency's ability to measure and report criteria pollutant measurements, FSs are not permitted to assist in the implementation of corrective actions or any other structural changes to ambient air monitoring stations.

Audit results are considered preliminary and unofficial until reviewed and approved by the respective EPA NPAP Regional Lead.

Audit vehicles and electrical generator exhaust contains carbon monoxide and other pollutants that can interfere with conducting the audit and should be located such that the exhaust is sufficiently far from and downwind from the monitoring station inlet probe.

The FS should communicate the expectation that the site operator should report their measurements to the FS in the same manner that measurements are reported to AQS for ambient air measurements. Practically, this means that sampling frequencies and measurement data handling characteristics such as truncation, averaging, rounding, and significant digits should be consistent with those employed for the routine measurement and reporting of ambient air concentrations.

For MVAs, CO and SO<sub>2</sub> audit results rely on the calibrated NPAP CO analyzer measurements and not the target concentrations programmed into the gas calibrator. The challenged CO concentrations measured by the NPAP CO analyzer are corrected for analyzer drift occurring over the course of the audit by analysis of the high CO standard before and after the audit. Ozone nominal concentrations are also not assigned based on the concentration value read from the gas calibrator, instead are determined by the NPAP ozone analyzer measurements corrected for the delivery line loss. For FBAs, the CO analyzer is not employed and the nominal challenge concentrations for CO and SO<sub>2</sub> are determined based on the certified concentrations in the multi-blend cylinder corrected for dilution with the flow rates of the standard and diluent gases measured by the flow transfer standard(s) prior to the audit.

Since the NPAP does not employ NO<sub>x</sub>, NO<sub>y</sub>, or NO<sub>2</sub> analyzers within the complement of audit instruments, NO<sub>2</sub> audit results rely on the NPAP CO analyzer measurements and reference the site-measured NO concentrations to construct a linear regression of the site NO monitor. The NO

concentrations measured by the site corrected for the linear regression are input into a calculation to determine the NO before and after generating NO<sub>2</sub> by GPT to determine the provided nominal NO<sub>2</sub> concentrations.

Note that due to the increased deployment of direct-read NO<sub>2</sub> analyzers in air monitoring networks, the NPAP NO<sub>2</sub> audit methodology will have to be updated. At the time of this SOP revision, a new method has not been developed. As discussed in Section 5.5.4.3, EPA intends to include such a procedure in a future revision of this SOP.

### 5.1.1 Audit Test Gas Flow Rate

The gas analyzers employed in ambient air monitoring are equipped with air sampling pumps and are engineered to sample ambient air at a nominal flow rate and at normal atmospheric pressures. Therefore, over pressurizing the sample inlet of these analyzers during auditing will likely result in erroneous measurements and possibly damage the equipment. To avoid over-pressurization, the audit gas flow rate is recommended to be 16 L/minute and maintained within  $\pm 1$  L/minute with a bypass vent installed in the delivery line at the station inlet probe as shown in Figure 2-1. Much of the generated test gas is exhausted out of this bypass vent when conducting TTP audits to ensure that station analyzers are not over-pressurized and that ambient air does not become entrained in the test gas, diluting or contaminating the test gas. The recommended flow rate of 16 L/minute has been demonstrated in most cases to provide sufficient flow to provide sufficient test gas to the onboard NPAP analyzers and the station analyzers without over-pressurization while ensuring ambient air is not entrained in the test gas.

Although 16 L/minute is typically a proper flow rate, FSs should verify the required flow rate. To estimate the audit gas flow rate provided to air monitoring stations, sum the total demand of audit analyzers in operation, the total demand of operating station analyzers, and demand of manifold vents to ensure excess audit gas is provided. The excess audit gas flow should be no less than 1-2 L/minute, though will typically be higher (e.g., approximately 5 L/minute).

The following is an example calculation of the audit gas flow demand to ensure excess flow is vented:

Most ambient air analyzers sample at a flow rate of approximately 1.1 L/minute. The NPAP delivery manifold should vent approximately 0.4 L/minute to ensure the onboard analyzers are not over pressurized during test gas generation and measurement. If both the NPAP ozone analyzer and CO analyzer are operating, their combined gas demand is 2.2 L/minute. If the air monitoring station is operating CO, SO<sub>2</sub>, and NO<sub>2</sub> monitors (each at 1.1 L/minute), their total demand is 3.3 L/minute. If the FS is supplying 16 L/minute of test gas, the gas vented at the station inlet is determined by subtracting the total known vent and demand from the total supplied.

In this case 0.4 L/minute (manifold vent), 2.2 L/minute (NPAP instruments), and 3.3 L/minute (station instruments) are subtracted from 16 L/minute for an excess flow of 10.1 L/minute.

If the air monitoring site utilizes a blower to pull air through the sampling manifold supplying ambient air to multiple analyzers, the blower must be turned off during the audit. In such configurations, the manifold blower pulls a high flow rate (typically much more than 16 L/minute) and will consume the audit gas flow and make up the remaining flow with ambient air, failing to flood the manifold with test gas and diluting or contaminating the test gas. For manifolds with blower configurations, the blower will serve as a vent, therefore an additional vent should not be installed on the delivery line connection at the sampling inlet.

## 5.2 Audit Concentrations Selection

Per Section B1.1 of the NPAP QAPP, the concentration range of the selected audit concentration points are to cover 80% of the site-reported concentrations for each of the required criteria pollutant gases for the previous calendar year. Following an analysis of nationwide ambient criteria pollutant concentrations, OAQPS has determined that the 80% criterion will generally be satisfied by selecting audit concentrations within Levels 2 to 5 for each of the criteria pollutant gases. The audit concentration level ranges are shown below in Table 5-1.

**Table 5-1. NPAP Audit Concentration Levels**

Audit Level	ppm			
	O <sub>3</sub>	SO <sub>2</sub>	NO <sub>2</sub>	CO
1	0.0040 - 0.0059	0.0003 - 0.0029	0.0003 - 0.0029	0.020 - 0.059
2	0.0060 - 0.019	0.0030 - 0.0049	0.0030 - 0.0049	0.060 - 0.199
3	0.020 - 0.039	0.0050 - 0.0079	0.0050 - 0.0079	0.200 - 0.899
4	0.040 - 0.069	0.0080 - 0.0199	0.0080 - 0.0199	0.900 - 2.999
5	0.070 - 0.089	0.0200 - 0.0499	0.0200 - 0.0499	3.000 - 7.999
6	0.090 - 0.119	0.0500 - 0.0999	0.0500 - 0.0999	8.000 - 15.999
7	0.120 - 0.139	0.1000 - 0.1499	0.1000 - 0.2999	16.000 - 30.999
8	0.140 - 0.169	0.1500 - 0.2599	0.3000 - 0.4999	31.000 - 39.999
9	0.170 - 0.189	0.2600 - 0.7999	0.5000 - 0.7999	40.000 - 49.999
10	0.190 - 0.259	0.8000 - 1.000	0.8000 - 1.000	50.000 - 60.000

The audited concentrations in Levels 3, 4, and 5 represent typical national ambient air concentrations. No audit levels should be performed above Level 5 without the approval of the National NPAP Lead.

Therefore, FSs and NPAP Regional Leads will not need to query AQS for site-reported ambient concentrations at any particular air monitoring station. Instead, each NPAP audit for any criteria pollutant gas will minimally contain an audit point concentration within Levels 5, 4, and 3 as well as an additional audit point concentration within Level 2 or 1. If the monitoring station routinely measures criteria pollutant gases at concentrations above Level 5, the FS (typically per Regional NPAP Lead) may add additional audit concentration points in Levels 6 through 10. Formal audit evaluation is based on monitoring station performance on Levels 3 through 10 and Levels 1 and 2 are intended for EPA to collect data on monitoring network performance (and Regions can additionally require pass/fail be evaluated for Levels 1 and 2). *Note: Table 5-1 includes audit Levels 6 through 10; however, FSs are not required to audit at these concentrations.* Acceptance criteria for NPAP TTP audits are defined in Table 5-2.

**Table 5-2. NPAP Audit Acceptance Criteria**

Criteria Gas	Audit Levels	Acceptance Criteria
SO <sub>2</sub>	1 and 2	< ± 1.51 ppb or ± 15.1%, whichever is greater, of the challenge gas concentration at each level
	3 through 10	< ± 15.1% of the challenge gas concentration at each level
NO <sub>2</sub>	1 and 2	± 1.51 ppb or ± 15.1%, whichever is greater, of the challenge gas concentration at each level
	3 through 10	< ± 15.1% of the challenge gas concentration at each level
O <sub>3</sub>	1 and 2	< ± 1.51 ppb or ± 10.1%, whichever is greater, of the challenge gas concentration at each level
	3 through 10	< ± 10.1% of the challenge gas concentration at each level
CO	1 and 2	< ± 0.031 ppb or ± 15.1%, whichever is greater, of the challenge gas concentration at each level
	3 through 10	< ± 15.1% of the challenge gas concentration at each level

### 5.3 Concentration Stability of Audit Measurements

Concentrations of audit test gases provided to the monitoring station must be stable before the site operator can provide a measurement. The FS will notify the station operator when the audit test gas concentration is acceptably stable at which time the station operator should use their own judgement when the concentration measured at the station is stable for reporting a concentration measurement.

NPAP audit concentrations and air monitoring station measurements should not be recorded (in PEAT) as part of the conducted audit until both the NPAP measurement and the air monitoring station measurement are stable.

#### 5.3.1 Concentration Stability for Measured Verification Audits

Stability for MVAs is demonstrated by observing the one-minute concentration measurement averages on the DAS (note that the stability must be documented in the DAS output; however, only the stable measurement is recorded in PEAT. The FS must maintain documentation of stability as output from the DAS). Generally, the test gas concentration measured by the NPAP analyzers must not indicate a consistent positive or negative trend. Ozone test gas concentration is considered to be stable when at least the most recent 5 one-minute average concentrations are within ± 0.001 ppm of the most recent five-minute average concentration. For CO, the test gas concentration is considered to be stable when at least the most recent 5 one-minute average concentrations are within ± 0.010 ppm of the most recent five-minute average concentration. If stability cannot be achieved in a reasonable timeframe, the FS may need to troubleshoot the system, which may require cleaning, investigating for leaks, or repairing the system. The audit level cannot be evaluated until concentration stability is acceptably demonstrated.

### 5.3.2 Concentration Stability for Flow-based Audits

For the first audit concentration point (this will typically be Level 5) to be conducted for a given TTP audit, the FS will generate the test gas for minimally 10 minutes prior to informing the station operator that a measurement can be made when their measurement is stable. For subsequent audit concentration levels, the FS will generate the test gas at a respective concentration for minimally 7 minutes prior to notifying the station operator that a measurement can be made and reported when their measurement is stable.

### 5.4 NPAP Analyzer Calibration Drift

CO analyzer calibrations exhibit drift over time, most notably at the zero response. This phenomenon is particularly pronounced when CO analyzers experience insufficient warm-up periods or when environmental conditions vary, such as when temperatures fluctuate more than approximately  $\pm 2^{\circ}\text{C}$ . To minimize the amount of measurement drift that occurs during a multi-blend audit, FSs should make efforts to ensure the CO analyzer is sufficiently warmed up (recommended to operate for 48 hours prior to an audit) prior to calibration, work efficiently to minimize the total time required to complete an audit, and maintain the temperature of the NPAP instruments at the proper temperature range with minimal fluctuation. The warm-up period is recommended as minimally 3.5 hours and experience has shown 48 hours or more minimizes the calibration drift. Despite these precautions, calibration drift of the CO analyzer is to be expected. The calculation to assign the audit concentrations account for the drift of the CO analyzer by requiring a pre-audit and post-audit standard measurement. Connection of the CO monitor to a battery back-up system (that can provide sufficient AC current and power as is provided by a generator or electrical grid connection) will permit extended time for the CO instrument to be powered on and sufficiently warmed up when a generator or electrical grid connection (shore power) is not available.

A one-hour warm-up is sufficient to minimize ozone analyzer drift prior to performing an ozone audit.

### 5.5 Conducting Ozone and Blended Gas Audits ( $\text{SO}_2$ , CO, and NO/NO<sub>2</sub>/NO<sub>x</sub>)

Audit procedures presented in this section refer to the equipment and plumbing schematic in Figure 2-1.

*Warning: Excessive backpressure in the NPAP plumbing will damage the gas calibrator and the analyzers. Before supplying power to the NPAP equipment, ensure that all valves used to control venting are open and ensure the sample delivery line cap has been removed.*

*The NPAP sample delivery line should be capped when not in use to prevent entry of debris and water. Always uncapped the sample delivery line before powering on the NPAP system and do not install the cap until the audit is completed and the gas generation system is powered off. If the sample delivery line is capped when the gas calibrator begins to produce flow, the backpressure will damage the gas calibrator and the analyzers.*

#### 5.5.1 Pre-audit Activities

To ensure audits are conducted efficiently and are considerate of station operator time, auditors should conduct the following pre-audit activities sufficiently in advance where possible. Of prime importance is the warm-up of the CO analyzer as described in Section 5.4 when conducting blended gas audits. Where possible, the following pre-audit activities should be conducted prior to arrival at the monitoring site (this may not be possible for FS operating case-based configurations).

##### 5.5.1.1 CO Analyzer Warm-up

If blended gas audits are to be conducted, the NPAP CO analyzer should be powered on and warmed up minimally 3.5 hours before the audit and it is highly recommended to be warmed up for 48 hours or more prior to the audit. Note that the CO analyzer does not need to be warmed up if a blended gas audit is not to be performed (i.e., only an ozone audit is to be conducted).

#### 5.5.1.2 Ozone Analyzer Warm-up

If an ozone audit is to be conducted, the ozone analyzer should be warmed up minimally one hour prior to conducting an audit as described in Section 5.5.3.1. Note the ozone analyzer warm up is not required if an ozone audit is not to be conducted.

#### 5.5.1.3 Delivery Line Conditioning

When conducting both ozone and blended gas audits, the delivery hose must be conditioned with ozone for minimally one hour prior to conducting an audit as described in Section 5.5.3.2. Position the outlet of the delivery hose such that its exhaust will not interfere with ambient air measurements at the monitoring site. To ensure minimal scrubbing of ozone when conducting audits, the delivery hose will need to be conditioned with a low level of ozone if the audit system has been out of routine use or service for several days or weeks. This may include generation of a low level ozone concentration (e.g., 15 ppb) for several days if the system has been idle for up to one week, or a higher ozone concentration (e.g., 150 ppb) at approximately 16 L/minute for several days if the system has been idle for over a week. Regardless of frequency of use, the delivery hose must also be conditioned for at least an hour prior to each audit with approximately 500 ppb ozone as described in 5.5.2.3.2.

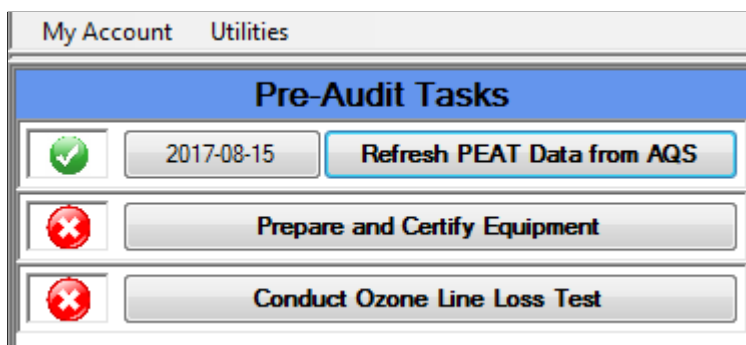
#### 5.5.1.4 Data Acquisition Initialization and Site Information Confirmation

Approximately one week (or more) before the audit, the FS should have completed the Confirm Monitor Information section within PEAT and distributed the report to the site operator to confirm the information within AQS is correct (as described in Section 2.3.1). Once on site, the FS will verify the latitude and longitude, monitor manufacturer and model, method code, and calibration date and correct any discrepancies.

Power on and boot the NPAP laptop/tablet computer, start the data acquisition software, and ensure that measurement data (CO analyzer and/or ozone analyzer outputs) captured by the DAS are being properly recorded and displayed by the data acquisition software.

Launch the PEAT software, log-in, and ensure all items in the Pre-Audit Tasks menu are current and complete (ensure green checkmarks are next to each item; refer to Figure 5-1). These pre-audit tasks must be completed before PEAT permits conducting the audit and recording data within PEAT. Note that an ozone line loss test is not required when only conducting blended gas audit audits (and ozone is not to be audited).

- Refresh PEAT Data from AQS: Queries AQS to update data within PEAT
- Prepare and Certify Equipment: Users update the audit equipment calibration/calibration verification and certification dates and values. Such includes certification dates for: High CO cylinder, Low CO cylinder, multiblend cylinder, ozone analyzer calibration, and ozone generator calibration.
- Conduct Ozone Line Loss Test: This function allows the conduct of the quarterly-required ozone loss test of the gas delivery line. Note that this test takes several hours and should be conducted on a different date in advance of an audit.



**Figure 5-1. PEAT Pre-Audit Tasks Menu**

## 5.5.2 Audit Activities Common to Both Blended Gas and Ozone Audits

### 5.5.2.1 Connecting the Delivery Line to the Station Inlet

It is expected that monitoring agencies will maintain the monitoring site grounds and shelter and provide an overall safe work environment at the air monitoring stations. If a ladder is required to connect to the sample inlet, follow all applicable safety precautions. If the site or sample inlet cannot be reached safely then the FS should immediately contact the NPAP Regional Lead to discuss next steps.

*Note that Back of the Analyzer (BOA) audits are still considered valid NPAP audits when sample inlets cannot be reached safely. Conducting BOA audits require Regional NPAP approval.*

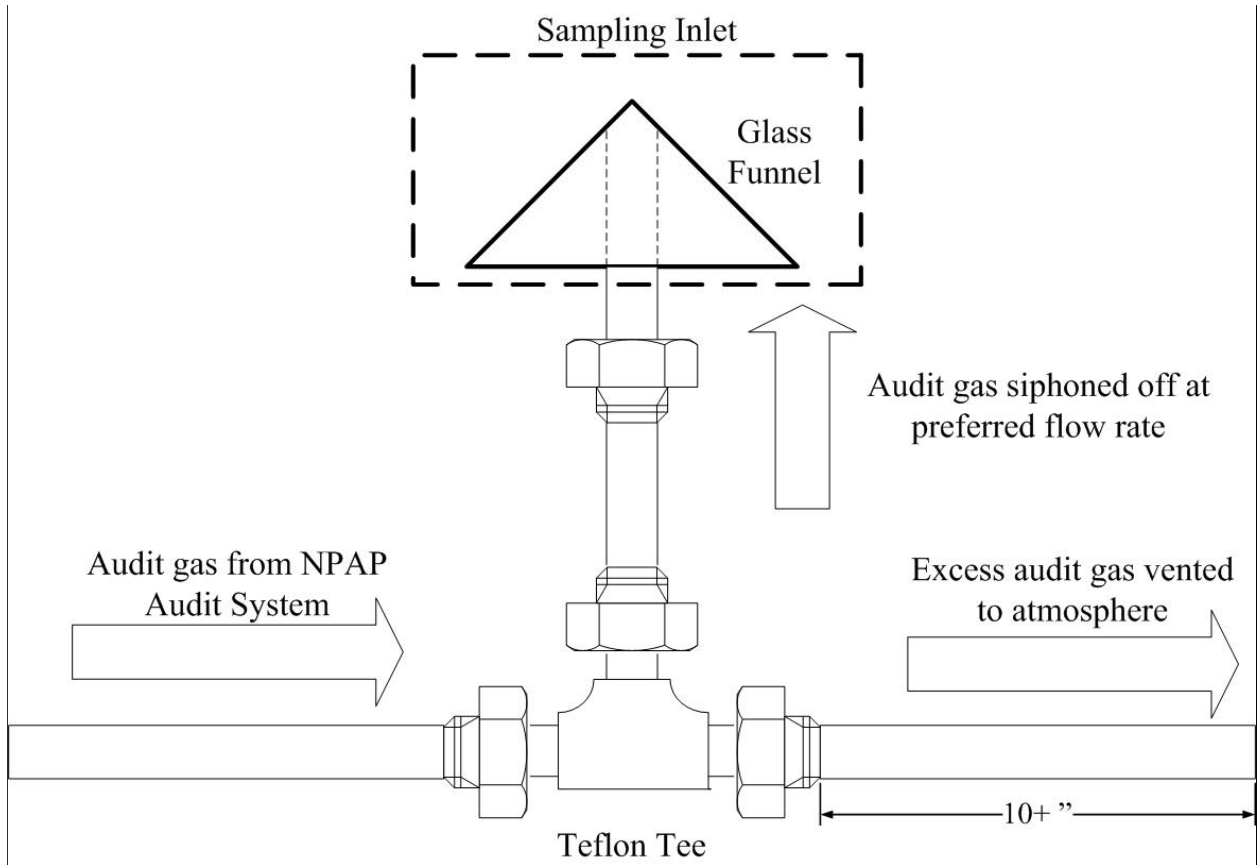
Prior to unreeling the sample delivery line and introducing audit gas in the vicinity of the station inlet, request that the site operator cease reporting data to AQS, i.e., *down the channel*. Failure to down the channel will not affect audit measurements, but may result in reporting data to AQS for the provided audit gases.

There are two typical configurations for connecting the audit delivery hose to a station inlet - with a secure “hard” plumbing connection to the inlet probe tubing (preferred) or employing a Teflon bag to shroud the inlet when a hard connection cannot be secured.

#### 5.5.2.1.1 Hard Connection to Inlet Probe Tubing

The most common inlet configuration employed at ambient air monitoring sites consists of ¼-inch OD Teflon® tubing shrouded by a borosilicate glass or stainless steel funnel as a rain shield. For such inlet configurations, connect the delivery line to the monitoring station inlet tubing with Teflon® connection fittings as shown in Figure 5-2 and Figure 5-3. The FS should bring extra Teflon® connection fittings in case they are needed to complete the connection of the NPAP sample delivery line.

To ensure the excess audit gas pressure is vented, construct a vent using a tee and an additional length of Teflon tubing. The vent tubing should be minimally 10 inches in length to prevent ambient air entrainment. If conditions are windy, a longer vent tube may be needed to reduce the influence wind has on the flow provided to the station inlet. FSs should be careful not to inadvertently cap the delivery line (as when adding tees and vents) as this will result in backpressure that will damage the gas dilution calibrator and analyzers.



**Figure 5-2. Hard Connection to Station Sampling Inlet Diagram**





**Figure 5-3. Hard Connection to Station Sampling Inlet**

#### 5.5.2.1.2 Soft Connection to Inlet Probe with a Teflon Bag

At sites where a hard connection cannot be secured (e.g., sites employing glass tubing for the inlet), the FS should use a Teflon<sup>®</sup> bag, fitted with a Teflon<sup>®</sup> union to allow connection the NPAP sample delivery line, to envelop the bell of the funnel. Secure the Teflon<sup>®</sup> bag in place (with a zip tie or wire tie). If a Teflon<sup>®</sup> bag is used, no additional vents are needed on the NPAP sample delivery line; the surface contact between the Teflon<sup>®</sup> bag and the inlet tubing will not seal completely, effectively serving as a vent. This soft connection configuration will require additional conditioning with audit gas to reduce the time required for the monitoring station concentration measurement to become stable. Guidance is discussed in the individual audit type sections that follow.

#### 5.5.2.2 Communicating Audit Points to Site Operators

NPAP TTP audits are single-blind performance evaluations where the concentrations of the test gas are known only to the FS and are blind to the site operator.

Once concentration stability is acceptably achieved for an audit point (as described in Section 5.3), the FS notifies the site operator to provide a measurement when the site measurement is concentration stable. The site operator is responsible for observing and judging when their station analyzer measurements are concentration stable. Once the site operator reports a measurement to the FS, the FS enters both the station measurement and the NPAP concentration measurement into PEAT. This process is repeated for each audit concentration point. To minimize transcription errors, the FS should ask the site operator to confirm the site concentration measurements as entered into PEAT.

### 5.5.3 Ozone Audit

Prior to conducting the ozone audit, the pre-audit activities described in Section 5.5.1 must be completed, which include warming up the ozone analyzer and conditioning the Teflon<sup>®</sup> delivery hose (which can be performed simultaneously).

#### 5.5.3.1 Ozone Analyzer Warm-Up

Ozone analyzers require a minimum of 1 hour of warmup prior to beginning the audit. The delivery line output must be away from the station inlet to ensure it does not impact ambient air measurements. To warm up the ozone analyzer:

1. Uncap the sample delivery line.
2. Ensure all venting needle valves are open.
3. Ensure that the main circuit breaker supplying power to the NPAP system is off.
4. Power on the generator or connect to a 30A electrical circuit at the air monitoring station.
5. Turn on the main circuit breaker to the audit system.
6. Power on the HVAC system (if so equipped). [*Note that even in cold weather, the backup power supply and zero air generator give off enough heat to warm an NPAP mobile laboratory space to an out of tolerance temperature.*]
7. Power on the UPS and power conditioner (this might be the same device).
8. Start the DAS software and power on supporting electronics (such as wi-fi).
9. Power on the ZAG and allow it time to come up to operating pressure.
10. Power on the gas dilution calibrator and set the zero air flow to 16 L/minute.
11. Power on the ozone analyzer.
12. Adjust the manifold needle valve such that calibration manifold vent rotameter reads approximately 0.4 L/minute. Observe this vent flow rate periodically throughout the audit and adjust as necessary to maintain ~0.4 L/minute.

#### 5.5.3.2 Delivery Line Conditioning for Ozone

Once the ozone analyzer warm-up activities have been completed, condition the delivery line with approximately 500 ppb ozone for minimally one hour at ~ 16 L/minute. To maximize efficiency, ozone analyzer warm-up and delivery line conditioning can be performed simultaneously. If the delivery hose has not been used for several days or weeks, additional conditioning with ozone is needed as described in Section 5.5.1.3.

#### 5.5.3.3 Conducting the Ozone Audit

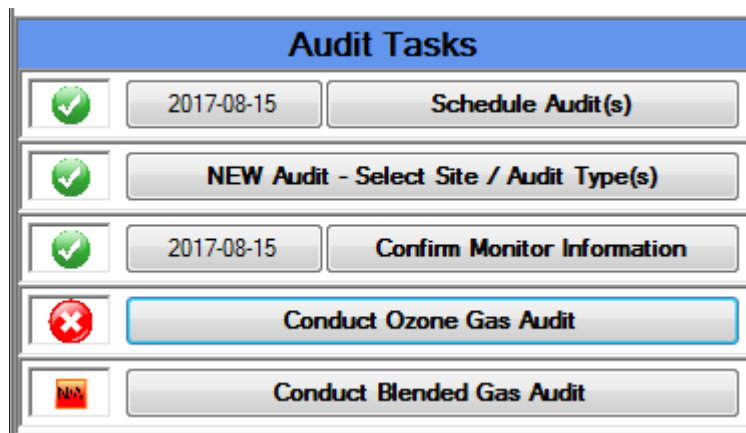
Once the pre-audit activities are completed, the FS can connect the Teflon<sup>®</sup> delivery hose to the station inlet probe as described in Section 5.5.2.1.

FSs will reference Table 5-1 when selecting audit concentrations. At a minimum, FSs are required to select one ozone concentration each in Level 5, 4, 3, and 2. FSs should select a concentration in Level 1 if there is sufficient time and the site analyzer sensitivity permits measurement.

There is expected to be some level of discrepancy between the target concentration programmed into the gas dilution calibrator and the concentration measured with the NPAP ozone analyzer. To ensure that selected audit concentrations measured by the ozone analyzer remain in the ranges defining the various audit levels, the FS should select an ozone concentration toward the middle of the concentration range for each level. Note that the formal concentration (and related audit level) of an audit point is the NPAP ozone analyzer measurement and the target concentration programmed into the gas dilution calibrator is irrelevant for evaluation purposes.

In PEAT (refer to Figure 5-4):

1. Click “Schedule Audit(s)” if this step has not been completed yet.
2. Click “NEW Audit - Select Site / Audit Type(s)” to select the site and the audit type.
3. Click “Confirm Monitor Information” to verify the latitude and longitude of the air monitoring station and the manufacturer and model of the analyzer. If any information within PEAT is incorrect, update by clicking “No – The \_\_\_\_\_ Information is NOT correct” on the appropriate tab: Confirm Site Information, Ozone – Confirm Monitor Information.
4. Click “Conduct Ozone Gas Audit” to open the audit form.



**Figure 5-4. PEAT Audit Tasks Menu**

The following subsections are arranged employing a convention of beginning an ozone audit with the higher concentration levels (e.g., Level 5) and progressing through lower concentrations (Levels 4, 3, and 2, respectively). This convention is recommended, but not required.

#### 5.5.3.3.1 First Ozone Concentration Point

*Note: If an additional connector was needed to connect the delivery hose to the monitoring station sampling inlet (a Teflon® bag or additional Teflon® tee and hose, etc.), it must be conditioned prior providing the first audit concentration to eliminate scrubbing effects. To condition the additional connections, generate a concentration approximately 1.5-fold the intended Level 5 concentration of ozone for minimally 5 minutes. After this additional conditioning period, begin generating the first ozone audit concentration point. This process will reduce the time required for the monitoring station ozone concentration measurement to stabilize.*

For the following measurements, ozone measurements are to be recorded in PEAT in ppm.

1. Select a target ozone audit concentration within the Level 5 range and enter this setting into the gas calibrator.
2. Record the target ozone concentration in the PEAT software in the field labeled “Ozone Setting”. (refer to Figure 5-5) for the corresponding audit concentration level.

Audit Point	Ozone Setting	NPAP Response	NPAP Corrected for Line Loss	Audited Station Response	% Difference	Audit Level
O3 Point #1	0.085					
O3 Point #2						
O3 Point #3						
O3 Point #4						
O3 Point #5						
Zero						

Average % Difference: 0.0000    Num Required Audit Levels: 3    Actual Completed: 0

Database: AQSPProd    Build: Normal    Status: Calculating Values COMPLETE

**Figure 5-5. Recording the Software Target Ozone Concentration in PEAT**

3. Allow approximately 15 minutes for the NPAP ozone analyzer (NPAP measurement) to stabilize, as described in Section 5.3, and annotate the time acceptable concentration stability was achieved on the DAS or strip chart. Once the concentration measurement is sufficiently stable, notify the site operator that they can report their measurement once their measurement is stable.
4. The site operator then reports the monitoring station measurement. Enter this reported measurement in the column labeled “Audited Station Response” (refer to Figure 5-6) for the corresponding audit concentration level.
5. Average the five most recent one-minute concentration averages from the NPAP ozone analyzer and record the value in the column labeled “NPAP Response” (refer to Figure 5-6) for the corresponding audit concentration level.

Audit Point	Ozone Setting	NPAP Response	NPAP Corrected for Line Loss	Audited Station Response	% Difference	Audit Level
O3 Point #1	0.0850	0.0798	0.0792	0.0820	3.5	5
O3 Point #2						
O3 Point #3						
O3 Point #4						
O3 Point #5						
Zero						

Average % Difference: 3.5000    Num Required Audit Levels: 3    Actual Completed: 1

Database: AQSProd    Build: Normal    Status: Calculating Values COMPLETE

**Figure 5-6. PEAT - Entry of NPAP Audit and Station Measurements**

#### 5.5.3.3.2 Second (Level 4) and Successive (Levels 3, 2, and 1) Ozone Concentration Points

After the first ozone concentration point has been completed and the data recorded in PEAT. Repeat the process following steps 1 through 5 above for successive audit points in concentration Levels 4, 3, 2 and, if conditions permit (sufficient time remains and station analyzer detection limits permit), Level 1.

#### 5.5.3.3.3 Ozone Post Audit Zero Point

1. Enter a target ozone concentration of zero into the gas dilution calibrator.
2. Record the target ozone concentration (0.0 ppm) in PEAT in the column labeled “Ozone Setting” in row Zero.
3. Wait for the ozone analyzer to show a stable blank reading (approximately 15 minutes) and notify the site operator that they can report their measurement once their measurement is stable.
4. The site operator then reports the monitoring station measurement. Enter this reported measurement in the column labeled “Audited Station Response” in row Zero.
5. Average the five most recent one-minute concentration averages from the NPAP ozone analyzer and record the value in the column labeled “NPAP Response” in row Zero.

#### 5.5.3.3.4 Ozone Audit Documentation Verification and Audit Conclusion

1. Preserve the audit data captured by the data logger by saving the acquired data file with the FSs annotations to the DAS PC. These data files will be archived. FS may also print a hard copy of the DAS data which includes annotations indicating concentration stability for each audit point and the readings that were taken and recorded as the NPAP audit concentration.
2. Click the Save button in the lower right of the audit form (refer to Figure 5-7) to save the audit data in PEAT. Once saved, close the audit form by clicking the Close button in lower right of the form.
3. Refer to Section 5.5.5.3 for post-audit shutdown and report distribution.

Audit Point	Ozone Setting	NPAP Response	NPAP Corrected for Line Loss	Audited Station Response	% Difference	Audit Level
O3 Point #1	0.0850	0.0798	0.0792	0.0820	3.5	5
O3 Point #2	0.0650	0.0622	0.0616	0.0600	-2.6	4
O3 Point #3	0.0350	0.0355	0.0348	0.0370	6.3	3
O3 Point #4	0.0150	0.0139	0.0132	0.0160	21.2	2
O3 Point #5	0.0063	0.0051	0.0044	0.0070	59.1	1
Zero	0.0000	0.0001	-0.0006	0.0000		

Average % Difference: 17.5000    Num Required Audit Levels: 3    Actual Completed: 5

Database: AQSProd    Build: Normal    Status: Complete

Buttons: Comments..., Save, Close

**Figure 5-7. PEAT – Saving a Completed Ozone Audit**

#### 5.5.4 Blended Gas Audits: CO, SO<sub>2</sub>, and/or NO<sub>2</sub>

Prior to conducting a blended gas MVA, the pre-audit activities described in Section 5.5.1 must be completed, which include warming up the CO analyzer and conditioning the Teflon<sup>®</sup> delivery line with ozone.

The following subsections describe conducting an audit for a single pollutant gas; however, FSs may conduct audits of multiple pollutant gases simultaneously provided there is a sufficient supply of Teflon<sup>®</sup> connectors and Teflon<sup>®</sup> tubing (for stations that have separate analyzer inlet probes) and the stock multiblend cylinder concentrations are in the proper relative ratios. Once the FS has mastered auditing a single pollutant, FSs are encouraged to conduct audits of multiple pollutant gases simultaneously as this is more efficient than auditing a single pollutant at a time.

FSs should follow the prescribed steps in the order presented. Failure to comply with the stated order may result in contamination and/or damage to equipment.

*Note: The high pressure cylinder regulators and connection lines must be purged each time the cylinders are to be opened for conducting an audit. Refer to the instructions on regulator purging in Section 4.3.5.*

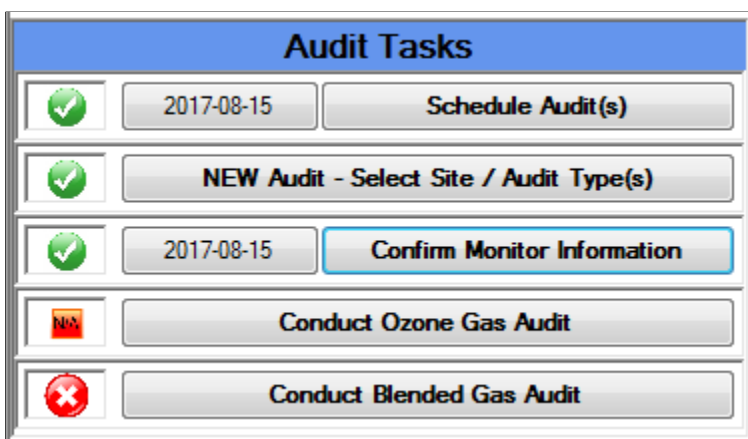
##### 5.5.4.1 CO Analyzer Calibration

Once the CO analyzer is warmed up, it is calibrated at an upscale concentration and zero concentration to set the slope and intercept each day of use prior to conducting a blended gas MVA. Once the calibration is established, the calibration is verified by measuring zero air (that has either been scrubbed through the external palladium scrubber or from the ultrapure zero air cylinder) and by analyzing the low concentration CO cylinder gas.

This SOP does not cover the details of conducting CO analyzer calibration as the instructions and procedures for achieving an acceptable calibration are unique to each manufacturer and individual instrument. Follow the CO analyzer manufacturer instructions for performing the two-point calibration.

In PEAT (refer to Figure 5-8):

1. From the Audit Tasks menu, click the “Schedule Audit(s)” if this step has not yet been completed.
2. Click the “NEW Audit - Select Site / Audit Type(s)” button to select the site and the audit type(s).
3. Click “Confirm Monitor Information” to verify the latitude and longitude of the air monitoring station and the manufacturer and model of the monitoring station analyzer(s). If any information is incorrect, update by clicking “No – The \_\_\_\_\_ Information is NOT correct” on the appropriate tab: Confirm Site Information, Blended Gas – Confirm Monitor Information.
4. Click the “Conduct Blended Gas Audit” to open the audit form.



**Figure 5-8. PEAT – Audit Tasks Table for Blended Gas Audits**

#### 5.5.4.1.1 CO Analyzer Calibration - Zero Concentration Point

Refer to the configuration schematic in Figure 2-1 for the location of various valves and system components.

1. Ensure that the Tank/Manifold three-way valve is set to allow flow from the gas dilution calibrator to the NPAP CO analyzer.
2. Program the gas calibrator to provide zero air at 16 LPM.
3. Configure the CO analyzer to the function for establishing the calibration zero point.
4. Observe the CO analyzer reading to become stable for approximately 5 minutes and re-zero the analyzer.
5. Stability is demonstrated when at least the most recent 5 one-minute averages are  $0.000 \pm 0.010$  ppm of most recent five-minute average as indicated on the DAS. If stability is not observed, continue to wait or repeat step 4.
6. Record the average of the most recent five consecutive one-minute average CO concentration readings in PEAT in the True Value column of the zero verification row.
7. Supply zero air from the ultrapure air source (either from ultrapure zero air cylinder or ZAG output additionally treated through an external Pd scrubber) and adjust the manifold needle valve so the manifold vent rotameter reads ~0.4 L/minute.
8. Allow the CO analyzer reading to stabilize for approximately five minutes then begin observing the measured concentration for stability.

9. Stability is acceptably demonstrated when at least the 5 most recent one-minute average CO concentration readings are  $\pm 0.01$  ppm of the most recent five-minute average concentration indicated on the DAS.
10. Average the five most recent one-minute average CO concentration readings.
  - a. If this average CO concentration is within  $\pm 0.020$  ppm of the average concentration determined in step 6, proceed to Step 11.
  - b. If the average CO measurement is more than 0.020 ppm lower than the zero value determined in step 6, this indicates the ZAG is not sufficiently scrubbing CO and that the zero air will require additional cleanup (e.g., scrubbing through an external palladium scrubber) if the multi-blend audit is to continue. If available, the Pd scrubber must remain in line for the remainder of the audit.
    - i. If the ZAG is demonstrated to be insufficiently scrubbing CO from the ZAG output and an external Pd scrubber is available, repeat Steps 3 through 6 with the ZAG output routed through the external palladium scrubber. Record the average concentration value from step 6 in the Instrument Response column in the zero verification row and skip to Section 5.5.4.1.2 to set the span point.
  - c. The measurement of the cylinder ultrapure zero air is expected to measure a higher concentration than the ZAG output; however, the zero air from the ZAG output treated with an external Pd scrubber should measure an approximately equal, or slightly lower, concentration than the ZAG output alone. If the average CO measurement for the cylinder ultrapure zero air or externally Pd scrubbed ZAG output is more than 20 ppb higher than the average concentration determined in Step 6, this indicates the ultrapure zero air cylinder or external palladium scrubber may be contaminated or there may be a leak in the system. The FS should then troubleshoot the system for leaks or malfunction and repeat steps 4 through 10.
11. Record the average of the five most recent consecutive one-minute average CO concentrations measured in step 10 in the Instrument Response column in the Ultrapure Zero row (refer to Figure 5-9).
12. Set the zero air source according to the following outcomes of step 10:
  - a. If the criterion in Step 10.a was met, set three-way valve so the zero air source is the ZAG output and bypass the cylinder ultrapure zero air or external palladium scrubber.
  - b. If the zero check in step 10 meets the conditions in step 10.b, the zero air source must be the ZAG output routed through the external Pd scrubber.

Pre Audit Calibration (All units are ppm)				
		Instrument Response	True Value	Percent Difference
	Ultrapure Zero	-0.0010	0.0000	
▶	Pre Audit High CO		39.0000	-100.00
	Pre Audit Low CO		0.9564	-100.00
	Pre Audit Zero		0.0000	

Figure 5-9. PEAT - Pre-Audit Calibration CO Analyzer Zero Response



### 5.5.4.1.2 CO Analyzer Calibration – Setting the Span Point

The CO analyzer span point/high point is established by measuring the high concentration CO gas cylinder.

1. Configure the CO analyzer to the function for establishing the span point.
2. Enter the nominal analytical concentration of the high CO gas cylinder (this is detailed on the cylinder certificate of analysis) into the CO analyzer. In PEAT, confirm this concentration matches that displayed in the True Value column and Pre-Audit High CO row in the Pre-Audit Calibration Table of the Conduct Blended Gas Audit window (this value is input in the Pre-Audit Tasks table under the Prepare Audit and Certify Equipment menu).
3. Open the regulator outlet valve for the high CO gas cylinder.
4. Open the tank valve for the high CO gas cylinder.
5. Adjust the regulator output pressure to 20 psi.
6. Engage the high CO solenoid switch to allow the high CO cylinder gas to flow.
7. Turn the Tank/Manifold three-way valve to allow the high CO cylinder gas to flow to the CO analyzer.

*Note: The Tank/Manifold 3-way valve isolates the calibration gas cylinders from the multi-component audit gas supplied to the sample delivery line.*

8. Adjust the tank needle valve until the tank vent rotameter reads ~0.4 L/minute.
9. Wait approximately 5 minutes for the CO analyzer reading to begin to stabilize, then set the analyzer reading to the high CO nominal concentration.
10. When 5 consecutive one-minute average measurements are within  $\pm 0.1$  ppm of the nominal high CO concentration, the measurement concentration is acceptably stable and the span point has been set successfully.
11. If stability criteria stated in step 10 are not observed, continue to wait for an acceptably 10-minute period or repeat steps 9 and 10.
12. Average the five most recent one-minute average CO readings and record this value in the Instrument Response column in the Pre Audit High CO row (refer to Figure 5-10).

Pre Audit Calibration (All units are ppm)				
		Instrument Response	True Value	Percent Difference
	Ultrapure Zero	-0.0010	0.0000	
	Pre Audit High CO	39.1000	39.0000	0.26
	Pre Audit Low CO		0.9564	-100.00
	Pre Audit Zero		0.0000	

**Figure 5-10. PEAT – Pre-Audit Calibration High CO (Span) Measurement Entry**

13. Place the CO analyzer into normal measurement mode.
14. Close the high CO cylinder tank valve.
15. Close the high CO cylinder regulator outlet valve.
16. Disengage the High CO solenoid switch to stop the flow of high CO cylinder gas.

### 5.5.4.1.3 CO Analyzer Calibration – Precision Point Calibration Verification

The two-point calibration is verified with the low CO gas cylinder.

1. In PEAT, enter the nominal analytical CO concentration from the COA of the low CO gas cylinder into the True Value column in the Pre Audit Low CO in the Pre Audit Calibration table of the Conduct Blended Gas Audit window.
2. Open the regulator outlet valve for the low CO gas cylinder.
3. Open the tank valve for the low CO gas cylinder.
4. Adjust the regulator output pressure to 20 psi.
5. Engage the low CO solenoid switch to allow the low CO cylinder gas to flow.
6. Adjust the tank needle valve until the tank rotameter reads ~0.4 LPM.
7. Allow approximately 15 minutes for the CO analyzer reading to stabilize.
8. When five consecutive one-minute average measurements are within  $\pm 3\%$  of the nominal low CO concentration, the measurement is stable and verifies the CO analyzer calibration.
9. If the conditions in step 8 are not observed, continue to wait for the measurements to stabilize until the criteria are met. If stability is achieved and values are not within  $\pm 3\%$  of the low CO nominal concentration, repeat the two-point calibration (Sections 5.5.4.1.1 and 5.5.4.1.2).
10. Calculate the average the five most recent one-minute average CO concentration readings for the low CO standard and record this value in the Instrument Response column in the Pre Audit Low CO field (refer to Figure 5-11).

Pre Audit Calibration (All units are ppm)				
		Instrument Response	True Value	Percent Difference
	Ultrapure Zero	-0.0010	0.0000	
	Pre Audit High CO	39.1000	39.0000	0.26
	Pre Audit Low CO	0.9562	0.9564	-0.02
	Pre Audit Zero		0.0000	

**Figure 5-11. PEAT - Pre-Audit Calibration Low CO Measurement Entry**

11. Turn the Tank/Manifold three-way valve to allow gas from the gas dilution calibrator to flow to the CO analyzer.
12. Close the low CO cylinder tank valve.
13. Close the low CO cylinder regulator outlet valve.
14. Disengage the low CO solenoid switch to stop the flow of cylinder gas.

#### 5.5.4.2 Conducting Blended Gas Audits for CO or SO<sub>2</sub>

Once the CO analyzer is calibrated, connect the Teflon<sup>®</sup> delivery hose to the station inlet as in Section 5.5.2.1.

FSs will reference Table 5-1 when selecting audit concentrations. At a minimum, FSs are required to select one concentration each in Levels 5, 4, 3, and 2 for each gas undergoing audit. FSs should select a concentration in Level 1 if there is sufficient time and the site analyzer sensitivity permits measurement.

FSs should expect some discrepancy between the target CO concentration programmed into the gas dilution calibrator and the concentration measured with the NPAP CO analyzer and CO analyzer zero/calibration drift over the course of an audit may increase such discrepancy, and that such drift

typically trends downward. To ensure that selected audit concentrations measured by the CO analyzer will remain within the concentration range specified for a given audit level, the FS should select concentrations toward the middle of the concentration range for each level.

In PEAT, check the appropriate boxes for the respective gases (parameters) to be audited for the blended gas audit (refer to Figure 5-12).

Select Parameters to Audit			
CO	<input checked="" type="checkbox"/>	SO2	<input type="checkbox"/>
		NO2	<input checked="" type="checkbox"/>
Post Audit Calibration (All units are ppm)			
	Instrument Response	True Value	Percent Difference
Post Audit Zero		0.0000	
Ultrapure Zero		0.0000	
Post Audit High CO		39.0000	-100.00

**Figure 5-12. PEAT – Selecting Gas Parameters for Blended Gas Audits**

The following subsections are arranged employing a convention of beginning a blended gas audit with the higher concentration levels (e.g., Level 5) and progressing through lower concentrations (Levels 4, 3, and 2, respectively). This convention is recommended, but not required.

5.5.4.2.1 Blended Gas Pre Zero Audit Point

1. Program the gas calibrator to deliver zero air at 16 L/minute. The zero air source will be that determined in Section 5.5.4.1.1 when setting the CO analyzer zero.
2. Adjust the manifold needle valve such that manifold rotameter vent reads ~0.4 L/minute.
3. In PEAT, Record “0.0000” in the CO Concentration Setting column and Pre Zero row in the Blended Gas Audit table (refer to Figure 5-13).

Blended Gas Audit (All units are ppm)												
	CO Concentration Setting	Ozone Setting	NPAP Reading	Station Reading SO2	Station Reading CO	Station Reading NO	Station Reading NO2	Station Reading NOx	% Diff SO2	% Diff CO	% NO2 Bias	
Pre Zero	0.0000		0.0000									
CO,SO2,NO/NOx Pt 1												
NO2 Pt 1												
CO,SO2,NO/NOx Pt 2												
NO2 Pt 2												
CO,SO2,NO/NOx Pt 3												
NO2 Pt 3												
CO,SO2,NO/NOx Pt 4												
NO2 Pt 4												
CO,SO2,NO/NOx Pt 5												
Post Zero												

**Figure 5-13. PEAT – Entering CO Concentration Setting**

4. Allow approximately 15 minutes for the NPAP CO analyzer measurement to stabilize. Once a stable measurement is obtained as described in Section 5.3, notify the site operator that they can report their measurement once their measurement is concentration stable (note this may take 10 or more minutes for the site measurement to become concentration stable).
5. Record the concentration reading (in ppm) from the site operator for the zero in PEAT in the Blended Gas Audit table in the appropriate Station Reading column and Pre Zero row (refer to Figure 5-14).

Blended Gas Audit (All units are ppm)											
	CO Concentration Setting	Ozone Setting	NPAP Reading	Station Reading SO2	Station Reading CO	Station Reading NO	Station Reading NO2	Station Reading NOx	% Diff SO2	% Diff CO	% NO2 Bias
Pre Zero	0.0000		-0.0040		0.0020						
CO,SO2,NO/NOx Pt 1											
NO2 Pt 1											
CO,SO2,NO/NOx Pt 2											
NO2 Pt 2											
CO,SO2,NO/NOx Pt 3											
NO2 Pt 3											
CO,SO2,NO/NOx Pt 4											
NO2 Pt 4											
CO,SO2,NO/NOx Pt 5											
Post Zero											

**Figure 5-14. PEAT – Blended Gas Audit Station Reading Pre-Zero Entry**

6. Average the five most recent one-minute CO average concentrations from the NPAP CO analyzer and record the value in the Pre-Audit Calibration table in the Instrument Response column and Pre Zero row (refer to Figure 5-15).
  - a. PEAT will automatically populate this value in the Blended Gas Audit table in the NPAP Reading column and Pre-Zero row. *Subsequent measurements will be entered in the Blended Gas Audit window.*

Pre Audit Calibration (All units are ppm)				
		Instrument Response	True Value	Percent Difference
	Ultrapure Zero	-0.0010	0.0000	
	Pre Audit High CO	39.1000	39.0000	0.26
	Pre Audit Low CO	0.9562	0.9564	-0.02
	Pre Audit Zero	-0.0040	0.0000	

**Figure 5-15. PEAT – Pre-Audit Zero CO Entry**

#### 5.5.4.2.2 Purging the Multiblend Cylinder Flow Path

Refer to Figure 4-1 for purging the multiblend cylinder regulator flow path. Failure to properly purge the flow path will require extended stabilization times.

1. Open the multiblend cylinder regulator outlet valve.
2. Open the multiblend cylinder tank valve.
3. Adjust the regulator output pressure to 20 psi.
4. Close the multiblend cylinder tank valve.
5. Close the multiblend cylinder regulator outlet valve.
6. Open the multiblend cylinder tubing connection purge valve until output pressure drops to 5 psi, then close the purge valve.
7. Open the multiblend cylinder regulator outlet valve.
8. Open the multiblend cylinder tank valve.
9. Repeat Steps 4 through 8 four more times.

#### 5.5.4.2.3 Blended Gas Audit - First CO or SO<sub>2</sub> Concentration Point (Level 5)

*Note: If an additional connector was needed to connect to the sample inlet (a Teflon® bag or additional Teflon® tee and hose, etc.), it needs to be conditioned to avoid scrubbing effects prior to providing the first audit concentration point. To condition the additional connections to the monitoring site inlet probe, generate a concentration approximately 1.5-fold the intended Level 5 concentration of CO or SO<sub>2</sub> for approximately 5 minutes before generating the first audit concentration point. This process will reduce the time required for the first audit concentration point to stabilize.*

1. Select a target audit concentration in the range of Level 5 and program it into the gas calibrator.
2. In PEAT in the Blended Gas Audit table, record the target CO concentration in the CO Concentration Setting column and CO,SO<sub>2</sub>,NO/NO<sub>x</sub> Pt 1 row.
3. Once a stable NPAP CO concentration measurement is obtained as described in Section 5.3, notify the site operator that they can report their measurement once their measurement is concentration stable (note this may take 10 or more minutes for the site measurement to become concentration stable).
4. Record the concentration reading(s) (in ppm) from the site operator for the first audit concentration point in PEAT in the Blended Gas Audit table in the appropriate Station Reading column(s) and CO,SO<sub>2</sub>,NO/NO<sub>x</sub> Pt 1 row (refer to Figure 5-14).
5. Average the five most recent one-minute CO concentration averages from the NPAP CO analyzer and record this value in the Blended Gas Audit table in the NPAP Reading column.

#### 5.5.4.2.4 Second (Level 4) and Successive (Levels 3, 2, and 1) CO or SO<sub>2</sub> Concentration Points

After the first audit concentration point has been completed and the data are recorded in PEAT, repeat the process following steps 1 through 5 above for successive audit points in concentration Levels 4, 3, 2 and, if conditions permit (sufficient time remains and station analyzer detection limits permit), Level 1.

#### 5.5.4.2.5 Post Zero Point

1. Program a target audit concentration of 0.000 ppm into the gas dilution calibrator.
2. In the Blended Gas Audit table in PEAT, record “0.0000” ppm in the CO Concentration Setting column in row Post Zero.
3. Allow approximately 15 minutes for the NPAP CO analyzer measurement to stabilize. Once a stable measurement is obtained (as described in Section 5.3), notify the site operator that they can report their measurement(s) once their measurement is concentration stable.
4. Record the concentration reading(s) (in ppm) from the site operator for the zero in PEAT in the Blended Gas Audit table in the appropriate Station Reading column(s) and Post Zero row.

**The CO analyzer calibration must be checked and recorded to ensure the CO analyzer calibration drift is considered in the audit concentration point assignments. Conduct these checks according to Section 5.5.4.4.**

### 5.5.4.3 Conducting Blended Gas NO/NOx/NO<sub>2</sub> Audits

**Prior to conducting an NO/NOx/NO<sub>2</sub> audit, the pre-audit activities described in Section 5.5.1, the CO analyzer calibration and calibration verification detailed in Section 5.5.2.4.1, and the multiblend cylinder regulator and line purge detailed in Section 5.5.2.5.2 must be completed.**

*NOTE: The procedure detailed in this section applies to auditing of NOx analyzers and does not permit the auditing of NO<sub>2</sub>-specific analyzers that do not comprise an NO-channel. OAQPS is developing a procedure to audit NO<sub>2</sub>-specific analyzers and this SOP will be updated to include this procedure when it has been validated.*

Reference Table 5-1 when selecting audit concentrations. Each audit must minimally include a concentration in Levels 5, 4, and 3 and additionally in either Level 2 or 1 for each gas undergoing audit.

*Note: To perform the NO<sub>2</sub> audit properly, GPT requires excess NO. If the audit test gas contains an excess of ozone the NO<sub>2</sub> audit gas concentration will not be accurate and the audit will not be valid.*

*This convention provides NO gas to the station to audit the NO channel of the NO/NOx analyzer for each audit level range. Once the NO audit concentration and station measurement have been recorded for the audit concentration level, the FS selects a slightly lower NO<sub>2</sub> concentration within the same level, and begins GPT to provide a standard NO<sub>2</sub> audit gas. This requires that the selected NO concentration must be toward the upper end of the concentration range in the level. This process is more complex than a CO or SO<sub>2</sub> blended gas audit as the station NO readings are employed to generate a linear regression to determine remaining NO after GPT. This convention effectively provides two different gases within the same respective concentration Level range to challenge the station analyzer.*

Check the appropriate boxes for the respective gases to be conducted for the blended gas audit (refer to Figure 5-17).

Select Parameters to Audit				
	CO	<input checked="" type="checkbox"/>	SO2	<input type="checkbox"/>
			NO2	<input checked="" type="checkbox"/>
Post Audit Calibration (All units are ppm)				
		Instrument Response	True Value	Percent Difference
▶	Post Audit Zero		0.0000	
	Ultrapure Zero		0.0000	
	Post Audit High CO		39.0000	-100.00

**Figure 5-17. PEAT – Selecting Parameters for Blended Gas NO<sub>2</sub> Audit**

The following subsections are arranged employing a convention of beginning an NO<sub>2</sub> audit with the higher concentration levels (e.g., Level 5) and progressing through lower concentrations (Levels 4, 3, and 2, respectively). This convention is recommended, but not required.

#### 5.5.4.3.1 NO<sub>2</sub> Pre Zero Point

1. Program the gas calibrator to deliver zero air at 16 L/minute.
2. Program the gas calibrator to deliver zero air at 16 L/minute. The zero air source will be that determined in Section 5.5.4.1.1 when setting the CO analyzer zero.
3. Adjust the manifold needle valve such that manifold rotameter vent reads ~0.4 L/minute.
4. In PEAT, record “0.0000” ppm in the CO Concentration Setting column in the Pre Zero row (refer to Figure 5-18).

Blended Gas Audit (All units are ppm)												
		CO Concentration Setting	Ozone Setting	NPAP Reading	Station Reading SO2	Station Reading CO	Station Reading NO	Station Reading NO2	Station Reading NOx	% Diff SO2	% Diff CO	% NO2 Bias
	Pre Zero	0.0000		0.0000								
▶	CO,SO2,NO/NOx Pt 1											
	NO2 Pt 1											
	CO,SO2,NO/NOx Pt 2											
	NO2 Pt 2											
	CO,SO2,NO/NOx Pt 3											
	NO2 Pt 3											
	CO,SO2,NO/NOx Pt 4											
	NO2 Pt 4											
	CO,SO2,NO/NOx Pt 5											
	Post Zero											

**Figure 5-18. PEAT – Pre-Zero CO Concentration Setting Entry**

- Allow approximately 15 minutes for the NPAP CO analyzer measurement to stabilize. Once a stable measurement is obtained as described in Section 5.3, notify the site operator that they can report their measurements once their measurements are concentration stable (note this may take 10 or more minutes for the site measurements to become concentration stable).
- Record the NO, NO<sub>2</sub>, and NO<sub>x</sub> concentration readings (in ppm) from the site operator for the zero in PEAT in the Blended Gas Audit table in the appropriate Station Reading columns and Pre Zero row (refer to Figure 5-19).

Blended Gas Audit (All units are ppm)												
		CO Concentration Setting	Ozone Setting	NPAP Reading	Station Reading SO2	Station Reading CO	Station Reading NO	Station Reading NO2	Station Reading NOx	% Diff SO2	% Diff CO	% NO2 Bias
	Pre Zero	0.0000		-0.0040			0.0000	0.0010	0.0010			
▶	CO,SO2,NO/NOx Pt 1											
	NO2 Pt 1											
	CO,SO2,NO/NOx Pt 2											
	NO2 Pt 2											
	CO,SO2,NO/NOx Pt 3											
	NO2 Pt 3											
	CO,SO2,NO/NOx Pt 4											
	NO2 Pt 4											
	CO,SO2,NO/NOx Pt 5											
	Post Zero											

**Figure 5-19. PEAT – Entering Pre-Zero Station Readings for NO, NO<sub>2</sub>, and NO<sub>x</sub>**

- Average the five most recent one-minute CO average concentrations from the NPAP CO analyzer and record the value in the Pre-Audit Calibration table in the Instrument Response column and Pre Zero row (refer to Figure 5-20).
  - PEAT will automatically populate this value in the Blended Gas Audit table in the NPAP Reading column and Pre-Zero row. *Subsequent measurements will be entered in the Blended Gas Audit window.*

Pre Audit Calibration (All units are ppm)				
		Instrument Response	True Value	Percent Difference
	Ultrapure Zero	-0.0010	0.0000	
	Pre Audit High CO	39.1000	39.0000	0.26
	Pre Audit Low CO	0.9562	0.9564	-0.02
	Pre Audit Zero	-0.0040	0.0000	

Figure 5-20. PEAT – Pre-Audit Calibration Zero CO Reading Entry

5.5.4.3.2 NO<sub>2</sub> Audit - First Concentration Point (Level 5)

*Note: If an additional connector was needed to connect to the sample inlet (a Teflon® bag or additional Teflon® tee and hose, etc.) it needs to be conditioned to avoid scrubbing effects prior to providing the first audit concentration point. To condition the additional connections to the monitoring site inlet probe, generate a concentration approximately 1.5-fold the intended Level 5 concentration of NO/NO<sub>2</sub>/NO<sub>x</sub> for approximately 5 minutes before generating the first audit concentration point. This process will reduce the time required for the first audit concentration point to stabilize.*

1. Select a target NO audit concentration in the upper portion of the Level 5 concentration range and program it into the gas calibrator.

***Note: It is critical that there be remaining NO after performing GPT to produce NO<sub>2</sub>, therefore FSs should select an NO concentration in the upper range of the audit concentration level such that the selected NO<sub>2</sub> concentration is lower than (by minimally 0.002 ppm) the selected NO concentration and still falls within the same audit concentration level, as practical. In some cases (e.g., Levels 2 and 3), it may be necessary to select an NO concentration in a level above the intended NO<sub>2</sub> concentration to ensure sufficient NO remains following GPT.***

2. Record the target CO concentration corresponding to the selected NO concentration in PEAT in the Blended Gas Audit table in the CO Concentration Setting column in the CO,SO<sub>2</sub>,NO/NO<sub>x</sub> Pt 1 row (refer to Figure 5-21).

Blended Gas Audit (All units are ppm)											
	CO Concentration Setting	Ozone Setting	NPAP Reading	Station Reading SO <sub>2</sub>	Station Reading CO	Station Reading NO	Station Reading NO <sub>2</sub>	Station Reading NO <sub>x</sub>	% Diff SO <sub>2</sub>	% Diff CO	% NO <sub>2</sub> Bias
Pre Zero	0.0000		-0.0040			0.0000	0.0010	0.0010			
CO,SO <sub>2</sub> ,NO/NO <sub>x</sub> Pt 1	1.1000										
NO <sub>2</sub> Pt 1											
CO,SO <sub>2</sub> ,NO/NO <sub>x</sub> Pt 2											
NO <sub>2</sub> Pt 2											
CO,SO <sub>2</sub> ,NO/NO <sub>x</sub> Pt 3											
NO <sub>2</sub> Pt 3											
CO,SO <sub>2</sub> ,NO/NO <sub>x</sub> Pt 4											
NO <sub>2</sub> Pt 4											
CO,SO <sub>2</sub> ,NO/NO <sub>x</sub> Pt 5											
Post Zero											

Figure 5-21. PEAT – CO Concentration Setting Entry of First Audit Point

3. Allow approximately 15 minutes for the NPAP CO analyzer measurement to stabilize. Once a stable measurement is obtained as described in Section 5.3, notify the site operator that they can



report their measurements once their measurements are concentration stable (note this may take 10 or more minutes for the site measurements to become concentration stable).

- Record the NO, NO<sub>2</sub>, and NO<sub>x</sub> concentration readings (in ppm) from the site operator for the zero in PEAT in the Blended Gas Audit table in the appropriate Station Reading columns and CO,SO<sub>2</sub>,NO/NO<sub>x</sub> Pt 1 row (refer to Figure 5-22).
- Average the five most recent one-minute CO average concentrations from the NPAP CO analyzer and record the value in the Blended Gas Audit table in the NPAP Reading column and CO,SO<sub>2</sub>,NO/NO<sub>x</sub> Pt 1 row (refer to Figure 5-22).

Blended Gas Audit (All units are ppm)											
	CO Concentration Setting	Ozone Setting	NPAP Reading	Station Reading SO <sub>2</sub>	Station Reading CO	Station Reading NO	Station Reading NO <sub>2</sub>	Station Reading NO <sub>x</sub>	% Diff SO <sub>2</sub>	% Diff CO	% NO <sub>2</sub> Bias
Pre Zero	0.0000		-0.0040			0.0000	0.0010	0.0010			
CO,SO <sub>2</sub> ,NO/NO <sub>x</sub> Pt 1	1.1000		1.0950			0.0483	0.0012	0.0495			
NO <sub>2</sub> Pt 1											
CO,SO <sub>2</sub> ,NO/NO <sub>x</sub> Pt 2											
NO <sub>2</sub> Pt 2											
CO,SO <sub>2</sub> ,NO/NO <sub>x</sub> Pt 3											
NO <sub>2</sub> Pt 3											
CO,SO <sub>2</sub> ,NO/NO <sub>x</sub> Pt 4											
NO <sub>2</sub> Pt 4											
CO,SO <sub>2</sub> ,NO/NO <sub>x</sub> Pt 5											
Post Zero											

**Figure 5-22. PEAT – Entry of NPAP Reading and Station Readings for NO, NO<sub>2</sub>, and NO<sub>x</sub>**

- The target CO concentration should remain unchanged for the duration of the audit point while generating NO<sub>2</sub> audit gas by GPT. Record the target CO concentration in PEAT in the Blended Gas Audit table in the CO Concentration Setting column in the NO<sub>2</sub> Pt 1 row (refer to Figure 5-23).

Blended Gas Audit (All units are ppm)											
	CO Concentration Setting	Ozone Setting	NPAP Reading	Station Reading SO <sub>2</sub>	Station Reading CO	Station Reading NO	Station Reading NO <sub>2</sub>	Station Reading NO <sub>x</sub>	% Diff SO <sub>2</sub>	% Diff CO	% NO <sub>2</sub> Bias
Pre Zero	0.0000		-0.0040			0.0000	0.0010	0.0010			
CO,SO <sub>2</sub> ,NO/NO <sub>x</sub> Pt 1	1.1000		1.0950			0.0483	0.0012	0.0495			
NO <sub>2</sub> Pt 1	1.1000										
CO,SO <sub>2</sub> ,NO/NO <sub>x</sub> Pt 2											
NO <sub>2</sub> Pt 2											
CO,SO <sub>2</sub> ,NO/NO <sub>x</sub> Pt 3											
NO <sub>2</sub> Pt 3											
CO,SO <sub>2</sub> ,NO/NO <sub>x</sub> Pt 4											
NO <sub>2</sub> Pt 4											
CO,SO <sub>2</sub> ,NO/NO <sub>x</sub> Pt 5											
Post Zero											

**Figure 5-23. PEAT – Entry of CO Concentration Setting for First NO<sub>2</sub> Point**

- Select the target NO<sub>2</sub> concentration within the Level 5 range that is less than the NO target concentration selected in step 1. Program the gas dilution calibrator to generate this concentration of ozone to begin the GPT to produce NO<sub>2</sub>.
- Record this target ozone concentration in PEAT in the Blended Gas Audit table in the Ozone Setting column in the NO<sub>2</sub> Pt 1 row (refer to Figure 5-24).

Blended Gas Audit (All units are ppm)												
	CO Concentration Setting	Ozone Setting	NPAP Reading	Station Reading SO2	Station Reading CO	Station Reading NO	Station Reading NO2	Station Reading NOx	% Diff SO2	% Diff CO	% NO2 Bias	
Pre Zero	0.0000		-0.0040			0.0000	0.0010	0.0010				
CO,SO2,NO/NOx Pt 1	1.1000		1.0950			0.0483	0.0012	0.0495				
NO2 Pt 1	1.1000	0.0350										
CO,SO2,NO/NOx Pt 2												
NO2 Pt 2												
CO,SO2,NO/NOx Pt 3												
NO2 Pt 3												
CO,SO2,NO/NOx Pt 4												
NO2 Pt 4												
CO,SO2,NO/NOx Pt 5												
Post Zero												

**Figure 5-24. PEAT – Entry of Ozone Concentration Setting for First NO<sub>2</sub> Point**

- Allow approximately 15 minutes for the NPAP CO analyzer measurement to stabilize. Once a stable measurement is obtained as described in Section 5.3, notify the site operator that they can report their measurements once their measurements are concentration stable. Note that GPT does not impact the CO concentration of the audit gas and the CO analyzer measurement should remain stable for each selected audit concentration of NO/NO<sub>2</sub>/NO<sub>x</sub> during GPT.
- Record the NO, NO<sub>2</sub>, and NO<sub>x</sub> concentration readings (in ppm) from the site operator in PEAT in the Blended Gas Audit table in the appropriate Station Reading columns and NO2 Pt 1 row (refer to Figure 5-25).
- Average the five most recent one-minute CO average concentrations from the NPAP CO analyzer and record the value in the Blended Gas Audit table in the NPAP Reading column and NO2 Pt 1 row (refer to Figure 5-25).

Blended Gas Audit (All units are ppm)												
	CO Concentration Setting	Ozone Setting	NPAP Reading	Station Reading SO2	Station Reading CO	Station Reading NO	Station Reading NO2	Station Reading NOx	% Diff SO2	% Diff CO	% NO2 Bias	
Pre Zero	0.0000		-0.0040			0.0000	0.0010	0.0010				
CO,SO2,NO/NOx Pt 1	1.1000		1.0950			0.0483	0.0012	0.0495				
NO2 Pt 1	1.1000	0.0350	1.0950			0.0140	0.0356	0.0496			-48.6%	
CO,SO2,NO/NOx Pt 2												
NO2 Pt 2												
CO,SO2,NO/NOx Pt 3												
NO2 Pt 3												
CO,SO2,NO/NOx Pt 4												
NO2 Pt 4												
CO,SO2,NO/NOx Pt 5												
Post Zero												

**Figure 5-25. PEAT – Entry of NPAP Reading and Station Readings for NO, NO<sub>2</sub>, and NO<sub>x</sub>**

#### 5.5.4.3.3 Successive (Level 4, 3, 2, and 1) NO/NO<sub>2</sub>/NO<sub>x</sub> Concentration Points

After the first NO<sub>2</sub> concentration point has been completed following Steps 1 through 11 above, repeat the processes for the successive audit points within the concentration ranges defined by Levels 4 and 3 and Level 2 or 1:

- Set the ozone target concentration to zero on the gas dilution calibrator.
- Select an NO<sub>2</sub> audit concentration in the desired audit level toward the middle or lower portion of the concentration range and select an NO audit concentration in the upper portion of that concentration range level greater than the desired NO<sub>2</sub> concentration. *Note: Residual NO is required when performing GPT and the selected NO concentration should preferably be at least 30% higher than the selected NO<sub>2</sub> concentration. To ensure there is sufficient residual NO after*

*GPT in lower concentration audit levels (Levels 3, 2, and 1), it may require selecting an NO concentration in one or two audit levels above the audit level for the intended NO<sub>2</sub> concentration.*

3. Program the selected target NO concentration into the gas dilution calibrator.
4. Record the CO concentration corresponding to the selected target NO concentration in PEAT in the Blended Gas Audit table in the CO Concentration Setting column and associated CO/SO<sub>2</sub>/NO/NO<sub>x</sub> (Pt 2, Pt 3, Pt 4, etc) row.
5. Wait for a stable CO reading (approximately 15 minutes) on the NPAP CO analyzer and notify the site operator when the concentration is stable. Wait for the site operator to measure a stable concentration of NO/NO<sub>2</sub>/NO<sub>x</sub> and record the reported NO, NO<sub>2</sub>, and NO<sub>x</sub> measurements in the Station Reading columns in the appropriate CO/SO<sub>2</sub>/NO/NO<sub>x</sub> (Pt 2, Pt 3, Pt 4, etc) row.
6. Average the five most recent one-minute CO concentration averages measured on the NPAP CO analyzer and record this value in the Blended Gas Audit form in the NPAP Reading column and appropriate CO/SO<sub>2</sub>/NO/NO<sub>x</sub> (Pt 2, Pt 3, Pt 4, etc.) row.
7. Program the gas dilution calibrator to provide ozone at this selected concentration of NO<sub>2</sub> to begin the GPT (and production of NO<sub>2</sub>) for the respective audit concentration point.
8. Record this gas dilution calibrator ozone setting in PEAT in Blended Gas Audit table in the Ozone Setting column and appropriate NO<sub>2</sub> (Pt 2, Pt 3, Pt 4, etc.) row.
12. Allow approximately 15 minutes for the NPAP CO analyzer measurement to stabilize. Once a stable measurement is obtained as described in Section 5.3, notify the site operator that they can report their measurements once their measurements are concentration stable. Note that GPT does not impact the CO concentration of the audit gas and the CO analyzer measurement should remain stable for each selected audit concentration of NO/NO<sub>2</sub>/NO<sub>x</sub> during GPT.
13. Record the NO, NO<sub>2</sub>, and NO<sub>x</sub> concentration readings (in ppm) from the site operator in PEAT in the Blended Gas Audit table in the appropriate Station Reading columns and appropriate NO<sub>2</sub> (Pt 2, Pt 3, Pt 4, etc.) row.
14. Average the five most recent one-minute CO average concentrations from the NPAP CO analyzer and record the value in the Blended Gas Audit table in the NPAP Reading column and appropriate NO<sub>2</sub> (Pt 2, Pt 3, Pt 4, etc.) row.

#### 5.5.4.3.4 Post Audit Zero NO/NO<sub>2</sub>/NO<sub>x</sub> Point

1. Enter a target audit concentration of zero for CO and ozone into the gas dilution calibrator such that calibrator delivers zero air.
2. In PEAT, record “0.0000” ppm as the target CO concentration in the Blended Gas Audit table in the CO Concentration Setting column and Post Zero row.
3. Wait for a stable reading (approximately 15 minutes) and notify the site operator. Wait for the site operator to measure a stable concentration.
4. Allow approximately 15 minutes for the NPAP CO analyzer measurement to stabilize. Once a stable measurement is obtained, notify the site operator that they can report their measurements once their measurements are concentration stable.
5. Record the NO, NO<sub>2</sub>, and NO<sub>x</sub> concentration readings (in ppm) from the site operator in PEAT in the Blended Gas Audit table in the appropriate Station Reading columns and Post Zero row.
6. Average the five most recent one-minute CO average concentrations from the NPAP CO analyzer and record the value in the Blended Gas Audit table in the NPAP Reading column and Post Zero row.

#### 5.5.4.4 Post Blended Gas Audit CO Analyzer Calibration Verification

At the conclusion of blended gas audits, the CO analyzer calibration is to be verified and the calibration drift occurring over the course of the audit characterized by analysis of the High CO standard gas. The calculations in PEAT include a correction for this calibration drift which applies to the recorded NPAP CO analyzer measured concentrations and includes both the Post Zero and post audit High CO measurement. This correction adjusts the concentrations of CO, SO<sub>2</sub>, and/or NO/NO<sub>2</sub>/NO<sub>x</sub> against which the monitoring site is evaluated. The drift of the NPAP CO analyzer calibration typically trends downward, resulting in corrected provided audit concentrations that are slightly lower than those obtained with the pre-audit calibration.

##### 5.5.4.4.1 Entering the Post Audit Zero Correction

1. Transcribe the Post Zero NPAP CO analyzer measurement from Section 5.5.4.3.4 step 6 into the Post Audit Calibration table in PEAT in the Instrument Response column and Post Audit Zero row (refer to Figure 5-27).

Post Audit Calibration (All units are ppm)				
		Instrument Response	True Value	Percent Difference
	Post Audit Zero	-0.0120	0.0000	
▶	Ultrapure Zero	0.0000	0.0000	
	Post Audit High CO	0.0000	39.0000	-100.00

**Figure 5-27. PEAT – Post Audit Calibration Correction Zero Measurement Entry**

##### 5.5.4.4.2 Post Audit High CO Span Point Calibration Check

1. Engage the solenoid switch to allow the high CO cylinder gas to flow.
2. Adjust the tank/manifold three-way valve to allow cylinder gas to flow to the CO analyzer.
3. Adjust the cylinder gas flow needle valve so the vent rotameter reads ~0.4 L/minute.
4. Allow approximately 15 minutes for the NPAP CO analyzer measurement to stabilize as described in Section 5.3.
5. Once the measurements are stable, average the five most recent one-minute average CO concentration readings and record this value in the Post Audit Calibration table Instrument Response column and Post Audit High CO row (refer to Figure 5-29).

Post Audit Calibration (All units are ppm)				
		Instrument Response	True Value	Percent Difference
	Post Audit Zero	-0.0120	0.0000	
	Ultrapure Zero	-0.0190	0.0000	
▶	Post Audit High CO	38.9000	39.0000	-0.26

**Figure 5-29. PEAT – Post Audit Calibration High CO Measurement Entry**

6. Adjust the tank/manifold three-way valve to allow gas from the gas dilution calibrator to flow to the CO analyzer.

7. Disengage the high CO solenoid switch.

### 5.5.4.4.3 Multi-blend Audit Documentation Verification

1. Preserve the audit data captured by the data logger by saving the acquired data file with the FSs annotations to the DAS PC. These data files will be archived. FS may also print a hard copy of the DAS data which includes annotations indicating concentration stability for each audit point and the readings that were taken and recorded as the NPAP audit concentration.
2. Click the Save button in the lower right of the audit form (refer to Figure 5-26) to save the audit data in PEAT. Once saved, close the audit form by clicking the Close button in lower right of the form.
3. Refer to Section 5.5.3 for post-audit shutdown and report distribution.

The screenshot displays the 'Conduct Blended Gas Audit' software window. At the top, it shows the 'Actual Audit Date' as 2017/04/04 and the 'NPAP Type' as 'Through The Probe (TFP)'. Below this are three calibration tables:

- Pre Audit Calibration (All units are ppm):**

	Instrument Response	True Value	Percent Difference
Ultrapure Zero	-0.0010	0.0000	
Pre Audit High CO	39.1000	39.0000	0.26
Pre Audit Low CO	0.9562	0.9564	-0.02
Pre Audit Zero	-0.0040	0.0000	
- Post Audit Calibration (All units are ppm):**

	Instrument Response	True Value	Percent Difference
Post Audit Zero	-0.0120	0.0000	
Ultrapure Zero	-0.0120	0.0000	
Post Audit High CO	38.9000	39.0000	-0.26
- NPAP Analyzer Calibration (ppm):**

	Slope	Intercept
	1.0002	-0.0080

The main data table is titled 'Blended Gas Audit (All units are ppm)'. It contains columns for CO Concentration Setting, Ozone Setting, NPAP Reading, Station Reading SO2, Station Reading CO, Station Reading NO, Station Reading NO2, Station Reading NOx, % Diff SO2, % Diff CO, and % NO2 Bias. The data rows include 'Pre Zero', 'CO,SO2,NO/NOx Pt 1' through 'Pt 5', and 'Post Zero'. The 'Post Zero' row shows a Station Reading NO2 of 0.0010 and a % NO2 Bias of 36.7%.

Below the main table is the 'Blended Gas Audit - Calculations (All units are ppm)' table, which includes columns for Actual CO, CO Level, Actual SO2, SO2 Level, Actual NO, Actual NO2, NO2 Level, Actual NOx, % Diff NO, % Diff NOx, NO Orig O3, Remaining NO, NO2 Actual NO2, NO2 Actual NOx, and % NO2 Bias. The 'Post Zero' row shows an Actual NO2 of 0.0000 and a % NO2 Bias of 0.0493.

At the bottom of the window, there is a status bar with 'Database: AGSProd', 'Build: Normal', and 'Status: Load Complete'. There are also 'Comments...', 'Save', and 'Close' buttons.

Figure 5-26. PEAT – Saving the Completed NO<sub>2</sub> Blended Gas Audit Form

## 5.5.5 Post-Audit Activities

### 5.5.5.1 Disconnecting from the Site Inlet Probe

After all audit measurements have been collected and the data saved, the FS disconnects the audit delivery line from the station inlet and reels it onto the spool. The inlet probe is left in the as-found condition. Once the sample delivery line is no longer contaminating the ambient air near the station inlet, inform the site operator to resume ambient air data collection recording, i.e., *bring the channel online*.

### 5.5.5.2 Shutdown of NPAP Audit Equipment

As soon as practical after the audit is complete, the NPAP audit equipment should be shut down as soon as practical after the audit according to the following order:

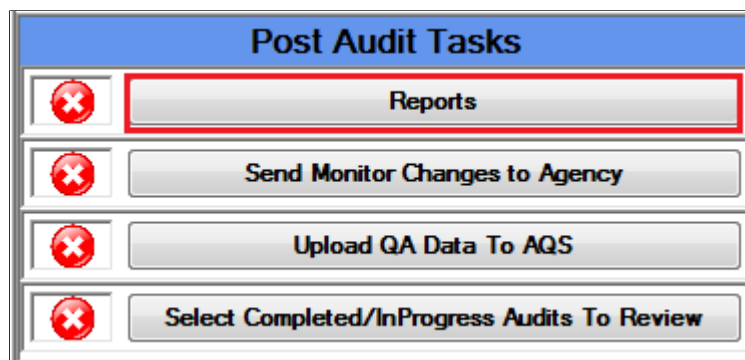
1. Switch off the data logger/DAS.
2. Switch off the CO and ozone analyzers.
3. Switch off the ZAG when the compressor is cycle is off.
4. Once the pressure in the ZAG has dissipated to 5 psig or lower, Switch off the gas calibrator.
5. Switch off the backup power supply and power conditioner.
6. Switch off the HVAC system (if so equipped).
7. Switch off the main breaker which supplies power to the NPAP equipment.
8. Switch off the generator/disconnect from shore power (unplug from the air monitoring station's electrical outlets).
9. Cap the audit delivery line to prevent contamination from debris and water.
10. Close all compressed gas tank regulator outlet valves.
11. Close all compressed gas tank main valves.
12. Secure all regulator clamshells to protect the compressed gas tank main valves during transport.  
Never transport compress gas tanks with unsecured regulator clamshells.

#### 5.5.5.3 Issuing the Audit Report

The FS will prepare and distribute an audit report following completion of the TTP audit. For MVAs, the audit report is prepared within PEAT and the FS can print a hard copy or generate a PDF of the report. Note that to prepare an electronically signed PDF report, the FS will need to have established an electronic signature within Adobe Acrobat software on the PEAT PC. [The audit report for FBAs will be prepared in PEAT when the capability is available. If FBA reports cannot be prepared in PEAT, the FS will generate a report in employing a validated template Microsoft Excel workbook. The report can be printed as a hard copy or prepared as a pdf.]

##### 5.5.5.3.1 Issuing a Printed Audit Report

In the Post Audit Tasks window, click the Reports button (see Figure 5-30) and print two copies. The FS and the site operator will sign both copies and the FS will retain one copy for NPAP recordkeeping and give one copy to the site operator.



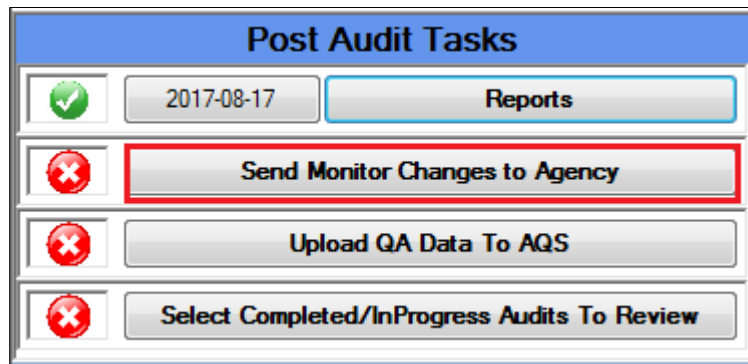
**Figure 5-30. PEAT – Generating the Final Audit Report**

### 5.5.5.3.2 Issuing an Electronic Audit Report

In the Post Audit Tasks window, click the Reports button as shown in Figure 5-30 and generate the report as PDF. Insert the FS electronic signature into the PDF and save the file to the PEAT PC. Transfer the audit report PDF to the audited monitoring agency through email or other file transfer process (e.g., USB flash drive). The monitoring agency is expected to respond to the reporting email to acknowledge receipt of the report and indicate concurrence with the audit outcome (e.g., site-reported measurements and evaluations at each audit level).

### 5.5.5.4 Notify PQAO of Monitor Changes

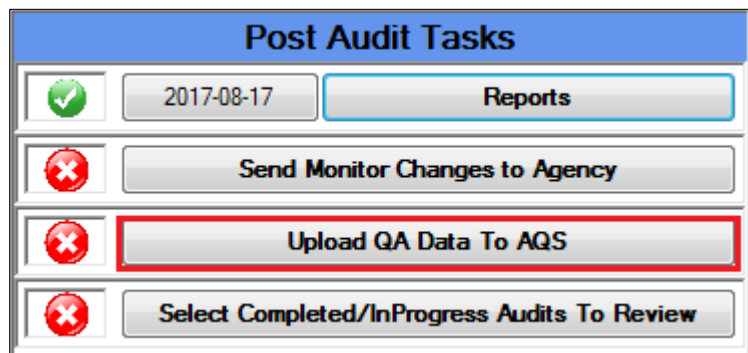
If the manufacturer and/or model number of the analyzers at the monitoring site are inconsistent with the AQS record, in the Post Audit Tasks window, click the Send Monitor Changes to Agency button (Figure 5-31) to generate a report with the updated monitor information. Save the report as both a PDF and an AQS Transaction file (.csv file) and e-mail these to the site operator and/or monitoring agency.



**Figure 5-31. PEAT – Sending Monitor Changes to SLT Agency**

### 5.5.5.5 Audit Upload to AQS via PEAT

PEAT will not upload audit data to AQS automatically. Instead, the FS must take action to report the audit data to AQS when the PC is connected to the internet. The FS clicks the Upload QA Data To AQS button (Figure 5-32) in the Post Audit Tasks window. This procedure places the audit data into the pre-production area within AQS.



**Figure 5-32. PEAT – Uploading Audit Data to AQS**

## **6.0 NPAP Audit Approvals**

### **6.1 Regional NPAP Lead Audit Approval**

Once the audit data are uploaded from PEAT into the pre-production area of AQS, EPA NPAP Regional Leads have the ability to review, validate, and approve the audit using the AQS audit review feature. During the review period, the NPAP Regional Lead may contact the FS for additional details or questions and may make changes to the entered audit data in AQS. The audit approval process within AQS is automated as described below in Sections 6.2.1 and 6.2.2; however, Regional Leads are expected to actively review and approve or reject audits within AQS. The automated process is a backup process that ensures audit data are not indefinitely stalled from input to AQS in the event of Regional Lead inaction.

The AQS status shows a default status of “F” (pre-production) for data in the pre-production area. NPAP Regional Leads assess QA requirements and the overall recorded data provided with the audit to determine if an NPAP TTP audit is valid. Once review is complete, NPAP Regional Leads will update the audit status to “I” (invalid) to reject the audit or to “P” (production) to approve the audit. Regional Leads should input a comment as to the reason an audit is not valid and may input comments for approved audits. Rejected audits, audits with audit status “I”, are not sent to the AQS production area and do not count as a completed audit. Once approved by the NPAP Regional Lead, the audit data move from the pre-production area and are housed in the production area of AQS.

Data collected for audit Levels 2 and 1 are collected to provide EPA with accuracy data of the monitoring sites at lower concentrations, but are not evaluated as pass/fail unless the Regional NPAP Lead has specified that these levels are to be formally evaluated for pass/fail.

### **6.2 AQS NPAP Audit Approval Form**

NPAP Regional Leads access the NPAP Audit Approval Form in AQS. Note this approval form is only available to Regional Leads with accounts with Screening Group Access privileges. The form can be found by selecting the Audit menu and selecting NPAP Review.

#### **6.2.1 Passing Audits**

Passing audits are those for which all Levels 3 through 10 concentrations meet the criteria listed in Table 5-2 for an ozone audit or blended gas audit. A failure of the specified criteria in any Level 3 through 10 indicates failure of the audit for a given pollutant. For passing audits, once PEAT uploads audit data to the pre-production area of AQS, NPAP Regional Leads have seven days to review the audit data. If no action is taken (e.g., audit approved or marked as invalid within AQS) within this timeframe, the data are automatically moved into the production database within AQS.

#### **6.2.2 Failing Audits**

Failing audits are those for which any Levels 3 through 10 concentrations exceeded the acceptance criteria in Table 5-2 for an ozone audit or blended gas audit. For failing audits, once PEAT uploads audit data to the pre-production area of AQS, NPAP Regional Leads have 30 days to review the audit data. If no action is taken (e.g., audit approved or marked invalid) within this timeframe, the data are automatically moved into the production database within AQS.

### **6.3 Error Corrections to NPAP Audit Data in AQS**

The introduction of PEAT has streamlined the audit process and included failsafes and controls within the audit process to ensure audits are conducted in the correct order and that materials and instruments are within calibration or certification. PEAT entry fields are controlled to permit only certain values or types



of data or information; however, PEAT cannot ensure that typographical errors (such as number transposition or entering information into incorrect data recording fields) do not occur and also cannot flag when data are entered incorrectly (e.g., an ozone line loss test was conducted but not captured properly in PEAT which results in an incorrect correction factor application to audit data). FSs and their supervisory personnel (whether contractor managers or NPAP Regional Leads) should therefore closely review audit data and EPA Regional Leads should additionally verify data transferred into the pre-production AQS area to ensure: the correct audit concentration levels (minimally 5, 4, 3, and either 2 or 1) were audited, there are no incomplete fields or missing data, results appear reasonable, dates and site identifiers are correct, and there are not obvious errors (a copy of the PEAT audit report is helpful for this review). If the FS or supervisor discovers an error, they should immediately contact the NPAP Regional Lead to notify them of the error. Likewise, if NPAP Regional Leads suspect a problem or error in the audit data, they should contact the FS for confirmation.

The NPAP Regional Lead can correct errant data in AQS. To make corrections to audit data in AQS, select the Maintain dropdown menu, select QA Assignments, and select NPAP Assessment.

#### 6.4 Verification of Audit Data

NPAP Regional Leads should periodically perform spot check reviews of the recently added NPAP audit data within AQS for their respective Region against the data recorded by the DAS and the annotated strip charts for the various audits. Additional reviews may include ensuring that certified nominal concentrations listed on COAs are listed properly in PEAT. Additionally, at the end of each calendar year, the NPAP Regional Lead should review that the NPAP audits expected are listed in AQS and that any missing audits are justified or rectified.

## 7.0 Corrective Action Following an NPAP Audit

### 7.1 Passing Audit

Once approved by the NPAP Regional Lead and uploaded to AQS, passing audits require no follow up actions.

### 7.2 Failing Audit

A failing NPAP audit indicates a problem with the measurement system at the monitoring site. Monitoring agencies are to take corrective action to address problems with the measurements at the site and communications between the monitoring agency and Regional Lead will occur per the NPAP QAPP Section B10.3.

## 8.0 Records Retention

All records required to reconstruct a TTP audit must be maintained per QAPP Section A8. These include hard copy and electronic records for instrument calibrations and calibration verifications, standard materials certifications, and measurements recorded and instrument settings assigned for providing test gases to the monitoring station.

## 9.0 References

1. 40 CFR Part 58 Appendix A, available at (accessed January 2022): <https://www.ecfr.gov/current/title-40/part58>
2. 40 Code of Federal Regulations Part 50, Appendices A, C, D, and F, available at (accessed January 2022): <https://www.ecfr.gov/cgi-bin/text-idx?SID=9504b603a9af9725e9724e6d5fe3bb01&mc=true&node=pt40.2.50&rgn=div5>
3. *Air Quality System (AQS) User Guide*. Issue 4. U.S. Environmental Protection Agency. May 26, 2021. Available at (accessed January 2022): [https://www.epa.gov/sites/default/files/2018-07/documents/aqs\\_user\\_guide\\_2018\\_2.pdf](https://www.epa.gov/sites/default/files/2018-07/documents/aqs_user_guide_2018_2.pdf)
4. Quality Assurance Project Plan for the Federal National Performance Audit Program (NPAP) for Criteria Pollutant Gases. EPA-454-B-19-012. U.S. Environmental Protection Agency. June 2021. Available at (accessed January 2022): [https://www.epa.gov/system/files/documents/2021-09/npap-qapp\\_revision-6\\_epa-454\\_b-19-012\\_september-14-final\\_0.pdf](https://www.epa.gov/system/files/documents/2021-09/npap-qapp_revision-6_epa-454_b-19-012_september-14-final_0.pdf).
5. Quality Assurance Handbook for Air Pollution Measurement Systems Volume II, U.S. Environmental Protection Agency. January 2017. Available at (accessed January 2022): [https://www.epa.gov/sites/default/files/2020-10/documents/final\\_handbook\\_document\\_1\\_17.pdf](https://www.epa.gov/sites/default/files/2020-10/documents/final_handbook_document_1_17.pdf)
6. Models T701, T701H, 701, and 701H Zero Air Generators, Operation Manual, Teledyne API, 07825F DCN8419, 11 June 2021. Available at (accessed January 2022): [https://www.teledyne-api.com/prod/Downloads/07825F%20-%20MANUAL,%20T701-T701H\\_701-701H.pdf](https://www.teledyne-api.com/prod/Downloads/07825F%20-%20MANUAL,%20T701-T701H_701-701H.pdf)
7. Series 9100 Computerized Ambient Monitoring Calibration System, Operating Manual, Revision 8, April 2013. Available at (accessed January 2022): [https://www.envionics.com/wp-content/uploads/2020/05/9100\\_service\\_manual.pdf](https://www.envionics.com/wp-content/uploads/2020/05/9100_service_manual.pdf)

## Appendix A: External Palladium Scrubber Assembly

An external palladium scrubber is employed to verify the ZAG is providing zero air that has been sufficiently scrubbed of CO. This external scrubber effectively scrubs several ppm of CO at a nominal 16 L/minute flow rate without the need for a catalyst heater.

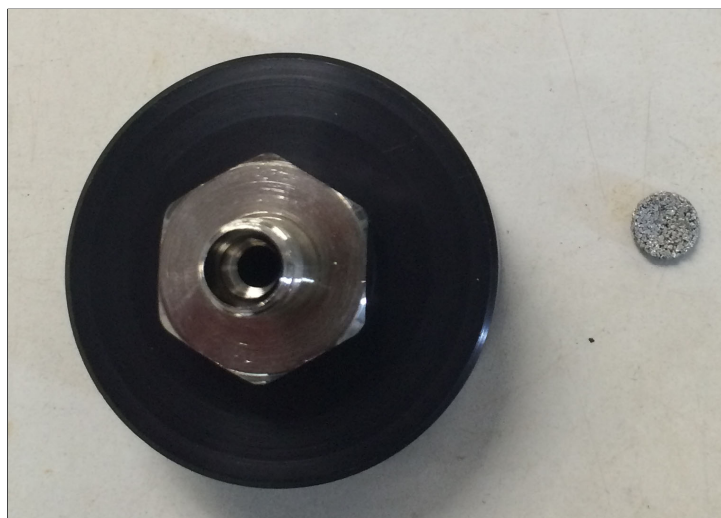
**Table A-1: External Palladium Scrubber Components<sup>a</sup>**

Part Description	Manufacturer	Part #
Refillable Hydrocarbon Trap	Restek	22013
Glass Wool	Pyrex	3950
Palladium Coated Alumina Pellets	Acros Organics	195082500

<sup>a</sup> Equivalent components can be sourced.

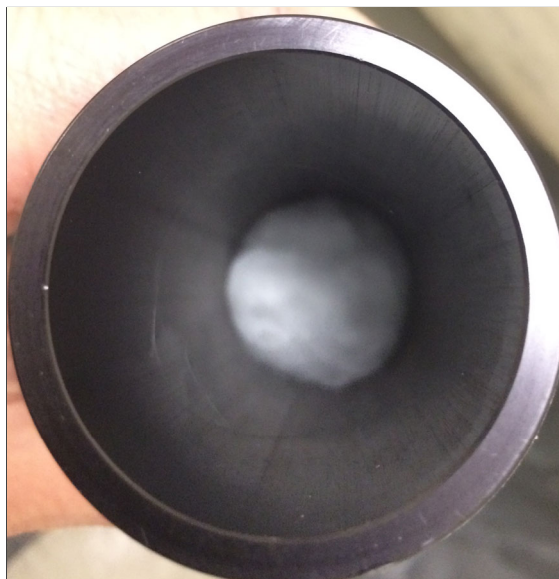
### Procedure:

1. Open the hydrocarbon trap and empty the contents. It may take a vice and strap wrench to open the body. Instruction for disassembly of the hydrocarbon trap is available here: <http://www.restek.com/pdfs/204-08-017.pdf>
2. Remove frit from both ends with a small screwdriver (refer to Figure A-1).



**Figure A-1: Removing Frits from End Caps**

3. Use compressed air to remove any large residual particles of carbon media from the hydrocarbon trap body and caps (wear safety glasses).
4. Rinse with hydrocarbon trap body and caps with deionized water and air dry.
5. Install one end cap and pack the trap body lightly with ~1 inch thick of glass wool against the installed cap (refer to Figure A-2).



**Figure A-2: Glass Wool Bottom Plug**

6. Fill the trap body with approximately 90 g of palladium coated alumina pellets (refer to Figure A-3).



**Figure A-3: Addition of Palladium Coated Pellets**

7. Lightly pack an approximately 1-inch thick plug of glass wool on top of the Pd coated pellets (refer to Figure A-4). The glass wool plug should be sufficient to keep the pellets in place without adding compression which can restrict flow.



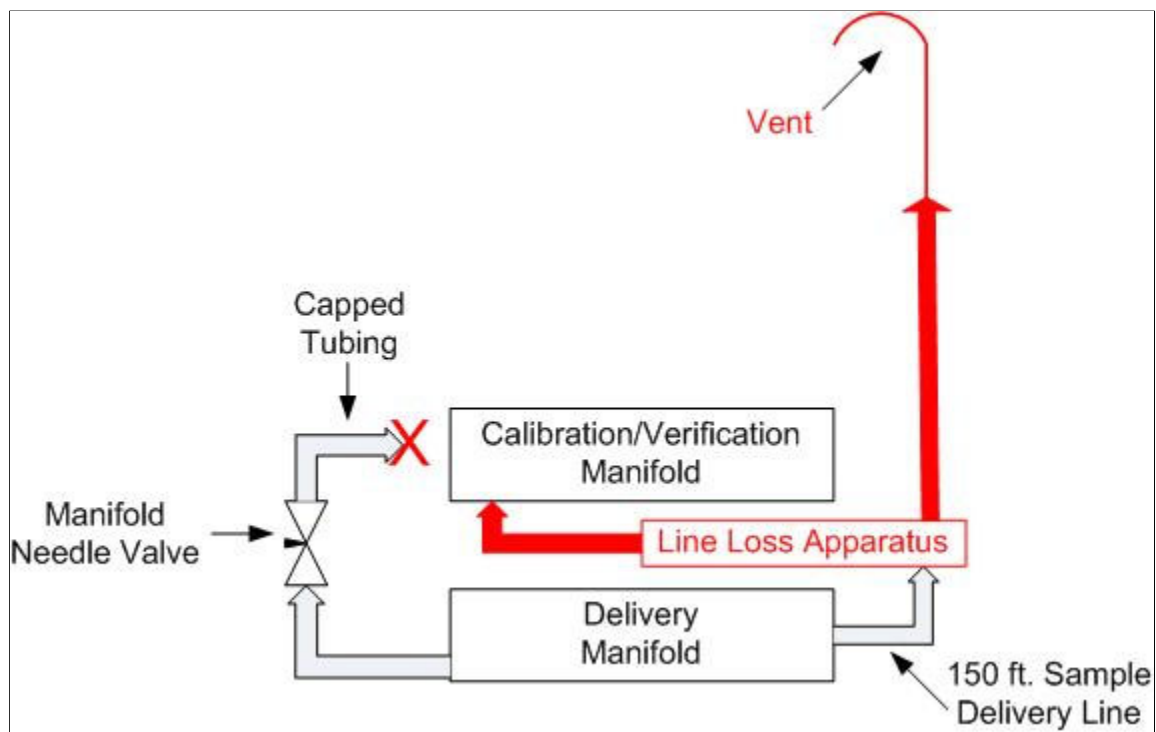
**Figure A-4: Glass Wool Top Plug**

8. Install the other cap onto the trap body and firmly hand tighten the two caps.
9. The external palladium scrubber is ready to be securely installed into the audit equipment apparatus to be used to check for CO contamination in the zero air generator. See SOP Figure 2-1 for the recommended plumbing schematic.

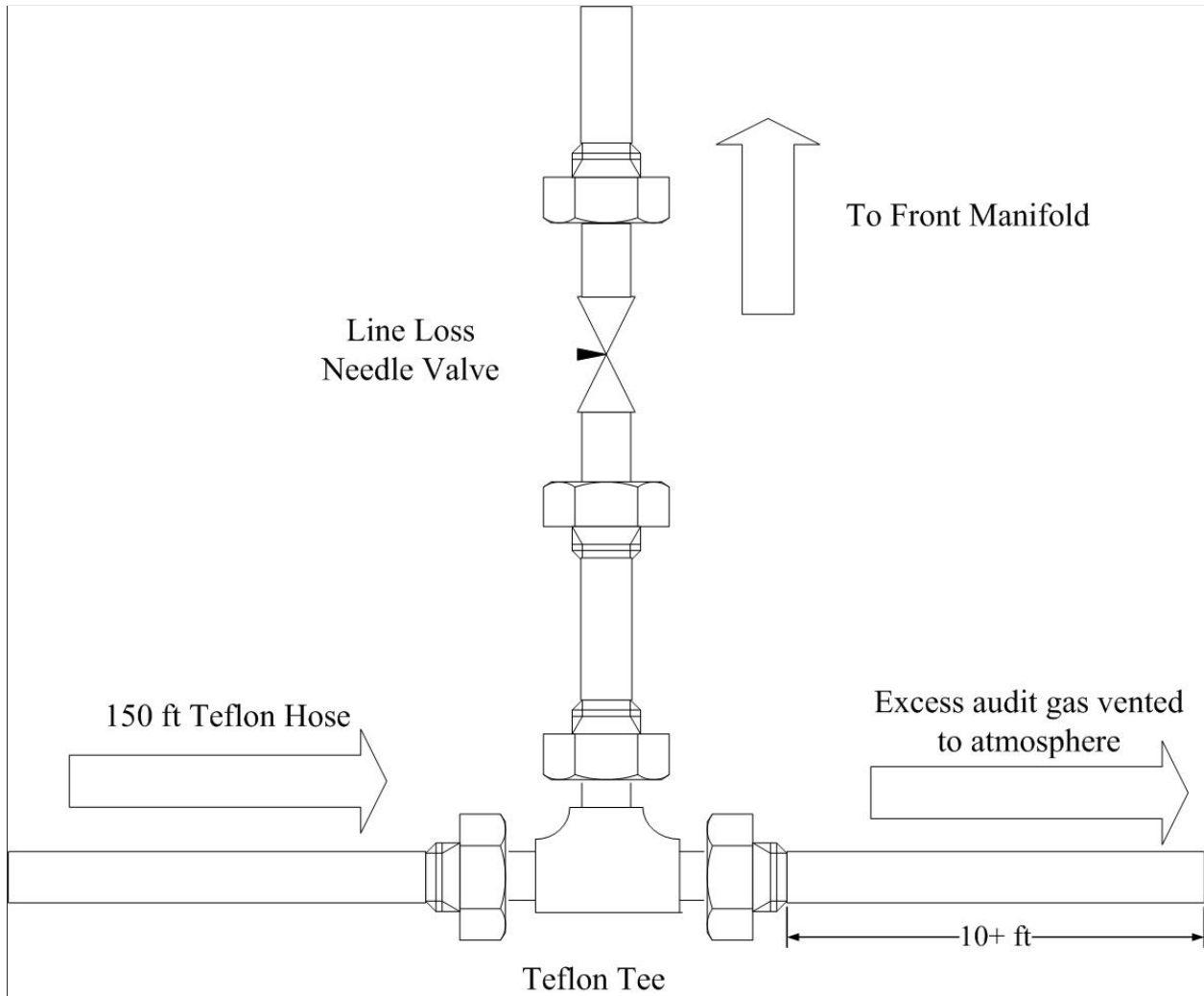
## Appendix B: Ozone Line Loss Test

An ozone line loss test must be performed prior to using a new audit gas delivery line hose. The test is performed after cleaning and conditioning a new delivery hose and quarterly thereafter to quantify the scrubbing effect of the (150-ft) Teflon® delivery line on audit concentrations of ozone. The result of a line loss test is a correction factor that is applied to the NPAP ozone analyzer measurements during ozone audits (this correction is not made for multi-blend audits) to determine the ozone concentration of the test audit gas provided to the station. The test consists of consecutive measurements taken of generated ozone test gas prior to (“inside”) and after (“outside”) routing through the delivery hose. Ideally there would be no loss (scrubbing) of ozone through the delivery line hose; however, even with carefully cleaning and conditioning there is some ozone loss. The goal of the ozone line loss test is to determine whether the ozone scrubbing of the delivery line hose is less than 2.5 ppb at any challenged concentration and to quantify the magnitude of the ozone scrubbing.

The test gas is generated at several concentrations representative of audit Levels 1 through 5 (refer to SOP Table 5-1). The ozone standard test gas is measured normally with the typical audit configuration depicted in Figure 2-1 for the baseline, or “inside” measurement where the ozone standard is delivered directly to the ozone analyzer. After establishing the baseline measurement, the tubing connecting the delivery manifold to the calibration/verification manifold is disconnected and capped, and the delivery hose, via a line loss apparatus, is substituted in its place. This configuration is referred to as the ‘outside’ measurement and is illustrated in Figure B-1. The line loss apparatus consists of a Teflon® tee with a vent line and a line loss needle valve and is illustrated in Figure B-2. Note that deviations from Figure 2-1 are highlighted in red in Figure B-1.



**Figure B-1: Line Loss “Outside” Configuration**



**Figure B-2: Line Loss Apparatus**

If the line loss test is performed with the NPAP audit equipment, the line loss vent should be routed to exhaust outside. The line loss test may also be performed in a laboratory, in which case the vent should be exhausted to a fume hood or snorkel. The vent line should be long enough ( $\geq 10$  ft) to ensure the ZAG does not intake the high ozone concentrations.

Measurements of the generated ozone concentrations for determining the line loss factor should meet the concentration stability criteria listed in SOP Section 5.3.

**Ozone Line Loss Procedure** (assumes use of NPAP audit system):

*Note: The delivery line is conditioned with approximately 500 ppb of ozone overnight prior to measuring ozone to calculate the line loss factor. Plan accordingly for the line loss process to take two consecutive days.*

1. Uncap the delivery hose.
2. Open all needle valves.
3. Verify the main circuit breaker supplying power to the NPAP system is off.
4. Power on the 30A electrical circuit (generator or shore power).
5. Turn on the main circuit breaker to the ozone generator and analyzer (NPAP system).
6. Maintain the environmental conditions of the ozone generator at 20 to 30°C (turn on HVAC system to maintain this range).
7. Power on the backup UPS and power conditioner.
8. Start up the datalogger and DAS and necessary supporting electronics (wi-fi, etc.).
9. Boot the NPAP laptop/tablet computer and ensure that measurement data are properly recorded and displayed by the DAS. Troubleshoot as necessary.
10. Power on the ZAG and allow it to come to operating pressure.
11. Power on the gas dilution calibrator and program it to produce 500 ppb ozone at a total flow rate of 16 L/minute.
12. Power on the ozone analyzer.
13. Adjust the manifold needle valve such that manifold vent rotameter reads ~0.4 L/minute.
14. Attach the line loss connection apparatus (Teflon<sup>®</sup> tee, line loss needle valve, and vent line) to the downstream end (exhaust) of the delivery hose.
15. Ensure the line loss needle valve is open and that the generated gas is flowing into the calibration/verification manifold.
16. Allow the system to condition for a minimum of 8 hours (overnight preferable).
17. Open PEAT and log in.
18. On the Pre Audit Tasks menu, click Prepare and Certify Equipment and update the ozone equipment information as needed. Click Save and Confirm Equipment when information is correct.
19. On the Pre Audit Tasks menu, click Conduct Ozone Line Loss Test. This opens the Ozone Line Loss Test window as shown in Figure B-3.



Ozone Line Loss Test				
Date Performed: Tuesday, July 25, 2017				
Ozone Setting				Percent Difference - Line Loss
Ozone Setting	Inside	Outside	%D Corrected For Zero	Avg % Difference
Pre Zero	0.0000	0.0000		-2.58
0.400	0.4000	0.4000	0.00	-1.29
0.175	0.1760	0.1750	-0.57	-1.29000
0.080	0.0810	0.0790	-2.47	0.98710
0.040	0.0410	0.0400	-2.44	
0.020	0.0200	0.0200	0.00	
0.010	0.0100	0.0090	-10.00	
Post Zero	0.0000	0.0000		
Average Zero	0.0000	0.0000		
Analyzer Coefficient and Background				
Coefficient		Background		
1.000494		-0.000670		
NPAP O3 Standard Verification				
Calibration Date	Coefficient	Background		
2017/08/16	0.9998	0.002		

**Figure B-3. PEAT – Copying the Previous Line Loss Value**

20. On the Ozone Line Loss Test window, update the Date Performed to the current date.
21. In the Percent Difference – Line Loss table, copy the value shown in the “Prev Qtr Line Loss” field to the “Cur Qtr Line Loss” field as shown in Figure B-3. If you replace the line enter a “1” in the “Prev Qtr Line Loss”.
22. In the Ozone Setting table, clear the previous line loss measurements in the Inside and Outside columns (refer to Figure B-4) so they all display zeroes.

Ozone Line Loss Test				
Date Performed: Tuesday, July 25, 2017				
Ozone Setting				Percent Difference - Line Loss
Ozone Setting	Inside	Outside	%D Corrected For Zero	Avg % Difference
Pre Zero	0.0000	0.0000		0.00
0.400	0.0000	0.0000	Invalid Result	-1.2900
0.175	0.0000	0.0000	Invalid Result	-0.64500
0.080	0.0000	0.0000	Invalid Result	0.99360
0.040	0.0000	0.0000	Invalid Result	
0.020	0.0000	0.0000	Invalid Result	
0.010	0.0000	0.0000	Invalid Result	
Post Zero	0.0000	0.0000		
Average Zero	0.0000	0.0000		
Analyzer Coefficient and Background				
Coefficient		Background		
Invalid Calculation		Invalid Calculation		
NPAP O3 Standard Verification				
Calibration Date	Coefficient	Background		
2017/08/16	0.9998	0.002		

**Figure B-4. PEAT – Clearing the Previous Ozone Measurements**

23. With the NPAP system plumbed according to Figure 2-1, program a target of 0.000 ppm ozone on the gas dilution calibrator to start the flow of zero air.
24. Wait approximately 15 minutes for to allow the ozone analyzer concentration measurement to stabilize as described in Section 5.3.

- Once acceptable stability has been achieved, average the five most recent one-minute ozone concentration measurement averages and record this value in the Ozone Setting table in the Inside column and Pre Zero row (refer to Figure B-5).

Ozone Line Loss Test				
Date Performed: Tuesday, July 25, 2017				
Ozone Setting				%D Corrected For Zero
Ozone Setting	Inside	Outside		
Pre Zero	0.0009	0.0000		
0.400	0.0000	0.0000		-100.00
0.175	0.0000	0.0000		-100.00
0.080	0.0000	0.0000		-100.00
0.040	0.0000	0.0000		-100.00
0.020	0.0000	0.0000		-100.00
0.010	0.0000	0.0000		-100.00
Post Zero	0.0000	0.0000		
Average Zero	0.0005	0.0000		

Percent Difference - Line Loss				
	Avg % Difference	Prev Qtr Line Loss	Cur Qtr Line Loss	Cur Line Loss Factor
	-100.00	-1.2900	-50.64500	0.49360

Analyzer Coefficient and Background	
Coefficient	Background
0.000000	0.000000

NPAP O3 Standard Verification		
Calibration Date	Coefficient	Background
2017/08/16	0.9998	0.002

**Figure B-5. PEAT – Entering the Pre-Zero Inside Line Loss Measurement**

- Convert the plumbing configuration as shown in Figure B-1.
- Adjust the line loss needle valve until the manifold rotameter reads ~0.4 L/minute. If necessary, also adjust the manifold vent needle valve.
- Wait approximately 15 minutes for to allow the ozone analyzer concentration measurement to stabilize as described in Section 5.3.
- Once acceptable stability has been achieved, average the five most recent one-minute ozone concentration measurement averages and record this value in the Ozone Setting table in the Outside column and Pre Zero row (refer to Figure B-6).

Ozone Line Loss Test				
Date Performed: Tuesday, July 25, 2017				
Ozone Setting				%D Corrected For Zero
Ozone Setting	Inside	Outside		
Pre Zero	0.0009	0.0004		
0.400	0.0000	0.0000		-55.56
0.175	0.0000	0.0000		-55.56
0.080	0.0000	0.0000		-55.56
0.040	0.0000	0.0000		-55.56
0.020	0.0000	0.0000		-55.56
0.010	0.0000	0.0000		-55.56
Post Zero	0.0000	0.0000		
Average Zero	0.0005	0.0002		

Percent Difference - Line Loss				
	Avg % Difference	Prev Qtr Line Loss	Cur Qtr Line Loss	Cur Line Loss Factor
	-55.56	-1.2900	-28.42500	0.71580

Analyzer Coefficient and Background	
Coefficient	Background
0.444444	0.000000

NPAP O3 Standard Verification		
Calibration Date	Coefficient	Background
2017/08/16	0.9998	0.002

**Figure B-6. PEAT – Entering the Pre-Zero Outside Line Loss Measurement**

- Convert the plumbing configuration as shown in SOP Figure 2-1.
- Adjust the manifold needle valve such that manifold vent rotameter reads ~0.4 L/minute.

32. The following steps generally repeat those detailed in steps 23 (alter the desired concentration entered) through 31 to measure target ozone concentrations of: 0.200, 0.125, 0.050, 0.010, and 0.000 (Post Zero) ppm:
  - a. Configure the measurement system in the normal configuration (SOP Figure 2-1).
  - b. Program the gas calibrator to generate the desired test concentration and wait approximately 15 minutes to allow the measurement to stabilize as described in Section 5.3.
  - c. Once acceptable stability has been achieved, average the five most recent one-minute ozone concentration measurement averages and record this value in in the Ozone Setting table in the Inside column and concentration row corresponding to the ozone target concentration of: 0.200, 0.125, 0.050, 0.010, and 0.000 (Post Zero) ppm.
  - d. Configure the measurement system in the line loss configuration (Figure B-1).
  - e. Allow the measurement to stabilize, as described in Section 5.3, for approximately 15 minutes.
  - f. Once acceptable stability has been achieved, average the five most recent one-minute ozone concentration measurement averages and record this value in in the Ozone Setting table in the Outside column and concentration row corresponding to the ozone target concentration of: 0.200, 0.125, 0.050, 0.010, and 0.000 (Post Zero) ppm.
  - g. Repeat steps b through f for subsequent concentrations.
33. PEAT will correct the measurements for the average of the Pre and Post Zero for the Inside and Outside measurements, respectively, and calculate a concentration difference for each of the 0.010, 0.050, 0.125, and 0.200 ppm concentration points.
34. Once all values have been generated and properly recorded in PEAT, click Save.
35. If the ozone loss for each of the challenged ozone concentrations is  $\leq 0.0025$  ppm, the line loss test is complete and will be valid for three months for the delivery hose.
36. If any individual concentration level shows an ozone loss  $> 0.0025$  ppm, the ozone loss attributed to the delivery line is excessive and requires additional conditioning or troubleshooting before a subsequent line loss test can be performed. An additional conditioning period of minimally 8 hours of 500 ppb ozone flow at 16 L/minute is recommended. Note that the delivery line cannot be employed for NPAP audits until each concentration demonstrates ozone loss  $\leq 0.0025$  ppm.

## Appendix C: Flow-Based Audit Procedure

The flow-based audit process can only apply to the SO<sub>2</sub> and CO multi-blend audits and for NO/NO<sub>2</sub>/NO<sub>x</sub> audits for instruments with an NO channel. The process isn't ready for direct-read NO<sub>2</sub>-only instruments without an NO channel. The flow-based process doesn't change the ozone audit at all since the O<sub>3</sub> analyzer goes with the equipment for this audit.

This process does not rely on calibrated MFC flow rates. Instead, the FS determines the audit level concentrations they intend to use in advance and verify the flow rates required to generate those concentrations. The flow rates of the diluent channel (typically remains at 14-16 LPM) and standard channel (typically flows ranging from 5 to 50 sccm) are measured prior to beginning the audit. The corresponding flow rate measurement at a given setting is recorded and the measured flow rate input into the calculation to determine the challenge concentration. The MFCs are tested at those flows again after the audit and should not change by more than 1% (this criterion is not yet prescribed).

### Equipment required:

1. Gas calibrator with 3 MFCs: 2-20 sccm, 10-100 sccm, and 10-100 L/min and ozone generator
  - a. EnviroNics 6100 or 6103 (9100 is no longer available for purchase)
  - b. Teledyne API T700U or T703U
2. Flow transfer standard or combination of flow transfer standards for low range (5-100 sccm) and high range (10 to 30 LPM) flow rates. This allows getting most L2-L5 concentrations with the current multi-blend tank concentrations.
  - a. MesaLabs Defender 530H and 530L or 530+
  - b. Alicat Whisper MWB-Series Mass Flow Meters (flow rate range of 0.005 to 20 SLPM)
3. Multi-blend tank (specs for CO, SO<sub>2</sub>, and NO concentrations)
4. ZAG
  - a. Teledyne T701H or equivalent
5. Ozone analyzer calibrated to Level 2 (against an SRP)
6. Validated spreadsheet (or PEAT) to determine audit concentrations and corresponding flow rates to be verified and employed for conducting the audit.

### Configuration

Install a valve (solenoid or manual) and tubing to route flow from the gas delivery flow path to the transfer standard flow meter to permit gas calibrator output to the flow meter.

### Procedure

1. Warm up and run the calibrator for about one hour prior to beginning flow standardization.
2. Verify the flows of the diluent and standard channel MFCs at the flow rates to be employed to deliver the test gases at the desired concentrations (minimally in Levels 5, 4, 3, and 2 for each audit gas). The flow rates to be input into the concentration calculation will be determined by flowing gas through the respective channel for a minimum of 7 minutes (the first point should be minimally 10 minutes) and averaging the last 5 minutes of this period for the data collection.
  - a. These concentrations can be determined in advance and the desired flows assigned.

- b. There are no acceptance criteria for the flows as the MFC calibration slope and intercept are ignored. Instead, the flow rate readings from the flow transfer standards at a given setting will be input into the calculations to determine the provided challenged concentrations.
  - c. Ensure the flow transfer standard is configured to EPA standard conditions of 25°C and 760 mmHg.
  - d. For the diluent flow rates, flow zero air for 10 minutes for the first flow rate and take the last 5 minutes of data to average for the flow rate measurement. For subsequent diluent flow rate measurements, flow zero air for a minimum of 7 minutes and take the last 5 minutes of data to average for the flow rate measurement.
  - e. For the standard flow rates, flow zero air (or the standard gas) for the first flow rate for 10 minutes and take the last 5 minutes of data to average for the flow rate measurement. For subsequent flow rate measurements, flow zero air (or the standard gas) for a minimum of 7 minutes and take the last 5 minutes of data to average for the flow rate measurement.
3. To conduct the audit, input the desired (and already flow-characterized) flow settings starting with the highest concentration level. Wait for the flow to stabilize and notify the station operator to provide a measurement when they feel their measurement is stable (this typically takes between 15 and 30 minutes).

See Flow Based Spreadsheet.