COLORADO
Department of Public Health & Environment

Air Pollution Control Division

Technical Services Program

APPENDIX GM4

Standard Operating Procedure for the Dynamic Dilution Calibrator
And Zero Air Generator

Page intentionally left blank

TALBE OF CONTENTS

TABLE OF TABLES

TABLE OF FIGURES

TABLE OF EQUATIONS

Standard Operating Procedure for Dynamic Dilution Calibrator

1 SCOPE AND APPLICABILITY

1.1 Introduction

This standard operating procedure (SOP) document describes the procedures used by members of the Air Pollution Control Division (APCD) to operate a dynamic dilution calibrator (calibrator) at one of the State of Colorado, Department of Public Health and Environment's (CDPHE) air quality monitoring sites. This includes calibrators at State and Local Air Monitoring Stations (SLAMS), Special Purpose Monitoring (SPM), Photochemical Assessment Monitoring Sites (PAMS) and NCore monitoring stations. The CDPHE used the Teledyne Advanced Pollution Instrumentation (TAPI) dynamic dilution calibrators in its air monitoring network and this SOP covers the 700,700E, 700EU and the T700 models. The procedures given in this SOP are a supplement to APCD's Quality Assurance Project Plan (QAPP), the latest information published in the Code of Federal Regulations, and the Operator's manual for TAPI dynamic dilution calibrators.

1.2 Method Overview

Calibration gas mixtures are generated internally by mixing EPA protocol source gases of known concentration with a diluent gas (zero air). These gas mixtures are then used to perform quality control (QC) checks, audits, and calibrations on various analyzers.

1.3 Format and Purpose

The sequence of topics covered in this calibrator method follows 2007 EPA guidance on preparing standard operating procedures (SOPs) (US EPA, 2007). This method was also written to help field operators understand how and why key procedures are performed.

2 SUMMARY OF METHOD

The dynamic dilution calibrator uses Mass Flow Controllers (MFCs) to create exact ratios of diluent and source gas by controlling the relative rates of flow of the various gases. This is accomplished under conditions where the temperature and pressure of the gases being mixed is known. The calibrator CPU calculates the required flow rates for the source gas and diluent gas for a given final concentration, shown in the equation below:

Equation 1. Calibration Gas Concentration equation

$$C_F = C_i \frac{F_g}{F_T} \quad (1)$$

where:

C_F = Final concentration of diluted source gas
C_i = source gas concentration (cylinder concentration)
F_g = source gas flow
F_T = Total gas flow through the calibrator (source gas flow rate + diluents gas flow rate)

For Gas Phase Titration (GPT), NO_2 calibration gas mixtures are created by mixing O_3, NO, and diluent gas in the mixing chamber. The calibrator generates the required concentration of O_3 internally, since under normal ambient conditions ozone is a short lived gas and cannot be reliably stored. The TAPI calibrators used by APCD in the air monitoring network all have the optional O_3 generator installed from the factory. The GPT principle is based on the rapid gas phase reaction between NO and O_3, which produces a concentration of NO_2. This reaction is given in the following equation:

Equation 2. NO and O_3 reaction

$$NO + O_3 \rightarrow NO_2 + O_2 + hv$$

where:

NO = Nitrogen Oxide
O_3 = Ozone
NO_2 = Nitrogen Dioxide
O_2 = Oxygen
hv = light

The reaction of NO and O_3 is very efficient, giving generally less than 1% residual O_3 under controlled circumstances. Therefore using GPT the concentration of NO_2 can be accurately predicted and controlled by the calibrator as long as the following conditions are met:

- The concentration of O_3 used in the mixture is known.
- The amount of the NO source gas used in the mixture is at minimum 20% greater than the O_3 concentration in the mixture.
- The volume of the mixing cell is known.
- The flow rates of the NO and O_3 gas are low enough to give a residence time of the reactants in the mixing cell of greater than 2.75 ppm per minute.

The amount of NO_2 being output by the calibrator will be equal to the amount of O_3 added, given the above conditions. This 1:1 ratio of NO_2 to O_3 is due to:

- The O_3 flow rate of the calibrator's O_3 generator is a fixed flow.
- The GPT mixing cell volume is known.
- The NO source gas concentration is known.

The calibrator adjusts the NO flow rate and diluent flow rate to create the appropriate NO_2 concentration at the output, once the total flow is determined and a target concentration for the O_3 generator are entered into the calibrator's software.

3 DEFINITIONS

The CDPHE/APCD/TSP QAPP contains an appendix of acronyms and definitions. Any commonly used shorthand designations for items such as the sponsoring organization, monitoring site, and the geographical area will be defined and included in Appendix P2 or in the QAPP.

4 HEALTH AND SAFETY WARNINGS

Gas Hazards

Calibrators use source gases such as carbon monoxide (CO), sulfur dioxide (SO_2), nitric oxide (NO), etc. CO is a colorless, odorless, and tasteless gas. It is a hazardous compound as it combines with hemoglobin and reduces the oxygen carrying ability of the blood. SO_2 is a hazardous compound with a sharp irritating order that causes severe respiratory tract, eye, and skin burns. NO is also a hazardous compound that causes skin and eye irritation, and contains material that can cause target organ damage. NO gas may be fatal if inhaled for a prolonged period or at a high concentration.

As several of the source gases are poisonous gases, calibration source tanks and delivery systems, or any other calibration span gas, should be vented to the atmosphere rather than into the shelter or other sampling area. If this is impossible, limit operator exposure to the gas by getting fresh air every 5 to 10 minutes. The operator must leave the area immediately if he/she experiences lightheadedness, headache or dizziness. Refer to the respective material data safety sheet (MSDS) for more information on hazards and safety.

<u>Electrical Hazards</u>

1. Always use a ground wire on all instruments.

2. If it is necessary to work inside a calibrator while it is in operation, use extreme caution to avoid contact with high voltage inside the calibrator. The calibrator has high voltages in certain parts of the circuitry, including a 110 volt AC power supply. Refer to the manufacturer's instruction manual and know the precise locations of these components before working on the instrument

3. Avoid electrical contact with jewelry. Remove rings, watches, bracelets, and necklaces to prevent electrical burns.

4. Always unplug the calibrator whenever possible when servicing or replacing parts.

5 CAUTIONS

To prevent damage to the equipment, the following precautions should be taken:

1. Keep the interior of the calibrator clean.

2. Inspect the system regularly for structural integrity.

3. To prevent major problems with leaks, make sure that all sample and calibration lines are reconnected after required checks and before leaving the site.

4. Inspect tubing for cracks and leaks.

5. It is recommended that the calibrator be leak checked after replacement of any pneumatic parts.

6. Use and transport of cylinders are a major concern. Gas cylinders may contain pressures as high as 2000 pounds per square inch. Handling of cylinders must be done in a safe manner. If a cylinder is accidentally dropped and the valve breaks off, the cylinder can become explosive or a projectile.

7. Transportation of cylinders is regulated by the Department of Transportation (DOT). It is strongly recommended that all agencies contact the DOT or Highway Patrol to learn the most recent regulations concerning transport of cylinders.

8. EPA protocol gases are hazardous materials. Long term exposure can cause problems with motor coordination and mental acuity. It is strongly recommended that all agencies have MSDS at all locations where gas cylinders are stored or used. MSDS can be obtained from the DOT or from your vendor.

6 INTERFERENCES

Interferences are physical or chemical entities that cause measurements to be higher (positive) or lower (negative) than they would be without the entity. The TAPI calibrator can become contaminated with substances that can react with reactive type test gases causing lower or higher concentration than expected. It is important to keep all the flow systems within the calibrator clean and free from contaminates. Other interferences include impurities present in the calibration source gas cylinders, and/or diluent air source.

7 PERSONNEL QUALIFICATIONS

General Personnel Qualifications are discussed in the CDPHE/APCD/TSP QAPP.

8 APPARATUS AND MATERIALS

8.1 Equipment

8.1.1 Calibrators

8.1.1.1 TAPI 700

The TAPI 700 is the first generation of the TAPI calibrators. The total flow is a user selectable flow that in universal to the calibrator and cannot be changed for different calibration sequences. Thus if the total flow is set at 4 LPM then the SO_2 calibration sequence and a NO calibration sequence will both be generated with a total flow of 4 LPM. This is restrictive if the gas cylinder concentrations and the Span/Precision levels are different. Care must be taken to select an appropriate total flow in order to keep the mass flow controllers flow within 10% of the minimum and maximum of full range scale (Teledyne-API, 2006).

8.1.1.2 TAPI Model 700E and 700EU

The TAPI 700E and 700EU calibrators are the second generation TAPI model in the 700 series. The 700E feature TAPI's E-series electronics and the ability to set the total flow for each generate step in the calibration sequence (Teledyne-API, 2009). The 700EU enables trace levels of Ozone to be produced to perform NCore and trace level gas concentrations.

8.1.1.3 TAPI Model T700

The TAPI T700 is the third generation in the 700 series calibrators. The T700 features TAPI's T-series electronics and has a Window CE operating system with a touch screen interface (Teledyne-API, 2013) (Teledyne-API, 2012).

8.1.2 Zero Air Generator

8.1.2.1 TAPI Model 701

The regenerative, heatless dryer removes water and produces gas with a dewpoint of less than -20°C (up to 15 SLPM flow rate) independent of the inlet dewpoint and assists in the removal of other gases, greatly increasing the life of the chemical scrubbers.

The basic Model 701 includes an oil and diaphragm free pump plus scrubbers to remove SO_2, NO, NO_2, O_3 and H_2S. Optional high performance scrubbers are available to remove CO and Hydrocarbons.

Inlet air is pulled into the pump and routed through a pre-cooler and water trap to remove moisture. The air then passes through the regenerative scrubber for final drying and then to the storage tank.

Tank pressure is monitored and maintained at a preset level by cycling the pump automatically as needed, thereby extending both the pump and scrubber life. Outlet air then passes through a filter to assure a clean, dry, analytical zero air supply. A microcontroller cycles the regenerative dryer and water trap valves to prevent the pump from starting against full head pressure.

8.1.3 Instrument Shelter

A shelter is required to protect the calibrator from precipitation and adverse weather conditions, maintain operating temperature, and provide security and electrical power. The following are operation shelter temperature requirements for the SLAMS and NCore networks.

SLAMs: 5-40 ^{o}C (20-30 ^{o}C preferred) at <± 2^{o}C Standard Deviation over 24 hours (Appendix MQO).

NCore: 20-30 °C, daily changes in hourly temperature should not exceed ±5 °C over 24 hours.

8.1.4 Data Acquisition System

The APCD employs three different models of onsite, data acquisition system equipment (DAS) in the operations of its air monitoring network. These are the ESC 8816 data logger, the ESC 8832 data logger, and the Agilaire 8872 data logger. The 8816 model is the oldest type of data logger in the network and is a predecessor to the 8832 and 8872 data loggers. The following are descriptions of these data loggers.

ESC 8816 Data Logger

The ESC Model 8816 Data System Controller is a microprocessor-based data acquisition system designed to acquire, process, store, report, and telemeter data in a multi-tasking environment. The 8816 is designed around an expansion bus that gives the user great flexibility in configuring the unit with a combination of analog and serial input and output (I/O) types.

For more details, refer to APCD's Datalogger SOP or the individual operator manuals (Environmental Systems Corporation, 2001).

ESC 8832 Data Logger

The ESC Model 8832 Data System Controller is a microprocessor-based data acquisition system designed to acquire, process, store, report, and telemeter data in a multi-tasking environment. The 8832 is designed around an expansion bus that gives the user great flexibility in configuring the unit with almost any combination of input and output types. It is the successor to the 8816 data logger and is more robust in numerous areas. Of significance is expanded memory, faster processing speeds, faster communication speeds, secure SSH communication protocol, and Modbus enabled communications with peripheral devices.

For more details, refer to APCD's Datalogger SOP or the individual operator manuals (Environmental Systems Corporation, 2006).

ESC 8864 Data Logger

The ESC Model 8864 Data System Controller is a microprocessor-based data acquisition system designed to acquire, process, store, report, and telemeter data in a multi-tasking environment. The 8864 is designed around an expansion bus that gives the user great flexibility in configuring the unit with almost any combination of input and output types. It is the successor to the 8832 data logger and is more robust in numerous areas. Of significance is expanded memory, faster processing speeds, faster communication speeds, remote Ethernet communications and polling and Modbus enabled communications with peripheral devices.

For more details, refer to APCD's Datalogger SOP or the individual operator manuals (Environmental Systems Corporation, 2018)

Agilaire 8872 Data Logger

The Model 8872 is a Windows-based data logger, a departure from the earlier 8816 / 8832 embedded systems designs. The 8872 includes a number of hardware and software features to ensure that the device matches the field reliability of the 8832, while offering the convenience of a Windows-based platform and integration with Agilaire's AirVision software.

The core of the 8872 is a fan-less PC, typically 2 GB of RAM. The device can be equipped with a 160 GB standard hard drive or, more commonly, a 64 GB solid state flash drive (SSD). For all digital versions of the 8872, the remainder of the enclosure simply provides convenient universal serial bus (USB), serial, and VGA I/O connections in a standard 3U rack mount enclosure, a form factor similar to the 8816 / 8832 family. However, the 8872 also supports traditional analog/discrete I/O via a variety of internal I/O modules and a protection / connector board to provide familiar detachable terminal block connections to the back. The layout of the connections is designed to make the unit easy to use as a 'drop in' replacement for an 8816 or 8832. (Agilaire, 2013)

For more details, refer to APCD's Datalogger SOP or the individual operator manuals.

8.1.5 Wiring, Tubing and Fittings

Teflon™ and borosilicate glass are inert materials that should be used exclusively throughout the calibration gas system. It is recommended that Polytetrafluoroethylene (PTFE) or Fluoroethylpropylene (FEP) Teflon™ tubing be used. PTFE or FEP Teflon is the best choice for the connection between an intake manifold and the bulkhead fitting. Examine the tubing and discard if particulate matter has collected on the tube's interior. All fittings and ferrules should be made of Teflon™ or stainless steel. Connection wiring to the DAS should be shielded two-strand wire for analog communications and properly shielded RS-232 serial cable or Cat5 or higher Ethernet cable for digital communications.

8.1.6 Reagents and Standards

The TAPI 700 series calibrator requires O_3 as a reagent for GPT with NO source gas. Since O_3 is short lived and highly reactive, it is generated internally by the 700 series calibrator. All source gas is obtained from cylinders whose contents must be traceable to NIST Standard Reference Material (SRM) gases via EPA Protocol procedures (US EPA, 2012).

8.1.7 Spare Parts and Incidental Supplies

TAPI 700: See Chapter 8 (Maintenance, Adjustment), Chapter 9 (Troubleshooting) in the TAPI "**Instruction Manual Model 700 Mass Flow Calibrator**" for specific maintenance and replacement requirements.

TAPI 700E and 700EU: See Chapter 10 (Maintenance Schedule and Procedures), Chapter 11 (General Troubleshooting & Repair of the M700E Calibrator) in the TAPI "**Operator's Manual Model 700E Dynamic Dilution Calibrator**" for specific maintenance and replacement requirements.

TAPI T700: See Chapter 8 (Maintenance), Chapter 9 (Troubleshooting and Service) in the TAPI "**Operation Manual Model T700 Dynamic Dilution Calibrator**" for specific maintenance and replacement requirements.

8.2 Verification/Calibration Equipment

8.2.1 O_3 Verification/Calibration System

Calibration of the Calibrator's O3 generator system, requires the Level 2 O_3 standard, a 701 zero air generator, a sampling manifold, and FEP tubing.

8.2.2 MFC Verification/Calibration System

See Standards SOP Appendix QA2, section 5.3.

8.2.3 Accessories and Incidental Supplies

For the O_3 generator calibration FEP tubing is needed to sample the O_3 produced. Also, see Standards SOP Appendix QA2, section 5.3 for a list of accessories and incidental supplies required for the MFC verification.

8.2.4 Reagents and Standards

See Standards SOP Appendix QA2 for a list of required reagents and standards for the MFC verification.

9 Calibrator Verification/Calibration

9.1 Introduction

The MFCs, O_3 generator, temperature, and pressure sensors need to be calibrated. MFC and O_3 generator verification/calibration is done every six months, and temperature and pressure sensor verification/calibration is done yearly or as needed.

9.1.1 O_3 generator Verification/Calibration

Procedure to Verify/Calibrate the O_3 generator, see the relevant Operator's manual for more detail. This is to be done post MFC verification.

1. Use the certified level 2 O_3 primary standard to determine the O_3 concentration output by the calibrator
2. Connect a line of tubing from the calibrator's output port to the level 2 O_3 standard's sampling manifold.
3. Using the same zero air source for both the calibrator and the level 2 O_3 standard, go to the O_3 gen cal mode and proceed through the various O_3 concentration levels.
4. At each concentration level, enter the O_3 concentration read from the level 2 O_3 standard display.
    a. If the calibrator has a photometer, then perform a bench calibration against the level 2 O_3 standard, then perform an automatic O_3 gen cal on the calibrator.

9.1.2 MFC, Temperature, and Pressure Sensor Verification/Calibration

Refer to the Standards SOP Appendix QA2, section 5.3 for the correct procedure to verify/calibrate the MFCs, and Section 9 of this SOP to verify/calibrate temperature sensors, and section 10 to verify/calibrate pressure sensors.

9.2 Reporting and Filing of Calibration Results

Standards SOP Appendix QA2 section 5.3 discusses reporting and filing MFC calibration results.

10 Operation and Maintenance

10.1 Introduction and Description of Operation

The TAPI 700 series calibrator is a dynamic dilution system that delivers calibration gas to a calibration gas manifold. The calibration gas manifold consists of solenoid valves controlled by the data logger, which routes the calibration gas to the appropriate gaseous analyzer (Figure 5). The calibrator uses highly accurate MFCs and compressed sources of EPA protocol gases to generate calibration gases for span and precision checks of gaseous analyzers. The calibrator is coupled with a TAPI zero air pack 701, which delivers zero air to the calibrator's "diluent air in" port and is used for zero checks of gaseous analyzers. Source gases are connected to the "cal gas" ports and up to four gas sources may be used. Calibration sequences are programmed into the calibrator in order to generate the desired concentration automatically as requested by the data logger or by a user through the front panel (Appendix A). The sequences are initiated by the data logger via external digital control inputs, or RS-232 serial interface, or Ethernet interface.

10.2 Equipment and Supplies

For a complete listing of supplies and equipment please see Section 8 of this standard operating procedure.

10.3 Logs and Forms

All actions at the site, scheduled and non-scheduled, are logged on forms. These forms are collected monthly, reviewed and filed together in monthly folders in a maintenance files cabinet. Three complete calendar years of log sheets and forms are retained and are readily available at the APCD offices. The intent of these forms is to be able to recreate events and actions taken well after the fact. Examples of these forms can be found at the end of the SOP.

The forms in routine use are:

1. MONTHLY STATION ACTIVITIES LOG (Figure 3)
2. MONTHLY CALIBRATOR ACTIVITIES LOG (Figure 4)
3. MONTHLY MAINTENANCE REPORT FORM (Figure 5)

10.4 General Operations

This section provides an overview of scheduled inspection and preventive maintenance procedures. To minimize downtime and ensure data quality, preventive maintenance is to be performed on all gaseous monitors in the network according to a schedule established by TSP, using the inspection criteria documented in this chapter. Below is a general summary of the types of maintenance checks performed.

Data from each site is evaluated daily. There is a daily morning review of overnight Quality Control checks, data validity flags, data completeness, data representativeness, logger messages, and shelter environmental status to determine if an immediate site visit is needed. Data loggers are contacted as needed to evaluate and configure instrument systems.

A Weekly on site inspection is performed once each calendar week.

The Precision tests and Zero/Span cycles are automated and controlled by the data logger, but may be done manually at any time, and are required to be performed manually once every two weeks.

A Monthly on site inspection is performed at the beginning of each calendar month.

Upon completion of an inspection, log entries onto the MONTHLY STATION ACTIVITIES LOG, MONTHLY CALIBRATOR ACTIVITIES LOG, and into a "Message to Central" are required. Enter all tasks performed, any malfunctions, or other actions needed, discovered during the inspection.

All scheduled checks are minimum requirements. Individual site circumstances may dictate a more frequent preventative maintenance schedule. Monthly, quarterly, and semi-annual inspections are always conducted by TSP-approved staff that has the training or experience to reliably perform the required checks or maintenance.

By contract agreement, it is the responsibility of all contracted site operators to notify TSP of any unusual instrument/equipment performance, possible malfunction, or outright malfunction, and action taken, if any. TSP in turn will take the appropriate action as soon as workload and priorities permit. TSP maintenance personnel will summarize work performed in a "message to central" for all non-scheduled maintenance activities.

10.5 Routine Preventative Maintenance and Scheduled Activities

Preventive maintenance inspections and services should follow the recommended intervals by the EPA, the manufacturer, or as determined by actual experience. If preventive maintenance services are not being done according to the minimum guidelines of the manufacturer as set forth in this standard operating procedure, the TSP may jeopardize any claim to a manufacturer's warranty and may jeopardize the validity of the data collected. The preventive maintenance inspections are scheduled to provide an opportunity to detect and repair damage or wear conditions before major repairs are necessary and the loss of data occurs. The documentation of these activities is essential for quality control tracking and for compliance with EPA's Quality Systems methods. Site and calibrator log sheets along with "messages to central" are part of the official record and the documentation of maintenance or observations are to be written clearly and concisely and in accordance of good laboratory practices. Scheduled activities such as MFC verification/calibration may be done either on site, or with the calibrator returned to the laboratory. Ozone generator verification/calibration, if necessary, must be done in the laboratory and compared to a certified level 2 ozone transfer standard (US EPA, 2012).

Table 1. Routine Preventative Maintenance and Schedule Activities

Procedure or Resource	Description
Every Onsite Visit	
	Check station for general condition and proper operation of heating, air conditioning, lighting, and sample pumps.
0	Check calibrator for faults and operability. Verify that the data logger is working correctly and reported values match the calibrator display.
Figure 2	If equipped, observe the operating condition of zero air pack. Check for faults and short cycling, and function of the water drop-out in the back of the 701 (Teledyne-API, 2014).
	Remove trash when waste receptacles are full. Remove from shelter all odorous trash, such as leftover food and food packaging.
10.6.3 Figure 3	Leave a "message to central" and a site log entry summarizing purpose of visit and a summary of all maintenance performed
Weekly Inspection / Maintenance	
	Perform Every Onsite Visit inspections as defined above.
	Perform general housekeeping as necessary. Includes sweeping station as necessary. Dispose of trash as necessary. Clean up trash and remove weeds/vegetation from surrounding property.
	Enter notes and initial calibrator log sheet. Leave a "message to central" summarizing purpose of visit and a summary of all maintenance performed. If the site visit is virtual, indicate that all diagnostics were reviewed and that the visit was virtual in the digital "message to central" function from the data logger
Figure 3	Log all bottle gas supply pressures on station log sheet

Procedure or Resource	Description
Figure 3	Log station maximum & minimum temperatures on station log sheet and reset thermometer if available.
Figure 3	Enter notes and initial station log sheet
10.6.3	Leave a "message to central" summarizing purpose of visit and a summary of all maintenance performed
10.6.5	Check calibrator time against a National Institute of Standards and Technology traceable time piece (i.e. cell phone) and adjust if (>± 2 min) see calibrator manual or clock procedure. For changes to a data logger clock contact GMM supervisor or central TSP staff first.
Monthly Inspection / Maintenance	
	Perform Weekly Inspection/Maintenance as defined above.
	Check associated wiring, power cables, and plumbing (lines and fittings) for wear, damage and proper installation.
10.6.4	Perform leak check of test gas manifold solenoid/s (if equipped)
Figure 3 **Figure 4**	Fill out new monthly station and calibrator (if equipped) log sheets for the upcoming month. Include the following key elements: • Calibrator log sheet – site name, month, year, calibrator range and calibrator firmware, calibrator SN and other appropriate info required by log sheet • Station log sheet - site name, month, year, bottle numbers, expiration date, concentration and pressure and other appropriate info required by log sheet
	Upon completion of the Monthly Maintenance site visit, all previous months log sheets are collected and placed in the monthly forms data collection box within 2 business days of being collected.
10.6.7	Replace the charcoal and/or purafil in 701 zero air generator if necessary.
Quarterly Inspections / Maintenance	
	None Required
Six Month Inspections / Maintenance	
10.6.1	Leak check Calibrator
9.1.1	Verification/Calibration of MFCs
Annual Inspections / Maintenance	
	Service 701 zero air generator as per manufactures specifications (Teledyne-API, 2014)
	Inspect and clean Heating, Ventilation and Air Conditioners (HVAC) units at site. Inspect for water access holes in the shelter, roof, and sides. Ensure AC unit is sealed against moisture on the shelter wall. • Perform maintenance in June or July

Procedure or Resource	Description
	• Replace or clean air conditioning and/or heater dust filters (if equipped) • Clean air conditioner coils
	Replace calibration gas supply lines for through-the-probe systems in 2015, 2018, and 2021. Each other year, remove the outer six inches of the calibration gas supply line and reattach to the sample inlet.

10.6 Maintenance Procedures

10.6.1 Calibrator Leak Check Procedure

See Standards SOP Appendix QA2, section 5.3.

10.6.2 Check Calibrator Diagnostic Test Parameters Procedure

1. With the Monthly Calibrator Activities Log (Figure 4), record the required test parameters.
2. Using the TST> button on the Calibrator front display; scroll through to record the test parameters.
3. Record the gauge pressure of the zero air pack.

10.6.3 Message to Central Procedure

<u>ESC 8816 or 8832</u>

1. Log in to the data logger.

4. From the top level menu Type **SMC** (**S Status Menu** > **M Message Menu** > **C Leave a Message for Central**) followed by hitting the **Enter** or **Return** key.

5. When the text entry display appears, type in up to 80 characters of text explaining the site visit, followed by your initials, example, “Weekly completed. No problems noted. – JJ” then hit the **Enter** or **Return** key on the keyboard to accept the log entry.

<u>Agilaire 8872</u>

1. Log in to the data logger using the AirVision™ application.
2. Select the **Home** tab > then **Data Editors** drop down menu.
3. From the drop-down menu select, **LogBook Entry Editor**, and click the round green icon with white “plus” symbol, entitled, **New Log Entry**.
4. Next, click on the **Category**: drop-drop down menu and choose **Logger Message**.
5. Select the drop-down menu item, **Site** and choose the appropriate site, for example, **Welby**.
6. Enter text explaining the purpose of the site visit, followed by your initials. Example, “Weekly completed. No problems noted. – JJ” hit the **Save** button at the top left to save your comments. The application will allow more characters than 80, but they are truncated for the Central computer.

10.6.4 Determination of Calibration Solenoid Manifold Bank Leak

1. Using the data logger, energize the solenoid that allows gas to escape to the room (usually labeled as the dump solenoid, Figure 6).

    a. On an 8832, from the main screen select D>O (Display > Outputs) and scroll to the appropriate digital output. Press C for closed (O will open) – in this case the C and O refer to the circuit and C means "energize" while O means "de-energize".

    b. On an 8872, in the Site Node Logger Toolbox, switch to the Digital Outputs tab and click the State button in the row with the Dump Solenoid. The State button will change from OPEN to CLOSED indicating the circuit is energized.

2. On the 700, generate zero air at 2-3 lpm while watching the pressure needle on the solenoid manifold.

    a. Press Generate.

    b. Press the species button until "zero" appears (it may read CO/SO2/NO, etc).

    c. Press Enter.

    d. Adjust the total flow to between 2 and 3 lpm and press enter.

3. When the pressure needle reaches >20 (but preferably less than 30) psi, put the 700 into Standby mode.

    a. It is normal for the pressure needle on the manifold to drop when putting the 700 into Standby. Use the post-drop number for this test.

4. Watch the pressure needle for 2 minutes. A drop of less than 5 psi over 2 minutes indicates there is no sufficient leak.

    a. If a drop of <5 psi occurs in 2 minutes, the leak check has passed.

    b. If a drop of >5 psi occurs in 2 minutes, troubleshoot the manifold or the 700 (the leak could be in either in this test) or contact the site operator.

5. Reverse steps taken in step 1 to de-energize the dump solenoid.

6. Leave a message for central detailing findings, including leak test conducted, passed or failed, actions taken if failed, and initials (10.6.3).

10.6.5 Time Change Procedure

1. Check calibrator time against a National Institute of Standards and Technology traceable time piece (i.e. cell phone) and adjust if (>± 2 min) .

2. On the front panel of the calibrator, press the SETUP button.

3. Press CLK>TIME.

4. Toggle the HOUR and MINUTE buttons to enter the current time.

5. Press ENTER to accept new time.

6. Press EXIT to get to the home menu.

7. Log the time difference on the Monthly Calibrator Activities Log (Figure 4).

10.6.6 Bottle Change Procedure

1. Make note of the pressure left in the old bottle (psi).

2. Close the old gas bottle valve (clockwise turn).

3. Remove the gas line from the back of the dilution calibrator for NO, SO_2 and some CO; most CO cylinders are connected directly to the analyzer.

4. Inspect the line and fittings and replace as necessary.

5. Remove the two-stage regulator from the gas bottle.

6. For 660 CGA stainless regulators install a new Teflon washer onto the stem connection.

7. Connect the regulator to the new gas bottle.

8. If replacing the regulator, move the calibration gas line from the old to the new regulator.

9. Purge the regulator and line:

    a. Using a quick connect with a push stop or your thumb over the end of the gas line, cap the gas line closed.

    b. Back off the regulator pressure knob, and close the regulator valve.

    c. Quickly open the gas bottle valve until the bottle-side pressure gauge reads the bottle psi.

    d. Quickly close the gas bottle valve.

    e. Open the regulator valve and the gas line until the regulator gauges go to zero psi.

    f. Close the regulator valve and the gas line.

    g. Repeat for a total of three times

10. Connect the gas line back to the appropriate gas port on the back of the dilution calibrator or CO analyzer, vent gas out of the line before tightening the fitting to ensure that gas is flowing through the line.

11. Set the regulator pressure to 30psi and ensure that the gas bottle valve and regulator valve are open, if connected to a calibrator verify that the gas pressure is within the required range.

12. Make note of the bottle change on the station log and record the new bottle number, gas type, concentration, expiration date and pressure.

13. Send two messages to central through the data logger (see 10.6.3)

    a. The first message will consist of the designation of "old", **old** bottle number, concentration(s), expiration date, and current bottle pressure.

    b. Use the following format.

i. **Bottle Change Old FF40348 NOx 9.89 NO 9.74 07/29/16 600**

c. The second message will consist of the designation of “new”, **new** bottle number, concentration(s), expiration date, and current bottle pressure.

d. Use the following format.

i. **Bottle Change New FF55716 NOx 9.81 NO 9.9 07/29/16 1000**

e. Substitute the lables“SO2”, “CO” for “NO, NOX” as needed in the messages.

14. Enter the new bottle concentration into the 700 calibrator if different than old bottle

a. On the 700 calibrator, press Setup > Gas > Cyl > Port(n) where n is the appropriate port number 1-4 connected to the gas bottle

b. On the 700 calibrator, make sure the displayed analyte is the correct bottle. Press Edit and use the keys to enter the new concentration. The units can be changed if necessary but under normal circumstances it should stay the same.

c. When finished, press Enter (or Exit to cancel) and press exit enough times to return to the main screen.

10.6.7 Charcoal or Purafil© Change Procedure in a 701 air pack

If data suggests that a contaminant is starting to break through the zero air pack, for example a high zero value on a NOx analyzer, the charcoal and/or Purafil should be changed. Some zero air packs do not have Purafil if there is no reason to remove NO from diluent air. In those cases, the container normally holding Purafil will have charcoal in it.

To change either charcoal or Purafil:

1. Turn the zero air pack off.
2. Open the front of the zero air pack. There are two matt-silver cylinders. Take note of their order and orientation.
3. Disconnect the input line normally on the top of the right-hand cylinder. This will release pressure build up within the zero air pack which can be loud or startling.
4. Disconnect the output line normally on the bottom of the left-hand cylinder. Remove both cylinders which may be held in place with a strap.
5. Remove one end of the hose connecting the two cylinders.
6. Remove the cap and the pad just inside the cap, and empty the contents into the trash.
7. Using a lint-free wipe, clean the inside of the cylinder and the pad.
8. If contamination is particularly high the pad on the other end of the cylinder may also be removed and cleaned.

9. Reassemble including refilling with fresh charcoal or Purafil by following the above steps in reverse order.

10.7 Calibration Gas Standards

Calibration gas standards are obtained from NIST-traceable sources that are verified and certified by the vendor. Concentrations within the cylinders are verified in the laboratory following the Gas Acceptance Testing SOP Appendix GM6. The gas standards are stored with valves closed in the laboratory at controlled temperatures and are only transported to sites when required. All cylinders are secured in an upright position with a bracket, chain, or low-stretch strap around the upper third of the cylinder to prevent falling or rolling. Installation of gas cylinders at a site must follow the bottle change procedure (10.6.6).

Refer to the Standards Verification/Calibration SOP in the CDPHE/APCD/TSP QAPP for more detailed information on standards and traceability of gas standards.

11 HANDLING AND PRESERVATION

Calibration standard gases are stored in cylinders at controlled shelter temperature. No discrete samples are collected, handled, or preserved. Therefore, a section for sample handling and preservation in this SOP is not required.

12 SAMPLE PRESERVATION AND ANALYSIS

Calibration standard gases are stored in cylinders at controlled shelter temperature. Therefore, a section for sample preservation and analysis in this SOP is not required.

13 TROUBLESHOOTING

13.1 Environmental Factors

Environmental conditions can play a role in the operational characteristics of calibrators. Some external factors may be constant while others are sporadic in nature. External factors to check include:

1. Is the shelter temperature stable throughout the calibration sequence?
2. Is vibration from other equipment causing an effect?
3. Is the air conditioner or heater blowing directly on the instrument?

13.2 General Factors

Other factors linked to the shelter and manifold design can contribute to poor calibration check results. The sample probe, water dropouts, and calibration lines should be checked on a regular basis to ensure integrity. The sample probe weather cap inlet should be cleaned every six months and the sample lines replaced every year. Through-the-probe (TTP) calibration lines are to be replaced once every three years and 6” trims of the inlet side of the calibration line are to be performed in the other years. Power to the site is another factor that can contribute to data loss. Incoming power needs to be stable and have a good waveform.

13.3 Calibrator Troubleshooting

Troubleshooting of problems with calibrators is specific to each calibrator and its design. Common problems with calibrators include:

1. Flow problems (high or low)

2. No readings or off-scale readings

3. Pressure too high or low (source calibration gas/ diluent gas pressure)

4. No display

5. No output

6. Temperature warnings

7. Calibrator completely inoperative

Troubleshooting sections in specific calibrator operation and service manuals, located at each site or in the APCD office, should be consulted to assist in resolving instrument problems. Equipment used in troubleshooting includes digital voltmeters, flow transfer standards, and temperature and pressure transfer standards.

Chapters 9, 11, and 9 outline troubleshooting techniques in the 700, 700E, 700EU, and T700 calibrator manuals, respectively. Troubleshooting techniques for the data logger and remaining sample system, including any external solenoid manifolds and calibration systems, are the purview of their respective SOPs, manuals, and the experience of qualified operators.

14 DATA ACQUISITION, CALCULATIONS, AND DATA REDUCTION

All data are collected, stored, and retrieved digitally from data loggers. The terms data logger and onsite data acquisition system (DAS) are used interchangeably throughout this SOP.

14.1 Data Acquisition

The APCD/TSP data acquisition system is comprised of three components: an onsite primary data acquisition system that collects data from all continuous monitoring equipment, an onsite secondary data acquisition system, or back-up system that collects data from the continuous monitoring equipment, and a centralized central polling system that routinely collects data from the primary data acquisition system and stores it in a SQL database for processing and validation.

14.1.1 Primary Onsite Data Acquisition Systems

The APCD employs three different models of onsite DAS in the operations of its air monitoring network. These are the ESC 8816 data logger, the ESC 8832 data logger, and the Agilaire 8872 data logger. The 8816 data logger is the oldest type of data logger in the network and is a predecessor to the 8832 and 8872 data loggers. See Section 8.1.4 for a more detailed description of these data loggers.

14.1.2 Secondary Onsite Data Acquisition Systems

No secondary backup data acquisition systems are used on the TAPI 700 calibrators or 701 zero air generators. The firmware utilized within this equipment does not support the internal Data Acquisition Systems (iDAS) that is standard with the gaseous analyzers.

14.1.3 Central Polling System

The APCD uses the AirVision software package for its central data management system. AirVision is a centralized data management and polling software system that is used to acquire, edit, validate, analyze, and report air quality data. A more detailed description of this application can be found in APCD's Data Logger and Central Polling Standard Operating Procedure.

14.2 Calculations and Data Reduction

Data are polled automatically via modems (analog phone, wireless cellular, or DSL) by the Central polling computer hourly. If needed, sub-hourly polls or remote checks can also be performed.

Data from the continuous air monitoring equipment are generally stored at hourly and minute resolution averages. The software on the Central polling computer stores the downloaded minute and hourly averages and is capable of aggregating these averaging intervals into larger averaging intervals such as 8-hour or 24-hour averages.

A more detailed description of the DAS is given in the CDPHE/APCD/TSP QAPP and in the manufacturers' manual.

15 COMPUTER HARDWARE AND SOFTWARE

The data acquisition system (DAS) used by the APCD/TSP for collecting data from continuous air monitors is generally described in Section 14 and in the CDPHE/APCD/TSP QAPP.

The primary DAS Central polling computer is a Windows based server. The Airvision data system on this server provides for polling the sites using dial-up modems and broadband access for data. A printer is attached to the system for printing out reports. The primary repository for data, and the engine for information assembly, is the Microsoft SQL Server operated and maintained by the Governor's Office of Information Technology. The CDPHE/APCD/TSP maintains a database owner position responsible for logical maintenance of the data system.

The 8872 is a Windows based PC with attached monitor, keyboard, and mouse. The 8832 and 8816 are proprietary hard-circuit systems that may or may not have attached screens and keyboards. Sites usually include other computer hardware and software such as switches, RS232 cables, Ethernet cables, and analog cables.

16 DATA MANAGEMENT AND RECORDS MANAGEMENT

16.1 Data Management

Data are generated from the calibrator at intervals internally set, ranging from an averaging time of 20 seconds to 5 minutes. The data is collected by the on-site data logger as near-real-time data (often every 3 to 10 seconds) and is aggregated into 1-minute averages. The Central polling computer collects these averages routinely.

Data are sent to the EPA centralized Air Quality System (AQS) database for long-term storage after it has been validated. Additionally, the data are stored and archived by the APCD/TSP in both electronic and hard copy formats. Monthly electronic data files and related printed material packets (maintenance forms, etc.) are produced.

A more detailed description of the data management is given in the Data Processing Central SOP in the CDPHE/APCD/TSP QAPP.

16.2 Records Management

Continuous ambient air monitoring data are archived both in electronic and hard-copy formats. Electronic data and calibration files from the primary DAS are archived. Data from the backup electronic strip chart recorders, where used, are downloaded annually and archived on a computer hard drive. Hard copy printouts of the data are kept at the APCD office for a minimum of three calendar years before being sent to an off-site archive/storage facility.

17 QUALITY ASSURANCE AND QUALITY CONTROL

Quality assurance and quality control are two terms commonly discussed, but often confused. Quality assurance refers to the overall process of ensuring that the data collected meet previously stated Data Quality Indicators (DQI) and associated measurement quality objectives (MQOs). The principal DQIs are precision, bias, representativeness, completeness, comparability, and sensitivity (US EPA, 2013). The principal MQO's are parameter specific and are listed in Appendix MQO of this QAPP. Quality control covers specific procedures established for obtaining and maintaining data collection within those limits.

17.1 Quality Assurance

The goal of the quality assurance program is to control measurement uncertainty to an acceptable level through the use of various quality control and evaluation techniques. The entire Quality Assurance effort put forward by the APCD is too large to include here. The scope of this SOP will describe efforts taken by site operators and data validation personnel to ensure the quality of the data collected meets standards set forth in various sections of the *Code of Federal Regulations*. For a complete description of the Quality Assurance and Quality Control process undertaken by the APCD, see the appropriate quality assurance appendices in the QAPP. Two of the most significant Quality Assurance procedures are described below.

17.1.1 Audits

Audits are evaluation processes used to measure the performance of effectiveness of a system and its elements. APCD quality assurance staff performs two types of audits. These audits are performed at a frequency as described in APCD QAPP.

Systems Audits - A systems audit is an on-site review and inspection of an ambient air monitoring program or air monitoring site to assess its compliance with established regulations governing the collection, analysis, validation, and reporting of ambient air quality data.

Performance Audits - A performance audit is a type of audit in which the quantitative data generated in a measurement system are obtained independently and compared with routinely obtained data to evaluate the proficiency of an analyst, laboratory, or measurement system. Two types of performance audits discussed below.

- Monitoring Organization Performance Audits - These performance audits are used to provide an independent assessment of the measurement operations of each instrument being audited. This is accomplished by comparing performance samples or devices of "known" concentrations or values to the values measured by the instruments being audited.

- National Performance Evaluation Program (NPEP) **–** These performance audits are implemented at the federal level although some programs may be implemented by the monitoring organizations if certain requirements are met.

17.1.2 Data Quality Assessment

Data Quality Assessment is used to assess the type, quantity, and quality of data in order to verify that the planning objectives, Quality Assurance Project Plan components, and sample collection procedures were satisfied and that the data are suitable for its intended purpose. Data Quality Assessment is a five-step procedure for determining statistically whether or not a data set is suitable for its intended purpose. This assessment is a scientific and statistical evaluation of data to determine if it is of the type, quantity, and quality needed and is performed annually by quality assurance staff to check if objectives were met.

17.2 Quality Control

Quality Control is the overall system of technical activities that measures the attributes and performance of a process, item, or service against defined standards to verify that they meet the stated requirements established by the EPA. Quality control includes establishing specifications or acceptance criteria for each quality characteristic of the monitoring/analytical process, assessing procedures used in the monitoring/analytical process to determine conformance to these specifications, and taking any necessary corrective actions to bring them into conformance.

Quality control refers to procedures established for collecting data within pre-specified tolerance limits. These pre-specified tolerances are defined in the Measurement Quality Objectives as defined in Appendix MQO of APCD's QAPP. While all Quality Control procedures are important, the most significant procedure employed by the APCD is the routine measurement of a known test gas by gaseous calibrators. All procedures documented in this SOP are Quality Control procedures because they allow the analytical systems to continue running in exceptional condition and serves to minimize out-of-control conditions as defined by APCD MQO's. By definition, the creation and use of this SOP is a Quality Control function. All Quality Control procedures are described in Sections 17 and 10 of this SOP. Three of the most significant Quality Control procedures are described below.

17.2.1 Performance and Precision Tests

A primary quality assurance task carried out by site operators is the performance of routine Quality Control checks. The APCD performs two types of Quality Control checks at the above mention precision level test gas concentrations. These two tests are called Performance checks and 1 point Quality Control checks. The former is an automated performance test used to evaluate the health of the sample system. The latter is a manual evaluation performed by qualified personnel who can attest to their validity and are reported to the EPA. The former are not reported to the EPA to prevent an artificial bias introduced by the large sample pool. Sites operated by subcontractors are not required to manually perform 1 point Quality Control checks. Instead, one performance check is selected at random from each two-week period to satisfy the 1 point Quality Control check requirement. The performance check is selected by APCD personnel and is included with the APCD-operated 1point Quality Control check submission to the EPA's AQS.

17.2.2 Verification/Calibrations

It is the goal of APCD to perform verification/calibrations on all calibrators every 6-months. For instructions on performing a calibration, see Appendix GM2 of APCD's QAPP.

17.2.3 Documentation

Documentation is an important component of the quality control system. Extensive certification paperwork and log sheets must be rigorously maintained for procedures, standards and calibrators. APCD takes special care to prepare and preserve backup copies of all data, especially calibration data. All data and supporting documentation should be held on-site for a minimum of three calendar years then sent for offsite archive. See Section 16 for additional information.

18 REFERENCES

Agilaire. (2013). *Agilaire Model 8872 Manual.* Knoxville, TN: Agilaire LLC.

Environmental Systems Corporation. (2001). *ESC Model 8816 Data Logger Engineering Manual.* Knoxville, TN: Environmental Systems Corporation.

Environmental Systems Corporation. (2006). *ESC Model 8832 Data Logger Engineering Manual.* Knoxville, TN: Environmental Systems Corporation.

Mesa Laboratories. (MK01-26 Rev H). *Definer 220 Series User Manual.* Butler, NJ: Mesa Laboratories.

Teledyne-API. (2012). *Addendum - Model T700U Calibrator.* San Diego, CA: Teledyne-API.

Teledyne-API. (2006). *Operation Manual - Model 700 Mass Flow Calibrator.* San Diego, CA: Teledyne-API.

Teledyne-API. (2009). *Operation Manual - Model 700E Dynamic Dilution Calibrator.* San Diego, CA: Teledyne-API.

Teledyne-API. (2013). *Operation Manual - Model T700 Dynamic Dilution Calibrator.* San Diego, CA: Teledyne-API.

Teledyne-API. (2014). *Operation Manual - Models T701, T701H, 701, and 701H Zero Air Generators.* San Diego, CA: Teledyne-API.

US EPA. (2012). *EPA Traceability Protocol for Assay and Certification of Gaseous Calibration Standards, EPA/600/R-12/531.* Research Triangle Park, NC: US EPA.

US EPA. (2007). *Guidance for Preparing Standard Operating Procedures.* Research Triangle Park, NC: US EPA OAQPS AQAD.

US EPA. (2008). *QA Handbook for Air Pollution Measurement Systems: Volume IV: Meteorological Measurments Version 2.0, EPA-454/B-08-002.* Research Triangle Park: US EPA.

US EPA. (2012). *Transfer Standards for Calibration of Ambient AIr Monitoring Analyzers for Ozone, EPA-454/B-10-001.* Research Triangle Park: US EPA.

Appendix A

Calibrator Sequence Programming

Calibrator sequences are set up to automatically generate diluted calibration gases. The data logger can initiate a sequence via analog, serial, or Ethernet communications. For more information on sequence programming see the respective calibrator manual. A typical calibrator sequence program is given below:

```
SEQLISTBEGIN
 SEQBEGIN
  NAME "00_Zero"
  REPEATCOUNT 1
  CCINPUT "000100000000"
  CCOUTPUT DISABLED
  TIMER DISABLED
  TIMERSTART 01/01/2014 00:00
  TIMERDELTA 001:00:00
  STEPBEGIN
   GENERATE ZERO 5.000
   DURATION 45.0
   STANDBY
  STEPEND
 SEQEND
 SEQBEGIN
  NAME "01_COSPAN"
  REPEATCOUNT 1
  CCINPUT "001000000000"
  CCOUTPUT DISABLED
  TIMER DISABLED
  TIMERSTART 01/01/2014 00:00
  TIMERDELTA 001:00:00
  STEPBEGIN
   GENERATE 4.0 PPM CO 4.000
   DURATION 45.0
   STANDBY
  STEPEND
 SEQEND
 SEQBEGIN
  NAME "02_COPREC"
  REPEATCOUNT 1
  CCINPUT "010000000000"
  CCOUTPUT DISABLED
  TIMER DISABLED
  TIMERSTART 01/01/2014 00:00
  TIMERDELTA 001:00:00
  STEPBEGIN
   GENERATE 1.0 PPM CO 4.000
   DURATION 45.0
   STANDBY
  STEPEND
 SEQEND
 SEQBEGIN
  NAME "03_SO2SPAN"
  REPEATCOUNT 1
  CCINPUT "100000000000"
```

```
  CCOUTPUT DISABLED
  TIMER DISABLED
  TIMERSTART 01/01/2014 00:00
  TIMERDELTA 001:00:00
  STEPBEGIN
    GENERATE 80 PPB SO2 4.000
    DURATION 45.0
    STANDBY
  STEPEND
SEQEND
SEQBEGIN
  NAME "04_SO2PREC"
  REPEATCOUNT 1
  CCINPUT "100100000000"
  CCOUTPUT DISABLED
  TIMER DISABLED
  TIMERSTART 01/01/2014 00:00
  TIMERDELTA 001:00:00
  STEPBEGIN
    GENERATE 20 PPB SO2 5.000
    DURATION 45.0
    STANDBY
  STEPEND
SEQEND
SEQBEGIN
  NAME "05_NOXCOND"
  REPEATCOUNT 1
  CCINPUT "101000000000"
  CCOUTPUT DISABLED
  TIMER DISABLED
  TIMERSTART 01/01/2014 00:00
  TIMERDELTA 001:00:00
  STEPBEGIN
    GENERATE 350 PPB NO 4.000
    DURATION 45.0
    STANDBY
  STEPEND
SEQEND
SEQBEGIN
  NAME "06_NOSPAN"
  REPEATCOUNT 1
  CCINPUT "110000000000"
  CCOUTPUT DISABLED
  TIMER DISABLED
  TIMERSTART 01/01/2014 00:00
  TIMERDELTA 001:00:00
  STEPBEGIN
    GENERATE 600 PPB NO 3.000
    DURATION 45.0
    STANDBY
  STEPEND
SEQEND
SEQBEGIN
  NAME "07_NO2SPAN"
  REPEATCOUNT 1
```

```
  CCINPUT "010100000000"
  CCOUTPUT DISABLED
  TIMER DISABLED
  TIMERSTART 01/01/2014 00:00
  TIMERDELTA 001:00:00
  STEPBEGIN
   GPT 600 PPB 350 PPB 3.000
   DURATION 45.0
   STANDBY
  STEPEND
 SEQEND
 SEQBEGIN
  NAME "08_NOPREC"
  REPEATCOUNT 1
  CCINPUT "011100000000"
  CCOUTPUT DISABLED
  TIMER DISABLED
  TIMERSTART 01/01/2014 00:00
  TIMERDELTA 001:00:00
  STEPBEGIN
   GENERATE 100 PPB NO 6.000
   DURATION 45.0
   STANDBY
  STEPEND
 SEQEND
 SEQBEGIN
  NAME "09_NO2PREC"
  REPEATCOUNT 1
  CCINPUT "111100000000"
  CCOUTPUT DISABLED
  TIMER DISABLED
  TIMERSTART 01/01/2014 00:00
  TIMERDELTA 001:00:00
  STEPBEGIN
   GPT 100 PPB 70 PPB 6.000
   DURATION 45.0
   STANDBY
  STEPEND
 SEQEND
 SEQBEGIN
  NAME "10_CENOSP"
  REPEATCOUNT 1
  CCINPUT "111000000000"
  CCOUTPUT DISABLED
  TIMER DISABLED
  TIMERSTART 01/01/2014 00:00
  TIMERDELTA 001:00:00
  STEPBEGIN
   GENERATE 800 PPB NO 2.200
   DURATION 45.0
   STANDBY
  STEPEND
 SEQEND
 SEQBEGIN
  NAME "11_CENO2SP"
```

```
    REPEATCOUNT 1
    CCINPUT "110100000000"
    CCOUTPUT DISABLED
    TIMER DISABLED
    TIMERSTART 01/01/2014 00:00
    TIMERDELTA 001:00:00
    STEPBEGIN
      GPT 800 PPB 500 PPB 2.200
      DURATION 45.0
      STANDBY
    STEPEND
  SEQEND
  SEQBEGIN
    NAME "12_CENPNSPAN"
    REPEATCOUNT 1
    CCINPUT "101100000000"
    CCOUTPUT DISABLED
    TIMER DISABLED
    TIMERSTART 01/01/2014 00:00
    TIMERDELTA 001:00:00
    STEPBEGIN
      GENERATE 800 PPB NPN 2.200
      DURATION 45.0
      STANDBY
    STEPEND
  SEQEND
  SEQBEGIN
    NAME "STANDBY"
    REPEATCOUNT 1
    CCINPUT "001100000000"
    CCOUTPUT DISABLED
    TIMER DISABLED
    TIMERSTART 01/01/2014 00:00
    TIMERDELTA 001:00:00
    STEPBEGIN
      GENERATE 0 PPB O3 4.000
      DURATION 0.2
      STANDBY
    STEPEND
  SEQEND
  SEQBEGIN
    NAME "13_NPNPREC"
    REPEATCOUNT 1
    CCINPUT "011000000000"
    CCOUTPUT DISABLED
    TIMER DISABLED
    TIMERSTART 01/01/2014 00:00
    TIMERDELTA 001:00:00
    STEPBEGIN
      GENERATE 100 PPB NPN
      DURATION 45.0
      STANDBY
    STEPEND
  SEQEND
SEQLISTEND
```

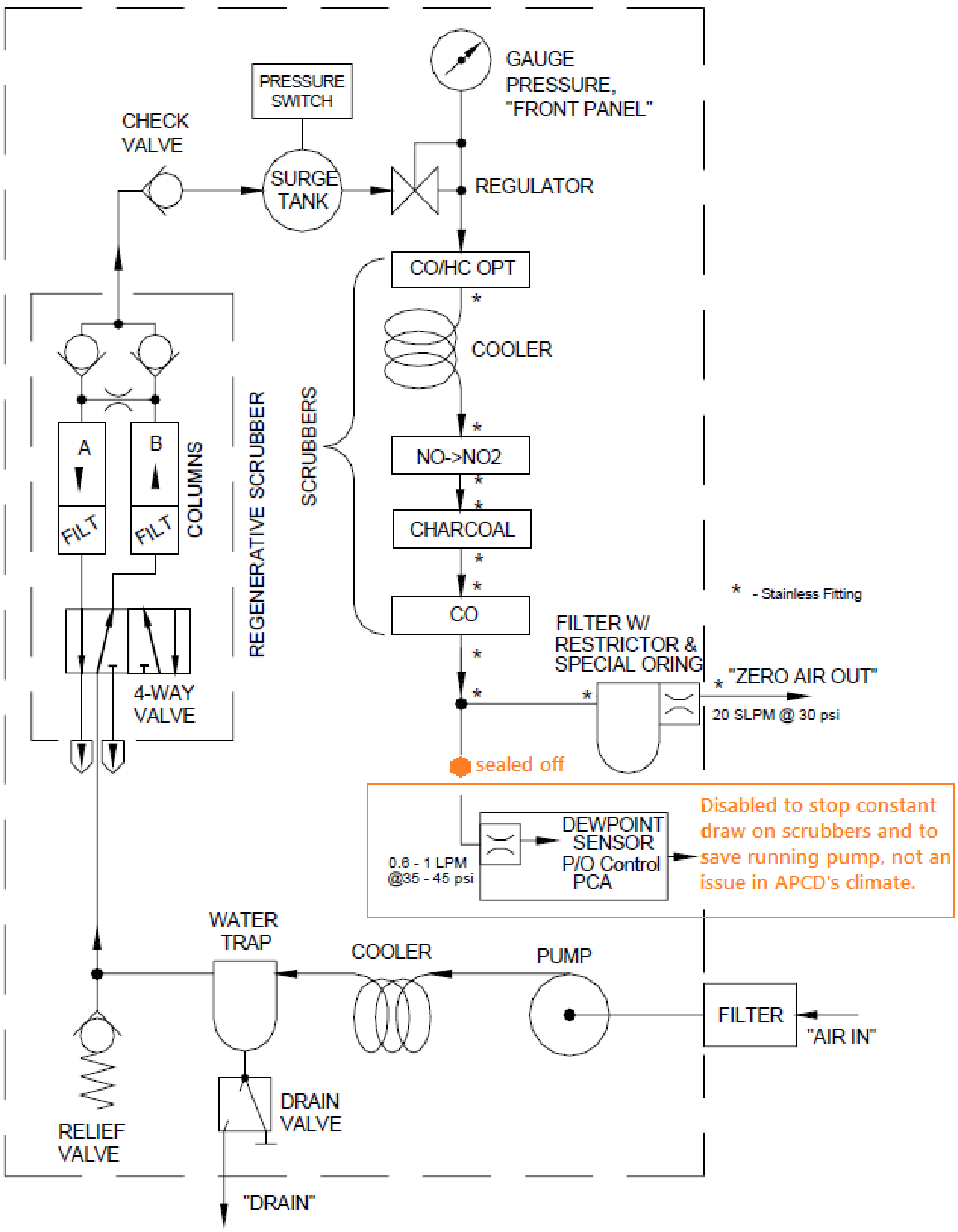

Figure 1. Typical zero-air supply system - TAPI 701H

STATION/MET

STATION: ______ / ______

	Supplier	Bottle #	Expiration	Conc	Month	Year
CO Span						
CO Prec						
NO						
NO2						
SO2						
O3	TAPI	SN:				

	Date						
Max Temp	<90F						
Min Temp	>50F						
CO Span Press	>200psi						
CO Prec Press	>200psi						
NO Press	>200psi						
NO2 Press	>200psi						
SO2 Press	>200psi						
Wind Speed	<100mph						
Wind Direction	>0<360						
Temp Shield	free						
Translator							
Data Collection							
	Operator						

Day	Time	Action	Initials	Date Online

Figure 2. Station and Met Log

API 700 / 701

700 sn: ___________ / ___________ STATION: ________________

1: A E T 2: A E T ______ / ______

Monthly Station Activities Log 701 sn: ___________ / ___________ Month Year

Monthly Station Activities Log	Date						
Cal Pressure	25 - 35						
Dil Pressure	25 - 35						
Reg Pressure	18 - 22 700EU: 7-10						
T-Flow	Set Point, >2						
Box Temp	ambient						
701 Pressure	25 - 35						
Charcoal	Changed?						
Solenoid Leak	<5 psi/min						
	Operator						

Day	Time	Action	Initials	Time Online

Figure 3. Calibrator Log

MAINTENANCE REPORT

DATE____

STATION____

ASSIGNED TO____

ORIGINATED BY____

ANALYZER or EQUIPMENT____ S/N______________

MALFUNCTION DESCRIPTION OR COMPLAINT

ACTION TAKEN

DATA TO BE DELETED (IF ANY)

ENTER EXACT DATES AND DATA HOURS

COMPLETED BY____

COMPLETION DATE____

J:\zsfiles\forms\forms.xls:MaintRpt

Figure 4. Maintenance Report Form

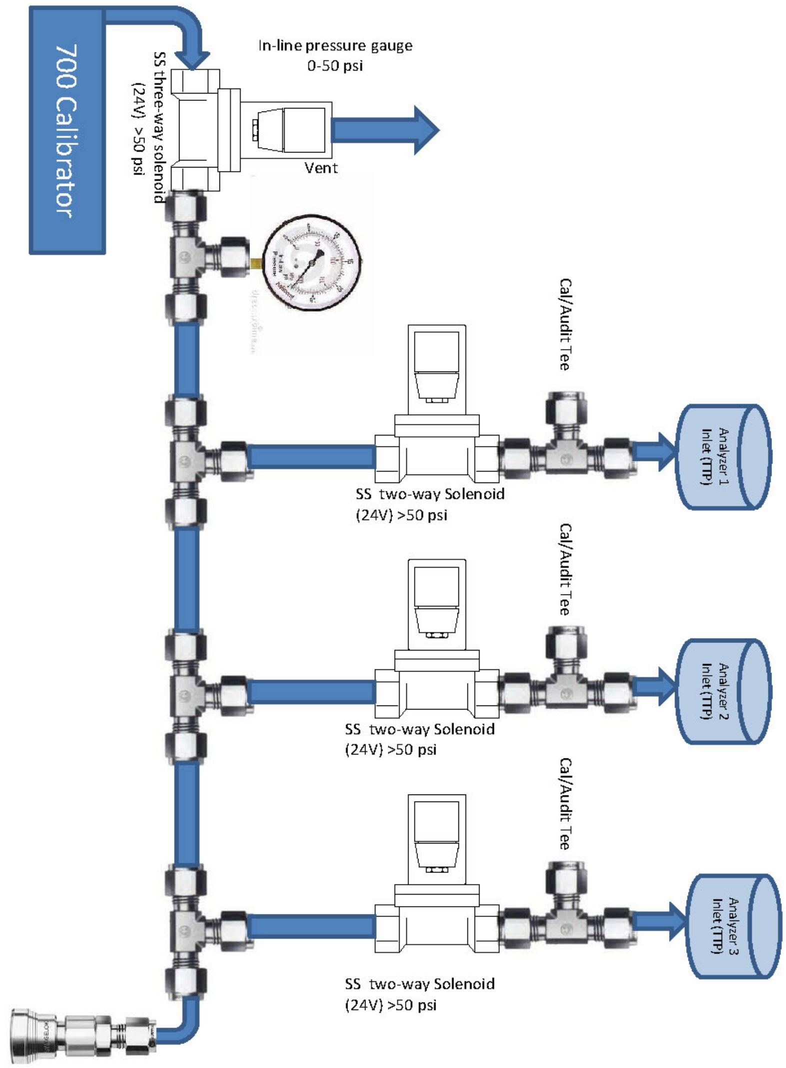

Figure 5. Calibration Solenoid Manifold