Air Pollution Control Division

Technical Services Program

APPENDIX GM1

Standard Operating Procedure for the Operation of Gaseous and Meteorological Monitoring Shelters

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Standard Operating Procedure for the Operation of Gaseous and Meteorological Monitoring Shelters

1 SCOPE AND APPLICABILITY

This standard operating procedure (SOP) document describes the procedures used by members of the Air Pollution Control Division (APCD) Technical Services Program (TSP) to operate continuous monitoring analyzers at state of Colorado, Department of Public Health and Environment (CDPHE) air quality monitoring sites. This includes analyzers at State and Local Air Monitoring Stations (SLAMS), special purpose monitoring (SPM) and NCore monitoring stations. The CDPHE uses a combination of Thermo Scientific CO and Teledyne gaseous analyzers in its air monitoring network and this SOP covers all these analyzers. These procedures are a supplement to APCD's Quality Assurance Project Plan (QAPP), the latest information published in the Code of Federal Regulations CFR), and the Operator's manuals for analyzers and data loggers.

1.1 Method Overview

Methods described in this SOP are widely variant, and include generalized methods adapted from manufacturers. Some methods will also borrow from other established SOPs. Methods include, but are not limited to, HVAC cleaning, temperature sensor checks, Teflon sample line changes and maintenance, leak checks, filter changes, and instrument verifications.

1.2 Format and Purpose

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

2 SUMMARY OF METHOD

General site operation is homogenous in several respects, regardless of analyses being performed. Operations that are required at any monitoring shelter are included here to provide centralized maintenance procedures. Methods for site operation and maintenance are described below and in appropriate companion SOPs and manuals.

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 this SOP or in the QAPP Appendix P2.

4 HEALTH AND SAFETY WARNINGS

For a thorough discussion of safety protocols please see the CDPHE Safety Manual available at https://sites.google.com/state.co.us/cdpheintranet/employee-resources/employee-safety. Note that a CDPHE login is required. Information on incident reporting and first aid are provided in the CDPHE Safety Manual. Excerpts below are sections from that manual that pertain directly to site operation.

Walking and Working Surfaces

PPE

Use footwear appropriate for the surface you are walking or working on.

Slip-on traction control devices may be used as well.

Sidewalks, walkways

Snow and ice should be cleared as much as practical before the majority of employees arrive on site to allow safe access.

Ice/Snow melt and/or sand may be used to provide additional traction.

Trails, roads and other passageways

Do not attempt to walk or drive across flooded roadways or trails where the depth is unknown.

Bridges

Do not attempt to cross bridges that appear to be unsafe, especially in vehicles.

Housekeeping

Good housekeeping is a means of prevention of personal injury. Good housekeeping leads to efficiency of work within the space. The following housekeeping and storage rules must be followed:

Aisle ways and exit routes shall be kept clear and unobstructed.

All indoor walking surfaces shall be reasonably free from oil, water, trash, tripping hazards, etc.

Materials that have exceeded their shelf life or no longer meet original specifications should be properly disposed of.

Cabinets or files drawers above head-height and window sills shall not be used for storage.

No material should be stored on the top surface of any storage cabinet, locker, or other structure that is not specifically designed for this purpose and provided with a protruding ledge to prevent falling of stock.

In no case should storage exceed six feet in height; for buildings equipped with sprinkler systems for fire suppression, no material should be stored within 18 inches of a sprinkler head.

Heavy objects should never be stored above waist height or on elevated decks, unless mechanical lifting equipment is used.

Dollies or wheeled carts should be available to move materials.

Adequate lighting should be provided for reading labels and identifying materials.

Every way of exit should be continuously maintained free of obstructions or other impediments to immediate use. Exits shall be clearly marked and adequately lit.

Free, unobstructed access should be maintained to electrical panels, safety disconnect switches, and fire extinguishing equipment or alarms. A minimum 18 inch clearance should be maintained.

All places of employment, passageways, storerooms, and service rooms shall be kept clean and orderly and in a sanitary condition.

The floor of every work area shall be maintained in a clean and, so far as possible, a dry condition. Wet floors shall either be dried or reported to building maintenance. Cords, hoses and tools shall not be left on floors when not in use and shall not be run across ANY walkways.

Portable Ladders

Step stools should be used as needed to access stored items. If items cannot be accessed safely by the employee, or if a step stool is not available, employees should contact building operations for assistance.

APCD uses telescoping ladders at sites where a ladder is not available. This ladder should be extended a minimum of three rungs above the level being climbed to.

Fire Prevention

Smoking is not allowed in any state building or vehicle. Smoking is only allowed in designated outdoor smoking areas. Do not throw matches, cigars, cigarettes, etc., into wastebaskets – use only ashtrays made of non-combustible material.

Follow all fire ban rules as defined by local authorities.

Fire prevention procedures:

Store all flammable liquids in approved safety containers with flame arrestors and spring actuated caps.

Keep acids and bases or oxidizers in separate cabinets.

Store poisons separately.

Keep fire equipment, such as fire extinguishers, accessible at all times.

Never use oil or grease on oxygen equipment.

Fire extinguishers

Fire extinguishers must be immediately accessible by the responding fire department. They should not be used by employees on the CDPHE campus.

Fire extinguishers will be mounted so that employees can easily locate and identify them. Typically signage is used indicating the location of extinguishers. Fire extinguishers may be installed in vehicles for field use in lieu of a fire extinguisher at each monitoring shelter. They shall be maintained in a fully charged, operable condition.

Discovering a Fire

Call 911

Alert other persons in the immediate hazard area. Notify the supervisor and/or emergency services.

Working Alone / Isolated Workers

Isolated workers must ensure their safety by letting someone else know where they are. Traveling workers should leave word with their supervisor or a co-worker of their intended destination and expected time of arrival and return, with contact information for the destination if available. At a minimum, contact another person periodically to confirm your location, if you remain isolated. If your destination changes, advise your designated contact your new location as soon as possible. When traveling by vehicle, practice defensive, courteous driving habits. Try not to drive at night, especially at the end of a long field trip when being tired might be a factor. Carry a change of clothing, a coat, food and water, and a first aid kit. Be prepared mentally and physically to survive in a bad situation.

Additional precautions are necessary for many employees, who routinely work alone in remote locations.

First, assess the hazards including ease or difficulty of motorized access, likelihood of radio or cell phone coverage, and equipment or tools to be used. Consider the likelihood of fatigue, and the legality to perform the task alone. For example, it is illegal to enter a permit-required confined space alone. Consider the ability and tools necessary if the vehicle breaks down or gets stuck, and adverse weather conditions.

Have a backup method to let someone know your location before you are out of reach.

In addition to items listed above, employees are encouraged to carry maps, a compass, and/or a GPS unit (with spare battery) and know how to use them. If going to the backcountry during hunting season, wear blaze orange.

If the designated contact does not hear from the isolated worker on schedule, that person should attempt to contact the person, either visually or by radio or phone. If unable to contact the person, notify at least one other person and begin a search.

Lifting and Material Handling

Store heavy hand carried items at heights where little or no lifting or reaching is required to move them. Do not lift more than 50 pounds or, if more, you must have assistance. Do not unnecessarily place objects on the ground if they must be picked up again soon after. Minimize your risk of injury by getting proper exercise and building up leg and abdominal muscles. When lifting, use the strong leg muscles to do most of the work. Do not try to hold a heavy object away to avoid getting dirty. Lift and carry items close to your body with a towel or similar object to protect your clothing. Use hand carts or dollies to move heavy objects. Get help to lift or move heavy objects. Plan your movements. Be sure shelves will support the weight of objects placed on them.

Vehicle Safety

All field personnel operating a state of Colorado fleet vehicle must read and sign the Vehicle Safety portion of the CDPHE Safety Manual. Transportation of large gas cylinders (described below) requires the use of an appropriate vehicle with bottle straps and/or stands, and the bottles must be in a separate compartment from the passenger. An exception to the separate compartment requirement may be made for small calibration gas cylinders.

Chemical Hazards:

Purafil is used in the zero air generators to remove nitrogen oxide from air. Sodium permanganate is a component within Purafil and should be handled with care. Sodium permanganate is a known irritant and care should be taken to avoid exposure to open wounds, burns, or mucous membranes. Prolonged exposure (usually over many years) to heavy concentrations of manganese oxides in the form of dust and fumes, may lead to chronic manganese poisoning, chiefly involving the central nervous system.

Condenser coil cleaner is used during HVAC maintenance and cleaning. Read, understand, and respect all indicated safety precautions and directions on the cleaner label.

Gas Hazards

Shelters that monitor for CO, SO2, and NO and their oxides use compressed gas cylinders as the quality control standard. Compressed gasses require placards and pose the primary threat of oxygen displacement (particularly SO2 and NO which are balance nitrogen). Regulators and calibration gas supply lines should be regularly inspected for leaks and repaired, if needed, immediately.

Transportation of compressed gas cylinders must follow DOT guidelines. Use of an oxygen sensor while transporting cylinders is highly recommended.

Compressed gas cylinders must be secured properly while in transit and on site, either with wall mounted straps or chains.

Electrical Hazards

1. Always use a third ground wire on all instruments.

2. If it is necessary to work inside an analyzer while it is in operation, use extreme caution to avoid contact with high voltage inside the analyzer. The analyzer 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 analyzer whenever possible when servicing or replacing parts.

5 CAUTIONS

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

1. Refer to the appropriate analytical SOP for cautions about analyzers and meteorological equipment.

2. Keep the interior of the shelter clean.

3. 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.

4. 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.

5. Shipping of cylinders is governed by the DOT. Contact the DOT or your local courier about the proper procedures and materials needed to ship high pressure cylinders.

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. Many analyzers have interference from water vapor. Water absorbs very strongly across several bands of IR spectra.

6.1 CO Interferences

There is a quenching effect of water on the absorption of infrared light by CO. The CO analyzer is equipped with a permeation dryer, which effectively removes all water and water vapor. The dryer should be routinely checked for leaks but is not otherwise user serviceable. In order to measure in the ppb range, it is important for the detector to be operated at a very stable temperature. To obtain a stable baseline, the temperature of the detector and optical bench must be maintained within ±1.0 degree Celsius (°C) of the set value.

6.2 NOx Interferences

The most common source of interferences is from gasses that cause third body quenching. Third body quenching occurs when other molecules in the reaction cell collide with the excited NO_2, causing the excited NO_2 to return to its ground state without releasing a photon of light. Quenching is an unwanted phenomenon and the extent to which it occurs depends on the properties of the collision partner. Larger, more polarized molecules such as H_2O and CO_2 are the most significant quenching interferents of NO chemiluminescence. Smaller less polar and electronically "harder" molecules such as N_2 and O_2 can cause interference, however, the concentrations of N_2 and O_2 are virtually constant in the ambient air measurements, and hence provide a constant amount of quenching that is accounted for in the calibration of the analyzer.

6.3 SO_2 Interferences

The most common source of interference is from other gases that fluoresce in a similar fashion to SO_2 when exposed to UV Light such as Nitrogen Oxide (NO) and Poly-Nuclear Aromatics (PNA), and certain hydrocarbons, of which meta-xylene and naphthalene are the most pervasive. The TAPI 100 series analyzers have been successfully tested for their ability to reject interference from most of these sources.

6.4 O_3 Interferences

UV ozone analyzers measure ozone concentration by absorption of electromagnetic radiation at a wavelength of 254 nm. Any other gas in the air sample that also absorbs at that wavelength could present interference. The UV analyzer operates by comparing absorption measurements of the sample air with measurements of the same sample air after removal of only the ozone by an ozone scrubber.

Ideally, a gas that absorbs at 254 nm will do so equally in both measurements, and the effect will cancel. The scrubber must remove 100% of the ozone while quantitatively passing other gases that absorb at 254 nm. Some gases, however, may be partially or temporarily absorbed by the scrubber, such that their concentration is not equal in both measurements. An interference can occur when a gas absorbs at 254 nm or produces some other physical effect (such as water condensing on scratches in the cell window), and does not pass freely through the ozone scrubber. Hence, proper scrubber performance is critical to minimizing interferences.

Negative interferences result from incomplete removal of ozone by the scrubber and from loss of ozone by reaction or absorption in dirty inlet lines, filters, analyzer plumbing components, and the measurement cells, particularly with long residence times. Condition all new sample lines and filters by exposing them to high concentrations of ozone (0.4 ppm) for at least 30 minutes. New tubing and filters that are not conditioned will absorb ozone for some time.

Ozone breakthrough has been shown to be a transient problem occurring primarily under humid conditions. Before use in high humidity environments, new scrubbers may need to be pre-treated by proprietary methods recommended by the manufacturer to saturate ozone absorption or reaction sites. Ozone breakthrough can also occur in dry conditions if the scrubber is not replaced according to the manufacturer's recommended schedule.

Three common positive interferences for UV ozone analyzers are discussed below. Specific data on some interferents are substantially incomplete. The guidance provided here is the current best judgment based on available information and is subject to modification pending availability of further data.

Operators are encouraged to report any observations or anecdotal data that might add to the understanding or awareness of interferences or other anomalies in ozone measurements with UV analyzers. Observations can be noted on the analyzer log sheet and as messages to Central.

Water vapor can affect UV-based ozone measurements under some conditions. When the humidity of the sample air is high enough to approach saturation, condensation of water may occur at various points in the sampling system or analyzer. Further, the scrubber may absorb water vapor such that some point of time is required before the air leaving the scrubber is at the same humidity as the sample air. At high humidity, condensation can also occur on scratches in the cell windows. During transition periods when the humidity of the sample air is increasing, such condensation may even occur during the sample air measurement, but not during the zero ozone measurement, resulting in a positive interference.

High humidity or condensation in the sample air may also affect the ability of the scrubber to pass other potentially interfering gases, such as aromatic hydrocarbons. Although condensed water did not affect ozone measurements in clean air tests, condensation in a dirty inlet line and other inlet components—especially particulate filters—is notorious for reducing measured ozone concentrations. Large amounts of liquid water can reduce or prevent sample airflow in inlet lines and filters and may cause damage to the analyzer cells or windows if it enters the analyzer.

Data quality will be enhanced by following the recommendations.

Operate UV ozone analyzers to avoid condensation of moisture anywhere in the analyzer, sample inlet line, or filter. Condensation may first occur in the particulate filter because the slight pressure drop there favors it. The best way to avoid condensation in the inlet sample air is to assure that the temperatures of all locations in the analyzer and sample inlet line remain above the dew point temperature of ambient air.

In sample line condensation can be reduced by maintaining a monitoring shelter at temperatures no lower than 26-27ºC (79-81ºF), if possible, in areas where dew point temperatures are high. Outdoor ambient air dew point temperatures can exceed 27ºC (80ºF) on hot, summer days, particularly in coastal areas or following rain.

Make sure that air conditioners or cool air ducts do not blow directly on the analyzer or on the inlet line.

Check the particulate filter and lines frequently for condensation, especially at times when the outdoor dew point temperatures are likely to be the highest (afternoons or hot, rainy days). Today's condensation may be gone by tomorrow.

Many aromatic hydrocarbons are known both to absorb light at 254 nm and to be readily absorbed or adsorbed on surfaces exposed to air samples. Smog chamber studies producing ozone by irradiation of toluene/NO_x mixtures showed that benzaldehyde and other aromatic photo oxidation products such as *o*-cresol and *o*-nitrotoluene were almost completely removed by ozone scrubbers used in ozone UV analyzers. Although scrubber retention of aromatic hydrocarbons produces a positive interference initially, the retained compounds may be released later when conditions change, giving rise to a negative interference. Under humid conditions, compounds may be desorbed from the scrubber.

Generally, aromatic hydrocarbons cannot be significantly removed from air samples without also altering the ozone concentration. Therefore, the only practical way to avoid interference from these compounds is to avoid sitting a UV analyzer in an area that may have significant concentrations of aromatic hydrocarbons.

Problems with hydrocarbon interferences can be minimized by taking the following precautions:

- Avoid applying herbicide and pesticide formulations near the monitoring shelter, to prevent interferences from outgas of hydrocarbons used in the formulations.

- Use a non-UV type analyzer when an ozone monitoring site must be located in an area where aromatic hydrocarbon concentrations are high. Chemiluminescence ozone analyzers are not affected by interference from aromatic hydrocarbons and are recommended for such sites.

Interference from mercury is generally not a problem at most sites because atmospheric concentrations are usually very low, but the possibility of locally high mercury concentrations in the vicinity of a monitoring site does exist. Local atmospheric contamination from mercury has been attributed to a wide variety of sources, ranging from dental fillings to herbicides used near a monitoring shelter. Anecdotal reports also suggest that field operators must be alert to the possibility of abnormal ozone readings caused by mercury vapor from broken equipment such as mercury thermometers. In one case, high ozone readings for nearly a year were attributed to a broken thermometer found on the roof near the sampling intake. In another, low readings were obtained for a week due to a broken thermometer found in a wastebasket inside a shelter where inside air was used to generate zero air. In both cases, ozone readings returned to normal range after the spilled mercury was removed.

Minimize the effect of mercury interference by taking the following precautions:

- Keep the monitoring station free of spilled mercury for measurement as well as health reasons.

- Inspect the area around a monitoring site for possible contamination from spilled mercury, application or disposal of mercury-containing chemicals, or other sources of possible mercury contamination.

- Never use a vacuum cleaner to pick up spilled mercury. More contamination can result if mercury vapor is spread through the area and liquid mercury remains in the bag. Instead, use a commercially available mercury clean-up kit that employs sponges and a bulb-type suction device.

- Examine ozone measurement data for unusual patterns or verify data with a non-UV ozone analyzer because the evidence of mercury contamination in the area may not be obvious.

7 PERSONNEL QUALIFICATIONS

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

8 APPARATUS AND MATERIALS

8.1 Monitoring Equipment

8.1.1 Instrument Shelter

A shelter is required to protect the analyzer from precipitation and adverse weather conditions, maintain operating temperature, provides security and electrical power. The following are operation shelter temperature requirements for the SLAMS and NCore networks (US EPA, 2013) (US EPA, 2005).

> SLAMs: 5-38 ºC (20-30 ºC preferred), evaluated on hourly averages at <± 2ºC Standard Deviation over 24 hours.
>
> NCore: 20-30°C, evaluated on hourly averages, daily changes in hourly temperature should not exceed ±5 °C over a 24-hour period.

8.1.2 Monitoring Equipment

The APCD TSP uses a combination of Thermo Scientific and TAPI monitors. Please review the theory of operation in the respective manual for more information.

To measure CO, the APCD uses a Thermo 48i-TLE trace level analyzer with a permeation dryer. A low flow of purge air is required to prevent dust buildup on the correlation wheel. The 48i-TLE internally measures and adjusts its baseline every six hours at 3, 9, 15, and 21 hours.

SO2 is measured by TAPI 100 series fluorescence analyzers. UV excites SO_2 and the SO_2* fluoresces on its return to a ground state. The fluorescence is measured and used to calculate SO_2 concentrations. 100 series analyzers do not adjust themselves to a baseline measurement and the APCD TSP may elect to perform post-processing data adjustments to account for any measured drift.

Oxides of nitrogen, including NO, NO_2, NOx, and NOy are measured using TAPI 200 series analyzers. The instrument exposes the sample gas to O_3 which causes NO to chemiluminesce, which is measured directly as NO. A catalytic reaction through either molybdenum or a photolytic cell converts NO_2 in the sample stream to NO, which is measured in addition to the existing NO, providing a NOx measurement. The difference between NOx and NO is considered the NO_2 measurement. Trace level analyzers have a gold plated reaction cell and pre-reactor to account for hydrocarbon interferents, and a larger pump providing a higher flow rate. NOy analyzers differ in that the reaction cell is at the inlet, converting NO_2 before any reaction that may have taken place in the sample stream. NOy analyzers require higher flow, and are equipped with a bypass pump chassis.

True NO_2 (a nomenclature intended to separate this measurement from the NOx-NO and NOy-NO measurements of 'NO_2') is measured by TAPI 500 series analyzers which use cavity-attenuated phase-shift spectroscopy (CAPS). The absorbance of light at 450nm is directly proportional to both path length and the concentration of NO_2 (Beer-Lambert law) providing a direct NO_2 measurement. The absence of a catalyst and the reduction in overall componentry of the 500 analyzer provides a faster and more precise NO_2 measurement.

O_3 is measured by TAPI 400 series analyzers. The 400 series analyzers measure the amount of UV light absorbed by the sample gas as it passes through a sample cell to determine the O_3 concentration per the Beer-Lambert law. A reference stream uses an ozone scrubber to determine the amount of possible interferents and removes those from the ozone measurement programmatically.

8.1.3 Test Gas System

The APCD uses three types of test gas systems, direct injection, dynamic dilution, and dynamic generation. For more information see Section 10.1.

Predominantly only used for CO, direct injection connects a NIST-traceable test gas bottle directly to the analyzer using a solenoid to switch between a span and precision level tank. The analyzer uses an internal solenoid to allow test gas into the sample stream.

Dynamic dilution uses a TAPI 700 calibration system. The 700 series uses a pair or trio of mass flow controllers to blend higher concentration NIST-traceable test gasses with air that has been purified of the gas being analyzed. This blended gas is then introduced to the sample inlet, using a solenoid manifold if more than one pollutant is measured at a site. The 700 is capable of titrating NO using an ozone generator, creating NO_2 (and O_2) for introduction to the TAPI 200 and 500 series analyzers. The generation of ozone in this case is identical to the method used in the third test gas system below.

Dynamic generation uses a TAPI 703 ozone calibrator. The 703 calibrators are certified against primary standards following EPA guidance, possibly through an intermediary standard. The 703 generates ozone using UV light and purified air, varying the voltage of the UV source to achieve the appropriate concentration, which is verified by an internal analysis bench. The test gas is then introduced directly to the O_3 sample inlet.

Note that it is possible to use the ozone generation of a TAPI 700 to test the performance of an O_3 analyzer. In practice this is only done when a 703 is not practical since the certification frequency of ozone transfer standards is more frequent than other certifications required by a 700.

8.1.4 Data Acquisition System

The APCD employs four 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, the ESC 8864 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, 8864, 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, 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, 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 builds on the 8832 controller with complete security and protection against viruses, unauthorized use, and hosting unauthorized software by the use of SSH and stronger password encryption.

For more details, refer to APCD's D1, Datalogger & Central SOP or the individual operator manuals (Environmental Systems Corporation, 2021).

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 D1, Datalogger & Central SOP.

8.1.5 Wiring, Tubing and Fittings

Teflon™ and borosilicate glass are inert materials that should be used exclusively throughout APCD's ambient air intake system. It is recommended that Polytetrafluoroethylene (PTFE), Fluoroethylpropylene (FEP) Teflon™, perfluoroalkoxy (PFA) tubing be used. PTFE or FEP Teflon is the best choice for the connection between an intake manifold and the bulkhead fitting. PFA is a newer formulated Teflon than FEP. Like FEP, it is translucent which is also not machined, but unlike FEP, it can be molded into fittings. It has been accepted as equivalent to FEP Teflon but there is no real advantage to using PFA. The use of stainless steel tubing and fittings in the sample train is no longer permissible for CO analyzers. Examine the tubing and discard if particulate matter has collected on the tube's interior. See Table 2 below for sample line maintenance requirements. All fittings and ferrules should be made of Teflon™. 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

All gas calibration and quality control concentrations are obtained by direct injection or dynamic dilution of gas from cylinders whose contents must be traceable to NIST Standard Reference Material (SRM) gases via EPA Protocol procedures.

8.1.7 Spare Parts and Incidental Supplies

In addition to the wiring, tubing, and fittings in Section 8.1.5, 1-micron sample filters, activated charcoal, and Purafil will be required for site maintenance.

8.2 Certification Equipment

Calibration and maintenance of the shelter temperature sensors requires a digital thermometer measuring to tenths of a degree Celsius. This field transfer standard should be verified quarterly against an in-house thermometer that is traceable by the manufacturer to a NIST standard.

HVAC maintenance may require a digital voltmeter, with a selectable voltage range from 0 to 240. It should be annually verified against the in-house voltage standard which has NIST traceability.

9 CALIBRATION

Analyzer calibration is specific to the method of detection and is covered in the GM2 Gas Analyzer Calibrations SOP of this QAPP.

10 OPERATION AND MAINTENANCE

10.1 Introduction and Description of Monitoring

The CDPHE APCD uses Thermo Scientific 48i-TLE monitors for carbon monoxide, and Teledyne analyzers for all other analytes. In some cases, the TSP uses trace level instruments, particularly when mandated by EPA.

The operation manual gives the details and requirements for each analyzer. The manuals are complete and cover all necessary procedures and controls for successful operation and maintenance. Addenda for trace level instruments are also available. Manuals, as well as this SOP, are required to be available at each monitoring site, either hard copy or digital, and at the TSP office. Operation manuals for data loggers provide their operating instructions and are also kept at each monitoring site and the central TSP office.

Each site is assigned to a group of site operators qualified by formal training, experience, on-the-job training, and courses offered by EPA. This group is responsible for all aspects of assigned site monitoring operation, including but not limited to maintenance, repair, documentation updates, and site logs. In addition to keeping the site operational with a minimal downtime, any of the senior level instrument specialists may be called upon to accept the responsibility of training of new TSP employees and/or contracted operators.

All of the gaseous analyzers have some capacity to store data, normally as internal digital data storage. TSP considers the data acquired by the site data logger system when properly validated to be the primary data source with the site analyzer internal digital data storage serving as an emergency backup and verification system.

Data quality and validity determinations are based partly on quality control data produced from onsite test systems. An “Onsite Test System” is a system of control hardware, software and standards at the monitoring location that is capable of accurately generating and introducing known concentrations of test gas to a monitoring system. These onsite test systems are capable of performing “Performance Tests” and “QC Precision Tests”. The different tests are used to assess and document different aspects of system performance and data quality. A “Performance Test” is an automated or manual evaluation of a monitoring system’s performance and is achieved through the introduction of a known concentration of test gas, typically at the span or precision level, and is not intended to be submitted to EPA for determinations of bias. A “Quality Control (QC) Test” is a manual check initiated every one per week by APCD staff, who can attest to its validity, and is achieved through the introduction of a known concentration of test gas at the precision level and whose purpose is to be submitted to EPA for determination of bias. “Performance Tests” and “QC Tests” are inherently different and are initiated by different sequences within the data logger. These sequences consist of phases that can vary in concentration, order, and duration.

Table 1. Test Targets

Pollutant	Span	Precision
Non-diluted EPA protocol CO	9 ppm	4 ppm
Diluted EPA protocol CO	4 ppm	1 ppm
NO2	300-400 ppb	60 ppb
SO2	80 ppb	20 ppb
O3	0.240 ppm	0.060 ppm

The APCD uses three different types of onsite test systems within the air monitoring network. Explanations of the onsite test systems are as follow.

Non-diluted EPA protocol test gas system

In this system the test gas is connected directly to the analyzer.

The onsite test gas delivery system introduces known test gas concentrations to analyzers in the network directly from compressed gas bottles into the sample stream at atmospheric pressure, normally by venting through the sample inlet. These test gases are considered transfer standards which meet the EPA protocol standard of certification and NIST traceability. To provide the desired span/precision concentration a solenoid selects which gas cylinder feeds the system. This system is enhanced by the use of the station data logger to control the span and precision process and data collection in the same manner if performed on site, remotely, or automatically. This standardizes the test process, reducing process errors. Data logger control of the tests and data averaging allows the tests results to be collected and reported by the central computer.

Diluted EPA protocol test gas system

The test gas and a zero-air source are connected to a dynamic dilution calibrator, which then connects to the analyzer. The onsite test system introduces known test gas concentrations to analyzers by blending known concentrations of test gases with diluent air having zero concentration of the test pollutant. A bottle of high concentration test gas and a source of diluent gas are connected to a Teledyne model 700x dilution calibrator containing two or more calibrated mass flow controllers. The dilution calibrator can then be instructed to generate calculated concentrations which are fed to a solenoid manifold configured to allow the gas to the sample inlet of the analyzer at atmospheric pressure. In the event a shelter samples for only a single pollutant, no manifold is necessary. The combination of the NIST traceable test gas and the calibrated mass flow controllers provides sufficient confidence in the calculated concentrations. This system is ideal for monitoring stations with span and precision requirements that are not otherwise achievable by the non-diluted EPA protocol test gas system. As with the non-diluted EPA protocol system, this system is enhanced by the use of the station data logger to control the span and precision process and data collection in the same manner if performed on site, remotely, or automatically. This standardizes the test process, reducing process errors. Data logger control of the tests and data averaging allows the tests results to be collected and reported by the central computer.

NO_2 titration of diluted EPA protocol test gas

NO_2 test gas is generated from NO gas using the gas-phase titration (GPT) function within the 700 dilution calibrator. The principle of GPT is based on the rapid gas-phase reaction between NO and O_3 that produces stoichiometric quantities of NO_2 as shown by the following reaction:

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

If the initial and final NO concentrations for this reaction are known, resulting concentration of NO_2 can be determined. Ozone is added to excess NO in the dilution calibrator, and the NO channel of the chemiluminescent analyzer detects the change in NO concentration. After the addition of O_3, the observed decrease in NO concentration is equivalent to the concentration of NO_2 produced. The concentration of NO_2 generated may be varied by increasing or decreasing the concentration of O_3 produced by a stable O_3 generator.

Generated EPA test gas system

The test gas is generated in a NIST-traceable ozone generator, which then connects to the analyzer.

The onsite test system generates ozone from zero air that has been dried and scrubbed for ozone. The formation of ozone from oxygen is endothermic. When exposed to ultraviolet light an oxygen molecule in a ground state will absorb the light energy and dissociate to a degree dependent on the energy and the particular wavelength of the absorbed light. The oxygen atoms then react with other oxygen molecules to form ozone. An ozone generator is calibrated against an EPA transfer standard such that voltages appropriate to produce the desired amount of ozone are stored in the source and can be altered programmatically during a source calibration. Combining the use of drying agents and ozone scrubbers before the generator with the known voltage of the generating lamp provides adequate confidence in the concentration of ozone being produced and introduced to the analyzer. This system is ideal for ozone sampling test gas systems since ozone is very reactive and difficult to store. This system is enhanced by the use of the station data logger that is capable of controlling the quality control test gas processes and data collection in a repeatable manner. Data logger control of the tests and data averaging allows the tests results to be collected and reported by the central computer.

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 forms are readily available on site. 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 this SOP.

The forms in routine use are:

- Figure 1. Station and Met Log
- Figure 2. CO Log
- Figure 3. SO_2 Log
- Figure 4. NO Log
- Figure 5. NO_2 Log
- Figure 6. O_3 Log
- Figure 7. O_3 Source Log

- Figure 8. Dilution Calibrator Log
- Figure 9. Transmissometer Transmitter Log
- Figure 10. Transmissometer Receiver Log
- Figure 11. Nephelometer Log
- Figure 12. Maintenance Report Form

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 check 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.

The bi-weekly inspection is performed two weeks after the beginning of each month and as needed.

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 once every week.

The Monthly inspection is performed at the beginning of each calendar month.

Upon completion of an inspection, log entries onto the Station and Met Log (Figure 1), all related gaseous pollutant logs, 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 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 digital “message to central” from the data logger for all non-scheduled maintenance activities.

10.5 Routine Preventative Maintenance and Scheduled Activities

Preventive maintenance inspections and services should follow the intervals recommended 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 analyzer log sheets along with the digital “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.

Table 2. 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.
10.6.2	Check all analyzers for faults and operability. Verify that the data logger is working correctly and reported values match the analyzer display.
	If equipped, observe the operating condition of zero air pack. Check for faults and short cycling.
	Remove trash when waste receptacles are full. Remove from shelter all odorous trash, such as leftover food and food packaging.
10.6.9 Figure 1	Leave a “message to central” and a site log entry summarizing purpose of visit and a summary of all maintenance performed
Every Week	
10.6.11	Perform Manual Quality Control Precision Test – Performed by APCD staff
Bi-weekly Inspection / Maintenance	
10.6.2	If onsite, note analyzer operational and diagnostic parameters on analyzer log sheets. • Check results from previous night’s Performance Test • Using the log sheet as guidance, record the analyzer calibration factors and analyzer diagnostic test parameters on analyzer log sheet. • Record any notes and initial the log sheet.
	If conducting a virtual site visit, review all diagnostics in AirVision. See appendix D1. Virtual site visits cannot be conducted at sites where diagnostics are not digitally collected. Ensure all diagnostics are within acceptable ranges by comparing them with Figures 1 through 8 as appropriate. Note any deviation in the “message to central”.
10.6.9	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.
Monthly Inspection / Maintenance	
	Perform Every Onsite Visit and Bi-weekly Inspection / Maintenance as defined above. Monthly inspections cannot be conducted virtually.
Figure 1	Log all bottle gas supply pressures and station minimum and maximum temperatures on station log sheet. Reset the thermometer if available. Enter any notes and initial station log sheet.
	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.
	Check analyzer readout and data logger readout for agreement. Verify agreement between devices is within ±0.2 ppm for CO and O3, ±1 ppb for SO2 and NOx.
10.6.7	Inspect and empty water drop out system, (if equipped) – note on analyzer log sheet if water found. If flask is removed, perform a leak check after reassembling the system.
10.6.4	Check dessicant moisture content and replace if mostly pink.

Procedure or Resource	Description
	Check associated wiring, power cables, and plumbing (lines and fittings) for wear, damage and proper installation.
	Inspect analyzer fan filters and clean as necessary (if equipped).
10.6.8	Check analyzer time against a National Institute of Standards and Technology traceable time piece (i.e. cell phone) and adjust if (>± 1 min) see analyzer manual or clock procedure. For changes to a data logger clock contact GMM supervisor or central PC staff first.
10.6.5	Check that the internal data acquisition program in the analyzer is operational.
10.6.3	Replace sample filter. Leak check the analyzer.
10.6.7	Perform leak check of test gas manifold solenoid/s (if equipped).
	Inspect the sample inlet cup. Clean or replace if necessary.
Appendix GM8 – Section 9.3.5	Verify accuracy of the shelter temperature sensor.
Figure 1 **Figure 2** **Figure 3** **Figure 4** **Figure 5** **Figure 6** **Figure 7** **Figure 8**	Fill out new monthly station, analyzer, and calibrator (if equipped) log sheets for the upcoming month. Include the following key elements: • Analyzer log sheet – site name, month, year, analyzer range and analyzer firmware, analyzer 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 • Calibrator log sheet - site name, month, year, model, firmware, SN and other appropriate info required by log sheet
	Upon completion of the Monthly Maintenance site visit, all previous months log sheets are collected and returned to CDPHE Campus within 2 business days of being collected.
Quarterly Inspections / Maintenance	
	At near-road shelters, trim sample lines by approximately 6”.
	Clean sample inlet cup – verify proper orientation. The calibration gas line should be on the inlet side of the center of the cup.
Six Month Inspections / Maintenance	
	None Required
Annual Inspections / Maintenance	
10.6.12	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 • Replace or clean air conditioning and/or heater dust filters (if equipped) • Clean air conditioner coils
10.6.10	In March or April, replace all sample inlet lines at every shelter for each analyzer. TTP calibration line maintenance – replace every 3 years or every 2 years at near-road shelters.
40 CFR Appendix	Perform Method Detection Limit (MDL) testing on NCore trace analyzers (reference CFR Method)

Procedure or Resource	Description
B to part 136	

10.6 Maintenance Procedures

10.6.1 Disable/Enable Analyzer in Data Logger

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Disable analyzer data channel:

From the top level menu, to disable a data channel from reporting to the data logger, the user must:

1. Choose menu options **CDM** (**C Configuration Menu** > **D Configure (Data) Channels** > **M Disable/Mark Channel Offline)** to view the list of available channels.

2. From the keyboard, using the down arrow button, scroll to the target channel name and hit the **Enter** or **Return** key. A limited list of channels that could be encountered includes:

Channel Option	Instrument or Analyzer / Channel
O3	Ozone Analyzer
O3 Cal	Ozone Calibrator
CO	Carbon Monoxide Analyzer/Calibrator
CO_Trace	Carbon Monoxide Trace Level Analyzer/Calibrator
NO	Nitrogen Oxide Analyzer
NO2	Nitrogen Oxide Analyzer
CNO2	CAPS true NO2 Analyzer
NOX	Nitrogen Oxide Analyzer
NOY	NOy Analyzer
SO2	Sulfur Dioxide Analyzer

3. Next, hit the **Esc** (Escape) key twice to get back to top level menu.

4. Select menu option **DF** (**D Real-Time Display Menu** > **F Display Readings w/flags**) to ensure the proper channel was disabled. You should see the letter D within parenthesis and adjacent to the targeted channel indicating it has been disabled.

Enable analyzer data channel:

From the top level menu to enable the data channel to resume reporting to the data logger, the user must:

1. Choose menu options **CDE** (**C Configuration Menu** > **D Configure (Data) Channels** > **E Enable /Mark Channel Online)** to view the list of available channels.

2. From the keyboard, using the down arrow button, scroll to the target channel name, and hit the **Enter** or **Return** key.

3. If all machines/instruments and/or channels are already on line, the user will receive a message stating "No channels are offline" at the bottom left screen. Otherwise a list of channel names will appear.

4. Next, hit the **Esc** key twice to get back to the top level menu.

5. Select menu option **DF** (**D Real-Time Display Menu** > **F Display Readings w/flags**) to ensure the proper channel was enabled. You should see parenthesis adjacent to the targeted channel without the letter D inside indicating the channel is enabled and reporting to the data logger.

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Disable analyzer data channel:

1. After logging in to AVTrend, if the Site Node Logger Toolbox is not open, from the top level menu select the **Home** tab > **Utilities** > **Site Node Logger Toolbox** > then select the **Channels** tab.

2. Identify the channel to be disabled. At the right side of the form, under the “Disabled” heading, click on the row with the target channel name. This action will change the channel state from “False” to “True” indicating that it is now disabled.

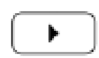
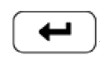
Enable analyzer data channel:

1. After logging in to AVTrend, if the Site Node Logger Toolbox is not open, from the top level menu select the **Home** tab > **Utilities** > **Site Node Logger Toolbox** > then select the **Channels** tab.

2. Identify the channel name to be enabled. At the right side of the form, under the “Disabled” heading, click on the row with the target channel name. This action will change the channel state from “True” to “False” indicating that it is now enabled.

10.6.2 Check Analyzer Calibrations Factors and Diagnostic Test Parameters Procedure

Refer to the appropriate manual for navigation trees to find diagnostic parameters. Copy parameter values from the display to the appropriate form.

Generally, on CO analyzers, a combination of the menu , play , and return buttons are used. Menu will enter the navigation tree or current selection, return allows for changing values, and play returns to the sampling screen. Up and down arrows change the selection. On TAPI instruments the TST buttons, <TST and TST>, scroll through values (APICOM) or the Dashboard screen displays multiple parameters at the same time (NumaView).

10.6.3 Filter Change Procedure

1. Disable the appropriate channel on the data logger (10.6.1)

2. Remove the old filter from the filter housing.

    a. Thermo analyzers use an external filter holder that may require holder wrenches.

    b. TAPI analyzers use an internal filter holder with a gripped ring. Care should be taken to preserve the integrity of the glass seal.

3. Place new filter into the filter housing using tweezers to handle the filter.

4. Tighten the filter holder closed.

5. Inspect lines and fittings for seal.

6. Perform a leak check from the back of the analyzer (10.6.7).

7. Enable channel on data logger (10.6.1).

10.6.4 Desiccant Regeneration

Desiccant changes from blue to pink as it absorbs water. When the desiccant container is mostly pink it should be swapped with dry desiccant. To regenerate desiccant (to dry it out) spread the granules thinly on a baking sheet and place in the oven in the laboratory for one hour at 210°C or 425°F. After one hour the desiccant should be stored in a sealed container at room temperature.

10.6.5 Internal Data Acquisition System Verification

The purpose of this procedure is to ensure that the internal data logging capabilities of the analyzers are functioning properly. The procedure was taken from the corresponding analyzer manuals.

<u>Thermo Analyzer</u>

To verify the internal data acquisition:

1. From the front panel Main Menu choose Instrument Controls > Datalogging Settings
2. Choose VIEW LOGGED DATA and press the down arrow to select Date/Time, press enter to accept
3. Use the down arrow to scroll down to the date when the previous monthly was completed and press enter to accept
    a. Use the right arrow to pan through and verify that data was captured in the internal memory
    b. If no valid data is stored, then notify the appropriate personnel of the issue immediately
4. Repeat the above steps and verify data acquisition for 5 other dates spanning the last month, ending with the current date
5. Return to the run screen by pressing RUN
6. Fill out the required data acquisition verification entry on the Monthly log sheet

<u>TAPI Analyzers</u>

To verify internal data logging:

1. Access the internal data stored on the analyzer through the front panel: SETUP > DAS > VIEW, refer to Figure 1 below for menu structure
2. Verify data is stored by selecting the first data channel and pressing VIEW, then press PV10 several times to view whether data was stored since the last data acquisition verification was performed
3. Press EXIT > NEXT > VIEW > PV10 to verify data in the other data channels
4. At a minimum, verify one parameter for each data channel
5. Continue to press EXIT until the analyzer returns to the sample mode
6. If data is not being stored, notify appropriate personnel
7. Fill out the required data acquisition verification entry on the Monthly log sheet

For NumaView, navigate to the Datalog View tab and graph the previous month for a parameter to verify datalogging operation.

10.6.6 Bottle Change Procedure

It is acceptable to change bottles by disconnecting the regulator in the field for CO and SO_2 bottles. NO bottle regulators should be changed at the laboratory, and have a vacuum purge performed on the regulator prior to deployment. The NO bottle can then be transported with the attached regulator using a regulator cap.

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; CO cylinders may be 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 exit valve.

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

   d. Close the gas bottle valve.

   e. Increase the regulator pressure knob to ~30psi

   f. Open the regulator exit valve with the line still capped

   g. Belch the line by lifting thumb or depressing the quick stop periodically until the cylinder pressure gauge go to less than 200 psi and keep line closed

   h. Back off the regulator pressure knob until closed.

   i. Close the regulator exit valve.

   j. 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. If the site does not use a dynamic dilution calibrator, skip to step 14. On an 8872 data logger, in AVTrend, open Configuration Editors > Logger Channels. Modify the logger entity. Switch to the Math Constants tab. Note the description in the right-most column. Use the description to determine which math constant reflects the gas being changed. Change that constant to match the new tank concentration. Save your changes.

    a. Example: You are changing the CO tank from a 300 ppm to a 305 ppm tank. In the Math Constant screen you see that the Description states CO is primary, NO is secondary. You will change the value of the primary math constant from 300 to 305 and save your changes.

14. At sites that use direct gas introduction, the span and precision values are stored as K01 and K02 math constants. On an 8832, type C>K and alter values. In AVTrend, open Configuration Editors > Logger Channels. Modify the logger entity. Switch to the Math Constants tab. Change the appropriate constant and save changes.

15. Send two messages to central through the data logger (see 10.6.9)

    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.

16. Enter the new bottle concentration into the 700 calibrator

    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 Leak Check Procedures

The purpose of this procedure is to provide guidance on determining the presence of a leak in the sample stream. The sample stream can consist of the analyzer, a water drop-out, and a sample line. This procedure also outlines how to determine if the sample manifold on a dynamic dilution calibration check system is leaking.

10.6.7.1 Determination of Sample Stream Leak

1. Disable analyzer channel on data logger (10.6.1).
2. Select Sample Pressure (Menu > Diagnostics > Pressure) and leave displayed on analyzer screen.
3. Cap the sample stream. Either:
    a. Disconnect the sample line and cap the sample inlet on the back of the analyzer (analyzer leak check).
    b. Cap the end of the water drop-out furthest from the analyzer (water drop-out leak check).
    c. Cap the end of the sample line (sample stream leak check).
4. Monitor the sample pressure until a reading of less than 10" (255 mm) of mercury is reached.
    a. If pressure is reached within 2 minutes, the leak check has passed.
    b. If pressure is not reached within 5 minutes, leak check has failed, troubleshoot or seek assistance from site operator.
5. Uncap the sample stream by reverting steps taken in step 3.
6. Enable analyzer channel on data logger (10.6.1).
7. Leave a message for central detailing findings, including leak test conducted, passed or failed, actions taken if failed, and initials (10.6.9).

10.6.7.2 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).
    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. 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. Revert 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 (10.6.9).

10.6.8 Time Change Procedure

Compare the Analyzer's time with the Data logger. If it is out of the +/- 2 minute specification, then adjust the Analyzer's time. Check the Data logger's time with cell phone time, if it is significantly off, contact the Data Manager.

Important Note! – All times on data loggers and analyzers are to be set to Mountain Standard Time and do not adjust for daylight savings.

Thermo Analyzer

This procedure was taken from the Thermo CO analyzer manual. For any time changes done to the analyzer make a note on the analyzer log sheet.

1. Press the Main Menu button
2. Use the arrow keys to choose INSTRUMENT CONTROLS and press ENTER
3. Navigate to the Date/Time and press ENTER
4. Press ENTER to edit
5. Use the right arrow pushbutton until "SETTING:" displays the unit of time desired for changing.
6. Set the correct time using the up or down arrow pushbuttons
7. Press ENTER to save the new time
8. Press RUN to exit and return to the run screen

TAPI Gaseous Analyzer

This procedure was taken from the TAPI NO_x analyzer manual. For any time changes done to the analyzer make a note on the analyzer log sheet.

1. Navigate to the TIME Display and determine whether a time change is necessary.

2. If the time needs to be adjusted, navigate to the Date Time menu

3. Toggle the numbers up or down to get the correct time

4. Press ENTER

5. EXIT to the home menu

6. Make a note on the NO_x log sheet of the time change

<u>Data logger</u>

If the clock on a data logger is incorrect, there may be more serious issues to consider including data validity and proper operation of the data logger. Contact the Data Manager.

10.6.9 Message to Central Procedure

<u>ESC 8816 or 8832</u>

1. Log in to the data logger.

2. 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.

3. 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. If more than 80 characters are needed, repeat steps 2-3.

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1. Log in to the AVTrend 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 Site drop-down menu and select the only option (This option is primarily for Central, where any site can be selected. At a site, only that site may be picked).

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.

10.6.10 Line change Procedure

1. All sample lines are to be changed annually or as needed if defects are suspected. Through the probe calibration lines are to be changed once every three years or when defects or degradation are suspected. Sample lines should be trimmed by approximately 1’ six months after installation and replaced annually.

    a. Near-road shelters require more frequent maintenance. Through the probe calibration lines are to be changed once every two years. Sample lines should be trimmed by approximately 6” once every quarter and replaced annually.

2. Disable analyzer channel on data logger (10.6.1).

3. Perform a leak check on the existing sample line to confirm data validity prior to changing the line (10.6.7).

4. Remove the existing line and measure out and cut a length of new sample line of approximately the same length as the old line including enough for future trimming. Use a designated tubing cutter to cut the Teflon tubing to ensure the cut is straight, at a 90 degree angle to the tubing’s outer wall, and not beveled.

5. Cover or cap the end of the new line prior to installation. This ensures dirt does not enter the line during the installation process. Remove the line cover or cap once the line is installed.

6. Note the final length of sample line.

7. Ensure fitting used in the sample train are made of Teflon. Borosilicate glass and stainless steel fitting can be used, however, their usage is less desirable and Teflon fittings should be used if available. The usage of dissimilar fitting materials is discouraged because of the potential for thread damage and improper sealing.

8. Empty the water dropout manifold (if equipped). If the dropout appears contaminated it may be physically cleaned or sonicated but solvents should not be used.

9. Perform a leak check on the new sample line (10.6.7).

10. If the line replaced is a sample line, note sample line length and determine residence time. All residence times must be < 20 seconds. The calculation of residence time requires knowledge of the sample flow rate, length of sample line, additional static volumes such as water dropouts, and the internal cross-sectional area of the tubing. When determining additional static volume, such as a water dropout, use only the volume that sees active gas flow. For example, the water catch flask on the bottom of the water dropout should not be included in volume calculations, only the upper portion of the manifold. Sample flow rate can be attained from the analyzer front panel, however, if the analyzer flow sensor has not been verified by a certified flow transfer standard within the past 6 months, then a certified flow transfer must be used to determine flow rate. This can be accomplished by attaching a certified flow transfer standard to the sample line inlet. All flows are measured at standard temperature and pressure (25 ºC and 1 atm).

Below is a table of internal cross-sectional areas for common ¼ Teflon tubes that can be use in residence time calculations.

Table 3. Internal Cross-Sectional Area for Teflon Tubing

Tubing Diameter	Inner Diameter (mm)	Outer Diameter (mm)	Inner Diameter Area (mm^2)
Thin Wall (3/16 x 1/4)	4.8	6.35	18.10

Medium Wall (5/32 x 1/4)	4.0	6.35	12.57
Thick Wall (1/8 x 1/4)	3.2	6.35	8.04

(Note* 1 cm^3 = 1 ml)

Equation 7. Residence Time

$$Residence\ Time\ (sec) = \left(\frac{\left(\left(\frac{ID\ area\ of\ tube\ (mm^2) \times Tube\ Length\ (in) \times\ 2.54 (\frac{cm}{in})}{100\ (\frac{mm^2}{cm^2})} \right) +\ Static\ Vol. (cm^3) \right)}{Sample\ Flow\ (\frac{cm^3}{min})} \right) \times 60\ (\frac{sec}{min})$$

11. Enable analyzer channel on data logger (10.6.1).

12. Note line change activities on log sheet.

13. Enter message to central, including the new residence times (10.6.9).

10.6.11 Perform Manual Precisions

<u>ESC 8816 or 8832</u>

1. Login to the data logger.

2. From the top level menu type CCS (C Configuration Menu > C Configure Calibrations > S Start a Calibration Program.)

3. A list of calibration options appears. To run a Quality Control precision select, QC-nn by scrolling down to that option and hitting the Enter or Return key.

4. Hit the Esc (escape) key twice to get back to the top level menu, then type, DF to verify the Precision Calibration was initiated. You should see the letter, “C” next to the CO reading indicating it is in the calibration mode, as shown. It will run for about 10 minutes. After a Manual Precision has run to completion, the new precision value will appear in the RL list.

5. Hit the Esc key twice to get to the top level menu then type RL to view, shown below.

6. Continue to step 8 in the Agilaire 8872 section

<u>Agilaire 8872</u>

1. Login to the 8872 data logger.

2. From the **Home** tab select **Utilities** > **Site Node Logger Toolbox**.

3. When the **Site Node Logger Toolbox** tab appears, select the **Calibration** tab. Once the Sequence Name page appears, select the calibration sequence that you wish to run. Each manual precision choice will have “QC” in the Sequence Name. For example, to run an ozone precision, at the right side of the window click on **Start** in the “QC-O3” row, and OK in the subsequent dialog.

4. Once the Precision has completed, on the **Home** tab click on **Reports**. From the drop-down menu, select **Calibration Results**.

5. When the “Report Criteria” window appears, notice the “Parameter Selection” section. On the keyboard, hold the **Ctrl** button down and click on each parameter for which you wish to see calibration results. Example, click on **ACTCONC**, **CO**, **NO**, **NO2**, **NOX**, and **O3CAL**, and **SO2** (or a subset of these depending on the site and available equipment.)

6. Now look at the “Date Range” section of the window. Modify the “Start Date” and time and “End Date” and time to coincide with the Precisions that you just ran.

7. Finally in the “Calibrations Results” section click on **Generate Report** to see the Precision results, presented in a report format.

    a. The “Value” column will show the average value collected by the analyzer. The “Expected Value” column contains the value that should have been generated by the calibration equipment. With O_3, the O_3 Cal “Expected Value” column shows the value the O_3 calibration equipment was attempting to generate and the “Value” column shows what it actually did generate. With NO_2, the ACTCONC section “Expected Value” column shows the value the NO_2 calibration equipment was attempting to generate and the “Value” column shows what it actually did generate.

8. Verify the results into the ZSPTracking database within 48 hours of completion.

    a. Open the database and click on Enter Manual

    b. In the new form, select your site from the Site Name drop list

    c. Select the appropriate criteria pollutant from the pollutant drop list. Note that the first pollutant is automatically selected.

    d. The values are entered into ZSPTracking automatically every night. This verification is best done the day after the precision is run.

    e. Verify the fields against the “Calibrations Results” report. If correct, click Capture Data. If not, contact the data manager.

10.6.12 Bard Heating/ Ventilation/ Air Conditioner Cleaning

Observe all safety precautions to protect personnel from injury. De-energize the A/C unit by turning off the appropriate breaker/breakers. If shelter has two Bard units turn off both sets of breakers to de-energize both units. Some of the larger Bard units have breakers behind a small panel on the side of the unit.

There is a comprehensive video that should be referenced before proceeding out into the field and performing a Bard a/c cleaning. This video will show you the safety precautions and give you a good reference as to what fasteners to remove. It may not be necessary to remove the condenser fan. The condenser can reasonably be accessed for mechanical cleaning with the appropriate long handled brush. A good reference for this video can be found here: https://www.youtube.com/watch?v=P7E9Ex9YVjk

Plan ahead for the number of a/c units to be serviced and purchase appropriate amount of a/c condenser spray cleaner, charged battery for water tank/sprayer, extra water, and necessary tools to remove grilles and fan shroud screws.

Upon arrival interrupt power to the a/c or a/c’s as necessary. Remove side, front grille, and air filter compartment cover. Remove shroud screws and move shroud grille back. There may be a screw inside the filter compartment that will restrict the shroud from moving back. Remove this screw and shroud should now be able to move back out of the way. With a medium stiffness brush, remove debris from the inner side of the condenser coil using an up and down motion so as to not bend the fins sideways and restricting air flow. If any of the fins are bent use coil comb to straighten fins.

After removing debris from inside of coil spray the inside of the coil with condenser cleaner spray (follow directions and precautions) and also spray the outside coils with the intent on getting the cleaner as deep into the fins as possible. Allow cleaner to sit and dissolve debris in coils for the allotted time indicated on the instructions.

After the cleaner has been allowed act on the dirt and debris rinse with water as thoroughly as possible. Refill water container and rinse a second time, and more as needed. Water may have collected in the bottom of the a/c unit so a drain may be needed to be removed to allow water to drain out. Do not leave water at the bottom of unit as the fan may come into contact with water when it is powered on.

Remove a/c filter and inspect/clean (use air compressor to blow in the reverse direction of normal airflow until clean) or replace. Remove any large debris/bugs/lint.

After condenser coil cleaning is complete check to make certain there are no tools or other objects in the fan area. Replace fan shroud and attach using original screws. Conduct another check for tools and other objects before replacing a/c filter cover and outside grilles.

After all panels and grilles and hardware are installed you can now re-energize the a/c breakers and allow a/c fan/compressor approximately two to three minutes to start putting out cool or warm air depending on inside temperature.

Clean area of tools, supplies and trash. Before leaving ensure a/c is working correctly. Leave a message to central stating that the a/c cleaning has been completed.

10.7 Calibration Standards

Refer to the QA2 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

Atmospheric criteria pollutant concentrations are monitored continuously; 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

Atmospheric criteria pollutant analysis receive no special preparation prior to analysis. 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 analyzers. 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 day (a 24-hour standard deviation of shelter temperature (ITEMP) is available on the data logger, and should be less than 2)?

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 data loss. The sample probe, water dropouts, and sample lines should be checked on a regular basis to ensure integrity. Dirty sample lines can artificially suppress readings of reactive analytes. Inlet and sample line maintenance should be done in accordance with section 10 above. The particulate filters used to protect the analyzers should be changed on a regular basis, as outlined in the specific instrument manuals and SOPs.

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 Instrument Troubleshooting

Troubleshooting of problems with analyzers is specific to each analyzer and its design. Common problems with instruments include:

1. Low or erratic flow
2. Erratic or noisy readings
3. No readings or off-scale readings
4. No display
5. No output
6. Analyzer completely inoperative

Troubleshooting sections in specific analyzer 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.

Troubleshooting techniques for the data logger and the remaining sample system, including any external solenoid manifolds and calibration systems, are the purview of their respective 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. Instrument internal data storage serves as a backup service in the event the data logger fails.

14.1 Data Acquisition

The APCD/TSP data acquisition system (DAS) is comprised of three components: an onsite primary DAS that collects data from all continuous monitoring equipment, an onsite secondary DAS, 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 8816/8832/8864 data loggers, and the Agilaire 8872 data logger. See Section 8.1.4 for a more detailed description of these data loggers.

14.1.2 Secondary Onsite Data Acquisition Systems

The APCD uses two different DASs to provide backup data in case of failure of the primary systems. The backup DASs are the analyzers' on-board data acquisition systems that are unique to each manufacturer. Internal data logging is available on the newer Thermo and Teledyne Air Pollution Instrumentation (TAPI) analyzers. A description of theses secondary data acquisition systems follows.

<u>Teledyne iDAS System</u>

The TAPI internal DAS (iDAS) is available on all analyzers. The non-volatile memory retains the data even when the instrument is powered off or the firmware is updated (back up before update advised). Access to the iDAS is available either through the front panel or the APICOM remote interface. The remote interface allows for data to be automatically downloaded to a remote PC. The iDAS is flexible in the parameters stored and triggering events to initiate data storage. The maximum iDAS data storage is limited to the analyzers available memory and the number of data parameters and channels.

<u>Thermo Internal Data Logging System</u>

The Thermo internal data logging is available in the 48i-TLE CO analyzer. The data is stored in memory on the C-Link Board, which is powered by a +5 volt battery when the instrument power is off. The internal data logging settings and data are accessible through the remote interface iPort software. The 48i-TLE also allows for front panel access to the internal data logging menu. The 48i-TLE has a significant amount of memory. Allocating 70% of the available memory will allow for 168 days' worth of long records, using a 1 minute averaging period for concentrations.

14.1.3 Central Polling System

The APCD uses AirVision 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. AirVision supports open data acquisition and data imports thru modular drivers that can be added to provide connectivity to a data source. The system has combined data editing and quality control tools that can be utilized in evaluating and validating data in the post-processing environment. The post-processing environment allows user control of the data from the management of raw data within the server environment through the exporting of validated data through built in reports or for external statistical evaluations and reporting. A more detailed description of this application can be found in APCD's Data Logger and Central Polling Standard Operating Procedure." (Agilaire, 2009)

<u>Central Polling Daily Tasks</u>

1. Task managers within Air Vision polls data from remote air quality monitoring sites at the top of each hour, at a minimum. Some sites may be polled at a greater frequency depending upon data needs. Data from each site is stored in a SQL database and made available for review and analysis after polling has been completed.

2. Ambient data on the AirVision Central polling computer is reviewed every business day in the morning, the previous 24 hours (or 3 days on Mondays) worth of data is reviewed for completeness and accuracy. This data review is used to determine if a physical site visit is required.

3. Low level (precision) and high level (span) test gas sequences are run on alternate days. The precision and span level tests are followed by a zero test and a two-minute recovery period. The results are reviewed each morning and plotted on control charts. It is the responsibility of one individual within

TSP to review the daily Zero/Span results, plot them on the control charts, and notify the technician responsible of any out of control condition. "Out of control" is defined as:

a. trending toward warning limit as defined on the control chart

b. points plotted exceeding the warning limit

c. points plotted exceeding the action limit as defined on the control chart

14.2 Calculations and Data Reduction

As mentioned above, data collected on a DAS are available as soon as the averaging period is complete. Data are polled automatically via modems (analog phone, wireless cellular, or DSL) by the Central polling computer hourly at least. 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.

14.2.1 Zero Adjustment Methods

Other than CO analyzers (see below) a zero adjustment method is not encouraged, and is normally done as part of the data validation process. Baseline adjustments may be conducted on any analyzer but require the assistance of management to ensure proper operation within specified criteria.

CO analyzers are unique in that the baseline drift of signal upwards is expected due to the dirtying of the analyzer's analytical systems. Typically, the dirtier the sample matrix the more rapid the baseline drift. Because this drift is so predictable, the APCD feels that compensations for this drift, whether by the analyzer or by post-processing, is appropriate and acceptable.

<u>Thermo 48i – TLE</u>

The Thermo i-series instruments, used by the APCD, are equipped with an auto-zero function that allows the instrument to automatically check and adjust the zero background on a periodic basis. While the gas-filter correlation IR measurement method used by this analyzer can provide highly specific, accurate and precise data, the ability to make continuous measurements at low ppm concentrations may be limited by gradual changes in electronic baseline, or zero background. This drift occurs primarily due to slight changes in environmental parameters, such as temperature or correlation wheels collecting dust. The enhanced trace level version of the 48*i* CO analyzer uses both hardware and software compensation to limit the impact of changes in the instrument's environment. While the auto-zero function greatly improves instrument stability, it is not intended to replace the routine calibration procedure. Thermo Fischer Scientific suggests the analyzer be programmed to make actual adjustments every two hours, however the APCD has found that adjustments made every six hours (03:00, 09:00, 15:00, 21:00hrs) to be sufficient. Post processing of this data and Quality Control data by APCD for additional zero adjustments are not made.

Other gaseous analyzers do not automatically adjust the baseline of the instrument. Post-processing zero adjustment may be required and is outlined in the data management SOP of this QAPP.

15 COMPUTER HARDWARE AND SOFTWARE

The 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 8864, 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 analyzer 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 and 1-hour averages. Some data streams may be stored at a third averaging interval, meteorological data can be stored as a 15-minute average, shelter temperature is stored at 24-hour average to calculate a standard deviation, and SO_2 data can be stored in a 5-minute average. Note the capacity of the on-site data logger is limited to three time-base averaging intervals and that the 5-minute SO_2 average supersedes the 15-minute meteorological average. The Central polling computer collects these averages routinely.

For reporting purposes, other averaging intervals are derived, such as an 8-hour moving average for ozone. In these cases, the data is aggregated by the Central polling computer for the purpose of the report and are often not stored independently. The Central polling computer connects to a SQL server, which is maintained, and backed up, by the Office of Information Technology.

Data are sent to the EPA centralized Air Quality System (AQS) database for long-term storage. 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 Appendix D1, the Datalogger & 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. 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 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. The principal MQO's are parameter specific and are listed in Appendix MQO of CDPHE's QAPP. Guidance for developing DQI's and MQO's is given in EPA's Quality Assurance Handbook (US EPA, 2013). 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 Appendix QA1 of APCD's 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. Detailed information about how specific audits are performed can be found in the Quality Assurance SOPs section.

- National Performance Audit Program (NPAP) – These performance audits are implemented at the federal level although some programs may be implemented by the monitoring organizations if certain requirements are met. General procedures for site operators during an NPAP audit follow:

    - The EPA NPAP contractor will work with management at APCD to determine sites and times for audits each year.

    - Prior to the auditor's arrival, the site operator will visit the site to ensure that all equipment is running properly and will verify with management that performance indicators are in line with expectations.

    - The site operator will meet the EPA contractor to assist during the audit. Assistance includes connection of the NPAP audit gas supply line to the inlet, and reading resultant concentrations after adequate equilibration to the auditor.

    - The continual proper operation of analytical equipment during the audit is the responsibility of the site operator. Ensure that sample pressure and reaction chamber pressure (as appropriate) do not fluctuate when auditor gas is introduced. Such fluctuations can indicate over-pressurization of the sample system and would invalidate the audit. The site operator has the authority to stop an audit if problems arise.

    - After completion of the audit, the site operator is responsible for verifying normal pneumatic setup of the sample train.

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 in 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 analyzers. All procedure 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 1 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 QC checks. The APCD performs two types of QC checks at the above mentioned precision level test gas concentrations. These two tests are called Performance checks and QC Precision checks. The former is an automated performance test that is performed nightly and is 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 QC Precision checks. Instead, one performance check is selected at random from each one-week period to satisfy the QC Precision check requirement. The performance check is selected by APCD personnel and is included with the APCD-operated QC Precision check submission to the EPA's AQS.

For instructions on performing a manual precision Quality Control check, see Section 10.6.11.

17.2.2 Calibrations

Calibration of an analyzer or instrument establishes the quantitative relationship between the actual value of a standard, be it a pollutant concentration, a temperature, or a mass value, and the analyzer's response (chart recorder reading, output volts, digital output, etc.). This relationship is used to convert subsequent analyzer response values to corresponding concentrations. Once an instrument's calibration relationship is established, it is checked at reasonable frequencies to verify that it remains in calibration. It is the goal of APCD to perform calibrations on all analyzers quarterly, however, circumstances my require calibrations be performed at the longer frequency of every 6-months. A 6-month calibration frequency still meets EPA recommended calibration frequency criteria.

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 sheet must be rigorously maintained for procedures, standards and analyzers. 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.

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Colorado Department of Public Health and Environment
Air Pollution Control Division - Technical Services Program

STATION/MET

STATION: ____________

/
Month Year

	Supplier	Bottle #	Expiration	Conc
CO Span				
CO Prec				
NO				
NOy				
SO2				
O3	TAPI	SN:		

	Date						
Max Temp	<90F						
Min Temp	>50F						
Inlet check	Clean, in place						
CO Span Press	>200psi						
CO Prec Press	>200psi						
NO Press	>200psi						
NOy Press	>200psi						
SO2 Press	>200psi				NO Scrubber		
Wind Speed	<100mph						
Wind Direction	>0<540						
Radiometer	Clean						
Radiometer	Dessicant						
Temp Shield	free						
	Operator						

Temp fans running (monthly): ____________

Day	Time	Action	Initials	Time

Use ✓ for yes and in-range and ✖ for no and out-of-range, Δ for changed

Figure 1. Station and Met Log

Colorado Department of Public Health and Environment
Air Pollution Control Division - Technical Services Program

CO Thermo 48

sn: ____________ / ____________

STATION: ____________

____ / ____
Month Year

Monthly Station Activities Log	Date						
Intercept (BKG)	<10 ppm						
Slope (COEF) Inter	0.7 - 1.3						
Bias Voltage	-130 - -100						
Internal Temp	15 - 45						
Bench Temp	35 - 55						
Sample Pressure	250 - 1000						
Sample Flow	0.35 - 1.5						
S/R Ratio	1.00 - 1.18						
AGC Intensity	150k - 300k						
Motor Speed	100						
Clock	+/- 2 min						
Dessicant	Changed?						
Filter	Changed?						
Leak Check	<250 S Press						
	Operator						

IDAS/DCR, >30 Days Initials: ____________ Water dropout (monthly): ____________

Day	Time	Action	Initials	Time Online

Use ✓ for yes and in-range and ✖ for no and out-of-range, Δ for changed

Figure 2. CO Log

Colorado Department of Public Health and Environment
Air Pollution Control Division - Technical Services Program

SO2 API 100

sn: __________ / __________
1: A E T 2: A E T

STATION: __________
/
Month Year

Monthly Station Activities Log

	Date						
Sample Pressure	ambient +/- 2						
Sample Flow	500 - 800						
Normal PMT	0 - 5000						
UV Lamp	A,E,T: 1000 - 4800 U: 2000 - 4000						
Lamp Ratio	30 - 120						
Slope	0.7 - 1.3						
Offset	<250						
HVPS	A,E,T: 400 - 900 U: 400 - 800						
R Cell Temp	49 - 51						
Box Temp	ambient +/-5						
PMT Temp (check stability)	A,E,T: 5 - 9 U: 7.5 - 11.5						
Clock	+/- 2 min						
Filter	Changed?						
Leak Check	<10 S Press						
	Operator						

IDAS (Monthly), >30 Days Initials: __________ Water dropout (monthly): __________

Day	Time	Action	Initials	Time

Use ✓ for yes and in-range and ✖ for no and out-of-range, Δ for changed

Figure 3. SO_2 Log

Colorado Department of Public Health and Environment
Air Pollution Control Division - Technical Services Program

NO API 200

sn: ________ / ________
1: A E T   2: A E T

STATION: ________
/
Month   Year

Monthly Station Activities Log	Date						
Sample Flow	E,T: 350-450 EU,TU,UP: 800-1000						
Ozone Flow	65 - 95						
HVPS	400 - 900						
R Cell Temp	E: 49 - 51 TU,UP: 39 - 41						
Box Temp	25 - 35						
PMT Temp	E,T: 5 - 9 EU,TU,UP: 3 - 7						
Converter Temp	310 - 320 NOy: 320 - 330						
R Cell Pressure	E,T: <10 EU,TU,UP: 2 - 5						
Sample Pressure	ambient +/-2						
Slope (NO/NOx)	0.7 - 1.3	/	/	/	/	/	/
Offset (NO/NOx)	-50 - 150	/	/	/	/	/	/
Clock	+/- 2 min						
Filter	Changed?						
Leak Check	<10 S Press						
	Operator						

IDAS (Monthly), >30 Days Initials: ________

Day	Time	Action	Initials	Time Online

Use ✓ for yes and in-range and ✗ for no and out-of-range, Δ for changed

Figure 4. NO Log

Colorado Department of Public Health and Environment
Air Pollution Control Division - Technical Services Program

NO_2 API 500U

sn: ________ / ________
1: T 2: T

STATION: ________ / ________
Month Year

Monthly Station Activities Log	Date						
Phase	Zero: 30±10						
MEAS_L	400-1800						
AREF_L	Zero: 400-800						
Sample Press	~1-5 < Ambient (Constant)						
Sample Temp	45±3						
Box Temp	Ambient±5						
Slope	1.0±0.3						
Offset	0.0±5						
Oven Temp	45±1						
Clock	+/- 2 min						
Filter Change	Δ = Changed						
Leak Check	<10 S Press						
	Operator						

IDAS (Monthly), >30 Days Initials: ________

Day	Time	Action	Initials	Time Online

Use ✓ for yes and in-range and ✗ for no and out-of-range, Δ for changed

Figure 5. NO_2 Log

Colorado Department of Public Health and Environment
Air Pollution Control Division - Technical Services Program

O3 API 400

sn: ________ / ________
1: A E T 2: A E T

STATION: ________
/
Month Year

Monthly Station Activities Log	Date						
O3 Measure	2500 - 4500						
O3 Reference	2500 - 4500						
Sample Pressure	ambient +/- 2						
Sample Flow	500 - 800						
Sample Temp	10 - 50						
Photo Lamp Tmp	58 +/- 0.1						
Box Temp	10 - 50						
Slope	.85-1.15						
Intercept	-5 to 5						
Clock	+/- 2 min						
Filter	Changed?						
Leak Check	<10 S Press						
	Operator						

IDAS (Monthly), >30 Days Initials: ________ Water dropout (monthly): ________

Day	Time	Action	Initials	Time Online

Use ✓ for yes and in-range and ✗ for no and out-of-range, Δ for changed

Figure 6. O_3 Log

Colorado Department of Public Health and Environment
Air Pollution Control Division - Technical Services Program

O3 SOURCE sn: __________ / __________ STATION: __________

/

Month Year

Monthly Station Activities Log **703**

	Date						
Box Temp	1: 12 - 48 3: 25 - 30						
O3 Lamp Temp	48 +/- 0.1						
O3 Reference	2500 - 4700						
Ph Lamp Temp	58 +/- 0.1						
Ph Samp Press	Ambient-1						
Ph Samp Temp	1: 10 - 50 3: 25 - 48						
Ph Slope	1 +/- 0.15						
Ph Offset	0 +/- 10						
Clock	+/- 2 min						
Dessicant	Changed?						
	Operator						

Use this side for the 703. 401 (on the other side) is different.

Day	Time	Action	Initials	Time Online

Use ✓ for yes and in-range and ✖ for no and out-of-range, Δ for changed

Figure 7. O_3 Source Log

Colorado Department of Public Health and Environment
Air Pollution Control Division - Technical Services Program

API 700 / 701

700 sn: __________ / __________ STATION: __________

1: A E T 2: A E T /

701 sn: __________ / __________ Month Year

Options: ______________

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 Check	<5 psi/min						
	Operator						

Day	Time	Action	Initials	Time Online

Use ✓ for yes and in-range and ✖ for no and out-of-range, Δ for changed

Figure 8. Dilution Calibrator Log

TRANSMITTER sn: __________ / __________ STATION: __________ / __________

Month Year

Monthly Station Activities Log	DATE						
LED ON							
ALIGN NEEDED							
OPERATOR							

Day	Time	Action	Initials	Date Online

Figure 9. Transmissometer Transmitter Log

TRANS RCVR sn: __________ / __________ STATION: __________ / __________

Month Year

Monthly Station Activities Log	DATE						
	○ ○	○ ○	○ ○	○ ○	○ ○	○ ○	○ ○
PRE READING							
POST READING							
CAL NUMBER							
HUMIDITY							
TEMP							
OPERATOR							

Day	Time	Action	Initials	Date Online

Use ✓ for yes and in-range and ✖ for no and out-of-range, Δ for changed

Figure 10. Transmissometer Receiver Log

Colorado Department of Public Health and Environment
Air Pollution Control Division - Technical Services Program

NEPH sn: __________ / __________ STATION: __________

/
Month Year

Monthly Station Activities Log	DATE						
BSCAT							
STATUS							
SPAN							
ZERO							
Operator							

Day	Time	Action	Initials	Date Online

Use ✓ for yes and in-range and ✖ for no and out-of-range, Δ for changed

Figure 11. Nephelometer 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 12. Maintenance Report Form