Air Pollution Control Division

Technical Services Program

APPENDIX GM7

Standard Operating Procedure for the OPTEC LPV-2 Transmissometer

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1 SCOPE AND APPLICABILITY

1.1 Introduction

Visibility is unique among air pollution effects in that it involves human perception and judgment. It has been described as the maximum distance that an object can be perceived against the background sky. Visibility also refers to the clarity with which the form and texture of distant, middle, and near details can be seen as well as the sense of the trueness of their apparent coloration. As a result, measures of visibility serve as surrogates of human perception. There are several ways to measure visibility but none of them tell the whole story or completely measure visibility as we experience it.

The Colorado Air Quality Control Commission established a visibility standard in 1990 for the Front Range cities from Fort Collins to Colorado Springs. The standard, an atmospheric extinction of 0.076 per kilometer (using a transmissometer), was based on the public's definition of unacceptable amounts of haze as judged from slides of different haze levels taken in the Denver area. At the standard, 7.6 percent of the light in a kilometer of air is blocked. The standard applies from 8 a.m. to 4 p.m. each day, during those hours when the relative humidity is less than 70 percent. Visibility, along with meteorology and concentrations of other pollutants for which National Ambient Air Quality Standards exist, is used to determine the need for mandatory wood burning restrictions and voluntary driving restrictions.

There is no quantitative visibility standard for Colorado's pristine and scenic rural areas. However, in the 1977 amendments to the Federal Clean Air Act, Congress added Section 169a[1] and established a national visibility goal that created a qualitative standard of “the prevention of any future and the remedying of any existing, impairment of visibility in mandatory Class I federal areas which impairment results from manmade air pollution”. The implementation of Section 169a has led to federal requirements to protect visual air quality in large national parks and wilderness areas.[2] Colorado has 12 Class I areas. Federal and state law prohibits visibility impairment in national parks and wildernesses due to large stationary sources of air pollution.

Visual air quality is an element of public welfare. Specifically, it is an important aesthetic, natural, and economic resource of the state of Colorado. The worth of visibility is difficult to measure, yet good visibility is something that people undeniably value. Impaired visibility can affect the enjoyment of a recreational visit to a scenic mountain area. Similarly, people prefer to have clear views from their homes and offices. These concerns are often reflected in residential property values and office rents. Any loss in visual air quality may contribute to corresponding losses in tourism and usually make an area less attractive to residents, potential newcomers, and industry.

There is increasing information that shows a correlation between ambient concentrations of particulate matter and respiratory illnesses. Some researchers believe this link may be strongest with concentrations of fine particles, which also contribute to visibility impairment. In July 1997, the EPA developed a National Ambient Air Quality Standard for particulate matter less than 2.5 microns in diameter ($PM_{2.5}$). Any control strategies to lower ambient concentrations of fine particulate matter for health reasons will also improve visibility.

The cause of visibility impairment in Colorado is most often fine particles in the 0.1 to 2.5 micrometer size range (one micrometer is a millionth of a meter). Light passing from a vista to an observer is either scattered away from the sight path or absorbed by the atmospheric fine particulate. Sunlight entering the pollution cloud may be scattered into the sight path adding brightness to the view and making it difficult to see elements of the vista. Sulfate, nitrate, and elemental and organic carbon are the types of particulate matter most effective at scattering and/or absorbing

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[1]. Clean Air Act as amended in 1977, section 169a (42 USC 7491)

[2]. Visibility Protection for Federal Class I Areas, codified at Title 40 Code of Federal Regulations, Pt. 51.300-309.

light. The man-made sources of these particulates include wood burning, electric power generation, industrial combustion of coal or oil, and emissions from cars, trucks, and buses.

There are several ways to measure visibility. Currently, the Division uses camera systems to provide qualitative visual documentation of a view. Transmissometers and nephelometers are used to measure the atmosphere's ability to attenuate light quantitatively.

A visibility site was installed in Denver in late 1990 using a long path transmissometer. Visibility in the downtown area is monitored using a receiver located near Cheesman Park and a transmitter located on the roof of a downtown building. This instrument directly measures light extinction, which is proportional to the ability of atmospheric particles and gases to attenuate image-forming light as it travels from an object to an observer. The visibility standard is stated in units of atmospheric extinction. Days when visibility is affected by rain, snow or high relative humidity are termed "excluded" and are not counted as violations of the visibility standard. A nephelometer was installed at the transmissometer receiver location in late 2000 to examine correlations between instrument types for future visibility studies. In September 1993, a transmissometer and nephelometer were purchased by the city of Fort Collins.

1.2 Method Overview

The Optec LPV-2 transmissometer measures the ability of the atmosphere to transmit light of a specific wavelength (generally 550 nm, green). It accomplishes this by continuously measuring the loss in light received from a light source of known intensity as the light beam travels a known distance. Unlike nephelometers, which only measure the scattering component of total extinction at a point source, the LPV-2 measures total extinction by integrating the light scattering and absorbing properties of the atmosphere along a selected sight path.

1.3 Format and Purpose

The sequence of topics covered in this method follows 2007 EPA guidance on preparing standard operating procedures (SOPs). This method was also written to help field operators understand why (not just how) key procedures are performed (US EPA, 2007).

2 Summary of Method

The LPV-2 transmissometer has two primary components: a light transmitter, and a light receiver. Additional instrumentation and support equipment generally includes instrument shelters, data collection systems, and temperature and humidity sensors. Both the transmitter and receiver operate under ambient conditions but require waterproof sheltering. Figure 1 shows typical transmitter and receiver shelters as configured in the IMPROVE network.

The LPV-2 transmitter emits a uniform, pulsed LED light beam of constant intensity at regular intervals for a programmed duration. The transmitter has two components: an electronic control box, and a light source. The transmitter optics performs two functions:

- Concentrates light from the LED lamp into a narrow, well-defined uniform cone, magnifying the beam to the equivalent of a 1500 watt lamp.

- Allows the operator to precisely aim the light at the receiver. Although a one degree cone of light is emitted from the transmitter, only the center 0.17 degree portion is used for routine monitoring. This portion of the beam is very uniform in illumination.

The intensity of the light emitted from the transmitter is precisely controlled by an optical feedback system, which continuously samples the center 0.17 degree portion of the outgoing beam and performs fine adjustments to keep the light output constant. Light emitted from the transmitter is pulsed 78 times a second by a digital control circuit. The light is pulsed to allow the receiver computer to differentiate the lamp signal from background or ambient lighting.

An eyepiece lets the operator precisely aim the light beam. The transmissometer is operated in continuous mode. In the continuous mode the transmitter projects the chopped signal continuously.

The LPV-2 receiver gathers light from the transmitter, converts it to an electrical signal, isolates and measures the received transmitter light, and calculates and outputs visibility results in the desired form. The receiver has three components, the long focal length telescope, the photo-detector eyepiece assembly, and the low power computer. The telescope gathers the transmitter light and focuses it on a photodiode that converts it to an electrical signal. The receiver computer "locks-on" to the transmitter light's pulsed frequency and separates the transmitter light from ambient lighting. The computer compares the measured transmitter light with the known (calibrated) transmitter light to calculate the transmission of the intervening atmosphere. The effect of atmospheric turbulence is minimized by using 6,250 samples of the signal to calculate a one-minute average reading. The resultant reading is held in the computer and available to a data logger until the next value is calculated. Like the transmitter, the receiver is equipped with an eyepiece to precisely aim the detector, and an interval timer to control the interval and duration of measurements. The receiver can operate in either a continuous or cycled mode. In the continuous mode the receiver measures one-minute averages (using 6,250 samples as described above) on a continuous basis. In the cycled mode the receiver is programmed to begin sampling at precise intervals and stays on for selected durations.

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

Electrical Hazards

- Always use a ground wire on all instruments.
- 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
- Avoid electrical contact with jewelry. Remove rings, watches, bracelets, and necklaces to prevent electrical burns.
- 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:

- Inspect the system regularly for structural integrity.
- Keep the interior of the shelter and enclosure clean.
- Inspect the enclosures regularly for structural integrity and weather tightness.

6 INTERFERENCES

The only known gaseous interference for this method is water vapor. Physical interferences can be caused by dirt on the optical windows.

Large bright surfaces can cause the visibility results to be artificially high. If bright surfaces are introduced into the view window, care should be taken to calibrate around them or mitigate them in some other way.

7 PERSONNEL QUALIFICATIONS

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

8 APPARATUS AND MATERIALS

Detailed equipment lists are provided at the start of the maintenance and auditing sections.

8.1 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, and the Agilaire 8872 data logger. The 8816 model is the oldest type of data logger in the network and is a predecessor to the 8832 and 8872 data loggers. The following are descriptions of these data loggers.

ESC 8816 Data Logger

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

For more details, refer to APCD's Data Logger SOP D1, 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 Data Logger SOP D1, or the individual operator manuals (Environmental Systems Corporation, 2006).

ESC 8864 Data Logger

To Be Developed

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 Data Logger SOP D1, or the individual operator manuals.

9 AUDIT

An audit consist of a comparison between two transmissometer units. In this case, it is a comparison of the existing site transmissometer with the newly calibrated transmissometer that will replace the existing site transmissometer upon completion of the audit. ARS will initially set up a date to conduct an audit based on a forecast of weather and visibility. The clearest visibility conditions, calm winds, and moderate temperatures are best for equipment and personnel.

ARS maintains two separate CDPHE owned OPTEC LPV transmissometers which allows for an equipment swap during the audit. For the audit, CDPHE personnel will arrive at the Federal Building and remove the OPTEC transmitter. CDPHE personnel will then meet the ARS auditor at the DESCI building where the auditor will supply a replacement transmitter, a receiver, and associated equipment and documents. The CDPHE personnel will then return to the Federal Building and install the equipment. The CDPHE personnel will work in coordination with the auditor via radio communication to conduct the OPTEC LPV audit following the auditor instructions. It is recommended that personnel bring water, food, shade and sunblock, and a lightweight portable chair as the audit can take several hours.

Upon completion of the audit, personnel will leave the OPTEC LVP transmitter on site. Double check the alignment, LED visibility, window installation and cleanliness, and paperwork completion for the newly installed transmitter. All other equipment will be packed and transported back to the DESCI building to the auditor. Personnel will also check all installation and settings at the DESCI building to ensure all equipment is running and recording properly. The auditor will also audit, maintain, and replace the temperature and humidity sensors as needed.

10 OPERATION AND MAINTENANCE

10.1 Equipment and Supplies

In 1991 the Colorado Department of Health, Air Pollution Control Division, Technical Services Program (TSP) installed an Optec LPV-2 transmissometer in Denver. The transmitter is located on the roof of the Federal Courthouse building in downtown Denver while the receiver is located on the roof of the DESCI building, 1.48 miles to the east-southeast.

An Environmental Systems Corporation (ESC) data logger is model 8832 used for data collection and as an operator/instrument control interface. All transmissometer data are collected from the ESC loggers by and stored on a central computer running software conforming to EPA guidance for automated continuous data collection.

Two manuals and one set of contractor-written SOP's give the operational details and requirements for the system. Both the LPV-2 and LPV-4 operator manuals are pertinent to Colorado's LPV-2 transmissometer (Optec, Inc, 1997), (Optec, Inc, 2011). Colorado's LPV-2 transmissometer was upgraded to an LED light source in July 2012. The LED light source is a new technology that is utilized in the LPV-4 units. Thus Colorado's LPV-2 unit contains components from the LPV-2 and LPV-4 platforms. The Optec LPV-2 and LPV-4 manufacturer's instruction manual covers all necessary procedures and controls for successful operation. The LPV-2 manual is available at the receiver location and at the central offices of TSP. The contractor-written SOP's for the Optec LPV-2 for the IMPROVE network are available for reference at the central offices of TSP (Air Resource Specialist, Inc., 1993 - 2005). For the ESC 8832 the manufacturer's technical manual provides all operating instructions and system keyboard command descriptions. This manual is also available at each site and at the central offices of TSP. Refer to these manuals regarding any aspect of operation of these systems.

The transmissometer site is assigned to a specific TSP employee qualified by formal training, experience, TSP on-the-job training, and contractor training. This employee is responsible for all aspects of assigned site monitoring operation, including but not limited to maintenance, repair, documentation updates, logs, etc. In addition to keeping the site operational with minimal downtime, any of the senior level technicians may be called upon to accept the responsibility for training of new TSP employees and contracted operators.

The ESC data logger is the primary data source, once validated.

10.2 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:

- MONTHLY VISIBILITY TRANSMITTER LOG (Figure 5)
- MONTHLY VISIBILITY RECEIVER LOG (Figure 6)
- MAINTENANCE REPORT FORM (Figure 7)

10.3 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 analyzers and sensors 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 Weekly inspection is performed once each calendar week 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 two weeks. The transmissometer has no such test however.

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

Upon completion of an inspection, log entries onto the MONTHLY VISIBILITY TRANSMITTER LOG, MONTHLY VISIBILITY RECEIVER LOG, and into a “Message to Central” are required. Enter all tasks performed, any malfunctions, or other actions needed, discovered during the inspection.

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

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

10.4 Routine Preventative Maintenance and Scheduled Activities

Preventive maintenance inspections and services should follow the recommended intervals by the EPA, the manufacturer, or as determined by actual experience. If preventive maintenance services are not being done according to the minimum guidelines of the manufacturer as set forth in this standard operating procedure, the TSP may jeopardize any claim to a manufacturer's warranty and may jeopardize the validity of the data collected. The preventive maintenance inspections are scheduled to provide an opportunity to detect and repair damage or wear conditions before major repairs are necessary and the loss of data occurs. The documentation of these activities is essential for quality control tracking and for compliance with EPA's Quality Systems methods. Site and analyzer log sheets along with "messages to central" are part of the official record and the documentation of maintenance or observations are to be written clearly and concisely and in accordance of good laboratory practices.

Table 1. Routine Preventative Maintenance and Schedule Activities

Procedure or Resource	Description
Every Onsite Visit	
	Check station for general condition and proper operation of heating, air conditioning, lighting, and sample pumps.
	Remove trash when waste receptacles are full. Remove from shelter all odorous trash, such as leftover food and food packaging.
10.5.2 Figure 6	Leave a "message to central" and a site log entry summarizing purpose of visit and a summary of all maintenance performed
Weekly Inspection / Maintenance	
	Perform Every Onsite Visit inspections as defined above.
	Perform general housekeeping as necessary. Includes sweeping station as necessary. Dispose of trash as necessary. Clean up trash and remove weeds/vegetation from surrounding property.
10.5.3.1	Transmitter – Perform maintenance as described in Section 10.5.3.1
10.5.4.1	Receiver – Perform maintenance as described in Section 10.5.4.1
10.5.2	Leave a "message to central" summarizing purpose of visit and a summary of all maintenance performed
Monthly Inspection / Maintenance	
	Perform Weekly Inspection/Maintenance as defined above.
	Check associated wiring, power cables, and plumbing (lines and fittings) for wear, damage and proper installation.
	Inspect analyzer fan filters and clean as necessary (if equipped).
10.5.3.2	Transmitter– Perform maintenance as described in Section 10.5.3.2
10.5.4.2	Receiver– Perform maintenance as described in Section 10.5.4.2

Procedure or Resource	Description
Figure 5 **Figure 6**	Fill out new monthly log sheets for the upcoming month.
10.5.5	Verify time on data logger.
	Upon completion of the Monthly Maintenance site visit, all previous months log sheets are collected and placed in the monthly forms data collection box within 2 business days of being collected.
Six Month Inspections / Maintenance	
	Clean cooling fans and blowers.
Annual Inspections / Maintenance	
	Annual Audit – Assist contractor in the performance of an annual audit. Guidance and procedures are to be obtained from the contractor.
	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

10.5 Maintenance Procedures

WHEN MAINTENANCE IS TO BE PERFORMED AT BOTH TRANSMITTER AND RECEIVER SITES, THE RECEIVER SITE SHOULD BE VISITED LAST AS THE RECEIVER ALIGNMENT IS THE MOST CRITICAL ALLIGNMENT OF THE TWO ADJUSTMENTS.

10.5.1 Disable/Enable Analyzer in Data Logger

ESC 8816/ 8832/ 8864

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.

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 machine 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 machine/instrument channel is enabled and reporting to the data logger.

<u>Agilaire 8872</u>

Disable analyzer data channel:

1. After logging in to AirVision™, 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 and not reporting to the data logger.

Enable analyzer data channel:

1. After logging in to AirVision™, 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 and will now report to the data logger.

10.5.2 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.

<u>Agilaire 8872</u>

1. Log in to the data logger using the AirVision™ application.

2. Select the **Home** tab > then **Data Editors** drop down menu.

3. From the drop-down menu select, **LogBook Entry Editor**, and click the round green icon with white "plus" symbol, entitled, **New Log Entry**.

4. Next, click on the **Category**: drop-drop down menu and choose **Logger Message**.

5. Select the drop-down menu item, **Site** and choose the appropriate site, for example, **Welby**.

6. Enter text explaining the purpose of the site visit, followed by your initials. Example, "Weekly completed. No problems noted. – JJ" hit the **Save** button at the top left to save your comments. The application will allow more characters than 80, but they are truncated for the Central computer.

10.5.3 Transmitter

10.5.3.1 Weekly Inspection

Disable data logger, if possible. (10.5.1)

Check receiver location in reticule and record position on daily log (Figure 5).

If alignment is necessary, center receiver location in reticule and note on daily log that alignment was performed.

Verify lamp is operating by visually checking.

Check lamp LED and record on/off status on daily log. If lamp LED is illuminated, a problem exists and should be investigated.

Remove the window from the transmitter shelter and clean using isopropyl alcohol and lint-free wipes.

Clean the lens on the transmitter with alcohol and wipes.

Replace the window on the transmitter shelter.

Check the instrument's alignment and adjust as necessary.

Enable data logger, if possible. (10.5.1)

10.5.3.2 Monthly Inspection

There is no longer a lamp change or voltage to check or record. The only monthly duty is changing the log sheet.

Perform weekly inspections as described above.

Check the instrument alignment and adjust as necessary.

10.5.4 Receiver

10.5.4.1 Weekly Inspection

Disable data logger. (10.5.1)

Using either the front panel LCD display on the receiver or the CRT connected to the DCN, check the present Beta Extinction value and record it on the daily log under "PRE-ALIGNMENT READING".

Check the position of the transmitter in the receiver reticule and record it on the daily log.

Adjust the transmitter light source to the center of the receiver's reticule.

Remove the window from the receiver housing and clean using isopropyl alcohol and a lint-free wipe.

Clean the lens of the receiver telescope using isopropyl alcohol and a lint-free wipe.

Allow the instrument to stabilize, then, using either the front panel LCD display on the receiver or the CRT connected to the DCN, check the Present Beta Extinction value and record it on the daily log under "POST-ALIGNMENT READING."

On the front panel of the receiver, check the "PATH" setting and ensure it is correct for this installation. (The path length is determined when the instrument is installed and should never change.)

On the front panel of the receiver, check the "GAIN" setting and ensure it is correct for this installation, then record the setting on the daily log. (The correct gain setting is determined by the type of equipment used, i.e., long or short telescopes, and the lamp characteristics determined during the annual calibration, and once set should not change unless one of the other parameters changes.)

On the front panel of the receiver, check the "CAL" setting. With the LED the "CAL" should not change!

Using the CRT connected to the DCN, check the relative humidity and temperature and record on daily log.

Enable data logger. (10.5.1)

10.5.4.2 Monthly Inspection

Perform weekly inspection as described above.

On the front panel of the receiver, check all settings to make sure none have been changed inadvertently.

10.5.5 Time Change Procedure

Data logger

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 Calibration Standards

All calibration and transfer standards are maintained by a private contractor. Guidance and documentation of these standards can be obtained from the contractor upon request.

11 HANDLING AND PRESERVATION

Atmospheric visibility measurements 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

Visibility measurements collect no air samples. 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. Interference from reflected or indirect light?
2. Is the shelter temperature stable throughout the day?
3. Is vibration from other equipment causing an effect?
4. Is the air conditioner or heater blowing directly on the instrument?

13.2 General Factors

Other factors linked to the shelter and mechanical systems design can contribute to data loss. The shelters and enclosures should be checked on a regular basis to ensure integrity and weather tightness.

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:

- Erratic or noisy readings
- No readings or off-scale readings
- Instrument locked up at a constant reading or output
- No output
- 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.

14 DATA ACQUISITION, CALCULATIONS, AND DATA REDUCTION

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

14.1 Data Acquisition

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

14.1.1 Primary Onsite Data Acquisition Systems

The APCD employs three different models of onsite DAS in the operations of its air monitoring network. These are the ESC 8816 data logger, the ESC 8832 data logger, and the Agilaire 8872 data logger. The 8816 data logger is the oldest type of data logger in the network and is a predecessor to the 8832 and 8872 data loggers. See Section 8.1.1 for a more detailed description of these data loggers.

14.1.2 Secondary Onsite Data Acquisition Systems

The APCD uses two different data acquisition systems to provide backup data in case of failure of the primary systems. The backup data acquisitions systems are the analyzer based on-board data acquisition systems that are unique to each manufacturer. In the event an on-board data acquisition system is not available (as with the OPTEC), a digital strip chart recorder is used. The second data acquisition system is a Monarch DC1250 DataChart digital data recorder. This logger system is used almost exclusively for the older carbon monoxide Thermo 48C analyzers that have limited internal data logging capabilities.

The APCD does not maintain a secondary onsite data acquisition system for non-criteria pollutants such as meteorology and visibility; this includes the transmissometer and nephelometer at the DESCI site.

14.1.3 Central Polling System

The APCD uses the AirVision software package for its central data management system. "AirVision is a centralized data management and polling software system that is used to acquire, edit, validate, analyze, and report air quality data. 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 Appendix D1, 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.

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. 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 Appendix D1, and in the manufacturers' manual.

15 COMPUTER HARDWARE AND SOFTWARE

The data acquisition system (DAS) used by the APCD/TSP for collecting data from continuous air monitors is generally described in Section 14 and in the CDPHE/APCD/TSP QAPP Appendix D1.

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 APCD/TSP uses several different types of data loggers: 8816, 8832, 8864, and 8872. The data logger currently used for APCD's transmissometer is an 8832. 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 averages, which are in turn aggregated into 1-hour averages. Some data streams may be stored at a third averaging interval, meteorological data can be stored as a 15-minute average 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. Visibility data is used in-house to determine compliance with Colorado's visibility standard and is not uploaded to the AQS system. Monthly electronic data files and related printed material packets (maintenance forms, etc.) are produced.

A more detailed description of the data management process is given in the Data Processing Central SOP in the CDPHE/APCD/TSP QAPP Appendix D1.

16.2 Records Management

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

17 QUALITY ASSURANCE AND QUALITY CONTROL

Quality assurance and quality control are two terms commonly discussed, but often confused. Quality assurance refers to the overall process of ensuring that the data collected meet previously stated Data Quality Indicators (DQI) and associated measurement quality objectives (MQOs). The principal DQIs are precision, bias, representativeness, completeness, comparability, and sensitivity. The principal MQO's are parameter specific and are listed in CDPHE's QAPP. Guidance for developing DQI's and MQO's is given in EPA's Quality Assurance Handbook (US EPA, 2013). The transmissometer does not have any regulatory DQIs or MQOs developed. 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.

17.2 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 APCD's QAPP. 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. By definition, the creation and use of this SOP is a Quality Control function. All Quality Control procedures are described in Sections 9 and 10 of this SOP. Two of the most significant Quality Control procedures are described below.

17.2.1 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 measure of extinction, 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 extinction value. 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 the transmissometer annually when the receiver and transmitter are removed after the annual audit for maintenance. Periodic checks are performed against the nephelometer during clean air episodes. Extinction values from the transmissometer and the nephelometer should be similar during clean air episodes.

For instructions on performing a calibration, see Section 9.

17.2.2 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.

18 BIBLIOGRAPHY

Agilaire. (2009). *AirVision Version 1.* Knoxville, TN: Agilaire LLC.

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

Air Resource Specialist, Inc. (1993 - 2005). *Transmissometer SOP - IMPROVE (Set of 11).* Fort Collins, CO: Air Resource Specialist, Inc.

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

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

Monarch Instruments. (MLK 071612 Rev1.62). *Data Chart 1250 Paperless Recorder Instruction Manual.* Amherst, NH: Monarch Instruments.

Optec, Inc. (1997). *Model LPV-2 Long Path Visibility Transmissometer.* Lowell, MI: Optec, Inc.

Optec, Inc. (2011). *Model LPV-3 & Model LPV-4 Long Path Visibility Transmissometer.* Lowell, MI: Optec, Inc.

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

US EPA. (2013). *Quality Assurance Handbook for Air Pollution Measurement Systems, Volume 2.* RTP, N: US EPA.

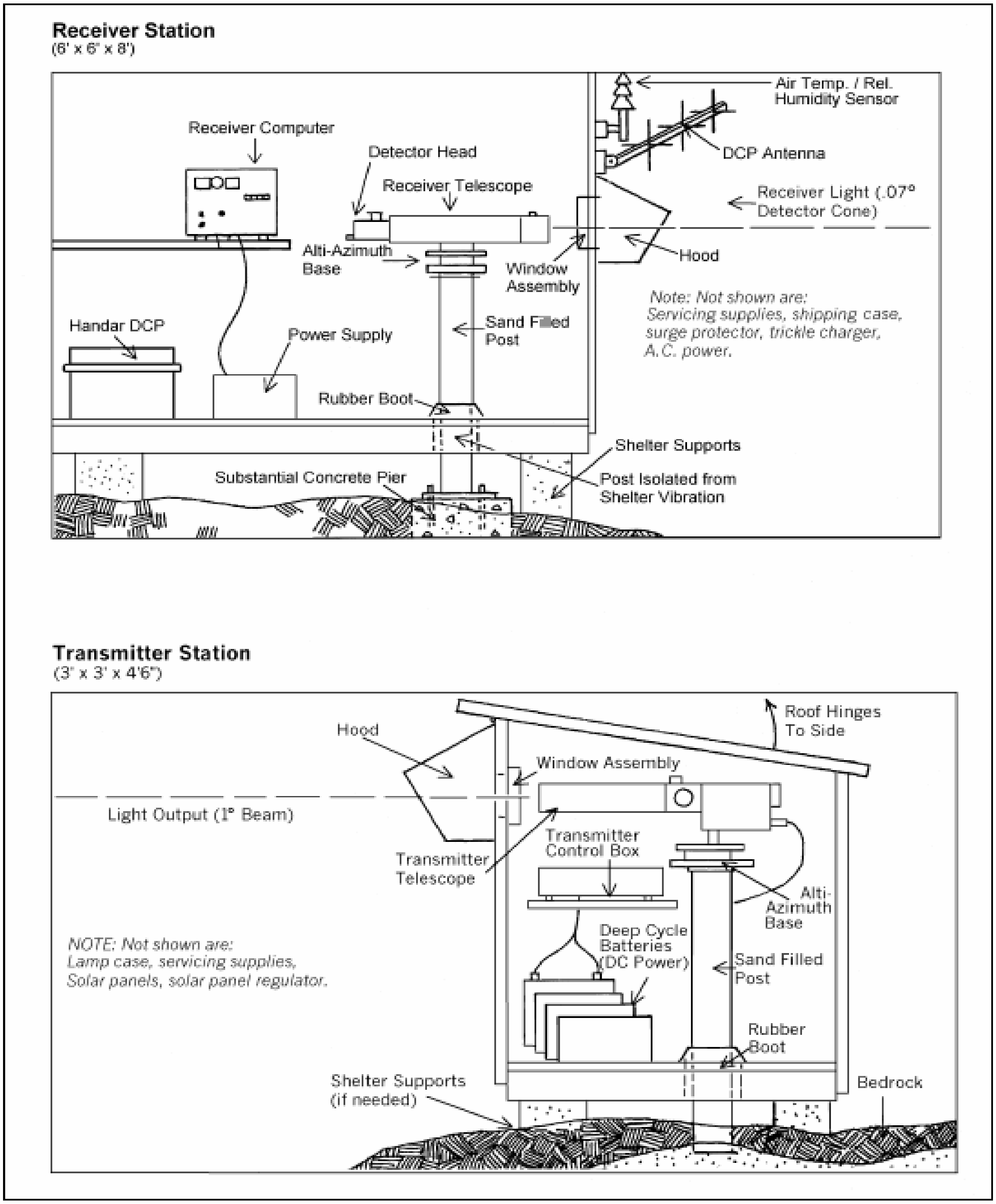

Figure 1. Typical Transmissometer Setup

COLORADO DEPARTMENT OF PUBLIC HEALTH AND ENVIRONMENT
Air Pollution Control Division - Technical Services Program

MONTHLY STATION ACTIVITIES LOG

VISIBILITY TRANSMITTER

MONTH: ___________ YEAR: ___________ STATION: ______________________________________

S/N: ________________________

DATE																								
RECEIVER LOCATION																								
ALIGNED?																								
LAMP #																								
LAMP LED (on / off)																								
FILAMENT VOLTS																								
OPERATOR																								

INSPECTIONS	WEEKLY:											MONTHLY:			ANNUAL:		
		DAY	BY	DAY	BY	DAY	BY	DAY	BY	DAY	BY		DAY	BY		DAY	BY

DAY	TIME OFF	ACTION DUE	BY	ACTION TAKEN	TIME ON	DAY	BY

USE REVERSE SIDE FOR ADDITIONAL INFORMATION 03-Jan-2005 j:\zsfiles\forms\MaintLogs.xls : viz-transtx

Figure 2. Transmissometer - Transmitter Log

COLORADO DEPARTMENT OF PUBLIC HEALTH AND ENVIRONMENT
Air Pollution Control Division - Technical Services Program

MONTHLY STATION ACTIVITIES LOG

VISIBILITY RECEIVER

MONTH: ___________ YEAR: ___________ STATION: ______________________________________

S/N: ________________________

DATE																								
LIGHT SOURCE LOCATION	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
PRE-ALIGNMENT READING																								
POST-ALIGNMENT READING																								
GAIN																								
CALIBRATION #																								
RELATIVE HUMIDITY (%)																								
TEMPERATURE (degF)																								
OPERATOR																								

INSPECTIONS	WEEKLY:											MONTHLY:			ANNUAL:		
		DAY	BY	DAY	BY	DAY	BY	DAY	BY	DAY	BY		DAY	BY		DAY	BY

DAY	TIME OFF	ACTION DUE	BY	ACTION TAKEN	TIME ON	DAY	BY

USE REVERSE SIDE FOR ADDITIONAL INFORMATION 03-Jan-2005 j:\zsfiles\forms\MaintLogs.xls : viz-transrx

Figure 3. Transmissometer - Receiver Log

MAINTENANCE REPORT

DATE____

STATION____

ASSIGNED TO____

ORIGINATED BY____

ANALYZER or EQUIPMENT____ S/N______________

MALFUNCTION DESCRIPTION OR COMPLAINT

ACTION TAKEN

DATA TO BE DELETED (IF ANY)

ENTER EXACT DATES AND DATA HOURS

COMPLETED BY________________________________

COMPLETION DATE________________________________

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

Figure 4. Maintenance Report Form