Air Resource Specialists, Inc.

Long-Range Transmissometer System For Visibility Monitoring

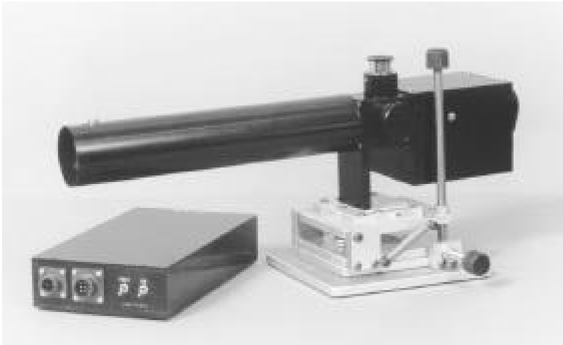
Technical Note 92-204

Introduction

When the requirement is continuous, accurate measurement of visual air quality, an Optec LPV-2 transmissometer system is the answer. The Optec LPV-2 continuously and directly measures the light transmission properties of the atmosphere along a selected sight path.

Air Resource Specialists, Inc. (ARS) successfully employs the LPV-2 to monitor conditions in pristine to urban environments and is experienced in all aspects of successful monitoring, including installation, training, calibration, servicing, data reduction, and reporting.

Transmissometer Receiver



Transmissometer Transmitter

Instrument Specifications

The LPV-2 transmissometer is manufactured by Optec, Inc. The instrument has evolved to its present configuration as a result of the visibility monitoring needs defined by the National Park Service (NPS) Visibility Monitoring and Data Analysis Program, and the Interagency Monitoring of Protected Visual Environments (IMPROVE) Committee.

The LPV-2 meets the following criteria:

- Measures the light transmission properties of the atmosphere both day and night at 550 nanometers or other preselected wavelengths
- Provides a variety of sampling and averaging options
- Directly integrates scattering and absorbing properties of aerosols and gases in the selected sight path; these transmission measurements have an exact relationship to the total atmospheric extinction coefficient
- Operates unattended for extended periods
- Operates at low power, 12-volt DC for remote and solar installations
- Operates at ambient temperatures
- Is modular, lightweight, and easily transported
- Is easily serviced

The first LPV-2 was installed in August 1986. Since that time, the instrument has become the standard against which other visibility monitoring techniques have been compared.

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Concept

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.

The LPV-2 transmissometer has two primary components: a light source (transmitter), and a light detector (receiver). Depending on the expected range of visual air quality, the components are generally placed form 0.5 to 10 kilometers apart. The system can take measurements day and night because the light emitted form the transmitter is “chopped” at 78 pulses a second to allow the receiver to differentiate the lamp signal from background, ambient lighting. The receiver-measured transmitter light intensity is compared to the known (calibrated) transmitter light output to calculate the percent transmission of the atmosphere. When the path distance is supplied, the receiver computer can calculate and express visibility measurements in terms of extinction (km^{-1}) or visual range (km).

The LPV-2 transmissometer system’s low power consumption permits remote operation from a small power supply, such as a solar power system. Both components have self-resetting, battery-backup circuitry to accommodate extended periods of unattended operation. Both components operate at ambient temperatures, but require sheltering from precipitation and dirt. Routine servicing of the system can be performed by trained, non-technical personnel. Instrument calibration, generally performed annually, and repair requires trained technical personnel or factory-authorized service.

Transmitter

Example Transmissometer Transmitter Shelter

The LPV-2 transmitter emits a uniform, chopped, incandescent 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 or transmitter.

The transmitter optics perform two functions:

1. It concentrates light from the 15 watt tungsten filament lamp into a narrow, well-defined uniform cone, magnifying the beam to the equivalent of a bare 1500 watt lamp; and
2. It allows the operator to precisely aim the light beam at the receiver. Although a 1-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 “chopped” at 78 pulses a second by a mechanical spinning disk in front of the lamp. The light is chopped 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 can be operated in either a "continuous" or "cycled" mode. In the continuous mode, the transmitter projects the chopped signal continuously. To prolong lamp life, reduce power consumption, or to accommodate various sampling strategies, the transmitter can be operated in the cycled mode. In the cycled mode, the transmitter is programmed on at precise intervals and stays on for selected durations.

Receiver

Example Transmissometer Receiver Shelter

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:

1. Long focal-length telescope
2. Photodetector eyepiece assembly
3. 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 chopped 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 datalogger 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 operates at ambient temperatures, but requires a waterproof shelter.

Siting

Transmissometer Installation
Denver, Colorado

When siting the transmissometer, the objectives of the monitoring program and instrument specifications are considered. The fundamental requirement for operation is a clear, unobstructed line-of-sight between the transmitter and receiver. To reduce the effects of thermal turbulence, the sight path should be elevated as far above the terrain surface as practical. In rural applications, the transmitter and receiver are typically located near terrain drop-offs; in urban applications, the sight path can be from one building to another.

When selecting a sight path distance, the expected range of visual air quality is considered. As a general guideline, remote areas in the western United States require a separation distance of between 5 and 10 kilometers, while sites in the East or in urban areas require a sight path of between 0.5 and 4 kilometers. The sight path distance must be measured to the nearest meter. In most cases, a slope-distance measurement with this accuracy can only be made with an electronic distance meter.

4 P.M.   Day 1

System Installation and Operation

The primary installation requirements are stable mounting posts, adequate sheltering, and a reliable power supply. The mounting system configuration should minimize telescope and image movement due to thermal effects. Alti-azimuth instrument bases allow precise alignment of the transmitter and receiver telescopes. Sheltering must be waterproof, but heating or cooling are not recommended. The transmitter and receiver operate on 12 volts DC and require 34 and 5 watts respectively for continuous operation. The system can be operated with solar power. Routine servicing can be performed by trained, non-technical personnel. System alignment and optical cleaning should be performed weekly; lamp replacement is required after 500 to 750 hours' use. System calibration and annual servicing must be performed by trained technical personnel or by the manufacturer.

8 A.M.   Day 2

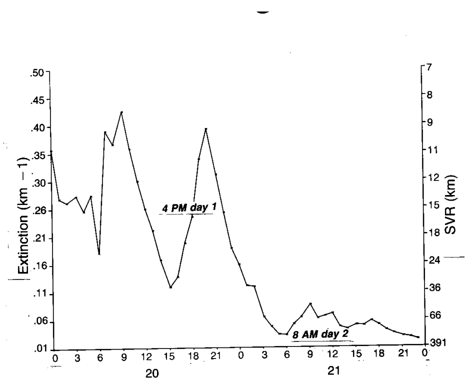
Data Recovery and Analysis

The receiver computer outputs visibility measurements to dataloggers, (in a 0-10 volt range) in the following user-selected formats:

- Raw receiver reading (counts)
- Extinction (km^{-1})
- Visual range (km)

The sight path distance is entered on the computer front panel to allow calculation of extinction and visual range. The computer front panel also displays the latest reading.

Since data can be output in selected engineering units, analysis is straight-forward. Pre- and post-calibration values for each operational lamp must be integrated into the analysis. Review of the data most appropriately includes an analysis of how weather, such as rain or fog, affects readings. To support this analysis, collocated air temperature and relative humidity measurements are recommended. Typical analyses can yield hourly, multiple hours, daily, or seasonal summaries of collected data.



Continuous Transmissometer Data
Compared with Photographic Evidence

Services Provided by Air Resource Specialists, Inc.

ARS has been closely involved in the development, testing, and operational application of the Optec LPV-2 transmissometer. ARS developed the standard operating procedures and data analysis procedures for the system, and has designed and installed systems for urban and remote pristine environments. The corporation specializes in supporting all phases of visibility-related monitoring and analysis from selection of the best monitoring approach to site selection, installation, training, calibration, maintenance, data analysis, and reporting. ARS' scientists and field specialists are available to discuss your specific monitoring and analysis needs.

For Further Information Contact

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