Model 3563 Integrating Nephelometer

Determine the integral scattering coefficient of aerosols in the cleanest atmospheric conditions.

Our high-sensitivity, three-wavelength Integrating Nephelometer with backscatter shutter (Model 3563) is designed for short- and long-term measurements of the light-scattering coefficient of atmospheric and laboratory aerosols. Particularly well-suited for studies involving climate, visibility, and air quality, the Model 3563 offers these key features:

- Sensitivity to light-scattering coefficients as low as 2.0×10^{-7} per meter (60-second averaging time)
- High vacuum integrity that ensures accurate measurements, even when sampling much cleaner or more polluted air than the instrument's immediate surroundings
- Real-time background subtraction of Rayleigh scattering of the air itself from the total scattering signal by measuring sample pressure and temperature
- Real-time, PMT dark-current and light-source compensation using a rotating reference chopper
- Measurement of total (7- to 170-degree) and backscatter (90- to 170-degree) signals using a rotating backscatter shutter to block the illuminated sample volume from 7 to 90 degrees
- Simultaneous three-color detection for wavelength-dependent measurements

Other features include:

- Internal relative-humidity and temperature sensors
- Built-in heater to minimize condensation on the instrument walls caused by high humidity
- Minimal sample heating to preserve the relative humidity of the aerosol sample
- Onboard microprocessors to collect and process data, control all instrument functions, and communicate with an external computer
- A variety of signal outputs to accommodate various computers and data loggers
- Automatic filter loop to purge the sample volume with clean air for zero-reference calibration
- Minimal aerosol sample loss through the system
- Selectable averaging time (from 1 to 4096 seconds)
- Internal clock with battery backup

Applications

TSI Integrating Nephelometers are designed specifically for studies of direct radiative forcing of the Earth's climate by aerosol particles, or studies of ground-based or airborne atmospheric visual air quality in clean areas. They may also be used as an analytical detector for aerosol particles whenever the parameter of interest is the light-scattering coefficient of the particles after a pretreatment step, such as heating, humidification, or segregation by size.

The light-scattering coefficient is a highly variable aerosol property. Integrating Nephelometers measure the angular integral of light scattering that yields the quantity called the *scattering coefficient*, which is used in the Beer-Lambert Law to calculate total light extinction.

Beer-Lambert Law

$$I / I_o = e^{(-\sigma x)}$$

where:

I_o = intensity of light source
I = intensity of light after passing through atmospheric path
x = thickness of medium through which light passes
σ = total extinction coefficient
(= scattering coefficient + absorption coefficient)

The high-sensitivity Integrating Nephelometer determines the scattering coefficient, from which the extinction coefficient is calculated. The symbol b is often used in place of σ to represent the total extinction coefficient.

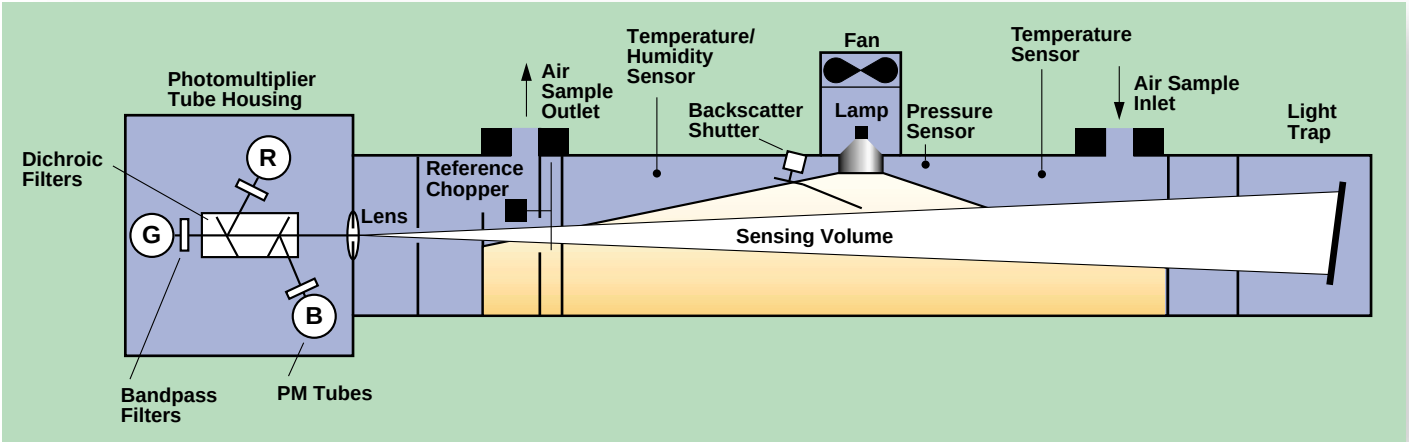
Operation

Model 3563 includes three-wavelength and backscatter features. During operation, a small, turbine blower draws an aerosol sample through the large diameter inlet port into the measurement volume. There, the sample is illuminated over an angle of 7 to 170 degrees by a halogen light source that has been directed through an optical pipe and opal glass diffuser. The sample volume is viewed by three photomultiplier tubes (PMTs) through a series of apertures set along the axis of the main instrument body. Aerosol scattering is viewed against the dark backdrop of a very efficient light trap. The light trap, apertures, and a highly light-absorbing coating on all internal surfaces combine to give a very low scattering signal from the walls of the instrument.

The light scattered by the aerosol is split into three colors using high-pass and band-pass color filters in front of the PMT detectors. A constantly rotating reference chopper provides three modes of signal detection. The first mode, described above, is a measure of the aerosol light-scattering signal allowed by an opening in the rotating shutter. The second mode blocks all light from detection and gives a measurement of the PMT dark current, which is subtracted from the measured signal. The third mode inserts a translucent portion of the shutter into the direct path of the light to provide a measure of the light-source signal. In this way, the instrument compensates for changes in the light source.

In backscatter mode, the backscatter shutter rotates in front of the light source to block light in the 7- to 90-degree range. When this portion of light is blocked, only light scattered in the backward direction is transmitted to the PMT detectors. The backscatter signal can be subtracted from the total signal to calculate forward-scattering data. When this measurement is not of interest, the backscatter shutter can be "parked" in the total-scatter position.

Periodically, an automated ball-valve built into the inlet can be activated to divert all of the aerosol



Model 3563 includes three wavelengths and a backscatter shutter, useful features for climate and air-quality studies.

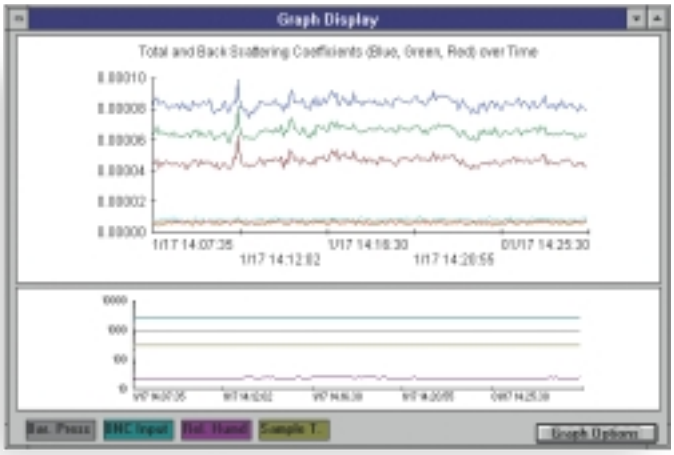
sample through a high-efficiency filter. This gives a measure of the clean-air signal for the local environment. This signal is subtracted, along with the PMT dark-current signal, from the aerosol-scatter signal to give only that portion of the scatter signal provided by the sample aerosol. Particle-scattering parameters for all three wavelengths of total and backscatter signal are continuously averaged and passed to a computer or data logger for permanent storage.

A built-in sample heater minimizes condensation on the instrument walls caused by humid aerosols. At high humidities, atmospheric particles such as sulfates and sodium chloride adsorb water and can therefore undergo phase transitions. The result would be changes in particle size, shape, and refractive index. Operating aerosol instruments in an air-conditioned laboratory often results in sample flows with greater than 100-percent relative humidity. The heater protects against this problem by warming the walls of the sample chamber to match the temperature of the inlet air sample. The heater can be switched on or off as needed.

Software

Model 3563 includes software that provides the tools needed to set up the instrument, check instrument status, start and stop data collection, and view data. The software enables you to display data records in a polled format that is easy to interpret. It also stores data in an unpolled format to a specified file.

Software makes it easy to set up the Model 3563.



Wavelength-dependent measurements show all three colors simultaneously.

To Order

Specify	*Description*
3563	Three-color Integrating Nephelometer with backscatter shutter, power supply, and software

In addition to the full-featured Model 3563 described in this document, TSI offers another model with only one wavelength and no backscatter option. The basic Model 3551 is intended primarily for applications involving visibility measurements. See separate product sheet for additional information.

Bibliography

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Specifications

Model 3563 Integrating Nephelometer

Sensor Assembly

Wavelengths	450 nm (blue), 550 nm (green), and 700 nm (red)
Bandwidth	40 nm (all wavelengths)
Sensitivity at 60-sec Averaging Time (aerosol scattering coefficient, σ_{sp})	
Red and Green Wavelengths	2.0×10^{-7}/m
Blue Wavelength	3.0×10^{-7}/m
Upper Detection Limit	2.0×10^{-2}/m at 60-sec averaging time
Averaging Time	1 to 4096 sec (selectable)
Drift	$<2.0 \times 10^{-7}$/m at 60-sec averaging time for up to one hour after filtered-air reference measurement for green wavelength
Optical Background Signal	
Blue and Green Wavelengths	$<5.0 \times 10^{-5}$/m
Red Wavelength	$<1.0 \times 10^{-5}$/m
Angular Integration	7 to 170°
Backscatter Shutter	Changes angular integration to 90 to 170°
Reference Chopper	Allows measurement of light intensity of a reference object illuminated by main lamp or of photodetector's dark signal
Filtered Air Chopper	High-efficiency particle filter switches into sample air stream automatically on computer demand or at intervals selected by user
Response Time	<10 sec
Recommended Flow Rate	20 to 200 L/min
Inlet/Outlet Dimensions	1-in. female NPT
Particle Transport Efficiency	>95% of unit-density particles from 0.05 to 5 µm in diameter
Temperature/Pressure Sensors	Built-in sensors allow corrections for changes in the Rayleigh-scattering coefficient of air within the sample volume
Humidity Sensor	Measures relative humidity of sample from 5 to 95% ±5%
Time and Date	Provided by internal, real-time clock with battery backup
Vacuum Integrity	<10 mm Hg/hr at a negative pressure of 700 mm Hg (not including blower)
Environmental Operating Conditions	
Ambient Temperature Range	10 to 40°C (50 to 104°F)
Ambient Humidity Range	0 to 95% RH noncondensing
Dimensions	1100 mm × 300 mm × 250 mm (43 in. × 12 in. × 10 in.)
Weight	<18 kg (<40 lb)
Power Requirements	Operates on 24.0 ±4.0 VDC at <5.0 A (175 W maximum), supplied by power supply (included)

Power Supply

Output	24.0 ±4.0 VDC at <5.0 A
Dimensions	305 mm × 178 mm × 102 mm (12 in. × 7 in. × 4 in.)
Weight	<5 kg (<11 lb)
Power Requirements	100/120/220/240 VAC, 50/60 Hz at <175 W

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