INTEGRATING NEPHELOMETER MODEL 3563

ACCURATELY DETERMINE THE SCATTERING COEFFICIENT OF ATMOSPHERIC AEROSOLS EVEN IN THE CLEANEST CONDITIONS.

The Integrating Nephelometer 3563 is a unique analytical instrument that measures light scattering properties of atmospheric and laboratory aerosols by measuring the light scattered by aerosol particles and subtracting light scattered by the gas.
It is handmade in the USA to provide the highest quality measurements possible with extremely low background noise in the detector. As such, it offers sensitivity to light scattering coefficients lower than 1.0 x 10^{7} meter^{-1} (blue and green wavelengths, 60-sec averaging time). It is the only commercial nephelometer that has proven to work reliably and continuously over many years in networks across the world.

This three-color nephelometer allows you to accurately measure both total and backscatter signals, with a wide angular integration from 7 to 170° and an angular truncation of the total scatter signal that is well understood and documented in peer-reviewed literature.

TSI Model 3563 allows the user to select the averaging time, so that data can be tailored to different test requirements; users can also vary flow rates from 20 up to 200 L/min, so diffusion losses of ultrafine particles can be minimized. It includes temperature and humidity sensors, and possesses high vacuum integrity making it best suited for high tower, aircraft, or similar high altitude measurements. Thanks to its built-in periodic auto calibration with HEPA-filtered air to compensate for changes in gas composition that affect Rayleigh scattering of air molecules, it produces accurate measurements, even in the most pristine, remote locations where small variations are often meaningful.

Applications

+ It is particularly well-suited for both short- and long-term measurements of aerosol optical properties related to climate, air quality, defense, visibility, as well as radiative transfer studies.

Features and Benefits

+ Highest sensitivity to light-scattering coefficients as low as 1.0 × 10^{-7} per meter (60-second averaging time)
+ High vacuum integrity with minimal draft 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 molecules from the total scattering signal while accounting for sample pressure and temperature
+ Automatic, PMT dark-current and real-time light-source compensation using a patented rotating reference chopper
+ Measurement of total (7 to 170°) and backscatter (90 to 170°) signals using a rotating backscatter shutter to block the illuminated sample volume from 7 to 90°
+ Exact calibration results with average deviations smaller than 2% compared to CO_2 theoretical values
+ High-quality instrumentation that is proven to be cost effective when the total cost of ownership is taken into account.

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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.

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° by a halogen light source that has been directed through a patented optical pipe and opal glass diffuser. The combination of a halogen light source and an elliptical dichroic mirror results in the lowest deviation from the ideal sine curve and smallest differences instrument to instrument. They also avoid partial failures seen on instruments using LED style lamps. 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 very low baseline scattering 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, patented 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° 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.

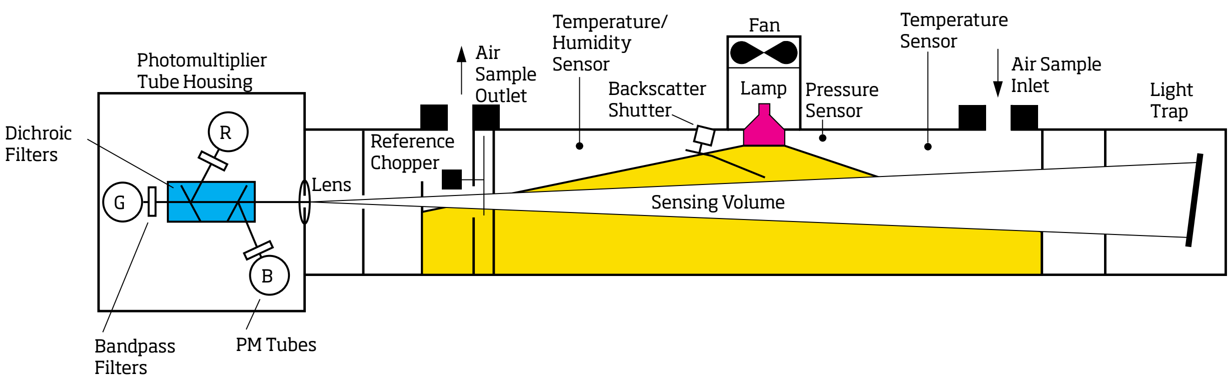
Beer-Lambert Law

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

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 s to represent the total extinction coefficient.



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

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

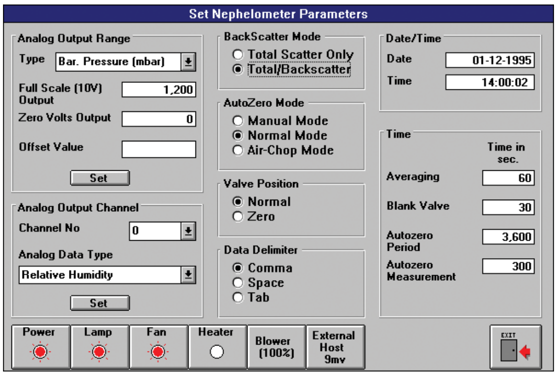
A built-in sample heater minimizes condensation on the instrument walls caused by humid aerosols. At high humidities, atmospheric particles such as sulfates and sodium chloride adsorb water and can therefore undergo phase transitions. The result would be changes in particle size, shape, and refractive 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 installed in the Model 3563 can be easily switched on or off as needed.

Additional Features

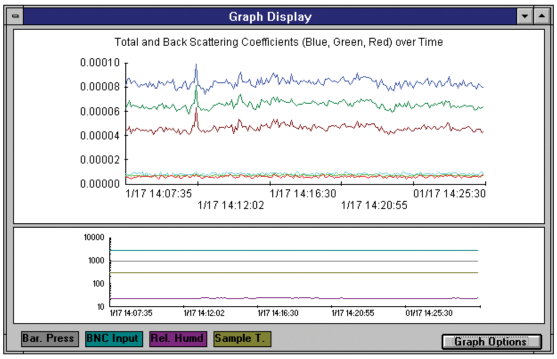
+ Automatic filter loop to purge the sample volume with clean air for zero-reference calibration
+ Minimal aerosol sample loss through external sampling system and the instrument due to high flow rate
+ Internal relative-humidity, pressure and temperature sensors (2)
+ Built-in heater to minimize condensation on the instrument walls caused by high humidity
+ 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
+ User selectable averaging time (from 1 to 4096 seconds)
+ Internal clock with battery backup

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

Integrating Nephelometer

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

Bibliography

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SPECIFICATIONS

INTEGRATING NEPHELOMETER
MODEL 3563

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, SP)

Blue and Green Wavelengths	1.0×10^{-7}/m
Red 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
<2.0×10^{-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	<5.0×10^{-5}/m
Red Wavelength	<1.0×10^{-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. (25 mm) 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 (H x W x D)
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

Specifications are subject to change without notice.

This instrument was developed by TSI under license from the University of Washington. Many of its design aspects are patented. Refer to patent numbers 3,563,661; 3,700,333; and 3,953,127.

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