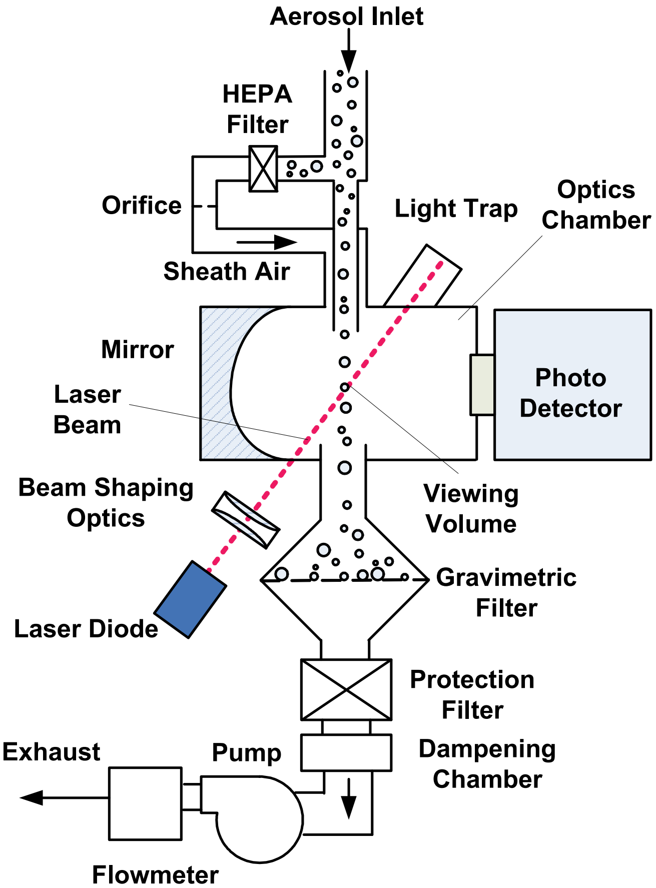
DUSTTRAK™ II AEROSOL MONITOR THEORY OF OPERATION

APPLICATION NOTE EXPMN-001

The Models 8530 and 8532 versions of DUSTTRAK™ II Aerosol Monitors are single-channel basic photometric instruments used to determine the mass concentration of aerosols in real time. The DUSTTRAK II Model 8530 (high concentration up to 400 mg/m^3) is a desktop instrument, while the Model 8532 is a handheld, with a concentration range up to 150 mg/m^3.



Using the schematic provided, aerosol is drawn in to the sensing chamber in a continuous stream using a diaphragm pump. Part of the aerosol stream is split ahead of the sensing chamber and passed through a HEPA filter and injected back in to the chamber around the inlet nozzle as sheath flow. The remaining flow, called the sample flow passes through the inlet entering the sensing chamber. Here, it is illuminated by a sheet of laser light. This sheet of laser light is formed from a laser diode. First, the light emitted from the laser diode passes through a collimating lens and then through a cylindrical lens to create a thin sheet of light. A gold coated spherical mirror captures a significant fraction of the light scattered by the particles and focuses it on to a photo detector. The voltage across the photo detector is proportional to the mass concentration of the aerosol over a wide range of concentrations. The voltage is then multiplied by a calibration constant which is determined from the ratio of a known mass concentration of the test aerosol to the voltage response of the DUSTTRAK II Aerosol Monitor. Typically, the test aerosol is Arizona Test Dust (or ISO 12103-1, A1 test Dust).

Light scattering instruments such as photometers respond linearly to mass concentration. The scattered light depends on the size distribution of the aerosol, refractive index, shape factor and density of the aerosol. During calibration, the light scattering response of the calibration aerosol to the laser light in terms of voltage across the photo detector is related to the density of the aerosol in terms of mass. The size distribution of the aerosol also affects the instrument's response. The light scattering from particles can be mathematically modeled using a complex set of equations based on Mie scattering theory. The dependence of the instrument's response on the aerosol properties is typical of all aerosol monitors in the market that are based on photometric measurement.

To improve the accuracy of the mass measurement, the unit can be calibrated with gravimetric sample(s) by conducting side-by-side comparisons with the DUSTTRAK II Aerosol Monitor readings to gravimetric samples. On the Desktop Model 8530, a 37-mm cassette sampler can be inserted in-line with the aerosol stream at the outlet of the optics chamber allowing the user to perform a gravimetric analysis without the need for using an external pump and filter holder.

The DUSTTRAK II Aerosol Monitor comes with a set of TSI designed impactors (PM_1, $PM_{2.5}$, Respirable/ PM_4, and PM_{10}) for users to perform size-selective sampling, if needed. The impactors easily attach to the inlet of the DUSTTRAK II Aerosol Monitor. For respirable fraction, a Dorr-Oliver cyclone is provided as a standard accessory as well. All TSI impactors are to be operated at 3.0 L/min. The recommended flow rate for the Dorr-Oliver cyclone is 1.7 L/min to achieve a 4 µm respirable cutpoint.

At TSI, the DUSTTRAK II Aerosol Monitor is calibrated against a reference photometer (Model 8587) that is gravimetrically calibrated to ISO 12103-1, A1 test dust (Arizona Test Dust). This test dust has a wide size distribution covering the entire size range of the DUSTTRAK II Aerosol Monitor and is representative of a wide variety of ambient aerosols.

The optics inside the DUSTTRAK II Aerosol Monitor is kept clean by surrounding the aerosol stream with a sheath of clean filtered air. This sheath air confines the aerosol to a narrow stream and prevents particles from circulating around the optics chamber and depositing on the optics. Sheath flow also improves the response time of the instrument. The user can also access the sheath and main flow filters that need to be changed periodically to maintain the flow ratio between the sample flow and sheath flow a constant. The DUSTTRAK II's firmware will automatically detect the life of those filters and warn the user to change them before the pressure drop across those filters become excessive.

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