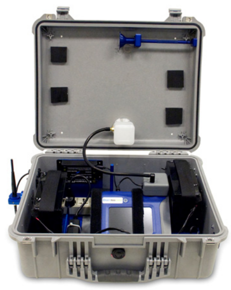
Inlet Aspiration Efficiency of the DUSTTRAK™ Environmental Enclosure Model 8535

Application Note ITI-060

The Model 8535 DUSTTRAK™ Environmental Enclosure utilizes an external omni-directional aerosol inlet to collect and direct particles into the desktop versions of the TSI DUSTTRAK™ II, DUSTTRAK™ II HC and DUSTTRAK™ DRX Aerosol Monitors. The design of the inlet maximizes the aspiration efficiency of aerosol particles in wind conditions ranging from calm air to wind speeds of 22 mph.

DUSTTRAK™ II or DRX Desktop Aerosol Monitor



Environmental Enclosure Model 8535 with inlet assembly stored

Environmental Enclosure in-use

Defining Aerosol Aspiration Efficiency

Aspiration efficiency is defined as the fraction of particles that are sampled, compared to the total number of particles actually present in the air. An aspiration efficiency of 1.0 means that all particles are sampled. Aspiration efficiency is size dependent. The larger the particle, the more likely it is to escape sampling because momentum effects prevent it from following the flow streams. Smaller particles follow the flow stream more easily, and are sampled with higher efficiency.

Our knowledge of aerosol mechanics allows us to make predictions about the aspiration efficiencies of an inlet sampling in either calm or moving air. The mathematical models used to predict efficiency assume the use of a thin-walled cylindrical probe which is bent into the direction of the wind. To correctly apply these mathematical models to the TSI inlet, knowledge about why particle losses occur is necessary. Losses can be attributed to gravitational settling, particle impaction, and sub- or super-isokinetic effects.

Sub-isokinetic sampling takes place when ambient wind speed is greater than the sampling velocity found at the inlet point of the aerosol sampler. This creates a high-pressure area in front of the inlet and causes the flow streamlines to diverge around it. Extremely small particles (less than 1.0 micron) have low momentum and follow the streamlines. Larger particles that have more momentum will have a tendency to remain traveling in the same direction and enter the sampler rather than follow the streamline around it. This can cause the larger particles to be artificially sampled, resulting in a mass concentration reading that is higher than the true value.

Super-isokinetic sampling can result in the disproportionate sampling of the smaller particles. The errors caused by super-isokinetic sampling are negligible for the Model 8535 because these small particles have very low mass and contribute very little to mass-based measurements made by a photometer (like the TSI DUSTTRAK™ II, DUSTTRAK™ II HC, or DUSTTRAK™ DRX Aerosol Monitors).

8535 Inlet Aspiration Efficiency Test Results

The aerosol inlet mounted on the 8535 DUSTTRAK™ Aerosol Monitor Environmental Enclosure was tested in an aerosol-generating wind tunnel to measure its aspiration efficiency characteristics. The wind tunnel generates aerosolized glass beads with a broad size distribution. Under the controlled environment used in these experiments, a stable aerosol concentration could be maintained for long periods of time. A TSI Aerodynamic Particle Sizer® Spectrometer (APS™) was used to count the number of particles being sampled by the 8535 inlet over a period of 1 minute. The true particle count (reference) was determined using a thin-walled bent tube sampler and mathematically adjusted to account for particle losses due to isokinetic sampling and particle impaction through the ninety degree bend. The APS was switched between the two samplers 11 times to statistically minimize any small fluctuations in aerosol concentration. The aspiration efficiency was calculated by taking the ratio of the particles sampled through the 8535 inlet to the particles sampled through the reference inlet. This same process was repeated for varying wind speeds of 5, 10, 14.1, and 22.4 mph. During all measurements, the inlet flow rate was maintained at 1.7 liters per minute, which is the flow rate used by the TSI DUSTTRAK™ II, DUSTTRAK™ II HC, or DRX Aerosol Monitors. The entire test set up is shown below in Figure 1.

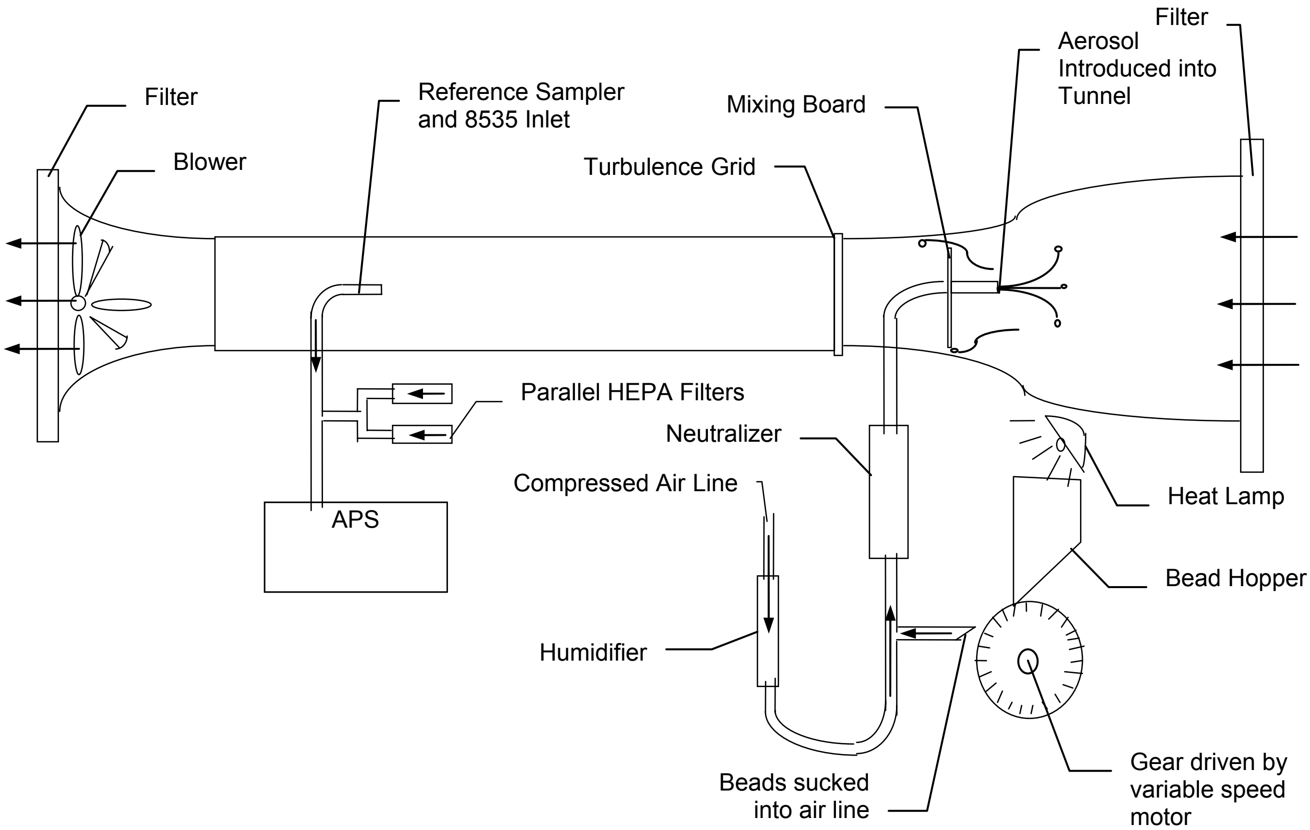
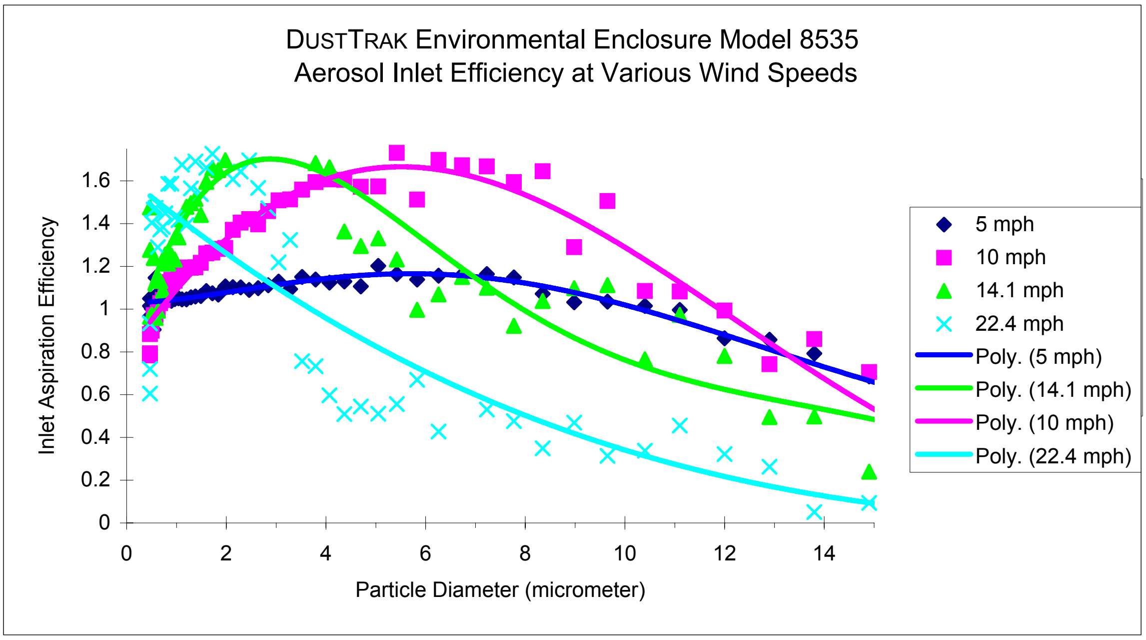


Figure 1 - Inlet Characterization Aerosol Wind Tunnel

The results obtained from this research show that the Model 8535 inlet samples all particles specified by the PM_{10} standard up to wind speeds of 22 mph.


DustTrak Environmental Enclosure Model 8535
Aerosol Inlet Efficiency at Various Wind Speeds
Inlet Aspiration Efficiency
Particle Diameter (micrometer)
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
0
2
4
6
8
10
12
14
5 mph
10 mph
14.1 mph
22.4 mph
Poly. (5 mph)
Poly. (14.1 mph)
Poly. (10 mph)
Poly. (22.4 mph)

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