DUSTTRAK™ DRX AEROSOL MONITOR CALIBRATION METHODS

APPLICATION NOTE EXPMN-005

The DUSTTRAK™ DRX monitor is calibrated with Arizona Road Dust (or ISO 12103-1, A1 test Dust) at TSI. For most applications, Arizona Road Dust calibration would be appropriate because it is representative of a wide variety of ambient aerosols. However, under situations where the aerosol being measured is significantly different from the A1 test dust, a custom calibration with the aerosol of interest is needed to achieve improved accuracy for mass and size differentiation.

The DUSTTRAK™ DRX monitor has two calibration factors: a photometric calibration factor (PCF) and a size calibration factor (SCF). The PCF accounts for the photometric response difference between A1 test dust and the aerosol being measured. The SCF accounts for the differences between aerodynamic size and optical response. The factory default values for PCF and SCF are 1.

TSI offers two calibration methods based on the end users ability to perform gravimetric sampling. For end users who do not have the ability to perform gravimetric sampling which requires filter media, accurate microbalance for weighing the filters and considerable investment in time, a standard calibration would be appropriate. The standard calibration is convenient and easy to perform. For sophisticated end users who want greater accuracy along with gravimetric sampling, we recommend the advanced calibration. The advanced calibration involves two gravimetric filter measurements and is more accurate than the standard method.

We should emphasize that the DUSTTRAK™ DRX monitor combines photometry with single particle sizing for mass measurement. Both photometry (PCF) and size (SCF) need to be calibrated. In most cases one cannot perform one gravimetric calibration to calibrate the DUSTTRAK™ DRX monitor, as we do for TSI DUSTTRAK™ Models 8520, 8530, and 8532. This is because one gravimetric calibration can only calibrate the photometric signal. If SCF is not calibrated, the DUSTTRAK™ DRX monitor will assign particles an incorrect size, which result in incorrect size segregated mass concentrations. The one gravimetric calibration will only work when the aerosol being measured is less than 2.5 µm.

DRX Standard Calibration

The primary goal of the standard calibration is to obtain the size calibration factor (SCF) for the aerosol of interest. The DUSTTRAK™ DRX's Graphic User Interface (GUI) will guide the user to measure the aerosol size distribution with and without a $PM_{2.5}$ impactor included in the accessory kit. The instrument will then automatically calculate the ratio of these two size distributions to calculate the SCF using the following formula:

$$SCF_{New} = \frac{2.5}{d_{50}} \times SCF_{Old},$$

where SCF_{New} and SCF_{Old} are the new and old SCF, respectively; 2.5 is the cut-off size of the $PM_{2.5}$ impactor; and d_{50} is the particle size measured by DUSTTRAK™ DRX monitor whose efficiency is 50% through the $PM_{2.5}$ impactor.

This standard calibration process is very easy and does not require external gravimetric filter sampling or a microbalance. Depending on the aerosol concentration, the calibration process can take from 4–40 minutes. With a calibrated SCF, the DRX will assign each sampled particle to the right size fraction, and then calculate the mass concentration based on the particle counts in the different size fractions. No calibration is made to the photometric component of the mass measurement. However, if desired, the user can still perform a gravimetric measurement to perform a photometric calibration following the PCF calibration procedure in the Advanced Calibration.

DRX Advanced Calibration

The advanced calibration method is employed to yield high size segregated mass concentration accuracy for $PM_{1.0}$, $PM_{2.5}$, Respirable and PM_{10} size fractions. It involves two gravimetric measurements to obtain PCF and SCF. The two gravimetric measurements can be done in sequence or in parallel, depending on the gravimetric sampling device availability.

Option 1: Serial Gravimetric Calibration

When the user has only one set of gravimetric sampling devices, the DUSTTRAK™ DRX advanced calibration can be performed in two serial steps. The experimental setup is in Figure 1a. The calibration steps are outlined below:

Step 1: PCF Calibration.

- Install a $PM_{2.5}$ impactor at the inlet of the external gravimetric filter.
- Co-locate and run the gravimetric sample and DUSTTRAK™ DRX monitor simultaneously to collect enough mass on the gravimetric filter.
- Calculate the $PM_{2.5}$ mass concentration ($PM_{2.5\_Grav}$) from the gravimetric filter based on the net mass collected on the filter, sampling time, flow rate, and total liters of air sampled.
- Read the DUSTTRAK™ DRX monitor average $PM_{2.5}$ mass concentration ($PM_{2.5\_DRX}$) from the screen or through TRAKPRO™ Data Analysis Software.
- Calculate the new PCF

$$PCF_{New} = \frac{PM_{2.5\_Grav}}{PM_{2.5\_DRX}} \times PCF_{Old}.$$

- Update the new PCF in user calibration settings.

Step 2: SCF Calibration.

- Install a PM_{10} impactor at the inlet of the external gravimetric filter.
- Co-locate and run the gravimetric sample and DUSTTRAK™ DRX monitor simultaneously to collect enough mass on the gravimetric filter.
- Calculate the PM_{10} mass concentration (PM_{10_Grav}) from the gravimetric filter based on the net mass collected on the filter, sampling time, flow rate, and total liters of air sampled.
- Read the DUSTTRAK™ DRX monitor average $PM_{2.5}$ ($PM_{2.5\_DRX}$) and PM_{10} (PM_{10_DRX}) mass concentration from the screen or though TRAKPRO™ Data Analysis Software.
- Calculate the new SCF

$$SCF_{New} = \left(\frac{PM_{10\_Grav} - PM_{2.5\_DRX}}{PM_{10\_DRX} - PM_{2.5\_DRX}} \right)^{\frac{1}{3}} \times SCF_{Old}.$$

- Update the new SCF in user calibration settings.

Option 2: Parallel Gravimetric Calibration

When the user has two sets of gravimetric sampling devices, the DUSTTRAK™ DRX monitor advanced calibration can be performed in the parallel configuration as shown in Figure 1b. The calibration steps are outlined below:

1. Install a $PM_{2.5}$ and a PM_{10} impactor at the inlet of the two external gravimetric filters, respectively.
2. Co-locate and run the gravimetric samples and DUSTTRAK™ DRX monitor simultaneously to collect enough mass on the gravimetric filters.
3. Calculate the $PM_{2.5}$ ($PM_{2.5\_Grav}$) and PM_{10} (PM_{10_Grav}) mass concentrations from the gravimetric filters based on the net mass collected on the filter, sampling time, flow rate, and total liters of air sampled.

4. Read the DUSTTRAK™ DRX monitor average $PM_{2.5}$ and PM_{10} mass concentration ($PM_{2.5\_DRX}$ and PM_{10_DRX}) from the DRX screen or through TRAKPRO™ Data Analysis Software.
5. Calculate the new PCF

$$PCF_{New} = \frac{PM_{2.5\_Grav}}{PM_{2.5\_DRX}} \times PCF_{Old},$$

and the new SCF

$$SCF_{New} = \left(\frac{PM_{10\_Grav} - PM_{2.5\_Grav}}{PM_{10\_DRX} - PM_{2.5\_DRX}} \right)^{\frac{1}{3}} \times SCF_{Old}.$$

6. Update the new SCF and PCF in the user calibration settings.

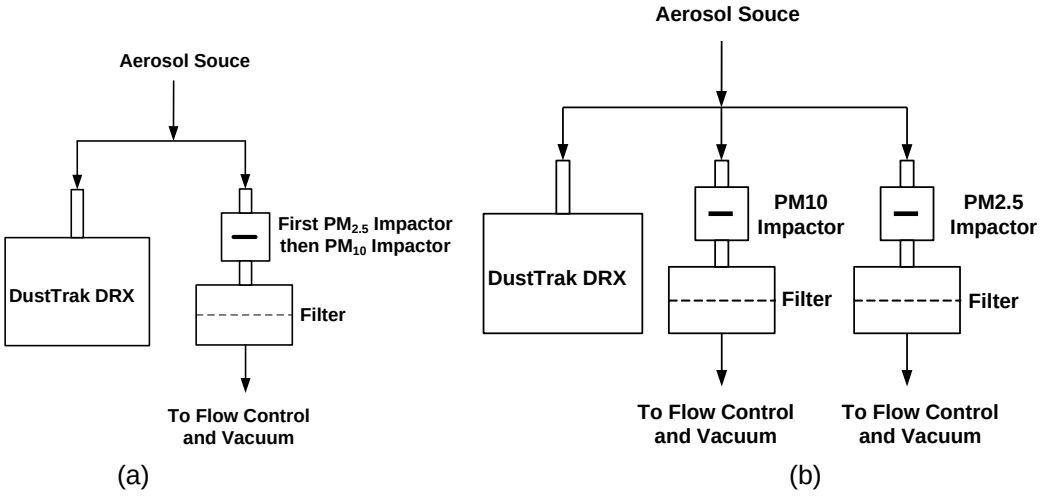

Figure 1. Experimental setup for (a) serial and (b) parallel gravimetric calibration.

A DUSTTRAK™ DRX monitor calibrated with the advanced calibration will accurately measure size segregated mass concentrations. However, this calibration requires the user to have access to an external gravimetric filter (e.g., 37-mm cassette sampler), sampling media, sampling pumps, and either a high accuracy microbalance to weigh the filters or access to an accredited Industrial Hygiene Laboratory. Pre-weighed filter media from accredited labs can also be used. The sampling time would typically have to be at least a couple of hours to have reliable gravimetric measurements. It is also recommended that the gravimetric measurements be made multiple times to obtain statistical/reasonable average sampled mass concentrations.

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