

# CUSTOM CAL FACTOR FOR DIESEL PARTICULATE MATTER (DPM)

APPLICATION NOTE EXPMN-009 (US)

Diesel Particulate Matter (DPM) is a very small aerosol composed of organic and elemental carbon, hydrocarbons, and sulfate. The carbon mixture can vary depending on fuel, engine type, duty cycle, engine maintenance, operator habits, emission control devices and lube oil consumption. <sup>1</sup>

Measurement of personnel exposure to DPM is typically performed by size-selective gravimetric sampling with analytical analysis for elemental carbon. Sampling pumps, filter media and cyclones or impactors designed to provide a 1 micron diameter cut point are typically used to collect samples for weighing an analysis. The data is not immediately available after conducting sampling due to the time lag required for laboratory analysis.

Recent efforts have been aimed at developing an instrument that can measure DPM in real-time. The TSI DustTrak™ Aerosol Monitor and the SidePak™ Personal Aerosol Monitor AM510 are light scattering photometric mass measurement instruments that can be used with PM1 impactors to measure DPM in real-time. Due to the complex nature of the DPM aerosol, the capabilities and limitations of photometric mass measurement instruments must be understood for effective use.

Light scattering photometric mass measurement instruments like the DustTrak and SidePak AM510 Monitors are calibrated to a test aerosol. The monitors are calibrated to the respirable fraction of ISO 12103-1, A1 Test Dust. Photometric instrument response will differ from gravimetric mass measurement when the physical properties of the sampled aerosol differ from the calibration aerosol.

Custom calibration factors (cal factors) can be developed to adjust the instrument response for aerosols that differ from the calibration aerosol. The formula for the DustTrak and SidePak AM510 Monitors custom cal factor is:

$$\text{New Cal Factor} = \frac{\text{Reference Gravimetric Concentration}}{\text{DustTrak Concentration}} \times \text{Current Cal Factor} .$$

A study was conducted to investigate a correlation between the TSI DustTrak Aerosol Monitor that performs measurements in real-time and the gravimetric samples collected with an SKC® impactor for measuring DPM in an underground metal mine in the Western US. Side-by-side sampling was performed to evaluate a correlation between the DustTrak Monitor readings and the actual gravimetric sampling results. Click [here](#) to read the study article “Evaluation of Sampling Methods to Measure Exposure to Diesel Particulate Matter in an Underground Metal Mine”. <sup>2</sup>

Table 1 contains the data from this study comparing the DustTrak Monitor readings to the Organic Carbon (OC), Elemental Carbon (EC) and Total Carbon (TC) mass measurements.

TSI and the TSI logo are registered trademarks of TSI Incorporated.  
DustTrak and SidePak are trademarks of TSI Incorporated.  
SKC is a registered trademark of SKC Inc.

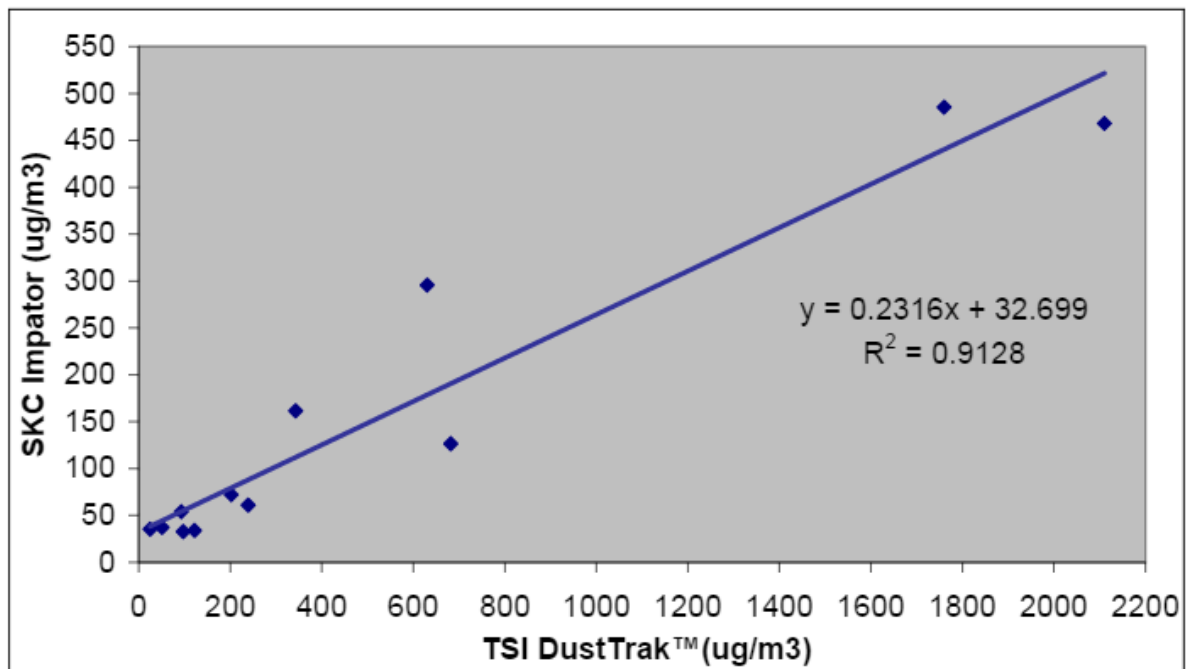


Figure 1 shows the correlation between the TSI DustTrak Monitor readings and the SKC Impactor measurements. The R<sup>2</sup>-0.91 indicates a good correlation between the DustTrak Monitor readings and the gravimetric measurement.

**Table 1.** DPM Samples Results

| Date    | Mine Location | OC<br>µg/cm <sup>3</sup> | EC<br>µg/m <sup>3</sup> | TC*<br>µg/m <sup>3</sup> | DustTrak™<br>µg/m <sup>3</sup> |
|---------|---------------|--------------------------|-------------------------|--------------------------|--------------------------------|
| 1/14/00 | Mine Shaft    | <17                      | <17                     | <34                      | 120                            |
| 1/14/03 | Ore Face      | 98                       | 370                     | 470                      | 2100                           |
| 1/14/03 | Mine Shop     | <19                      | <19                     | <37                      | 51                             |
| 1/15/03 | Mine Shaft    | <19                      | <18                     | <36                      | 25                             |
| 1/15/03 | Ore Face      | 130                      | 350                     | 490                      | 1800                           |
| 1/15/03 | Mine Shop     | <19                      | 36                      | <54                      | 93                             |
| 1/16/03 | Ore Dump      | <16                      | <16                     | <32                      | 97                             |
| 1/16/03 | Ore Face      | 48                       | 78                      | 130                      | 680                            |
| 1/16/03 | Mine Shop     | <20                      | 41                      | <61                      | 240                            |
| 1/17/03 | Ore Face      | 51                       | 110                     | 160                      | 340                            |
| 1/17/03 | Ore Face      | 84                       | 210                     | 300                      | 630                            |
| 1/17/03 | Mine Shop     | 30                       | 42                      | 72                       | 200                            |

\*TC = OC + EC; all values rounded to two significant digits



**Figure 1.** Correlation between TSI® DustTrak® Monitor and SKC® Impactor

Using the custom calibration formula for the DustTrak Monitor applied to the applicable data from this study, a custom cal factor for DPM can be developed. **Note:** Gravimetric results listed as “less than” were omitted from the calculation.

**Table 2.** New Cal Factor Calculations

| TC<br>ug/m <sup>3</sup><br><i>Reference</i> | DustTrak<br>ug/m <sup>3</sup><br><i>Instrument</i> | New Cal<br>Factor<br>DPM as TC |
|---|--|--------------------------------|
| <34   | 120  | --                             |
| 470   | 2100   | 0.22                           |
| <37   | 51   | --                             |
| <36   | 25   | --                             |
| 490   | 1800   | 0.27                           |
| <54   | 93   | --                             |
| <32   | 97   | --                             |
| 130   | 680  | 0.19                           |
| <61   | 240  | --                             |
| 160   | 340  | 0.47                           |
| 300   | 630  | 0.48                           |
| 72  | 200  | 0.36                           |
| average                                     |  | 0.33                           |

*DustTrak Custom Cal Factor: DPM = 0.33*

Based on the data from this operation, the DustTrak Monitor custom cal factor for DPM as total carbon varied between 0.19 and 0.48 with an average of 0.33. Using the average 0.33 to set the instrument photometric cal factor will change the instrument response to more closely align with the gravimetric concentrations for this aerosol. This process can be followed with co-located DustTrak or SidePak AM510 Monitors and gravimetric concentration measurements for any aerosol to more closely align the light scattering photometric response to the gravimetric concentration of the sampled aerosol.

**Note:** *The results of this study and this cal factor are not intended to be representative of all DPM measurements in all situations. Different operations should collect data with co-located gravimetric and light scattering photometric mass measurement instruments to develop similar cal factors.*

---

## Reference

- <sup>1</sup> Bruce K. Cantrell & Winthrop F. Watts Jr. (1997) Diesel Exhaust Aerosol: Review of Occupational Exposure, Applied Occupational and Environmental Hygiene, 12:12, 1019-1027, DOI: 10.1080/1047322X.1997.10390643. Link: <http://www.tandfonline.com/doi/abs/10.1080/1047322X.1997.10390643>
- <sup>2</sup> Stephenson, et al; Evaluation of Sampling Methods to Measure Exposure to Diesel Particulate Matter in an Underground Metal Mine; *Mining Engineering* 58(8):39-45 (2006).



UNDERSTANDING, ACCELERATED

TSI Incorporated – Visit our website [www.tsi.com](http://www.tsi.com) for more information.

USA Tel: +1 800 874 2811  
 UK Tel: +44 149 4 459200  
 France Tel: +33 1 41 19 21 99  
 Germany Tel: +49 241 523030

India Tel: +91 80 67877200  
 China Tel: +86 10 8219 7688  
 Singapore Tel: +65 6595 6388