# PHOTOMETRIC CALIBRATION FACTOR (PCF) PROCEDURES FOR DIESEL PARTICULATE MATTER (DPM)

APPLICATION NOTE EXPMN-013 (US)

## Background

Workplace exposure monitoring for diesel particulate matter (DPM) is conducted using NIOSH Analytical Method 5040. The Permissible Exposure Limit (PEL) for DPM is 160 μg/m$^3$ of total carbon (TC) for a full 8-hour work shift. Compliance with the Permissible Exposure Limit (PEL) is enforced by the Mine Safety and Health Administration (MSHA) and the Occupational Safety and Health Administration (OSHA).

DPM is composed of two types of carbon; organic carbon (OC) and elemental carbon (EC). Total Carbon (TC) is defined by adding the measurements of EC + OC together. MSHA and OSHA look at TC as the surrogate measurement for DPM exposure.

DPM particle size is defined as having an upper limit particle size of 0.8 μm. Air sampling for DPM is conducted using a size selective inlet conditioner with a 0.8 μm cut point.

Sub-micron sampling for DPM is performed using a personal sampling pump connected to a 10-mm Dorr-Oliver® nylon cyclone and DPM cassette with attached integral sub-micron impactor (or other NIOSH approved DPM sampling trains). After collection, the DPM samples are sent to a laboratory for analysis. This NIOSH reference sampling method has a time gap between sample collection and receiving results from the analytical lab.

There is a need for a real time sample methods to reduce this time gap. Using real-time, direct reading instruments that provide immediate access to measurement information enables health and safety professionals to quickly recognize exposure and respond promptly to protect workers.

Real-time, light scattering photometric instruments are not considered reference methods for DPM sampling. These instruments are calibrated to a known test aerosol, typically called Arizona Road Dust or A1 Test Dust. Photometric instrument response is precise and very repeatable; however, DPM has significantly different light scattering properties than that of the test aerosol. Therefore, a light scattering photometric instrument response will not agree with reference sampling methods until a photometric calibration factor has been developed. The steps below summarize the process for conducting a series of co-located, paired sample sets to collect the necessary data to develop a photometric calibration factor.

## Photometric Calibration Factor (PCF)

Photometric Calibration Factors (PCF) can be developed and used for light scattering photometric instruments for specific aerosols when the aerosol being measured is expected to remain consistent. Using these photometric calibration factors will help photometric measurements align closer to comparable gravimetric reference sample methods.

The steps below outline a procedure to determine a Photometric Calibration Factor for DPM (measured as Total Carbon) using a co-located, paired reference method sampler along with a photometric instrument such as a TSI DustTrak™ II Aerosol Monitor or a SidePak™ AM520/AM520i Personal Aerosol Monitor.

### Equipment Needed

- DustTrak II Aerosol Monitor equipped with Dorr-Oliver cyclone and 0.8 µm DPM cyclone kit, *or* SidePak AM520/AM520i Personal Aerosol Monitor equipped with Dorr-Oliver cyclone and 0.8 µm DPM cyclone kit.
- Personal sampling pump with DPM sampling train using a Dorr-Oliver Cyclone (or other NIOSH approved respirable cyclone) and a 37-mm DPM filter cassette.

### Procedure to Develop DPM PCF

1. Select work area where DPM is generated.
2. Set up photometer and sampling pump in similar manner.
    - For the DustTrak II and AM520/AM520i, use the Dorr-Oliver Cyclone (to cut down on the impactor loading) and the 0.8 µm DPM Cyclone in series.
    - For the sample pump use a NIOSH 5040 approved DPM sampling train with a 37-mm DPM filter cassette
3. Use the appropriate flow rates for both instruments depending on the impactors and/or cyclones.
    - Set flow rate for DustTrak II and AM520/AM520i equipped with Dorr-Oliver Cyclone and 0.8 µm DPM cyclone at 1.7 L/min.
    - See manufacturer instructions for proper flow rate for DPM sampling train on sample pump.
4. Zero the photometer prior to sampling.
5. Calibrate the sample pump prior to sampling using a sacrificial DPM sampling train with a 37-mm DPM filter cassette.
6. Co-locate both samplers side-by-side either in a work area or on a worker in the breathing zone.
7. Start photometer and sampling pump at same time, sample for same duration.
    - Data log aerosol measurements with photometer.
    - Collect gravimetric sample with sample pump.
    - Sample time does not need to be full shift like compliance monitoring. The key is to collect at least the minimum volume necessary for valid analysis according to NIOSH analytical method 5040.

8. Sample a few locations to gather data. (***Note:*** *Ideally use a statistically significant number of samples to properly represent the worker population.*)
   - Review light scattering photometric instrument monitoring data as it becomes available.
   - Conduct more sampling if considerable data variability is found.
9. Send gravimetric samples to an accredited analytical lab.
10. Compare photometric and gravimetric data.
    - Calculate averages for each.
    - If sample variability is high, collect more samples to improve the representation of the sample population.
11. Calculate new photometric calibration factor using the formula below:

| | |
|---|---|
| *PCF* | = Photometric Calibration Factor |
| *Reference Concentration* | = Average Gravimetric Concentration |
| *Data Log Concentration* | = Average Photometric Concentration |
| *ECF* | = Existing Calibration Factor (by default Factory calibration is 1.0) |

$$PCF = \frac{Reference\ Concentration}{Data\ Log\ Concentration} \times ECF$$

12. Enter new Photometric Calibration Factor into the photometer.
13. Repeat the co-located, paired sampling process using new PCF setting in photometer.

    ***Note***: *Conducting at least one additional paired sample set using the new PCF will help to verify the photometric calibration factor is applicable to the reference aerosol.*
14. Compare gravimetric and PCF photometric sample data.
    - Results should be closer, or "more accurate," using the new PCF.

Using this procedure, photometric calibration factors can be developed for different workplace aerosols. Using gravimetric sampling data as a base line, a photometer programmed with a photometric calibration factor can be used to quickly identify potential workplace exposures with greater accuracy in real time.

See Application Note *EXPMN-009—Custom Cal Factor for Diesel Particulate Matter (DPM)* for an example of these calculations performed in published research.

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