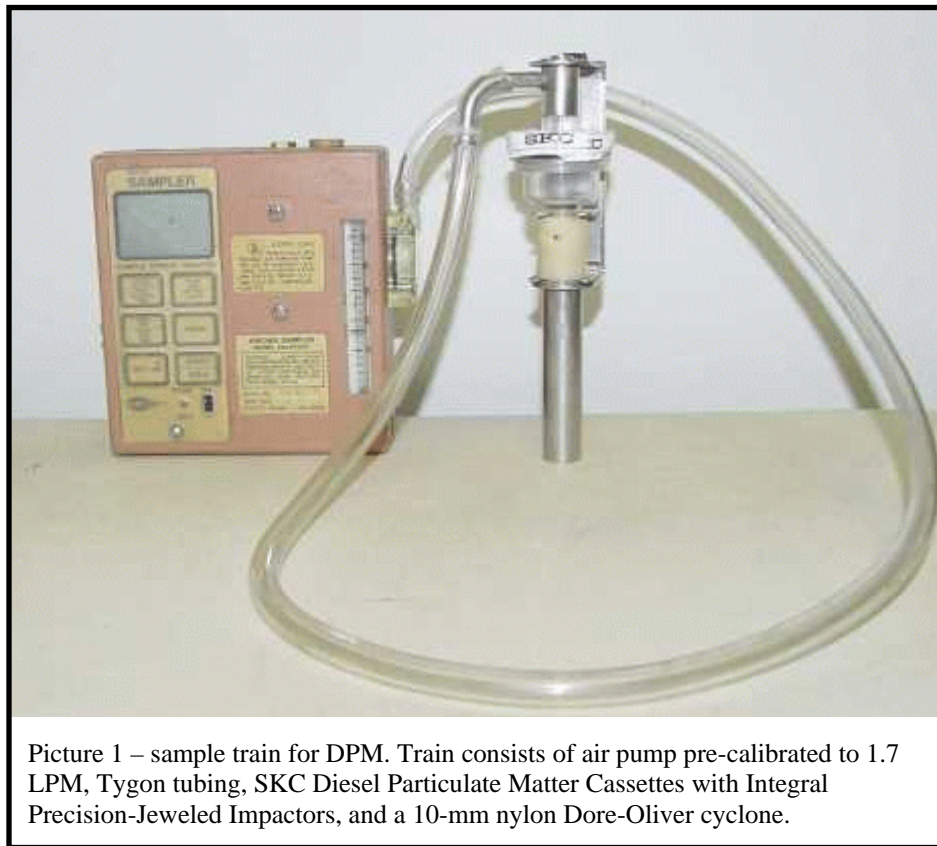


Chapter 6

Diesel Particulate Matter (DPM) Sampling Procedures

This chapter will demonstrate how to measure Diesel Particulate Matter (DPM). DPM is a product of the exhaust from a diesel engine. Although the exhaust will contain many different elements, such as gasses and vapors, only the particulate that is emitted will be sampled.

The use of diesel engines can produce a mixture of gases, vapors, and particulates. Hazardous gases in diesel exhaust include carbon monoxide, nitrogen dioxide, and sulfur dioxide, while the vapors include volatile organic compounds, aldehydes, and Polycyclic Aromatic Hydrocarbons (PAHs). DPM is considered a probable human carcinogen by the International Agency for Research on Cancer (IARC). Based upon the best available scientific evidence, MSHA has determined that DPM puts miners at excess risk for diseases of the heart and lung, including lung cancer.



Picture 1 – sample train for DPM. Train consists of air pump pre-calibrated to 1.7 LPM, Tygon tubing, SKC Diesel Particulate Matter Cassettes with Integral Precision-Jeweled Impactors, and a 10-mm nylon Dore-Oliver cyclone.

The sampling train consists of:

- Personal sampling pump – There are several different brands of personal sampling pumps available. The sample pump must be calibrated to 1.7 liters per minute (LPM) in order for the 10-mm cyclone to work properly.

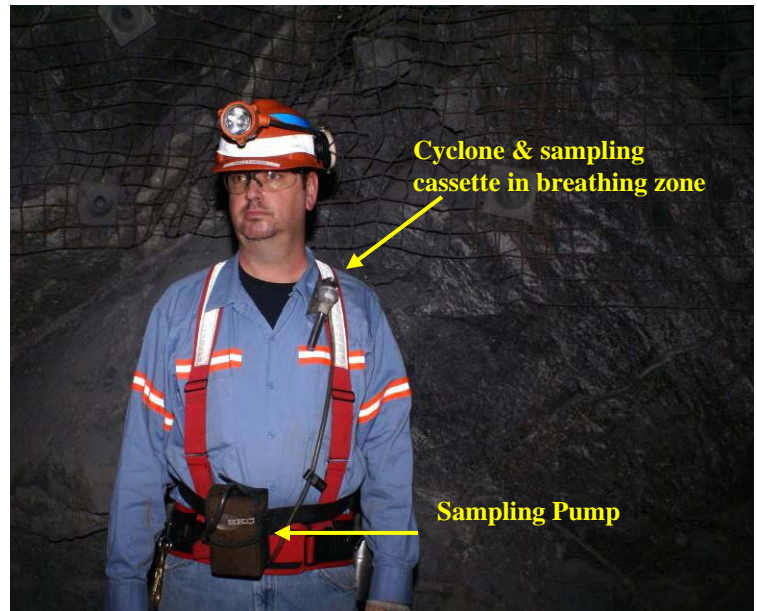
- Tygon tubing – the Tygon tubing connects the personal sampling pump to the 10-mm nylon cyclone. The tubing must be long enough that the pump can be worn on the employee’s waist and the cyclone can be mounted on the employee’s collar.
- 10-mm nylon cyclone – There are several different brands of cyclones available. Two most common are MSA & Sensidyne Gillian. (MSA is shown in picture 1 above). Although a cyclone is not required when using the SKC Impactor Cassettes, it is a ‘best-practice’. Large amounts of larger particles could plug-up the impactor inside the cassette, causing erroneously low results, or cause channeling on the quartz-fiber filter which will also cause erroneous results. The cyclone will ‘pre-screen’ the larger particles to eliminate these interferences. (Please note: DPM is smaller than one micron. The cyclones will not separate out submicron particles, thus will not interfere with the DPM loading on the cassette).
- SKC Diesel Particulate Matter Cassettes with Integral Precision-Jeweled Impactors. Please note that other 37-mm cassettes with Quartz-Filter fiber may be used instead of the SKC cassette. However, several substances can interfere with the results, such as carbonatious ore, oil mist, etc. The impactor in the SKC cassette is very successful at removing these interferants before they contaminate the sample.

Calibration Procedures:

- Calibrate the air sampling pump to 1.7 LPM following the “DPM” calibration procedures in the “Pump Calibrations Procedures” chapter.

Sampling Procedures:

- Select employee(s) to be sampled. Explain that the purpose of the sampling is to monitor the employee’s exposure to DPM over his shift.
- Explain to the employee how the cyclone works and not to tip the cyclone upside down while sampling. (The cyclone works by separating out large particles from the sample stream. The large particles fall to the grit pot at the bottom of the cyclone, and the small particles travel up to the cassette where they are captured. Tipping the cyclone upside down may cause the large particles to fall to the cassette, contaminating the sample).
- Instruct the employee to wear the sample the entire shift.
- Attached the pump to the employee. This can be done several ways:



- Attach the pump to the employee's belt
- Use the carrying case & straps that usually come with a sampling pump
- Use a vest, such as a fishing vest to carry the pump.
- Attach the cyclone/cassette assembly to the employee's collar. This should be within the employee's breathing zone (within 12-inches around the employee's head).
- Explain to the employee that the sample inlet must face away from clothing, etc. at all times. Do not cover the sample with coat, coveralls, etc.
- Check on the sample every couple of hours to ensure:
 - Pump is still running
 - Sample is still in correct position
 - Employee is still performing same task
 - Etc.

Collect Samples When Sampling is Complete:

- Collect sample train
- Record sample run time in minutes
- Perform post calibration as described in the Pump Calibration Procedures chapter
- Shut off pump
- Remove cassette from cyclone and insert plugs into inlet & outlet
- Charge pump for next sampling
- Clean cyclones using soap and water and allow to thoroughly dry
- Send samples to IH-Accredited lab for analysis. Request NIOSH 5040 method for Elemental and Organic Carbon Analysis.

Interpreting Results:

- Two results will be received from the lab: Elemental Carbon & Organic Carbon. The total carbon (elemental + organic) is used as a surrogate to determine DPM.
- Results will be given in micrograms per sample (ug/sample). This will need to be converted to micrograms per cubic meter (ug/m³) by using the following:
 - Multiply the average liters per minute (LPM) by the amount of minutes the pump ran when sampling. This will give you the total liters ran through the sample cassette.
 - Multiply the total liters (from above) by .001 to convert to cubic meters (m³).
 - Divide the ug/sample (received from lab) by the cubic meters (calculated above) to get ug/m³.
 - Do this for both the organic & elemental results. Once both are calculated, add them both together to get the total carbon amount. MSHA's Permissible Exposure Limit (PEL) is based on the total carbon amount.
- Compare to MSHA's current (PEL) to determine whether the exposure was over or under the PEL.
 - From 2007 through May 19, 2008, the PEL is 350_{tc} ug/m³ of total carbon. If the total carbon (elemental + organic) is over 350_{tc} ug/m³, then multiply the elemental carbon (ug/m³) by 1.3. If that total is also over 350_{tc} ug/m³, then an over-exposure has occurred.

- Beginning May 20, 2008, the PEL is reduced to 160_{tc} ug/m³. However, at the time of the printing of this manual, MSHA has not determined a final multiplier for elemental carbon (such as the 1.3 multiplier used in 2007).

Example utilizing the 2007 PEL:

Employee sampled for full 12-hour shift:

Average air flow1.72 LPM
 Shift duration (sampling time).....720 minutes
 Organic carbon amount (received from lab).....25 ug/sample
 Elemental carbon amount (received from lab).....52 ug/sample

Calculate Air Volume

- Average Liters per Minute = $(1.72+1.72)/2 = \dots\dots\dots 1.72$ LPM
- Total Liters (1.72 LPM * 480) =826 Liters

Please note that 480 minutes is used to Shift Weight the result although the sample time was actually 720 minutes.

- Total cubic meters (m³) 826 liters * .001=0.826m³

Calculate Exposure:

- Step 1:
 - Organic Carbon: $25 \text{ ug/sample} / 0.826 \text{ m}^3 = 177_{oc} \text{ ug/m}^3$
 - Elemental Carbon: $52 \text{ ug/sample} / 0.826 \text{ m}^3 = 185_{ec} \text{ ug/m}^3$
 - Add both together:
 - $177_{oc} \text{ ug/m}^3 + 185_{ec} \text{ ug/m}^3 = 362 \text{ ug/m}^3$

Since the total of organic + elemental carbon is over 350_{tc} ug/m³, you must now multiply the elemental carbon by 1.3 to determine if an over-exposure has occurred. If this amount had been under 350_{tc} ug/m³, an over-exposure would not have occurred and you would not have to go any farther.

- Step 2:
 - Multiply elemental carbon amount by 1.3
 - $185_{ec} \text{ ug/m}^3 * 1.3 = 241_{tc} \text{ ug/m}^3$

Since the product of the elemental carbon times 1.3 is under the PEL of 350_{tc} ug/m³, no over-exposure has occurred.