MEASURING DIESEL PARTICULATE MATTER
EXPOSURE IN DIESEL EXHAUST

In 1988 the International Agency for Research on Cancer (IARC) identified diesel exhaust as probably carcinogenic to humans. As the concern for exposure to diesel exhaust (DE) grew, studies were conducted to provide carcinogenic evidence. In 2012, a large study was published by the US National Cancer Institute and the National Institute for Occupational Safety and Health (NIOSH). This study demonstrated that underground miners who were exposed to diesel exhaust emissions had significantly more incidences of lung cancer. Following this study, the IARC reclassified diesel exhaust as carcinogenic to humans.

Diesel Particulate Matter (DPM) is a major component of DE and is detrimental to health. DPM contains soot particles made up primarily of carbon, ash, metallic abrasion particles, oxides of sulfur and nitrogen, as well as silicates. The majority of DPM is <1 micro meter in size. Diesel soot particles consist of a solid elemental carbon core with other substances such as organic carbon compounds (or hydrocarbons) attached to the surface. These carbon components make up 80 to 85% of DPM and fall in two major groups: organic carbon (OC) and elemental carbon (EC). Both types of carbon can be measured using a thermal – optical analysis flame ionization detector, and they can be combined to measure total carbon (TC).

There are many occupations that expose workers to DE/DPM; it can be a hazard to miners, construction workers, heavy equipment operators, tunnel workers and railroad workers to name a few. Essentially anyone working with or around equipment that uses diesel combustion as a source of energy is at risk.

DIESEL PARTICULATE MATTER REGULATORY STANDARDS

The Occupational Safety and Health Administration (OSHA) does not have a permissible exposure limit (PEL) for DPM. However, OSHA does have limits for other components of DE such as Nitrogen Dioxide and Nitric Oxide. ACGIH released a 2001 notice of intended changes proposing a 20 µg/m³ standard for elemental carbon, but this was withdrawn in 2003.

In 2008, Mine Safety and Health Administration (MSHA) published a final rule of 160 µg/m³ of total carbon for underground metal and non-metal mines. Although MSHA uses total carbon as the surrogate, total carbon is subjected to interferences from contribution of non-DPM particles such as oil mist, coal dust, and cigarette smoke. It is suggested that elemental carbon, which is not prone to interferences, is a better marker for exposure. Ongoing research indicates a correlation in the concentrations of both EC and TC. Its goal is to come up with a factor that can be applied to the EC result, thereby converting it to TC and avoiding interferences.
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SAMPLING FOR DIESEL PARTICULATE MATTER
DPM is sampled and analyzed according to the NIOSH 5040 method. The sampler consists of a quartz fiber filter that has been previously baked to reduce its hydrocarbon background, as it positively interferes with analysis results. They are sampled at a flow of 2 to 4 L/min for 142 to 19000 liters of air. There are several samplers to choose from depending on the sampling environment and data usage. Two major choices include:

- **SKC baked quartz filter** (37 or 25 mm) in standard styrene 3 piece cassettes (Cat. 225-401 or 401-25): these samplers are generally used in non-mining operations or above ground where there are no interferences from other particulates. They are sampled open-faced to ensure even distribution of particulate on the filter, which is a necessary condition for the calculation. These filters can be used with a cyclone for particle size selection if in a dusty area.

- **SKC DPM cassette** (Cat No. 225-317): these samplers are preloaded with a submicron impactor which screens out particles 1 micron or greater. These samplers also contain two quartz filters, one for the sampling and one as an internal dynamic blank. This cassette is generally used when sampling in mines and areas with particulate from other sources.

DIESEL PARTICULATE MATTER ANALYSIS AND REPORTING LIMITS
Bureau Veritas analyzes diesel particulate matter at a reporting limit of 2 µg for both OC and EC and 4 µg for TC, well below proposed regulatory limits. Bureau Veritas was one of the first commercial laboratories to have a thermal optical analyzer with flame ionization detection and among the first to provide DPM analysis following the NIOSH 5040 standard.