Diesel Particulate Matter (DPM)

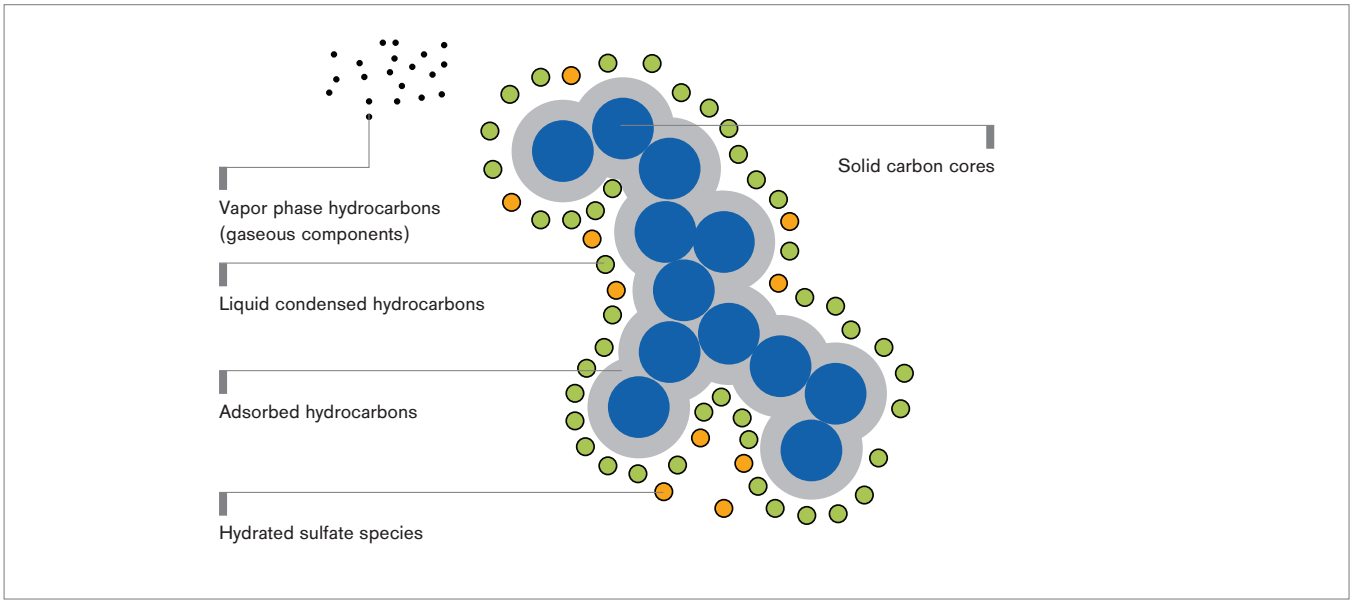
There is always a health risk from diesel particulate matter in engine emissions in places where heavy, diesel-powered vehicles and machines are deployed in mines. Appropriate respiratory protection equipment provides effective protection for employees working in such areas.

In addition to the exhaust fumes generated by the combustion process in diesel engines, the resulting emissions also contain particulate matter (aerosols). These are made up of carbon particles and ultra-fine droplets of a mixture of semi-volatile organic compounds. Individual particles are microscopically small and have typical diameters of 15 to 30 nm. They tend to agglomerate to create irregularly formed chains or clusters of particles that, with sizes of <1 µm, are still extremely small. The main component of these particulate agglomerations is elementary carbon. In comparison to their small size, these particulate agglomerations have an enormous surface area that adsorbs residues of unburned fuel and lubricants and other chemical compounds.[1, 2]

DPM PRESENTS A RISK TO HEALTH

Due to their small size, fine dust particles can easily find their way into the human body through the respiratory tract. Once in the body, they can cause severe damage by building deposits in the pulmonary alveoli (the air sacs in the lung) and the brain. In 2012, the International Agency for Research on Cancer (IARC), an institution of the World Health Organization (WHO), classified DPM as a Group 1 carcinogen. As a consequence of this, several mining nations have lowered the recommended threshold limit values for workplaces to as little as 0.1 mg/m^3 (TWA – time weighted average, based on an eight-hour shift).

Schematic representation of DPM



Source: Twigg and Phillips, 2009

OVERVIEW: SELECTED RECOMMENDED THRESHOLD LIMIT VALUES FOR DPM (INTERNATIONAL)

Nation	Exposure limit
Australia (AIOH)	0.1 mg/m^3 TWA (8 h), based on the proportion of EC – Elemental Carbon
USA (MSHA) Underground (ores/minerals)	160 µg/m3 TWA (8 h), based on the proportion of TC – Total Carbon (elemental carbon plus organic carbon)
Canada (dependent on Province/Territory)	0.4 mg/m3 (TC – Total Carbon) to 1.5 mg/m^3
Germany (BAuA)	From 0.1 mg/m^3: Work permitted only with respiratory protection equipment

Legend: AIOH – Australian Institute of Occupational Hygienists; MSHA – Mine Safety and Health Administration; BAuA – Bundesanstalt für Arbeitsschutz und Arbeitsmedizin (Federal Institute for Occupational Safety and Health); TWA – Time weighted average

According to the National Institute for Occupational Safety and Health in the USA, underground mineworkers are exposed to extremely high concentrations of DPM that can be more than 100 times the typical environmental concentration at the surface and more than 10 times what may be found in other workplaces.

The level of personal DPM exposure can depend on the job performed. At particular risk are the operators or drivers of heavy, diesel-powered vehicles or equipment such as drilling machines and excavators, especially in underground mines.

MEASURES FOR THE REDUCTION OF DPM EMISSIONS

Essentially, the concentration of DPM emissions in workplaces in the mining industry can be positively influenced by a number of factors. These include ideally configured ventilation systems to flush the harmful substances out of the mine workings. Modern diesel technologies and efficient diesel particulate filters also play an important role. Engine maintenance schedules including DPM monitoring also help to reduce DPM emissions.

RESPIRATORY PROTECTION AND FILTER PERFORMANCE

Wherever it is not possible to reduce DPM concentrations in the workplace to levels compliant with the recommended threshold limit values, it is essential that employees wear respiratory protection equipment. But what criteria determine the choice of filters and breathing masks? This question is handled differently depending on the country and the regulations to be observed. Initial guidelines are the anticipated maximum DPM concentrations, local threshold values, and a subsequent comparison with the designated

protection class of a particular particle filtering half mask also referred to as a filtering facepiece (FFP) mask or the combination of a half mask and an appropriate filter class. In addition, Dräger always recommends the utilization of higher-quality respiratory protection equipment such as the Dräger X-plore® 3500 or Dräger X-plore® 2100 half masks with the corresponding filters when carcinogenic substances may be encountered.

FILTRATION EFFICIENCY TESTING AFTER LOADING WITH SOOT

By way of example and in accordance with European Standard EN 1822, Dräger tested the filtration efficiency of several masks/filters after being loaded with soot from the combustion of various fuels with a soot generator. This altered the filtering performance in different ways to a degree not only dependent on the filter material, but also on the fuel involved and the particle size selected for testing. The filtration efficiency for individual particle sizes was thus determined according to EN 1822. The smallest value from each of these test series can be read from the following table (Table 1). In contrast, the determination of filtration efficiency according to EN 143/149 reflects the overall bandwidth of a defined particle size spectrum. These standard values for filter classification according to EN 143/149 are provided for your comparison.

TABLE 1

	Protection class in accordance with EN 143/149	Required filtration efficiency for classification according to EN 143/149	Filtration efficiency determined after loading with soot according to EN 1822
Dräger X-plore® 1320 V	FFP2	94%	>96.3%
Dräger X-plore® 1320 V Odour	FFP2	94%	>95.6%
Dräger X-plore® 1720 V	FFP2	94%	>96.9%
Dräger X-plore® 1720 V Odour	FFP2	94%	>98.2%
Dräger X-plore® 1520 V	FFP2	94%	>98.2%
Dräger X-plore® P3 R Filter*	P3	99.95%	>99.99%
Dräger X-plore® Pure P3 R Filter*	P3	99.95%	>99.97%
Dräger X-plore® 2100 Filter FMP3 R D	P3	99.95%	>99.99%

* for Dräger X-plore® 3300/3500/5500 half and full masks

Source: internal study, data on file / Test for filtration efficiency according to EN 1822 after loading with soot from the combustion of various fuels (25 mg) to simulate exposure to soot over a period of 1 – 2 days

SPECIFIC TESTS FOR SPECIFIC REQUIREMENTS

It is hard to make a generalized statement about the filtration performance of particle filtering half masks (FFP) or half masks with filters for diesel exhaust emissions. There are so many differences in the construction of the filters and the materials employed in their construction. There is also no standardized definition for the size of diesel soot particles. Only specific testing can enable us to make a more precise statement about filtration performance. The masks/filters tested by Dräger (see above) fulfill these requirements insofar as they continue to provide very high filtering performance even after being loaded with various types of soot. Further results of the tests: in some cases, the values determined after being loaded with soot proved to be worse than the value registered before loading while, in other cases, they actually improved. In several cases, the tests also showed that the breathing resistance may increase. Should this be noticed during a working shift, it is advisable to change the mask or filter. We also recommend that employees with particular sensitivity to emission odors should consider the use of an odor filter.

Due to the classification of DPM as a carcinogen, Dräger recommends the wearing of a half mask when working in environments in which DPM concentrations exceed specified workplace threshold limits. Half masks like the Dräger X-plore® 2100/3500 generally provide a tightly fitting seal and, in return, have very low leakage characteristics. At the same time, the filters of the half masks also maintain high filtering performance after being loaded with soot. The mask's combination of a tightly fitting seal and high filtering performance ensures a high level of protection.

ORDERING INFORMATION

Filter	Filter class	Items per box	Order no.
Dräger X-plore® 1320 V	FFP2 NR D	10	39 51 214
Dräger X-plore® 1320 V Odour**	FFP2 NR D	10	39 51 215
Dräger X-plore® 1720 V	FFP2 NR D	10	39 51 084
Dräger X-plore® 1720 V Odour**	FFP2 NR D	10	39 51 085
Dräger X-plore® 1520 V	FFP2 NR D	200	39 51 147
Dräger X-plore® P3 R Filter	P3 R	22	67 38 011
Dräger X-plore® Pure P3 R Filter	P3 R	20	67 38 354
Dräger X-plore® 2100 Filter	FMP3 RD	20	67 36 777

** Additional active charcoal filters for filtering out odors below the threshold limit

[1] Source: AIOH – Australian Institute of Occupational Hygienists: Diesel Particulate Matter & Occupational Health Issues, July 2013; https://www.aioh.org.au/documents/item/15; accessed: May 9, 2016
[2] Source: TERA – Toxicology Excellence for Risk Assessment; http://m.business.govt.nz/worksafe/about/who-we-work-with/consultation/closed-for-consultation/consultation-wes-diesel-particulate-matter/diesel-particulate-matter-proposed-wes.pdf; accessed: May 9, 2016
[3] Source: http://www.iarc.fr/en/media-centre/iarcnews/2012/mono105-info.php: Accessed: May 9, 2016
[5] Source: AIOH – Australian Institute of Occupational Hygienists: Diesel Particulate Matter & Occupational Health Issues, July 2013; https://www.aioh.org.au/documents/item/15; accessed: May 9, 2016
[5] Source: AIOH – Australian Institute of Occupational Hygienists: Diesel Particulate Matter & Occupational Health Issues, July 2013; https://www.aioh.org.au/documents/item/15; accessed: May 9, 2016
[6] https://www.osha.gov/dts/hazardalerts/diesel_exhaust_hazard_alert.html; accessed: May 9, 2016
[7] Gangal M. Summary of Worldwide Underground Mine Diesel Regulations, October 2012, http://www.mdec.ca/2012/S3P3-Gangal.pdf; accessed: May 9, 2016 http://www.cdc.gov/niosh/mining/topics/DieselExhaust.html; accessed: May 9, 2016
[8] Dahmann D, Monz C, Sönksen, H. Exposure Assessment in German potash mining. International Archives of Occupational and Environmental Health. 2007; 81(1):95-107 https://www.researchgate.net/publication/6268222_Exposure_assessment_in_German_potash_mining; accessed: Wednesday, July 06, 2016

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