E. MNM Miners' Personal Exposure Limit (PEL)

General comments on MNM miners PEL:

- One commenter described the emissions reduction program at a non-U.S. mine operator. This company set an internal Occupational Exposure Limit (OEL) of 0.1 mg/m^3 Elemental Carbon (EC, NIOSH 5040) in 2005. In 2016, this company adopted a requirement to manage exposures to as low as technically feasible with an interim requirement of 0.03 mg/m^3, which will require PPE for some workers while controls are developed. This new limit is based on the 2015 Institute of Occupational Medicine on DPM and lung cancer. This company has found that average exposure can be reduced to less than 0.03 mg/m^3 in the vast majority of similar exposure groups (SEGs, maximum of 0.05 mg/m^3) or to less than 0.05 mg/m^3 (for most SEGS, maximum of 0.08 mg/m^3) using the Lands 95% upper confidence limit of the mean exposure. This commenter stated that these levels can largely be achieved using existing technology so long as every effort is made to ensure engines burn the cleanest ultra-low sulfur fuel, are well maintained with a focus on emission reduction, and appropriate exhaust filtering technology is employed. This commenter also described success reducing exposures in an underground coal mine - no SEG has a mean exposure exceeding 0.03 mg/m^3 EC, and just one SEG has exposure exceeding 0.05 mg/m^3 (95% UCL of the mean).

27. What existing controls were most effective in reducing exposures since 2006? Are these controls available and applicable to all MNM mines?

a) Two commenters described a combination of approaches used in reducing DPM exposures, including the use of fuel additives or alternate fuels, new engine technologies, completion of semiannual testing on engines to ensure proper function and early identification of any issues, reduction in the amount of hand scaling being performed, increased mine ventilation, and administrative work practices (i.e. spreading equipment out in the mine, rather than being focused in one area).

b) The second commenter also described using dry filtration systems, HEPA-filtered equipment cabs on a JS500 loader, and ensuring workers are not working downwind of operations. This commenter stated that there is no single tool that was consistently identified as "most effective," which is consistent with MSHA's "DPM Toolbox." This commenter stated that the toolbox identifies nine categories of tools that can be used to reduce DPM exposure, including the use of: low emission engines, low-sulfur fuel, fuel additives and alternative fuels, after-treatment devices, ventilation, enclosed cabs, diesel engine maintenance, work practices and training, and fleet management. This commenter stated that, whether a specific tool is necessary should be evaluated on a case-by-case basis.

c) A third commenter stated that biodiesel should be used to replace diesel fuels in diesel powered mine equipment and vehicles to reduce emissions of diesel particulate matter and other toxic gaseous components of diesel exhaust. This commenter cited studies showing that using biodiesel can reduce particulate matter emissions by 50%, and that biodiesel can be used as a blend with petroleum based fuels. This commenter also stated that biodiesel can be used in new or already existing technology, eliminates sulfate, and can promote longer engine lives for engines that recirculate engine exhaust because of the lower concentration of carbon. [Comment].

d) A fourth commenter stated that advances in engine technology (driven by EPA regulatory changes) suggest that more protective standards are feasible in mines. This commenter stated that adopting the latest in available technological advances, to the extent they are feasible, is necessary in the absence of an exposure limit for DPM.

e) A fifth commenter stated that numerous controls have been implemented effectively to reduce exposures since 2006 and meet 30 CFR requirements [Comment]. These have been thoroughly studied by NIOSH and other organizations. This commenter described these technologies as follows:

- Diesel oxidation catalytic converters (DOCs): the effects of a DOC on DPM concentrations have been found to be relatively minor and are a function of engine operating conditions and fuel type. In general, the effectiveness of a DOC as a DPM control is primarily dependent on the fraction of OC present in the engine exhaust, because the total PM reduction efficiency increases with an increase in OC content of the exhaust.
- Diesel particulate filter (DPF) and disposable filter elements (DFE) systems: DPF systems, certified and/or verified by a number of organizations, are extensively used in underground mining and other industries to curtail DPM emissions. DPF systems for underground mining applications have been extensively evaluated in long-term studies, short-term studies, and laboratory studies. The evaluated DPFs removed, in the majority of test cases, at least 90 percent of the particles by mass and number. Over 670 light-duty vehicles, equipped with DPFs or a filtration system with disposable filter elements (DFEs) to meet 30 CFR 72.502, are effectively being used in underground coal mines in the U.S.
- Partial-flow DPFs (pDPFs) or flow-through filters (FTFs): these are currently used in a few applications in U.S. underground mines, and are simpler, less costly, and less effective solutions for applications where DPF systems might be difficult to implement. Under steady state conditions, pDPF/FTF of various

designs were found to be between 6% and 70% efficient in reducing the number of diesel aerosols. An on-road test showed substantial fluctuations in performance of pDPFs/FTFs. In practice, due to the dynamics of the filtration, regeneration, and potential for sudden release of trapped DPM, it is very difficult to reproduce data and produce reliable estimates of filter efficiency.

- Alternative fuels: Changing the fuel supply from petroleum diesel to fatty acid methyl ester (FAME) biodiesel and/or hydrotreated vegetable oil renewable diesel (HVORD) is considered by a number of underground MNM mine operators in the U.S. to be a viable method for controlling DPM emissions. Currently, U.S. underground mines using biodiesel fuels are almost exclusively using FAME biodiesels, which are made from various vegetable oils and animal fats through the process of transesterification. When compared to low sulfur and ultralow sulfur petroleum diesels (LSD and ULSD), FAME biodiesels reduce emissions of total DPM and nonvolatile fractions of DPM and, under certain engine operating conditions, can increase the particle-bound volatile organic fraction of DPM. In-use studies have shown the potential of neat soy methyl ester (SME) FAME and SME biodiesel blends to reduce the exposures of underground miners to EC, TC, and total DPM mass. Substantial increases in emissions of the organic carbon (OC) fractions of TC and DPM have been observed when the engine was fueled with SME FAME fuels and operated at light-load conditions. Further, when compared to those emissions generated by combustion of ULSD, FAME biodiesel aerosols were found to have higher toxicity and to cause more abnormalities in male mice reproductive systems. Recently, some underground operations started fueling their diesel-powered equipment with blends of hydrotreated vegetable oil renewable diesel (HVORD). These fuels are derived from vegetable and algae oils and animal fats via the hydrogenation and isomerization process. HVORD is almost exclusively made of paraffinic and iso-paraffinic hydrocarbons and is virtually free of aromatic hydrocarbons, metals, sulfur, nitrogen, and oxygen-containing compounds. HVORD, in general, has favorable effects on PM mass and NOx emissions, and minor effects on CO and total hydrocarbon emissions. When compared with FAME biodiesel fuels, HVORD produces lower NOx and higher CO, total hydrocarbons, and PM mass and number emissions. Finally, HVORD has the potential to adversely affect N02 emissions from naturally aspirated engines equipped with certain types of DOCs.
- Protective cabs: Enclosing operators in environmental cabs with pressurization and filtration systems was found to help some parts of the underground mining industry reduce the exposures to DPM. Environmental cabs have been a viable DPM control strategy in cases where the majority of the duties can be executed by workers that do not have to leave their environmental cabs on a frequent basis. Further, the effectiveness of several types of cabin air filtration elements used in the removal of diesel aerosols (EC and TC mass) has been assessed. With a relatively low cost and good

efficiency, MERV 16 filters were found to be a viable alternative to substantially more expensive and flow-restrictive HEPA filters.

- Treating Crankcase Emissions: Crankcase emissions have proven to be a large contributor to overall particulate emissions from older diesel engines. As a result of successful efforts in reducing tailpipe emissions, the relative contribution of crankcase emissions to overall emissions is becoming more and more significant. Blow-by from untreated crankcase emissions can contribute as much as 20% of the mass total PM emissions from EPA Tier 2 and Tier 3 engines and exceed the tailpipe emissions of EPA Tier 4 engines. This issue is addressed by selected regulations promulgated by the EPA [40 CFR 1039.115] and the EU Commission [EUCD 2012]. As the regulations note, crankcase emissions from heavy-duty and light-duty underground mining vehicles should not be discharged directly into the underground mine atmosphere. If such discharges cannot be technically prevented, at least during engine certification, those emissions should be included in the total engine emissions.
- This commenter cited many studies addressing these technologies [Comment], and submitted one discussing how fuel composition affects combustion products. [Schonborn 2009].

28. What are the technological challenges and relative costs of reducing the DPM exposure limit?

a) Two commenters stated that Tier 4 engines will be needed to make further gains in exposure reduction, because measures such as ventilation and work practices have already been implemented [to the extent practical]. These commenters noted that Tier 4 engines are not available for some types of mining equipment, and that replacing equipment with Tier 4 engines would be enormously expensive.

b) One commenter stated that lowering the DPM exposure limit would effectively mandate full-fleet adoption of Tier 4 engines, which would require legal changes to equipment permissibility regulations and engine design.

c) This commenter noted that water scrubber systems might be effective, but are not available for many machines used in underground mines, and would be “incredibly costly.”

d) The second commenter implied that allowing worker rotation would be helpful in reducing exposures, stating that the current standard does not allow for personnel change out or shift rotation as acceptable administrative controls to meet the DPM limit, even though underground miners may have shifts lasting greater than or less than 8 hours. This commenter then stated that a more restrictive limit without the option of applying administrative controls would create an even greater challenge.

e) The second commenter noted that it will be difficult to model the potential reductions from new engines until more of them are in place and their performance can be studied.

f) Both commenters stated that current compliance monitoring provides only a snapshot of exposure conditions, and does not assess median or average exposures over time. One stated that MSHA's data set is not adequate to determine whether a lower DPM standard is required. The other stated that the current standard "does not allow for standard deviation with the set of actual DPM values," which will make compliance with a lower future standard even more acute. This commenter noted that, with the range of current exposures, there may be mines for which reductions would be much more difficult than for other mines.

g) One commenter noted that further DM exposure reductions would be very costly (millions of dollars for one miner operator), particularly for smaller companies, and that increased operating costs would harm competitiveness with off-shore producers.