Comment Code	Comment Code Description	DCN	Link to Comment	Commenter Name	Comment
A	Non-Permissible Equip in Underground Coal Mines	MSHA-2014-0031-0059-A4	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0059-A4.pdf	Celeste Monforton	MSHA's standards for light-duty equipment are woefully out-of-date. Specifically, under 72.502 MSHA requires light-duty equipment engines, which were introduced in underground coal mines, to meet one of the following: • 5.0 gr/hr of DPM; • DPM requirements equivalent to the EPA non road Tier 2 standards; or • EPA's 1986 DPM standards for highway vehicles. However, current diesel engine technology can reduce DPM emissions well beyond what these standards require. In fact in the U.S., all non-road diesel engines produced today and installed in new equipment are required to meet EPA Tier 4 standards. Regrettably, the exception are the engines used in underground mining. There's no justification for permitting mine operators to expose miners to polluting diesel engines---and the associated health risks---when cleaner engines are available and in use in all other areas of commerce.
A	Non-Permissible Equip in Underground Coal Mines	MSHA-2014-0031-0062-A6	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0062-A6.pdf	Paul Schulte	Published study. Title: Evaluation of the contribution of light-duty vehicles to the underground atmosphere diesel emissions burden.
A	Non-Permissible Equip in Underground Coal Mines	MSHA-2014-0031-0069-A3	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0069-A3.pdf	Edward Green	In connection with its review of the adequacy of protections for coal miners, MSHA should: . . .e) Follow through to update the agency's Part 7, Subpart E approval requirements for non-permissible diesel engines as promised in the preamble to the 2001 rule. The current approval process was issued in 1996, but was largely based on a system dating back to the 1960s. When MSHA promulgated its rule in 2001, it committed to updating the approval process for engines to be used in outby areas of underground coal mines. The agency indicated if would adopt a more streamlined approach and rely heavily on the U.S. EPA's approval program for engines used in off-road applications. Moreover, the agency wrote it would establish a program under which the engine-emission tests conducted for an EPA approval would satisfy the Part 7 testing requirements. We believe this streamlined approach will greatly improve and expedite the engine approval process and will meet an important goal for coal miners' health: the introduction ofthe most advanced diesel engine and after-treatment technologies.
A1	Emissions data / evidence for 2.5 g/hr or less	MSHA-2014-0031-0042-A1	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0042-A1.docx	Gene Davis	The agency has the answer to this request. A quick look at the National Diesel Inventory will show that out of approximately 3400 pieces of light duty equipment only about 90 have engines that are listed as emitting less than the 2.5 g/hr standard. The exception to this is the light duty equipment being used in Pennsylvania, West Virginia and Ohio where all equipment must include a diesel after-treatment system. All light duty equipment in these three states do emit less that 2.5 g/hr by state law not by MSHA regulation.
A1	Emissions data / evidence for 2.5 g/hr or less	MSHA-2014-0031-0042-A1	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0042-A1.docx	Gene Davis	This brings me to the point of the 2.5g/hr standard. To limit a diesel engine to 2.5 g/hr is not a standard it allows lower horsepower (hp) engines to emit more DPM that higher hp engines. To institute a DPM standard you must include the approved vent plate quantity of a given engine and extrapolate the DPM into mg/m³. This then becomes a standard. The chart below will illustrate this: *(see "Chart for A1")* Although this chart is a small sampling you can see that 2.5 g/hr is not a standard. This approach allows the smaller hp engines to emit 3 to 4 times as much DPM per cubic meter of air than their higher hp counterparts. Since the reason for this round of rule making is to curtail miner's exposure to DPM we must apply the vent plate air quantity to the DPM output of the engine to achieve a DPM standard. This is the approach that Pennsylvania, West Virginia and Ohio have adopted. After all we must never assume that our coal miners will have more than vent plate quantity in an area that a piece of diesel powered equipment is being operated.
A1	Emissions data / evidence for 2.5 g/hr or less	MSHA-2014-0031-0059-A4	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0059-A4.pdf	Celeste Monforton	MSHA's 2.5 gr/hr DPM standard is not a viable standard for comparison because it does not take into account horsepower. As the horsepower increases, so does the DPM concentrations. As listed in the MSHA diesel list of approved engines, only small engines have DPM concentrations less than 2.5 gr/hr. Tier 4 engines and most engines approved by MSHA for use in light-duty equipment can meet a 2.5 gr/hr standard if a DPM filter is installed. Mine operators can refer to DPM filter efficiency information to determine how low DPM emissions can be reduced by installing a DPM filter. MSHA has DPM filter efficiency data in its Part 7 engine listings. This information should be made available to the industry (mine operators and miners.)
A1	Emissions data / evidence for 2.5 g/hr or less	MSHA-2014-0031-0061-A1	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0061-A1.docx	Josh Roberts	Yes. Pennsylvania, West Virginia, and Ohio all require a diesel after-treatment system and all light duty equipment in these three states emit less than 2.5 g/hr. Also, the National Diesel Inventory shows that out of 3400 pieces of light duty equipment only 90 have engines that are listed as emitting less than 2.5 g/hr.

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A1	Emissions data / evidence for 2.5 g/hr or less	MSHA-2014-0031-0062-A4	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0062-A4.pdf	Paul Schulte	Yes, there is evidence that some equipment being operated in underground mines emits 2.5 grams/hour (g/hr) of diesel particulate matter (DPM) or less, but the evidence is mixed and not formally published. Analysis of the national coal inventory data [MSHA 2016a], collected under 30 CFR 72.520, shows that non-permissible, light-duty, diesel-powered equipment in U.S. coal mines is powered by a wide variety of MSHA-approved diesel engines. The engines fall into the following categories and percentages: 11-25 horsepower (hp) (3.2%), 25-50 hp (12.3%), 50-75 hp (21.8%), 75-175 hp (44.1%), and 175-750 hp (18.6%). Furthermore, our analysis [Bugarski and Barone 2016] indicates that the engines in 788 out of 3,411 non-permissible, light-duty, diesel-powered equipment (approximately 23%) should emit less than 2.5 g/hr of DPM. Of the light-duty vehicles, 116 should meet the 2.5 g/hr criteria and are powered by diesel packages supplied by original equipment manufacturers (OEMs). These packages meet the 2.5 g/hr DPM criteria without any modifications, with the majority having outputs between 11 and 25 hp. The engines of the other 672 light-duty equipment were retrofitted by a third party with diesel particulate filters (DPFs) or filtration systems with disposable filter elements (DFEs) to meet the 2.5 g/hr DPM criteria. Because laboratory or in-use particulate matter (PM) emissions data are not available for the majority of the engines, no firm evidence exists that these vehicles, when operated in underground coal mines, emit less than 2.5 g/hr of DPM. Finally, the national coal diesel inventory data indicate that at least 97% of permissible and 90% of non-permissible heavy-duty (hd) equipment emit less than 2.5 g/hr of DPM, and that at least 50% of non-permissible light-duty (ld) equipment (including generators and compressors) emit more than 5 g/hr of DPM [MSHA 2016a].
A1	Emissions data / evidence for 2.5 g/hr or less	MSHA-2014-0031-0067-A1	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0067-A1.pdf	G. Joseph Betar	My company is the primary dealer for light and heavy duty non-permissible diesel powered mantrips manufactured by Fiat Chrysler Automobiles (FCA) under the brand names RAM and Jeep 38. Currently none of the light duty non-permissible diesel powered mantrips manufactured by FCA will emit less than will emit less than 2.5 g/hr of DPM as delivered by FCA.
A2	Technical / admin. challenges meeting 2.5 g/hr	MSHA-2014-0031-0042-A1	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0042-A1.docx	Gene Davis	Most of the equipment that has come into Pennsylvania, West Virginia and Ohio over the past 20 years with exhaust after-treatment systems have been built by OEM's that also provide equipment for the nation and there have been no problems retrofitting after-treatment systems into this equipment for the three States listed above so there should be no reason most if not all equipment can be retrofitted with an after-treatment system.
A2	Technical / admin. challenges meeting 2.5 g/hr	MSHA-2014-0031-0059-A4	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0059-A4.pdf	Celeste Monforton	Adding DPM filters or purchasing Tier 4 engines is feasible for the mining industry. Moreover, all light-duty machines can be equipped with a DPM filter. DPM filters are available in many designs and technologies which make the application feasible for light-duty machines.
A2	Technical / admin. challenges meeting 2.5 g/hr	MSHA-2014-0031-0061-A1	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0061-A1.docx	Josh Roberts	The equipment in Pennsylvania, West Virginia, and Ohio have been built with an exhaust after-treatment system built by the OEM. There has been no issues retrofitting this equipment and there should be no problem doing this in other states.
A2	Technical / admin. challenges meeting 2.5 g/hr	MSHA-2014-0031-0062-A4	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0062-A4.pdf	Paul Schulte	Our analysis of the engines currently used by the U.S. coal mining industry [MSHA 2016a] indicates the following administrative, engineering, and technological challenges: • Engines rated below 25 hp. Approximately 88% of sub-25 hp engines currently used in underground coal mines meet the 2.5 g/hr DPM criteria. The vehicles powered by Kubota D902-E3-UV (07-ENA090004}, Kubota D1105-E3-UV (07-ENA110010}, Kubota D1105-E4-UV (07-ENA110011}, Mitsubishi S3L2-Y361DPH (07-ENA110016), and Daihatsu DM950DTH (07-ENA070004) contribute less than 2.5 g/hr of DPM [MSHA 2016a]. Some ofthese engines also meet U.S. Environmental Protection Agency (EPA) Tier 4 final standards (PM < 0.40 g/brake horsepower-hour (bhp-hr) [EPA 2016].
A2	Technical / admin. challenges meeting 2.5 g/hr	MSHA-2014-0031-0062-A4	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0062-A4.pdf	Paul Schulte	Engines rated between 25 and 75 hp. Approximately 9% of engines with outputs between 25 and 75 hp meet the 2.5 g/hr DPM criteria [MSHA 2016a]. In the majority of the cases, these low DPM emissions were achieved primarily by the retrofit-type DPFs and, in a few cases, by filtration systems with DFE. Exhaust aftertreatment might be an option for vehicles that have enough space for installation of such a system. Replacement of existing engines with same-size engines that meet EPA Tier 4 final standards [EPA 2016] is one of the alternative solutions. All EPA Tier 4 final engines (PM< 0.022 g/bhp-hr) with outputs between 25 and 75 hp should meet 2.5 g/hr standard.
A2	Technical / admin. challenges meeting 2.5 g/hr	MSHA-2014-0031-0062-A4	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0062-A4.pdf	Paul Schulte	Engines rated between 75 and 175 hp. Data available in the national coal diesel inventory [MSHA 2016a] indicate that DPM emissions from approximately 36% of engines rated between 75 and 175 hp are maintained under 2.5 g/hr by retrofit-type DPFs or filtration systems with DFEs. In general, the technology is available to reduce emissions from the currently used engines in this size range. However, due to a wide variety of engine/vehicle designs and duty cycles, the available solutions need to be evaluated for each individual case. Controlling DPM emissions from approximately 0. 7% of engines in this category that emit more than 20 g/hr of DPM (e.g., Caterpillar 3304 PCNA, Caterpillar 3306 PCNA) is technologically or economically challenging [Bugarski and Barone 2016]. The efficiencies of two MSHA-verified hightemperature DFEs are listed as 83% and 80% (at 650 oF) [MSHA 201Gb]. Reducing DPM emissions from 20+ g/hr to 2.5 g/hr with 83% or less efficient filter is mathematically impossible. High DPM emissions translate to short life expectancy of the filters. The DFEs are often changed in intervals not longer than 8 hours which is relatively costly. Replacing existing engines with same-size engines that meet EPA Tier 4 final standards (PM< 0.015 g/bhp-hr) [EPA 2016], and therefore should not emit more than 2.5 g/hr, is one of the alternative solutions. In order to ensure simultaneous reduction in PM mass and number emissions, it is necessary to use solutions that involve exhaust filtration and minimize the adverse effects of exhaust aftertreatment systems on particulate number emissions [Thiruvengadam et al. 2012; Herner et al. 2011; Robinson et al. 2016].

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A2	Technical / admin. challenges meeting 2.5 g/hr	MSHA-2014-0031-0062-A4	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0062-A4.pdf	Paul Schulte	Engines rated between 175 and 750 hp. Approximately 6% of engines that are rated between 175 and 750 hp emit less than 2.5 g/hr [MSHA 2016a]. This level of DPM emissions has been achieved primarily by deploying the retrofit-type DPFs or, in few cases, filtration systems with DFE. Therefore, it appears that the technology is available to reduce emissions from the majority of the engines in this size range. Reducing DPM emissions to 2.5 g/hr from approximately 9% of engines in this size range that emit more than 20 g/hr of DPM (e.g., Cummins ISB325, General Motors L6T) might be technologically or economically challenging [Bugarksi and Barone 2016]. High DPM emissions translate to short life expectancy of the filters. The DFEs are often changed in intervals not longer than 8 hours which is relatively costly. Replacement of existing engines with same-size engines that meet EPA Tier 4 final standards (PM < 0.015 g/bhp-hr) [EPA 2016] is one of the alternative solutions. However, some replacement engines with high-power outputs might not meet the 2.5 g/hr standard.
A3	Costs/advantages/disadv of meeting 2.5 g/hr	MSHA-2014-0031-0042-A1	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0042-A1.docx	Gene Davis	From my experiences I believe that most equipment can be fitted with an after-treatment system for a cost of 12,000 to 25,000 dollars per equipment. While this may sound expensive you must remember that most light duty mining equipment cost between $90,000 and $140,000 and the cost of the after-treatment systems has not kept equipment out of the three states.
A3	Costs/advantages/disadv of meeting 2.5 g/hr	MSHA-2014-0031-0059-A4	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0059-A4.pdf	Celeste Monforton	There would be a modest cost to mine operators to either add a DPM filter to a light-duty machine or to retrofit a machine with a Tier 4 engine. The benefit of doing either option is a reduction in DPM emissions by as much as 90 percent.
A3	Costs/advantages/disadv of meeting 2.5 g/hr	MSHA-2014-0031-0061-A1	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0061-A1.docx	Josh Roberts	The cost would be around 20,000 dollars per equipment. However, some of the nation's largest coal producing states are already required to invest this money in their equipment to protect the health of their miners. The cost to not adopting lower emission standards would be far higher for the miners themselves if they were to contract lung cancer.
A3	Costs/advantages/disadv of meeting 2.5 g/hr	MSHA-2014-0031-0062-A4	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0062-A4.pdf	Paul Schulte	Introduction of the 2.5 g/hour standard should substantially reduce DPM emissions from at least 77% of light-duty vehicles [MSHA 2016a]. Because light-duty vehicles account for approximately 67% of all diesel-powered vehicles currently in U.S. underground coal mines [MSHA 2016a], when the changes required by the standard are implemented it is expected to result in substantial reductions in exposures of underground miners to DPM. NIOSH has determined that this change in the standard would require retrofitting a substantial number of existing light-duty vehicles with DPFs and filtration systems with DFEs or repowering those vehicles with similar-size engines that meet EPA Tier 4 final standards. We cannot comment as to the costs ofthe retrofits, but manufacturers ofthe equipment may be able to address this issue.
A3	Costs/advantages/disadv of meeting 2.5 g/hr	MSHA-2014-0031-0067-A1	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0067-A1.pdf	G. Joseph Betar	In order to reduce emissions below 2.5 g/hr of DPM, a suitable aftermarket DPF would need to be installed on all light duty non-permissible diesel powered mantrips manufactured FCA. The approximate cost to install the type of DPF currently used to meet the 2.5 g/hr DPM standard by my company is $7,500. This cost does not include the continual replacement of disposable filters. For mines with large numbers of light duty non-permissable diesel powered equipment manufactured by FCA, this would represent significant costs both for the initial installation and subsequent filter replacements.
A3	Costs/advantages/disadv of meeting 2.5 g/hr	MSHA-2014-0031-0067-A1	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0067-A1.pdf	G. Joseph Betar	I looked at the average fleet size of 50 light duty non-permissible diesel powered mantrips which is not uncommon in the mines that my company deals with. I estimate the initial costs for the average coal mine would be $375,000 for installation of a DPF system for its feet. I estimate annual filter replacement costs would be $225,000 for the fleet.
A4	EPA: percent underground not meeting current stds	MSHA-2014-0031-0059-A4	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0059-A4.pdf	Celeste Monforton	The most current data is already available to MSHA in its national diesel engine inventory data base. MSHA should provide the industry (mine operators and miners) with data on the percentage of non-permissible, light-duty, diesel-powered equipment operating in underground mines that does not meet the current EPA emissions standards. I urge MSHA to make the data for both standards publicly available and to update it periodically. It will provide worthwhile information on the availability of feasible engine technology. Moreover, it will demonstrate how far behind the mining industry is in installing less-polluting diesel engines. The mining industry is too slow to adopt engine technology standards that are required for the rest of the US diesel equipment sales market.
A4	EPA: percent underground not meeting current stds	MSHA-2014-0031-0062-A4	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0062-A4.pdf	Paul Schulte	Currently, the EPA requires that non-road diesel engines meet the Tier 4 final emissions standard [40 CFR 1039; EPA 2016]. In order for an engine to meet the requirements of Tier 4, the emissions of carbon monoxide (CO) non-methane hydrocarbons (NMHC) nitrogen oxides (NOx) and PM need to be at or below the standards listed in Table 1. Table 1. EPA Tier 4 final standards [g/kWh (g/bhp hr)] Engine Power / Year / CO / NMHC / NMHC + NOx / NOx / PM ... Our analysis of the national coal diesel inventory data [MSHA 2016a] indicates that currently only engines in 6 out of 3,411 non-permissible, light-duty, diesel-powered equipment meet EPA Tier 4 final standards [EPA 2016]. Therefore, based on the data in MSHA [2016], approximately 99.8% of engines in the non-permissible, light-duty, diesel-powered equipment do not meet the current EPA emissions standard.
A4	EPA: percent underground not meeting current stds	MSHA-2014-0031-0067-A1	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0067-A1.pdf	G. Joseph Betar	Based on reviewing the list of MSHA approved engines currently installed in most light duty non-permissible diesel powered matrips, I estimate that nearly 100% of the units will not meet the current EPA emissions standard without modifications but more likely engine or machine replacement would be required.

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A5	Modifications to meet EPA. Percent/types unable	MSHA-2014-0031-0059-A4	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0059-A4.pdf	Celeste Monforton	DPM filters are feasible controls that can be installed on all types of light-duty equipment. This includes DPM filters that can be regenerated or disposable type filters that can be installed with proper exhaust cooling systems. This type of DPM filter technology is currently being installed on light-duty equipment in Pennsylvania, Ohio, and West Virginia. By adding a DPM filter to any light-duty machine, DPM concentrations will be reduced to levels equivalent to EPA's Tier 4 DPM standard. MSHA has a wealth of information in its diesel equipment inventory. It contains the most up-to-date data on the types of DPM filters, by manufacturer and model, which are installed on permissible, heavy duty, and light-duty equipment. The data is especially robust with respect to installations at mines in Pennsylvania, Ohio, and West Virginia.
A5	Modifications to meet EPA. Percent/types unable	MSHA-2014-0031-0061-A1	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0061-A1.docx	Josh Roberts	The UMWA offers no comment on this question. These modifications and after-treatment systems were talked about in our opening statement. Oxidation catalyst, DPM filters, and exhaust emissions control and conditioning system are all examples of this.
A5	Modifications to meet EPA. Percent/types unable	MSHA-2014-0031-0061-A1	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0061-A1.docx	Josh Roberts	Pennsylvania and West Virginia recognized the shortcomings of the Federal diesel regulations and moved forward with their own standards. Both of these states require state of the art filtration systems, newer engines, higher ventilation requirements, and stringent maintenance and training plans, stricter fuel storage standards, and emission standards that far exceed the Federal Standards. The state of West Virginia prohibited the use of diesel equipment in underground mines until the year 2004. The state waited until improvements in engine exhaust conditioning equipment was developed before permitting the use of diesel equipment underground. The West Virginia rule also requires the use of an oxidizing catalyst, strictly limiting diesel emissions and regulating both NO2 and NO.
A5	Modifications to meet EPA. Percent/types unable	MSHA-2014-0031-0062-A4	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0062-A4.pdf	Paul Schulte	Theoretically, modifications in order to meet EPA Tier 4 final emissions standards would involve retrofitting existing engines with advanced integrated exhaust aftertreatment systems to control PM, NMHC, CO, and NOx emissions. Certain types of DPF systems (or filtration systems with disposable filter elements), diesel oxidation catalytic converters (DOCs), and selective catalyst reduction (SCR) systems are currently used successfully to control diesel emissions [Bugarski et al. 2012a]. In practice, the design and extent of modifications needed for existing equipment and the success of intervention is dependent on the specifics of individual applications. Due to the technological challenges of integrating advanced exhaust aftertreatment systems with existing engine systems and their long-term operation over a wide variety of duty cycles in the challenging environment of underground mines, the success of some retrofit programs is uncertain. In particular, reducing DPM emissions from engines that emit more than 20 g/hr of DPM to Tier 4 final levels presents major technologic and economic challenges [Bugarski and Barone 2016]. Repowering existing vehicles with the power packages offered by original equipment manufacturers which meet EPA Tier 4 final standards [EPA 2016] is likely a more plausible solution than retrofitting existing engines with advanced exhaust aftertreatment systems. In the U.S., most engine manufacturers currently offer diesel-power packages with advanced emissions control systems integrated into the engine systems.
A5	Modifications to meet EPA. Percent/types unable	MSHA-2014-0031-0067-A1	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0067-A1.pdf	G. Joseph Betar	In my opinion, meeting Tier 4 final EPA standards on existing engines installed in light duty non-permissible diesel powered mantrips manufactured by FCA would require the installation of essentially the current EPA on-highway emissions control package. There are significant barriers to this retrofit as these electronically controlled engines lack the proper programming to support these systems. Adopting the necessary programming to the existing fleet would require the development of new engine calibrations for each unique model of engine and the costs would be prohibitive. Requiring these engines to meet Tier 4 final EPA standards, would in my opinion force coal mine operators to replace these machines. For a fleet of 50 machines, the cost would be approximately $3,500,000. Given the current financial condition of most underground coal mining companies, I believe this requirement would severely cripple the mining industry.
A6	Costs/advantages/disadv for all equipto meet EPA	MSHA-2014-0031-0059-A4	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0059-A4.pdf	Celeste Monforton	MSHA is in the best position to obtain this type of cost information directly from equipment manufacturers. There are a number of manufacturers that are selling diesel-powered engines and equipment to mine operators in Pennsylvania, Ohio and West Virginia. MSHA should easily be able to obtain information on the cost of equipping a variety of light-duty equipment with only a DPM filter.
A6	Costs/advantages/disadv for all equipto meet EPA	MSHA-2014-0031-0062-A4	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0062-A4.pdf	Paul Schulte	The primary intent of EPA Tier 4 technology-forcing regulations [40 CFR 1039] was to reduce both DPM and NOx emissions for currently used engines (predominantly EPA Tier 2 and 3 engines) by approximately 90%. The advantage of replacing currently used engines in the majority of currently used light-duty vehicles [MSHA 2016a] with those that meet EPA Tier 4 final emissions standards is that this change should result in substantially lower contributions of PM mass and NOx concentrations in underground coal mines. Because light-duty vehicles make up approximately 67% of all vehicles currently in U.S. underground coal mines [MSHA 2016a], the change in the standard is expected to result in lower exposures of underground miners to DPM and improve miners' protection from lung cancer as summarized in the MSHA RFI Background section. However, the disadvantage is that such a requirement would potentially result in the need to repower the majority of existing 25+ hp engines with power packages offered by original equipment manufacturers which meet the EPA Tier 4 final standards.
A7	Outby equip limit by ventilation: adv/disadv/cost	MSHA-2014-0031-0059-A4	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0059-A4.pdf	Celeste Monforton	MSHA specifies air quantities in Part 75.325(f) for diesel powered equipment and the current MSHA name plate standards have resulted in reductions in diesel emissions. However, increasing ventilation name plates for machines, especially for DPM control on light-duty equipment operating in outby areas, is problematic. It is not feasible to monitor the air, or even determine over a shift which air course a machine is operating. Moreover, since MSHA cannot measure concentrations of DPM in underground coal mines, increases in ventilation rates on a name plate for individual machines, is not feasible. As a result, miners' exposures to DPM cannot be evaluated to determine if an increase in ventilation is actually reducing DPM exposure.

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A7	Outby equip limit by ventilation: adv/disadv/cost	MSHA-2014-0031-0061-A1	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0061-A1.docx	Josh Roberts	This helps ensure that the DPM is being moved out of the mine atmosphere properly by not allowing too many machines to operate when there is not sufficient air in the area. We do not see any disadvantages to this other than the operator not being able to have the flexibility to operate as many diesel machines as they would want on a single split of air.
B	Maintenance, Recordkeeping Underground Coal Mines	MSHA-2014-0031-0050-A1	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0050-A1.pdf	Robert McDonald	No vehicle, either company or contractor owned, is permitted to return to the underground environment if its emissions performance exceeds the in-house limit for that vehicle. Each vehicle and engine type has been assessed to identify the key maintenance requirements to minimise emissions. As the mine generally uses older style engines, particular attention is paid to the fuel delivery system including the fuel pump and injectors. It has also been found that emissions levels from some engines are affected by the oil condition and oil changes can bring the engine within limits.
B	Maintenance, Recordkeeping Underground Coal Mines	MSHA-2014-0031-0050-A1	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0050-A1.pdf	Robert McDonald	The Queensland coal mines agreed limit for exhaust emissions for all engines is 40 mg/m3 of diesel particulate matter (DPM). The limit is not regulated. The Broadmeadow mine identified that lower limits were achievable based on the performance of engines in the fleet and in-house limits in the range 20 to 26 mg/m3 . depending on the engine type, have been established. These limits apply to concentrations at the manifold and do not take account of exhaust treatment. Gas and particulate testing is undertaken each 28 days with a Bosch BEA 850 analyser.
B	Maintenance, Recordkeeping Underground Coal Mines	MSHA-2014-0031-0050-A1	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0050-A1.pdf	Robert McDonald	Emissions Based Maintenance All vehicle maintenance is carried out as per OEM recommendations and maintenance plans are specific to each vehicle type. All primary servicing is performed in surface workshops and smaller maintenance repairs and inspections are carried out in underground workshops. Maintenance items specific to controlling DPM exposure include: • Servicing of lubrication system and injectors • Inspection and servicing of cabin integrity including windows, doors, seals and pressurising systems • Replacement of air conditioner return and cabin pressure filters • Servicing of air filters, oil filters and fuel lines • DPM emissions testing using a MAHA MP-4 emissions tester. Major mechanical services, which involve the above items and emissions tests for particulate matter, are performed at least monthly on all BHP Billiton fleet.
B	Maintenance, Recordkeeping Underground Coal Mines	MSHA-2014-0031-0050-A1	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0050-A1.pdf	Robert McDonald	Emissions Testing Program As mentioned above, emissions testing is performed on BHP Billiton fleet vehicles at 1 M mechanical services using a MAHA MP-4 DPM analyser. Baseline data has been collected and used to develop specific standards for each vehicle type that identify engine issues leading to increased emissions. These limits are reviewed periodically as older vehicles are replaced. Emissions testing data has also been used to test the effectiveness of exhaust filtration devices applied to vehicles. These requirements apply to company owned and contractor vehicles. Additionally, no vehicle is permitted to enter the underground workings without testing to ensure they meet site emission standards and that an exhaust filter is fitted.
B	Maintenance, Recordkeeping Underground Coal Mines	MSHA-2014-0031-0069-A3	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0069-A3.pdf	Edward Green	In connection with its review of the adequacy of protections for coal miners, MSHA should: . . .d) Adopt an emission-based maintenance program that includes all types of diesel-powered equipment. Emission-based maintenance programs have become commonplace since MSHA's rule was issued in 1996, and the States of Pennsylvania, West Virginia and Ohio already require all of their diesel-powered equipment to be emission checked to determine the "tune" of the engine. Based on recommendations contained in MSHA's Diesel Toolbox, MSHA staff assisted many metal and nonmetal mine operators in setting up emission-based maintenance programs for all diesel-powered equipment in their fleets.. All light-dury equipment used in underground coal mines should be covered by the requirements of 75.1914(g) to ensure they are "in tune."
B1	Weekly CO testing on light-duty equipment	MSHA-2014-0031-0042-A1	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0042-A1.docx	Gene Davis	If we are serious about minimizing miner's exposure to DPM we must include light duty equipment into our regular weekly emissions testing. This testing will alert you of potential engine problems that will cause the engine to emit higher concentrations of DPM. In the chart listed above (Figure 1) you must understand that the concentration of DPM has been extrapolated using data from a pristine engine if we allow the engine to operate in a state of deterioration the DPM concentration will be higher. The weekly testing of light duty equipment should not pose any problems for the mining community as they are already performing this test on all heavy duty and permissible equipment, which means that the mine operators must already have the exhaust gas analyzers and the trained people needed to perform this testing. Since all equipment, including light duty equipment must be checked weekly for safety reasons the addition of the test would only add about 5 to 7 minutes of additional time to each piece of light duty equipment.

Comment Code	Comment Code Description	DCN	Link to Comment	Commenter Name	Comment
B1	Weekly CO testing on light-duty equipment	MSHA-2014-0031-0042-A1	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0042-A1.docx	Gene Davis	The commenter made this comment as part of his discussion of diagnostic system test requirements (comment code B3), but it appears to be more applicable to comment code B1: This brings us to a point that I must make. In your prelude to Part B of this announcement you reiterate a statement from the current regulation that says: "carbon monoxide concentration must not exceed 2500 parts per million". This statement has no place in the current regulation. This has been taken from the engine approval criteria in 30 CFR Part 7. While it is necessary for engine approval it should never be listed in the regulation pertaining to field testing of diesel engines. During engine approval testing, the engine is placed on a dynamometer and operated throughout its operational range and if at any point the engine produces any more than 2500 ppm of CO the engine fails and will not be approved in its present state. However once the engine has been approved and placed into a piece of equipment it should never even remotely approach 2500 ppm of CO. Most approved engines working in the field today will have CO concentrations of about 80 to 300 ppm of CO. during emissions testing. This statement can be construed to allow a given diesel engine to operator at 8 to 30 times the CO approval concentration! We also know that as CO concentration increases in an engine the DPM concentration also increases. If this rule is going to minimize the DPM exposure to miner's this statement must be removed. So to allow a diesel engine any diesel engine even pre EPA tier engines to emit upwards of 2500 ppm are ludicrous and certainly detrimental to the health of miners.
B1	Weekly CO testing on light-duty equipment	MSHA-2014-0031-0059-A4	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0059-A4.pdf	Celeste Monforton	There are several advantages to requiring emission checks on light-duty equipment. Foremost, weekly checks will identify excess DPM emissions in instances of engine faults. Without emission-based maintenance, an engine fault could go unnoticed and expose miners to excessive concentrations of DPM. The same procedure that is already used for permissible and heavy duty equipment (75.1914(g)) would be feasible for light-duty equipment. The procedure may have to be modified slightly, for example, when establishing a repeatable loaded engine operating condition. An engine check procedure is feasible, however, and is already required for light-duty equipment being used in Pennsylvania, Ohio, and West Virginia. Moreover, an emission-based maintenance requirement has been successfully implemented in many underground metal and non-metal mining operations for a variety of diesel equipment. The weekly time frame could be adjusted for light-duty equipment based on operating time or work load. In addition, I recommend a revision to 75.1914(g)(4). Specifically, remove the sentence "carbon monoxide concentration shall not exceed 2500 Parts per million." This provision relates to testing for engine approval under Part 7 and should not be intended to represent how an engine should operate in an underground mine. As written, 75.1914(g)(4) leads to unacceptable levels of carbon monoxide. The appropriate method is to establish a baseline emissions level for all diesel powered equipment, as required in Pennsylvania, Ohio, and West Virginia.
B1	Weekly CO testing on light-duty equipment	MSHA-2014-0031-0061-A1	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0061-A1.docx	Josh Roberts	Testing non-permissible, light-duty, underground diesel-powered equipment on a weekly basis will let you know early on if there is any problems in the engine that would cause it to emit higher levels of DPM. Time and cost would be minimal because the operator is already required to do this testing on all heavy duty and permissible equipment.
B1	Weekly CO testing on light-duty equipment	MSHA-2014-0031-0062-A4	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0062-A4.pdf	Paul Schulte	Testing of non-permissible, light-duty, underground diesel-powered equipment periodically, such as on a weekly basis, for carbon monoxide (and potentially additional pollutants) would be critical to keeping emissions at certification levels. Current regulations [30 CFR 72.500; 30 CFR 72.501; 30 CFR 72.502] indirectly limit personal exposures of underground miners to diesel aerosols by limiting tailpipe PM emissions. In light of these regulations, maintaining in-use engine emissions at certification levels during the entire engine life and using effective aftertreatment technologies are critical to providing adequate protection to miners. Emissions-based engine and exhaust aftertreatment maintenance [McGinn et al. 2010] are very important tools in reducing the exposure of underground miners to diesel aerosols and gases.
B2	Nox emissions testing adv/ disadv/ costs coal mine	MSHA-2014-0031-0042-A1	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0042-A1.docx	Gene Davis	While I am not opposed to including the NO and NO_2 concentration during and engine emissions test I do not believe in field work that these two gases will give a clear indication of how the engine is operating. As you state the engine OEM's will use the production of NO and NO_2 to control DPM production but this is being done in a laboratory setting where changes to engine timing and other factors can be evaluated. However, once the engine has been approved these types of changes are no longer permitted to be performed on a given engine. The approved engine must be maintained in approved condition. Therefore while the concentration of NO and NO_2 are helpful to know I do not believe they can be used to curtail the production of DPM in the field.
B2	Nox emissions testing adv/ disadv/ costs coal mine	MSHA-2014-0031-0059-A4	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0059-A4.pdf	Celeste Monforton	Exhaust emissions tests on individual pieces of equipment are not needed for NO or NO2. In 70.1900, MSHA already requires on-shift NO2 measurements which determine increases in NO2 from a source. If a Tier 4 engine has a system that uses NO2 to reduce DPM, than the system will be checked during regular maintenance. Tier 4 engine systems also have checks to determine proper performance which includes monitoring of NO and NO2 emissions.
B2	Nox emissions testing adv/ disadv/ costs coal mine	MSHA-2014-0031-0062-A4	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0062-A4.pdf	Paul Schulte	The formation of PM and NOx inside the combustion chamber is greatly affected by a number of engine parameters, including air-to-fuel ratio and temperature [Heywood 1988]. In general, the relationship between PM and NOx emissions is inverse, and controlling NOx and PM emissions from traditional diesel engines involves a trade-off [Johnson 2009]. For example, in the case of traditional diesel engines, high-temperature combustion results in lower PM emissions but higher NOx emissions and vice versa. Therefore, reducing the emissions of nitric oxide (NO) and nitrogen dioxide (N02) is not an effective method of indirectly controlling particulate production. However, the results of such measurements could be used to periodically assess the performance of an engine and the effectiveness of exhaust aftertreatment systems [McGinn et al. 2010]. The measurement of NO and N02 emissions is particularly critical in monitoring the performance of catalyzed exhaust aftertreatment devices such as DOCs converters, catalyzed DPF systems [MSHA 2011], and SCR systems. The results of continuous measurement of NOx emissions over the duty cycle are critical for optimizing the performance of SCR systems.

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B3	Diagnostics system test requirements	MSHA-2014-0031-0042-A1	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0042-A1.docx	Gene Davis	We will have to take a look at the test that is currently being performed on a weekly basis for heavy duty and permissible equipment. First the emissions test that is that is being used is referred to in slang as a stall test, but in actuality it is a "Repeatable Loaded Engine Operational Test". The repeatable nature of this test must include the intake restriction and backpressure of the engine as well the operating temperature of the the engine. The intake restriction and backpressure of the engine must be within the engine OEM approval spec prior to performing the test, also the engine operating temperature must show that the engine is running at normal operating temperature. While the operating temperature does not have to be exactly the same for each test it must show that the engine has met normal operating temperature prior to testing. These are the repeatable factors of the test. The loaded factor of the test can be measured by the O_2 or CO_2 concentration during the test. This loading of the engine is critical for proper testing. The CO concentration is what tells us if the engine is operating properly but the CO concentration of any engine is dependent upon the load on the engine. In other words the O_2 or CO_2 concentration validates the CO concentration of an engine. So as you have asked what should be included in the testing the answer is all of the above. All diesel emissions test should include a check list to be filled out prior to testing that includes, Engine make and model, intake restriction, backpressure, engine operating temperature, prior to testing and O_2 or CO_2 concentration during testing and finally the CO concentration. While the CO concentration is the important factor it can be skewed if the other parameters of the test are not in the proper range for a given engine.
B3	Diagnostics system test requirements	MSHA-2014-0031-0059-A4	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0059-A4.pdf	Celeste Monforton	A modern electronic-controlled engine will have a diagnostic system to check performance. MSHA therefore can enforce the performance in the maintenance standards. If a DPM filter is installed on a machine, the filter manufacture will include a back-pressure gauge. MSHA can enforce this through requirements for maintenance checks and log books.
B3	Diagnostics system test requirements	MSHA-2014-0031-0061-A1	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0061-A1.docx	Josh Roberts	MSHA should require all of the diagnostics system tests to include engine speed (testing the engine at full throttle against the brakes with loaded hydraulics), operating hour meter, total intake restrictions, total exhaust back pressure, cooled exhaust gas temperature, coolant temperature, engine oil pressure, and engine oil temperature. These test would give early indications of anything that may be going on in the equipment that may adversely affect the diesel emissions in areas that you normally wouldn't be looking had it not been required. This will give the operator the ability to make adjustments and perform maintenance in these areas sooner rather than later. This would save them money in downtime and maintenance cost as well as keeping diesel emissions down.
B3	Diagnostics system test requirements	MSHA-2014-0031-0062-A4	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0062-A4.pdf	Paul Schulte	Engine speed, operating hour meter, total intake restriction, total exhaust back pressure, cooled exhaust gas temperature, coolant temperature, engine oil pressure, and engine oil temperature are some of the engine parameters that are regularly recorded during laboratory emissions testing [30 CFR Part 7; 40 CFR Part 1065; Directive 97 /68/EC]. These parameters are critical to the validity of any emissions testing, should be required for periodic emissions testing, and would be critical to the success of any emissions-assisted maintenance efforts [McGinn et al. 2010].
B4	Test recordkeeping adv/disadv/costs	MSHA-2014-0031-0050-A1	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0050-A1.pdf	Robert McDonald	Assessment of engine emission performance must be quantitative so that changes in individual engines can be tracked over time and engines with emissions outside acceptable control ranges can be identified and remedied.
B4	Test recordkeeping adv/disadv/costs	MSHA-2014-0031-0061-A1	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0061-A1.docx	Josh Roberts	Being able to see trends in the records would be able to give you an advanced notice if something was going wrong as far as the emissions is concerned. The savings in keeping the maintenance up on the equipment would far out way the costs of logging the tests in record books.
B5	Use of test records (WV, PA, OH)	MSHA-2014-0031-0061-A1	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0061-A1.docx	Josh Roberts	Records are kept in a book similar to any maintenance or examination record book. The resources needed for this would be to just get an additional book for diesel maintenance.
B5	Use of test records (WV, PA, OH)	MSHA-2014-0031-0069-A3	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0069-A3.pdf	Edward Green	In connection with its review of the adequacy of protections for coal miners, MSHA should: a) Conduct a survey of the contribution of light-duty equipment to DPM emissions in underground mines. The States of Pennsylvania, West Virginia and Ohio require mine opemtors to keep written maintenance records, based on opeating hours, for all their equipment. Thls information can be a starting point for assessing the contribution of DPM by light-duty equipment.
B6	Training for diesel operators and maintenance	MSHA-2014-0031-0050-A1	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0050-A1.pdf	Robert McDonald	Fitters are trained by original equipment manufacturers (OEMs) to undertake the required maintenance and, where emissions exceed specified limits, to diagnose and rectify the faults responsible.
B6	Training for diesel operators and maintenance	MSHA-2014-0031-0050-A1	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0050-A1.pdf	Robert McDonald	There are three aspects to training: • equipment maintainers are trained to undertake maintenance which is specifically aimed at reducing emissions. They are competent to operate the gas and particulate measurement equipment and are responsible for changing all exhaust filters • equipment operators are provided with training to minimise emissions which includes quite simple requirements such as not leaving equipment idling • all mining personnel are provided with DPM awareness training, which help them avoid potential higher exposure situations.
B6	Training for diesel operators and maintenance	MSHA-2014-0031-0050-A1	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0050-A1.pdf	Robert McDonald	All operators at Broadmeadow mine are trained and authorised to operate the machines within the OEM specifications.

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B6	Training for diesel operators and maintenance	MSHA-2014-0031-0061-A1	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0061-A1.docx	Josh Roberts	A minimum eight hour course should be required to operate diesel powered equipment. This should include classroom training on diesel fundamentals and equipment-specific hands-on training on the job. Eight hours of annual diesel equipment operator refresher training, separate from that required by MSHA regulations at 30 CFR Part 48 should be required annually. The training should include instruction in the following: engine fundamentals, diesel regulations, diesel emissions, factors that affect diesel emissions, emission control devices, diagnostic techniques, preoperational inspection, ventilation, fire suppression systems, operating rules, emergency procedures, and record keeping procedures. A minimum of sixteen hours of training should be required to perform maintenance on diesel equipment regarding the general function, operation, maintenance and testing of emissions control and conditioning components. Annual retraining programs of eight hours should be required for individuals performing maintenance on diesel equipment and should include the following subjects: Federal and state requirements Company policies related to diesel equipment Emissions control system design and component technical training On-board engine performance and maintenance diagnostics system design and component technical training Service and maintenance procedures and requirements for the emissions and control systems Emissions testing procedures and evaluation and interpretation of test results
C	Exhaust After-Treatment and Engine Technologies	MSHA-2014-0031-0040	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0040.html	Thomas Bayne	A major step in controlling the DPM levels comes directly from the equipment itself. New technologies and government regulations aimed at reducing harmful gasses will have a direct impact on air quality. The Tier 4 diesel motors have proven to improve performance of the motor with lowering the emission concentrations. Empire Caterpillar states that along with improved performance the Tier 4 diesel motors will only use Ultra Low Sulfur Fuel and will require CJ-4 Low Ash Oil. While these products may increase costs, the tradeoff on monies spent will be offset by the improved performance of the motor.
C	Exhaust After-Treatment and Engine Technologies	MSHA-2014-0031-0050-A1	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0050-A1.pdf	Robert McDonald	Higher Exposed SEGs Figure 2 above shows that in 2014 the SEGs with the highest mean exposure were the Shotcreters and the Magazine Keeper and that by 2016 the exposure of the workers in both SEGs was reduced by 60%. Continuously Regenerating Trap (CTR) DPFs have been fitted on shotcrete rigs which were the highest emitting vehicles in the underground mine achieving a 99% reduction in emissions from baseline testing. In the case of the Magazine Keeper, vehicles were rerouted away from the magazine which resulted in a significant exposure reduction in that area of the mine. For other SEGs, any exposure measurement recorded in excess of 0.03 mg/m3 is investigated to identify and address the reasons.

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C	Exhaust After-Treatment and Engine Technologies	MSHA-2014-0031-0050-A1	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0050-A1.pdf	Robert McDonald	Introduction Olympic Dam mine is a large underground multi-metallic mine producing copper (principal commodity) uranium, gold and silver. Located in central South Australia, the mine operates by the sublevel open stoping method using modern mining equipment. Being a hard rock mine, Olympic Dam is freed of the constraints of a coal mine where mining equipment is required to be intrinsically safe. Olympic Dam has implemented a number of higher order controls and is developing a range of other controls to further reduce exposure to diesel exhaust including: • Using high quality, low sulphur diesel fuel • Engaging with suppliers to improve engine design and exhaust treatment devices • Replacing older diesel equipment with new technologies where possible • Replacing open cabin machinery and vehicles with enclosed cabin equipment fitted with air filtration units • Installation of diesel exhaust filtration devices to heavy underground machinery e.g. jumbos and trucks • Increased ventilation in mine areas where diesel equipment is in use • Focused attention on high exposure SEGs.
C	Exhaust After-Treatment and Engine Technologies	MSHA-2014-0031-0055-A1	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0055-A1.docx	Catherine Doherty	Another advantage of the use of biodiesel is that it makes the use of diesel particulate filters more attractive (Bugarski et al., 2010). They are utilized commonly to reduce the exposure of particulate matter to workers in underground mines but are not used as much as they could be because they are complex and expensive. A diesel particulate filter is a device that removes diesel particulate matter and the soot from diesel exhaust from a diesel engine. This removal can occur passively or actively and this is called regeneration. Passively, the removal process occurs because of the heat of the diesel exhaust during the operation of the engine or by adding a catalyst to the diesel particulate filter (“Diesel particulate filter,” 2016). The use of biodiesel with diesel particulate filters (DPF) can promote regeneration in the in DPF systems because of underground mines tendency to have a low balance point temperature. This can eliminate extra expenses related to DPFs and negate the need for active regeneration of the filters (Bugarski et al., 2010).
C	Exhaust After-Treatment and Engine Technologies	MSHA-2014-0031-0057-A22	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0057-A22.pdf	Mark G Ellis	The most comprehensive examination to date of the emissions and health effects of new technology heavy duty diesel (NTDE) engines – engines meeting the US 2007/2010 and EURO VI/6 fuel and emission standards – has demonstrated dramatic improvements in emissions and the absence of any significant health effects (especially cancer). In the newly released Executive Summary of the Advanced Collaborative Emissions Study (ACES), the Health Effects Institute (HEI) concludes that “the overall toxicity of exhaust from modern diesel engines is significantly decreased compared with the toxicity of emissions from traditional-technology diesel engines.” The ACES Executive Summary, and links to all other reports of the project, can be found at the HEI website (http://pubs.healtheffects.org/view.php?id=447). The Health Effects Institute is an independent, non-profit research institute funded jointly by the US Environmental Protection Agency and industry to provide credible, high-quality science on air pollution and health for air quality decisions. HEI sponsors do not participate in the selection, oversight or review of HEI science, and HEI’s reports do not necessarily represent their views.
C	Exhaust After-Treatment and Engine Technologies	MSHA-2014-0031-0057-A22	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0057-A22.pdf	Mark G Ellis	Low Sulfur Fuels and New Emission Control Technologies the Key Overall, the ACES results show that the aftertreatment technologies used in such modern diesel engines are highly effective and that they meet — and exceed — the reductions mandated by U.S. and EURO regulations. The study reports the effectiveness of diesel particulate filters in reducing particulate matter (PM) emissions by more than 90% and of selective catalytic reduction systems in reducing smog-forming nitrogen oxide (NOx) emissions by 94%. Emissions of more than 300 other compounds — some with known carcinogenic and toxic properties — were also significantly reduced compared with exhaust from older diesel engines. This combination of new technology enabled by ultra low sulfur diesel fuel (10 ppm sulfur) meets US 2007/2010, EURO VI/6, China 6, and Bharat Stage VI standards. These new engines move well beyond the previous diesel engines (e.g. US 2004, EURO IV/4 and V/5 – and the equivalent China 4 and 5 and Bharat Stage IV and V) to substantially reduce both PM and NOx exposures.
C	Exhaust After-Treatment and Engine Technologies	MSHA-2014-0031-0057-A22	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0057-A22.pdf	Mark G Ellis	The ACES results are expected to play an important role in future risk reviews of diesel engines by international and US agencies. “We are already seeing a transition in America’s roads with over 30% of the trucks and buses in use today meeting these new standards; these vehicles are now being subjected to significant in-use on-road compliance testing to ensure that these improvements occur outside the laboratory,” said Dan Greenbaum, President of HEI. “These results confirm the great strides that government and industry have made to reduce diesel risk – and argue for even greater efforts to accelerate the replacement of older diesel engines.”

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C	Exhaust After-Treatment and Engine Technologies	MSHA-2014-0031-0057-A31	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0057-A31.pdf	Mark G Ellis	From summary of 24 page executive summary: What This Study Adds • ACES set out to evaluate emissions and health effects from new-technology (MY 2007 and 2010) heavy-duty, on-road diesel engines. • The results show that the aftertreatment technologies used in such modern diesel engines are highly effective and that they meet — and exceed — the reductions mandated by U.S. regulations. The study reports the effectiveness of diesel particulate filters in greatly reducing PM emissions and of selective catalytic reduction systems in reducing NOx emissions; similarly, emissions of more than 300 other compounds — some with known carcinogenic and toxic properties — measured in the exhaust were also reduced relative to exhaust from traditional-technology diesel engines. ... • ACES results demonstrate, even after considering some inherent limitations in any such study, that diesel particulate filters greatly reduce the amount of PM from modern diesel engines and that the overall toxicity of exhaust from modern diesel engines is significantly decreased compared with the toxicity of emissions from traditional-technology diesel engines.
C	Exhaust After-Treatment and Engine Technologies	MSHA-2014-0031-0058-A2	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0058-A2.pdf	Timothy French	Report: A global and historical perspective on the exposure characteristics of traditional and new technology diesel exhaust [not excerpted] Truck and Engine Manufacturers Association (EMA) / Association for Emissions Control by Catalyst (AECC) / Manufacturers of Emission Controls Association (MECA) / Conservation of Clean Air and Water in Europe (CONCAWE) / European Automobile Manufacturers' Association (ACEA) / APPENDIX 1 EMISSION CONTROL TECHNOLOGIES FOR DIESEL ENGINES
C	Exhaust After-Treatment and Engine Technologies	MSHA-2014-0031-0062-A15	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0062-A15.pdf	Paul Schulte	[Not excerpted. Contains only cover of book entitled Particle Filter Retrofit for All Diesel Engines. Mayer. 2008]
C	Exhaust After-Treatment and Engine Technologies	MSHA-2014-0031-0062-A7	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0062-A7.pdf	Paul Schulte	Report: [Stachulak et al 2014] The Effect of Diesel Oxidation Catalysts on NO2 Emission from Mining Vehicles [no abstract]
C	Exhaust After-Treatment and Engine Technologies	MSHA-2014-0031-0063-A1	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0063-A1.pdf	Hunter Prillaman	One of the primary methods operators have used to reduce DPM exposure in underground mines is to place into service upgraded equipment (including new equipment and retrofit control devices, as well as monitoring devices). Obviously, operators can only deploy equipment that is available and appropriate for use in the mine environment. Thus, in developing a future standard, MSHA must take into account the crucial role of the original equipment manufacturers (OEM). The OEMs must design and produce the monitoring and mining equipment needed to meet a more stringent DPM standard. This can be very challenging. For example, NLA members have noted that the Tier 4 engine technology has not yet fully matured, and there are numerous other, related issues that still need to be overcome. Even when enhanced engines and monitoring equipment become more readily available, mines will need adequate time to fully deploy these devices. Most of the equipment in question will be capital expenditures for the regulated entities. As such, these will need to be planned well in advance of any future compliance date for a lower DPM standard. In addition, evaluations of the equipment under normal operating conditions will be necessary. Changes to standard maintenance schedules and procurement of service contracts, which will present challenges to certain mines due to geographic location, also will require time to implement. It is vital for MSHA to consider these practical challenges working in partnership with stakeholders in the context of the inter-agency approach.
C	Exhaust After-Treatment and Engine Technologies	MSHA-2014-0031-0069-A12	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0069-A12.xlsx	Edward Green	To access spreadsheet, click "view original comment letter."
C	Exhaust After-Treatment and Engine Technologies	MSHA-2014-0031-0069-A13	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0069-A13.xls	Edward Green	Spreadsheet, fleet after treatment data

Comment Code	Comment Code Description	DCN	Link to Comment	Commenter Name	Comment
C	Exhaust After-Treatment and Engine Technologies	MSHA-2014-0031-0069-A3	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0069-A3.pdf	Edward Green	Protections for Coal Miners MSHA's standards issued in 1996 and 2001 on diesel-powered equipment were instrumental in moving the coal mining industry forward to recognize and address the health hazards of diesel exhaust for underground coal miners. We recognize your personal role during your tenure at the United Mine Workers International nion and that ofyour colleagues in keeping attention on this occupational health issue. More than 16 years, however, have passed since MSHA's initial regulation on diesel equipment, and key advances bave been made in diesel engine and exhaust after-treatment technologies. Today there are more than 5,000 diesel engines in underground coal mines. The 2001 DPM final rule addresses the contribution of DPM to miners' exposure from permissible, heavy-duty equipment, generators and compressors. Under 30 CFR 72.500 and 72.501, mine operators are required to install high efficiency DPM filters on these types of equipment to reduce DPM exposures. This equipment, however, only accounts for about 30 percent of tlle entire underground diesel-powered fleet. The remaining 70 percent of the underground fleet is considered light-duty equipment and is nIot covered under those sections. MSHA addressed the light-duty fleet in 72.502 by simply requiring mine operators to introduce cleaner burning engines into their fleets. We believe that the large number of the existing (i.e., grandfathered) light duty equipment must be further evaluated to determine its contribution to miners' exposure to DPM. Moreover, this evaluation should include assessing how MSHA's Part 72 standards should be improved based on currently available technology. We understand that in 2001, the record was divided between commenters who thought that light-duty equipment operates like heavy-duty equipment and made significant contributions to miners' exposure to DPM and others who did not. Since that time, however, the States of Pennsylvania, West Virginia and Ohio have finalized DPM standards that exceed (are more restrictive than) the federal standard for their light-duty equipment. These States require that ALL light-duty equipment have high-efficiency DPM filters installed. Under MSHA's 72.502 rele, in contrast, mine operators are allowed to introduce engines into their light.duty fleet thst were considered "clean" a full 12 years ago. A more protective rule would requite that older technology have a high-efficiency DPM filter installed. Much has changed in diesel-engine technology in the past 12 years, yet MSHA's rule has not kept up with those improvements.. Without MSHA revising 72.502, mine operators have no incentives to introduce the most modern diesel engines and after-treatment technologies that are available for their light-duty equipment.
C	Exhaust After-Treatment and Engine Technologies	MSHA-2014-0031-0069-A3	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0069-A3.pdf	Edward Green	In connection with its review of the adequacy of protections for coal miners, MSHA should: . . .c) Reevaluate the remaining types of light-duty equipment currently operating in the underground fleet to determine if additional equipment should be included under 72.501 . For example in the 2001 rule, MSHA required generators and compressors that were considered light-duty equipment to meet the same DPM emission limits in 72.501 as heavy-duty equipment. MSHA made that determination based on the contribution of generators and compressors to miners' exposure to DPM. Now, more than a decade later, it is time to update their contribution and prepare a report for the same kind of assessment for other light-duty equipment.
C	Exhaust After-Treatment and Engine Technologies	MSHA-2014-0031-0069-A9	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0069-A9.pdf	Edward Green	The U.S. Environmental Protection Agency (EPA) established strict regulations for highway diesel engine exhaust emissions of particulate matter (PM) and nitrogen oxides (NOx) to aid in meeting the National Ambient Air Quality Standards. The emission standards were phased in with stringent standards for 2007 model year (MY) heavy-duty engines (HDEs), and even more stringent NOX standards for 2010 and later model years. The Health Effects Institute, in cooperation with the Coordinating Research Council, funded by government and the private sector, designed and conducted a research program, the Advanced Collaborative Emission Study (ACES), with multiple objectives, including detailed characterization of the emissions from both 2007- and 2010-compliant engines. The results from emission testing of 2007-compliant engines have already been reported in a previous publication. This paper reports the emissions testing results for three heavy-duty 2010-compliant engines intended for on-highway use. These engines were equipped with an exhaust diesel oxidation catalyst (DOC), high-efficiency catalyzed diesel particle filter (DPF), urea-based selective catalytic reduction catalyst (SCR), and ammonia slip catalyst (AMOX), and were fueled with ultra-low-sulfur diesel fuel (~6.5 ppm sulfur). Average regulated and unregulated emissions of more than 780 chemical species were characterized in engine exhaust under transient engine operation using the Federal Test Procedure cycle and a 16- hr duty cycle representing a wide dynamic range of real-world engine operation. The 2010 engines' regulated emissions of PM, NOX, nonmethane hydrocarbons, and carbon monoxide were all well below the EPA 2010 emission standards. Moreover, the unregulated emissions of polycyclic aromatic hydrocarbons (PAHs), nitroPAHs, hopanes and steranes, alcohols and organic acids, alkanes, carbonyls, dioxins and furans, inorganic ions, metals and elements, elemental carbon, and particle number were substantially (90 to >99%) lower than pre-2007-technology engine emissions, and also substantially (46 to >99%) lower than the 2007-technology engine emissions characterized in the previous study.
C1	After-market treatment cost, effectiveness	MSHA-2014-0031-0042-A1	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0042-A1.docx	Gene Davis	We have a mixture of paper filters (which must include exhaust gas cooling to be used) and ceramic based (both cordierite and silicon carbide) DPM filters in operation in Pennsylvania. As mentioned early in my comments it will cost approximately 12,000 to 25,000 dollars to retrofit a DPF system into a current piece of equipment.
C1	After-market treatment cost, effectiveness	MSHA-2014-0031-0042-A1	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0042-A1.docx	Gene Davis	The last comment I would like to make is, to include an oxidation catalyst in all DPF after-treatment systems. The proper use of an oxidation catalyst will will do two things for the underground coal miner. First it will greatly reduce the CO concentration in the exhaust and it will also burn up approximately 20 to 30 % of the OC factor of DPM. The uses of these items are required by Pennsylvania, West Virginia and Ohio. They are not very costly and do not require a lot of engineering to install, and if maintained properly give a great return on your expenditure.
C1	After-market treatment cost, effectiveness	MSHA-2014-0031-0050-A1	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0050-A1.pdf	Robert McDonald	in an underground coal mine ...., there is the additional challenge that all equipment and engines must be intrinsically safe and comply with local regulatory requirements. This limits the ability to employ the latest technology engines and prevents the use of those diesel exhaust filters, which operate at high temperature.

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C1	After-market treatment cost, effectiveness	MSHA-2014-0031-0050-A1	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0050-A1.pdf	Robert McDonald	Exhaust particulate filters Broadmeadow is an underground coal mine and all equipment entering the mine must be certified as intrinsically safe. Large vehicle exhausts are fitted with water traps. The use of high temperature auto-regenerating ceramic filters is not available in the coal mining environment. Filters must be low temperature and able to withstand the high humidity environment post the water trap. Filters were initially installed in 2013 on larger underground equipment and this was then extended to all equipment. This resulted in an approximately 50% reduction in worker exposure. The initial filters were of a washable type; however, there were concerns with the quality and that the life of the filter was just a single shift. A review identified a fibreglass based filter, Brand FST, which is better able to withstand the humid atmosphere and extends the life of filter from 8 to around 50 hours. Filter replacement on smaller vehicles which operate for 6 to 8 hours per day is built into the weekly maintenance service. In the first hour 'green' filters operate at about 90% efficiency which then rises to close to 100% for the balance of the service life.
C1	After-market treatment cost, effectiveness	MSHA-2014-0031-0050-A1	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0050-A1.pdf	Robert McDonald	The fibreglass filters are about 3 times costlier but have a service life which is 6 times longer. The savings extend beyond the cost of filters to the reduced cost of technician time attending to filter changes and increased machine availability. The cost of filter disposal is also impacted and has been further reduced but crushing filters to approximately one fifth of their original volume.
C1	After-market treatment cost, effectiveness	MSHA-2014-0031-0050-A1	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0050-A1.pdf	Robert McDonald	An exhaust back pressure system is installed in larger vehicles to monitor filter loading. Change out occurs at 10 kPa back pressure across the filter. Filter hours are logged for each vehicle individually and filters are always changed by trained technicians. When filters are changed, attention is paid to installation to ensure an effective seal and prevent exhaust by-pass. Exhaust system backpressure without filters is logged and reduced to less than 2 kPa to ensure maximum filter life, i.e. exhaust backpressure is due to filter clogging and not to other exhaust build-up.
C1	After-market treatment cost, effectiveness	MSHA-2014-0031-0050-A1	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0050-A1.pdf	Robert McDonald	In 2013, Olympic Dam began a program to retrofit all heavy machinery with Diesel Particulate Filters (DPFs) on a priority risk basis. DPF's have now been fitted to all currently in service BHP Billiton trucks and loaders and trials are progressing to fit DPFs to ancillary fleet machines which do not have suitable OEM solutions.
C1	After-market treatment cost, effectiveness	MSHA-2014-0031-0050-A1	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0050-A1.pdf	Robert McDonald	BHP Billiton's AD55 truck fleet has been retrofitted with OEM DPFs resulting in an average reduction of 66% from baseline emission testing results from 2013. New AD60 CAT trucks are fitted with DPF as standard and have lower emissions than AD55 machines.
C1	After-market treatment cost, effectiveness	MSHA-2014-0031-0050-A1	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0050-A1.pdf	Robert McDonald	There are a significant number of light vehicles operating underground. Trials of partial flow DPF technology has been trialled on light vehicles achieving an approximately 75% reduction.
C1	After-market treatment cost, effectiveness	MSHA-2014-0031-0057-A5	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0057-A5.pdf	Mark G Ellis	All but one of our members uses after-treatment technology on their diesel-powered equipment. Of those who use after-treatment technology, the processes vary. At one end of the spectrum are those companies who have fitted their equipment with catalytic converters and installed dry filter systems. Other companies employ catalytic or capturable diesel particular filters (DPFs). The former have a replacement cost of $12,000-$15,000 per unit and have a removal efficiency of about 60%, while capturable DPFs cost $30,000/unit and provide 95% removal efficiency. Replacing the filters on capturable DPFs costs an additional $15,000. At least one company uses Diesel Exhaust Fluid (DEF), in addition to DPF, to reduce diesel particular matter. Other companies use a broader range of tools to reduce diesel particulate matter (DPM). Some employ loaders with filters that convert up to 90% of DPM to carbon dioxide and water, while other companies employ a suite of removal technologies such as DPM filters and Urea injection; or Sinistered Metal Filters (which cost roughly $50,000 to purchase and install, and $6,000 annually to maintain), Diesel Filter Elements (which cost $23,500 to install and $121,000 annually to maintain), and Diesel Oxidation Catalysts (which cost $17,000 to install). The latter three technologies capture anywhere from 83% to 99% of DPM. Other companies reduce DPM by upgrading from Tier 3 to Tier 4 engines or by installing Dry Systems Technology (DST) dry scrubbers on larger horsepower equipment. While one company estimates that upgrading from Tier 3 to Tier 4 engines costs about $16,000 per machine, another company estimates that the cost of installing a new Tier 4 engine in an existing machine may be much higher once companies account for the cost of the engine, Electronic Control Modules (ECM), and the labor associated with installation and modifications. Furthermore, the practical difficulties of replacing the engine in existing equipment persuades some companies to upgrade to Tier 4 engines only once their existing equipment is retired. Installation of DST scrubbers costs $110,000 per engine. The durability of the above technologies varies, but most technologies, including catalytic DPFs, Tier 4 engines, and DPM filters, need replacement or rebuilding after about 5,000 hours. DST scrubbers, however, are permanent.
C1	After-market treatment cost, effectiveness	MSHA-2014-0031-0059-A4	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0059-A4.pdf	Celeste Monforton	MSHA's diesel inventory has up-to-date data on the manufacturers and model types of DPM filters. MSHA should make this information available to the industry (mine operators and miners.) As mentioned previously, manufacturers of light-duty equipment use in Pennsylvania, Ohio, and West Virginia can supply MSHA with the cost information for DPM filters.
C1	After-market treatment cost, effectiveness	MSHA-2014-0031-0061-A1	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0061-A1.docx	Josh Roberts	There are both paper and ceramic based filters. Paper filters are typically changed during the 100 hour maintenance of the equipment. Ceramic filters can be cleaned by burning the soot off of the filter and reused. Ceramic filter can last thousands of hours. The disadvantage being; the costs of such systems being around $20,000 to install one of these systems onto a piece of equipment. The advantage being; these systems can reduce the emissions by around 90-95%. Resulting in significantly improved air quality.

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C1	After-market treatment cost, effectiveness	MSHA-2014-0031-0062-A10	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0062-A10.pdf	Paul Schulte	Filtration systems with disposable filter elements (DFEs) are used in the underground coal mining industry to control particulate matter emissions from diesel-powered permissible and non-permissible coal mining equipment. This study was conducted in underground mine conditions to evaluate three types of high-temperature DFEs used in those filtration systems. The DFEs were evaluated for their effects on the concentrations and size distributions of diesel aerosols and concentrations of nitric oxide (NO) and nitrogen dioxide (NO2). Those effects were compared with the effects of a standard muffler. The experimental work was conducted directly in an underground environment using a unique diesel laboratory developed in an underground experimental mine. After an initial DFE degreening period, the filtration system with all three DFEs was found to be very effective at reducing total mass concentrations of aerosols in the mine air. The effectiveness of DFEs in filtering aerosol mass was found to be a function of the engine operating conditions. The efficiency of the new DFEs significantly increased with operating time and buildup of diesel particulate matter in the porous structure of the filter elements. A single laundering process did not exhibit substantial effects on the performance of the DFE elements. The effectiveness of DFEs in removing aerosols by number was strongly influenced by engine operating mode. The concentrations of nucleation mode aerosols in the mine air were found to be substantially higher for DFEs when the engine was operated at high-load modes rather than at low-load modes. Initial heating of certain DFEs resulted in visible white smoke and substantially elevated aerosol number concentrations. The effects of the DFEs on the total concentration of nitrogen oxides (NOx) were found to be minor. The NO2 fraction was found to be generally lower for the DFEs than for the muffler. The engine-out NO2 fraction and the total NOx was found to be substantially higher for low-load modes than for high-load modes.
C1	After-market treatment cost, effectiveness	MSHA-2014-0031-0062-A18	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0062-A18.pdf	Paul Schulte	[Contains only first page of study on particle filter effectiveness and costs. Abstract included here as excerpt. Mayer (2009).] Four of these Particulate Reduction Systems (PMS) were tested on a passenger car and one of them on a HDV. Expectation of the research team was that they would reach at least a PM-reduction of 30% under all realistic operating conditions. The standard German filter test procedure for PMS was performed but moreover, the response to various operating conditions was tested including worst case situations. Besides the legislated CO, NOx and PM exhaust-gas emissions, also the particle count and N02 were measured. The best filtration efficiency with one PMS was indeed 63%. However, under critical but realistic conditions filtration of 3 of 4 PMS was measured substantially lower than the expected 30 %, depending on operating conditions and prior history, and could even completely fail. Scatter between repeated cycles was very large and results were not reproducible. Even worse, with all 4 PMS deposited soot, stored in these systems during light load operation was intermittently blown-off. Due to these stochastic phenomena the behavior of these systems is hardly predictable. Furthermore the provision of N02 , through catalysis ahead of the filter or in the filter matrix, is inherent in these systems. Some of this secondary N02 is emitted. Cost/benefit ratio is high compared to full-flow filters and Diesel engines equipped with partialflow filters are inferior to SI engines regarding global warming potential. Based on these findings it is concluded that the sustainable performance of partialflow filters is not yet determined.
C1	After-market treatment cost, effectiveness	MSHA-2014-0031-0062-A19	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0062-A19.pdf	Paul Schulte	[Contains only first page of study on tailpipe emissions following catalytic treatment. Robinson.] Introduction of modern diesel aftertreatrnent, primarily selective catalytic reduction (SCR) designed to reduced NO has increased the presence of urea decomposition bypro ducts, main!; ammonia, in the aftertreatment system. This increase in ammonia has been shown to lead to particle formation in the aftertreatment system. In this study, a state of the art diesel exhaust fluid (DEF)-SCR system was investigated in order to determine the influence of DEF dosing on solid particle count. Post diesel particulate filter (DPF) particle count (> 23 nm) is shown to increase by over 400% during the World Harmonized Transient Cycle (WHTC) due to DEF dosing. This increase in tailpipe particle count warranted a detailed parametric study ofDEF dosing parameters effect on tailpipe particle count. Global ammonia to NOx ratio, DEF droplet residence time, and SCR catalyst inlet temperature were found to be significant factors in post-DPF DEF based particle formation. Thermogravimetric analysis (TGA) of ammonia salt particles and urea decomposition byproducts indicate significant chance of measurement using the Particle Measurement Programme (PMP) Particle Number (PN) method. These DEF based particles were not intended to be addressed by the PMP PN methodology, but are found to be over 80% ofPN post DPF.
C1	After-market treatment cost, effectiveness	MSHA-2014-0031-0062-A25	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0062-A25.pdf	Paul Schulte	[Author: Bugarski] A series of field and laboratory evaluations were conducted in order to characterize the effects of a Mann+Hummel SMF-AR® diesel particulate filter (DPF) system on the aerosols and criteria gases emitted by diesel engines. This system, with a durable sintered metal filter media and available active regeneration via an on-board electrical heater, has been considered for retrofitting diesel engines used in light- and medium-duty underground mining applications. Two DPF systems were installed on a forklift and locomotive from the underground mining fleet of the Vale's Creighton Mine and evaluated over a 1,500-hour trial. This evaluation was complemented with field and laboratory emissions tests. The field tests were performed on the vehicles while at the Creighton Mine surface shop. During those tests, the emissions were assessed for the engines operated at hydraulic stall, high idle, and low idle conditions. The laboratory tests were executed at the diesel engine emissions laboratory at the National Institute for Occupational Safety and Health (NIOSH), here the DPF removed from the forklift was further evaluated at four steady-state engine operating conditions as well as at transient conditions using a custom-designed duty cycle. Very similar methodologies were used during field and laboratory tests to measure concentrations of aerosols and criteria gases in the diesel exhaust, both upstream and downstream of the DPF system. The concentrations and size distributions of aerosols were measured using a fast mobility particle sizer spectrometer, in exhaust diluted by a partial flow dilution system. The concentrations of CO2, CO, NO, and NO2 were measured in the raw exhaust using a Fourier transform infra-red spectrometer. Both field and laboratory emissions tests showed that the evaluated DPF systems were very effective in reducing aerosol emissions from all tested engines, and for all test conditions. The systems were found to have minor effects on gaseous emissions from those engines. The findings from this study should help the mining industry to better understand the benefits and challenges of using DPF systems to control the exposure of underground miners to diesel aerosols.

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C1	After-market treatment cost, effectiveness	MSHA-2014-0031-0062-A5	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0062-A5.pdf	Paul Schulte	Published study.[Stachulak 2005] Study title and abstract: Long-Term Evaluation of Diesel Particulate Filter Systems at !nco's Stobie Mine The objective, of the Diesel Emissions Evaluation Program (DEEP)-sponsored project at Inca's Stobie mine, was to conduct a long-term field evaluation of selected diesel particulate filter (DPF) systems, available to the underground mining industry. Nine state-of-the-art DPF systems were retrofitted to hea\•y-duty and light-duty vehicles and were subjected to extensive long-term in-mine evaluation. Periodic efficiency tests were conducted at various stages of the study (in 2001, 2002 and 2004) to establish in-use efficiencies and durabilities of the tested DPF systems. During efficiency tests, the vehicles/engines were operated over several steady-state operating conditions. Various instruments were used to measure particulate and gaseous emissions upstream and downstream of the filter systems. The results were used to assess the effects of the filter systems on the concentrations of diesel particulate matter (DPM), nitric oxide, nitrogen dioxide and carbon monoxide in the vehicle exhaust. Experience with the operational issues related to deployment of the fllter systems on underground mining vehicles, coupled with the assessment of the filtration efficiencies, were the primary objectives of the study. The variety of filtration systems and regeneration concepts used in this study offered the opportunity to investigate the advantages and disadvantages of the various types. Some of the major issues studied were criteria for selecting the filter media, means of regeneration, the long-term operational reliability, and the occurrence of unwanted secondary emissions.
C1	After-market treatment cost, effectiveness	MSHA-2014-0031-0062-A9	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0062-A9.pdf	Paul Schulte	[Not excerpted. Published study by Bugarski, 2009]
C1	After-market treatment cost, effectiveness	MSHA-2014-0031-0063-A1	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0063-A1.pdf	Hunter Prillaman	NLA members have had varying experiences with after-treatment technologies. Companies using catalytic diesel particulate filters have reported that these devices achieve around 60% removal efficiency, and that the filters last approximately 5,000 hours and show 70-80% durability during that time. Replacement of the filters costs between $12,000-15,000 per unit. In addition, equipment can be out of service for lengthy periods of time while a new filter is obtained and installed (one member reported a delay of over a month for these repairs). Capturable filters have better removal efficiency (one user reports 95% removal, while others have not had the equipment in service long enough to make an evaluation), but the cost is $30,000 per unit, with replacement of just internal parts running $14,000 and cleaning costing $2,000. One member reported that an effort to install a DPM filter on a 65-ton haul truck was not successful, because the filter (which cost $40,000) failed to regenerate properly and had to be removed. Members have identified several other problems with Tier 4 filter systems. For example, the engine must continue to run if a re-gen is in process (about 15-20 minutes), and if there is a short circuit the motor will not run and the equipment is stuck in place. Members have also experienced increased maintenance costs with this equipment. It has also been reported that equipment that requires significant idling time may not regenerate filters adequately, resulting in premature failures and systems shutdowns. Finally, the methods and timing for filter regeneration can be complex, leading to an increased risk of human error and the need for technician assistance. (See also the response to question 18 below with respect to light-duty vehicles.)
C1	After-market treatment cost, effectiveness	MSHA-2014-0031-0069-A3	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0069-A3.pdf	Edward Green	In connection with its review of the adequacy of protections for coal miners, MSHA should: . . .b) Update Table 72.502-1 to reflect requirements already in place under U.S. EPA regulations on diesel engine and after-treatment technologies. When written, Section 72.502 was intended to only allow mine operators to introduce light-duty equipment with "'cleaner" engines, but Table 72.502-1 is outdated given all the advances in clean-engine technology.
C2	Costs/advantages/disadv for 3 filter efficiencies	MSHA-2014-0031-0057-A5	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0057-A5.pdf	Mark G Ellis	Adoption of DPM filters with 95% removal efficiency has a number of significant drawbacks, not least of which are the associated costs. We are concerned that these DPM filters are expensive and not cost-effective when compared to other methods of DPM reduction. DPM filters with 95% removal efficiency also have coatings that produce a greater amount of NO2 then peer technologies, and are not easily retrofitted onto existing equipment. Administrative controls and alternative technologies, such as additional ventilation, provide more cost effective means of reducing DPM. MSHA has not expressed a preference for engineering controls relative to administrative controls, and IMA-NA believes this policy allows its members to meet DPM requirements in a cost-effective manner. Those who use the technology replace filters at different intervals. One company replaces filters every 24 hours, one replaces filters every 4,500 hours, another changes filters every nine to ten months, while some companies have never replaced their filters. We note, however, that one advantage of dry filter systems is that operators can change the filters themselves, which reduces the time needed to service equipment.

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C2	Costs/advantages/disadv for 3 filter efficiencies	MSHA-2014-0031-0059-A4	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0059-A4.pdf	Celeste Monforton	All commercially available DPM filters will reduce DPM with high efficiencies which would meet Tier 4 engine standards. MSHA has the data on its diesel inventory to determine DPM filter efficiency with ventilation rates in order to calculate an exposure. MSHA should provide the most up-to-date data from the inventory to the industry (mine operators and miners.)
C2	Costs/advantages/disadv for 3 filter efficiencies	MSHA-2014-0031-0061-A1	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0061-A1.docx	Josh Roberts	The disadvantage being; the costs of such systems being around $20,000 to install one of these systems onto a piece of equipment. The advantage being; these systems can reduce the emissions by around 90-95%. Resulting in significantly improved air quality.
C2	Costs/advantages/disadv for 3 filter efficiencies	MSHA-2014-0031-0062-A4	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0062-A4.pdf	Paul Schulte	Filtration systems with DFEs and DPFs are currently used extensively in underground coal mines in the U.S. According to the data in the national coal diesel inventory [MSHA 2016a], more than 370 heavy-duty permissible packages include filtration systems with DFEs. Over 1,140 non-permissible, heavy-duty engines are retrofitted with DPFs or filtration systems with DFEs to meet MSHA [30 CFR 72.501], Pennsylvania [PADEP 2009], and West Virginia [WVMHST 2016] standards. Over 670 light-duty vehicles are equipped with DPFs or filtration systems with DFEs [MSHA 2016a] to meet these standards [30 CFR 72.502]. Only a few recently certified non-permissible engines with integrated DPM controls [MSHA 2016a] do not require an additional ventilation or filter to comply with the 2.5 g/hr standard or 0.12 mg/m3 standard. For the majority of currently used engines that need to meet the 2.5 g/hr standard [MSHA 2016a], reducing the DPM emissions to the level of 120 µg/m 3 would require additional air or a higher-efficiency filter. The success ofthe current regulations [30 CFR 72.500; 30 CFR 72.501; 30 CFR 72.502] strongly depends on the in-use effectiveness of exhaust aftertreatment, specifically filtration systems with DFEs and DPFs. In support of the intent of the regulations to protect the health of underground miners, we assess that the DFEs used in the underground coal mining industry should meet more stringent standards to secure use of the products that provide adequate protection. One area that requires improvement is the efficiency of DFEs throughout their useful life [Bugarski et al. 2011; Bugarski 2016; Davies 2016]. In general, the current procedures for the certification of diesel engines and verification of exhaust aftertreatment technologies need to be improved to accommodate for differences in the variety of deployed diesel engines and exhaust aftertreatment technologies [Thiruvengadam et al. 2012; Herner et al. 2011; Robinson et al. 2016]. The procedures should detect the potential for the generation of secondary emissions of toxic substances that are not part of the original engine-out emissions [Czerwinski et al. 2007; Heeb et al. 2008]. Therefore, to use adequate technologies that offer both reduction in particulate mass as well as in particle number emissions [Mayer et al. 2009a], the standards should be modified to include reference to exhaust particulate number concentrations [FOEN 2016]. Current regulations [30 CFR 72.500; 30 CFR 72.501; 30 CFR 72.502] indirectly limit personal exposures of underground miners to diesel aerosols and gases by limiting tailpipe emissions. Given these regulations, maintaining in-use engine emissions at the certification level during the entire engine life and using effective aftertreatment technologies are critical to providing adequate protection to miners. Due to sufficient reliability and durability, diesel engines are used in underground mines for many years, and engines are often rebuilt several times during their useful life. More stringent standards, as described above, are needed to ensure that in-use emissions from diesel-powered vehicles operated in underground mines are close to certification level emissions. Similarly, the in-use performance of exhaust aftertreatment technologies should be periodically verified during the device's useful lifetime.
C2	Costs/advantages/disadv for 3 filter efficiencies	MSHA-2014-0031-0063-A1	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0063-A1.pdf	Hunter Prillaman	Most filters available to lime operations have either 60% or 95% removal efficiency. Observed disadvantages of the 95% DPF include a much higher associated cost, coatings that produce increased NO2 emissions resulting in the need for additional controls, and availability only on engines at Tier 3 status or higher. Additionally, retrofitting existing equipment with more efficient filters can create visibility issues as these filters have to be very large to capture the exhaust of older engines. The 95% DPF in use at lime operations is relatively new, so the typical timing of replacement is not yet known. For 60% filters, operators have experienced duty cycle replacement at around 5,000 hours (approximately every 3 years), although some members have reported greater difficulties with Tier III equipment, resulting in replacement at around 2000 hours. Some members have experienced more serious problems with filters, including filters that required daily replacement on a powder truck. These filters were discontinued because they were both cumbersome and expensive, and were not cost-effective.
C3	Sensor types on aftermarket treatment (NH3, NOx)	MSHA-2014-0031-0057-A5	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0057-A5.pdf	Mark G Ellis	Most members indicated that after-treatment devices do not use sensors, such as ammonia, nitrogen oxide, or nitrogen dioxide. However, one company measures diesel exhaust for particulate matter, nitrogen oxide, and other gases with some regularity.
C3	Sensor types on aftermarket treatment (NH3, NOx)	MSHA-2014-0031-0059-A4	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0059-A4.pdf	Celeste Monforton	Modern Tier 4 engines have the required sensors to make the after-treatment system work properly as installed by the engine manufacturer.
C3	Sensor types on aftermarket treatment (NH3, NOx)	MSHA-2014-0031-0061-A1	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0061-A1.docx	Josh Roberts	Carbon Monoxide and temperature are the only sensors that we are aware of that come built into the after-treatment devices. Other sensors such as nitrogen oxide and nitrogen dioxide can be built into the system but are add-ons from state law requirements.
C3	Sensor types on aftermarket treatment (NH3, NOx)	MSHA-2014-0031-0062-A4	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0062-A4.pdf	Paul Schulte	A sensor for measurement of NOx emissions upstream and downstream of a SCR system is available from Continental Automotive (Smart NOx Sensor UniNOx) [Continental 2016]. The sensor measurement results are used to control urea dosing and to diagnose the operation of the SCR system. A sensor for measurement of ammonia levels in the exhaust of diesel vehicles equipped with an SCR aftertreatment system (0 to 100 ppm) is available from Delphi [Delphi 2016]. The sensor output can be used to provide feedback to the SCR system, helping to provide optimal reduction of NOx emissions [Wang et al. 2007].

Comment Code	Comment Code Description	DCN	Link to Comment	Commenter Name	Comment
C3	Sensor types on aftermarket treatment (NH3, NOx)	MSHA-2014-0031-0063-A1	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0063-A1.pdf	Hunter Prillaman	Equipment in use at lime operations has back pressure and temperature sensors built into the equipment. Some members also perform separate testing on equipment exhaust for specific contaminants. Some engines with urea injection have a NOx sensor.
C4	Integrated after treatment cost, effectiveness	MSHA-2014-0031-0050-A1	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0050-A1.pdf	Robert McDonald	Where possible, Caterpillar engines were upgraded with the Ventilation Reduction package incorporating selective engine hardware and software to minimize DPM in the engine exhaust. The package is consistent with exhaust filters and requires the use of ULSD fuel. This effectively provides more modern engine management systems to older engines.
C4	Integrated after treatment cost, effectiveness	MSHA-2014-0031-0050-A1	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0050-A1.pdf	Robert McDonald	The Loader fleet has been fitted with OEM DPFs in conjunction with a recent OEM ventilation reduction engine upgrade which has reduced total emissions of the loader fleet by an average of 77% from baseline emission testing results from 2013.
C4	Integrated after treatment cost, effectiveness	MSHA-2014-0031-0050-A1	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0050-A1.pdf	Robert McDonald	The following table shows the emissions reduction achieved for one truck by firstly upgrading the engine management system and then fitting an exhaust filter. Table 2: Progressive emissions reductions achieved in one truck Test Date / Test Type / Veh. No. / Veh. Model / Veh. Type / DPM Improvement / Average mg/m3 14/01/2014 / Free Acc. / LDO5O / R2900G / Loader / 25.7 27/02/2014 / Free Acc. / LDO5O / R2900G / Loader / VR Spec / 10.3 8/04/2014 / Free Acc. / LDO5O / R2900G/ Loader / VR Spec+ DPM filter / 4.6
C4	Integrated after treatment cost, effectiveness	MSHA-2014-0031-0057-A5	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0057-A5.pdf	Mark G Ellis	As discussed in response to Question 14 the members who use integrated engine and exhaust after-treatment systems do so at significant expense. One member who replaced its engines and dry filter systems expended over $2.5 million to date and has seen a commensurate decrease of 95% per modified piece of equipment. While at least one respondent concedes that integrated systems work well, almost every respondent also expressed the opinion that such systems are complex, costly, and require on-going maintenance. The effectiveness and cost of such maintenance were described in response to Question 14.
C4	Integrated after treatment cost, effectiveness	MSHA-2014-0031-0059-A4	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0059-A4.pdf	Celeste Monforton	MSHA has that data on the diesel inventory and should provide it to the industry (mine operators and miners.)
C4	Integrated after treatment cost, effectiveness	MSHA-2014-0031-0061-A1	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0061-A1.docx	Josh Roberts	The cost of most systems will be around $20,000 and the emission reductions would be anywhere from 75-95%.
C4	Integrated after treatment cost, effectiveness	MSHA-2014-0031-0063-A1	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0063-A1.pdf	Hunter Prillaman	Integrated systems are in use at some lime operations. They are more complex, require additional maintenance expertise, and possess more operational steps than older equipment, and thus impose higher costs, including labor costs. Companies seeking to deploy such systems have also experienced significant delays in delivery.
C5	High efficiency DPM filters cost/adv/disadv	MSHA-2014-0031-0042-A1	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0042-A1.docx	Gene Davis	if an EPA tier II engine and after-treatment system is maintained in proper operating condition this approach will rival the DPM output of even the newest EPA tier IV engines. See the chart below. *(see "Chart for C5")* The chart above shows two diesel engines that are very similar in hp ratings and vent plate quantity while the engine listed first is an EPA tier IV engine and has been approved with an after treatment system, the DPM output is very low at .005 mg/m³ but the other engine is one that is currently being used in Pennsylvania and is EPA tier II, by rule the State agency requires an after-treatment system to be included on all diesel powered equipment. As you can see the system that is being extrapolated for this engine is a ceramic based filter that has been tested by MSHA and awarded an efficiency rating of 93%, when this system is applied to the older EPA tier II engine the results are even lower that the newer costly EPA tier IV engine at .004 mg/m³. So with so many older diesel engines operating in the nations coal mines should we press for newer engines or simply install and properly maintain available systems onto our current diesel fleet. This seems to be the prudent approach to me.
C5	High efficiency DPM filters cost/adv/disadv	MSHA-2014-0031-0050-A1	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0050-A1.pdf	Robert McDonald	Ancillary fleet, including rock breakers and tool-carriers, have had DPFs trialled from three different suppliers. Results have varied and effectiveness of the technology over replacement with more efficient engines is being considered. The best solution will be implemented across the remaining ancillary fleet.

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C5	High efficiency DPM filters cost/adv/disadv	MSHA-2014-0031-0057-A5	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0057-A5.pdf	Mark G Ellis	There are a number of disadvantages to equipping light-duty diesel-powered equipment with high-efficiency DPM filters, primarily that the technology is cost prohibitive. Multiple members suggested that there are more cost-effective engineering or administrative controls that reduce DPM, particularly in light of the fact that large mobile equipment is a greater source of DPM than light duty equipment. Small, light-duty engines are often incapable of generating enough heat to regenerate the diesel particulate filter. While truck filters are designed to clean themselves at highway speeds, most equipment never reaches such speeds. Instead, equipment with a DPM filter must often be manually regenerated, a service that often must be done off-site by the dealer. This substantially increases the equipment's operational costs. In fact, one company estimates that dealer servicing for a single piece of equipment can cost several thousand dollars and is sometimes required more than once per year. These operational costs, in addition to the cost of purchasing the equipment, makes installation and use DPM filters often financially not feasible. Other companies use buggies in their mines, which are neither produced with DPM filters nor capable of being retrofitted. One member noted that light-duty trucks with DPM filters produce excess smoke during filter cleaning and during engine malfunctions. Finally, two members emphasized that EPA adopted Tier 4 diesel engine standards in 2004. Those standards permit manufacturers to determine what control technologies are needed to meet DPM requirements, and one member suggested that engines could not be altered to include DPM filters and still maintain Tier 4 compliance. As to benefits, two members noted that DPM filters can reduce emissions.
C5	High efficiency DPM filters cost/adv/disadv	MSHA-2014-0031-0059-A4	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0059-A4.pdf	Celeste Monforton	As stated previously, DPM filters are feasible on all light-duty machines. Cost information is available from manufacturers who are selling equipment in Pennsylvania, Ohio, and West Virginia.
C5	High efficiency DPM filters cost/adv/disadv	MSHA-2014-0031-0061-A1	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0061-A1.docx	Josh Roberts	The only disadvantage being the cost of such systems being around $20,000 to install one of these systems onto a piece of equipment. The advantage being; these systems can reduce the emissions by 95%. Resulting in significantly improved air quality.
C5	High efficiency DPM filters cost/adv/disadv	MSHA-2014-0031-0062-A16	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0062-A16.pdf	Paul Schulte	[Contains only cover page for technical paper. Khalek 2011. Abstract included as excerpt.] As part of the Advanced Collaborative Emissions Study (ACES), regulated and unregulated exhaust emissions from four different 2007 model year U.S. Environmental Protection Agency (EPA)-compliant heavy-duty highway diesel engines were measured on an engine dynamometer. The engines were equipped with exhaust high-efficiency catalyzed diesel particle filters (C-DPFs) that are actively regenerated or cleaned using the engine control module. Regulated emissions of carbon monoxide, nonmethane hydrocarbons, and particulate matter (PM) were on average 97, 89, and 86% lower than the 2007 EPA standard, respectively, and oxides of nitrogen (NOx) were on average 9% lower. Unregulated exhaust emissions of nitrogen dioxide (N02) emissions were on average 1.3 and 2.8 times higher than the N02 emissions reported in previous work using 1998- and 2004- technology engines, respectively. However, compared with other work performed on 1994- to 2004-technology engines, average emission reductions in the range of 71- 99% were observed for a very comprehensive list of unregulated engine exhaust pollutants and air toxic contaminants that included metals and other elements, elemental carbon (EC), inorganic ions, and gas- and particle-phase volatile and semi-volatile organic carbon (OC) compounds. The low PM mass emitted from the 2007 technology ACES engines was composed mainly of sulfate (53%) and OC (30%), with a small fraction of EC (13%) and metals and other elements (4%). The fraction of EC is expected to remain small, regardless of engine operation, because of the presence of the high-efficiency C-DPF in the exhaust. This is different from typical PM composition of pre-2007 engines with EC in the range of 10-90%, depending on engine operation. Most of the particles emitted from the 2007 engines were mainly volatile nuclei mode in the sub-30-nm size range. An increase in volatile nanoparticles was observed during C-DPF active regeneration, during which the observed particle number was similar to that observed in emissions of pre-2007 engines. However, on average, when combining engine operation with and without active regeneration events, particle number emissions with the 2007 engines were 90% lower than the particle number emitted from a 2004- technology engine tested in an earlier program.
C5	High efficiency DPM filters cost/adv/disadv	MSHA-2014-0031-0062-A4	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0062-A4.pdf	Paul Schulte	Light-duty vehicles have been found to be responsible for a major fraction of the DPM burden in underground metal mines [Rubeli et al. 2004]. Currently, over 670 light-duty, nonpermissible vehicles are successfully operated in underground coal mines with high-efficiency DPFs or filtration systems with DFEs [MSHA 2016a]. If retrofitted with high-efficiency DPM filters, light-duty diesel-powered equipment would contribute substantially less to the concentration of DPM in the underground environment. However, retrofitting existing light-duty vehicles with high-efficiency DPM filters would involve significant technological challenges including lack of regeneration strategies, physical size of the systems, and higher complexity. For some applications, it could be more feasible to repower vehicles with engines that meet EPA Tier 4 final standards [EPA 2016].
C5	High efficiency DPM filters cost/adv/disadv	MSHA-2014-0031-0063-A1	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0063-A1.pdf	Hunter Prillaman	At some lime operations, light-duty equipment is not a significant source of DPM compared to large mobile equipment. There have also been difficulties with diesel particulate filters on light-duty equipment, such as those that are standard on model year 2007 and newer pickup trucks. These vehicles have been observed to produce more smoke than the older trucks when the filter cleaning cycle begins or during engine malfunctions. Another drawback to the newer generation engines is the requirement to take them to the dealer for regeneration of the filters due to operating conditions in the mine. The truck filters are typically designed to clean themselves at highway speeds. Many of these trucks in mine use never reach highway speeds (because of low speed limits in the mine, and because some of them are not licensed for highway use) and therefore do not clean reliably. Taking them to the dealer (or manually regenerating the filters, which is possible for some equipment) is costly and imposes delay on availability of the equipment for use in the mine. For light duty vehicles that do not have filters as standard equipment, retrofitting can be difficult because of the size of the filters required.

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C5	High efficiency DPM filters cost/adv/disadv	MSHA-2014-0031-0069-A10	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0069-A10.pdf	Edward Green	As part of the Advanced Collaborative Emissions Study (ACES), regulated and unregulated exhaust emissions from four different 2007 model year U.S. Environmental Protection Agency (EPA)-compliant heavy-duty highway diesel engines were measured on an engine dynamometer. The engines were equipped with exhaust high-efficiency catalyzed diesel particle filters (C-DPFs) that are actively regenerated or cleaned using the engine control module. Regulated emissions of carbon monoxide, nonmethane hydrocarbons, and particulate matter (PM) were on average 97, 89, and 86% lower than the 2007 EPA standard, respectively, and oxides of nitrogen (NOx) were on average 9% lower. Unregulated exhaust emissions of nitrogen dioxide (NO2) emissions were on average 1.3 and 2.8 times higher than the NO2 emissions reported in previous work using 1998- and 2004- technology engines, respectively. However, compared with other work performed on 1994- to 2004-technology engines, average emission reductions in the range of 71– 99% were observed for a very comprehensive list of unregulated engine exhaust pollutants and air toxic contaminants that included metals and other elements, elemental carbon (EC), inorganic ions, and gas- and particle-phase volatile and semi-volatile organic carbon (OC) compounds. The low PM mass emitted from the 2007 technology ACES engines was composed mainly of sulfate (53%) and OC (30%), with a small fraction of EC (13%) and metals and other elements (4%). The fraction of EC is expected to remain small, regardless of engine operation, because of the presence of the high-efficiency C-DPF in the exhaust. This is different from typical PM composition of pre-2007 engines with EC in the range of 10 –90%, depending on engine operation. Most of the particles emitted from the 2007 engines were mainly volatile nuclei mode in the sub-30-nm size range. An increase in volatile nanoparticles was observed during C-DPF active regeneration, during which the observed particle number was similar to that observed in emissions of pre-2007 engines. However, on average, when combining engine operation with and without active regeneration events, particle number emissions with the 2007 engines were 90% lower than the particle number emitted from a 2004- technology engine tested in an earlier program.
C6	Engine replacement type (Tier 4, 4i)/cost	MSHA-2014-0031-0050-A1	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0050-A1.pdf	Robert McDonald	Additional exposure reductions will largely require the use of higher tier engines or electrification.
C6	Engine replacement type (Tier 4, 4i)/cost	MSHA-2014-0031-0050-A1	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0050-A1.pdf	Robert McDonald	The Olympic Dam [hardrock] mine [in Australia] approaches this aspect in several ways. The focus is on having the latest technology in engines. Older engines have been replaced on a planned replacement schedule so that the majority of engines used in heavy equipment are Tier 3 and will be Tier 4 by 2020. Table 1 below shows the progress in transitioning to new engine technologies.
C6	Engine replacement type (Tier 4, 4i)/cost	MSHA-2014-0031-0050-A1	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0050-A1.pdf	Robert McDonald	Contractors' vehicles are required to have an EPA rated Tier 4 engine, or if a Tier 4 solution is not available an EPA Tier 3 engine retrofitted with Continuously Regenerative Trap (CRT) style diesel particulate filter (DPF). Particulate exhaust emissions of these vehicle must be< 0.5 mg/m3 post filtration when measured by real time analyser or similar light scattering measurement device.
C6	Engine replacement type (Tier 4, 4i)/cost	MSHA-2014-0031-0050-A1	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0050-A1.pdf	Robert McDonald	Low emission V8 1VD engines are being purchased as replacements for 1 HZ engines. 1VD engine emissions are lower emissions than 1 HZ engines fitted with DPFs.
C6	Engine replacement type (Tier 4, 4i)/cost	MSHA-2014-0031-0057-A5	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0057-A5.pdf	Mark G Ellis	Again, the responses vary. Not every company has replaced engines on existing equipment. Some members have purchased new equipment with Tier 4 engines, rather than retrofitting old equipment or engines. One member upgraded its Wagner loader fleet, Eimco 913 LHD fleet, and replaced forklifts, which contained Perkins engines, with Gehl forklifts. However, replacing engines is often not feasible (either due to the cost of installing new engines or because of configuration differences). Purchasing or leasing equipment with Tier 4 engines as older equipment retires is often more cost-effective but can still be quite expensive. One member estimated that replacing its existing fleet of equipment will cost tens of millions of dollars. Another indicated that the significant cost and time associated with obtaining Tier 4 equipment means it sometimes has to settle for Tier 3 drilling and bolting equipment. A further complication is that some Tier 4 engines are not supported by a dealer network in the company's area. This limits that company's choice of engines and its ability to source parts and technicians in its region. Other members have opted to replace existing engines. One company estimated its cost $72,000 to install a Tier 4 engine on a piece of its equipment, and received a price quote of $40,000 to install a Tier 4 engine on other equipment. Again, engineering or administrative controls, such as engine repowering, are more cost-effective means of reducing DPM.
C6	Engine replacement type (Tier 4, 4i)/cost	MSHA-2014-0031-0059-A4	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0059-A4.pdf	Celeste Monforton	MSHA has the data on its diesel inventory and should provide the up-to-date data to the industry (mine operators and miners.)
C6	Engine replacement type (Tier 4, 4i)/cost	MSHA-2014-0031-0063-A1	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0063-A1.pdf	Hunter Prillaman	Engine replacement is generally not feasible due to configuration differences and high costs. In addition, several OEMs have indicated that they are not interested in performing the engineering work that would be required to replace engines. Thus, typically lime operations switch to Tier 4 engines only when the entire piece of equipment is replaced. There can be a significant lead time to obtain Tier 4 equipment, and in some cases operators have found it necessary to accept new Tier 3 equipment as replacements. Furthermore, the cost of Tier 4 equipment is significantly higher.
C7	New equip Tier 4, 4i, used equip Tier 3, 4i, 4	MSHA-2014-0031-0057-A5	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0057-A5.pdf	Mark G Ellis	Examples of equipment that can be powered by Tier 4i or Tier 4 engines include: Wagner loaders, the Eimco 913 LHD, Gehl forklifts, CAT wheel loaders, CAT haul trucks, some track drills, JLG's, Bobcat forklifts, and CAT 980K loaders. At least one member noted that trucks, loaders, excavators, highway truck-based units, drills, bolters, and powder trucks often have Tier 4 engines. However, new heavy equipment is not equipped with Tier 4 engines, and most members stated that the overwhelming majority of their company fleets are equipped with Tier 3 engines.
C7	New equip Tier 4, 4i, used equip Tier 3, 4i, 4	MSHA-2014-0031-0059-A4	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0059-A4.pdf	Celeste Monforton	MSHA has the data on its diesel inventory and should provide the up-to-date data to the industry (mine operators and miners.)

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C7	New equip Tier 4, 4i, used equip Tier 3, 4i, 4	MSHA-2014-0031-0063-A1	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0063-A1.pdf	Hunter Prillaman	Much of the equipment in lime industry underground mines is gradually being replaced with Tier 4 equipment, although as noted above this is costly and can take an extended period of time. Equipment affected includes trucks, loaders, excavators, drills, bolters, and powder trucks, as well as smaller equipment such as gators, welders, and generators. Only a small portion of the relevant equipment in underground mines in the lime industry has been replaced with Tier 4 equipment to date.
C8	Integrated DPF on Tier 4, 4i engines	MSHA-2014-0031-0057-A5	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0057-A5.pdf	Mark G Ellis	Some Tier 4 engines used in underground mines are equipped with DPF systems, while other engines are not. One member noted that all of its Tier 4 engines have integrated systems and another indicated that all of its equipment with greater than 30 hp has DPF. At the other end of the spectrum, one member indicated that none of its equipment has DPF systems. The other companies fall within this range. For instance one company has several JLG's with Tier 4 engines and DPM filters, another has forklifts with Tier 4 engines and DPF technology, and another has highway-based Tier 4 units with DPF. Other specific examples of equipment that includes DPF are track drills, a CAT hauler truck, a CAT wheel loader, and a Komatsu wheel loader.
C8	Integrated DPF on Tier 4, 4i engines	MSHA-2014-0031-0059-A4	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0059-A4.pdf	Celeste Monforton	MSHA has the data on its diesel inventory and should provide the up-to-date data to the industry (mine operators and miners.)
C8	Integrated DPF on Tier 4, 4i engines	MSHA-2014-0031-0063-A1	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0063-A1.html	Hunter Prillaman	Many Tier 4 engines in use in the lime industry have integrated systems, but some meet emission requirements in other ways. For example, some Cat Tier 4i engines use engine fueling and control technology along with an oxidation catalyst muffler.
C9	Tier 4, 4i how long in use, cost	MSHA-2014-0031-0057-A5	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0057-A5.pdf	Mark G Ellis	IMA-NA's members adopted Tier 4i or Tier 4 engines at different times. The first members to install Tier 4 engines did so in 2009. Most members, however, installed Tier 4 engines or purchased equipment with Tier 4 engines about two years ago. One or two members first used Tier 4 engines even more recently. Heavy equipment with Tier 4 engines started coming online on or around 2012. The members either agree that maintaining the equipment imposes additional costs, or state that insufficient time has elapsed since employing the new engines to estimate additional costs. Only one member suggested that the increase in maintenance costs has been negligible. Some members noted that the service calls on equipment with Tier 4 engines are longer than equipment with older engines, and that they often have to order special parts with greater frequency for Tier 4 engines. Another member explained that the complexity of the systems, coupled with the need for a CAT technician to service the equipment, increases maintenance costs substantially. According to one member, a piece of equipment with a Tier 4 engine cost an additional $30k over a 2.5 year period.
C9	Tier 4, 4i how long in use, cost	MSHA-2014-0031-0059-A4	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0059-A4.pdf	Celeste Monforton	MSHA has the data on its diesel inventory and should provide the up-to-date data to the industry (mine operators and miners.)
C9	Tier 4, 4i how long in use, cost	MSHA-2014-0031-0063-A1	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0063-A1.html	Hunter Prillaman	Tier 4 engines on heavy equipment began to be used widely in the lime industry only in the last few years, so long-term service and maintenance costs are not yet clear. However, the systems are complex and require highly-trained technicians for service, so servicing costs are already significant. Some members have observed that service calls on equipment with the Tier 4i/Tier 4 engines are usually longer than on equipment with older engine types, and plants need to special order parts more frequently for these engines.
C10	equip %tage Tier 4, 4i enginers	MSHA-2014-0031-0042-A1	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0042-A1.docx	Gene Davis	a large majority of the underground fleet in Pennsylvania is made up of EPA tier II and Tier III engines, I know of no Tier IV engines currently being used in Pennsylvania.
C10	equip %tage Tier 4, 4i enginers	MSHA-2014-0031-0050-A1	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0050-A1.pdf	Robert McDonald	[In a Queensland mine] The bulk of the diesel fleet are front-end loaders, with the majority powered by Caterpillar 3126 engines, and a smaller number by Caterpillar 3306 engine or the newer Caterpillar C9 engines. Additionally, there are a number of PJB and Drift runner personnel transport vehicles which use Perkins 1104 and 1006 engines respectively.
C10	equip %tage Tier 4, 4i enginers	MSHA-2014-0031-0050-A1	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0050-A1.pdf	Robert McDonald	Where possible, vehicles with older engine technology are retired. Just one Tier 1 engine loader remains in service; the majority are Tier 2 while the newer loaders have electronically controlled Tier 3 engines. Tier 4 engines presently do not meet the intrinsically safe regulatory requirements.
C10	equip %tage Tier 4, 4i enginers	MSHA-2014-0031-0057-A5	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0057-A5.pdf	Mark G Ellis	IMA-NA's members do not operate underground coal mines.
C10	equip %tage Tier 4, 4i enginers	MSHA-2014-0031-0057-A5	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0057-A5.pdf	Mark G Ellis	IMA-NA's members do not operate underground coal mines.
C10	equip %tage Tier 4, 4i enginers	MSHA-2014-0031-0059-A4	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0059-A4.pdf	Celeste Monforton	MSHA has the data on its diesel inventory and should provide the up-to-date data to the industry (mine operators and miners.)
C10	equip %tage Tier 4, 4i enginers	MSHA-2014-0031-0063-A1	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0063-A1.html	Hunter Prillaman	Although this question appears to address coal mines, a minority of underground diesel equipment at lime operations is equipped with Tier 4i or Tier 4 engines.
D	Monitoring MNM Miners Exposures to DPM	MSHA-2014-0031-0050-A1	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0050-A1.pdf	Robert McDonald	A program of personal exposure monitoring is in place with measurement conducted using NIOSH method 5040, based on elemental carbon. The monitoring program is now conducted monthly to assist in the improvement program. All cases where exposure is found to exceed the current maximum requirement of 0.03 mg/m3 are investigated to identify and address potential sources of exposure and exposure situations.

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D	Monitoring MNM Miners Exposures to DPM	MSHA-2014-0031-0050-A1	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0050-A1.pdf	Robert McDonald	Exposure Monitoring A program of personal exposure monitoring is in place and measurement is conducted using NIOSH method 5040, based on elemental carbon. The implementation of the emission reduction program has reduced exposure to the point where the mean exposure of all SEGs is less than 0.05 mg/m3 expressed as EC and just two SEGs exceed 0.04 mg/m3. Using the Lands 95% UCL of the mean exposure, all SEGs have exposure less than 0.08 mg/m3 and 65% have exposure less than 0.05 mg/m3 . See Figure 4 below.
D	Monitoring MNM Miners Exposures to DPM	MSHA-2014-0031-0054-A1	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0054-A1.docx	Brooke Henderson	There are a few tools that can be used to identify when there is particulate matter present in the area. There is a National Institute for Occupational Safety and Health (NIOSH) has Method 5040 which provides acceptable ways of sampling and analyzing the diesel exhaust in the area. The different monitors used detect the elemental carbon through thermal optical refractory and the Black carbon through light absorbing characteristics. The problem with these methods is that these tests are not able to measure the diesel particulate matter in short term analysis; because of this the real time monitors are gaining more and more attention form NIOSH. The real time monitors are more accurate at detecting the diesel exhaust than the previously mentioned methods. The problem with the real time monitors is that the environmental changes affect the sensors in these systems. Changes in the humidity and temperature of the area cause for false readings. Studies have shown that real time monitors give good accurate reading within the first two hours but after that they start to falter (Ho Yu et al., 2015). The monitors are improving but there are still many bugs to fix and work through to make the spaces safe for the workers in the mines. The carbon can also be used to identify major gas releases based off of the particulate matter mass. Carbon has a more dense structure than many of the other substance found in diesel exhaust. Because of this weight it can easily be picked up by different monitors. Unfortunately they cannot tell us how many particles are being put out in the air but they can tell us the quantity. The more carbon that is detected the worse the breathing quality the miners will have and the higher the chance of lung cancer (Arhami et al., 2005). The weight of the carbon is a very common but imperfect way of measuring the release of diesel exhaust. .... In conclusion the diesel exhaust can be very harmful to the human respiratory tract and therefore it needs to monitored in our mines very closely. The monitors that we do have are on the right tack but they are not quite acceptable. New methods are proving to have good ways of detecting the exhaust but unfortunately we have no good ways of keeping them under control. The current statues in place are not currently working to keep our workers free of cancer and therefore they need to be changed and more closely monitored.
D	Monitoring MNM Miners Exposures to DPM	MSHA-2014-0031-0060	https://projects.erg.com/commresponse/docs/MSHA-2014-0031-0060.html	Dr. B Belle (Aus & S Africa)	In the absence of any Occupational Exposure Limit (OEL) for Diesel Particulate Matter (DPM) in SA and most of the mining world, the Mine Safety and Health Administration (USA) rule is currently being used as a benchmark for the ventilation engineering designs. Various countries (Australia and South Africa) have embarked on their respective journey in establishing the DPM measurements and developing exposure data for ventilation planning and regulatory purposes. The currently accepted DPM limits are based upon the belief that they are economically and technically feasible for the mines to reach and to some extent health based findings. What is known from the South African studies is that for underground platinum mines, a median TC/EC ratio of 1.8 with a range of 1.2 to 5.8 was observed. For South African coal mines, a median TC/EC ratio of 1.44 with a range of 1.25 to 2.13 was observed. While it is common practice in the USA to use the ratio of TC/EC for metal mines to be 1.3, the ratio found in local platinum mines is 2.2 and for coal mines, the ratio was 1.53 which is lower than Australian studies, i.e., 1.96. This Australian coal mine DPM TC/EC ratio of 1.96 do not hold true based on the latest statistics. In this context, it is valuable if the proposed MSHA DPM rule addresses the following: 1. Can the rule makers share or provide the latest USA DPM statistics on TC/EC ratios? Also, provide reasons for any deviation from the historic TC/EC ratio of 1.3 if such is the case? 2. While, the current US studies have developed appropriate error factors (currently 1.14 for TC and 1.2 for EC) for compliance determination, with an historic TC/EC ratio of 1.3, a table of error factors for different practical TC/EC ratios as obtained from the latest US DPM data would be beneficial. 3. While the DPM personal exposure measurements are carried out diligently in metal/non-metal mines, why the coal mines in USA do not carry out personal DPM exposure measurements? Can the rule makers provide at least the justifications for not carrying out personal DPM exposures in coal mines? How would establish DPM dose-response curves in future? 4. Can the latest rule also provide the technical information on deposition area standard used in the calculation of DPM concentration as in NOSH 5040 method, i.e., is the deposition area 8.55 cm2 or 8.40 cm2 or 8.04 cm2? This would assist in international harmonization of comparing the DPM results as well as establishing ventilation dilution factors in current and new mine ventilation system designs globally.
D	Monitoring MNM Miners Exposures to DPM	MSHA-2014-0031-0062-A13	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0062-A13.pdf	Paul Schulte	[Not excerpted. Contains only cover page for technical paper. Czerwinski (2007).]

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D	Monitoring MNM Miners Exposures to DPM	MSHA-2014-0031-0062-A2	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0062-A2.pdf	Paul Schulte	NIOSH study. [Noll and Birch]. Study abstract: Effects of Sampling Artifacts on Occupational Samples of Diesel Particulate Matter Total carbon (TC) is sometimes used to measure or characterize diesel particulate matter (DPM) in occupational settings such as underground mines. DPM samples are collected on quartz fiber filters. When using quartz fiber filters, adsorption of gas phase organic carbon (OC) has been reported, causing a positive bias in the particulate TC results (adsorption artifact). Most of the data on the sampling artifacts and corrections apply to environmental air sampling,wheresamples are collected at a much higher filter face velocity and the OC concentrations are generally much lower relative to occupational sampling. In this study, we investigated the effects of adsorption artifact on samples from occupational settings. Samples were collected with and without denuders to determine the amount of gas phase OC collected and the accuracy of certain corrections. In underground stone mines, the adsorption artifact was found to positively bias the particulate TC by greater than 20% for filter loadings below 25 µg/cm2 TC (8-h time weighted average) 262 µg/m3). The tandem filter correction reduced the effect of the artifact, as high as 60% of the TC value, to less than 11% for laboratory data. It also significantly reduced the effect of the artifact obtained for field samples.
D	Monitoring MNM Miners Exposures to DPM	MSHA-2014-0031-0062-A22	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0062-A22.pdf	Paul Schulte	[Not excerpted. Contains only the first page of an article reviewing in-use emissions testing with portable emissions measurement systems (PEMS). Vlachos (2014).]
D	Monitoring MNM Miners Exposures to DPM	MSHA-2014-0031-0062-A3	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0062-A3.pdf	Paul Schulte	NIOSH study. [Noll, Mischler et al.] Study title: Measuring diesel particulate matter in underground mines using submicron elemental carbon as a surrogate.
D	Monitoring MNM Miners Exposures to DPM	MSHA-2014-0031-0069-A6	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0069-A6.pdf	Edward Green	MSHA, in the current regulations, uses two different approaches to regulating exposure to diesel exhaust in (a) Metal/Non-Metal Mines (MNM) and (b) Coal Mines. For MNM mines, the regulations focus on the workplace environment and limiting exposure to Diesel Particulate Matter (DPM) to the Permissible Exposure Limit (PEL) that is specified as 160 µg Total Carbon per m3, averaged over 8 hours. It is noteworthy that the Total Carbon (TC) metric for DPM includes both Elemental Carbon (EC) and Organic Carbon (OC). This is different than the REC metric based only on EC estimated in DEMS and used in analyses by both the original investigators and independent analysts. In contrast, worker protection of coal miners from exposure to diesel exhaust focuses on indirect control of the airborne mine environment by setting emission limits (grams of Diesel Particulate Matter/hour) for diesel-powered equipment. This approach is dictated by the complex ambient atmospheric environment in coal mines with carbon present in the coal dust as well as carbon (both EC and OC) present in diesel exhaust particles and carbon emitted to the air from other sources. At the very least, in assessing its standards, the Companies ask MSHA to continue to be mindful of the difficulties coal operators face in accurately measuring the diesel exhaust exposure for their workforce.
D1	Alternative surrogates, LOD, interferences	MSHA-2014-0031-0057-A5	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0057-A5.pdf	Mark G Ellis	Most of IMA-NA's members have not evaluated the efficacy of alternative surrogates. However, one defect of using TC as a surrogate is that it cannot be measured in real time, which in turn delays the response time to correct elevated concentrations of DPM. CO may be a viable alternative. It is easier to detect and can be measured in real time. Organic byproducts, such as shale oil, can interfere with the detection of TC. At least one member noted that MSHA has sought comments on alternatives for TC for over 15 years, but has consistently settled on TC as the most efficacious surrogate. The problem with adopting a new surrogate, in part, is that we will have to compare the TC data with the new data, which will make it difficult to measure DPM levels over time and to measure our progress reducing DPM.

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D1	Alternative surrogates, LOD, interferences	MSHA-2014-0031-0062-A4	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0062-A4.pdf	Paul Schulte	NIOSH does not have sufficient data to recommend an alternative surrogate to the currently used combination of total carbon (TC) and elemental carbon (EC). A number of factors make sampling, analysis, and direct measurement of DPM in the occupational environment or in the tailpipe challenging. These factors include submicron size, relatively low-mass concentrations when compared to total particulates in the air, complex physical and chemical makeup, the dynamic nature of formation and transformation of DPM, interactions within the environment, potential interferences with other sources of aerosols, and a large number of physical and chemical processes that affect the formation and transformation of diesel aerosol particles [Bugarski et al. 2012b]. Thus, a detailed characterization of diesel aerosols often requires multiple measurements using various sampling techniques and instruments, elaborate sampling strategies, and careful interpretation of the results. Currently, TC and EC are both used as surrogates to monitor exposure of underground metal and nonmetal miners to DPM [71 Fed. Reg. 28924]. This approach has a number of deficiencies, but also some major advantages. The results of the TC concentration monitoring are prone to the generation of artifacts due to issues related to monitoring the organic fraction of TC. The positive and negative artifacts are related to potential sampling interference, adsorption of the gas-phase volatile and semi-volatile species on the quartz filter media, desorption of volatile droplets or particle-bound volatile material from the filter media, and filter media handling [Bugarski et al. 2012b]. Mechanically generated dust, cigarette smoke, welding fumes, oil mist, and gas phase organics emitted by diesel engines can interfere with the TC measurements. The current practices to minimize the effects of some of these interferences are: (1) sampling with a 0.8-11m impactor (DPM cassette, SKC 225-317) to minimize the contribution of mechanically generated dust to DPM samples; (2) preventing sampling in the presence of cigarette smoking, welding, and drilling; and (3) applying dynamic blank correction to correct for adsorption of gas-phase volatile and semi-volatile species on the quartz filter media [Noll et al. 2005; Noll et al. 2006; Noll and Birch 2008]. Using EC as a supplemental surrogate could potentially ensure compliance with a permissible exposure limit (PEL) when direct measurements of TC are not producing accurate results due to organic carbon (OC) related errors. However, the uncertainties associated with establishing a mine-specific TC/EC ratio [71 Fed. Reg. 28924] might contribute to the overall uncertainty of the results. An approach that involves using EC as a stand-alone surrogate to DPM would potentially eliminate some ofthe sampling and analytical uncertainties, but might not be equally protective to miner's health as the TC/EC approach. In most U.S. underground mines, EC is selective and unique to DPM and makes up a significant portion of the DPM mass [Birch and Cary 1996a; Birch and Cary 199Gb; Birch et al. 1999; Birch 2002; NIOSH 2016; Noll et al. 2006]. For the few mines that have small quantities of EC in the dust, the submicron particle-size classifier in the SKC DPM cassette would minimize this interference because dust size is typically greater than 1 micron [Noll et al. 2006; Noll et al. 2005]. Cigarette smoke and oil mist should not significantly interfere with the EC analysis [Noll et al. 2006]. Thus, the uncertainty in EC measurement, based on thermo-optical carbon analysis [NIOSH 2016], should be reduced relative to TC because potential OC interferences are minimized. And, with an EC surrogate, the uncertainty associated with establishing a mine-specific TC/EC ratio would be eliminated. However, the relationship between the EC and OC or TC depends on engine type, engine operating conditions, fuel type, and exhaust aftertreatment type, and has been recognized as a possible drawback to use of an EC
D1	Alternative surrogates, LOD, interferences	MSHA-2014-0031-0063-A1	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0063-A1.html	Hunter Prillaman	Lime companies have noted that TC cannot be measured in real time, which delays the response time to correct any elevated concentrations. MSHA should consider other surrogates, including carbon monoxide (CO). This consideration should include a careful analysis of how other activities in the mine could affect levels of potential surrogates.
D2	Alternative surrogates, adv/disadv/cost	MSHA-2014-0031-0057-A5	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0057-A5.pdf	Mark G Ellis	Most members did not feel equipped to answer this question and refer to MSHA to the response to Question 24.
D2	Alternative surrogates, adv/disadv/cost	MSHA-2014-0031-0062-A26	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0062-A26.pdf	Paul Schulte	[Contains only the first page of a study reviewing method for monitoring occupational exposure to particulate diesel exhaust. Birch (1996).] Diesel exhaust has been classified a probable human carcinogen, and the National Institute for Occupational Safety and Health (NIOSH) has recommended that employers reduce workers' exposures. Because diesel exhaust is a chemically complex mixture containing thousands of compounds, some measure of exposure must be selected. Previously used methods involving gravimetry or analysis of the soluble organic fraction of diesel soot lack adequate sensitivity and selectivity for low-level determination of particulate diesel exhaust; a new analytical approach was therefore needed. In this paper, results of investigation of a thermal-optical technique for the analysis of the carbonaceous fraction of particulate diesel exhaust are discussed. With this technique, speciation of organic and elemental carbon is accomplished through temperature and atmosphere control and by an optical feature that corrects for pyrolytically generated carbon, or 'char,' which is formed during the analysis of some materials. The thermal-optical method was selected because the instrument has desirable design features not present in other carbon analysers. Although various carbon types are determined by the method, elemental carbon is the superior marker of diesel particulate matter because elemental carbon constitutes a large fraction of the particulate mass, it can be quantified at low levels and its only significant source in most workplaces is the diesel engine. Exposure-related issues and sampling methods for particulate diesel exhaust also are discussed.

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D2	Alternative surrogates, adv/disadv/cost	MSHA-2014-0031-0062-A4	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0062-A4.pdf	Paul Schulte	If EC were used in place of TC and EC as a DPM surrogate, the number of samples and analyses needed to determine exposure would be reduced. Further, the analysis of area samples to derive a conversion factor for converting the EC results for personal samples to TC equivalents would not be necessary. Additionally, when using EC, there would be no need to analyze a dynamic blank (i.e., a bottom filter in cassette with tandem filters) to correct for adsorbed OC-an approach which MSHA employs for at least the area samples. However, using EC as a surrogate for DPM has several potential limitations, including the dependence of the relationship between the EC and TC/DPM on engine type, engine operating conditions, fuel type, and exhaust aftertreatment [66 Fed. Reg. 27864; Bugarski et al. 2012b; Khalek et al. 2011], and the absence of any information on the toxicologically and health-pertinent organic fractions of DPM [Totlandsdal et al. 2012; Turner et al. 2015]. As knowledge of the health effects of exposure to diesel emissions becomes refined, it may be important to introduce other metrics to monitor exposure. Particle number, surface area, or size distribution may provide better monitoring, hazard assessment, and risk management related to the exposure to diesel aerosols emitted from contemporary engines and control technologies, particularly those with high mass-specific surface areas. When these technologies are implemented, the assessment of the DPM exposure of underground miners may not be comprehensive ifthe monitoring is limited to TC and EC [Cauda et al. 2012]. In particular, the current practice of monitoring exposure of miners in U.S. underground metal/nonmetal mines [71 Fed. Reg. 28924] to nano and ultrafine DPM aerosols in terms of TC and EC mass concentrations might not be sufficient to adequately assess exposures to DPM when changes occur in the size of diesel aerosols [Bugarski et al. 2009; Bugarski et al. 2010], concentrations of nucleation mode aerosols [Bugarski et al. 2009; Herner et al. 2011], and in chemical composition [Bugarski et al. 2010; Khalek et al. 2011; Herner et al. 2011] after the introduction of contemporary control technologies and strategies. These types of monitoring strategies still need further development and validation.
D2	Alternative surrogates, adv/disadv/cost	MSHA-2014-0031-0063-A1	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0063-A1.html	Hunter Prillaman	MSHA should consider other surrogates, including CO, focusing on the technical challenges and benefits of each method.
D3	Advances in exposure assessment to reduce PEL	MSHA-2014-0031-0045-A1	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0045-A1.pdf	Pierre Mousset Jones	Both the 5040 method and the NIOSH continuous DPM sampler are filter based which have inherent problems with accuracy and, in particular, maintainability with the continuous sampler as the filter gets progressively loaded with DPM. A proven maintenance free continuous DPM sampler based on acoustic and laser technology has been available for some time and has been used extensively for DPM and carbon particulate measurements on the surface in cities, around major forest fires, and for diesel vehicle emission measurements. This technology has been tested in an underground mine and the results can be seen in the attached paper. It is suggested that more use be made of this DPM sampling technology in both Coal and Metal/Non-metal underground mines and further development of the instrument be undertaken for a smaller, more robust, and more portable unit to be used by mine supervisors and miners.
D3	Advances in exposure assessment to reduce PEL	MSHA-2014-0031-0046-A1	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0046-A1.pdf	Pierre Mousset Jones	study manuscript. [Arnott et al] ABSTRACT: This paper presents real time photoacoustic measurements of diesel-soot black-carbon (BC or EC) and Dusttrak nephelometer total carbon (TC) concentrations in a Nevada gold mine. Comparisons with time integrated filter-based measurements of EC and TC accomplished using the NIOSH 5040 method were found to be 50% smaller than the integrated real time measurements. This work was initiated primarily as a demonstration project for the usefulness of photoacoustic instruments in measuring BC in the mine environment. Real time black carbon measurements are very useful for determining miner exposure, for providing feedback in mine ventilation systems, and for quantifying machine specific emission rates to understand the operating conditions for specific machines that produce greatest black carbon concentrations. This paper reports real time measurements of DPM from a loaded and empty hauler as it is operated in a drift with a 12% grade. The photoacoustic instruments were demonstrated to be satisfactory for BC measurements in the mine environment. 5 Summary and Conclusion Photoacoustic EC measurements are well defined and are known to be more accurate than TC measurements by optical methods such as the Dusttrak. It has been shown that real time measurements of TC in DPM by the Dusttrak instrument are about 50% larger than those obtained by the NIOSH 5040 method, and a similar result was found for the photoacoustic EC measurements when compared with NIOSH EC. Other studies have shown excellent correlation of EC measurements by these methods, even though the amount of EC and TC was different. Therefore, it is recommended that in-mine analysis of real time EC and TC measurement using photoacoustic and Dusttrak instruments be calibrated to provide the same results as an equivalent EC and TC measurement by the NIOSH 5040 method for compliance applications. Figures 4 and 5 demonstrate that the photoacoustic instruments can handle the DPM EC loads typical in mines. MSHA regulations for miner workplace health are likely to be stated both in terms of TC and equivalent EC values. The mining industry has a requirement to comply with MSHA regulations, and could deploy photoacoustic instruments for EC measurements.
D3	Advances in exposure assessment to reduce PEL	MSHA-2014-0031-0057-A5	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0057-A5.pdf	Mark G Ellis	Continuous monitoring systems can be used to measure incomplete combustion gases, but the devices are unreliable and not suited to industrial environments. For instance, an article in the Journal of Occupational and Environmental Hygiene concluded that monitored results deviate up to 20% from NIOSH Method 5040 results.1 Another possible tool is diesel particulate monitors, which can monitor elemental carbon in real time. The monitors employ a particle capture and light transmission to discern elemental carbon values, which in turn correlate with NIOSH 5040 test results. While the monitors assist in evaluating adjustments to ventilation, they do not measure TC levels.

Comment Code	Comment Code Description	DCN	Link to Comment	Commenter Name	Comment
D3	Advances in exposure assessment to reduce PEL	MSHA-2014-0031-0062-A4	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0062-A4.pdf	Paul Schulte	If EC is used in place of currently used TC and EC as a DPM surrogate, the NIOSH Analytical Method 5040 would be adequate to assess DPM concentrations at compliance levels (and much lower) in metal/nonmetal (MNM) and coal underground mines. NIOSH 5040 limit of detection (LOD) for EC is about 2.0 ~g/m3 for a 960-L air sample collected on a 37-mm filter, with a 1.5-cm2 punch from the filter analyzed. If a lower LOD is desired, a larger sample volume and/or a 25-mm filter may be used. If a 1920-L sample is collected on a 25-mm filter, an LOD of about 1.0 ~g/m3 can be achieved [NIOSH 2016]. Increasing the flow rate would require development of a new size selector that offers a similar cut point to the SKC impactor at this increased flow. To permit the use of the SKC DPM cassette, operated at 1.71iter per minute (lpm) sampling flow rate, the LOD could be reduced by adapting the cassette to accommodate a 25-mm filter instead of the currently used 37-mm filter. The disadvantage of lowering the LOD by using a smaller collection area is that it also reduces the dynamic range (i.e., lowers the upper concentration limit) because the filter will be overloaded at high DPM concentrations, causing variable flow or leakage. A recent NIOSH study (Cauda et al. [2014]) shows that the performance of the DPM cassette (SKC 225-317) is altered during prolonged sampling in dusty environments. The penetration efficiency of the DPM cassette was found to change with exposure of the sampler to respirable dust particles. Particle penetration efficiency shifts towards smaller sizes with the accumulation of dust particles inside the size separator. This shift can potentially generate negative bias in sampling DPM in the mining environment. A sharp cut cyclone whose penetration efficiency is not affected by respirable dust particles may provide a solution to this problem [Cauda et al. 2014]. NIOSH has developed a near real-time EC monitor [Noll et al. 2013; Noll and Janisko 2013; Noll et al. 2014]. Real-time, on-site measurements with this monitor provide timely information that can be used as an engineering tool to identify factors contributing to overexposures, characterize exposure patterns (e.g., high transient exposures), and allow for quick deployment of engineering controls. The monitor measures the EC concentration via laser extinction.
D3	Advances in exposure assessment to reduce PEL	MSHA-2014-0031-0063-A1	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0063-A1.html	Hunter Prillaman	NLA is concerned about the reliability of continuous monitoring systems for incomplete combustion gases, especially when used in the mine environment. An evaluation of real-time monitoring systems published in the Journal of Occupational and Environmental Hygiene found the monitored results could deviate up to 20% from the NIOSH Method 5040 results. MSHA should carefully evaluate sampling methods before using them to support a modified exposure limit.
E	MNM Miners Personal Exposure Limit (PEL)	MSHA-2014-0031-0050-A1	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0050-A1.pdf	Robert McDonald	In 2005, BHP Billiton's internal OEL for diesel exhaust was set at 0.1 mg/m3 measured as elemental carbon (EC) according to NIOSH Method 5040. In 2016, BHP Billiton introduced a requirement to manage exposures to as low as technically feasible with an interim requirement of 0.03 mg/m3, following an independent expert review of the most recent science underpinning diesel exhaust exposure and lung cancer risk by the Institute of Occupational Medicine (Summary DEP Report - separate attachment 1)2 . For some workers this will require the use of personal protective equipment while we identify and implement additional controls to reduce exposure levels.
E	MNM Miners Personal Exposure Limit (PEL)	MSHA-2014-0031-0050-A1	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0050-A1.pdf	Robert McDonald	The overall finding of these studies is that average exposure can be reduced to less than 0.03 mg/m3 in the vast majority of SEGs (maximum of 0.05 mg/m3) or to less than 0.05 mg/m3 (for most SEGS [similar exposure groups], maximum of 0.08 mg/m3) where the Lands 95% UCL (our method for comparing personal exposure to our OEL) is used as the measure of exposure assessment. These levels can largely be achieved using existing technology so long as every effort is made to ensure engines burn the cleanest ultra-low sulphur fuel, are well maintained with a focus on emission reduction, and appropriate exhaust filtering technology is employed.
E	MNM Miners Personal Exposure Limit (PEL)	MSHA-2014-0031-0050-A1	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0050-A1.pdf	Robert McDonald	The implementation of the emission reduction program has reduced exposure to the point where no SEG has a mean exposure exceeding 0.03 mg/m3 expressed as EC. Using the Lands 95% UCL of the mean exposure just one SEGs has exposure exceeding 0.05 mg/m3 .
E1	Existing controls - most effective	MSHA-2014-0031-0055-A1	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0055-A1.docx	Catherine Doherty	I believe 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.
E1	Existing controls - most effective	MSHA-2014-0031-0055-A1	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0055-A1.docx	Catherine Doherty	There are many ways to control exposure in underground mines in order to stay in compliance with this limit but better ventilation and the reduction of diesel particulate emissions from diesel-powered equipment is most commonly thought of as the most effective method to do this (Bugarski et al., 2010). Making for better ventilation in mines is simple but not effective enough, so the focus must be on how to reduce the particulate emissions from diesel-powered machinery. As mentioned before, the composition of the fumes emitted by a diesel-powered engine depends on the fuel source (Cohen, Borak, Hall, Sirianni & Chemerynski, 2002), so to reduce the emissions of toxic gases, the fuel source can be changed from petroleum based diesel fuel to biodiesel fuel (Bugarski et al., 2010).
E1	Existing controls - most effective	MSHA-2014-0031-0055-A1	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0055-A1.docx	Catherine Doherty	Biodiesel is produced by a reaction of a renewable lipid source, such as vegetable oil or animal fat, with methanol or ethanol under heat; this process is called transesterification (Bowman, Hilligoss, Rasmussen, & Thomas, 2006). This chemical reaction yields glycerin and biodiesel which is also known as alkyl ester (Howell & Weber, 1996). The discovery of this new fuel came about as a result of a search for an alternative to petroleum based fuels because of a fear of fossil fuel shortages since fossil fuels are a non-renewable resource (Pinto et al., 2005). This alternative and renewable source has been registered as a pure fuel with the Environmental Protection Agency and is a legal fuel for commerce (Howell & Weber, 1996). Although the biodiesel industry focuses primarily on underground mining because of the need for methods to decrease the occupational exposure to underground mine workers of diesel particulate matter, biodiesel can be used to replace diesel in all diesel powered equipment or vehicles in all occupational work sites or even just for commercial use (“Mining,” n.d.). An example of its commercial use is Willie Nelson taking advantage of this environmentally friendly fuel alternative and making it available for others as well.

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E1	Existing controls - most effective	MSHA-2014-0031-0055-A1	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0055-A1.docx	Catherine Doherty	Using biodiesel in place of regular diesel was found to greatly reduce emissions of diesel particulate matter (Bugarski et al., 2010). It also eliminates the thick black exhaust, or carbon soot, that is produced by petro-diesel fuels which allows for more visibility in underground work sites such as underground mines (Bowman, Hilligoss, Rasmussen, & Thomas, 2006). Although biodiesel is sometimes criticized to be cost prohibitive, the advantages weigh out this disadvantage greatly. If using it in it's pure form is too expensive it can be used as an additive and be blended with petroleum based fuels. Mixing the two isn't as effective as using biodiesel in its pure form but levels of particulate output will still be reduced. Biodiesels reduction of particulate matter has been proved when testing in the field as well as in the lab. Its use has been recorded to reduce particulate matter emission to 50% when using its pure form as compared to diesel fuel, so depending on the proportions of a biodiesel and petro-diesel mixture, the engine type, and filtration systems, one could calculate the percentage of diesel particulate matter being emitted from the engine being used. Also, biodiesel can be used in new or already existing technology which means new technology doesn't need to be employed or invested in to take advantage of this alternative. Blended or in it's pure form, biodiesel works very similarly to petroleum based diesel fuels when operating an already existing diesel or compression ignition engine technology. It's use in existing technology will not create a hindrance on the performance of the equipment.
E1	Existing controls - most effective	MSHA-2014-0031-0055-A1	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0055-A1.docx	Catherine Doherty	Biodiesel works great in new equipment technologies as well because it reduces the emissions of solid carbon component of diesel particulate matter, while the sulfate component is eliminated, and the soluble component stays at the same level or sometimes increases. Because catalysts decrease the output of the soluble component of diesel particulate, biodiesel is a quite compatible match for this technology. It also can promote longer engine lives for engines that recirculate engine exhaust because of the lower concentration of carbon (Howell & Weber, 1996).
E1	Existing controls - most effective	MSHA-2014-0031-0056-A1	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0056-A1.pdf	Donald Hoppert	Technological advances in diesel engine design and emission controls, compelled in part by regulatory changes by the U.S. Environmental Protection Agency, suggest that more protective standards for mine workers are feasible.
E1	Existing controls - most effective	MSHA-2014-0031-0056-A1	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0056-A1.pdf	Donald Hoppert	The regulations adopted by MSHA in 2001 were crucial in reducing mine workers' exposure to diesel particulate matter. However, the regulations were based on the technological feasibility that existed at that time. In the 15 years since those rules were issued, significant technological advances have been made with respect to diesel engine performance and emission controls. Adopting the latest in technological that are available, to the extent they are feasible, is necessary in the absence of a threshold limit value on DPM. We urge MSHA to examine these advances and act on the opportunity to better protect mine workers from the risk of cancer and other adverse health effects. We commend MSHA for examining the adequacy of its regulations on diesel exhaust and appreciate the opportunity to offer our comments.
E1	Existing controls - most effective	MSHA-2014-0031-0057-A5	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0057-A5.pdf	Mark G Ellis	The responses from IMA-NA's members again varied. Some members identified specific tools they have used to reduce DPM exposure, while others described the suite of methods they use to reduce exposure at their mines. For instance, at least one member suggested that dry filtration systems, which are applicable to all mines, are most effective, while another described its use of a cab with HEPA filtration to reduce the DPM levels from a JS500 loader. Increased air ventilation was also consistently identified as an effective means of reducing DPM exposure since it dilutes the total concentration of carbon. Administrative controls, such as ensuring that employees are not working downwind of operations or spreading equipment out in a mine rather than concentrating equipment in one area, can also reduce concerns about exposure. Other tools that were identified include biodiesel, the use of fuel additives, semiannual testing of engines to ensure proper functioning, and reducing hand scaling. Importantly, there is no single tool that was consistently identified as "most effective," which is consistent with MSHA's "DPM Toolbox." 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, and enclosed cabs. Diesel engine maintenance, work practices and training, and fleet management were also identified as methods of reducing DPM exposure. Whether a specific tool is necessary should be evaluated on a case-by-case basis.
E1	Existing controls - most effective	MSHA-2014-0031-0062-A21	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0062-A21.pdf	Paul Schulte	[Not excerpted. Contains only the first page of a study on how the composition of fuel effects combustion products. Schonbom (2009).]
E1	Existing controls - most effective	MSHA-2014-0031-0062-A4	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0062-A4.pdf	Paul Schulte	Numerous controls have been implemented effectively to reduce exposures since 2006 and have been thoroughly studied by NIOSH and other organizations, as detailed below. • Deploying DOCs: DOCs have been widely deployed on underground mining vehicles to control CO and hydrocarbon (HC) emissions [Bugarski et al. 2015]. DOCs typically do not affect NOx emissions, but might adversely affect N02 emissions [Stachulak and Gangal 2013; Bugarski et al. 2015]. However, 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 [Bugarski et al. 2010]. 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 ofthe exhaust [Shah et al. 2007].
E1	Existing controls - most effective	MSHA-2014-0031-0062-A4	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0062-A4.pdf	Paul Schulte	Using DPF and DFE systems: DPF systems, certified and/or verified by a number of organizations [MSHA 2015; FOEN 2016], 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 [Stachulak et al. 2005; McGinn et al. 2004], short-term studies [NIOSH 2006a,b; Bugarski et al. 2009; Bugarski et al. 2012a], and laboratory studies [Bugarski et al. 2013; Bugarski et al. 2016a]. The evaluated DPFs removed, in the majority oftest 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) [MSHA 2016a] to meet 30 CFR 72.502, are effectively being used in underground coal mines in the U.S.

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E1	Existing controls - most effective	MSHA-2014-0031-0062-A4	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0062-A4.pdf	Paul Schulte	Implementing pDPFs or FTFs: Partial-flow DPFs (pDPFs) or flow-through filters (FTFs) are currently used in a few applications in U.S. underground mines. These 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 [Mayer et al. 2009b; Heikkila et al. 2009]. An on-road test showed substantial fluctuations in performance of pDPFs/FTFs [Mayer et al. 2009b]. In practice, due to the dynamics ofthe filtration, regeneration, and potential for sudden release of trapped DPM, it is very difficult to reproduce data and produce reliable estimates of filter efficiency.
E1	Existing controls - most effective	MSHA-2014-0031-0062-A4	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0062-A4.pdf	Paul Schulte	Changing Fuel Supply from USLD to FAME and/or HVORD: 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 metal and nonmetal mine operators in the U.S. to be a viable method for controlling DPM emissions and complying with current MSHA regulations [30 CFR 57.5060]. 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 [Graboski and McCormick 1998]. When compared to low sulfur and ultralow sulfur petroleum diesels (LSD and ULSD), FAME biodiesels reduce emissions oftotal DPM and nonvolatile fractions of DPM [Bugarski et al. 2010] and, under certain engine operating conditions, can increase the particlebound volatile organic fraction of DPM [Stackpole 2009; Bugarski et al. 2010]. In-use studies have shown the potential of neat soy methyl ester (SME) FAME [Bugarski et al. 2010] and SME biodiesel blends [NIOSH 2006a,b; Bugarski et al. 2010; Bugarski et al. 2014] 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 [Schonborn et al. 2009; Bugarski et al. 2010]. Further, when compared to those emissions generated by combustion of ULSD, FAME biodiesel aerosols were found to have higher toxicity [Yanamala et al. 2013] and to cause more abnormalities in male mice reproductive systems [Kisin et al. 2014]. Recently, some underground operations in the U.S. 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 [Stevanovic et al. 2013; Westphal et al. 2013; Kim et al. 2014; Bugarski et al. 201Gb]. When compared with FAME biodiesel fuels, HVORD produces lower NOx and higher CO, total hydrocarbons, and PM mass and number emissions [Westphal et al. 2013; Kim et al. 2014; Bugarski et al. 201Gb]. Finally, HVORD has the potential to adversely affect N02 emissions from naturally aspirated engines equipped with certain types of DOCs [Bugarski et al. 201Gb].
E1	Existing controls - most effective	MSHA-2014-0031-0062-A4	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0062-A4.pdf	Paul Schulte	• Using Environmental Cabins with Pressurization and Filtration Systems: Enclosing operators in environmental cabs with pressurization and filtration systems was found to help some parts of the underground mining industry in efforts to reduce the exposure of workers to DPM [Noll et al. 2014]. 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 filtration elements used in the filtration systems of underground mining environmental cabins in the removal of diesel aerosols (EC and TC mass) has been assessed in both the NIOSH laboratory and the field [Noll et al. 2014]. Finally, two types of minimum efficiency reporting value (MERV) lG filters were found to be 94% and 98% effective in removing diesel aerosols. Two types of high efficiency particulate air (HEPA) filters removed over 99% of diesel aerosols. With a relatively low cost and good efficiency, MERV 1G filters were found to be a viable alternative to substantially more expensive and flow-restrictive HEPA filters [Noll et al. 2014].
E1	Existing controls - most effective	MSHA-2014-0031-0062-A4	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0062-A4.pdf	Paul Schulte	Treating Crankcase Emissions: Crankcase emissions have proven to be a large contributor to overall particulate emissions from older diesel engines [Hill et al. 2005]. 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. If crankcase emissions are not treated, blowby 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 [Jaaskelainen 2009]. This issue is addressed by selected regulations promulgated by the U.S. EPA [40 CFR 1039.115] and the EU Commission [EUCD 2012]. As the regulations note, crankcase emissions from HD and LD 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.
E1	Existing controls - most effective	MSHA-2014-0031-0063-A1	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0063-A1.html	Hunter Prillaman	NLA members have found that a combination of approaches has been most effective 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).

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E2	Challenges/costs of reducing the PEL	MSHA-2014-0031-0057-A5	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0057-A5.pdf	Mark G Ellis	Reducing DPM to comply with existing limits has been costly. Reducing the DPM exposure limit further would be very costly, and particularly harmful to smaller companies that do not have substantial resources. IMA-NA's members are already competing with off-shore producers for share in the export market. Increasing operating costs (one company estimated that reducing the current DPM standard would cost millions of dollars) would further harm IMA-NA's members' competitiveness. IMA-NA's members are in agreement that compliance with a lower standard would require them to replace existing equipment, because most companies have already adopted the basic administrative measures and ventilation improvements that can reduce exposure to DPM to below the current standard on a consistent basis. [Companies are also constrained by the availability of existing technology. For instance, installing water scrubber systems on all diesel equipment might reduce DPM exposure, but it would be incredibly costly and water scrubber systems are not currently available for many of the machines used in underground mines.] At a minimum, therefore, a lower standard would effectively mandate full-fleet adoption of Tier 4 engines. However, Tier 4 engines are not available for much of the equipment used in underground mines. Moreover, requiring such equipment would entail legal changes to equipment permissibility regulations and engine design. It is also not clear that a lower DPM standard is needed or that a lower standard would remedy defects in the existing system. MSHA's sampling between 2006 and 2015 is incomplete and does not provide a basis for a lower DPM standard. Industry does not even know the size of the testing data set or the breadth of the MNM industry included in the study. Further, DPM testing only shows a snapshot in time of DPM exposure, it does not show median or average DPM exposure over time, so MSHA does not have a reliable means of evaluating whether a new standard is required. Lowering the standard would not remediate this problem.
E2	Challenges/costs of reducing the PEL	MSHA-2014-0031-0063-A1	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0063-A1.html	Hunter Prillaman	First, it is important for MSHA to understand the range of current exposures, and not just the average. There may be mines for which reductions would be much more difficult than for other mines. Much of the challenge lies with the difficulty of obtaining replacement equipment with lower emissions. Tier 4 engines are simply not available for all the equipment utilized in underground mining. In addition, it will take time to adapt after the equipment is available because mines would not typically replace all their equipment at once, because of the enormous capital expense of doing so. Furthermore, 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. Several challenges to compliance with the current standard could be even more difficult with a more stringent standard. For example, 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. A more restrictive limit without the option of applying administrative controls would create an even greater challenge. Similarly, the current compliance monitoring method provides only a snapshot in time. It does not allow for standard deviation with the set of actual DPM values, nor does it provide the median or average DPM value over time. As such, the method provides only a partial picture of the true DPM exposure for miners at any given mine. These challenges would be even more acute with a more stringent DPM standard. Finally, many changes (such as to ventilation and work practices) have already been made at underground mines, making it difficult to find additional sources of reductions, at least until Tier 4 equipment can be deployed more widely.
F	Other Information	MSHA-2014-0031-0069-A1	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0069-A1.pdf	Edward Green	The RFI ... set out ... a description of some recent research with regards to these health effects.... MSHA has not identified other recent key scientific literature.... The research cited by MSHA simply does not deal with underground coal mines... in light of (1) the enormous amount of ventilated air, mandated by federal and state laws in all underground coal mines, which dilutes and sweeps diesel exhaust away from underground coal miners nearby diesel-powered engines and (2) the fact that the carbon content of diesel exhaust cannot be accurately measured in underground coal mines because coal itself is virtually pure carbon.... The Companies [Murray Energy, its trade association the Bituminous Coal Operators Association and Interwest Mining Company] firmly believe that the current MSHA regulations regarding diesel exhaust in underground coal mines are so protective of miners that, categorically, there is no need to change them.... The Companies have heard that MSHA has received other pleas urging the revision of the current diesel rules.... [we] intend to file a Freedom of Information Act (FOIA) request with the agency to obtain these and other relevant communications and records.... The Companies are firmly of the view that new regulations simply are neither necessary nor feasible.... The existing fleets provide superb protection for the Companies miners, such that new regulations are not necessary. Spreadsheets of the Companies diesel-powered fleets are attached. Fundamentally, therefore, the Companies want to state categorically that they believe the current MSHA diesel-exhaust related rules are more than amply protective of the health of their employees. There is no need to engage in a new rulemaking on this issue for underground coal mines. Having said that, the Companies are providing MSHA with these comments in good faith; and are more than happy to participate as partners in the incipient NIOSH-MSHA Diesel Exhaust Health Effects Partnership.

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F1	Other information	MSHA-2014-0031-0040	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0040.html	Thomas Bayne	The increase of ventilation is also a control that will help advance the atmosphere in mining. Without engineering controls to remove the DPM from the work area, a buildup of particles will eventually create a health hazard. The increase of air monitoring devices calibrated at regular intervals will assist in creating ventilation patterns that move the largest concentrations of air pollutants. Air will travel the path of least resistance and using engineering techniques to develop flow patterns that maximize the employees' air quality are essential to safety. Underground mines that have sufficient ventilation will benefit employees in multiple areas such as productivity and morale.
F1	Other information	MSHA-2014-0031-0040	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0040.html	Thomas Bayne	The importance of including wording in the regulation that allows for improvements to be made without having to endure the entire process for a formal rule change is important. This could be accomplished thru a general duty clause and enforced thru worksite inspections. The desired outcome would be the emphasis placed on employee health and air quality with the employers having a total understanding of their responsibilities.
F1	Other information	MSHA-2014-0031-0050-A1	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0050-A1.pdf	Robert McDonald	The Broadmeadow mine manages the number of diesel-powered plant into ventilation splits by diesel-tag-boards. The regular review of tag board allocation and their placement is required to ensure compliance as the mine develops; this ensures optimum placement and setting of diesel-tag boards to improve DPM dilution efficiency. Further controls are applied through integrated planning detailing vehicle allocations in the panels, and job setup with consideration of vehicle exhaust to reduce exposure. Broadmeadow mine UG machines are fitted with over speed protection to prevent over revving however, they do not have a protection device for limiting idling. This is presently dependent on operator behaviour, which creates an opportunity for improvement through culture and compliance. The machines are tested every 28 days to ensure the maximum allowable revs are within OEM specifications.
F1	Other information	MSHA-2014-0031-0050-A1	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0050-A1.pdf	Robert McDonald	Diesel Exhaust Fluid Addition This fluid is a urea solution and is added to the raw exhaust. The aim of the product is to allow an over stoichiometric fuel mixture to be used. While this results in a cleaner burn, nitrogen oxides formation is increased. The urea solution converts the nitrogen oxides to nitrogen and water.
F1	Other information	MSHA-2014-0031-0055-A1	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0055-A1.docx	Catherine Doherty	Diesel particulate matter is the component of this exhaust that is particularly dangerous because it is made of tiny particles that when inhaled, will settle and deposit in the lower part of the lung. The exhaust can also include carbon monoxide and dioxide, sulphur dioxide, nitrogen oxides, and aldehydes including benzene, formaldehyde, and polycyclic aromatic hydrocarbons ("ECLOSH: Diesel exhaust," 2002), but the composition ultimately depends on the type of engine that is employing the diesel fuel, the environmental conditions, and fuel source (Cohen, Borak, Hall, Sirianni & Chemerynski, 2002).
F1	Other information	MSHA-2014-0031-0057-A1	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0057-A1.pdf	Mark G Ellis	Exhaust filters and alternative fuels such as biofuels were only emerging technologies in 2001, and it took several years for all stakeholders to gain experience, through trial and error, until parties gained confidence in their use. Thus, the Task Force is very pleased to see that, based on MSHA's analysis of its own inspectors' sampling from 2006 to 2015, the average DPM exposures of MNM underground miners have decreased by 57 percent....
F1	Other information	MSHA-2014-0031-0057-A17	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0057-A17.pdf	Mark G Ellis	We make use of diesel-powered equipment at Westvaco to augment our extensive use of electric-powered machinery. Electrical-powered equipment is used to mine the trona ore at what are called faces, transport it at teh mine horizon ver miles via conveyors to central shafts, which are up to 1600 feet in depth, and then hoist the ore to the surface for processing. Most importantly, all of our ventilation equipment is electrically powered. Our mine is highly ventilated since it is a "gassy" mine with potential for build-up of methane.... When and where we use diesel-powered equipment depends on several factors, including the tasks at hand, engine efficiency, and horsepower needs. Diesel powered equipment is used primarily to transport personnel and material from the bottom of the shafts to the mine's working faces and in support operations. The remainder of this letter is a critique of the Health Effects Institute process for engaging stakeholders in the Diesel Exhaust in Miners Study (DEMS). This mine is mine "I" in the DEMS studies.
F1	Other information	MSHA-2014-0031-0059-A4	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0059-A4.pdf	Celeste Monforton	MSHA should update Table 57.5067-1 to require that the most up-to-date Tier 4 engines be used in underground metal and non-metal (MNM) mines. As with the standards for underground coal mines, Table 57.5067-1 is outdated. It is feasible for the MNM mining industry to comply with Tier 4 engine DPM standards. I look for MSHA's leadership in the year ahead to propose a regulation to address these and other deficiencies in the current DPM regulations. I also concur with the comments submitted in response to MSHA's RFI by the American Public Health Association

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F1	Other information	MSHA-2014-0031-0059-A4	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0059-A4.pdf	Celeste Monforton	Background The standards issued by MSHA in 1996 and 2001 on diesel-powered equipment were instrumental in moving the mining industry forward to recognize and address the health hazards of diesel exhaust for underground miners. More than 16 years have passed, however, since these regulations on diesel equipment were put in place. Significant advances have been made in diesel engine and exhaust after-treatment technologies during that time period. MSHA's regulations must be updated to reflect these advances. MSHA's RFI indicates that 66 percent of diesel engines operating in underground coal mines are classified as light-duty equipment. But MSHA's standards for light-duty equipment are woefully out-of-date. Specifically, under 72.502 MSHA requires light-duty equipment engines, which were introduced in underground coal mines, to meet one of the following: • 5.0 gr/hr of DPM; • DPM requirements equivalent to the EPA non road Tier 2 standards; or • EPA's 1986 DPM standards for highway vehicles. However, current diesel engine technology can reduce DPM emissions well beyond what these standards require. In fact in the U.S., all non-road diesel engines produced today and installed in new equipment are required to meet EPA Tier 4 standards. Regrettably, the exception are the engines used in underground mining. There's no justification for permitting mine operators to expose miners to polluting diesel engines---and the associated health risks---when cleaner engines are available and in use in all other areas of commerce. EPA's Tier 4 DPM standards are approximately 90 percent cleaner than those for Tier 2 engines. Moreover, many of MSHA's approved engines under Part 7 have DPM emissions greater than a Tier 2 standard. If MSHA fails to revise Table 72.502-1, mine operators have no incentives to introduce the most modern diesel engines and after-treatment technologies that are available for their light-duty equipment fleet. Since the Part 72 DPM standards were based on technological feasibility of diesel engines at the time the standards were promulgated, MSHA must update its regulations so that they conform to current feasible engine technology. This technology can reduce DPM exposure by 90 percent.
F1	Other information	MSHA-2014-0031-0062-A14	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0062-A14.pdf	Paul Schulte	[Not excerpted. Contains only cover page and table of contents for North American Mine Ventilation Symposium. Calizaya (2012).]
F1	Other information	MSHA-2014-0031-0062-A23	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0062-A23.pdf	Paul Schulte	[Not excerpted. Contains only first few pages of book entitled Internal Combustion Engin Fundamentals. Heywood (1988).]
F1	Other information	MSHA-2014-0031-0062-A24	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0062-A24.pdf	Paul Schulte	[Not excerpted. Contains only the first page of a study reviewing combustion products of renewable fuels. Westphal (2013).]
F1	Other information	MSHA-2014-0031-0062-A8	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0062-A8.pdf	Paul Schulte	[Contains an article on test procedures and quality standards for particle filters to retrofit utility vehicles. Mayer (2009).] A new approach is needed to test particle filters for retrofitting Diesel engines. Considering the toxicity of the particles as also the physical and chemical attributes of particle filters, the optimal scheme is to test the components themselves independent of the deployment. That scheme ensures the highest effectiveness with least effort. It also enables evaluation of worst-case situations and assesses the hazards of secondary emissions. The Swiss standard SNR 277 205, which mandates the VERT test procedure, is a first step in that direction.

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F1	Other information	MSHA-2014-0031-0069-A3	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0069-A3.pdf	Edward Green	2012 letter to Joe Main (duplicate of DCN 0070) Protections for Metal & Non-metal Miners In connection with its review ofprotections for metal and nonmetal miners, we respectfully recommend that MSHA undertake the following actions: a) Prepare and disseminate to the public a simple annual report that describes the results of inspector sampling for DPM (ie., measures of total carbon (TC) and elemental carbon (EC) at underground mines, and the current control measures used in the work area where the samples were collected. Making such information available to the public (e.g., miners, operators, other agencies and worker safety advocates) will help assess whether mine operators have implemented all feasible contmls. It will also serve to remind the workers and the general public that the concentration of DPM permitted by MSHA's health standard is not a safe exposure level. The exposure limit was based on tecbnological and economic feasibility at the time the rules were published. At the current 160 ug/m3 DPM exposure limit (8-hour timne-weighted average) allowed by MSHA, the agency's risk assessment estirnated between 15 to 313 excess cases of lung cancer per 1.000 workers. The risk estimates for cardiovascular, cardiopulmonary and other adverse health effects also warrant sustained attention. b) Conduct exposure monitoring at a representative sample of surface mining operations to assess miners' exposure to DPM, using methods already proven accurate in underground mines. Prepare a simple annual report that summarizes the exposure findings for the surface miners who are not coverred by MSHA's DPM regulation. We viewed MSHA's DPM standards as good first steps when [hey were publisbed, but just that - a first step toward protecting this at-risk population. We believe it is unfortunate that, without opportunity for comment, MSHA subsequendy dropped several requirements of those standards for underground metal and nonmetal mines that would have significantly contributed to protecting these miners. The two recommendations made above will help assemble the evidence for what additional regulation of this hazard is warranted and feasible to protect miners in this sector, including surface miners and contractors servicing surface mines.
F1	Other information	MSHA-2014-0031-0069-A4	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0069-A4.pdf	Edward Green	Duplicate of DCN MSHA-2014-0031-0037
F1	Other information	MSHA-2014-0031-0069-A5	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0069-A5.pdf	Edward Green	... at a time when the Companies are dealing with the greatest ever economic downturn of the entire coal industry, MSHA must take into special account the economic feasibility of any regulatory steps MSHA may advance as a next step of the RFI.... Once deployed underground, engine emission limits are not tested in real time. Real-time testing would be unworkable in an underground coal mine considering that the ambient atmosphere contains particles of carbon from the coal being mined, as well as the carbon contained in the coal itself. This regulatory scheme for exposure of miners to diesel exhaust in underground coal mines is thus necessarily very different from that in underground metal and nonmetal mines.... Dr. McClellan will have some additional commentary to give you on our behalf.... MSHA must consider all "of the latest scientific evidence in the field." The Companies also endorse Dr. McClellan's Critique of the HEI Report referenced in the RFI. And very importantly, the Companies agree with the idea of establishing an MSHA-NIOSH Partnership with all the stakeholders to discuss in detail the questions MSHA has raised in the RFI.... MSHA has said the agency's mind is open at this juncture as to whether additional rules dealing with the exposure of underground miners to diesel exhaust are necessary. The Companies are pleased to hear that; but, candidly, we wonder about its accuracy. We say that because we are aware of 2012 1etters from the United Mine Workers' of America (the "UMWA") and a group of public health academicians appearing to petition MSHA to promulgate stricter DPM standards for both coal and metal/nonmetal mines than those currently in effect. The Companies also understand that, at the Pittsburgh public meeting, representatives of the UMWA and the United Steelworkers of America called upon MSHA for new and more stringent rules. We also want to say, categorically, that although we are not opposed to new rules, we want to make sure they are need and science-based.... The Companies also wish to remind MSHA of its mandatory obligation to consider the feasibility of any new rules the agency may adopt. Feasibility not only includes technological feasibility (a difficult enough requirement), but also economic feasibility. In that regard, MSHA must take into account the fact that the US domestic coal mining industry is under severe stress, with several major coal producers undergoing Chapter 11 reorganization as we meet here today, and with prices down and environmental regulatory pressure up.

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F1	Other information	MSHA-2014-0031-0070	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0070.pdf	Celeste Monforton	[Duplicate of MSHA-2014-0031-0069-A3]
F1	Other information	MSHA-2014-0031-0073	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0073.pdf	Dennis O'Dell	[Duplicate of MSHA-2014-0031-0069-A2]
F2	Diesel emissions partnership	MSHA-2014-0031-0044	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0044.pdf	Mark G Ellis	I write to you on behalf of the Industrial Minerals Association – North America (IMA-NA) Diesel Emissions Task Force. Formed approximately one year ago, the Task Force is made up of operators of underground mines producing trona, calcium carbonate, industrial sand, and wollastonite. All of the members of the Task Force use at least some diesel equipment in their mining operations and we all share a commitment to the health and safety of our employees. Some of the members of the Task Force also volunteered to participate as study mines in the Diesel Exhaust in Miners Study (DEMS) conducted by the National Institute for Occupational Safety and Health (NIOSH) and the National Cancer Institute (NCI). .... These questions are not only extraordinarily technical, but also may be best addressed by working with the manufacturers of diesel engines and suppliers of mining equipment. Engine and equipment manufacturers would be much more familiar with technical details and changes in diesel technology that were not accounted for in DEMS. In fact, these are important issues best addressed by all stakeholders working together to understand the evolving science on the potential health effects of worker exposure to diesel exhaust, as well as current technologies and current mining practices. Accordingly, we request that MSHA and NIOSH form a Diesel Exhaust Health Effects Partnership with the mining industry, including both coal and metal/nonmetal mines, diesel engine manufacturers, and representatives of organized labor. That Partnership would be best positioned to address these complex issues and reach a consensus on the path forward, informed by MSHA's fact-gathering efforts.
F2	Diesel emissions partnership	MSHA-2014-0031-0057-A1	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0057-A1.pdf	Mark G Ellis	Most of the IMA-NA underground mining companies producing those minerals participate in the activities of the Task Force, which was organized in 2015 for, among other reasons, to bring to bear the resources of the IMA-NA on the impending RFI. IMA-NA underground producing member companies represented on the Task Force include Carmeuse Lime & Stone, Ciner Resources Corporation, Fairmount Santrol, Huber Carbonates, Imerys, Lhoist North America, Mississippi Lime Company, Solvay Chemicals, Tata Chemicals, Tronox Alkali, Vanderbilt Minerals and Unimin Corporation. At its organizational meeting, the Task Force, which is chaired by Tronox Alkali General Counsel Richard P. Pasquier, developed the following proactive mission statement: The mission of the IMA-NA Diesel Emissions Task Force is to function as a forum for mine operators to learn as much as possible about the health effects of diesel exhaust, especially its carcinogenic potential, to protect IMA-NA members' employees in their occupational settings.
F2	Diesel emissions partnership	MSHA-2014-0031-0057-A1	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0057-A1.pdf	Mark G Ellis	First, IMA-NA polled all of its Task Force members seeking responses to Questions 14 through 28. These are the questions relevant to MNM mines. Even though IMA-NA has aggregated its members' responses, those producer members remain concerned that many of these questions seek responses which could contain business-confidential information. Thus, as you will see in the third attachment to this letter (IMA-NA Attachment 3), which is an aggregation of responses received; you may think some of the answers are somewhat vague. That is because we have purposely made them so in order to protect the confidential nature of responses we received. The second reason why the Task Force's answers to the questions posed cannot be as responsive as MSHA may have wished for is that the Task Force simply does not know the answers to a number of the questions in the RFI. In that respect, and in our desire to bring to bear the resources of the Task Force, other industrial (to include not only other sectors of the mining industry, but also manufacturers of diesel engines and mining equipment) and organized labor stakeholders, as well as MSHA, and (especially) NIOSH, the undersigned and IMA-NA's outside counsel, Ed Green, met with senior executives of NIOSH and MSHA and suggested that we all work together in a "partnership" on the challenging problems posed in the RFI. We shall discuss this "partnership" further below; but for now, suffice it to say, the inaugural meeting of the NIOSH/MSHA Diesel Exhaust Partnership will be held on December 8 in Washington, PA. The Task Force is eager to participate in both that meeting, as well as subsequent Partnership meetings.

Comment Code	Comment Code Description	DCN	Link to Comment	Commenter Name	Comment
F2	Diesel emissions partnership	MSHA-2014-0031-0057-A1	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0057-A1.pdf	Mark G Ellis	We are particularly of the view that this Partnership will be very helpful to MSHA and all other stakeholders in grappling with the RFI's questions; not to mention other questions that we suspect will be identified as the work of the Partnership ensues. MSHA's use of Requests for Information are useful mechanisms for the development of improved safety and health regulations—especially in cases like this RFI that deal with very complex technical issues. The Task Force believes the RFI has truly set the stage for the Partnership to engage with a large audience of expert private sector stakeholders and MSHA and NIOSH experts in an informal iterative process likely to result in a work-product that will provide the basis for any additional regulation (if any) of the exposure of underground MNM miners to diesel exhaust. We are also pleased that MSHA and NIOSH have scheduled the inaugural meeting of the Partnership expeditiously on December 8. In the separate discussions that Mr. Green and I had with senior NIOSH and MSHA executives this past July, we understood that: (a) the two agencies would draft a protocol or charter for the Partnership, which would then be available for review and comment by us and other private sector partners before being finalized; and (b) especially from MSHA's point of view, it would be expected the Partnership would be able to develop regulatory recommendations, if any, for consideration by MSHA in around two years from its first meeting next month. That time-line would not affect the life of the Partnership, as we, NIOSH, and MSHA agree, we believe, that the Partnership will likely continue to work on useful research about diesel exhaust health effects. The Task Force looks forward to participating in the December 8 Partnership meeting, as well as reviewing the draft protocol/charter for the Partnership.
F2	Diesel emissions partnership	MSHA-2014-0031-0057-A29	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0057-A29.pdf	Mark G Ellis	It is readily apparent that these questions are not only extraordinarily technical, but also may be best addressed by working with the manufacturers of diesel engines and suppliers of mining equipment. As I mentioned, there have been substantial improvements in diesel engine technology and exhaust after-treatment systems over the past quarter century, which largely were driven by the Environmental Protection Agency's (EPA) diesel engine standards. Engine and equipment manufacturers would be much more familiar with those changes than mine operators. As a result, Tronox Alkali and the IMA-NA propose that MSHA and NIOSH work with the mining industry (both metal/nonmetal and coal), diesel engine manufacturers, diesel mining equipment manufacturers, and representatives of organized labor to form a Diesel Exhaust Health Effects Partnership to address these complex issues and reach consensus on the path forward.
F2	Diesel emissions partnership	MSHA-2014-0031-0057-A32	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0057-A32.pdf	Mark G Ellis	duplicate of DCN 0031 42576 Re: Request for Establishment of a Diesel Exhaust Health Effects Partnership and Request for Extension of Comment Period for Request for Information on Exposure of Underground Miners to Diesel Exhaust (Docket No. MSHA-2014- 0031) by 90 days Dear Mr. Secretary and Dr. Howard, I write to you on behalf of the Industrial Minerals Association – North America (IMA-NA) Diesel Emissions Task Force. Formed approximately one year ago, the Task Force is made up of operators of underground mines producing trona, calcium carbonate, industrial sand, and wollastonite. All of the members of the Task Force use at least some diesel equipment in their mining operations and we all share a commitment to the health and safety of our employees. Some of the members of the Task Force also volunteered to participate as study mines in the Diesel Exhaust in Miners Study (DEMS) conducted by the National Institute for Occupational Safety and Health (NIOSH) and the National Cancer Institute (NCI). The Task Force was formed to enable its member companies to learn as much as possible about the health effects of diesel exhaust in order to protect our employees' health. The Task Force also promotes and is interested in the exchange, testing, and verification of scientific information concerning the use of diesel equipment in mining operations. As a result, the Task Force and its members have had a keen interest in the publications that have resulted from DEMS, including papers published both by the original investigators and subsequent analyses performed by independent analysts working with the DEMS data. The Task Force also is interested in and plans to offer a response to the Mine Safety and Health Administration's (MSHA's) Request for Information on Exposure of Underground Miners to Diesel Exhaust (Docket No. MSHA-2014-0031). The IMA-NA Diesel Emissions Task Force has begun to review the specific questions posed in the RFI. It is readily apparent that these questions are not only extraordinarily technical, but also may be best addressed by working with the manufacturers of diesel engines and suppliers of mining equipment. Engine and equipment manufacturers would be much more familiar with technical details and changes in diesel technology that were not accounted for in DEMS.
F2	Diesel emissions partnership	MSHA-2014-0031-0057-A33	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0057-A33.pdf	Mark G Ellis	August 5, 2016 response by NIOSH to IMA-NA request for partnership.

Comment Code	Comment Code Description	DCN	Link to Comment	Commenter Name	Comment
F2	Diesel emissions partnership	MSHA-2014-0031-0057-A35	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0057-A35.pdf	Mark G Ellis	September 13, 2016 response by MSHA to IMA-NA request for partnership
F2	Diesel emissions partnership	MSHA-2014-0031-0063-A1	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0063-A1.html	Hunter Prillaman	NLA notes that technological approaches that may be appropriate in coal mines may not be appropriate in metal/non-metal mines, because of significant differences in the configuration and equipment use in those mines. Indeed, underground metal/non-metal mines can differ significantly from mine to mine, even among those mining the same commodity (such as limestone). There can be major differences in access, vault height, availability of ventilation, risks from other airborne materials, and size of equipment that is used in the mine. These differences mean that MSHA must proceed thoughtfully in considering new DPM standards for metal/non-metal underground mines, and must take into account the experience of operator and labor stakeholders. Once again, NLA believes that the planned partnership is the best way to achieve this level of communication.
F2	Diesel emissions partnership	MSHA-2014-0031-0066-A1	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0066-A1.pdf	Joseph Casper	NSSGA is pleased that MSHA has agreed to work with the National Institute of Occupational Safety and Health (NIOSI-~ in a diesel exhaust health effects partnership. Just as NSSGA works with MSHA via the Alliance for education and training, so too does NSSGA work with NIOSH on behalf of worker safety and health. NSSGA would be pleased to engage in this process. bviously, this is a very complicated area. While NSSGA members work diligently to limit miners' exposure to diesel exhaust, there are a number of factors affecting this, including technology employed, availability of ventilation, age and maintenance condition of equipment used, etc. NSSGA is pleased that, in recent years, average diesel particulate matter exposures for MNM miners have been significantly reduced.
F2	Diesel emissions partnership	MSHA-2014-0031-0069-A1	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0069-A1.pdf	Edward Green	The Companies [Murray Energy, its trade association the Bituminous Coal Operators Association and Interwest Mining Company] strongly support the NIOSH-MSHA Diesel Exhaust Health Effects Partnership.... The Companies plan to actively participate.
F3	Low sulfur fuels, additives	MSHA-2014-0031-0040	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0040.html	Thomas Bayne	There are several control procedures that can be taken to reduce the DPM molecules that are released into the miners' air space. A control item that will assist in bringing the exposure level of DPM down from current levels would be the use of low sulfur fuels. While this method is already in place, the use of low sulfur fuels coupled with fuel additives will make an impact on the exhaust quality. In addition to purchasing the low sulfur fuel the guarantee of the sulfur amount should be tested periodically for consistency and accuracy of content. Distributors of diesel fuel receive their fuel from other sources and the quality or composure of the fuels may fluctuate. For this reason alone the importance of regulated testing of diesel fuel is important.
F3	Low sulfur fuels, additives	MSHA-2014-0031-0050-A1	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0050-A1.pdf	Robert McDonald	Fuel Quality The Broadmeadow mine uses Ultra Low Sulphur Diesel (ULSD) which contains no more than 7 parts per million of sulphur. Regular FLAG (Fuel, Lubricant, Air, Coolant) audits are conducted to ensure the quality of the fuel and the fuel handling systems. Fuel delivered to the Broadmeadow operation is filtered between the delivery truck and bulk storage and filtered again when taken from that tank to vehicle top up tanks. Maintenance programs ensure the filter systems are clean and functioning correctly.
F3	Low sulfur fuels, additives	MSHA-2014-0031-0050-A1	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0050-A1.pdf	Robert McDonald	The Olympic Dam [hardrock] mine uses only high quality ultra-low sulphur fuel, which is suitable for use with after treatment devices and filtered prior to delivery to onsite tanks. Oil is low SAPS (sulphated ash, phosphorous and sulphur) oil which is specifically designed to be used in modern turbo engines, particularly those fitted with diesel particulate filters.
F3	Low sulfur fuels, additives	MSHA-2014-0031-0055-A1	http://projects.erg.com/commresponse/docs/MSHA-2014-0031-0055-A1.docx	Catherine Doherty	... Biodiesel requires less energy to produce (Bowman, Hilligoss, Rasmussen, & Thomas, 2006), is much less toxic to humans and the use of alternative fuels can also reduce our dependence on foreign fuel supply, create domestic manufacturing jobs and is a good way to reduce CO2 emissions into our atmosphere (Howell & Weber, 1996). ... Biodiesel also contains oxygen, 11% to be exact, which allows the fuel to burn more completely leaving less toxic gases in the air (Bowman, Hilligoss, Rasmussen, & Thomas, 2006). Even though biodiesel is much safer for humans and the environment than regular diesel fuel, it must still be handled and stored the same as regular diesel. This means that it must be stored in a clean, dry, dark environment and should not be exposed to temperature extremes. Over time, biodiesel will degrade certain types of natural rubber compounds and elastomers, so fuel pump seals and other storage or distribution equipment cannot contain these compounds or else there will be leaking (Howell & Weber, 1996).