

IMA-NA Responses to RFI Questions 14-28

Like most companies, IMA-NA's members consider their internal processes to be confidential business information. To accommodate these concerns, we have summarized the range of answers provided in response to Questions 14-28 by our members and omitted identifying information.

14. What exhaust after-treatment technologies are currently used on diesel-powered equipment? What are the costs associated with acquiring and maintaining these after-treatment technologies and by how much did they reduce DPM? How durable and reliable are after-treatment technologies and how often should these be replaced? Please be specific and include examples and the rationale for your response.

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 particulate 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.

15. What are the advantages, disadvantages, and relative costs of using DPM filters capable of reducing DPM concentrations by at least 75 percent or by an average of 95 percent or to a level

that does not exceed an average concentration of 0.12 milligrams per cubic meter (mg/m³) of air when diluted by 100 percent of the MSHA Part 7 approved ventilation rate for that diesel engine? How often do the filters need to be replaced?

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 than 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.

16. What sensors (e.g. ammonia, nitrogen oxide (NO), nitrogen dioxide (NO₂)) are built into the after-treatment devices used on the diesel-powered equipment?

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.

17. Are integrated engine and exhaust after-treatment systems used to control DPM and gaseous emissions in the mining industry? If so, please describe the costs associated with acquiring and maintaining integrated systems, and the reduction in DPM emissions produced.

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.

18. What are the advantages, disadvantages, and relative costs of requiring that all light-duty diesel-powered equipment be equipped with high-efficiency DPM filters?

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.

19. In the mining industry, are operators replacing the engines on existing equipment with Tier 4i (interim) or Tier 4 engines? If so, please specify the type of equipment (make and model) and engine size and tier. Please indicate how much it costs to replace the engine (parts and labor).

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.

20. What types of diesel equipment purchased new for use in the mining industry is (sic) powered by Tier 4i or Tier 4 engines? What types of diesel-powered equipment, purchased used for use in the mining industry, are powered by Tier 3, Tier 4i or Tier 4 engines?

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.

21. Are Tier 4i or Tier 4 engines used in underground mines equipped with diesel particulate filter (DPF) systems (e.g., advanced diesel engines with integrated after-treatment systems)? Please provide specific examples.

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.

22. How long have Tier 4i or Tier 4 engines been in use in the mining industry and what additional cost is associated with maintaining equipment equipped with these engines?

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.

23. *What percentage of underground coal mines' total diesel equipment inventory is equipped with Tier 4i or Tier 4 engines?*

IMA-NA's members do not operate underground coal mines.

24. *MSHA requests information on alternative surrogates, other than TC, to estimate a miner's DPM exposure. What is the surrogate's limit of detection and what are potential interferences in a mine environment?*

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.

25. *What are the advantages, disadvantages, and relative costs for using the alternative surrogate to determine a MNM miner's exposure to DPM? Please be specific and include the rationale for your response.*

Most members did not feel equipped to answer this question and refer to MSHA to the response to Question 24.

26. *MSHA requests information on advances in sampling and analytical technology and other methods for measuring a MNM miner's DPM exposure that may allow for a reduced exposure limit.*

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 An IMA-NA member's own testing corroborates the article's conclusion.

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

¹ Yu, C. H., Patton, A. P., Zhang A., Fan Z., Weisel, C. P., & Lioy, P. J. (2015). Evaluation of Diesel Exhaust Continuous Monitors in Controlled Environmental Conditions. *Journal of Occupational and Environmental Hygiene*, 12(9), 577-587.

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.

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

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.

28. Based on MSHA's data, MNM miners' average exposures are well below the existing standard of $160_{TC} \mu\text{g}/\text{m}^3$. What are the technological challenges and relative costs of reducing the DPM exposure limit?

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.² 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.

² 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.