# Best Practices for Underground Diesel Emissions

*NIOSH and the Coal Diesel Partnership recommend practices for successfully using ceramic filters to control diesel particulate emissions*

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An extra ceramic filter will minimize downtime when dirty filters need to be regenerated.

Approximately 45% of U.S. coal is produced from underground mining. The use of diesel engines to power underground mining equipment has steadily increased over the past four decades in an effort to improve mine safety and productivity. Several advantages realized with the use of diesel-powered mining equipment in underground coal mines are listed in Table 1.

The primary disadvantage of using diesel equipment in underground coal mines is that diesel exhaust emissions can contaminate mine ventilation air. The major constituents of diesel exhaust are gaseous emissions (which include carbon monoxide, carbon dioxide, oxides of nitrogen, sulfur oxides and unburned hydrocarbons) and diesel particulate matter (DPM). The Mine Safety and Health Administration (MSHA) has incorporated threshold limit values for all gaseous components of diesel exhaust into their regulations. These have been established by the American Conference of Governmental Industrial Hygienists.

To regulate DPM emissions in underground coal mines, MSHA has established diesel equipment tailpipe DPM emission standards[1] in 30CFR72.500, 30CFR72.501 and 30CFR72.502 (See Table 2). The low tailpipe DPM emission standards mandate the use of exhaust aftertreatment devices, in particular diesel particulate filters, on most underground diesel equipment.

As the number of underground mines using or planning to use diesel powered equipment continues to increase, mine operators are struggling with the issue of whether to use high-temperature paper or regenerating ceramic DPM filters on outby equipment. Both general types of filters have advantages and disadvantages (See Table 3).

Paper DPM filters are highly efficient at capturing DPM, relatively inexpensive, easy to change out, and disposable. Once a filter has reached maximum load, it can be replaced underground with a new filter and discarded. This eliminates the need for in-mine regeneration of the filter or bringing equipment out of the mine for filter regeneration. The DPM collected on high-temperature paper filters, however, can ignite if the exhaust temperature is too high and there is excessive buildup of DPM on the filter.

Regenerating ceramic filters are also very efficient in capturing DPM. They also can be easy to change, can be reused multiple times, and are less susceptible to catching fire. However, ceramic filters are significantly more expensive than paper filters and must be regenerated on a regular basis. In general, these filters have to be regenerated on the machine or removed from the machine and placed in a regeneration unit for up to eight hours to burn off soot and other materials. The time between regeneration events is dependent on the duty cycle of the diesel-powered equipment. Given the belief that ceramic DPM filters are difficult to maintain, mine operators currently using high-temperature paper filters are reluctant to switch to ceramic units.

Following a recommendation of the Coal Diesel Partnership[2], members of the Partnership DPM Filter Task Group visited an underground coal operation in West Virginia in August 2005. The purpose of the visit was to examine the mine's use of ceramic diesel particulate filters on several pieces of outby mining equipment and document the effectiveness of the mine's DPM filter program. Findings from the visit were to aid in the future development of a "Best Practices" document for using ceramic diesel particulate filters.

## Approach & Findings

The Partnership DPM Filter Task Group's visit began by means of discussions with mine officials about the operation's approach for using ceramic DPM filters. During these discussions, mine management reported that they have been successfully using ceramic diesel particulate filters since shortly after the West Virginia diesel rule was enacted in March 2004. In addition, group members examined two of three pieces of diesel equipment used at the mine and talked with the diesel mechanic at the

**Table 1: Advantages and Disadvantages of Diesel-Powered Equipment Use in Underground Coal Mines**

| Advantages | Disadvantages |
|---|---|
| Eliminates electrical shock from trolley wires and electrical cables | Contamination of mine air with diesel emissions |
| Eliminates explosion hazards from trolley wires and electrical cables | Diesel fuel storage and handling concerns |
| Eliminates personnel injury from heavy lifting and manual labor | |
| Improves ventilation in face area by eliminating the need to regulate air velocity in trolley wire entries | |
| Equipment mobility | |

Table 2: MSHA Underground Coal Diesel Particulate Matter Exposure Limits

| Equipment Category | DPM Emission Limit |
|---|---|
| Light duty outby | <5 grams/hour |
| Heavy duty outby | <2.5 grams/hour |
| Heavy duty permissible | <2.5 grams/hour |

operation about the processes he follows for ceramic DPM filter maintenance.

The task group found several elements that they believe are important to the mine's success in using ceramic DPM filters. These elements include: use of modern diesel equipment, regular engine maintenance, scheduled filter regeneration, and a dedicated diesel emissions mechanic.

The mine's three pieces of outby equipment were purchased new and incorporated clean engines with low emissions. This equipment includes: a Getman[3] Grader powered by a Mercedes 904 diesel engine; an A.L. Lee Mini-Trac powered by a Deutz 2011 engine; and a Getman Tow Tractor also equipped with a Mercedes 904 engine. All three pieces of machinery were equipped with a diesel oxidation catalyst and a Cat Trap particulate filter produced by Engine Control Systems of Newmarket, Ontario, Canada. These were installed by the equipment manufacturer prior to delivery.

The mine conducts regular emissions evaluations on all three pieces of diesel equipment. These include both Bacharach smoke spot and tailpipe carbon monoxide (CO) tests. As part of its DPM filter program, the mine also performs regular checks of engine backpressure.

Mine management saw a need to minimize downtime for filter regeneration to guarantee maximum equipment availability. As such, each time the mine purchased a piece of diesel equipment, management elected to acquire a spare ceramic filter. The advantage of having two filters per vehicle is that one filter can be regenerating while the other filter is in use thus eliminating down time associated with filter regeneration.

The mine has one mechanic who is primarily dedicated to the maintenance of all underground diesel equipment at the mine. Mine management believes this eliminates many problems since this point-of-contact knows all of the details and maintenance particulars of each piece of diesel equipment. The mechanic keeps track of operating hours for all diesel engines, as required by West Virginia law and typically uses this as a gauge to determine when the filters on each machine are due for change out and regeneration.

## Best Practices

Based on their findings, the task group offered several best practice recommendations that a mine may want to follow to implement a successful ceramic DPM filter program.

- Mines using diesel equipment under ground should consider having a diesel point person, or champion, for their pro gram. Having one champion eliminates many problems since this point-of-contact person knows all of the details and maintenance particulars of the diesel-powered equipment.
- Mine operators should use the lowest emitting engines available. The use of clean engines will extend the time between filter regeneration or change out.
- Mine operators should conduct regular emissions testing; these tests should include both smoke spot and CO tests.
- Mines should regularly monitor engine backpressure; increased backpressure is a good indicator of the need to regenerate or replace the DPM filter.
- Mine operators should consider using both backpressure warning devices and pressure gauges to monitor engine backpres - sure.
- Mines should use engine operating hours as a supplementary metric to determine when the filters on each machine are due for change out and regeneration.
- Mine operators using diesel equipment should consider purchasing extra ceramic filters for their equipment; this will help minimize downtime when dirty filters must be regenerated.

Many more components make up a diesel program. The best practices identified, however, are believed to be key elements for implementation of a successful effort using ceramic filters.

Table 3: Advantages and Disadvantages of Diesel Particulate Filters by Type

| Filter Type | Advantages | Disadvantages |
|---|---|---|
| High temperature paper | High efficiency | Potential fire hazard with elevated filter inlet exhaust temperature (650°F) or excessive filter loading |
| | Inexpensive compared to other filter types | |
| | Easy change-out | |
| | Disposable | |
| Regenerating ceramic | High efficiency | Expensive compared to paper filter |
| | Easy change-out | Requires regular regeneration |
| | Re-usable | Filter regeneration time |
| | Reduced fire hazard relative to paper filter | |

## Footnotes

[1] An ambient DPM standard for coal mines was not considered feasible because there was no known way to distinguish between coal mine dust and DPM.

[2] The Coal Diesel Partnership is comprised by representatives of the National Institute for Occupational Safety and Health (NIOSH), Bituminous Coal Operators Association (BCOA) and United Mine Workers of America (UMWA). The partnership was formed with the primary objective of reducing the exposure of underground coal miners to particulate matter and gaseous emissions from diesel-powered equipment.

[3] Mention of any company or product does not constitute endorsement by NIOSH.