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M/NM Mine Best Practices for Ceramic Filter Regeneration and Cleaning

Ceramic diesel particulate filters (DPF), also know as “soot traps” or just “traps” are being utilized in the M/NM underground mining industry to comply with the new DPM regulations. These filters capture diesel particulate matter (DPM) or “soot” to prevent its release into the mine atmosphere. This soot must be removed from the filter to keep it functioning properly. The process of removing the combustible portion of the collected soot is called “regeneration” which is the burning off of the soot by raising the temperature of the filter element so that combustion of the soot occurs. When the soot combusts, the soot -- which is almost pure carbon -- is converted to gaseous carbon dioxide and carbon monoxide, that pass through the filter. Diesel soot is not entirely comprised of combustible carbon but also contains noncombustible ash resulting primarily from the additives used in crankcase lubrication oils, fuel or intake air additives, and from the fuel itself. The removal of the ash from the filter is called “cleaning” and, although necessary to do, is done much less frequently than regeneration. Ash can be removed from the filter by several different methods. The filter manufacturers will provide the hardware, instructions, or a service to remove the ash from the filter’s they supply.

Unless recommended by the filter manufacturer, the filter must not be cleaned using water or other chemicals. Cleaning of filters by these methods may damage the material securing the filter in its canister. This can result in the loosening of the filter element in the canister and subject it to damage from vibration.

Diesel particulate filters must not be cleaned or regenerated in a manner that results in a miner being exposed to soot or the exhaust gas from the regeneration unit. Some examples of improper regeneration or cleaning include turning filter around and using the engine’s exhaust gases to flush out the filter and using compressed air to clean the filter without capturing the DPM.

The key to the successful regeneration and cleaning of filters is to follow the manufacturers instructions.

Since filters are new to the mining industry the hazards associated with their regeneration are not commonly known. Some of the hazards include:

- Electrical
- Fire
- Ventilation
- Handling
- Gassy Mines (Explosion)

What follows are recommended best practices for controlling these hazards.

Electrical:
Active regeneration, either on-board of off-board the machine, requires an oven to heat the ceramic filters and a controlled air flow through the filter. The oven usually requires

from 120 volts single phase to 480 volt three phase for the heating element. Some regeneration units are not listed by a Nationally Recognized Independent Test Lab, such as UL or CSA. Regeneration units must comply with MSHA electrical regulations. The applicable MSHA electrical regulations are contained in part 57, subpart K – Electricity.

The regeneration unit should have built-in safety features including over-temperature protection (high temperature fusible link) of the heating coils and a closed-loop temperature controller on the heater. A redundant timer should also be considered to prevent extended regeneration times in case of timer failure.

Fire:
One fire hazard can be associated with "uncontrolled regeneration." This usually occurs when there is too much soot on the filter and runaway combustion results in excessive heat and the melting of the filter element. This can be prevented by following the filter manufacturer's recommendations for when to clean the filter. Monitoring the backpressure of the system is essential to make sure the filter is regenerated before it is overloaded with soot.

Other fire related hazards can arise from the surface temperature of the regeneration unit during regeneration. Internal temperatures of regeneration units can reach 1400°F. Depending on the regeneration system design, its external surfaces and the exhaust gases from the unit could get hot enough to ignite combustible material or burn personnel. Regeneration units can be insulated or guarded (in accordance with manufacturer recommendations) to reduce the hazard. In general, combustible materials should be kept at least 25 feet from the regeneration unit. Reference §57.4500.

Diesel particulate filter regeneration stations must be provided with fire protection of a type, size, and quantity that can extinguish fires of any class in their early stages which could occur as a result of the hazards present. Reference §57.4200.

The regeneration station area should be provided with signs identifying hazards. These hazards can be identified in discussions with MSHA and the filter manufacturer. Reference §5720011.

Ventilation:
Diesel particulate filter regeneration stations should be ventilated with a sufficient volume of air to prevent the accumulation of heat and toxic or explosive gases. Reference §57.5005 and §57.5060.

Adequate ventilation is also a concern during normal machine operation when a platinum-based catalyzed ceramic filter is installed on the machine. A potential health hazard can be caused by these platinum-based catalyzed filters . Use of these type filters may result in increased production of nitrogen dioxide (NO_2) gas, as compared to NO_2 emissions produced by engines operating without these type filters, causing miners to be exposed to increased concentrations of NO_2. Symptoms of overexposure to NO_2 include irritation to the eyes, nose and throat, cough, decreased pulmonary function, chronic bronchitis, breathing difficulty, chest pain, pulmonary edema, and rapid heartbeat. Reference PIB P02-04 and §57.5005.

Handling:
Appropriate personal protective clothing must be provided and used when handling diesel particulate filters or at filter regeneration stations where a thermal hazard is present. Reference §57.15006. Again, regeneration units can be insulated or guarded (in accordance with manufacturer recommendations) to reduce the hazard.

Gassy Mines (Explosion):
Since regeneration units are not approved by MSHA as explosion-proof and may get hot enough to ignite methane, they must not be used where MSHA approved equipment is required. Reference §§57.22302 through 57.22305.