

TABLE VII-2.—SCENARIOS FOR ACTIVE REGENERATION—Continued

System name	Regenerating location	Regenerating controller location	Comments
Off-board	Off equipment	Fixed-location	DPFs are exchanged and must be small enough to be handled by one person. Increases number of DPFs needed.
On-board fuel burner	On-equipment	On-equipment during operation ...	System is complex yet provides advantages of operating during equipment use; manufacture has been discontinued.

Scenarios for active regeneration systems are listed in Table VII-2. The first two systems listed in Table VII-2 may require sufficient machine down time for regeneration, which is usually about one hour between shifts. Also, the equipment should be parked at a designated location during the regeneration period. MSHA recognizes that presently in some mines, production equipment is not brought to a specific location at the end of a shift. At mines where this occurs, mine operators may need to make changes to accommodate such DPF regeneration designs. Alternatively, mine operators may choose to have the equipment operator remove the DPF at the end of each shift and have the next operator replace it with a regenerated unit at the start of the shift. In short, mine operators must plug in the regeneration system at the end of the shift, or DPFs must be transported from the regeneration area to the equipment location. Multiple filters may be installed on a machine in the place of one filter in order to decrease the size and weight of the filters.

Under certain circumstances, some passive DPF systems have exhibited marginal regeneration. This is due to the fact that the duty cycle exhaust temperature is such that some but not all of the DPM is removed during the normal work shift. Slowly the DPM builds up until the DPF must be regenerated manually. In some instances, this needs to be done every 250 hours which would coincide with the regular preventive maintenance cycle for diesel powered equipment.

Achieving a long service life: The key to achieving a long service life from any DPF is to monitor and strictly adhere to exhaust back pressure limits and taking action appropriately. Passive regenerating systems are especially sensitive to equipment duty cycle. A change in duty cycle may reduce exhaust temperatures to a point that regeneration does not spontaneously occur. It is crucial that prompt attention is given to this situation and it is remedied before exhaust backpressures

even reach the specified backpressure limit. Continuing to operate with an increasing exhaust backpressure will lead to overloading the DPF with soot. When regeneration is initiated, the large mass of soot may create temperatures hot enough to crack or melt the filter element, thus compromising the filter's efficiency. A similar scenario applies to active systems. Failure to timely regenerate the filter will cause increases in back pressure during a production shift which, if continued, will cause loss of engine power and may invalidate engine warranties.

Thermal runaway may also occur during manual regeneration. Because of the build up of ash, an unburnable component of diesel soot arising from burning lubrication oil, the baseline back pressure of any DPF will rise slowly. Approximately every 1,000 hours, the DPF should be cleaned of the ash following the manufacturer's procedure.

Engine malfunctions and effects on DPF: Normally in mining, engine malfunctions are indicated by excessively smoky exhaust. That indicator will not occur with DPF systems. Malfunctions such as excessive soot emissions, intake air restriction, fouled injector, and over-fueling, may result in an abnormal rise in back pressure in systems that do not spontaneously regenerate. Also, these conditions could lead to abnormal changes in back pressure in passive systems because the malfunction may raise exhaust temperatures causing the excess soot to be burned off. These malfunctions may be detected during the usual 250-hour maintenance and emissions checks conducted upstream of the DPF using carbon monoxide (CO) as an indicator.

The other major filter malfunction is excessive oil consumption that is sometimes associated with blue smoke that could be masked by the performance of the DPF. However, excessive oil consumption leads to a rapid increase in baseline backpressure due to ash accumulation. Excessive oil

consumption can be detected if records are kept on oil usage.

Detecting malfunctioning DPF: As noted above, the DPF can be damaged mainly by thermal events such as thermal runaway. Shock, vibration, or improper "canning" of the filter element in the DPF can also lead to leaks around the filter element. A Bacharach/Bosch smoke spot test can be used to verify the integrity of a DPF. Smoke spot numbers below "1" indicate a good filter; smoke numbers above "2" indicate that the DPF may be cracked or leaking. Smoke spot and CO tests during routine 250 hour preventative maintenance is a good diagnostic practice. Note that although a smoke spot number above "2" may indicate a cracked or leaking filter, such a result does not necessarily mean the filter has "failed" and is not functioning adequately. In MSHA evaluations of DPF performance at the Greens Creek mine, filters that tested with smoke numbers above "2" were still shown to be over 90% effective in capturing elemental carbon, based on subsequent NIOSH 5040 analysis of the smoke spot filters.

Some commenters have suggested that diesel particulate filters are not a feasible DPM control option because they are not commercially available for the full range of engine horsepower used in underground metal and nonmetal mining equipment, especially low horsepower units (less than 50 hp) and high horsepower units (greater than 250 hp). MSHA has found that suitable DPFs for engines of the horsepower used in underground metal and nonmetal mining equipment are commercially available. The following discussion addresses low horsepower and high horsepower applications, respectively.

Low horsepower engines ranging from around 5 horsepower to around 100 horsepower are frequently used in ancillary and support mining equipment such as personnel transports, utility tractors, "gators," fork lifts, pumps, welders, compressors, and similar equipment, both mobile and stationary. The duty cycle of this type of equipment