Handout

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EGSA – Training

Load Banks in Conjunction with a Diesel Particulate Filter

D/DCommittee

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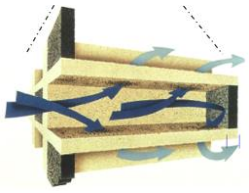
A diesel particulate filter (DPF) removes particulate matter from diesel exhaust by physical filtration. Many filter types are available, but the most common type is a ceramic (cordierite or silicon carbide) honeycomb monolith. The structure is like an emissions catalyst substrate but with the channels blocked at alternate ends. The exhaust gases must therefore flow through the walls between the channels and the particulate matter (PM) is deposited on the walls.



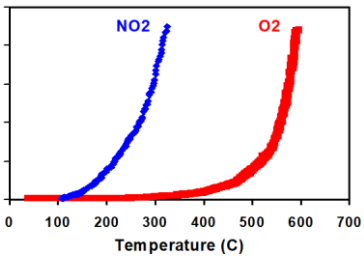
The filtration efficiencies of diesel particulate filters are >99% for solid matter. Since diesel particulate matter has a non-solid portion, the total efficiency for this is lower than this (approx. 90% to 95%).

Because any filter has a finite capacity, all particulate filter systems include some means of regeneration or cleaned out intermittently or continuously if they are not to block engine exhaust by creating excessive back pressure. This is most important, since an overfilled filter can damage the engine and can itself damage the DPF. The material that becomes trapped in the filter is in most part carbon [C] particles (soot) with some absorbed hydrocarbon.

Two common techniques for removing soot particles trapped by a DPF (other than mechanical cleaning) are:

Soot Combustion with oxygen (O2) . . .
[C] + O2 → CO2

Soot Combustion with nitrogen dioxide (NO2) . . .
[C] + NO2 → CO2 + NO



NO2-based systems are greatly favored because the **(NO2)** reaction takes place at lower temperatures (seen in most diesel engine exhaust), as compared to **(O2)** based systems needing higher temperatures for the reaction to occur.

Two principle DPF types are:

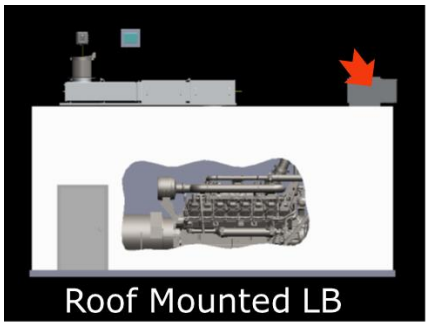
Passive – which are able to regenerate themselves using only the exhaust gas stream and without additional energy inputs.

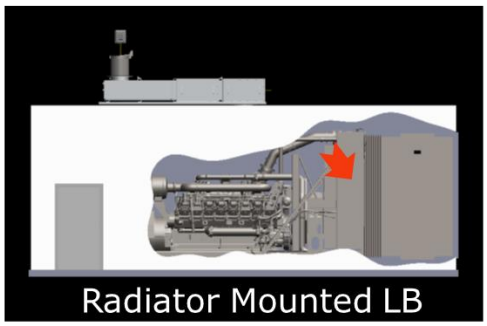
Active – which require an external source of additional energy to drive either of the two typical regeneration techniques (i.e., with oxygen or with nitrogen dioxide). It is desirable to maximize the amount of passive regeneration that can be achieved, since passive regeneration is 'free', requiring no additional energy.

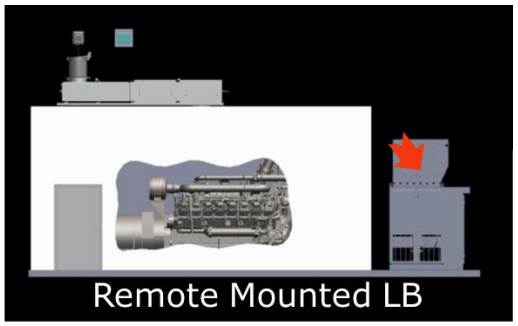
When air permit regulations require a reduction in PM from a diesel engine, the addition of a DPF will achieve this goal, however, unlike a muffler - that requires almost no attention or maintenance . . . a DPF must be qualified for proper engine service and must be monitored (to varying degrees) to continue to operate well and continue to reduce emissions from diesel engine exhaust.

- If the emergency electrical load of a standby/emergency generator application is lower than a load which would enable the passive DPF to regeneration . . . then a load bank should be used to assure DPF regeneration (when needed) and thus prevent excessive engine back pressure, which can shutdown or damage the engine. Adding such a load bank (whether as a rental load bank or as a permanent load bank . . . creates an Active DPF application).

- Running a generator at higher than parasitic load is both good for the generator and helps assure the backup power system is going to be reliable because when testing the generator for proper operation, it can be tested at high enough load to mimic an actual emergency condition.







- When a load bank is part of a passive DPF system approach, you can create an DPF filter system that can actively regenerate at will, and thus assure reliable generator performance overall and for long periods of time. The three common ways a load bank (LB) can be added to an engine generator that is equipped with a passive DPF, are shown above.

- The roof and radiator mounted LB are almost always matched one-to-one with the engine/generator, but a remote mounted LB can be shared between several generators, thus providing significant capital cost savings.

- As mentioned, . . . it is the emergency electrical load(s) that oversees whether it is best to add a LB to a DPF application. For example, if the plant electrical load during an outage is going to vary between 45% to 85% of generator capacity, then during this range of emergency load we need to confirm if the DPF will be regenerating (burning soot) off the DPF filter so that excessive engine back pressure is prevented during the emergency outage.
- Finding out what is the lowest engine load that will regenerate the DPF and prevent a growth (increase) of DPF back pressure is referred to as sizing the LB to the minimum regeneration temperature.
- Then by comparing the lowest emergency load vs. the lowest DPF regenerating load . . . we determine what size LB to bring out to a site for a DPF regeneration or what LB to permanently install on the engine/DPF application.
- For example, if the generator is going to have to deliver an emergency load in the range of 40% to 80% of capacity and it is determined that the DPF will continuously regenerate at 50% load or above*, then a LB of at least 10% of capacity should be added to assure regeneration during emergencies.
- Or for example, if the generator will only have between 10% to 25% of capacity to provide during an electrical outage, and the DPF still requires 50% of capacity load or above to regenerate, then in this case, a LB of at least 40% of capacity should be added. NOTE: it is always good to provide about 15% to 30% more LB than what was calculated to account for fluctuations in exhaust conditions vs. other conditions (ex. outside temperature) and thus give the site a margin in LB capacity.

* 50% of generator capacity or higher, is usually the amount of LB sizing needed to assure continuous regeneration conditions for the DPF

When using a Rental LB at the generator site to regenerate*

- It is best to bring out a LB that is equal to the generator capacity. This will assure being able to run the generator to 100% load, and thus not worry about not having enough load to regenerate the DPF.

- After connecting the LB to the generator with passive DPF, start running at a low load (perhaps 25% of so) for a while (10 minutes or so) to establish the amount of back pressure on the engine at this lower load. NOTE: DPF units should have a back pressure monitor which will display the back pressure on the engine when the engine is running. If not, then connect a back pressure gauge or electronic gauge to the exhaust outlet (usually just before the DPF inlet) to measure back pressure.

- If during this 25% load test condition the back pressure measured is under the maximum allowable engine back pressure, you can proceed to raising load higher with the LB (10% more would recommended). Then recheck after a few minutes what this higher load back pressure is, and again if it is lower than the maximum allowable engine back pressure (which you must find out from the engine manufacturer) then raise load on the engine another 10% and re-measure back pressure.

- Continue in this fashion of raising engine load and measuring back pressure until you get to a point of either seeing back pressure decrease slowly as a function of time, or you reach the maximum allowable engine back pressure. If you reach the maximum engine back pressure and don't see the back pressure decreasing as a function of time (give it at least 20-30 minutes before concluding it isn't). If it isn't, then the DPF filter is too excessively fouled to be regenerated in-place safety, and the actual filter elements should be removed for a mechanical cleaning of the filter elements.

- If, however, you begin to see a decreasing of back pressure on the engine as you ramp up load in 10% or so increments . . . then hold that load on the engine to enable the DPF to regenerate as completely as possible (i.e. you see a steady reduction in engine back pressure, but then it pegs out and no longer decreases . . . which signals that the maximum cleaning has occurred and hopefully has restore the engine back pressure to what was present at the time of first DPF install (i.e. nearly a pristine clean state as it was when once new).

When using a permanent LB at the generator site to regenerate*

- The size LB should have already been selected properly to regenerate, and it is just a matter of following the same type of regeneration scheme as mentioned for the rental LB procedure.

- Again, pay attention to engine back pressure readings while regenerating and don't exceed maximum allowable engine back pressure. If there is no load that results in decreasing back pressure, then it is very likely the DPF is too heavily plugged/fouled with soot (engine left going at too low a long for too long a time before regenerating the DPF), and the need for a mechanical DPF cleaning is best.

PRECAUTIONS: 1). Never attempt to over-pressure the engine by going to higher load because this can result in either engine or DPF or both becoming damaged. 2). Running at too high a load for regeneration when a lower load would suffice is also not recommended, because excessive heat in the DPF could be generated and thermal damage may occur. 3). Always record and document readings during LB regeneration . . . this will help properly document the regeneration and provide a permanent record of its performance . . . which is recommended at least once a year.

- A passive DPF should be regenerated once a year if insufficient engine load is present during routine testing. This is based on a routine engine/generator testing program of less than 50 hours per year per generator. Hours run for emergency backup are not being counted towards the 50-hour total, because it is assumed that during emergency loads, the passive DPF is continuously regeneration and soot build up is not accumulating during the emergency outage(s).
- If there are any questions about the load bank operation or the DPF operation, or how one vs. the other should be operated, then one should seek qualified and/or the manufacturer's help in resolving such issues.
- Along with keeping records of load bank and DPF operation and maintenance, there should also be records of engine operation and maintenance kept. This will help in any future troubleshoot of the DPF or the load bank, since some unusual engine operation or lack of engine maintenance can impact the performance of the DPF or indirectly affect the performance of a permanent load bank.
- Because backup power engine generators as well as load banks and passive DPF systems vary widely: by type, by size, by specifications, by ambient conditions, operation, exhaust process conditions, etc., . . . this handout is not meant to cover all possible scenarios or to imply that all matters regarding equipment operation, safety, etc. are addressed by this handout This handout is simply to further one's education of such devices and their features. Furthermore, this handout is not meant to be a substitute for the manufacturer procedures, manuals, and guidelines of their product(s) or the combinational use of same.
- As a service provider for engine/generator backup power systems, you may come across a system design with a passive DPF or one with passive DPF plus load bank . . . and perhaps this handout will be of some help in addressing these types of systems from the standpoint of operation, maintenance, and service discussion.

Multi-Engine Applications at the same location

- A single remote load bank can be configured to regenerate more than one passive DPF (i.e., benefit of having less number of load banks vs. number of engine/generators at a site). When this type of system is designed and implemented considerable project savings can be realized without compromising reliability or emission control.

- Furthermore, with the use of a DPF data-logger/monitor that has remote communicate and can daisy-chain communications via a single ethernet connection . . . the owner of a multi-engine application will realize benefits in maintenance, manpower, monitoring and regeneration of each DPF system.

- With a smart design of both passive DPFs, load banks and DPF datalogger/monitors, an economy of scale is realized and for some clients who install 10's upon 10's of engine/generators at one facility, will realize many 100's of thousand of dollars in capital savings and 10's of thousand of dollars in maintenance and reporting costs over the lifespan of the emergency engine generators.