Passive, Active, or Load Bank?
The Case for Improved Diesel Particulate Filtration

By Daniel Serrano & Daniel Williams

What is the use of a house if you haven’t got a tolerable planet to put it on?
-Henry David Thoreau

Knowledge is power.
- Sir Francis Bacon

Introduction
Your passive diesel particulate filter (DPF) may be on the verge of failure. Since 2004, when major legislation caused most California businesses to scramble to meet compliance, facilities managers, business owners, and power generation technicians have installed thousands of passive DPF units on stationary engines across the state. However, many operators have neglected (or been unable to initiate) the maintenance procedures specific to these units, and for many, catastrophic failure lurks around the corner.

The following paper will explain why passive units fail, and the benefits of augmenting or upgrading your facility’s passive DPFs to avoid costly repairs to your stationary diesel engine’s DPF system—or the engine itself. This paper will specifically discuss passive DPF technology, load banks and their applications, and characteristics of active DPF technology; address potential maintenance issues inherent to either system; and offer practical advice to facilities managers and business owners on choosing a service provider for their equipment.
Diesel Emissions and Passive Filtration: A Review

Diesel Emissions

All diesel engines emit particulate matter (PM)—a mixture of solid carbon, hydrocarbons (partially burned fuel and lube oil), and sulfur oxides with small amounts of ash. These emissions are byproducts of processes such as incomplete combustion of fuel, high-pressure mixture component reactions, and engine oil/oil additive combustion that, while not ideal, occur during any diesel engine’s operation. Combustion of non-hydrocarbon components of diesel fuel, such as sulfur compounds or various fuel additives, also produces PM, and unfortunately, these emissions cannot be eradicated, only managed.

In recent years, the medical and scientific communities have begun to investigate the potentially dangerous effects of diesel emissions. While their research is new, and in many cases their results are still pending interpretation, it would appear that the PM portion of diesel exhaust is the most deleterious to human health; most publications now agree that the solid carbon (along with organic material) found in PM is particularly dangerous. Particulates that are smaller than ten microns are considered especially dangerous because they bypass the body’s natural defenses and penetrate deep into the lungs. This creates the potential for both cancerous and non-cancerous health effects.

In 1998, the State of California identified diesel exhaust as a toxic air pollutant, and in 2004, the California Air Resource Board (CARB) passed legislation limiting particulate output from stationary diesel engines with power output in excess of fifty horsepower, requiring owners to bring these applications into compliance through modification or to remove them from service. This rule, which covers the engines found in electric power gen-sets, grinders, rock crushers, sand screeners, cranes, cement blowers, air compressors, water pumps, and various applications, necessitated an immediate response from equipment owners, who frequently opted to outfit their engines with one of several aftermarket emissions-control solutions. Diesel particulate filters were the most popular choice.

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Passive DPF Technology

Through the process of state verification of emission control products, CARB and various local Air Quality Management Districts (AQMD) made DPFs attractive choices for many equipment owners: the devices trap more than 85% of the PM (level III verification) in the exhaust from the engines on which they are installed, bringing them into compliance with emissions laws with minimal engine modification. Most commonly, a DPF is a wall-flow monolith with alternatively plugged cells that force the exhaust to pass through a porous wall (see Figure 1), trapping particulate inside.

However, because they filter exhaust very efficiently, DPF systems can quickly accumulate substantial amounts of PM which, in turn, will increase the amount of restriction in the exhaust flow and increase backpressure. If neglected, this increase in backpressure can cause power loss or damage to the engine and permanent damage to the DPF system. Repair or replacement of the DPF can be extremely costly. To prevent damage, the DPF system is built to clean itself by regenerating: burning the trapped PM, which converts it into CO_2 and water vapor. These gases then pass through the filter and lower backpressure on the engine.

Passive DPF systems, which represent the majority of CARB-verified systems, rely on the engine to create high exhaust temperatures at the filter (usually 465°F to 752°F) through high-load operation: they must operate at high loads (60% to 90% of their maximum) to reach the temperatures needed to burn their stored particulate. However, some generators do not see this kind of use. Standby generators get most of their run time during maintenance and testing, at little or no load, in preparation for a power outage. During this low-load run time, a DPF will accumulate PM, but since it is not operated under conditions sufficient to initiate regeneration, the PM simply accumulates, and gradually restricts the exhaust escaping the system. Backpressure on the engine will rise consequentially, and if unattended, will destroy the system. Even during a power outage, a generator may not have enough load to cause regeneration, and for this reason, many passive systems will fail.

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Zentrek Industries*: A Case Study
(*Actual name changed to protect confidentiality)

Zentrek Industries, a major industrial supplier in the Bay Area, operates a processing plant with several standby generators. In 2004, Zentrek installed passive DPFs on their emergency power generation equipment to comply with CARB regulations. In 2009, they discovered that their engines were operating with an unacceptable level of backpressure. Despite rigorous maintenance and scheduled testing of their generators, their engines were in danger of failing because they couldn’t regenerate their DPFs with the loads that were being used—their filters continued to plug with diesel particulate matter.

Zentrek’s Facilities Manager contacted an experienced service provider in the Bay area, who found that monthly operation over the years did not create enough load to support the passive DPF. Since soot accumulated in the unit’s filters and the temperature rarely rose to a level conducive to PM oxidation, the units were unable to regenerate, and the particulate matter trapped inside them continued to increase. After several years of use, the filters were almost completely clogged... And Zentrek Industries had a serious problem.

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Since their DPFs increased backpressure beyond the published engine limits, Zentrek was technically no longer in compliance with the CARB legislation affecting their engines. Facing stiff fines, the organization’s Facilities Manager approached several generator service providers and found, to his dismay, that the cost of replacing the filters was prohibitively high—$12,000 to $20,000 per filter. With six to nine individual filters in each engine’s DPF, Zentrek was faced with a bill of $108,000 to $120,000 each to replace their improperly-maintained units, as well as the associated downtime and uncertain possibility of initiating future regeneration in their newly-serviced units.

Unfortunately for Zentrek Industries, inaction was not an option: if an emergency lasting more than a few hours was to occur, Zentrek’s filters could completely fail. In one scenario, the exhaust pressure would bypass the packing material holding the filter in place and cause the filter to vibrate and shatter, dispersing dust and PM into the atmosphere. In another scenario, increased heat caused by the emergency operation or by the engine having to work harder to push the exhaust through would cause the filter to start an uncontrolled burn and destroy the unit. Regeneration was no longer an option, either: at the advanced state of blockage in Zentrek’s filters, regeneration would be akin to blowing hot oxygen on a lump of burning coal—the temperature would get extremely hot, and melt and destroy the filter.

Finally, with non-compliance a non-option, Zentrek’s Facilities Manager was approached by a service provider familiar with their problem, who recommended active DPF technology [see section two]. Although replacing their units eventually cost Zentrek Industries $3.4 million, they still saved money: the new, active DPFs’ cost was comparable to the bank of replacement filters each passive unit would require and potential downtime costs from a non-functioning generator—the lower maintenance costs of an active system will also prevent further expense in the future.
The Case for Improved Filtration

Zentrek Industries’s experience illustrates the case for improved exhaust filtration for backup stationary power generation units very clearly: a backup unit, which during normal operation operates at maximum capacity for only minutes at a time and at irregular intervals, is subject to different maintenance requirements than a system operating at 60% to 90% capacity for longer periods of time. Managers of DPF-equipped emergency power generation equipment should familiarize themselves with the special maintenance requirements of their equipment and the additional equipment available to augment the weaknesses specific to each system.

STEP 1. Determine Your Needs

The first step in actively managing your facility’s DPF needs is to determine the proper filtration system for your organization. How often do you operate your stationary engine? What is your budget? How frequently will you service your DPF unit?

If you operate your stationary engine at 60% to 90% of its maximum capacity for a few hours or more at a time, a passive DPF should be sufficient to bring your engine into compliance with CARB emissions standards and prevent potential backpressure-related engine failure. Provided that you follow your DPF manufacturer’s instructions and allow your stationary engine to produce enough heat to initiate regeneration, your DPF’s maintenance requirements should be minimal. For non-backup, non-emergency applications, a passive DPF is usually sufficient. However, if your unit operates only sporadically or for only short periods at a time (as is the case for most backup units) you may need to augment your passive DPF with a load bank, or replace it with an active unit.

A thorough survey of your facility’s energy needs and examination of your current maintenance schedule with a qualified service provider should be your first step in determining your needs. A representative from a qualified provider will be willing to visit your site, examine your equipment, and address your concerns. Your provider’s technician will evaluate your filters to check for accumulated PM and to determine if they are regenerating as needed. If necessary, he or she will also recommend corrective action or additional equipment.

STEP 2. Upgrade Your Equipment

Load Bank Technology: Augment Your Passive DPF

When attached to your passive DPF system, a load bank will simulate the conditions found in a generator operating near full capacity; the high heat will allow regeneration to occur within your DPF, and the PM trapped inside will disintegrate and exit the system. In most cases, periodic use of a load bank on your DPF will be sufficient to keep it unblocked. Your budget will determine whether you install a load bank permanently or arrange for a service provider to perform the operation on a scheduled basis, but either option should suffice, provided you follow the specific maintenance requirements recommended by your DPF’s manufacturer.

There are several factors to consider regarding physical transportation and placement of a load bank at your facility. While portable load banks have become significantly smaller and more manageable in recent years, the units are still large, and often carry additional transformers to accommodate the differing voltage specifications particular to the various sites that any given unit may serve. Plan the unit’s arrival in advance, and prepare your site and personnel for the visit: The logistics of this type of operation can be complex: coordinating street closures, the arrival of forty foot trailers at five AM, running out the cables, and commissioning for an eight AM start on a Saturday morning. The [operation] can vary according to the number of generators […] and there may be a heat run up to twelve hours.

Discuss in detail the challenges specific to your facility in planning the arrival of a load bank with your service provider: have you provided adequate clearance through your facility’s lot for the unit to be delivered and
installed? Have your security personnel been notified and briefed on the provider’s arrival? Will their presence disrupt your employees or customers? If you plan to install one or several load banks at your facility, take their size and your facility’s voltage requirements into consideration as well: you may need a transformer in addition to the load bank. Your service provider should be thoroughly educated on your specific site preparation and logistics needs, and will plan with you to make the process run as smoothly as possible.

**Active Filtration: The Low-Maintenance Option**

An active DPF system differs most crucially from its passive counterpart in that it uses an electric current to incinerate diesel particulate trapped in its filter. This electric type is the only option for stationary engines at this time—there are other types of technology that use diesel fuel to create a flame inside the DPF unit which will sufficiently increase exhaust temperature, but these are only available in California for on-road and off-road mobile applications. Unlike a passive system, an active DPF requires no engine heat or exhaust to operate effectively, and as such, is not subject to the same load requirements as a passive system that has not been augmented with a load bank.

Because an active DPF does not require many hours of high-load operation, fuel savings alone help significantly in reducing the overall cost of the unit. Active DPF-equipped stationary engines are thus exempt from much of the maintenance associated with unmodified or load bank-augmented passive systems, although they may require a significantly higher capital investment from the user.

As with a load bank, preparation for your facility’s special needs is integral to a successful active DPF installation. Talk to your service provider about the various options available to you—what is the proper make and model filter for your stationary engine? How will you power the unit—unlike passive units, active DPFs require electricity to initiate regeneration; is your facility’s power grid prepared for this new configuration? As with most other concerns related to your DPF, a trained and knowledgeable service provider will be able to answer your questions and help you prepare your facility prior to the unit(s)’s arrival.

**STEP 3. Form a Maintenance Plan (And Follow It)**

After determining your facility or application’s specific needs from a DPF system, you should consider the specifics of your chosen solution: with your new unit—load bank or active DPF—in place, begin considering its maintenance needs, and form a plan. Talk specifically about your generator’s future needs with your service provider—they will most likely have service plans that can be tailored to your specific needs, and will definitely be able to estimate the cost of service across various timelines so you can include their services in your budget.

Generators equipped with a passive DPF should have some kind of diagnostic module to monitor exhaust temperature, backpressure, time, and date. These monitoring devices will let you know when the filter needs to be regenerated. The data from the monitoring device should be looked at periodically and after any power outage. Ask your provider what to look for on the unit, and monitor it regularly. You are the first line of defense against failure,

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and your quick response to potential problems could save your organization thousands of dollars in repair bills and hours of costly downtime.

Most passive DPF manufacturers size their filters to allow twelve to twenty-four ten-minute cold starts prior to needing regeneration, and monitoring your engine’s backpressure during a load test will show you the exact point when your particular filter starts to regenerate. Pay attention to your filter’s PM accumulation, and get to know when it needs to regenerate. By monitoring the process, you will become familiar with your particular unit and its needs, thus allowing you to more accurately measure its performance and anticipate potential problems.

Finally, make sure to have backup personnel at your organization who are knowledgeable of your equipment and maintenance schedules. Your planning will do your organization no good if you cannot follow your schedule due to an illness or vacation.
## DPF System Comparison

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<th>Passive DPF</th>
<th>Passive DPF + Load Bank</th>
<th>Active DPF</th>
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<tbody>
<tr>
<td><strong>Initial cost</strong></td>
<td>Lowest</td>
<td>Low initial cost to purchase passive DPF units, significant additional expense to purchase load bank (they are often rented)</td>
<td>Highest initial cost</td>
</tr>
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<td><strong>Lifetime cost</strong></td>
<td>Dependant on operating circumstances—low, if proper operating conditions are met; very high if improperly maintained</td>
<td>Rental units represent ongoing expense, in addition to recurring interruptions; purchased units generate minimal operating costs</td>
<td>Relatively low—units are not subject to maintenance requirements of passive DPFs</td>
</tr>
<tr>
<td><strong>Reliability</strong></td>
<td>Highly dependant on operating circumstances — must be used under certain conditions to ensure reliability</td>
<td>Reliable, although rented units are subject to differing levels of use</td>
<td>Highly reliable</td>
</tr>
<tr>
<td><strong>Size</strong></td>
<td>Smallest</td>
<td>Large</td>
<td>Similar to passive units</td>
</tr>
<tr>
<td><strong>Electrical power draw</strong></td>
<td>None</td>
<td>Substantial, but intermittent and somewhat user-scheduled</td>
<td>Minimal (&lt;1%), periodic</td>
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<td><strong>Maintenance</strong></td>
<td>Relatively high—units self-clean only under ideal circumstances and should be monitored closely</td>
<td>Rented units require minimal maintenance on part of customer—purchased units require more vigilance</td>
<td>Minimal by comparison—units automatically initiate regeneration electrically with high efficiency</td>
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### Which System is Ideal for Which User?

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<th>Emissions solution...</th>
<th>Ideal user...</th>
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| Passive DPF           | • Available building load (60%-90%) can be applied for regeneration  
• Engine operates 60%-90% capacity for long periods  
• Regularly maintains and monitors filters |
| Passive DPF + Load Bank | • Follows regimented schedule closely  
• Can withstand interruption in service to operate load bank |
| Active DPF            | • Operates standby stationary engine  
• Operates engine sporadically, or at low levels  
• Willing to accept higher initial cost  
• Desires minimal maintenance |
Conclusion

Ultimately, the only ways to avoid potential problems with your passive DPF system are to augment it with a load bank or to upgrade to an active DPF system. While each option represents a short-term increase in expense, they all fall short of the cost of repairs to any DPF system following catastrophic failure. By partnering with a trained and educated service provider, you will avoid costly mistakes and help keep your business profitable into the future.

Finally, remember that when you contact a provider for information about your facility’s DPF systems, you are paying for a service, and (ideally) beginning a lasting and mutually-beneficial relationship. Don’t be afraid to ask questions. Augmenting or replacing your passive DPF system is an expensive proposition, and while it is a proven means of dealing with the weaknesses inherent to passive systems, no solution is foolproof. Ask your provider about the maintenance requirements particular to your system, and follow his or her advice. An ounce of prevention is always worth a pound of soot, ruined equipment, and a massive repair bill.

AUTHORS:

Daniel Serrano is the Emissions Specialist at Peterson Power Systems, the Northern California dealership for Caterpillar power equipment. He attended ITT Technical Institute, where he received a degree in Design; he then spent four years as a designer for CleanAIR Systems, Inc., where he designed emissions retrofit equipment for European and North American equipment (including the largest emissions retrofit project in United States history.) Daniel then spent several years as a national emissions sales representative at CleanAIR, helping the company become the first CARB-certified emissions solutions provider in California and the number one supplier of diesel particulate filters to the mining industry. He joined Peterson in 1997, and is responsible for emissions-control equipment sales throughout the company’s territory.

Daniel Williams is the Marketing Communications Coordinator for Peterson Holding; he attended George Mason University, where he studied English Literature and Composition. Prior to joining Peterson, he worked in the marketing department of a national federation of human service charities based in Northern Virginia.

REFERENCES:


QUINN POWER SYSTEMS

3500 Shepherd St. • City of Industry, CA 90601 • 562.463.6040 • www.quinnpower.com