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# Nett VorTEQ™ Active DPF System

v1.2

# Contents



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## Introduction

Diesel particulate matter (DPM) is one of the most troublesome emissions from the diesel engine. Due to its sub-micron particle size, DPM is almost totally respirable. Elevated concentrations of DPM, which may accumulate in the ambient air, present a serious health concern and are the subject of increasingly more stringent environmental and occupational health regulations worldwide.

Nett Technologies designed the VorTEQ™ active diesel particulate filter (DPF) system to effectively control DPM emissions from diesel engines in such applications as construction machinery, port and rail yard equipment, diesel forklifts, urban buses, municipal vehicles, and diesel generator sets. The active system offers more flexibility for regeneration and can be designed for regeneration at any engine operating condition. Thus with an active system, regeneration is possible at idle or at light engine load conditions, when the exhaust gas temperature is below the catalyst light-off temperature.

The VorTEQ™ active DPF system utilizes a wall-flow monolith substrate to capture the soot produced by a diesel engine. The filter is regenerated using a diesel fuel burner, which periodically increases the filter temperature to a level necessary to oxidize the collected particulates. The VorTEQ™ active DPF system typically provides an over 95% reduction in DPM emissions and total elimination of the black smoke.

## What is Diesel Particulate Matter?

*Diesel particulate matter*, as defined by the US EPA regulations and sampling procedures, is a complex aggregate of solid and liquid material. Its origin is carbonaceous particles generated in the engine cylinder during combustion. The primary carbon particles form larger agglomerates and combine with several other, both organic and inorganic components of diesel exhaust. Generally, DPM is divided into three basic fractions:

- Solids - dry carbon particles, commonly known as soot,
- SOF - heavy hydrocarbons adsorbed and condensed on the carbon particles, called Soluble Organic Fraction,
- $SO_4$ - sulfate fraction, hydrated sulfuric acid.

The actual composition of DPM will depend on the particular engine and its load and speed conditions. "Wet" particulates can contain as much as 60% or more of the hydrocarbon fraction (SOF), while "dry" particulates are comprised mostly of dry carbon. The amount of sulfates is directly related to the sulfur content of the diesel fuel.

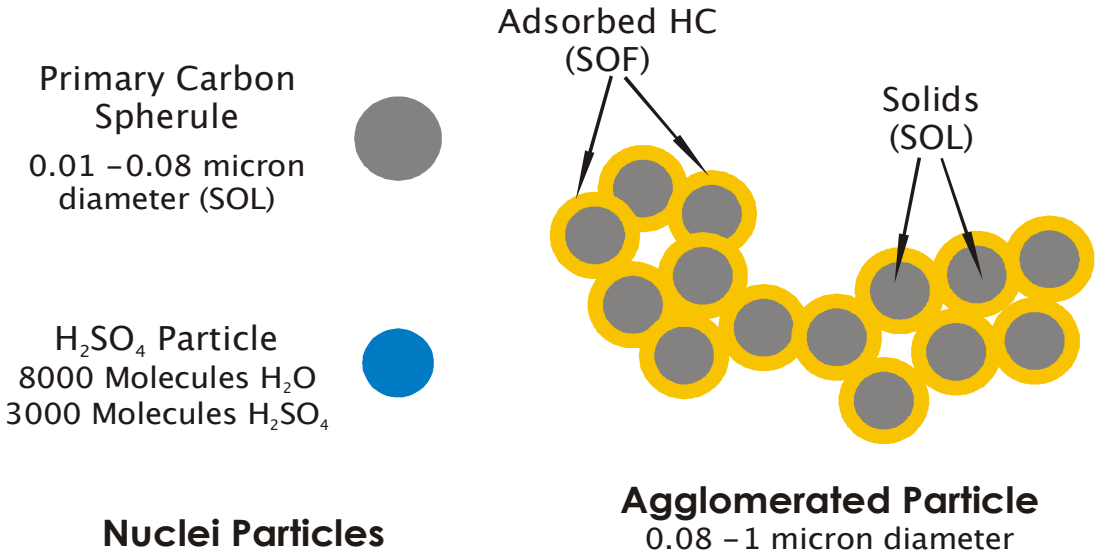


**Figure 1. Schematic Composition of Diesel Particulate Matter**

Diesel particulates are very fine. The primary (nuclei) carbon particles have a diameter of 0.01 - 0.08 microns, while the agglomerated particles diameter is up to one micron. As such, diesel particulate matter is almost totally respirable and has a significant health impact on humans. It is known to increase the risk of heart and respiratory diseases. It has been also classified by several government agencies as either "human carcinogen" or "probable human carcinogen".

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## Components of Nett VorTEQ™ Active DPF System

The main components of the VorTEQ™ active DPF system are:

- Diesel particulate filter
- Diesel fuel burner
- Fuel pump
- Electronic control unit (ECU)
- Driver display/interface unit

A schematic of the system is shown in Figure 2.

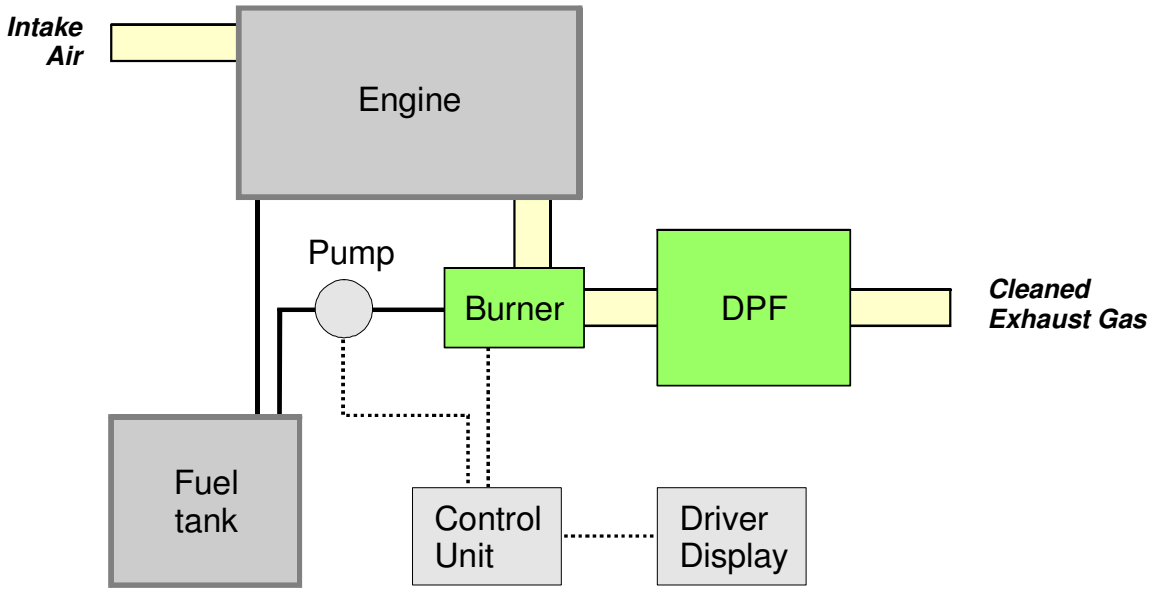


**Figure 2. Nett VorTEQ™ Active DPF System Schematic**

The filter monolith is wrapped in a fiber mat and packaged into a stainless steel housing, which is installed in the vehicle's exhaust system.

The burner is installed upstream of the DPF. In most applications, the burner is integrated with the particulate filter into one burner/DPF unit. In some applications, a separate burner unit is installed upstream of the DPF. The choice of configuration depends on the availability of space on the vehicle and the customer preferences.

The operation and regeneration of the filter is controlled by an electronic control unit. During regeneration, the fuel is supplied to the burner by a fuel pump and ignited by a glow plug. The burner utilizes the exhaust gas as a source of oxygen for combustion—a feature that makes a dedicated combustion air supply unnecessary. The control unit initiates the regeneration and maintains the fuel injection rate to achieve the desired DPF inlet temperature. The control unit also signals the need for regeneration to the driver through the driver display system.

The driver display unit informs the operator about the system status, filter pressure drop level, the need for filter regeneration, and regeneration process details.

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## Operation—Soot Collection Phase

The VorTEQ™ active DPF system utilizes a silicon carbide (SiC) wall-flow monolith (filter substrate) to capture the soot produced by diesel engines. The cylindrical filter element consists of many square parallel channels running in the axial direction, separated by thin porous walls, as shown in Figure 3.

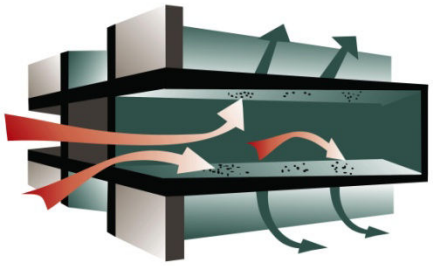

**Figure 3. Gas Flow in the Filter Monolith**

The channels are open at one end and plugged at the other, which forces the particle laden exhaust gases to flow through the walls. Gas is able to escape through the pores in the wall material. Particulates, however, are too large to escape and are trapped in the filter walls and in the inlet channels. Thus, the gas leaving the filter is free from diesel particulates.

The filter is catalyzed with a light loading of a platinum (Pt) based catalyst. The function of the catalyst is to control gaseous emissions (CO, HC) and diesel odor during filter operation and regeneration.

The filter emission performance depends on the engine and test conditions. DPM emissions are typically reduced by 90-98%, CO by about 80%, and gaseous HC by about 60%.

## Filter Regeneration

The filter must be periodically cleaned from the collected particulates to restore its filtration capacity and to avoid excessive pressure drop of the exhaust gas. This cleaning process—known as filter *regeneration*—is accomplished by increasing the filter temperature to oxidize (or burn off) the particulate matter. The control unit determines the need for regeneration based on the monitoring of the pressure drop across the DPF unit.

The particulate filter is regenerated using a fuel burner. The function of the burner is to increase the exhaust gas temperature through combustion of diesel fuel.

The burner is designed to operate under engine idle conditions. Two regeneration modes are possible:

- Manual regeneration, and
- Automatic regeneration.

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In most applications, the system is factory pre-programmed for *manual regeneration*. In the manual regeneration mode, the control unit signals the need for regeneration to the operator, who should stop the vehicle with the engine idling, and manually initiate the regeneration sequence through the display/interface unit. Once the regeneration is initiated, the control unit starts the burner and controls the fuel flow rate to the burner to maintain the preprogrammed temperature profile at the filter inlet. Once the regeneration is completed, the ECU signals it to the operator through the display unit.

Optionally, the system can be programmed for *automatic regeneration*. In the automatic regeneration mode, the control unit attempts to perform the regeneration automatically during vehicle operation. As the burner can be only operated during idle or light-load engine conditions, the ECU must detect when the engine conditions can support regeneration.

The idle or light-load operation is detected based on the measurement of exhaust gas temperature. If the idle condition is determined, the control unit will initiate regeneration automatically. If the vehicle begins to operate at a higher engine load, the ECU will interrupt the regeneration, and another regeneration attempt will be initiated during the next engine idle period.

The automatic regeneration mode is suitable for engines and vehicles with duty cycles that include repeated idle or light-load operation periods. In such applications, the filer regeneration can be performed in fully automatic mode, without any involvement of the vehicle operator.

If the vehicle duty cycle does not include sufficient idle periods, the automatic regeneration cannot be completed and the DPF pressure drop continues to increase. In such cases—after a number of unsuccessful automatic regeneration attempts—the control unit will prompt the driver to stop the vehicle and to perform manual regeneration.

The duration of regeneration is about 10-15 minutes. The frequency of regeneration can vary depending on the engine, its duty cycle, and other factors. Typically, the regeneration needs to be performed once for every 6-8 hours of operation.

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## Standard Models and Sizing Charts

Standard models of the Nett VorTEQ™ Active DPF system are listed in Table 1. Sizing for particular engines and applications should be consulted with our office before ordering.

**Table 1 Nett VorTEQ™ Active DPF System**

| Model | Max. Engine Power | |
|---|---|---|
| | hp | kW |
| **VX502** | 33 | 25 |
| **VX503** | 43 | 33 |
| **VX504** | 54 | 41 |
| **VX705** | 75 | 56 |
| **VX707** | 94 | 71 |
| **VX709** | 113 | 85 |
| **VX910** | 135 | 101 |
| **VX913** | 162 | 121 |
| **VX1011** | 147 | 110 |
| **VX1014** | 184 | 138 |
| **VX1017** | 221 | 165 |
| **VX1116** | 211 | 158 |
| **VX1120** | 254 | 190 |
| **VX1326** | 338 | 253 |

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