Nett Technologies Inc.
2-6707 Goreway Drive, Mississauga, Ontario
Canada L4V 1P7
tel: 905.672.5453
fax: 905.672.5949
e-mail: sales@nett.ca
web: http://www.nett.ca

fact sheet

S-Series Catalytic Diesel Particulate Filters

v3.0

Contents

Introduction

Diesel particulate matter (DPM) is probably the most troublesome emission 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 S-Series particulate filters to effectively control DPM emissions from heavy-duty engines in such applications as mining, tunneling, ports and rail yards, buses, trucks, and municipal vehicles. The filters utilize ceramic wall-flow monoliths which physically capture the particulates. The monoliths are coated with a catalyst which lowers the soot combustion temperature and facilitates self-regeneration of the filter under elevated exhaust temperatures. The exhaust temperatures needed for proper filter operation are typically encountered in most heavy-duty diesel engine applications. Nett S-Series soot filters typically provide an over 90% reduction in DPM emissions and total elimination of the black smoke.

fact sheet

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 up to 60% 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.

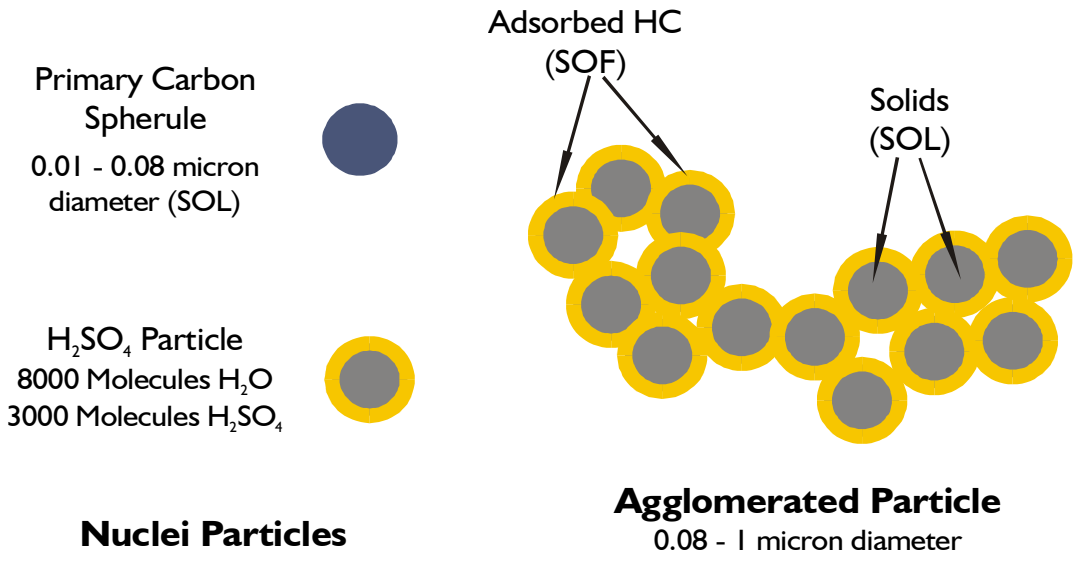

Figure 1. Schematic Composition of Diesel Particulate Matter

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 in the range of a few microns. As such, diesel particulate matter is almost totally respirable and has a significant health impact on humans. It has been classified by several government agencies as either “human carcinogen” or “probable human carcinogen”. It is also known to increase the risk of heart and respiratory diseases.

fact sheet

How the Filter Works

Nett® S-Series diesel filters utilize cordierite or silicon carbide wall-flow monoliths to trap the soot produced by heavy-duty 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 2.

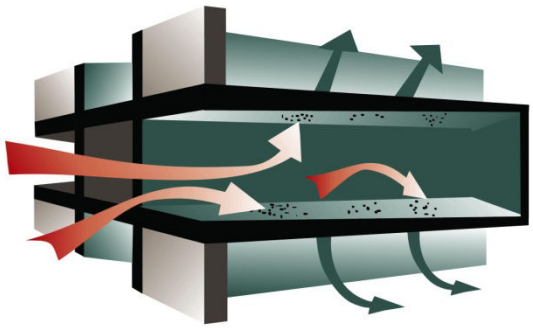

Figure 2. Gas Flow in the Filter Monolith

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.

A proprietary noble metal catalyst is coated onto the inside surface of the filter monolith. The catalyst lowers the soot combustion temperature allowing the filter to regenerate. The accumulated soot is oxidized in the filter during regular operation of the engine. For about 25-30% of the engine operating time, the exhaust temperatures must be at least 275-300°C (530-575°F) for proper filter regeneration when ULSD (ultra-low sulfur diesel) fuel is used. The exact temperature requirements change with engine technology, with installations on older, dirty engines requiring higher exhaust temperatures for regeneration. For example, filters installed on older off-highway engines with high DPM emissions (e.g., >= 0.30 g/bhp-hr) may require temperatures of 325-400°C (615-750°F). The regeneration also depends on other factors, such as the vehicle duty cycle, filter sizing and type of diesel fuel used. ULSD fuel (S < 15 ppm wt.) is now widely available and should be used whenever possible with any diesel particulate filter.

Usually, a recording of the engine exhaust gas temperature is taken before the installation of an S-Series filter. In applications where the exhaust temperatures are too low or high temperatures are seen only for very short periods, the filter may cause excessive engine back pressure. In extreme cases, clogging of the unit may occur.

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

fact sheet

Filtration Efficiency and Pressure Drop

The soot filtration efficiency of the Nett® S-Series catalytic diesel filter increases with the soot loading in the unit. Even at low soot loads the filter efficiency exceeds 90% (blue line in Figure 3). The visible smoke is completely eliminated by the filter, resulting in a dramatic improvement of smoke opacity readings.

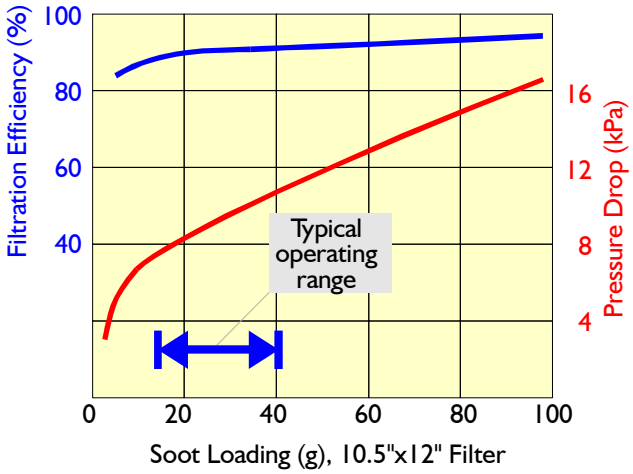

Figure 3. Typical Filtration Efficiency and Pressure Drop

Typical exhaust gas pressure drop on a properly regenerating filter is between 5 and 10 kPa (20-40" H_2O). There is a relationship between the exhaust gas temperature and the filter pressure drop. Applications with higher exhaust temperatures regenerate better, accumulate less soot in the filter, and experience lower pressure drop.

The filter pressure drop is also influenced by the engine-out DPM emissions. Dirty engines with high soot emissions require that more DPM is captured and oxidized in the filter, resulting in higher average soot loading and pressure drop. For this reason, filters are likely to work at a higher pressure drop when installed on high polluting engines.

fact sheet

Gas Phase Performance

Due to the presence of the oxidation catalyst, reductions in carbon monoxide (CO) and hydrocarbon (HC) emissions are also observed in the filter. The gas phase performance of the Nett® S-Series filters is similar to that of a standard diesel oxidation catalyst, as illustrated in Figure 4.

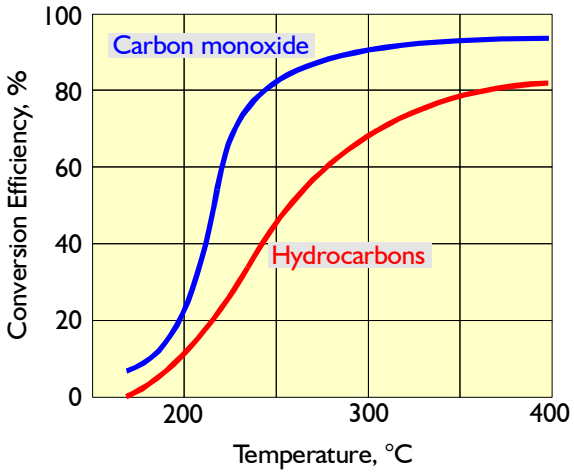

Figure 4. Conversion of CO and HC in Nett® S-Series Filter

The oxidation of soot in the filter requires quantities of oxygen. At moments, the concentration of oxygen in the filter may be insufficient for the reaction with CO. Therefore, the conversion efficiency of carbon monoxide may deteriorate when filters with high soot loading are regenerated.

Nett® S-Series filters do not change the total nitrogen oxides (NO_x) emissions from diesel engines.

Catalyst Types

Depending on the application, Nett® particulate filters can be ordered with one of the following catalyst types:

- Standard catalyst (SG and SX)
- Sulfate-suppressant catalyst (SI and SZ)
- NO_2 suppressant catalyst (SN and SO)

The standard catalyst provides the best activity and the lowest regeneration temperature requirements. However, if high sulfur fuels are used, the catalyst may generate sulfate particulates at elevated temperatures. As a general guideline, the standard catalyst should be used in the following applications:

- All applications with ultra-low sulfur fuel (S < 15 ppm).
- All applications, regardless of fuel sulfur level, where sulfates are not considered a particulate emission and are not regulated. Examples of such applications include underground non-coal mining in the U.S. (DPM exposures measured as total carbon)

fact sheet

or occupational health environments in Germany (particulates measured as elemental carbon).

The sulfate-suppressant catalyst eliminates the sulfate creation at the expense of a somewhat increased regeneration temperature requirement, typically by 10-15°C (20-30°F). This catalyst is used for applications with higher sulfur fuels (S > 15 ppm) which are sensitive to sulfate particulate emissions, such as most urban buses operated on high sulfur fuels.

Substrate Types

Nett® diesel particulate filters are available with two types of substrates:

- Cordierite substrates
- Silicon carbide (SiC) substrates

Cordierite substrates perform satisfactory in most heavy-duty applications with high exhaust temperatures. However, in low-temperature applications which may experience "uncontrolled regenerations", cordierite is more susceptible for damage from high temperatures, such as melting. Silicon carbide has higher maximum operating temperature limits and better durability in high temperature applications. Disadvantages of SiC include higher weight and higher cost.

Standard Models of Nett S-Series Filters

Standard models of cordierite and SiC diesel particulate filters are listed in Table 1 and Table 2, respectively. Sizing for particular engines and applications should be consulted with our office before ordering.

fact sheet

Table 1 - Nett® Diesel Particulate Filters: Cordierite Substrates (SG)

Model	Overall Dimensions			
	Diameter		Length	
	inch	mm	inch	mm
SG502	6.2	157	14.8	376
SG705	8.1	206	18.5	470
SG706	8.1	206	19.5	495
SG707	8.1	206	20.5	521
SG709	8.1	206	22.5	572
SG910	9.6	244	23.5	597
SG913	9.6	244	25.5	648
SG914	10.1	257	26.1	663
SG1014	11.1	282	24.7	627
SG1017	11.1	282	26.7	678
SG1116	11.9	302	26.6	676
SG1120	11.9	302	28.6	726
SG1123	11.9	302	30.6	777
SG1226	12.7	323	30.6	777
SG1228	12.7	323	31.6	803
SG1337	13.7	348	34.5	876
SG1543	15.7	399	34.2	869
SG1863	18.7	475	36.3	922
SG2077	20.7	526	38.2	970

Table 2 - Nett® Diesel Particulate Filters: Silicon Carbide (SX)

Model	Overall Dimensions			
	Diameter		Length	
	inch	mm	inch	mm
SX502	6.2	157	14.8	376
SX503	6.2	157	16.8	427
SX504	6.2	157	18.5	470
SX705	8.1	206	18.5	470
SX707	8.1	206	20.5	521
SX709	8.1	206	22.5	572
SX910	9.6	244	23.5	597
SX913	9.6	244	25.5	648
SX1011	11.1	282	22.7	577
SX1014	11.1	282	24.7	627
SX1017	11.1	282	26.7	678
SX1116	11.9	302	26.6	676
SX1120	11.9	302	28.6	726
SX1326	13.7	348	29.5	749

Custom housing designs are available to fit any engine configuration. A filter control box including exhaust temperature and pressure drop gauges to monitor the filter performance is also available.

fact sheet

Sizing Charts

Sizing charts for standard models of cordierite and SiC diesel particulate filters are listed in Table 3 and Table 4, respectively. Sizing for particular engines and applications should be consulted with our office before ordering.

Due to technology progress and stringent emissions regulation, engine-out PM levels from modern diesel engines are much lower than PM levels 10 years ago. The maximum engine power for S-Series filters in the sizing charts below apply to more recent model year engines.

Table 3 - Nett® Diesel Particulate Filters: Cordierite Substrates (SG)

Model*	Max. Engine Power *	
	hp	kW
SG502	33	25
SG705	75	56
SG706	85	64
SG707	94	71
SG709	113	85
SG910	135	101
SG913	162	121
SG914	181	135
SG1014	184	138
SG1017	221	165
SG1116	211	158
SG1120	254	190
SG1123	296	221
SG1226	336	251
SG1228	360	269
SG1337	479	358
SG1543	563	420
SG1863	810	605
SG2077	1000	746

* The max. power applies to engines with engine-out PM of 0.05g/bhp-hr

fact sheet

Table 4 - Nett® Diesel Particulate Filters: Silicon Carbide (SX)

Model*	Max. Engine Power *	
	kW	hp
SX502	33	25
SX503	43	33
SX504	54	41
SX705	75	56
SX707	94	71
SX709	113	85
SX910	135	101
SX913	162	121
SX1011	147	110
SX1014	184	138
SX1017	221	165
SX1116	211	158
SX1120	254	190
SX1326	338	253

* The max. power applies to engines with engine-out PM of 0.05g/bhp-hr

Life Span and Durability

Catalyzed ceramic particulate filters have been used in underground mining applications for many years. The mining experience indicates that filters installed on properly selected engines have life spans of 8,000 to 12,000 engine hours. In retrofit highway applications, catalyzed filters have been demonstrated to last for more than 240,000 km (150,000 miles). The filter life span, however, may be shortened due to engine maintenance problems and/or improper duty/regeneration cycle. For example, excessive heat release, which may occur during the regeneration of a soot-overloaded unit, may cause catastrophic damage to the ceramic filter monolith.

The S-Series filter regeneration and durability can be negatively influenced by the following factors:

- leaking injectors or dirty intake air cleaners
- excessive engine oil consumption or presence of lube oil in the exhaust gas
- changes in the vehicle duty cycle resulting in lower exhaust gas temperatures.

fact sheet