

3M Diesel Filter Cartridges

For Particulate Emission Control



Technical Bulletin

3M Innovation

Diesel Particulate Filter

Every diesel powered vehicle, while friendly from an endurance, global warming and fuel economy perspective, also spews out exhaust containing particulate matter (PM). As part of an overall engine management and exhaust management system, diesel particulate filters serve to significantly reduce PM emissions. These filter systems, comprising 3M filter cartridges, can be used on automobiles, buses, trucks, generators and off-road vehicles.

3M™ Diesel Particulate Filter cartridges are made of Nextel™ ceramic fibers also manufactured by 3M. These are the same high performance fibers used in flame curtains, stationary hot gas filters, thermocouple wire insulation and as components of the NASA Space Shuttle tiles among many other applications. There are numerous advantages in using filter cartridges made from Nextel™ polycrystalline metal oxide fibers.

- **Cartridge Durability**

The Nextel™ fibers are wound in continuous layers around the filter support tube resulting in inherent structural durability. The cartridges do not rely on separate and performance limited mounting systems to support the filter elements; they are securely fixed within the container using known and durable mechanical means (i.e. welding) and are thus able to withstand rigorous operating conditions.

- **Filtration and Mass**

The textile and continuous layers around the filter support tube result in particulate matter being trapped through the depth of the filter rather than only on the surface. The filter cartridges are light weight and have a low thermal mass. A low thermal mass has been shown to be beneficial with respect to regeneration performance.

- **Small Particulate Efficiency**

Initial test results have shown enhanced small particulate "nano-particle" filtration efficiencies.

- **Design Flexibility**

The flexibility of the Nextel™ fibers and cartridge design enables cartridge and system configurations of multiple different shapes and sizes to adapt to the available vehicle space and application requirements. Additionally, the filtration efficiency can be easily modified based on application requirements.

- **Thermal Shock Resistance**

With continuous temperatures of 1204°C (2200°F) and short-term use temperatures as high as 1371°C (2500°F) filter cartridges made from Nextel™ fibers demonstrate excellent thermal shock resistance.

- **Mechanical Durability**

Good absorption of mechanical vibration precludes catastrophic failure of the filter cartridge due to mechanical shock.

- **Excellent Sound Attenuation**

Typical sound attenuation resulting from use of the filter cartridge is equal to or better than a standard muffler. Accordingly, they are often used as a replacement for the application muffler.

- **Recyclable**

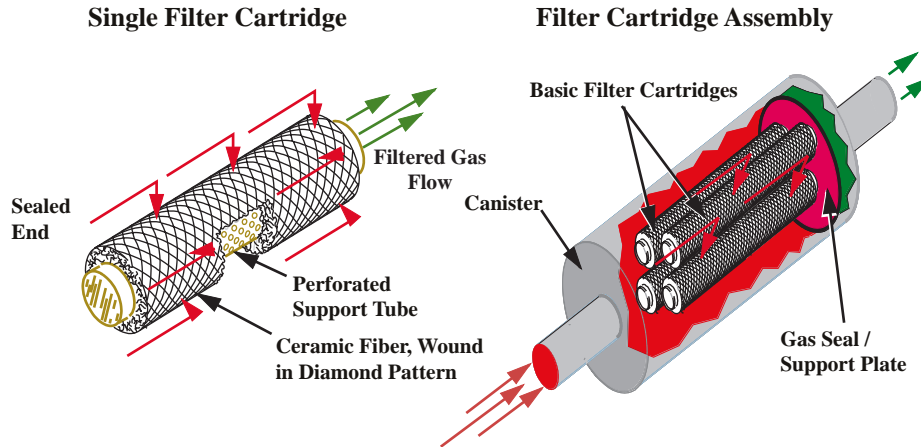
Processes are available whereby the Nextel™ fibers can be reclaimed and converted into alternative product forms.

3M offers three fundamental types of diesel particulate filter cartridges.

The Basic Cartridge

This cartridge type has Nextel™ ceramic fiber wound around a cylindrical metallic perforated hollow tube closed at one end. Its placement in the canister ensures the flow of exhaust from the outside to the inside to ensure maximum PM entrapment. This cartridge is the most commonly used and is incorporated with multiple regeneration techniques.

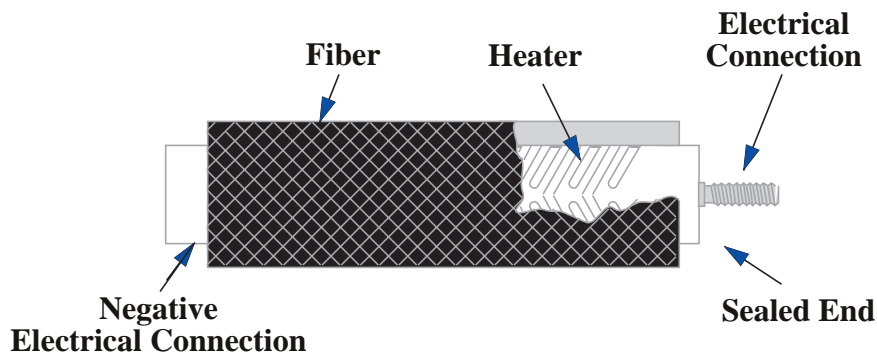
BASIC FILTER CARTRIDGE and ASSEMBLY



The Electrical Cartridge Type

This cartridge is similar to the basic cartridge except that the cylindrical tube is also the heating element. While also sealed off at one end, its placement is such that the open end faces the exhaust inlet causing flow to go from inside to out. This maximizes the regeneration effectiveness during the regeneration process by capturing PM near the electrical heater support tube.

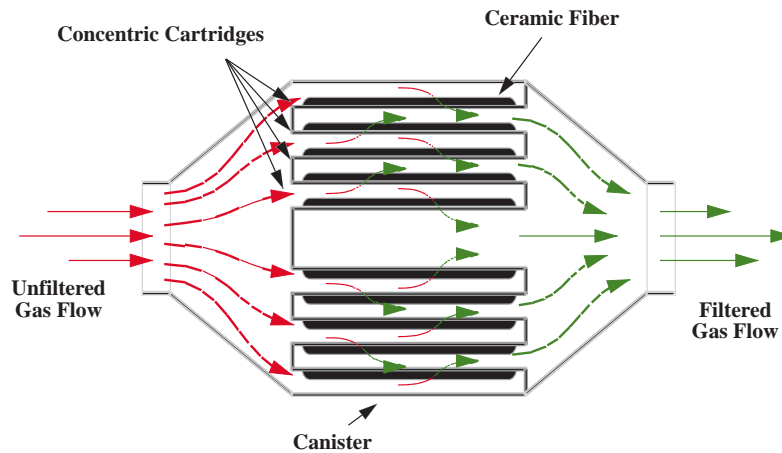
CARTRIDGE WITH HEATER



The Concentric Cartridge type

The concentric tube pack is made up of several Nextel™ fiber wound concentric filter cartridges. Each filter cartridge is slightly larger than the previous one. They are separated by annular rings which block the space between the concentric support tubes on alternate ends. This configuration forces exhaust gases to flow through the filter media, trapping particulate in the fiber.

CONCENTRIC TUBE PACK FILTER



Regeneration Methods

3M Diesel Particulate Filters are compatible with diesel particulate systems utilizing various regeneration (cleaning) methods

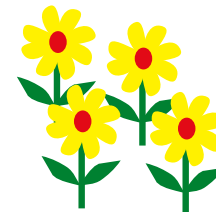
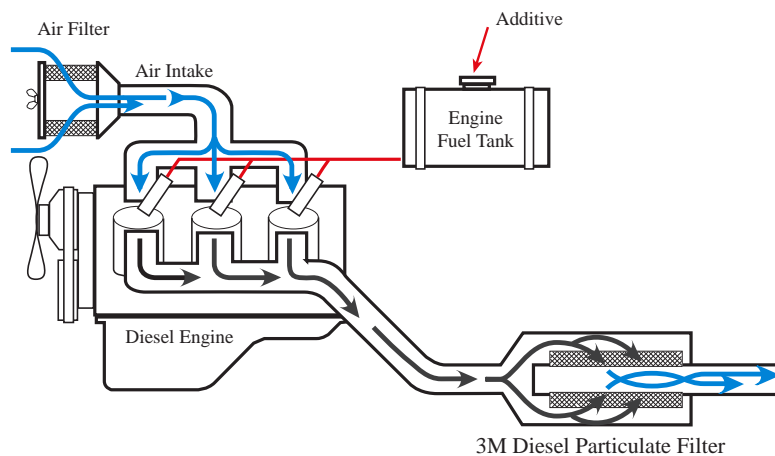
Burner Regeneration System

These are systems where the exhaust is preheated by an external burner before feeding into the diesel particulate filter canister. Very often the burner is supplied by fuel bled off from the existing fuel tank with supplemental ignition. It is necessary to heat the exhaust periodically in order to raise the temperature high enough (generally over 600°C (1112°F)) to burn off the deposited soot on the cartridges and thus cause a regeneration.

Fuel Borne Additive Regeneration System

In this concept, a catalytic fuel additive (some form of metallic catalyst) is mixed with the fuel (usually from a central fuel tank) causing the soot to burn at lower temperatures (generally below 400°C (752°F)). This alleviates the need for an auxiliary external heat source. The catalytic fuel additive combusts and becomes part of the soot particle. The liquid additive works well in situations requiring central fueling like urban transportation buses, utility trucks etc. Liquid on-board additive dosers have been developed and are successfully being used in operation on a variety of applications. The on-board dosers can be incorporated and optimized as part of the engine management, exhaust, and emission control system.

LIQUID DOSED REGENERATION METHOD



Electrical Regeneration System

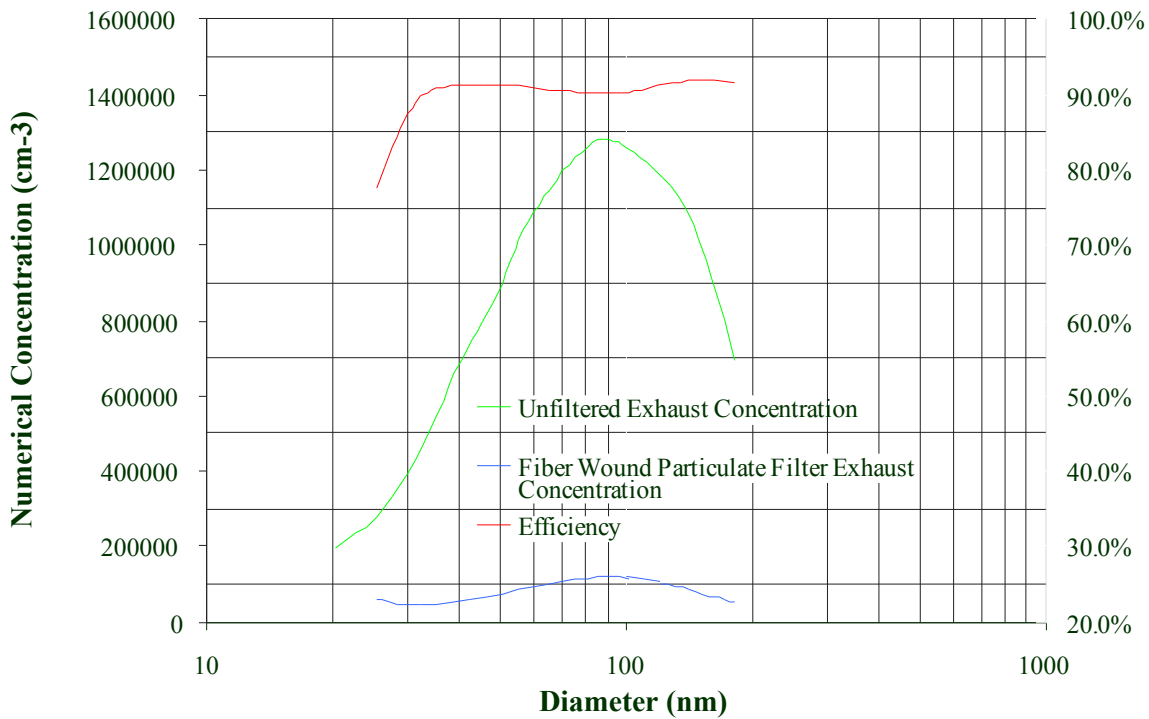
These systems depend on electrical heating to provide the regeneration. The electrical source is usually from the vehicle battery or a stationary electrical source. Depending on the onboard diagnostics it may or may not require operator involvement. The electrical efficiency of these systems is enhanced because the underlying supporting metal tube is also the heating element thus forming a single integrated unit.

Continuous Regenerating Trap

This particular concept involves the use of an NO catalyst which is used to significantly lower the temperature at which particulate matter regeneration occurs within the filter element(s). Low sulfur diesel fuel (< 50 ppm) is required for this technology to work effectively.

SMALL PARTICULATE FILTRATION EFFICIENCY

Particle Concentration Vs. Diameter as Tested by V.E.R.T.



In-Use Durability / Field Experience

Long-term durability of the 3M™ Diesel Particulate Filter Cartridges has been demonstrated in-use on a variety of applications that include buses, trucks, fork trucks, and utility vehicles/engines with multiple regeneration techniques. Additionally, in-house laboratory durability has been proven over thousands of hours of testing and regeneration cycles.

The table below highlights the current status of field experience using 3M Diesel Filter technologies with various regeneration methods:

3M Filter Technology	Regeneration Method	# of Units	Vehicle Type	Location	In-Use Results	Date Started
Basic Filter Design	Fuel Additive	≈ 500	Fork Trucks	Europe	Up to 6000+ hours	1996 – on-going
Electrical Filter Design	Electrical Resistive Element	≈ 400-500	Fork Trucks	Europe	Up to 10000+ hours	1994 – on-going
Basic Filter Design	Fuel Additive	≈ 40	Street Sweepers	Europe		1998 – on-going
Basic Filter Design	Fuel Additive	≈ 50	Buses	Europe		1998 – on-going
Basic & Concentric Filter Designs	Fuel Additive	14	Buses	Romania	Up to 165,000 km	1992
Basic Filter Design	Fuel Burner	≈ 250	Utility Vehicles	Europe	2-3 years operation	1993 – unknown

Summary as of August 1999.

The basic and concentric filter designs have been successfully demonstrated using fuel burner and fuel borne additives for regeneration. Hundreds of systems are currently in-use with 2-3 years operating experience over a variety of applications using fuel borne additives for regeneration.

City bus demonstrations using 3M Diesel Filter technology and fuel borne additives are currently in-progress in Europe. To-date approximately 50 systems are in-use with additional installations scheduled.

A bus retrofit demonstration was also successfully conducted in Romania using fuel additives and 3M Diesel Filter Cartridges; the study was conducted on 14 city buses. PM reductions of 70-90% were achieved with more than 1,250,000 kilometers successfully accumulated.

The 3M electrical filter cartridge has been successfully used in hundreds of systems. Durability has been demonstrated with 5-6 years of in-use experience and with many systems having achieved greater than 10,000 hours of operating performance.

Basic Filter Cartridge

Filter Cartridge Name	Filter Cartridge Number	Power	Max Flow Rate	Soot Holding	Efficiency	Flow	Diameter	Length
Trade Name	3M Stock Number	Watts	m3/min (acfm)	@ pD	Mass Based	Direction	mm	mm
XW3C-081	98-0400-6056-2	NA	10 (353)	11g @ 40kPa	85-95%	Out-to-In	98	292
XW3C-080	98-0400-6055-4	NA	16 (565)	17g @ 40 kPa	85-95%	Out-to-In	144.8	292
XW3C-079	98-0400-5840-0	NA	10 (353)	11g @ 40kPa	85-95%	In-to-Out	102	292
XW3C-071	98-0400-5116-5	NA	4.41 (50)	2.4g @ 25kPa	80-90%	Out-to-In	50.8	178
XW3C-056a	98-0400-5172-8	NA	3 (105)	6g @25 kPa	85-95%	Out-to-In	61	350
XW3C-053a	98-0400-5719-6	NA	3.35 (118)	9g @ 40 kPa	85-95%	Out-to-In	68	500
XN-454	98-0400-2217-4	NA	15 (529)	16g @25 kPa	85-95%	Out-to-In	96.5	1014

Electric Filter Cartridge

XW3H-078	98-0400-5841-8	800	10 (353)	11g @ 40 kPa	85-95%	In-to-Out	102	270
XW3H-070	98-0400-5115-7	600	2.83 (100)	5g @40 kPa	85-95%	In-to-Out	70	260

Concentric Tube Pack

XW3T-028	98-0400-5108-2	NA	31.1 (1100)	70g @ 25 kPa	85-95%	Both	219	711
XW3T-039	98-0400-5109-0	NA	15.6 (550)	25g @ 25kPa	85-95%	Both	219	331.5

* Other cartridge sizes are also available

Initial Information Needed to Make a Recommendation for an Application

- Engine exhaust rate (or rated power, engine displacement, max RPM, turbo/non-turbo, max engine temperature)
- Size constraints (maximum volume that filters can occupy)
- Regeneration method (fuel burner, fuel additive, catalyst, other, etc...)
- Desired efficiency
- Maximum allowable back pressure (usually given by the engine manufacturer)
- Filter canister location in relation to the engine

All filter systems utilizing 3M Diesel Particulate Filter cartridges not only capture *a large number of particulates* but also *extremely small particulates* (less than one micron) thus *reducing* fine particulate emissions significantly as well.

These filter systems result in solutions which are:

- **Effective**
—typically *result in over 90% reduction of PM*
- **Cost Effective**
—*retrofit can be performed quickly and generally replace the muffler*
- **Durable**
—*minimum interruption in the operation of the vehicles—low downtime*
- **Passive**
—*minimum operator dependency, increasing reliability*

3M Diesel Particulate Filter Cartridges **Your solution to reducing particulate matter** **for diesel powered applications . . .**

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