About Diesel Particulate Filters

Pollution caused by diesel engines

Pollution generated by the combustion process in diesel engines includes oxides of Nitrogen (NO & NO\(_2\), commonly referred to as NOX), carbon monoxide (CO), hydrocarbons (HC), and particulate matter (PM) - the solid content in the exhaust gas, which is primarily soot (combustible matter, mainly carbon) and ash (incombustible matter, mainly residues of compounds within the lubricating oil). Particulate matter is normally seen in the form of dark or black smoke.

The effect of pollution

Pollution from diesel engines affects air quality, creates smog and haze, and has serious effects on health.

Carbon Monoxide (CO), a compound of carbon and oxygen, is produced by the combustion process of the engine. It combines with haemoglobin in the bloodstream preventing the absorption of oxygen. In extreme cases, inhalation can cause death through asphyxiation. It can be removed from the exhaust gas by an oxidation catalyst.

Hydrocarbons (HC), an organic compound of hydrogen and carbon, produce emissions in exhaust gases which are undesirable and are legislated for. They are known to be carcinogenic but can be removed from the exhaust gas by use of an oxidation catalyst.

Nitrogen Dioxide (NO\(_2\)), a compound of nitrogen and oxygen, is a major contributor to photochemical smog and acid rain, and is irritating to the eyes, respiratory system and skin. It can be removed from the exhaust gas by commercialised NOX abatement systems in common use on Euro 4/5 vehicles today. This may also include EGR as used by MAN & Scania.

Nitrogen Monoxide (NO), a compound of nitrogen and oxygen, is toxic by inhalation and irritating to eyes and skin. NO can be abated in the same way as NO\(_2\).

Increasing worldwide average temperatures, as a result of climate change, are making the situation even more serious, and making the need to control and eventually eliminate emissions even more pressing.

Legislation

Europe and North America are currently leading the way on the regulation of diesel engine emissions.

European legislation sets standards for heavy duty diesel engines which regulate the NOX, particulate matter, hydrocarbons, carbon dioxide and smoke. Particulate matter, NOX, HC and CO emission levels are measured in g/kW hr.
Low emission zones, where vehicles entering the zone must meet a specific exhaust emissions standard, currently exist in numerous US and Mainland European Cities. Presently the only UK Low Emission Zone is London with Edinburgh, Manchester, Leeds and Birmingham under review. The standard typically specifies a specific Euro Standard or a Euro Standard plus the fitting of a DPF (Diesel Particulate Filter).

In order to comply with current and future particulate matter emission legislation, DPFs are now widely used to remove Particulate Matter from the exhaust of diesel engines.

**What are Diesel Particulate Filters (DPFs)?**

Diesel Particulate Filter (DPF) is a generic term used to describe systems which reduce particulate matter in diesel engine exhaust emissions. They are used within ‘full-filtration’ or ‘closed–filter’ systems, making them highly efficient in removing particulate matter. Retrofit DPFs are in common use around Europe today.

DPFs force the diesel exhaust through a substrate, a structure of microscopic pores in the form of either a ceramic or a metallic honeycomb. This traps the harmful particulate matter against its walls. DPFs are 85 percent or more effective, with an efficiency in the high nineties often being attained. Ceramic ‘wall-flow’ DPFs are also extremely efficient at removing very small carbon particles from the exhaust; these particles are sometimes known as PM10 or PM2.5. These very small particles are also widely regarded as the most dangerous as, due to their size, they have the ability to penetrate very deeply into the human lung.

**Problems with DPFs**

With use, particulate matter builds on the walls of the DPF, restricting exhaust flow and leading to an increase in exhaust gas backpressure. The lower the backpressure, the better the engine performance, so a restricted exhaust flow will lead to reduced power and performance, and, inevitably, an increase in fuel consumption and in pollution.

**Filter regeneration systems**

DPFs (first fit or retrofit) must therefore be ‘regenerated’, a process that oxidizes the particulate matter and so returns the filter close to its original, clean state.

Without the presence of a catalyst (commonly referred to as FBC – fuel born catalyst) an exhaust gas temperature of approximately 600-650°C is required to effectively oxidise the carbon particulate, turning it into harmless gases. Because these temperatures do not normally occur under usual engine operating conditions, it is necessary to apply additional measures. These can be engine management measures or the utilization of a catalyst. Several different strategies are commonly employed with retrofit filter technologies:

- Addition of an ECU and dosing pump to supply a special additive to the fuel which enables soot within the filter to be burnt at around 300-350°C.
• Placement of a precious metal coated ceramic honeycomb upstream of the filter which enables soot to be burnt at around 300-350°C.
• Coating the DPF itself with precious metal which enables soot to be burnt at around 300-350°C.

Most commonly available systems make use of some form of OBD (on board diagnostics) giving the vehicle operator visibility as to the state of the DPF.

Nevertheless, incombustible residues can still build up and the filter will require periodic professional cleaning coupled with thorough inspection to remove excess ash and soot.

**What will happen if the filter is not cleaned?**

If the filter is not regularly cleaned and inspected it can become blocked, causing soot and ash to build up, this increases the chances of a damaging exothermic reaction taking place which will melt or crack the filter. At this point a costly brand new replacement filter must be fitted. It should be noted that damage caused by exothermic reaction is not always obvious.

**The cleaning process**

Emission Control, in consultation with its Technical Partners, Pirelli Eco Technology S.p.a and Donaldson Filters, has developed a specialist `8 Hour Cleaning Cycle` process which deep-cleans the filter. This produces the best possible performance.

The cleaning process takes about 8 hours to complete, with the performance of the filter being tested throughout the rigorous procedure. Mobile cleans are available on the market but are of inferior quality and consist of little more than an air line ‘blow out’. This achieves little in terms of cleaning the inner pores of the DPF substrate, which is crucial to maintaining performance.

Most vehicles are fitted with an Electronic Service LED, which continuously monitors backpressure and indicates when servicing of the filter is necessary. Backpressure measurements can also be made manually. It is strongly recommended that backpressure is checked regularly to avoid excess accumulation of ash and soot which will eventually lead to filter damage.

The service interval can be judged by analysing the work rate of the vehicle. Therefore if an engine has a low work output, or idles for long periods, this may reduce effective regeneration and lead to soot accumulation and an earlier service requirement. The following is a guide:

**A high and sustained work rate** (eg a long haul truck, or intercity train or coach) has a typical service interval of **1 year**.

**A variable engine work rate** (eg all purpose delivery truck, or bus operating in a mix of city and rural areas) has a typical service interval of **9 months**.
A low engine work rate (e.g. a bus operating in heavy traffic and congested city centres, or a waste refusal vehicle) has a typical service interval of 6 months, but back pressure should be monitored at least once every 6 weeks.