TAKE A DEEP BREATH

With the correct particulate filter, diesel emissions can be almost as clean as mountain air. It's a solution that practically guarantees compliance with the latest regulations

Despite major progress in reducing particulate matter emissions from diesel engines in recent years, this continues to be a source of concern for a variety of health agencies across the world. Several recent studies have identified diesel particulate as a carcinogenic substance, yet when an engine is equipped with the right particulate filter, its exhaust fumes can be cleaner than the air we breathe. The trick lies in knowing which solutions are available for transforming any diesel engine into a lean, green machine.

Due to the growing concern, a number of agencies are going beyond regulating the engine emissions and targeting their regulations to the vehicles themselves. Off-highway vehicle emission regulations are now in effect on construction sites in Switzerland,

Sweden and Japan. Many confined-space applications, such as mines and tunnels, are more vigorously targeting emissions from diesel-powered equipment. In other cases, programs to retrofit existing vehicles with particulate filters are emerging in the USA, western Europe and Asia. Often, the end-user drives the need for low diesel particulate emissions, either for local aesthetic reasons, or for meeting the requirements of a project specification.

Diesel particulate filters are the best way to achieve ultra-low emissions of diesel particulates and, in most cases, provide dramatic results that are seen with the naked eye (or to put it more precisely, are noticeable by their absence). DCL has extensive experience in assisting OEMs with engineered diesel particulate filter solutions that meet their customer requirements while allowing off-highway vehicles to maintain their productivity.

To comply with these regulations and participate in the programs being offered, the owners of off-highway diesel equipment face numerous challenges in retrofitting their equipment. Vehicles used in construction, material handling, or mining applications are very often built or employed in ways that do not allow for retrofitting with standard on-highway after-treatment devices. This is where DCL comes in. Working together with OEMs, the company offers solutions to their emission problems, resulting in compliance with the strictest regulations.

The health issue

Over the last few decades, asthma and allergies have become more prevalent than ever throughout Europe and North America, with children being affected the most. Almost one in three children suffer from asthmatic symptoms in some areas (Reference 1).

Environmental air pollution is among the major threats to respiratory health, especially during childhood. A World Health Organization (WHO) study on air pollution in eight major Italian cities, published in June 2000, reports 30,000 asthma attacks per year among children under 15 years old. Children living near roads carrying heavy traffic experience double the risk of suffering from respiratory problems compared to those living near less congested streets (Reference 1).

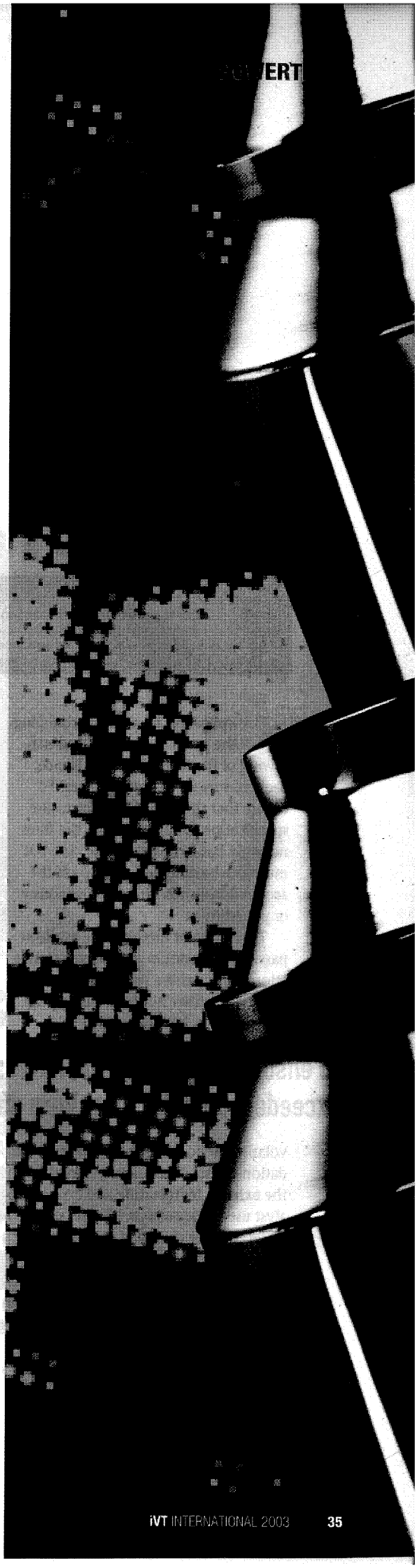
Fine particulate matter, such as that emitted by diesel engines, has been related to increased health risks in adults and children. This is due to the fact that the smaller the particles, the higher their potential to be drawn deep into the lungs, and the higher the potential for inflammatory reactions. Particulates with diameters of 0.02-0.05μm, which are typical for modern diesel engines, have twice the potential to induce inflammation as particulates with diameters from 0.2-0.5μm (Reference 2).

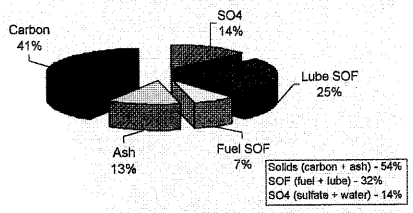
In a North American study, over half a million people were observed over the course of 16 years. The study found a distinct correlation between the discharge of fine particulate matter (less than 2.5μm), and sulphur oxide-related pollution, with the incidence of mortality. Each 10μg/m^3 elevation in fine particulate air pollution was associated with a 4%, 6%, and 8% increase respectively in the risk of all-cause, cardiopulmonary and lung cancer mortality. It was concluded that long-term exposure to combustion-related fine particulate air pollution is an important environmental risk factor for cardiopulmonary and lung cancer mortality (Reference 3).

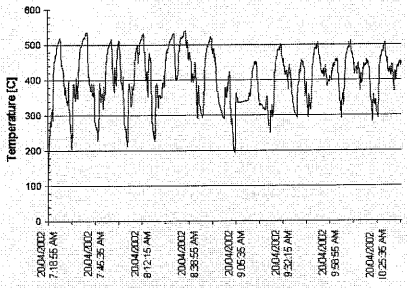
In North America, the California Air Resources Board (CARB) has labelled diesel exhaust as a toxic air contaminant and is planning a statewide retrofit program to reduce the exposure risk. The US EPA is also promoting voluntary retrofit programs in order to reduce exposure to diesel particulate matter.

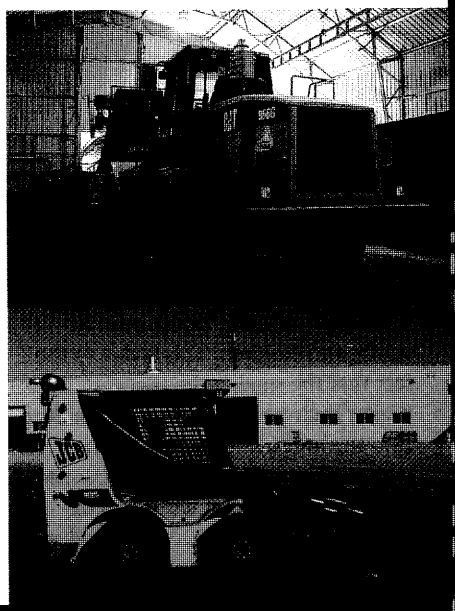
Particulate control strategies

Particulate filters (as shown in the main picture) are generally made from porous cordierite or silicon carbide materials and clean the diesel exhaust by means of their ability to physically collect soot particles. While the gaseous components of the exhaust pass through the alternately blocked-off channels of the ceramic filter substrate, the solids that are too large are held behind within the channel pores and on the interior filter channel walls.









CLOCKWISE FROM ABOVE:
FIGURE 1: **Engine exhaust-temperature time profile**
FIGURE 2: **Composition breakdown of diesel particulate matter**
In confined space applications, or to meet project requirements, the end-user often drives the need for low diesel particulate emissions

This collection results in partial plugging of the pores in the filter and narrowing of the filter channels. Hence, backpressure on the engine rises. To ensure that the engine's backpressure specification is not exceeded, the filter not only has to be the proper size, but must also be designed to burn off the accumulated soot, either continuously or periodically.

Two different methods are available: passive regeneration and active regeneration. With passive regeneration technology, the filter not only collects the soot particles, but also oxidizes the volatile fractions. Furthermore, soot oxidation occurs continuously, based on the exhaust temperature and type of catalyst used. The catalyst is either used as a fuel additive or coated directly onto the walls of the filter. Its role is to reduce the intrinsic soot ignition temperature from about 600°C to within the range achieved during normal vehicle operation – below 350°C.

If these exhaust temperature conditions are not reached, active regeneration can be applied. In an active system, the filter only collects particulate over a certain time period, after which it must be actively cleansed of soot. There are different methods to achieve this, one of which is the heating of the filter by electrical power to a temperature suitable for soot oxidation. DCL employs its vast knowledge resources to work together with the customer to determine the proper filter strategy.

The right solution

In correctly matching the retrofit device to the application, equipment owners and operators encounter various challenges: heavy-duty versus light-duty operation, high or low exhaust temperatures, custom-made equipment with tight packaging constraints, sulphur content, and so forth.

One major factor in making the decision whether or not to retrofit with a particulate filter is the condition of the engine. The engine must be well maintained, with lube oil consumption below 1.5% of fuel consumption, and not too dirty, i.e. possess a Bosch smoke number below five. If the lube oil consumption were any higher, it would unnecessarily shorten the life span of the filter, as well as adversely affect the filter regeneration properties.

For a filter to properly function, the regeneration method must be matched

To ensure the engine's backpressure specification is not exceeded, the filter must burn off the accumulated soot

to the vehicle application, the exhaust temperature and hence the duty cycle, the particulate matter emissions, and the fuel sulphur level. The engine exhaust-temperature time profile and engine emissions are critical factors and must be properly interpreted, as illustrated in Figure 1. DCL examines the vehicle characteristics and its operating parameters to provide an optimised filter system for each application.

The other consideration is the amount and specific properties of the engine emissions, which are a result of the fuel and lube oil, as well as the overall maintenance status of the engine. Figure 2 gives a breakdown of the typical composition for a typical heavy-duty diesel engine.

DCL currently offers an extensive product line for the retrofitting of off-highway diesel equipment. Products include oxidation and three-way catalytic converters, a wide range of passive and active diesel particulate filters, as well as silencers and a range of accessories in both standard and custom configurations for meeting every need of all types of engine.

High-value, low-cost ergonomics

Having made the decision to retrofit with particulate filters, the owner who works with DCL will not only bring his equipment into compliance with regulations, but will be seen as an employer concerned with the health of his employees. Additionally, owners who make this important decision greatly contribute to particulate emissions reduction, which especially protects those living close to construction sites from respiratory tract ailments. ***iVT***

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References

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