

The DPR FUTURE

It all started with a simple demonstration.

The Hino technician knelt down alongside a running truck and methodically unfolded a white piece of cloth. Holding the cloth in front of the exhaust pipe he called to the driver for a blip of the throttle – you could clearly see a small puff of black smoke hit the cloth and leave a black stain.

We then moved to another truck – this one equipped with Hino's Diesel Particulate Active Reduction System (DPR) targeted at Japan's tough 2005 regulations. Same demonstration – another white cloth appeared but this time when the engine raced, no exhaust could be seen and the cloth remained as white as it was before the test.

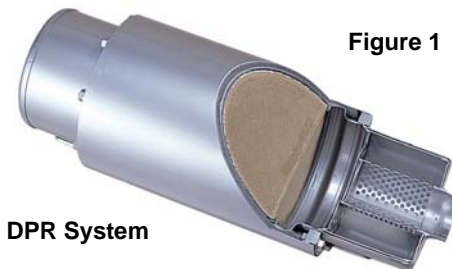
The difference? Hino's DPR – a diesel particulate filtration system designed for the the world's future of cleaner air, and proven on the tough streets of Tokyo.

Sometimes a simple demonstration can say more than any engineering overview or scientific report.

How DPR Works

Here's the challenge – the US EPA emission regulations for 2007 call for a 90% reduction in the particulate level of diesel exhaust – a move from 0.1 grams per brake horsepower hour (g/bhp-hr) to 0.01 g/bhp-hr. To reach those levels, manufacturers are adding diesel particulate filters that trap soot before it travels out the exhaust pipe. Most people will refer to diesel particulate filtration (DPF). At Hino, we talk about diesel particulate active reduction (DPR) – we like to be different.

Particulate reduction is all about temperature. Soot captured in the DPR has to be burned down with a controlled temperature. If all diesel engines ran at highway speeds all the time, they would generate sufficient exhaust temperature to effectively burn off the majority of the particulates remaining after the primary combustion. But, of course, trucks cycle. They run in city traffic where engines constantly transition between lugging at low speeds and racing as a loaded truck moves through the gears. In that kind of environment, exhaust gases vary widely in temperature with the result that particulates captured in the DPR can accumulate without burning down. Therefore, a system to constantly remove these particulates is required. The Hino DPR does that by introducing both oxygen and heat to oxidize or burn off the soot periodically so the filter does not plug up and cause back pressure that can decrease fuel economy and do serious damage to engine components.



The Hino DPR moves exhaust gases through a catalyst that oxidizes hydrocarbons to form carbon dioxide, water and a change in temperature.



It then traps any remaining soot in a filter.

To periodically burn off accumulated soot particles, the system uses the engine control unit (ECU) to trigger small fuel injection bursts after primary combustion to add energy and heat to the exhaust gases, thereby burning off soot in the filter.

The key to DPR performance is the ability to trap and regenerate the soot while not allowing the back pressure of the system to increase to levels that negatively affect fuel consumption performance.



It is one thing to demonstrate DPR technology in a clean laboratory running carefully monitored low sulfur fuel drawn from nice clean tanks. It is quite another to assure both performance, reliability and durability in the hard knocks of the everyday world. That's where Hino's Japanese experience benefits the trucks we sell in the United States.

Real World Results

Japan's 2005 emission regulations are very similar to our EPA 2007 requirements. With particulate levels of .02 g/bhp-hr (relative to current USA levels of .10 and 2007 levels of .01) the challenges for Hino, the largest producer of heavy and medium duty trucks in Japan, were formidable. But typical of other leading edge advancements introduced by the company, Hino's engineering solutions for the Japan 05 regulations have performed well.

At the time of this publication's printing, over 8,000 medium duty Hino trucks have been sold with full Japan 05 emissions equipment installed. We estimate those units to have an accumulated mileage experience of nearly 54,000,000 miles. And over 68,000 Hino trucks (Heavy, Medium and Light duty) equipped with DPR filters have been sold since Hino's DPR launch in 2003, representing an estimated 1.3 billion miles of real world (predominantly low speed urban applications) experience. Based on the successful application of those trucks, Hino is confidently introducing this technology to the United States truck market.

It shouldn't surprise anyone that Hino has been successful in its introduction of DPR. Like any other Hino approach, this program involved many hours of testing and great attention to detail through every phase of design and development. Laboratory and field test modes combined to demonstrate the DPR's performance, durability and reliability in a wide range of operating atmospheres.

The result is the introduction of a sophisticated technology designed to live in a sometimes unsophisticated world. The Hino DPR works – it is a design we are proud to add to our USA product line.

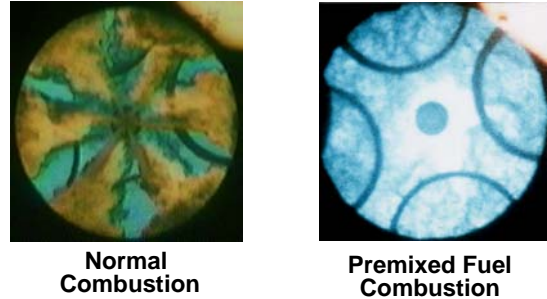
The Denso Advantage

One of the advantages Hino has in the area of engine design is its working partnership with Denso Corporation. The Denso Common Rail Fuel Injection System used on our J-Series engines is leading edge technology and Denso is positioned to move the great results they can demonstrate today to even higher levels with the introduction of post-combustion injection, pre-mixed air/fuel ratios and the future application of piezoelectric triggering mechanisms.

Premixed Fuel

Controlling the air fuel mixture can greatly affect the amount of particulates produced in the combustion process. Figure 2 shows the difference between normal diesel combustion and the results obtained in the premixing of air and fuel by the Denso system.

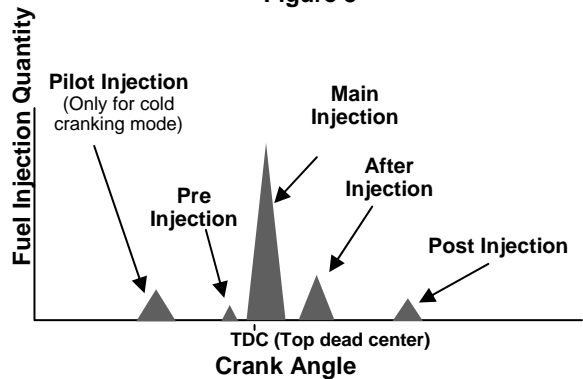
Figure 2



Multiple Injections

To control the desired level of noise, power, responsiveness and emissions, the Denso Common Rail System in Hino engines will fire up to five times per engine revolution. A pilot injection will be used for cold cranking mode, with pre-injection helping to lower noise and start the flame propagation; primary and after injections will burn as much of the fuel as possible; and a final post injection will increase exhaust temperatures to assure proper catalyzing of the particulates for active regeneration of the DPR.

Figure 3



The challenge, of course, is that all of this injector movement is happening in diesel fuel that will now be 15 parts per million (ppm) sulfur rather than the current 500 ppm. More movement with less lubricity. A problem? Not according to the experience gained in our field experience in Japan. The Denso system has proven itself to be able to handle the tough stop and go traffic of Tokyo and we are fully confident that it is ready for the US market as well.



Every report of this type needs some fine print – so here it is. Our idea in publishing these papers is to keep you informed on our progress as a company. The contents are as accurate as possible at the time of publishing. But everything may change if we get a better idea.