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DEVELOPMENT AND DEPLOYMENT OF ADVANCED EMISSION CONTROLS FOR THE RETROFIT MARKET

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ABSTRACT

Bringing a diesel retrofit product to market involves two primary phases: development and deployment. Critical product development steps include technology selection, system integration, laboratory and durability testing, and regulatory agency verification work. This initial product development phase is then followed by a deployment phase, which consists of building and managing the infrastructure for installation, distribution, service, sales and warranty support. Building relationships with regulators and air quality program developers is also a critical aspect of the deployment process. A successful path to market requires close cooperation between developer, distributor, customer and regulator.

INTRODUCTION

Cleaire Advanced Emission Controls has developed an integrated NO_x and PM control system, called Longview™, which can be applied to a wide variety of engines and applications. In April 2003, Longview became the first broadly-applicable combined NO_x and PM emission control system to be verified by CARB. The Longview is verified to reduce NO_x by 25% and PM by 85%. Key elements of the Longview include a NO_x reduction catalyst, a catalyzed diesel particulate filter, a reagent injection system, and a combined controller/datalogger called the MLC®. Key criteria for the end user are affordability, minimal impact on vehicle operations and ready access to qualified service and support facilities. Important features for regulators and grant programs are verifiable emission reductions and cost-effectiveness.

Cleaire is a division of Cummins West, Inc., the exclusive distributor of Cummins Incorporated products and Komatsu

heavy equipment in central and northern California. The seven branches of Cummins West operate throughout central and northern California as well as Hawaii. Cummins West has over 350 employees and is a \$100 million organization. Cleaire and Cummins West are located in San Leandro, CA. In addition, Cleaire has a manufacturing facility in San Diego. CaTTS (California Truck Testing Services), is also a division of Cummins West. It is located in Richmond, CA and has 1 of 6 heavy-duty chassis dynamometer laboratories in North America. The CaTTS facility is used for development and verification of Cleaire technologies. Excellent results in the test cell and proven durability in the field are thereby combined with an organization competent to handle sales, installation and service activities to support the product. Together, Cleaire and Cummins West, Inc. offer effective environmental solutions to a variety of customers.

Emission controls in the retrofit market are important because significant reduction in NO_x (NO and NO₂) and PM (particulate matter) can be achieved now. There is no need to wait for fleet turnover to improve air quality. With retrofit, ozone and air toxicity can improve immediately.

The paper will discuss the basic design features of the Longview system, present laboratory and field test results, and discuss the key process steps required for successful launch and support of retrofit emission control systems.

NOMENCLATURE

CaTTS, California Truck Testing Services
NO_x, NO and NO₂

PM, particulate matter
 MLC, Monitor, Logger, Controller
 NRC, NO_x reduction catalyst
 HC-SCR, Hydrocarbon Selective Catalytic Reduction
 LNC, Lean NO_x Catalyst
 HC, Hydrocarbon
 DPF, Diesel Particulate Filter
 DOC, Diesel Oxidation Catalyst
 CARB, California Air Resources Board
 UDDS, Urban Dynamometer Driving Schedule
 NYCB, New York City Bus
 ULSD, Ultra Low Sulfur Diesel
 ppm, parts per million
 FEI, Fuel Economy Impact
 FES, Fleetguard Emissions Solutions

DEVELOPMENT

The Cleaire Longview is an integrated NO_x and PM control system consisting of catalysts and filters. It is the first retrofit product to decrease NO_x and PM emissions from diesel engines in a variety of applications. This is a significant development because NO_x is the prime contributor of ground level ozone, also known as smog. PM is a toxic air contaminant. The system components have many features. Figure 1 shows the modular packaging system of the catalysts and filters, which allow for flexibility and variety in use.

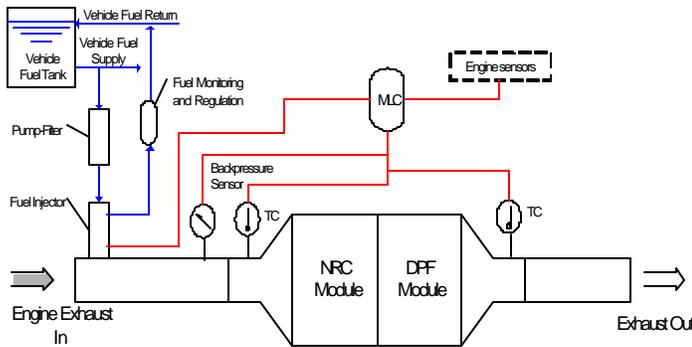


Figure 1. Cleaire Longview

The MLC® is the device employed to monitor, log, and control the system. Hydrocarbon dosing by means of diesel fuel injection reduces NO_x and allows for high enough temperatures to regenerate the filter.

The NRC (NO_x reduction catalyst) in the Longview is also known as HC-SCR (Hydrocarbon Selective Catalytic Reduction) or a high temperature LNC (Lean NO_x Catalyst). The NRC uses the HC (hydrocarbon) in the exhaust and the additional hydrocarbon from fuel injection to reduce NO_x to N₂ and O₂. So, diesel fuel (HC) is the reducing agent. An advantage to this system is that a second storage tank for the reducing agent is not needed. The reagent injection system draws fuel from the same supply as the engine. In addition, there are no issues with ammonia slip since diesel fuel and not ammonia or liquid urea is the reducing agent. HC slip is addressed by a DPF (Diesel Particulate Filter) or a DOC (Diesel Oxidation Catalyst) downstream of an NRC.

The Cleaire Longview system has been through both performance and verification testing. Engines used for testing have been Cummins M11/ISM, ISC, and ISX engines as well as International DT-466 engines. Tests have been conducted on transient UDDS (Urban Dynamometer Driving Schedule) and NYCB (New York City Bus) cycles as well as steady-state 4-5-6 cycles. Fuels used in testing are CARB (California Air Resources Board) #2 Diesel and ULSD (Ultra Low Sulfur Diesel). CARB fuel has a sulfur content maximum sulfur content of .05% while ULSD fuel has a maximum sulfur level of 15 ppm (parts per million). Figure 2 displays the results of emissions testing on a 1997 M11 Cummins Engine using ULSD fuel and the UDDS and the NYB transient test cycles.

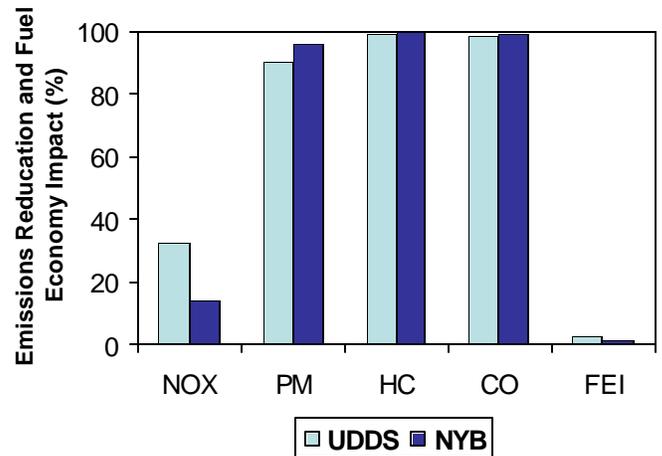
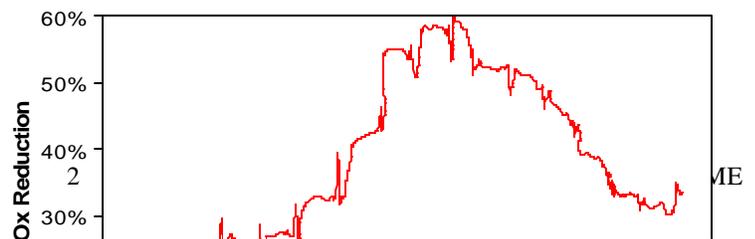


Figure 2. Longview Emission Reductions with ULSD Fuel on the UDDS and NYB Transient Cycles Using a 1997 Cummins M11 Engine

Cleaire has field test experience. There are over 90 systems in the field. The applications in the field are varied. For instance, units are installed on transit, refuse, line haul vocational, and off-road applications. To the success of the field test units, over 1,800 installations are committed over the next 18 months.

The Longview became CARB verified in April 2003. It provides 25% NO_x and over 85% PM emissions reduction. NO_x reduction as a function of engine out temperature is shown in Figure 3.



duty cycle in order to regenerate the DPF, the elimination of back pressure monitoring, and the elimination of data logging.

Figure 3. NO_x Reduction as a Function of Engine Out Temperature

The Longview is the first retrofit product verified by CARB to reduce both NO_x and PM emissions from diesel engines on buses and trucks. Specifically, the Longview was verified for heavy-duty trucks and buses powered by 1994-2002 Cummins M11/ISM and International DT-466 engines and with the use of ULSD fuel.

In addition to the Longview, Cleaire is developing a product called the Lonestar. The benefits of Lonestar are 40% NO_x reduction, cost effectiveness (\$/ton NO_x), fuel tolerant, and requires no filter maintenance. It is targeted at the non-urban bus market. Systems are available now, and the EPA verification is in progress. Lonestar and Longview are alike in that both have electronically controlled (MLC) dosing systems and both use NRCs. In contrast, Lonestar uses a DOC where the Longview uses a DPF. A DOC is coated with an oxidizing catalyst which promotes oxidation of HC, CO, and PM. Lonestar decreases NO_x by 40% and PM up to 25% (as opposed to 25% NO_x and 85% or more PM reduction with a Longview). Some advantages of Lonestar over Longview are the elimination of elevated temperatures for a certain percent of

DEPLOYMENT

The deployment model of Cleaire systems was developed with the aspects of technology development, program development, and customer as well as user needs in mind. A distribution network was set up to support installation, service, and support. This is done through FES (Fleetguard Emissions Solutions). FES is a wholly owned subsidiary of Cummins, Inc. It offers Cleaire products nationally by leveraging the Cummins distribution network for installation, service, and support capabilities. FES partners with Cleaire on manufacturing, distribution, training, warranty administration, and program management. Cummins distributors will be used for their expertise in sales and marketing, installation, service, and lease and maintenance agreements.

SUMMARY

In conclusion, Cleaire has developed novel, state of the art retrofit systems to provide immediate emissions benefits to existing engines with no major engine or infrastructure changes. Fleetguard Emission Solutions and the Cummins distribution network is well positioned to support the widespread deployment of Cleaire technologies today. The potential for massive reductions in NO_x and PM is possible through widespread deployment of retrofit as well as neofit technologies in on-road and off-road applications.

ACKNOWLEDGMENTS

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