



The Opportunity for EPA Emerging Technology Verification

The USEPA Emerging Technologies Program is aimed to develop and commercialize new, cutting-edge technologies that reduce diesel emissions. Tinnerman / Shadowood technology was accepted onto the USEPA Emerging Technology List in 2008. This technology will significantly reduce emissions from diesel powered vehicles and has been tested to show a >65% reduction of NOx. This system, TEC 2010 generates hydrogen from a diesel fuel reformer and uses that reformato to reduce NOx and to regenerate the DPF. This system also reduces HC, CO, and PM2.5 by >90%. This emerging technology based on a diesel fuel reformer (DFR) and exhaust gas catalytic conversion, controls HC, CO, NOx and PM simultaneously.

The Chemistry

NOx - The new NOx reduction system is based on the lean NOx trap (LNT) catalyst, assisted by a diesel fuel reformer. The DFR is also used to desulfate the LNT periodically to remove the sulfur stored from the burned fuel and to maintain high catalyst NOx reducing efficiencies.

HC/CO – Oxidized by a platinum bearing oxidation catalyst following NOx reduction.

PM- The oxidation catalyst also acts as a heat source for DPF regeneration. During DPF regeneration, reformato from the DFR is rerouted to the oxidation catalyst producing an exothermic reaction in heating the DPF to burn-off the stored PM.

The H₂ in the reformato also lowers the temperature at which sulfur can be removed, thus increasing the durability of the LNT catalyst. The reformer-assisted LNT system is capable of achieving 65% or greater NOx reduction with aged catalysts, without the compliance or duty-cycle issues associated with urea-SCR. This approach for NOx reduction is an attractive alternative to a urea-SCR system, particularly for retrofit, especially where urea infrastructure and compliance issues limit urea-SCR application. Furthermore, the reformato-assisted LNT system operates at temperatures below 225 °C, where urea-SCR systems do not, so the proposed approach can maintain high rates of NOx conversion regardless of the engine's in-use duty-cycle.

The Objective

The objective of this proposal is to demonstrate, validate and commercialize an emissions reduction technology by retrofitting at least 20 diesel on-road vehicles that are equipped with 2004-2006 International DT466 or 2004-2006 Cummins ISB/ISC engines. This proposal provides an opportunity for Tinnerman / Shadowood to obtain feedback from fleet partners on their technology while it is in-use. This retrofit approach will improve air quality sooner than gradually replacing existing vehicles with new vehicles compliant with the 2010 standard, and do so cost-effectively.

Tinnerman/Shadowood is proposing to partner with an entity and local fleets to verify their emerging technology under various test protocols. The field testing will provide faster feedback on durability and performance to allow the manufacturer to verify the TEC 2010 on the in-use fleets up to a year to establish emission baselines and the impact of the emerging technology on emissions. All vehicles

must use ULSD fuel for the initial testing and aging of parts which will be used in the verification study

The aged aftertreatment systems from the vehicles will be used to support the Tinnerman/Shadowood test plan as submitted to EPA. The field and laboratory test data and subsequent reports to EPA, will give support to EPA's review as to whether the technology is beneficial enough to be added to EPA's verified technology list.

Tinnerman - Tinnerman was established in 1870 and specializes in assembly and products that improve the assembly process for over 1000 global customers. Tinnerman ships nearly 4 billion assemblies and components annually. Products used to improve the assembly of buildings to transportation, high tech, and medical applications. Tinnerman engineers design and develop new specialty products for new and unique assembly needs, or use existing products in new ways to help their customers keep costs down. Tinnerman specializes in many processes like stamping, injection molding, roll forming, welding, and complex tight tolerance assembly. Tinnerman is already working with the growing green technology segment and is in production with a number of green technology companies from clean emissions to solar panels.

Tinnerman has the combined capabilities required to develop and commercialize a cost-effective emissions reduction diesel exhaust aftertreatment system. Most importantly, this team can develop and commercialize the proposed system rapidly, so heavy-duty diesel trucks and potentially off-road equipment as well could also be retrofitted with this system.

Shadowood - Shadowood is a licensor of the Delphi's Diesel Fuel Reformer and On-Board Ammonia Generation and is the IP holder for retrofits. Previous to this time, a team of engineers and technicians from Delphi in the US and Europe began developing an alternative to urea/SCR. This work culminated in On-board Ammonia Generation where the needed reductant, ammonia, was generated on-board the vehicle thus eliminating the need for a second fluid. Performance of the system was successfully demonstrated on both US Federal and EU cycles with appropriately aged components. In 2008, Delphi offered the DFR and OAG Intellectual Property for sale and Shadowood procured the IP.

Particulate Matter (PM) control was added and the entire system for controlling all four constituents HC, CO, NO_x, and PM was renamed to Total Emission Compliance 2010 or TEC2010. Shadowood has partnered with Tinnerman, Inc. as the manufacturer of the TEC2010.

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