Johnson Matthey Locomotive DPF Demonstration

Technology Manufacturer
Johnson Matthey

Co-Participants
Port of Long Beach, Port of Los Angeles, Union Pacific Railroad, South Coast Air Quality Management District, California Air Resources Board

Project Objective

The Ports, in conjunction with CARB, SCAQMD, Union Pacific Railroad and Johnson Matthey partnered to demonstrate and evaluate the effectiveness of a Johnson Matthey diesel particulate filter (DPF) as an aftertreatment device on a Union Pacific Railroad Switcher Locomotive equipped with three (3) Tier 3 700 horsepower (hp) gensets (total 2,100 hp).
The purpose of the demonstration was to determine whether the installation of the Johnson Matthey system would allow the Tier 3 engines to meet Tier 4 PM emission standards, and to quantify additional reductions in carbon monoxide and hydrocarbon emissions. This project was also designed to demonstrate the transferability of Johnson Matthey's DPF technology, which is typically used in on-road heavy-duty vehicle applications, to an off-road locomotive application.

Technology Description

The Johnson Matthey Switcher Locomotive DPF System consists of multiple DPF, diesel oxidation catalyst (DOC), and catalyzed soot filter (CSF) components and was expected to achieve greater than 85 percent PM reduction in order to allow Tier 3 engines to meet federal Tier 4 locomotive engine emission standards for PM. The Catalyzed Continuously Regenerating Technology (CCRT™) system is a modified version of Johnson Matthey's Continuously Regenerating Technology (CRT™) used in on-road applications, with the addition of a specialized coating to the filter. The coating enhances the passive regeneration potential of the system at lower temperatures. According to Johnson Matthey, lower DPF regeneration temperatures are important in a switcher locomotive application because locomotive engines, with the significant amount of time spent at idle, have a temperature profile that is too low for other types of DPFs. Additionally, the system is designed with a feature to minimize back pressure that helps to increase the service life between filter cleanings.

The design modifications made to the locomotive CCRT™ (L- CCRT™) for this project consisted of multiple DOC and CSF pairs. The sizing of the system and the choice of specific DOC and CSF depended on the exhaust characteristics of the engine. Johnson Matthey conducted baseline testing on a 2007 model year, QSK19 engine at Southwest Research Institute (SwRI) and gathered useful data on the engine out temperature, exhaust flow, and emissions. From this testing, an alpha system was designed and installed on one of the three genset engines of Union Pacific switcher UPY-2737. This earlier test served as a precursor to the following CARB AQIP demonstration, in which Union Pacific switcher UPY-2755 was fitted with three DOC and CSF pairs (one for each genset).

The demonstration required 3,000 engine hours of operation in order to determine the durability of the Johnson Matthey system against the shock and vibrational forces experienced

during standard switcher locomotive operation. TAP project funding was allocated to cover emissions testing throughout the project and support the technology verification effort.

Results

Design and installation of the Johnson Matthey system took place in early 2011. After successful installation, the zero-hour emissions testing showed the Johnson Matthey system achieved Tier 4 PM emission levels. The retrofitted switcher was placed into Union Pacific's revenue service in July 2011 to fulfill the engine-hour durability testing requirement per the CARB AQIP agreement. Upon completion of the first 1,500 hours, the switcher was sent to SwRI to undergo the second round of emissions testing. Results from the 1,500 hour summary report demonstrated that the Johnson Matthey system performed well, averaging below Tier 4 levels at a PM output of 0.01 g/bhp-hr, well below the Tier 4 PM emission limit for the switcher duty cycle (0.030 g/bhp-hr). The switcher experienced minor mechanical problems (not related to the DPF) that resulted in unfavorable utilization during the latter half of 2012. The switcher was repaired in order to accumulate the 3,000 hours needed for CARB verification.

UPY-2755 accrued 3,000 hours of durability usage in March 2013 and was transferred to the SWRI testing facility to undergo final testing and data analysis. Results showed that the DPF performed at an average PM output of 0.021 g/bhp-hr, which is under the Tier 4 threshold of 0.030 g/bhp-hr, while achieving CO and HC emission reductions of 99% and 90%, respectively. The on-board data logger showed that the back pressure did not increase during the period from 0 to 3000 durability hours, which is a sign of system health. Meanwhile, the system was regenerating during the entire period and did not produce a significant amount of ash. Final test results indicated low back pressure across all three engines and despite the unrelated engine mechanical issues; the DPF was able to stay below the required emissions standard. The locomotive will continue to use the L- CCRT™ and the data logger to collect data after the project term. The project demonstration concluded on December 2, 2013 and Johnson Matthey submitted the final project report, which is available on the CAAP website. The CARB verification portion of the project was completed in February 2014 with CARB's approval of the L- CCRT™, retrofitted onto a NREC 3GS21 locomotive model, with a PM emission level of 0.02 g/bhp-hr. The project's final report is available on the TAP website.

Benefits

The benefits of the L-CCRT were verified by CARB with a PM emission level of 0.02g/bhp-hr. This verification is only for the use of the L-CCRT DPF on the NREC three-engine genset switch locomotive, or locomotive model 3GS21. Test results also demonstrated a reduction in CO and HC of 99% and 90%.

Project Costs

The total budget for this project was $692,356, of which Johnson Matthey committed $146,246 in cash match funding (21 percent total). Half of the project costs were covered by a CARB Air Quality Improvement Program (AQIP) grant in the amount of $346,178 to support the durability demonstration effort. TAP funding in the amount of $150,000 ($75,000 per Port) was covered emissions testing and verification costs.

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