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AIR QUALITY IMPROVEMENT PROGRAM
ADVANCED TECHNOLOGY DEMONSTRATION PROJECT
BAY AREA AIR QUALITY MANAGEMENT DISTRICT

FINAL REPORT

June 2, 2014



AQIP GRANT NUMBER – G10-AQIP-13
CONSTRUCTION AND DEMONSTRATION OF A
TIER 4 GENSET LOCOMOTIVE

NATIONAL RAILWAY EQUIPMENT CO.
and
RICHMOND PACIFIC RAILROAD CORPORATION



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EXECUTIVE SUMMARY

Following a research and development period, National Railway Equipment Co. (NRE) has introduced a Tier 4 N-ViroMotive locomotive. The N-ViroMotive product line consists of ultra-low emitting four and six axle road and switcher locomotives that feature one or more self-contained modular power plants (MMP) or NRE power on demand (POD) technology. These MMP/PODs contain an engine, generator/alternator and an engine cooling system designed for installation and subsequent removal-and-replacement as one entity on locomotive under frame. The N-ViroMotive GenSet locomotives with one or more PODs replace the conventional locomotive's large single engine. The N-ViroMotive GenSet locomotives feature world class, highly reliable electronic control systems that manage all engine, alternator and traction motor functions for both optimal fuel management and significantly improved adhesion capability. The results provide customers with a state-of-the-art locomotive that operates cleaner and has a longer service life than any other comparable road and switcher model locomotive.

The Bay Area Air Quality Management District (BAAQMD), in partnership with NRE and Richmond Pacific Railroad Corporation (RPRC), demonstrated a Tier 4 switcher locomotive in the Richmond Pacific Railroad rail yard in Richmond, California. The N-ViroMotive Ultra-low emission locomotive was designed and constructed by NRE at one of its Illinois facilities using two U.S. EPA Tier 4 Interim certified engines that are U. S. Environmental Protection Agency (U.S. EPA) certified as meeting Tier 4 emission standards for locomotives of 1.3 grams per/brake horsepower per hour (g/bhp-hr) of Oxides of Nitrogen (NOx) and 0.03 g/bhp-hr of Particulate Matter (PM).

Prior to delivery to the RPRC rail yard in Richmond, California, the locomotive was tested to establish an initial baseline emissions profile meeting the Tier 4 standards. However, due to fuel contamination issues with the first baseline emission testing procedure, a second baseline was necessary and was performed at the RPRC rail yard in October 2013.

The locomotive was then tested for durability while in revenue service consisting of 1,500 hours of operation which was completed on May 16, 2014. The unit was then returned to service to complete a total of 3,000 hours of operation to meet verification requirements of Air Resources Board (ARB) that are separate from this grant.

The results of the May 16, 2014, emission testing at 1,500 hours indicated that the demonstration was a success in that it achieved lower emissions than U.S. EPA Tier 4 emission requirements and further supports that the project fully met ARB verification requirements under this grant.

The next and final phase, separate from this grant, is for ARB verification which will be requested after emission testing is done at 3,000 hours of service. An addendum to this report will be prepared and sent to ARB at that time. The locomotive will remain in the State of California until at least 2016 under the terms of this agreement.

During the course of this project, three additional Tier 4 GenSet switcher locomotives have been commissioned outside of California. Once ARB verification has been issued, public incentive funding can be used to facilitate widespread commercialization within California.

Acknowledgments

The work reported in this document received funding by the California Air Resources Board (ARB) Air Quality Improvement Program (AQIP), pursuant to Assembly Bill 118 (AB 118), under State of California Grant 10-AQIP-13, dated June 23, 2011. This Tier 4 GenSet Locomotive demonstration project was made possible by a partnership among the National Railway Equipment Company (NRE), Richmond Pacific Railroad Company (RPRC), the Bay Area Air Quality Management District (BAAQMD), and ARB.

Background

In June, 2011, BAAQMD, in partnership with NRE and RPRC, was awarded a grant from the ARB for \$529,810.00 to construct and demonstrate a Tier 4 switcher in the RPRC rail yard in Richmond, California. Those emission standards are 1.3 g/bhp-hr of Oxides of Nitrogen (NO_x) and 0.03 g/bhp-hr of Particulate Matter (PM).¹ An N-ViroMotive ultra-low emission locomotive was designed and constructed by NRE at its Dixmoor, Illinois facility.

Target

The immediate target market for this Tier 4 GenSet locomotive will be more than 100 switcher locomotives currently operating throughout California. A GenSet locomotive is a locomotive having one or more self-contained modular power plants. Each modular power plant contains an engine (diesel or other fuel-consuming source of mechanical power—such as a gas turbine), an electrical generator or alternator, and an engine cooling system. Each modular power plant was designed for installation and subsequent removal-and-replacement as one entity on the locomotive under frame or platform. A GenSet locomotive may have one or more such modular power plants which cumulatively provide all of the locomotive's propulsion power. A switcher locomotive is used primarily in and around rail yards to assemble and disassemble trains, move railroad cars around, and make short transfer runs. One of the primary jobs assigned to this switcher unit was transfers of Nissan Leaf battery electric automobiles from marine shipping off-load from Japan to rail loading for delivery throughout the nation.

Rail yards, such as the Richmond rail yard, are often located in economically disadvantaged communities that are highly impacted by exposure to emissions from rail yard activities.²

Locomotives continue to represent the largest source of remaining rail yard diesel PM compared to non-locomotive sources (i.e., trucks, cargo handling equipment, and transport refrigeration units). Rail yard diesel PM represents significant local and regional cancer risks. Locomotive emission reductions resulting from the introduction of Tier 4 technology support existing State

¹ Prior to delivery, the locomotive was tested to establish a baseline emissions profile that showed emission levels were meeting the Tier 4 Standard. The locomotive was shipped to Richmond, California, for durability testing consisting of 1,500 hours of operation, however, due to fuel contamination issues, ARB rejected those results and a second baseline was established by ENTEC on October 15, 2013.

² According to the United States Census Bureau, in 2012 20.1 percent of the population for the zip code location of the Richmond Rail Yard (94804), are below 100 percent poverty level and 27 percent are below 125 percent of poverty level.

Implementation Plan commitments for California. Reducing exposure to air toxics through the demonstration, verification, and eventual market penetration of this reduced-emissions locomotive technology will provide a great benefit for California's public health and environment.

Purpose of Field Demonstration

The purpose of the project was to field demonstrate a Tier 4 GenSet locomotive emissions system's durability while reducing emissions that are significantly below the currently required Tier 3 U.S. EPA locomotive emission standards without the use of add-on after-treatment or Selective Catalyst System (SCR)/urea technologies that represent locomotive engineering and rail yard logistics challenges. Achieving Tier 4 emission standards without the use of these technologies is an added benefit for future rail yard applications.

The N-ViroMotive ultra-low emission locomotive is a proven technology developed and manufactured by NRE. The N-ViroMotive product line uses multiple off-road engines that supply power to power electronic devices that, in turn, feed individual traction motors. The benefits are reduced NOx and PM emission, improved emergence of efficiency, and reduced fuel consumption. Additional benefits include higher unit availability, significantly increased adhesion, and lower decibel ratings.

Project Summary

The project began with execution of the grant in June 2011. BAAQMD coordinated the project with NRE as the contractor and NRE secured RPRC to act as a partner to conduct the field demonstration in its rail yard located in Richmond, California. Once designs for the locomotive were approved by ARB in April 2012, NRE began the manufacture of a Tier 4 GenSet locomotive, which was designed to meet all Federal Railroad Administration, American Association of Railroads and U.S. EPA requirements. Using a GP 7 switcher locomotive as the core, it was stripped to its frame and repowered from the frame up, powered by NRE Tier 4 PODs. Everything above the deck was new material, components and fabrication.

Upon completion of the locomotive, initial baseline emission testing was conducted at NRE's Dixmoor, Illinois, facility in December 2012. Although results from the initial baseline testing were positive, ARB eventually disqualified the test due to contaminated fuel and required a second baseline emission test. In the meantime, the completed locomotive was delivered to the RPRC rail facility in Richmond, California, in March 2013 to commission the unit, conduct the second baseline emission test and begin in-service durability testing.

A second baseline emission test was completed in October 2013 and was approved by ARB in January 2014.

Following successful completion of emissions testing on May 16, 2014, the unit was returned to service to begin to accumulation of an additional 1,500 hours of operation to complete a total of 3,000 hours as required for an ARB verification process that is separate from this grant. Upon completion of the 3,000 hour durability milestone is expected to be completed by fall 2014.

NRE will apply for final verification of the application with ARB and move forward with commercialization of this and subsequent Tier 4 GenSet locomotives in California.

Under the terms of the original and amended agreements, the Tier 4 GenSet locomotive will remain in operation within the State of California at least until 2016.

GenSet switcher locomotives are growing in numbers in California with over 100 units currently in service statewide. Three additional NRE U.S. EPA Tier 4 compliant switcher locomotives have been successfully commissioned outside of California with a fourth locomotive build underway. Therefore, NRE commercialization of this advanced technology is already moving forward. Once ARB verification has been gained, ensuring Tier 4 emission levels, public incentive funding from the ARB Carl Moyer Memorial Air Quality Attainment Program can be used to accelerate the market penetration of this clean locomotive technology.

Project Results

Schedule:

Construction of the project extended twelve months longer than originally planned due to production constraints after project award and interfacing problems with the engine control module (ECM).

In January 2012, ARB approved a 90-day extension providing additional completion time.

In May 2013, NRE requested additional time and ARB approved a grant amendment due to delays associated with fuel documentation during the initial baseline emission testing.

As the project progressed, additional delays were experienced in late 2013 and early 2014, associated with reduced available work in the Richmond switchyard which required NRE to request a second extension. Because ARB was not able to roll remaining project funds into another fiscal year, the grant was amended a second time to allow NRE additional time to meet key project milestones by the completion date of June 2, 2014.

The amended completion date of June 2, 2014 only allowed the project to achieve the mid-way 1,500 hours of durability and emissions testing. It did not allow for the original target of 3,000 hours of durability and emissions testing. Therefore, the project funding was reduced by \$19,000.00. NRE has, however, continued durability testing outside the scope of this grant and will submit the Final 3,000 Hour Emission Test to ARB for purposes of verification and as an addendum to this report with an expected completion in fall 2014.

Application:

NRE conducted verification testing of its GenSet locomotive, a 2GS12B switch engine utilizing two (2) PODs. A GenSet locomotive is a locomotive having one or more self-contained modular power plants (MMP) or NRE's power on demand (POD). Each POD contains an engine (diesel or other fuel-consuming source of mechanical power—such as a gas turbine), an electrical generator or alternator, and an engine cooling system. Each POD was designed for installation

and subsequent removal-and-replacement as one entity on the locomotive under frame or platform. A GenSet locomotive may have one or more PODs which cumulatively provide one-hundred percent of the locomotive's propulsion power.

Both PODs in this application are powered by 15 liter diesel engines with an exhaust after treatment system and passive regeneration PM and NOx emissions.

Operation:

After design, construction, testing, and initial baseline emission testing was completed in January 2013, the Tier 4 GenSet locomotive was deployed to RPRC in Richmond, California. RPRC personnel were trained on the mechanics, operation, and maintenance of the unit. The locomotive was placed into service on March 15, 2013, to begin durability testing. In order to achieve the first 1,500 hours of operation, RPRC originally planned to use the unit five to six days a week for ten hours a day. However, this did not happen consistently due to a reduction in available business for the unit.

ENTEC's initial baseline emission report was submitted to BAAQMD and ARB for their review in April 2013, during which time the Tier 4 GenSet locomotive remained in operation at RPRC. ARB notified NRE in May 2013 that the baseline emission test report was deficient because the fuel properties reported failed to comply with standard practices of fuel properties reporting. NRE was unsuccessful in tracing the fuel used in the Baseline Emission Testing and could not satisfy the reporting protocol. As a result, ARB required NRE to retest the locomotive using U.S. EPA locomotive testing procedures as required by the project grant agreement and further required that hours of operation already accumulated on the unit could not count toward the first 1,500 hours of operation.

EMISSION REDUCTIONS:

Emission Test Results

ENTEC conducted locomotive emission tests for NRE on October 15, 2013, at the RPRC rail yard located in Richmond, California, to determine baseline emissions for the locomotive. The emissions were tested at low idle and eight notch load settings spanning the operational range of the locomotive in order to determine the emission rates of PM, NOx, carbon monoxide, sulfur dioxide, total hydrocarbons and the opacity of visible emissions.

Emission tests were conducted using U.S. EPA test methods as outlined in *40 CFR 1065*. NOx carbon monoxide, sulfur dioxide and total hydrocarbons emissions were determined by continuous sampling of the raw exhaust. The opacity of visible emissions was determined on the raw exhaust and PM emissions were determined by batch sampling of the diluted exhaust. A copy of the (accepted) October 13, 2013 ENTEC Baseline Emission Report utilized for finalization of this demonstration is attached hereto and labeled as Figure 3 – October 15, 2013 Tier 4 on Page 21.

The locomotive was pulled from service for emission testing by ENTEC on May 15, 2014, after 1500 hours of service. The locomotive was then returned to service for further compilation of

3000 hours which would be applied to the ARB verification for the N-ViroMotive Tier 4 GenSet locomotive.

The May 16, 2014 ENTEC 1500 Hour Emission Report is attached hereto and labeled as Figure 4 - May 16, 2014 Tier 4 at 1500 Hours on Page 22.

The results of the two emissions tests by ENTEC were then compared for the weighted averages of PM, NOx, carbon monoxide, sulfur dioxide, opacity, as illustrated below in Table 1.

	10/15/2013		05/15/2014		U.S. EPA Tier 4	
	Baseline		1500 Hours		Switch Locomotive Standard	
PM	0.000033	g/bhp-hr	0.0000178	g/bhp-hr	0.03	g/bhp-hr
NOx	1.178	g/bhp-hr	1.106	g/bhp-hr	1.3	g/bhp-hr
Carbon Monoxide	0.0004	g/bhp-hr	0.0136	g/bhp-hr	2.4	g/bhp-hr
Sulfur Dioxide	0.023	g/bhp-hr	0.032	g/bhp-hr	N/A	g/bhp-hr
Opacity	0.0026%		0%		20%	

Table 1- Baseline and 1500 Hour Emission Results Compared with U.S. EPA Tier 4

Fuel Test Results

Diesel fuel samples were taken directly from the locomotive fuel tank. The fuel tank was locked out until emission testing was completed. Fuel samples were sent to Saybolt Inc. for analysis per 40 CFR Part 1065 Subpart H. Diesel fuel was additionally tested for elemental composition to assist ENTEC in calculating the exhaust flow rate. The baseline fuel testing was performed in October, 2013 by Saybolt, Inc. is attached hereto Figure 5 – October 2013 Fuel Test Results on Page 25.

A fuel sample was taken by Saybolt, Inc., on May 8, 2014 and was submitted as Rail Car #2015 ULSD Red Dye Submitted Sample NRE, Richmond Pacific RR.

The results of the fuel testing completed by Saybolt, Inc. on May 13 2014, is attached and labeled as Figure 6 - May 13, 2014 Fuel Test Results on Page 26.

Task Milestones- Project Tasks

TASK 1 – PROJECT MANAGEMENT

Task 1.1 – Schedule Kick-off Meeting with project participants: NRE, Project Management Teams, Cummins, Inc., RPRC, BAAQMD and ARB

On November 15, 2011, an initial teleconference was held to discuss the development of the project schedule and deliverables.

Task 1.2 – Meeting with NRE, Cummins, Inc., RPRC and BAAQMD for review of Project Schedule for timeline and roles of Project Team Members.

On December 6, 2011, a conference call was held to discuss the Project Schedule, timeline and the roles of the project team members.

Deliverable: Detailed Project Schedule and Detailed Timeline

Due Date: August 17, 2011

On December 19, 2011, NRE provided BAAQMD and ARB with the Mechanical Specifications, General Arrangement, Equipment Layout, Project Schedule and Project Timeline.

Task 1.3 - Obtain ARB Project Liaison approval of the detailed Project Schedule and Detailed Project Timeline

On December 19, 2011, ARB approved the detailed Project Schedule and Detailed Project Timeline.

Task 1.4 – Obtain ARB Project Liaison approval to move to Task 2

On December 28, 2011, NRE received ARB’s approval to move to Task 2.

TASK 2 – ENGINEERING AND DESIGN

Task 2.1 – NRE will design the general arrangement for the components of the Tier 4 GenSet Locomotive, determine mechanical and electrical needs and produce schematics for production

The next major task for NRE was to design the general arrangement for the components of the Tier 4 GenSet locomotive, determine the mechanical and electrical needs and produce schematics for production.

Issue Encountered:

During a conference call on January 23, 2012, NRE requested a 90-day extension to complete the electrical interface issues associated with the GenSet and submitted the same in writing on January 25, 2012. ARB granted the extension on January 27, 2012 and NRE provided a revised project schedule to accommodate the extension.

Task 2.2 – Obtain ARB Project Liaison approval of the preliminary engineering and design plans for the project

Deliverable: Final Report on Project Engineering and Design Plans

Due Date: Revised from October 19, 2011, to April 15, 2012 or sooner

On April 10, 2012, NRE completed the final electrical specification and forwarded to BAAQMD and ARB for approval.

Task 2.3 – Obtain ARB Project Liaison approval to move on to Task 3

On April 16, 2012, BAAQMD, ARB and NRE held a conference call to discuss the documents that had previously been submitted. NRE received ARB's approved to move to Task 3.

TASK 3 – PURCHASING AND FABRICATION

Task 3.1 – Obtain ARB Project Liaison approval to begin purchasing project components

NRE received ARB Project Liaison's approval to begin purchasing project components.

Task 3.2 – Begin purchasing material and electrical components

Deliverable: Report on Purchases of Tier 4 GenSet Locomotive Components

Due Date: Revised from November 9, 2011, to April 25, 2012

On April 30, 2012, NRE provided BAAQMD and ARB with NRE's Bill of Material (BOM) and Rabbit Build schedule along with the U.S. EPA Certification for the Tier 4 engines to meet grant requirements for documentation of purchases.

Task 3.3 – Obtain ARB Project Liaison approval to begin fabrication of the Tier 4 GenSet Locomotive

On May 8, 2012, NRE received ARB's approval to begin fabrication of the Tier 4 GenSet locomotive.

Additional Activity:

On May 17, 2012, NRE submitted Invoice S-127330 in the amount of \$50,000 for completion of Task 2.

Task 3.4 – Begin fabrication of skid mounted PODs, control stands and other components that are required for manufacture of the Tier 4 GenSet Locomotive as detailed in the Final Report on the Project Engineering and Design Plans

Deliverable: Report on Fabrication of Tier 4 GenSet Locomotive Components

Due Date: Revised from December 14, 2011, to May 15, 2012

NRE advised BAAQMD and ARB that all parts had been purchased or ordered. The 15 liter engines were at NRE's Mt. Vernon, Illinois facility and fabrication of the cab structure, engine hoods and chopper compartments was underway.

Task 3.5 – Obtain ARB Project Liaison approval to move on to Task 4

On May 21, 2012, NRE received ARB approval to move to Task 4.

TASK 4 – PRODUCTION

Task 4.1 – Begin manufacture of the Tier 4 GenSet Locomotive at NRE's Dixmoor, Illinois facility

On August 2, 2012, NRE advised BAAQMD and ARB that fabrication of the Tier 4 PODs had begun. The Tier 4 GenSet used a GP 7 frame and everything above the frame was new. The main electrical cabinet, control cabinet and control console were near completion and being assembled and wired. Work continued on the engine hood and chopper compartment as well.

Issue Encountered:

On August 2, 2012, NRE notified BAAQMD and ARB of integration issues with the locomotive relating to the regeneration of the diesel particulate filter (DPF) and micro-process systems. NRE worked to promptly resolve the problem.

Additional Activity:

On September 6, 2012, NRE reported that the project was closer to schedule than had been originally thought. Diagnostic testing was performed on the engines and only found minor issues which were resolved at that time.

Deliverable: Interim Report on Manufacture of the Tier 4 GenSet Locomotive

Due Date: Revised from February 29, 2012 to June 25, 2012

On October 3, 2012, NRE reported that the Tier 4 GenSet locomotive was approximately seventy five percent complete from a structural and wiring perspective. The first POD was completed and assembled at NRE's Mt. Vernon, IL facility. However, NRE noticed that the control system was not communicating properly and continued to work through these issues and completed work on the second POD.

Issue Encountered:

The integration of the electrical components caused some delays resulting in a revision for the schedule. Under the revised schedule it might be difficult to complete the project prior to the June 14, 2013 deadline.

Additional Activity:

NRE, BAAQMD and ARB continued discussion about engaging ENTEC to do the field emission testing. ARB approved ENTEC to conduct the emission testing of the locomotive on October 24, 2012, BAAQMD provided ARB ENTEC's protocol for emission testing on

October 30, 2012. ARB approved ENTEC protocol for emission testing October 30, 2012. (Task 9)

On July 12, 2012, NRE prepared Invoice S-128059 in the amount of \$200,810 for the completion of Task 3. However; this invoice was not submitted to ARB until November 27, 2012.

Task 4.2 – Obtain ARB Project Liaison approval to move forward with completion of the manufacture of the locomotive

On December 4, 2012, NRE received ARB’s approval to move to Task 4.3.

Task 4.3 – Completed the manufacture of the Tier 4 GenSet Locomotive

Deliverable: Final Report on the Manufacture of the Tier 4 GenSet Locomotive

Due Date: Revised from April 11, 2012 to August 15, 2012

During the final phase of production, all electrical wiring and components were completed and the electrical cabinet was installed. The PODs were installed and wired. The new cab was completed with the control console, engineer seats, heaters, air conditioning, new windows, flooring, hand rails and steps. Choppers were installed and wired. All modification to the frame had been completed including traction motors, brake equipment and a refurbished fuel tank.

Task 4.4 – Obtain ARB Project Liaison approval to move on to Task 5

On January 11, 2013, NRE received ARB’s approval to move to Task 5.

TASK 5 – TESTING OF THE LOCOMOTIVE

Task 5.1 – NRE will test the various components of the Tier 4 GenSet Locomotive at its Dixmoor, Illinois, facility for efficiency and truck operation to ensure all electrical, mechanical and software parts are functioning as designed

Deliverable: Report on Test of Tier 4 GenSet Locomotive Components and Functionality.

Due Date: Revised from April 25, 2012 to June 17, 2013

With the completion of the locomotive, the two PODs were installed in the Tier 4 locomotive. A new application quality assurance test was performed and the locomotive was load box tested. Results of the load box testing revealed problems with the traction motor flow rates which were not balanced and the central air system and voltage regulator did not meet specifications which was resolved during testing. The engine governor tuning was also found to be unacceptable for a locomotive application and was adjusted at this time.

Task 5.2 – Obtain ARB Project Liaison approval to move on to Task 6

NRE received ARB Project Liaison’s approval to move to Task 6 on March 14, 2013.

TASK 6 – PAINTING OF TIER 4 GENSET LOCOMOTIVE

Task 6.1 – Paint Tier 4 GenSet Locomotive at NRE’s Dixmoor, Illinois, facility including priming, painting, clear coating and application of relevant decals

The Tier 4 GenSet locomotive was painted NRE’s colors of dark blue and gold. BAAQMD provided logos to be applied to the unit. The locomotive was transferred to the paint shop where it was primed and painted. The decals were applied and the unit was clear coated. NRE completed painting the Tier 4 GenSet in mid-November 2012.

On November 29, 2012, ARB approved an ARB logo prepared by NRE to be used on the Tier 4 GenSet locomotive.

Task 6.2 – Obtain ARB Project Liaison approval to move on to Task 7

NRE received ARB’s approval to move to Task 7 on March 21, 2013.

TASK 7 – FINAL INSPECTION OF TIER 4 GENSET LOCOMOTIVE

Task 7.1 – NRE will perform at its Dixmoor, Illinois, facility the second quality assurance inspection to ensure that all Tier 4 GenSet locomotive components are functioning as designed

Deliverable: Report on Final Inspection of Tier 4 GenSet Locomotive

Due Date: Revised from May 16, 2012, to June 17, 2013

In coordination with Cummins, NRE performed all the necessary quality assurance inspections of the Tier 4 GenSet locomotive.

Task 7.2 - Obtain ARB Project Liaison approval to move on to Task 8

NRE received ARB’s approval to move to Task 8 on April 8, 2013.

TASK 8 – INSPECTION OF TIER 4 GENSET LOCOMOTIVE

Task 8.1 – Invite RPRC and BAAQMD to inspect the Tier 4 GenSet locomotive at NRE’s Dixmoor, Illinois, facility

Deliverable: Report on Tier 4 GenSet Locomotive Inspection

Due Date: Revised from May 23, 2013, to June 17, 2013

Representatives from ARB, BAAQMD and RPRC were invited to travel to NRE’s Dixmoor, Illinois, facility to inspect the Tier 4 GenSet. However, because of extensive delays encountered earlier in the project and budget restraints, ARB, BAAQMD and RPRC decided to conduct an on-site inspection once the Tier 4 GenSet locomotive arrived in California.

Members from NRE, ARB, BAAQMD and RPRC held an on-site meeting at the RPRC Richmond facility on May 17, 2013. Attendees were on-site at the staging area to view, inspect and board the locomotive. After the hands-on tour a meeting was conducted to further explain the technology behind the Tier 4 GenSet locomotive and discuss details of the project and the field demonstration.

Task 8.2 – Obtain ARB Project Liaison approval to move on to Task 9

NRE received ARB’s approval to move to Task 9 on May 17, 2013.

TASK 9 – BASELINE EMISSION TESTING (ZERO HOURS)

Task 9.1 – Obtain ARB Project Liaison prior approval on the baseline emission testing protocol to be used on the Tier 4 GenSet Locomotive

ARB had previously approved the ENTEC testing protocol for baseline emission testing on October 30, 2013 (previously referenced in Task 4.1).

Task 9.2 – In consultation with ARB, NRE and RPRC, and other demonstration project participants, an on-board data monitoring protocol will be created to collect locomotive notch data in a format to be determined by ARB for the entire field demonstration period.

ARB previously approved ENTEC to perform the Baseline Emission Testing in compliance with Federal Test procedure for locomotives, as detailed in the Code of Federal Regulations (CFR) 40 CFR Part 92, 40 CFR Part 1033, 40 CFR Part 1065 and consultation with ARB.

Task 9.3 – Before shipping the locomotive to RPRC, baseline engine emission testing will be performed on the Tier 4 GenSet locomotive in compliance with the Federal Test procedure for locomotives, as detailed in the Code of Federal Regulations (CFR) 40 CFR Part 92, 40 CFR Part 1033, 40 CFR Part 1065 and consultation with ARB

On December 6, 2012, ENTEC conducted locomotive emission tests for NRE at NRE’s facility located in Dixmoor, Illinois. The tests were conducted to determine the baseline emissions profile for the Tier 4 GenSet locomotive. The emissions were tested at low idle and eight notch load setting, spanning the operation range of the locomotive in order to determine the emission rates of PM, NOx, carbon monoxide, sulfur dioxide, total hydrocarbons, and the opacity of visible emissions.

Task 9.4 – Provide ARB with a preliminary report on the emission testing of the Tier 4 GenSet Locomotive

Deliverable: Report on Baseline Emission Testing of the Tier 4 GenSet Locomotive

Due Date: Revised from May 23, 2013 to June 17, 2013

Due to the complexity of the report ENTEC's Final Report on Baseline Emission Testing was not completed until April 3, 2013 and was subsequently forwarded to BAAQMD and ARB for review.

Issue Encountered:

On May 7, 2013 the ARB advised NRE that the fuel samples did not meet ARB standards. The failure of proper fuel management (contamination) and fuel testing (improper tests) resulted in a failed test as a whole. The fuel samples that were taken showed an estimated five percent contamination with Low Sulfur Diesel fuel which resulted in a 33ppm sulfur concentration which exceeds the 15ppm level for Ultra Low Sulfur Diesel fuel. ARB instructed NRE to perform another Baseline Emission Test on the Tier 4 GenSet and that any hours of operation accumulated prior to rescheduled test would not be counted toward the 1,500 hours of operation.

Due to this significant setback, ARB allowed an 11-month extension from June 1, 2013 to May 15, 2014, at which time a Final Report would be due to ARB. Unfortunately due to scheduling conflicts, ENTEC was not able to field test the Tier 4 GenSet until October 15, 2013, thus causing additional delays.

ENTECC conducted a second baseline emission test on the Tier 4 GenSet on October 15, 2013, at RPRC Richmond, California facility. NRE provided BAAQMD and ARB preliminary fuel test results on November 21, 2013, and emission test results from ENTEC on December 16, 2013. The completed ENTEC report was furnished to ARB for review on January 17, 2014.

Additional Activity:

On May 10, 2013, ARB sent to NRE a Preliminary Verification Procedure.

On June 18, 2013, NRE submitted Invoice S 133198 in the amount of \$50,000 for the completion of Task 7.

On June 28, 2013, NRE provided BAAQMD and ARB with Preliminary Emission Verification Test Plan.

On July 10, 2013, ARB provided comments to NRE on Preliminary Emission Verification Test Plan.

On August 7, 2013, NRE provided BAAQMD and ARB with a revised Preliminary Emission Verification Test Plan.

On August 13, 2013, ARB provided additional comments to NRE on Preliminary Emissions Verification Test Plan.

On October 4, 2013, NRE submitted final revision of ARB Preliminary Emission Verification Test Plan.

Task 9.5 – Obtain ARB Project Liaison approval to move on to Task 10

On January 14, 2014, NRE received ARB’s approval to move to Task 10.

TASK 10 – SHIPMENT OF THE TIER 4 GENSET LOCOMOTIVE TO RPRC FACILITY IN RICHMOND, CALIFORNIA

Task 10.1 – RPRC and BAAQMD verify that the Tier 4 GenSet locomotive has arrived in Richmond, California

On February 26, 2013, the Tier 4 GenSet locomotive, Unit #2015, was way billed from NRE’s Silvis, Illinois, facility.

On March 11, 2013, the Tier 4 GenSet locomotive arrived in Richmond, California.

Upon arrival the unit was placed in RPRC’s Maintenance facility for inspection. Some minor issues occurred in transit but were discovered and quickly corrected.

Issue Encountered:

Prior to shipping the Tier 4 GenSet locomotive to RPRC, NRE shipped the locomotive to its Silvis, Illinois, facility where addition track testing could be conducted.

NRE’s Silvis facility conducted a number of tests on the Tier 4 GenSet to ensure it would function properly. Several problems were encountered which caused delay in shipping the unit out. Problems encountered included voltage regulator problems, issues with the governor, control implementation, validation and mechanical modifications that were corrected.

Task 10.2 – Obtain ARB Project Liaison approval to move on to Task 11

January 23, 2014. NRE received ARB’s approval to move to Task 11.

TASK 11 – COMMISSIONING OF THE TIER 4 GENSET LOCOMOTIVE

Task 11.1 – After arrival at RPRC’s Richmond, California facility, NRE’s Field Service will inspect the Tier 4 GenSet locomotive to insure that all systems are operating as designed

Task 11.2 – NRE’s Field Service will train RPRC personnel on the proper operation and maintenance of the Tier 4 GenSet locomotive

Prior to placing the Tier 4 GenSet into service, a representative from NRE’s Field Service was on hand to commission the unit and train RPRC personnel on the functionality, operation and maintenance of the locomotive. Unit #2015 was in good operating condition and was placed into service to begin the first phase of emission testing at 1,500 hours of operation.

Task 11.3 – Obtain ARB Project Liaison to move on to Task 11.4

On January 23, 2014, NRE received ARB’s approval to move to Task 11.4.

Task 11.4 – RPRC will place the Tier 4 GenSet locomotive in revenue service at its Richmond, California, facility and begin the first 1,500 hours phase of durability testing

On March 15, 2013, RPRC placed the Tier 4 GenSet, Unit #2015 into service.

Task 11.5 – Obtain ARB Project Liaison approval to move on to Task 12

On January 23, 2014, NRE received ARB’s approval to move to Task 12.

Task 12 – Tier 4 GenSet Engine Testing First Phase

Task 12.1 – Obtain ARB Project Liaison prior approval on the emission testing protocol to be used on the Tier 4 GenSet Locomotive.

NRE received ARB’s approval for the emission testing protocol on October 30, 2012, and again on February 10, 2014.

Task 12.2 – After 1,500 hours of Tier 4 GenSet locomotive operation, engine emission testing will be performed in compliance with the Federal Test Procedure for locomotives, as detailed in the Code of Federal Regulations (CFR) 40 CFR Part 92, 40 CFR Part 1033, 40 CFR Part 1065 and in consultation with ARB

Deliverable: Report of Tier 4 GenSet Locomotive Functionality and Locomotive Notch Data During First Phase of Durability Testing

Due Date: Final Draft Report revised from December 19, 2013 to May 15, 2014

The 1,500 hour mid-life emission testing was completed on the Tier 4 GenSet locomotive on May 15, 2014. Although there were some testing issues and a few restarts, NRE and ENTEC were able to collect all of the data required for a complete emission test. ENTEC returned to Baton Rouge to prepare the preliminary results. Preliminary test results were submitted to BAAQMD and ARB for review on May 27, 2014.

Task 12.3 – Provide ARB with a preliminary report on the emission testing of the Tier 4 GenSet locomotive

Deliverable: Final Report on Emission Testing of the Tier 4 GenSet Locomotive at 1,500 Hours of Operation

Due Date: June 2, 2014

The Grantee will update ARB annually on the locomotive’s usage within California until July 30, 2016, when the requirements of Provision 2.4 are met.

Budget

COST		FUNDING AMOUNT
Cash Contributions:	NRE Funds	\$ 1,147,413
	AQIP Grant Amount	510,810
Sub Total Cash		\$1,658,223
In-Kind Contribution	NRE	61,175
TOTAL PROJECT COST		<u>\$1,719,398</u>

Payment Schedules

Date	Task	Milestone Description	AQIP Project Funding
October 19, 2011	Task 2: Engineering and Design	Report on Project Engineering and Design Plans	\$ 50,000
December 14, 2011	Task 3: Purchasing and Fabrication	Report on Fabrication Locomotive Components	\$ 200,810
June 3, 2013	Task 7: Final Inspection of Tier 4 GenSet locomotive	Report on Final Inspection of the Locomotive	\$ 50,000
May 29, 2014	Task 12: Tier 4 POD Engine Emission Testing	Report on Emission Testing of the Locomotive at 1,500 Hours of Operation	\$150,000
June 2, 2014	Task 12.3 Hours achieved above 1,500 hours	Report of Tier 4 GenSet hours of operation achieved during operations above 1,500 hours towards meeting 3,000 hours durability requirement [formula: (\$30,000 / 1,500) X (Hours achieved above 1,500 by June 2, 2014)]	Up to \$30,000
June 2, 2014	Task 13.4	ARB Approval of Final Report	\$30,000
		AQIP Funding Total	\$510,810

Electrical and Mechanical Specifications

This new generation GenSet locomotive uses two 15 liter Tier 4 Interim engines. The concept is to use heavy-duty Tier 4 interim industrial technology in a multi-level engine/POD switcher. The advantages are many: a Tier 4 switcher emission without SCR/urea; the use of proven, durable and latest technology platform; and, equipped with a diesel particulate filter.

The U.S. EPA 2013 Model Year Certificate of Conformity with the Clean Air Act of 1990, effective August 15, 2012 was issued on August 15, 2012 to Cummins, Inc., for the Engine Family Name: DCEXG15.-AAA. The engines were manufactured within the provisions of *40 CFR Part 1033, Subpart H*, after having been tested and found to confirm to applicable requirements pursuant to *§213 of the Clean Air Act (42 U.S.C. §7547)* and *40 CFR 1033*. A copy of said certification is attached labeled as Figure 2- U.S. EPA Certification for Cummins DCEXG15.0AAA on Page 20.

The unit is an N-Viromotive 2GS12B GenSet locomotive using two GenSets. A GenSet locomotive is a locomotive having one or more self-contained modular power plants. Each modular power plant contains an engine (diesel or other fuel-consuming source of mechanical power—such as a gas turbine), an electrical generator or alternator, and an engine cooling system. Each modular power plant was designed for installation and subsequent removal-and-replacement as one entity on the locomotive under frame or platform. A GenSet locomotive may have one or more such modular power plants which cumulatively provide all of the locomotive's propulsion power.



Figure 1 - Unit #2015 - NR156 2GS12B Locomotive

CONCLUSION

The main purpose of the ARB solicitation and grant that funded this demonstration project was to demonstrate locomotive engines and/or after treatment systems that meet or exceed the U.S. EPA Tier 4 emissions level (1.3 g NO_x/bhp-hr and 0.0 g PM/bhp-hr) in revenue service.

This final report clearly shows that NRE has exceeded the emission reductions needed to qualify this locomotive for this grant having reached or exceeded Tier 4 emission reduction levels. As seen in the results of the two emission tests conducted at commissioning and at 1,500 hours, there were significant reductions in both NO_x and PM levels as required by the grant. The grant required an emissions level at or below 1.3 g NO_x/bhp-hr is a 40 percent reduction over current U.S. EPA Tier 3 standards. As tested during commissioning the NO_x levels were 1.178 g/bhp-hr and PM levels were 0.000033 g/bhp-hr which is less than 0.1 percent of allowable levels to be eligible for this grant and clearly in compliance with U.S. EPA Tier 4 emission levels. The 1,500 hour emission test revealed NO_x levels at 1.106 g/bhp-hr and PM levels at 0.000018 g/bhp-hr showing that the technology has had little to no deterioration of criteria pollutant emissions over the 1,500 hours of field operations.

The combination of proper POD management technology and an effective diesel particulate filter have proven over the required test period that this locomotive with its technology not only fulfills the grant requirement, but exceeds them by a large margin.

NRE has confidence this technology will continue to exceed the requirements and expectations of ARB and BAAQMD. Other added benefits from the use of this switcher locomotive are zero visible smoke emissions and quiet operation, compared to similar locomotives, which will make this a very attractive product for railroad operation and more widely accepted by the people living near rail yards where this technology is employed.

In further support of the success of its Tier 4 technology, NRE reports that other Tier 4 N-ViroMotive units, similar to the NREX Unit #2015 used for this demonstration project, have been commissioned by the U.S. Navy in Earle, New Jersey, and by Amtrak in Washington, D.C. Union Station.

The NRE N-ViroMotive Tier 4 technology has proven itself for the successful application in both new and rebuilt locomotives. The target goal for this technology replacing over 100 switcher locomotives operating in California is feasible especially given the results of this demonstration project that are specifically noted herein. Further low-income areas that are often in close proximity to rail yards will realize health benefits associated with cleaner locomotive technology. NRE is fully prepared to meet the rail industry needs for the production of Tier 4 N-ViroMotive units not only in California, but for the entire United States.

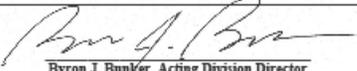
	UNITED STATES ENVIRONMENTAL PROTECTION AGENCY 2013 MODEL YEAR CERTIFICATE OF CONFORMITY WITH THE CLEAN AIR ACT OF 1990	OFFICE OF TRANSPORTATION AND AIR QUALITY ANN ARBOR, MICHIGAN 48105	
Certificate Issued To: Cummins Inc. (U.S. Manufacturer or Importer) Certificate Number: DCEXG15.0AAA-003	Effective Date: <u>08/15/2012</u> Expiration Date: <u>12/31/2013</u>	 Byron J. Bunker, Acting Division Director Compliance Division	Issue Date: <u>08/15/2012</u> Revision Date: <u>N/A</u>
Engine Family Name: DCEXG15.0AAA		Vehicle/Engine Category: Locomotive	
<p>Pursuant to Section 213 of the Clean Air Act (42 U.S.C. section 7547) and 40 CFR 1033, and subject to the terms and conditions prescribed in those provisions, this certificate of conformity is hereby issued with respect to the test engine which has been found to conform to applicable requirements and which represents the following locomotive engines, by engine family, more fully described in the documentation required by 40 CFR 1033 and produced in the stated model year.</p> <p>This certificate of conformity is conditional upon compliance of said manufacturer with the provisions of 40 CFR Part 1033, Subpart H. Failure to comply with these provisions may render this certificate void <i>ab initio</i>.</p> <p>This certificate of conformity covers only those new locomotive engines which conform in all material respects to the design specifications that applied to those engines described in the Application for Certification required by 40 CFR 1033 and which are produced during the model year stated on this certificate of the said manufacturer, as defined in 40 CFR 1033.</p> <p>It is a term of this certificate that the manufacturer shall consent to all inspections described in 40 CFR 1068.20 and authorized in a warrant or court order. Failure to comply with the requirements of such a warrant or court order may lead to revocation or suspension of this certificate for reasons specified in 40 CFR 1068. It is also a term of this certificate that this certificate may be revoked or suspended or rendered void <i>ab initio</i> for other reasons specified in 40 CFR 1068.</p>			

Figure 2- U.S. EPA Certification for Cummins DCEXG15.0AAA



**TABLE 2-1
LOCOMOTIVE TEST
TEST RESULTS SUMMARY**

Tier 4 Baseline

Client: National Railway Equipment Company (NREC) Entec Project No.: 613115
 Location: Richmond Rail Yard Client Project No.:
 Locomotive Manufacturer: NREC Locomotive Model: 2GS128
 Engine Manufacturer: Cummins, Inc. Engine Model Year: 2012
 Engine Model: GSX15 Engine Serial No(s): 79471744 / 79471745
 Engine Family: DCEXG15.0AAA Max. Rated Horsepower: 1200

LOAD SETTING	Idle Low		Notch 1		Notch 2		Notch 3		Notch 4		Notch 5		Notch 6		Notch 7		Notch 8		WEIGHTED AVERAGES (1)		
	DATE	TIME	15-Oct-13	15-Oct-13	15-Oct-13	15-Oct-13	15-Oct-13	15-Oct-13	15-Oct-13	15-Oct-13	15-Oct-13	15-Oct-13	15-Oct-13	15-Oct-13	15-Oct-13	15-Oct-13	15-Oct-13	15-Oct-13			
PARTICULATE			0.0000826	0.00001956	0.00003038	0.00001920	0.00000966	0.00001431	0.00001122	0.00000992	0.00001431	0.00000992	0.00001431	0.00000992	0.00001431	0.00000992	0.00001431	0.00000992	0.00001431	0.00000992	
			g/decf	g/hr	g/hr																
			0.0000448	0.0000389	0.0000484	0.0000295	0.0000172	0.0000213	0.0000147	0.0000213	0.0000147	0.0000213	0.0000147	0.0000213	0.0000147	0.0000213	0.0000147	0.0000213	0.0000147	0.0000213	
OXIDES OF NITROGEN as NO2			252.5	186.4	161.1	213.0	148.8	187.9	198.4	238.6	347.8	1905.4	1610.0	1.178							
			g/hr	g/hr	g/hr	g/hr	g/hr	g/hr	g/hr	g/hr	g/hr	g/hr	g/hr	g/hr	g/hr	g/hr	g/hr	g/hr	g/hr	g/hr	g/hr
			4.448	1.140	0.834	1.051	0.835	0.855	0.959	1.150	1.610	1.178									
NITROGEN DIOXIDE (NO2)			44.5	118.9	75.6	86.8	82.2	74.6	78.8	93.2	91.9	504.6	442.5	0.502							
			g/hr	g/hr	g/hr	g/hr	g/hr	g/hr	g/hr	g/hr	g/hr	g/hr	g/hr	g/hr	g/hr	g/hr	g/hr	g/hr	g/hr	g/hr	g/hr
			0.783	0.728	0.392	0.432	0.462	0.380	0.381	0.449	0.425	0.502									
CARBON MONOXIDE			< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	
			g/hr	g/hr	g/hr	g/hr	g/hr	g/hr	g/hr	g/hr	g/hr	g/hr	g/hr	g/hr	g/hr	g/hr	g/hr	g/hr	g/hr	g/hr	g/hr
			< 0.0011	< 0.0004	< 0.0003	< 0.0003	< 0.0003	< 0.0003	< 0.0003	< 0.0003	< 0.0003	< 0.0003	< 0.0003	< 0.0003	< 0.0003	< 0.0003	< 0.0003	< 0.0003	< 0.0003	< 0.0003	
SULFUR DIOXIDE			2.1	3.7	2.7	3.3	2.7	2.2	2.4	2.5	2.3	0.023	0.023	0.023	0.015	0.015	0.015	0.015	0.015	0.015	
			g/hr	g/hr	g/hr	g/hr	g/hr	g/hr	g/hr	g/hr	g/hr	g/hr	g/hr	g/hr	g/hr	g/hr	g/hr	g/hr	g/hr	g/hr	g/hr
			0.051	0.032	0.020	0.023	0.021	0.015	0.015	0.016	0.015	0.023	0.023	0.015	0.015	0.015	0.015	0.015	0.015	0.015	
THC as propane			2.5	< 0.1	< 0.1	< 0.1	0.3	0.3	0.3	< 0.1	0.9	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	
			g/hr	g/hr	g/hr	g/hr	g/hr	g/hr	g/hr	g/hr	g/hr	g/hr	g/hr	g/hr	g/hr	g/hr	g/hr	g/hr	g/hr	g/hr	g/hr
			0.82	< 0.06	< 0.09	< 0.12	1.05	1.19	< 0.22	< 0.22	4.99	< 0.22	< 0.22	< 0.22	< 0.22	< 0.22	< 0.22	< 0.22	< 0.22	< 0.22	
THC as propane			g/hr	g/hr	g/hr	g/hr	g/hr	g/hr	g/hr	g/hr	g/hr	g/hr	g/hr	g/hr	g/hr	g/hr	g/hr	g/hr	g/hr	g/hr	g/hr
			0.0436	< 0.0003	< 0.0003	< 0.0003	0.0018	0.0016	0.0016	0.0016	0.0042	< 0.0003	< 0.0003	< 0.0003	< 0.0003	< 0.0003	< 0.0003	< 0.0003	< 0.0003	< 0.0003	
OPACITY, VISIBLE EMISSIONS			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
			%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
CARBON DIOXIDE			3.17	8.28	9.23	9.53	8.84	9.44	9.75	10.01	10.01	6.52	6.52	6.52	6.52	6.52	6.52	6.52	6.52	6.52	
			Vol% dry	Vol% dry	Vol% dry	Vol% dry	Vol% dry	Vol% dry	Vol% dry	Vol% dry	Vol% dry	Vol% dry	Vol% dry	Vol% dry	Vol% dry	Vol% dry	Vol% dry	Vol% dry	Vol% dry	Vol% dry	Vol% dry
MOISTURE			4.43	8.57	9.29	9.50	8.96	9.42	9.67	9.54	9.88	9.54	9.88	9.54	9.88	9.54	9.88	9.54	9.88	9.54	
			Vol%	Vol%	Vol%	Vol%	Vol%	Vol%	Vol%	Vol%	Vol%	Vol%	Vol%	Vol%	Vol%	Vol%	Vol%	Vol%	Vol%	Vol%	Vol%
EXHAUST FLOW			102.51	355.38	506.46	687.74	1026.73	1142.22	1294.29	1465.46	1690.71	1465.46	1690.71	1465.46	1690.71	1465.46	1690.71	1465.46	1690.71	1465.46	
			discfm	discfm	discfm	discfm	discfm	discfm	discfm	discfm	discfm	discfm	discfm	discfm	discfm	discfm	discfm	discfm	discfm	discfm	discfm
ENGINE FUEL FIRING RATE			0.017	0.159	0.253	0.354	0.489	0.581	0.682	0.758	0.916	0.682	0.758	0.916	0.682	0.758	0.916	0.682	0.758	0.916	
			g/min	g/min	g/min	g/min	g/min	g/min	g/min	g/min	g/min	g/min	g/min	g/min	g/min	g/min	g/min	g/min	g/min	g/min	g/min
ENGINE G1 SPEED			900	1378	1499	1690	1699	1699	1699	1699	1800	1699	1699	1800	1699	1699	1800	1699	1699	1800	
			rpm	rpm	rpm	rpm	rpm	rpm	rpm	rpm	rpm	rpm	rpm	rpm	rpm	rpm	rpm	rpm	rpm	rpm	rpm
ENGINE G2 SPEED			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
			rpm	rpm	rpm	rpm	rpm	rpm	rpm	rpm	rpm	rpm	rpm	rpm	rpm	rpm	rpm	rpm	rpm	rpm	rpm
ENGINE G3 SPEED			19	189	318	448	594	728	870	987	1186	870	987	1186	870	987	1186	870	987	1186	
			bhp	bhp	bhp	bhp	bhp	bhp	bhp	bhp	bhp	bhp	bhp	bhp	bhp	bhp	bhp	bhp	bhp	bhp	bhp
TOTAL ENGINE POWER			14.1	140.6	236.8	334.4	442.9	542.9	646.5	736.3	884.5	646.5	736.3	884.5	646.5	736.3	884.5	646.5	736.3	884.5	
			kWatt	kWatt	kWatt	kWatt	kWatt	kWatt	kWatt	kWatt	kWatt	kWatt	kWatt	kWatt	kWatt	kWatt	kWatt	kWatt	kWatt	kWatt	kWatt
APPLIED WIGHTING FACTORS			0.299	0.124	0.123	0.058	0.036	0.036	0.036	0.015	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	

(1) Weighted average. Switch (<2000 bhp), Single Idle, 40 CFR 1033.530, Table II
 40 CFR 1033.530(e) Exemptions for Automated Start-Stop. Selected idle weighted average adjustment is -50% for idle notch settings.

Figure 3 – October 15, 2013 Tier 4 Baseline Results

ENTEC SERVICES
TABLE 2-1
LOCOMOTIVE TEST
TEST RESULTS SUMMARY

Tier 4 @ 1500 Hours

Client: National Railway Equipment Company (NRE)	Entec Project No.: 614137
Location: Richmond Rail Yard	Client Project No.:
Locomotive Manufacturer: NREC	Locomotive Model: ZGS12B
Engine Manufacturer: Cummins, Inc.	Engine Model Year: 2012
Engine Model: QSX15	Engine Serial No(s): 79471744 / 79471745
Engine Family: DCEXG15.0AAA	Max. Rated Horsepower: 1200

LOAD SETTING	Idle Low	Notch 1	Notch 2	Notch 3	Notch 4	Notch 5	Notch 6	Notch 7	Notch 8	WEIGHTED AVERAGES (1)
DATE	16-May-14	16-May-14	16-May-14	16-May-14	16-May-14	16-May-14	16-May-14	16-May-14	16-May-14	
TIME	1350-1409	1415-1434	1440-1459	1505-1524	1538-1555	1600-1619	1625-1644	1855-1914	1920-1939	
PARTICULATE	0.00001039 g/dscf 0.002204 g/hr 0.0001160 g/cfhp-hr	0.00000894 0.003431 0.0000175	0.0000749 0.003769 0.0000121	0.0000951 0.010913 0.0000187	0.00001088 0.010913 0.0000187	0.00000601 0.007109 0.0000099	0.00000397 0.005052 0.0000059	0.00000390 0.005052 0.0000054	0.00000796 0.012518 0.0000105	0.0000178
OXIDES OF NITROGEN (NOx)	258.2 ppmv dry 177.8 g/hr 9.360 g/cfhp-hr	146.2 182.1 0.929	122.4 200.0 0.641	132.6 281.0 0.638	119.7 397.3 0.680	126.6 486.4 0.677	136.7 564.6 0.657	159.4 712.5 0.722	286.3 1463.6 1.231	1.106
NITROGEN DIOXIDE (NO2)	33.2 ppmv dry 22.9 g/hr 1.205 g/cfhp-hr	79.7 99.3	49.5 80.8 0.259	40.6 86.0 0.195	53.4 177.0 0.303	44.2 169.9 0.236	40.3 166.4 0.194	45.5 203.3 0.206	58.4 298.5 0.251	0.337
CARBON MONOXIDE	4.0 ppmv dry 1.66 g/hr 0.0875 g/cfhp-hr	3.2 2.42 0.0124	3.3 3.33 0.0107	3.9 5.01 0.0113	2.1 4.24 0.0073	2.2 5.20 0.0072	2.7 6.87 0.0080	4.9 13.20 0.0134	4.9 15.10 0.0127	0.0136
SULFUR DIOXIDE	2.8 ppmv dry 2.7 g/hr 0.140 g/cfhp-hr	3.6 6.2 0.032	3.4 7.7 0.025	3.3 9.7 0.022	3.5 16.3 0.028	3.4 18.1 0.025	3.5 19.9 0.023	3.9 24.1 0.024	4.2 29.7 0.025	0.032
THC as propane	1.1 ppmv wet 1.2 ppmv dry 0.77 g/hr 0.0408 g/cfhp-hr	0.3 0.3 0.42 0.0021	0.2 0.2 0.33 0.0010	0.2 0.2 0.47 0.0011	0.3 0.3 0.94 0.0016	0.3 0.3 1.07 0.0015	0.3 0.3 1.22 0.0014	0.4 0.4 1.79 0.0018	0.4 0.4 1.98 0.0017	0.0030
OPACITY, VISIBLE EMISSIONS	%	0	0	0	0	0	0	0	0	0
CARBON DIOXIDE	Vol% dry	2.81	8.48	9.95	10.83	10.53	11.07	10.90	11.28	
OXYGEN	Vol% dry	17.49	9.74	7.82	6.66	8.19	6.32	6.49	6.28	
MOISTURE	Vol%	4.20	8.92	10.06	10.69	9.79	10.86	10.74	11.02	
EXHAUST FLOW	dscfm	212.06	383.55	503.05	652.41	1021.69	1272.24	1376.08	1574.37	
ENGINE FUEL FIRING RATE	gal/min	0.032	0.176	0.271	0.383	0.534	0.763	0.813	0.962	
ENGINE G1 SPEED	rpm	899	1399	1500	1699	1700	1699	1700	1799	
ENGINE G2 SPEED	rpm	0	0	0	0	1400	1399	1499	1799	
TOTAL ENGINE POWER	bhp	19	196	312	442	584	719	859	1189	
	kWatt	14.2	146.2	232.7	329.6	435.5	640.6	736.0	896.6	
APPLIED WEIGHTING FACTORS		0.299	0.124	0.123	0.058	0.036	0.015	0.002	0.008	

(1) Weighted average, Switch (<2300 bhp), Single Idle, 40 CFR 103.530, Table II
 40 CFR 103.530(e) Exemptions for Automated Start-Stop. Selected idle weighted averages adjustment is 50% for idle notch settings.

Figure 4 - May 16, 2014 Tier 4 at 1500 Hours



NATIONAL RAILWAY EQUIPMENT CO.
1100 SHAWMEE ST.
P.O. BOX 1416
VERNON, MISSISSIPPI 39752
United States
229533001

Attention of : Mr. S.S Somai
Your reference : Rail Car# 2015 Analysis

Analysis Report

Report number : 10920000611.2IL13
Main Object : Rail Car # 2015
Report Date : 10-11-2013
Date of issue : 10-11-2013
Sample object : Rail Car # 2015
Sample type : Submitted
Sample submitted as : ULSO
Marked : Rail Tank Car Rail Car # 2015 Submitted Sample

Sample date : 10-09-2013
Place of sampling : North Railways
Date received : 10-11-2013
Date completed : 10-11-2013
Sample number : 1114987

NAME	METHOD	UNIT	RESULT
Distillation	ASTM D 86		

Provisional parameters apply in the evaluation of the test results specified above. Please refer to ASTM D2534 (except for analysis of F70) and P 202 with respect to the utilization of test data to determine conformance with specifications.

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NATIONAL RAILWAY EQUIPMENT CO.
1100 SHAWMEE ST.
P.O. BOX 1416
VERNON, MISSISSIPPI 39752
United States
229533001

Attention of : Mr. S.S Somai
Your reference : Rail Car# 2015 Analysis

Analysis Report

Report number : 10920000611.2IL13
Main Object : Rail Car # 2015
Report Date : 10-11-2013
Date of issue : 10-11-2013
Sample object : Rail Car # 2015
Sample type : Submitted
Sample submitted as : ULSO
Marked : Rail Tank Car Rail Car # 2015 Submitted Sample

Sample date : 10-09-2013
Place of sampling : North Railways
Date received : 10-11-2013
Date completed : 10-11-2013
Sample number : 1114987

NAME	METHOD	UNIT	RESULT
Density at 15°C	ASTM D 4052	g/mL	0.8283
Gravity API at 60 °F	ASTM D 4052	°API	30.2
Kinematic Viscosity at 40°C	ASTM D 445	cSt	2.219
Sulphur (S)	ASTM D 5453	ppm	5.3
Cetane Index	ASTM D 876	°C	237.9
Distillation at 50% recovered		°C	47
Cetane Index*	ASTM D 4737	°C	194.7
Distillation 10 wt% recovered		°C	237.9
Distillation 50 wt% recovered		°C	333.8
Distillation 90 wt% recovered		°C	48.1
Cetane Index (prec A)			46.4
Cetane Index (prec B)			
Heat of Combustion	ASTM D 240	BTU/lb	19839
Net Heat of Combustion			
Elemental analysis	ASTM D 8291		
Hydrogen		wt%	13.67
Aromatic/Polyaromatic	ASTM D 5186		
Polynuclear Aromatics			
Total Aromatics		wt%	1.5
Mono- Aromatics			
FIA (hydrocarbon types)	ASTM D 1319		
Saturates		vol %	84.6
Olefins		vol %	1.4
Aromatics		vol %	14.0
Total		vol %	100

Provisional parameters apply in the evaluation of the test results specified above. Please refer to ASTM D2534 (except for analysis of F70) and P 202 with respect to the utilization of test data to determine conformance with specifications.

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P.O. BOX 4110
HOUSTON, TEXAS 77240-0110
United States
229333001

Attention of : Mr. S.S. Sciml
Your reference : Rail Car# 2015 Analysis

Analysis Report

Report number : 130933000061112L/13
Main Object : Rail Car # 2015
Report Date : 10-11-2013
Date of issue : 10-11-2013
Sample object : Rail Car # 2015
Sample type : Submitted
Sample submitted as : ULSI
Marked : Rail Tank Car Rail Car # 2015 Submitted Sample

NAME	METHOD	UNIT	RESULT
Initial boiling point LI		°C	174.5
5% Recovered		°C	188.6
10% Recovered		°C	194.7
20% Recovered		°C	203.2
30% Recovered		°C	213.5
40% Recovered		°C	225.3
50% Recovered		°C	237.9
60% Recovered		°C	253.5
70% Recovered		°C	272.8
80% Recovered		°C	297.2
90% Recovered		°C	313.2
95% Recovered		°C	333.8
Final boiling point		°C	376.2
Recovery		vol %	88.0
Residue		vol %	1.5
Loss		vol %	0.5

Provisional parameters apply in the absence of the evaluation of the test results specified above. Please also refer to ASTM D2004 (except for analysis of PFO) and P 207 with respect to the utilization of test data to determine contaminants with specifications.

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Remarks:

- 1 JT
- 2 JT
- 3 JT
- 4 DRK
- 5 JT
- 6 JT
- 7 JT
- 8 JT
- 9 JT
- 10 JT
- 11 JT
- 12 DRK
- 13 DRK
- 14 DRK
- 15 DRK
- 16 DRK
- 17 DRK
- 18 DRK
- 19 DRK
- 20 DRK
- 21 JT

Signed by: Michael Oliver Thury - Laboratory Supervisor
Issued by: Saybolt LP
Place and date of issue: Metairie - 10-11-2013

Provisional parameters apply in the absence of the evaluation of the test results specified above. Please also refer to ASTM D2004 (except for analysis of PFO) and P 207 with respect to the utilization of test data to determine contaminants with specifications.

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1100 SHANNSEE ST.
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62984 MT. VERNON
United States
228553071

Attention of : Mr. S.S. Storr
Your reference : Rail Car# 2015 Analysis

Analysis Report

Report number : 13020809041111L1J3
Method : Rail Car# 2015
Report Date : 10-16-2013
Date of Issue : 10-17-2013
Sample object : Rail Car # 2015
Sample type : Submitted
Sample submitted as : U.S.D
Marked : Rail Tank Car/Rail Car # 2015 Submitted Sample

Sample date : 10-09-2013
Date of sampling : 10-11-2013
Date analyzed : 10-11-2013
Date completed : 10-16-2013
Sample number : 114887

NAME	METHOD	UNIT	RESULT
Sulfur (S)	ASTM D 563	wt%	0.0020
Nitrogen	ASTM D 572	wt%	0.0083
Elemental analysis			
Carbon	ASTM D 5291	wt%	81.28
Hydrogen		wt%	12.87
Calculated Oxygen by Difference	Normalized/Calculated	wt %	5.84
Calculated Oxygen	Calculated	Btu/gal	13737
Heat of Combustion-calculated		Btu/gal	128517
Gross Heat of Combustion			
Net Heat of Combustion			
Heat of Combustion	ASTM D 240	Btu/lb	19839
Gross Heat of Combustion		Btu/lb	16692
Net Heat of Combustion			

Signed by: Michael Oliver Tilly, Laboratory Supervisor
Issued by: Saybolt LP
Printed Date of Report: 10/16/2013

Please do not attempt to use the results of this test unless specifically advised. Please refer to ASTM D2004 for complete description of test and for all methods for the calculation of heat data to determine compliance with specifications.

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Print Date: 10-16-2013
Page: 1 of 1

Figure 5 – October 2013 Fuel Test Results



NATIONAL RAILWAY EQUIPMENT CO.
 62864, MT. VERNON
 P.O. BOX 1416
 UNITED STATES
 229533001

Attention of : Mr. S.S. Somal
 Your reference : Rail Car# 2015 Analysis

Analysis Report

Report number : 1309300006344.2U/L14
 Main Object : Rail Car # 2015
 Submitted date : 05-06-2014
 Date received : 05-13-2014
 Date completed : 05-13-2014
 Sample object : Rail Car # 2015
 Sample type : ULSO
 Sample submitted as : ULSO
 Marked : Rail Car # 2015 ULSO Red Dye Submitted Sample NRE, Richmond Pacific RR

NAME	METHOD	UNIT	RESULT
Densim. Nitrogen 2		wt%	0.0695
Densim. Sulfur 1		wt%	0.0322
Cal. Oxygen by difference 4		wt%	3.75
Distillation	ASTM D 86		
at boiling point		°C	169.6
5% Recovered		°C	187.8
10% Recovered		°C	193.6
15% Recovered		°C	198.8
20% Recovered		°C	205.4
30% Recovered		°C	216.8
40% Recovered		°C	229.0
50% Recovered		°C	242.8
60% Recovered		°C	259.1
70% Recovered		°C	278.7
80% Recovered		°C	302.6
90% Recovered		°C	338.8
Final boiling point		°C	384.4
Recovery		vol %	97.5
Residue		vol %	1.5
Loss		vol %	1.0

Remarks:
 1 Density calculated from API Table 3.
 2 Derived from ASTM D702 Result
 3 Calculated from Density Result
 4 Normalized Calculated

Signed by: Laura Nichols - Laboratory Manager
 Issued by: Saybolt LP
 Place and Date of Issue: Houston, TX 05-13-2014

Please refer to the test results specified above. Please also refer to ASTM D2284 (except for analysis of BTG) and IP 200 with respect to the utilization of test data to determine compliance with specifications.

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NATIONAL RAILWAY EQUIPMENT CO.
 62864, MT. VERNON
 P.O. BOX 1416
 UNITED STATES
 229533001

Attention of : Mr. S.S. Somal
 Your reference : Rail Car# 2015 Analysis

Analysis Report

Report number : 1309300006344.2U/L14
 Main Object : Rail Car # 2015
 Submitted date : 05-06-2014
 Date received : 05-13-2014
 Date completed : 05-13-2014
 Sample object : Rail Car # 2015
 Sample type : ULSO
 Sample submitted as : ULSO
 Marked : Rail Car # 2015 ULSO Red Dye Submitted Sample NRE, Richmond Pacific RR

NAME	METHOD	UNIT	RESULT
Grossly API at 60 °F	ASTM D 4652	°API	38.4
Density at 15 °C	ASTM D 4652	g/mL	0.8276
Density at 15 °C		ppm	3.2
Sulphur (S)	ASTM D 5453	ppm	3.2
Kinematic Viscosity at 40°C	ASTM D 445	cSt	2.332
Cetane Index	ASTM D 4737	°C/F	193.60300
Distillation 10 vol% recovered		°C/F	242.84689
Distillation 50 vol% recovered		°C/F	338.88338
Distillation 90 vol% recovered		°C/F	48.2
Cetane Index	ASTM D 576	°C/F	242.88338
Cetane Index			48.8
Heat of Combustion	ASTM D 240	Btu/gal	138972
Gross Heat of Combustion		Btu/gal	128671
Net Heat of Combustion		Btu/lb	19851
Gross Heat of Combustion		Btu/lb	18648
Net Heat of Combustion		Btu/lb	18648
Aromatic/Polyaromatics	ASTM D 5186		
Polynuclear Aromatics			1.2
Mono-Aromatics			9.8
Total Aromatics			11
FIA (hydrocarbon types - corrected)	ASTM D 1319		
Saturates		vol %	88.6
Olefins		vol %	1.2
Aromatics		vol %	10.2
Total		vol %	100
Total Nitrogen	ASTM D 4629	mg/kg	4.5
Elemental analysis	ASTM D 5291		
Carbon		wt%	83.05
Hydrogen		wt%	13.19

Remarks:
 1 Density calculated from API Table 3.
 2 Derived from ASTM D702 Result
 3 Calculated from Density Result
 4 Normalized Calculated

Signed by: Laura Nichols - Laboratory Manager
 Issued by: Saybolt LP
 Place and Date of Issue: Houston, TX 05-13-2014

Please refer to the test results specified above. Please also refer to ASTM D2284 (except for analysis of BTG) and IP 200 with respect to the utilization of test data to determine compliance with specifications.

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Figure 6 - May 13, 2014 Fuel Test Results