

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

FINAL REPORT
ADDENDUM – May, 2015



AQIP GRANT NUMBER – G10-AQIP-13
CONSTRUCTION AND DEMONSTRATION OF AN
NRE N-VIROMOTIVE TIER 4 GENSET LOCOMOTIVE

NATIONAL RAILWAY EQUIPMENT CO.
and
RICHMOND PACIFIC RAILROAD CORPORATION



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EXECUTIVE SUMMARY

The California Alternative and Renewable Fuel, Vehicle Technology, Clean Air, and Carbon Reduction Act of 2007 (Assembly Bill 118) created the Air Quality Improvement Program (AQIP), a voluntary incentive program administered by the California Air Resources Board (ARB) to fund clean vehicle and equipment projects, air quality research, and workforce training. In June 2010, ARB adopted the AQIP Funding Plan for FY 2010-11, which included funding for projects for demonstration and administration of advanced locomotive engines and/or aftertreatment systems that reduce emissions from locomotives to the Ultra-Low Emitting Locomotive emission level or below. In July 2011, ARB entered into an advanced technology demonstration grant for a Tier 4 GenSet locomotive project with the Bay Area Air Quality Management District (BAAQMD) and National Railway Equipment Co. (NRE). This final report documents that project from inception through the successful completion of the grant.

Following a research and development period, 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.

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 Cummins QSX15 model 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 (NO_x) and 0.03 g/bhp-hr of Particulate Matter (PM). Although Cummins engines were used in this instance, NRE's locomotive design enables other qualified Tier 4 engines to be utilized as prime engines also.

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 tested for durability while in revenue service consisting of 1,500 hours of operation which was completed on May 15, 2014. The unit was then returned to service to

complete a total of 3,000 hours which accrued on October 30, 2014. These emissions tests meet the verification requirements of Air Resources Board (ARB) for Tier 4.

The results of the May 16, 2014, emission testing at 1,500 hours and of the October 30, 2014 emissions testing at 3,000, indicate 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 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. Tier 4 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

Locomotive emission reductions resulting from the introduction of Tier 4 technology support existing State Implementation Plan commitments for California. Reducing exposure to air toxics through the demonstration, verification, and eventual market penetration of this reduced-

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.

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.

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 the 1,500 hour emissions testing on May 15, 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 the ARB verification process. The 3,000 emissions testing hours were successfully completed on October 30, 2014.

Based on the completely successful ARB Verification test process, NRE will move forward with commercialization of this and subsequent Tier 4 GenSet locomotives in California and nationwide.

Under the terms of the original and amended agreements, the Tier 4 GenSet locomotive used in this demonstration 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.

Test Locomotive

A GP 7 switcher locomotive was used as the core. It was stripped to its frame and repowered from the frame up, powered by two (2) NRE PODs using Cummins QSX15 Tier 4 diesel engines rated at 600 Horsepower each. Everything above deck was new material and fabrication.

The QSX15 operates on diesel fuel with 15 ppm sulfur maximum (ULSD). This engine utilizes cooled exhaust gas recirculation (EGR) along with a combustion system that has been optimized for low NO_x, particulate, and HC emission. Additionally, this engine uses a Diesel Oxidation Catalyst (DOC) combined with a catalyzed Diesel Particulate Filter (DPF) for HC, CO and PM control. Active regeneration strategy is utilized to maintain a clean DPF system.

The locomotive microprocessor control system “NFORCE” determines if one (1) or (2) engines will operate based on the power demand selected by the operator. This engine selection process insures that the minimum numbers of engines are in use reducing both emissions and fuel consumption.

Project Results

Schedule:

Construction of the project extended twelve months longer than originally planned due to production constraints after project award and NFORCE locomotive control interfacing problems with the QSX15 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 allowed the project to achieve the mid-way 1,500 hours of durability and emissions testing. This time expiration constraint 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. However, NRE continued the durability testing outside the time expiration of this grant and is now submitting this 3,000 hour emission report as its Final Report Addendum.

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 aftertreatment system and passive regeneration PM and NOx emissions.

Operation:

After design, construction, locomotive 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 5 to 6 days a week for 10 hours a day. However, this did not happen consistently due to a reduction in available business for the unit.

Entec Services, Inc. (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 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 – ENTEC Summary October 15, 2013 Tier 4 .

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 – ENTEC Summary May 16, 2014 Tier 4 at 1500 Hours.

The results of the three 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.

Emissions Test Results Summary

| | 10/15/2013 Baseline | | 05/15/2014 1500 Hours | | 10/30/2014 3000 hours | | U.S. EPA Tier 4 Switch Locomotive Standard | |
|------------------------|------------------------|----------|--------------------------|----------|--------------------------|----------|---|----------|
| | | g/bhp-hr | | g/bhp-hr | | g/bhp-hr | | g/bhp-hr |
| PM | 0.0037729 | g/bhp-hr | 0.0021542 | g/bhp-hr | 0.0009180 | g/bhp-hr | 0.03 | g/bhp-hr |
| NOx | 1.175 | g/bhp-hr | 1.007 | g/bhp-hr | 0.770 | g/bhp-hr | 1.3 | g/bhp-hr |
| Carbon Monoxide | 0.0004 | g/bhp-hr | 0.0123 | g/bhp-hr | 0.0314 | g/bhp-hr | 2.4 | g/bhp-hr |
| Sulfur Dioxide | 0.022 | g/bhp-hr | 0.029 | g/bhp-hr | 0.0145 | g/bhp-hr | N/A | g/bhp-hr |
| Opacity | 0% | | 0% | | 0% | | 20% | |

Table 1- Baseline, 1500 Hour and 3000 Hour Emission Results Compared with U.S. EPA Tier 4

The weighted averages of the final 3000 hour Load Test is illustrated in Table 2 below. The full ENTEC Locomotive Test –Test Results Summary is attached hereto as Figure 3 – ENTEC Summary October 15, 2013 Tier 4 Baseline Results (Page 1 of 3); Figure 4 – ENTEC Summary May 16, 2014 Tier 4 at 1500 Hours (Page 2 of 3); and Figure 5 – ENTEC Summary October 30, 2014 - Tier 4 at 3000 Hours (Page 3 of 3).

Test Cycles (Test Results Summary Tier 4 at 3000 Hours)

| Test Mode | Notch Setting | Time in Mode (Minutes) | Sample Averaging Period for emissions |
|-----------|---------------|------------------------|---------------------------------------|
| A | Idle | 19 | 0.598 |
| 1 | Notch 1 | 19 | 0.124 |
| 2 | Notch 2 | 19 | 0.123 |
| 3 | Notch 3 | 19 | 0.058 |
| 4 | Notch 4 | 19 | 0.036 |
| 5 | Notch 5 | 20 | 0.036 |
| 6 | Notch 6 | 10 | 0.015 |
| 7 | Notch 7 | 10 | 0.002 |
| 8 | Notch 8 | 19 | 0.008 |

Table 2 - Test Cycles Summary Tier 4 at 3000 Hours

NRE’s 2GS12B is equipped with NLIMIT, an EPA SmartWay verified AESS (Automatic Engine Start Stop) system. Table 3 below illustrates emissions reductions both with and without the benefits of NLIMIT used in the emissions calculations in compliance with 40 CFR 1033 for AESS.

| Raw Values | | Brake Horsepower | | | PM (g/hr) | | | NOx (g/hr) | | | CO (g/hr) | | | HC (g/hr) | | |
|------------|-------|------------------|---------|---------|-----------|----------|----------|------------|---------|---------|-----------|---------|---------|-----------|---------|---------|
| notch | duty | 0 hr | 1500 hr | 3000 hr | 0 hr | 1500 hr | 3000 hr | 0 hr | 1500 hr | 3000 hr | 0 hr | 1500 hr | 3000 hr | 0 hr | 1500 hr | 3000 hr |
| 0 | 0.598 | 19 | 19 | 19 | 0.08458 | 0.110578 | 0.030095 | 74.9 | 92.5 | 59.8 | 0.02 | 0.86 | 0.16 | 0.73 | 0.4 | 1.24 |
| 1 | 0.124 | 189 | 196 | 199 | 0.829588 | 0.448162 | 0.081264 | 215.1 | 182.1 | 124.3 | 0.07 | 2.42 | 40.34 | 0.06 | 0.42 | 0.86 |
| 2 | 0.123 | 318 | 312 | 318 | 1.820026 | 0.525316 | 0.208228 | 264.9 | 200 | 168.5 | 0.1 | 3.33 | 0.85 | 0.09 | 0.33 | 0.6 |
| 3 | 0.058 | 448 | 442 | 457 | 1.634122 | 0.796481 | 0.321303 | 475.7 | 281 | 256.2 | 0.14 | 5.01 | 1.13 | 0.12 | 0.47 | 0.87 |
| 4 | 0.036 | 594 | 584 | 595 | 1.249394 | 1.52544 | 1.083899 | 496.1 | 397.3 | 270.4 | 0.2 | 4.24 | 1.42 | 1.05 | 0.94 | 0.91 |
| 5 | 0.036 | 728 | 719 | 727 | 1.597912 | 1.326058 | 0.434024 | 622.6 | 486.4 | 348.5 | 0.23 | 5.2 | 1.74 | 1.19 | 1.07 | 1.11 |
| 6 | 0.015 | 870 | 859 | 868 | 2.389427 | 0.775523 | 0.818318 | 833.9 | 564.6 | 472 | 0.26 | 6.87 | 2.04 | 0.22 | 1.22 | 1.33 |
| 7 | 0.002 | 987 | 987 | 987 | 2.247731 | 0.966575 | 1.558957 | 1135.5 | 712.5 | 759 | 0.29 | 13.2 | 2.9 | 0.25 | 1.79 | 2.02 |
| 8 | 0.008 | 1186 | 1189 | 1189 | 4.186248 | 2.443819 | 2.144631 | 1909.4 | 1463.6 | 2013.6 | 0.33 | 15.1 | 4.25 | 4.99 | 1.99 | 3.87 |

| Weighted Values | | Brake Horsepower | | | PM (g/hr) | | | NOx (g/hr) | | | CO (g/hr) | | | HC (g/hr) | | |
|-----------------|-------|------------------|---------|---------|-------------|----------|----------|------------|---------|---------|-----------|---------|---------|-----------|---------|---------|
| notch | duty | 0 hr | 1500 hr | 3000 hr | 0 hr | 1500 hr | 3000 hr | 0 hr | 1500 hr | 3000 hr | 0 hr | 1500 hr | 3000 hr | 0 hr | 1500 hr | 3000 hr |
| 0 | 0.598 | 11.362 | 11.362 | 11.362 | 0.05057884 | 0.066126 | 0.017997 | 44.7902 | 55.315 | 35.7604 | 0.01196 | 0.51428 | 0.09568 | 0.43654 | 0.2392 | 0.74152 |
| 1 | 0.124 | 23.436 | 24.304 | 24.676 | 0.102868912 | 0.055572 | 0.010077 | 26.6724 | 22.5804 | 15.4132 | 0.00868 | 0.30008 | 5.00216 | 0.00744 | 0.05208 | 0.10664 |
| 2 | 0.123 | 39.114 | 38.376 | 39.114 | 0.223863198 | 0.064614 | 0.025612 | 32.5827 | 24.6 | 20.7255 | 0.0123 | 0.40959 | 0.10455 | 0.01107 | 0.04059 | 0.0738 |
| 3 | 0.058 | 25.984 | 25.636 | 26.506 | 0.094779076 | 0.046196 | 0.018636 | 27.5906 | 16.298 | 14.8596 | 0.00812 | 0.29058 | 0.06554 | 0.00696 | 0.02726 | 0.05046 |
| 4 | 0.036 | 21.384 | 21.024 | 21.42 | 0.044978184 | 0.054916 | 0.03902 | 17.8596 | 14.3028 | 9.7344 | 0.0072 | 0.15264 | 0.05112 | 0.0378 | 0.03384 | 0.03276 |
| 5 | 0.036 | 26.208 | 25.884 | 26.172 | 0.057524832 | 0.047738 | 0.015625 | 22.4136 | 17.5104 | 12.546 | 0.00828 | 0.1872 | 0.06264 | 0.04284 | 0.03852 | 0.03996 |
| 6 | 0.015 | 13.05 | 12.885 | 13.02 | 0.035841405 | 0.011633 | 0.012275 | 12.5085 | 8.469 | 7.08 | 0.0039 | 0.10305 | 0.0306 | 0.0033 | 0.0183 | 0.01995 |
| 7 | 0.002 | 1.974 | 1.974 | 1.974 | 0.004495462 | 0.001933 | 0.003118 | 2.271 | 1.425 | 1.518 | 0.00058 | 0.0264 | 0.0058 | 0.0005 | 0.00358 | 0.00404 |
| 8 | 0.008 | 9.488 | 9.512 | 9.512 | 0.033489984 | 0.019551 | 0.017157 | 15.2752 | 11.7088 | 16.1088 | 0.00264 | 0.1208 | 0.034 | 0.03992 | 0.01592 | 0.03096 |

| AESS idle reduction factor: 0.5 | | PM (g/bhp-hr) | | | NOx (g/bhp-hr) | | | CO (g/bhp-hr) | | | HC (g/bhp-hr) | | |
|--|--|---------------|----------|----------|----------------|----------|----------|---------------|----------|----------|---------------|----------|----------|
| | | 0 hr | 1500 hr | 3000 hr | 0 hr | 1500 hr | 3000 hr | 0 hr | 1500 hr | 3000 hr | 0 hr | 1500 hr | 3000 hr |
| Duty cycle weighted brake specific emissions, No NLIMIT/AESS | | 0.003769883 | 0.002154 | 0.000918 | 1.174208 | 1.007326 | 0.769734 | 0.00037 | 0.012311 | 0.031378 | 0.003409 | 0.002745 | 0.006331 |
| With 50% idle reduction from NLIMIT/AESS | | 0.003622852 | 0.001949 | 0.000875 | 1.044004 | 0.840418 | 0.673638 | 0.000335 | 0.010741 | 0.03142 | 0.00214 | 0.002033 | 0.00424 |

Table 3 - Emissions Reductions from NLIMIT/AESS per 40 CFR 1033

Fuel Consumption Summary

The Fuel Consumption Summary is more fully defined in Tables 4 and 5 below. The “MW-hrs” chart quantifies the total energy expended during the full 3031 hours verification test period. Essentially this was done by multiplying the time accumulated in each throttle notch by the horsepower developed in that throttle notch position.

Estimated Fuel Consumption and MW-hrs for Field Demonstration

| Notch | Eng. Hr's. Percent in Each Throttle notch | Brake HP | Auxiliary HP | Traction HP (net) | Fuel rate measured, lb/bhp-hr | Engine Hours | lbs of fuel | MW-hrs (brake) | MW-hrs (net, traction) |
|-------|---|----------|--------------|-------------------|-------------------------------|--------------|-------------|----------------|------------------------|
| Idle | 58.4 | 19 | 19 | 0 | 0.55 | 1770 | 18496.5 | 25.088 | 0 |
| N1 | 18.81 | 198 | 51 | 147 | 0.362 | 571 | 40927 | 84.341 | 62.62 |
| N2 | 13.09 | 317 | 60 | 257 | 0.35 | 397 | 44047.15 | 93.883 | 76.11 |
| N3 | 5.58 | 453 | 82 | 371 | 0.346 | 169 | 26488.72 | 57.111 | 46.77 |
| N4 | 1.86 | 593 | 100 | 493 | 0.356 | 56 | 11822.05 | 24.773 | 20.6 |
| N5 | 0.79 | 727 | 101 | 626 | 0.347 | 24 | 6054.456 | 13.016 | 11.21 |
| N6 | 0.46 | 868 | 103 | 765 | 0.344 | 14 | 4180.288 | 9.0653 | 8 |
| N7 | 0.24 | 987 | 118 | 869 | 0.346 | 7 | 2390.514 | 5.154 | 4.54 |
| N8 | 0.77 | 1189 | 129 | 1060 | 0.351 | 23 | 9598.797 | 20.401 | 18.19 |

| | | | | | | | | | |
|-------|--|--|--|--|--|------|------------|----------|--------|
| TOTAL | | | | | | 3031 | 164005.475 | 332.8323 | 248.04 |
|-------|--|--|--|--|--|------|------------|----------|--------|

NOTE:

- Engine hours from NFORCE statistics log download at 3031 hours
- Auxiliary HP from NFORCE real-time data logging during emissions tests
- Fuel Rate (BSFC) from Cummins factory data documents

Table 4- Estimated Fuel Consumption and MW-hrs for Field Demonstration

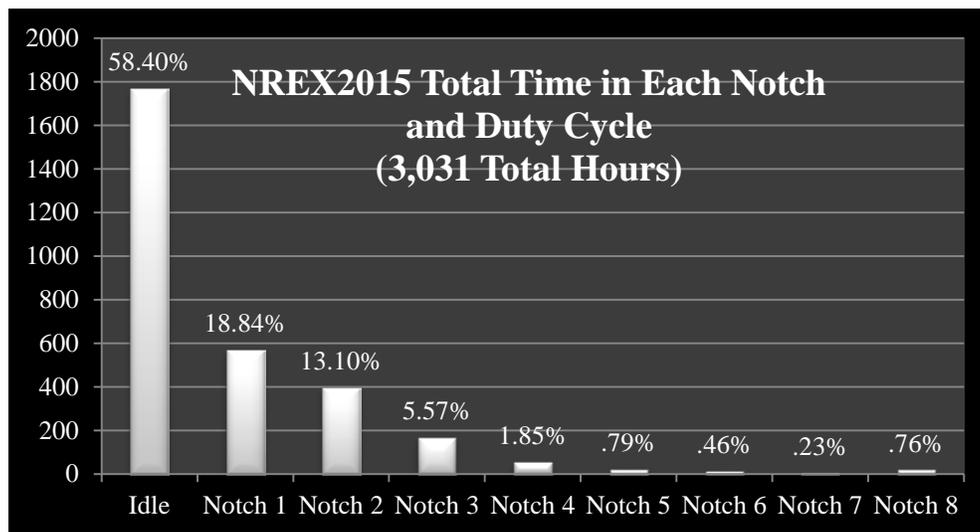


Table 5 - Total Time in Each Notch and Duty Cycle

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 10 – Saybolt October 2013 Fuel Test Results.

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 11 - Saybolt May 13, 2014 Fuel Test Results (Page 1 of 2).

Results of the fuel testing completed by Saybolt, Inc. on October 27, 2014, is attached hereto labeled as Figure 13 -Saybolt Analysis Report 10-27-2014 –(Page 1 of 3).

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 idle and eight notch load setting, spanning the operation range of the locomotive in order to determine the emission rates of PM, NO_x, 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, 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 33 parts per million (ppm) 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.

ENTEC 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 additional 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 | | <u>\$1,658,223</u> |
| In-Kind Contribution | NRE | | 61,175 |
| TOTAL PROJECT COST | | | <u><u>\$1,719,398</u></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 DCEXG15.0 ,

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.



LOCOMOTIVE ID:
#NREX 2015

ENGINES: (2)
Cummins QSK15 Tier 4

RATED POWER:
600 horsepower (each)

CYLINDER ARRANGEMENT:
Inline 6

DISPLACEMENT:
15 Liters

RATED ENGINE SPEED:
18,000 rpm

*EMISSION CONTROL/
AFTERTREATMENT:*
Cooled EGR, DOC, DPF
Catalized DPF

Figure 1 - Unit #2015 - NR156 2GS12B Tier 4 Locomotive

CONCLUSION

The main purpose of the ARB solicitation and grant that funded this demonstration project was to demonstrate locomotive engines and/or aftertreatment 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 and Addendum data clearly show that NRE has demonstrated that this Tier 4 GenSet locomotive has exceeded the emission reductions proposed in this grant and has met durability requirements for the full 3,000 hours required for the ARB verification of this application. As seen in the results of all three emission tests conducted at commissioning, at 1,500 hours, and at 3,000 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 which is a 40 percent reduction over current U.S. EPA Tier 3 standards. As tested during commissioning the NO_x levels were 1.175 g/bhp-hr and PM levels were 0.0037729 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 1.007 g/bhp-hr and PM levels at 0.0021542 g/bhp-hr and at 3000 hours emission test revealed NO_x levels at 0.770 g/bhp-hr and PM levels at 0.0009180 g/bhp-hr, all together showing that the technology has had little to no deterioration of criteria pollutant emissions over the 3,000 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 that 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.

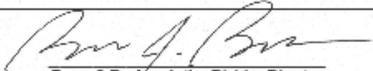
| | | | |
|---|---|---|--|
|  | UNITED STATES ENVIRONMENTAL PROTECTION AGENCY 2013 MODEL YEAR CERTIFICATE OF CONFORMITY WITH THE CLEAN AIR ACT OF 1990 | OFFICE OF TRANSPORTATION AND AIR QUALITY ANN ARBOR, MICHIGAN 48105 | |
| Certificate Issued To: Cummins Inc. (U.S. Manufacturer or Importer) Certificate 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 DCEXG15.0



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

Tier 4 Baseline

| | | | |
|-------------------------|--|-------------------------|---------------------|
| Client : | National Railway Equipment Company (NRE) | Entec Project No. : | 613115 |
| Location : | Richmon Rail Yard | Client Project No. : | |
| Locomotive Manufacturer | NREC | Locomotive Model | 2GS12B |
| 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 | Notch 1 | Notch 2 | Notch 3 | Notch 4 | Notch 5 | Notch 6 | Notch 7 | Notch 8 | WEIGHTED AVERAGES (1) |
|---|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|-----------------------|
| DATE | | 15-Oct-13 | ----- |
| TIME | | 1240-1255 | 1315-1330 | 1345-1400 | 1415-1430 | 1440-1455 | 1505-1520 | 1530-1545 | 1555-1610 | 1620-1635 | ----- |
| PARTICULATE | g/dscf | 0.00001544 | 0.00003891 | 0.00005989 | 0.00003960 | 0.00002028 | 0.00002332 | 0.00003077 | 0.00002556 | 0.00004127 | |
| | g/hr | 0.084580 | 0.829588 | 1.820026 | 1.634122 | 1.249394 | 1.597912 | 2.389427 | 2.247731 | 4.186248 | |
| | g/bhp-hr | 0.0044751 | 0.0043987 | 0.0057306 | 0.0036443 | 0.0021037 | 0.0021946 | 0.0027474 | 0.0022764 | 0.0035291 | 0.0037729 |
| OXIDES OF NITROGEN as NO2 | PPMv dry | 252.5 | 186.4 | 161.1 | 213.0 | 148.8 | 167.9 | 198.4 | 238.6 | 347.8 | |
| | g/hr | 74.9 | 215.1 | 264.9 | 475.7 | 496.1 | 622.6 | 833.9 | 1135.5 | 1909.4 | |
| | g/bhp-hr | 3.962 | 1.140 | 0.834 | 1.061 | 0.835 | 0.855 | 0.959 | 1.150 | 1.610 | 1.175 |
| NITROGEN DIOXIDE (NO2) | PPMv dry | 44.5 | 118.9 | 75.6 | 86.8 | 82.2 | 74.6 | 78.8 | 93.2 | 91.9 | |
| | g/hr | 13.2 | 137.2 | 124.4 | 193.9 | 274.1 | 276.7 | 331.1 | 443.8 | 504.6 | |
| | g/bhp-hr | 0.698 | 0.728 | 0.392 | 0.432 | 0.462 | 0.380 | 0.381 | 0.449 | 0.425 | 0.472 |
| CARBON MONOXIDE | PPMv dry | < 0.1 | < 0.1 | < 0.1 | < 0.1 | < 0.1 | < 0.1 | < 0.1 | < 0.1 | < 0.1 | |
| | g/hr | < 0.02 | < 0.07 | < 0.10 | < 0.14 | < 0.20 | < 0.23 | < 0.26 | < 0.29 | < 0.33 | |
| | g/bhp-hr | < 0.0010 | < 0.0004 | < 0.0003 | < 0.0003 | < 0.0003 | < 0.0003 | < 0.0003 | < 0.0003 | < 0.0003 | < 0.0004 |
| SULFUR DIOXIDE | PPMv dry | 2.1 | 3.7 | 2.7 | 3.3 | 2.7 | 2.2 | 2.4 | 2.5 | 2.3 | |
| | g/hr | 0.9 | 6.0 | 6.3 | 10.2 | 12.5 | 11.2 | 13.9 | 16.7 | 17.9 | |
| | g/bhp-hr | 0.046 | 0.032 | 0.020 | 0.023 | 0.021 | 0.015 | 0.016 | 0.017 | 0.015 | 0.022 |
| THC as propane | PPMv wet | 2.5 | < 0.1 | < 0.1 | < 0.1 | 0.3 | 0.3 | < 0.1 | < 0.1 | 0.9 | |
| THC as propane | PPMv dry | 2.6 | < 0.1 | < 0.1 | < 0.1 | 0.3 | 0.3 | < 0.1 | < 0.1 | 0.9 | |
| | g/hr | 0.73 | < 0.06 | < 0.09 | < 0.12 | 1.05 | 1.19 | < 0.22 | < 0.25 | 4.99 | |
| | g/bhp-hr | 0.0388 | < 0.0003 | < 0.0003 | < 0.0003 | 0.0018 | 0.0016 | < 0.0003 | < 0.0003 | 0.0042 | 0.0034 |
| OPACITY, VISIBLE EMISSIONS | % | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| CARBON DIOXIDE | Vol% dry | 3.17 | 8.28 | 9.23 | 9.53 | 8.84 | 9.44 | 9.75 | 9.57 | 10.01 | |
| OXYGEN | Vol% dry | 16.94 | 9.47 | 7.94 | 7.40 | 8.56 | 7.56 | 7.01 | 7.31 | 6.52 | |
| MOISTURE | Vol% | 4.43 | 8.57 | 9.29 | 9.50 | 8.96 | 9.42 | 9.67 | 9.54 | 9.88 | |
| EXHAUST FLOW | dscfm | 91.29 | 355.38 | 506.46 | 687.74 | 1026.73 | 1142.22 | 1294.29 | 1465.46 | 1690.71 | |
| ENGINE FUEL FIRING RATE | gal/min | 0.015 | 0.159 | 0.253 | 0.354 | 0.489 | 0.581 | 0.682 | 0.758 | 0.916 | |
| BRAKE SPECIFIC FUEL RATE | gal/bhp-hr | 0.048 | 0.051 | 0.048 | 0.047 | 0.049 | 0.048 | 0.047 | 0.046 | 0.046 | 0.048 (2) |
| ENGINE G1 SPEED | rpm | 900 | 1378 | 1499 | 1690 | 1699 | 1699 | 1699 | 1699 | 1800 | |
| ENGINE G2 SPEED | rpm | 0 | 0 | 0 | 0 | 1399 | 1400 | 1500 | 1799 | 1799 | |
| TOTAL ENGINE POWER | bhp-hr | 19 | 189 | 318 | 448 | 594 | 728 | 870 | 987 | 1186 | |
| | kWatt | 14.1 | 140.6 | 236.8 | 334.4 | 442.9 | 542.9 | 648.5 | 736.3 | 884.5 | |
| (2) non-weighted average. Measured fuel rate for Idle was greater than expected; therefore, average data from Notches 1-8 were used | | | | | | | | | | | |
| (1) APPLIED WEIGHTING FACTORS | | 0.598 | 0.124 | 0.123 | 0.058 | 0.036 | 0.036 | 0.015 | 0.002 | 0.008 | ----- |

Figure 3 – ENTEC Summary October 15, 2013 Tier 4 Baseline Results (Page 1 of 3)



**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 : | 2GS12B |
| 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 | Notch 1 | Notch 2 | Notch 3 | Notch 4 | Notch 5 | Notch 6 | Notch 7 | Notch 8 | WEIGHTED AVERAGES (1) |
|---|------------------------------|-------------------------------------|-------------------------------------|-------------------------------------|-------------------------------------|-------------------------------------|-------------------------------------|-------------------------------------|-------------------------------------|-------------------------------------|-----------------------|
| DATE | | 16-May-14 | |
| TIME | | 1350-1409 | 1415-1434 | 1440-1459 | 1505-1524 | 1536-1555 | 1600-1619 | 1625-1644 | 1855-1914 | 1920-1939 | ----- |
| PARTICULATE | g/dscf g/hr g/bhp-hr | 0.00001671 0.110578 0.0058199 | 0.00001947 0.448162 0.0022865 | 0.00001740 0.525316 0.0016837 | 0.00002035 0.796481 0.0018020 | 0.00002488 1.525440 0.0026121 | 0.00001867 1.326058 0.0018443 | 0.00001016 0.775523 0.0009028 | 0.00001171 0.966575 0.0009793 | 0.00002587 2.443819 0.0020554 | 0.0021542 |
| OXIDES OF NITROGEN (NO + NO2) | PPMv dry g/hr g/bhp-hr | 258.2 92.5 4.867 | 146.2 182.1 0.929 | 122.4 200.0 0.641 | 132.6 281.0 0.636 | 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 | 1.007 |
| NITROGEN DIOXIDE (NO2) | PPMv dry g/hr g/bhp-hr | 33.2 11.9 0.626 | 79.7 99.3 0.507 | 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 | 0.305 |
| CARBON MONOXIDE | PPMv dry g/hr g/bhp-hr | 4.0 0.86 0.0455 | 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 | 0.0123 |
| SULFUR DIOXIDE | PPMv dry g/hr g/bhp-hr | 2.8 1.4 0.073 | 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 | 0.029 |
| THC as propane | PPMv wet | 1.1 | 0.3 | 0.2 | 0.2 | 0.3 | 0.3 | 0.3 | 0.4 | 0.4 | |
| THC as propane | PPMv dry g/hr g/bhp-hr | 1.2 0.40 0.0212 | 0.3 0.42 0.0021 | 0.2 0.33 0.0010 | 0.2 0.47 0.0011 | 0.3 0.94 0.0016 | 0.3 1.07 0.0015 | 0.3 1.22 0.0014 | 0.4 1.79 0.0018 | 0.4 1.99 0.0017 | 0.0027 |
| OPACITY, VISIBLE EMISSIONS | % | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| CARBON DIOXIDE | Vol% dry | 2.81 | 8.48 | 9.95 | 10.83 | 9.65 | 10.53 | 11.07 | 10.90 | 11.28 | |
| OXYGEN | Vol% dry | 17.49 | 9.74 | 7.82 | 6.66 | 8.19 | 7.03 | 6.32 | 6.49 | 6.28 | |
| MOISTURE | Vol% | 4.20 | 8.92 | 10.06 | 10.69 | 9.79 | 10.46 | 10.86 | 10.74 | 11.02 | |
| EXHAUST FLOW | dscfm | 110.27 | 383.55 | 503.05 | 652.41 | 1021.69 | 1183.57 | 1272.24 | 1376.08 | 1574.37 | |
| ENGINE FUEL FIRING RATE | gal/min | 0.017 | 0.176 | 0.271 | 0.383 | 0.534 | 0.675 | 0.763 | 0.813 | 0.962 | |
| BRAKE SPECIFIC FUEL RATE | gal/bhp-hr | 0.053 | 0.054 | 0.052 | 0.052 | 0.055 | 0.056 | 0.053 | 0.049 | 0.049 | 0.053 (2) |
| ENGINE G1 SPEED | rpm | 899 | 1399 | 1500 | 1699 | 1700 | 1699 | 1699 | 1700 | 1799 | |
| ENGINE G2 SPEED | rpm | 0 | 0 | 0 | 0 | 1400 | 1399 | 1499 | 1798 | 1799 | |
| TOTAL ENGINE POWER | bhp-hr kWatt | 19 14.2 | 196 146.2 | 312 232.7 | 442 329.6 | 584 435.5 | 719 536.2 | 859 640.6 | 987 736.0 | 1189 886.6 | |
| (2) non-weighted average. Measured fuel rate for idle was greater than expected; therefore, average data from Notches 1-8 were used | | | | | | | | | | | |
| (1) APPLIED WEIGHTING FACTORS | | 0.598 | 0.124 | 0.123 | 0.058 | 0.036 | 0.036 | 0.015 | 0.002 | 0.008 | ----- |

Figure 4 – ENTEC Summary May 16, 2014 Tier 4 at 1500 Hours (Page 2 of 3)



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

Tier 4 @ 3000 Hours

| | | | |
|---------------------------|--------------------------------------|-------------------------|---------------------|
| Client : | National Railway Equipment Co. (NRE) | Entec Project No. : | 6514190 |
| Location : | Richmond Rail Yard | Client Project No. : | |
| Locomotive Manufacturer : | NRE | Locomotive Model : | 2GS12B |
| 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 | Notch 1 | Notch 2 | Notch 3 | Notch 4 | Notch 5 | Notch 6 | Notch 7 | Notch 8 | WEIGHTED AVERAGES (1) |
|---|--|-------------------------------------|-------------------------------------|-------------------------------------|-------------------------------------|-------------------------------------|-------------------------------------|-------------------------------------|-------------------------------------|-------------------------------------|-----------------------|
| DATE | | 30-Oct-14 10:21-10:40 | 30-Oct-14 10:48-11:07 | 30-Oct-14 11:23-11:42 | 30-Oct-14 11:52-12:11 | 30-Oct-14 12:51-13:10 | 30-Oct-14 13:19-13:39 | 30-Oct-14 10:57-11:07 | 30-Oct-14 11:28-11:38 | 30-Oct-14 14:47-15:06 | ----- ----- |
| PARTICULATE | g/dscf g/hr g/bhp-hr | 0.00000620 0.030095 0.0015839 | 0.00000456 0.081264 0.0004084 | 0.00000805 0.208228 0.0006548 | 0.00000937 0.321303 0.0007031 | 0.00002509 1.083899 0.0018217 | 0.00000823 0.434024 0.0005970 | 0.00001322 0.818318 0.0009428 | 0.00001769 1.558957 0.0015795 | 0.00001664 2.144631 0.0018037 | 0.0009180 |
| OXIDES OF NITROGEN | PPMv dry g/hr g/bhp-hr | 227.8 59.8 3.1477 | 128.7 124 0.625 | 120.4 168.5 0.530 | 138.0 256.2 0.561 | 115.6 270.4 0.454 | 122.1 348.5 0.479 | 140.9 472.0 0.544 | 159.2 759.0 0.769 | 288.6 2013.6 1.693 | 0.770 |
| NITROGEN DIOXIDE (NO2) | PPMv dry g/hr g/bhp-hr | 26.5 6.9 0.3655 | 53.4 51.6 0.259 | 33.1 46.3 0.146 | 25.0 46.4 0.102 | 33.4 78.2 0.131 | 27.9 79.8 0.110 | 27.8 93.0 0.107 | 28.8 137.2 0.139 | 51.4 358.9 0.302 | 0.168 |
| CARBON MONOXIDE | PPMv dry g/hr g/bhp-hr | 1.0 0.16 0.0084 | 68.6 40.34 0.2027 | 1.0 0.85 0.0027 | 1.0 1.13 0.0025 | 1.0 1.42 0.0024 | 1.0 1.74 0.0024 | 1.0 2.04 0.0024 | 1.0 2.90 0.0029 | 1.0 4.25 0.0036 | 0.0314 |
| SULFUR DIOXIDE | PPMv dry g/hr g/bhp-hr | 1.8 0.7 0.0354 | 2.4 3.2 0.0159 | 2.0 4.0 0.0124 | 1.9 5.0 0.0110 | 2.1 6.9 0.0116 | 2.1 8.5 0.0116 | 2.1 9.8 0.0113 | 2.1 14.2 0.0144 | 2.8 26.9 0.0227 | 0.0145 |
| THC as propane | PPMv wet PPMv dry g/hr g/bhp-hr | 4.7 4.9 1.24 0.0655 | 0.8 0.9 0.86 0.0043 | 0.4 0.4 0.60 0.0019 | 0.4 0.5 0.87 0.0019 | 0.4 0.4 0.91 0.0015 | 0.4 0.4 1.11 0.0015 | 0.4 0.4 1.33 0.0015 | 0.4 0.4 2.02 0.0020 | 0.5 0.6 3.87 0.0033 | 0.0063 |
| OPACITY, (VISIBLE EMISSIONS) | % | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| CARBON DIOXIDE | Vol% dry | 3.29 | 8.71 | 9.80 | 10.63 | 9.52 | 10.23 | 10.61 | 10.68 | 10.54 | |
| OXYGEN | Vol% dry | 17.25 | 9.37 | 7.62 | 6.17 | 8.06 | 6.83 | 6.14 | 5.97 | 6.22 | |
| MOISTURE | Vol% | 4.84 | 9.61 | 10.55 | 11.10 | 10.33 | 10.90 | 11.20 | 11.20 | 11.08 | |
| EXHAUST FLOW | dscfm | 80.85 | 297.30 | 430.92 | 571.49 | 720.05 | 878.92 | 1031.79 | 1468.46 | 2148.37 | |
| ENGINE FUEL FIRING RATE | gall/min | 0.0154 | 0.1510 | 0.2462 | 0.3545 | 0.3998 | 0.5244 | 0.6384 | 0.9150 | 1.3205 | |
| BRAKE SPECIFIC FUEL RATE | gall/bhp-hr | 0.0486 | 0.0455 | 0.0465 | 0.0465 | 0.0403 | 0.0433 | 0.0441 | 0.0556 | 0.0666 | 0.049 (2) |
| ENGINE G1 SPEED | rpm | 899 | 1398 | 1497 | 1699 | 1699 | 1700 | 1698 | 1700 | 1799 | |
| ENGINE G2 SPEED | rpm | 0 | 0 | 0 | 0 | 1400 | 1389 | 1500 | 1796 | 1799 | |
| TOTAL ENGINE POWER | bhp-hr kWatt (bhp*.7456999) | 19 14.2 | 199 146.2 | 318 232.7 | 457 329.6 | 595 435.5 | 727 536.2 | 868 640.6 | 987 736.0 | 1189 886.6 | |
| (2) non-weighted average. Measured fuel rate for Idle was lower than expected; therefore, average data from Notches 1-9 were used | | | | | | | | | | | |
| (1) APPLIED WEIGHTING FACTORS | | 0.598 | 0.124 | 0.123 | 0.058 | 0.036 | 0.036 | 0.015 | 0.002 | 0.008 | ----- |

Figure 5 – ENTEC Summary October 30, 2014 - Tier 4 at 3000 Hours (Page 3 of 3)

NATIONAL RAILWAY EQUIPMENT CO.
 1100 SHAWNEE ST.
 P.O. BOX 1416
 62864, MT. VERNON
 United States
 229533001



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

Analysis Report

Report number : 13093/00006111.2/L/13 Sample date : 10-09-2013
 Main Object : Rail Car # 2015 Place of sampling : North Railways
 Report Date : 10-11-2013 Date received : 10-11-2013
 Date of issue : 10-11-2013 Date completed : 10-11-2013
 Sample object : Rail Car # 2015 Sample number : 1114967
 Sample type : Submitted
 Sample submitted as : ULSD
 Marked : Rail Tank Car Rail Car # 2015 Submitted Sample

| NAME | METHOD | UNIT | RESULT |
|---|-------------|--------|--------|
| Density at 15°C ¹ | ASTM D 4052 | g/mL | 0.8283 |
| Gravity API at 60 °F ² | ASTM D 4052 | °API | 39.2 |
| Kinematic Viscosity at 40°C ³ | ASTM D 445 | cSt | 2.219 |
| Sulphur (S) ⁴ | ASTM D 5453 | ppm | 5.3 |
| Cetane Index | ASTM D 976 | | |
| Distillation at 50% recovered ⁵ | | °C | 237.9 |
| Cetane Index ⁶ | | - | 47 |
| Cetane Index | ASTM D 4737 | | |
| Distillation 10 vol% recovered ⁷ | | °C | 194.7 |
| Distillation 50 vol% recovered ⁸ | | °C | 237.9 |
| Distillation 90 vol% recovered ⁹ | | °C | 333.8 |
| Cetane Index (proc A) □ | | - | 48.1 |
| Cetane index (proc B) □ | | - | 46.4 |
| Heat of Combustion | ASTM D 240 | | |
| Net Heat of Combustion □ | | BTU/lb | 19839 |
| Elemental analysis | ASTM D 5291 | | |
| Hydrogen □ | | wt% | 13.67 |
| Aromatic/Polynuclear Aromatics | ASTM D 5186 | | |
| Polynuclear Aromatics □ | | - | 1.5 |
| Total Aromatics □ | | - | 14.8 |
| Mono- Aromatics □ | | - | 13.3 |
| FIA (hydrocarbon types) | ASTM D 1319 | | |
| Saturates □ | | vol % | 84.6 |
| Olefins □ | | vol % | 1.4 |
| Aromatics □ | | vol % | 14.0 |
| Total □ | | vol % | 100 |

Precision parameters apply in the evaluation of the test results specified above. Please also refer to ASTM D3244 (except for analysis of RFG) and IP 367 with respect to the utilization of test data to determine conformance with specifications.

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 Website: www.saybolt.com E-mail: sayboltlp.general@corelab.com
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 Page 1 of 4

Figure 6 - Saybolt October 2013 Fuel Test Results (Page 1 of 5)

NATIONAL RAILWAY EQUIPMENT CO.
1100 SHAWNEE ST.
P.O. BOX 1416
62864, MT. VERNON
United States
229533001



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

Analysis Report

Report number : 13093/00006111.2/L/13 Sample date : 10-09-2013
Main Object : Rail Car # 2015 Place of sampling : North Railways
Report Date : 10-11-2013 Date received : 10-11-2013
Date of issue : 10-11-2013 Date completed : 10-11-2013
Sample object : Rail Car # 2015 Sample number : 1114967
Sample type : Submitted
Sample submitted as : ULSD
Marked : Rail Tank Car Rail Car # 2015 Submitted Sample

| NAME | METHOD | UNIT | RESULT |
|--------------|-----------|------|--------|
| Distillation | ASTM D 86 | | |

Precision parameters apply in the evaluation of the test results specified above. Please also refer to ASTM D3244 (except for analysis of RFG) and IP 367 with respect to the utilization of test data to determine conformance with specifications.

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Figure 7 - Saybolt October 2013 Fuel Test Results (Page 2 of 5)

NATIONAL RAILWAY EQUIPMENT CO.
 1100 SHAWNEE ST.
 P.O. BOX 1416
 62884, MT. VERNON
 United States
 229533001



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

Analysis Report

Report number : 13093/00006111.2/L/13 Sample date : 10-09-2013
 Main Object : Rail Car # 2015 Place of sampling : North Railways
 Report Date : 10-11-2013 Date received : 10-11-2013
 Date of issue : 10-11-2013 Date completed : 10-11-2013
 Sample object : Rail Car # 2015 Sample number : 1114967
 Sample type : Submitted
 Sample submitted as : ULSD
 Marked : Rail Tank Car Rail Car # 2015 Submitted Sample

| NAME | METHOD | UNIT | RESULT |
|-------------------------|--------|-------|--------|
| Initial boiling point □ | | °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 % | 98.0 |
| Residue | | vol % | 1.5 |
| Loss | | vol % | 0.5 |

Precision parameters apply in the evaluation of the test results specified above. Please also refer to ASTM D3244 (except for analysis of RFG) and IP 367 with respect to the utilization of test data to determine conformance with specifications.

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Figure 8 - Saybolt October 2013 Fuel Test Results (Page 3 of 5)

Remarks:

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

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

Precision parameters apply in the evaluation of the test results specified above. Please also refer to ASTM D3244 (except for analysis of RFG) and IP 357 with respect to the utilization of test data to determine conformance with specifications.

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Page 4 of 4

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 1100 SHAWNEE ST.
 P.O. BOX 1416
 62864, MT. VERNON
 United States
 229533001



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

Analysis Report

Report number : 13093/00006111.11/L/13 Sample date : 10-09-2013
 Main Object : Rail Car # 2015 Place of sampling : North Railways
 Report Date : 10-16-2013 Date received : 10-11-2013
 Date of issue : 10-17-2013 Date completed : 10-16-2013
 Sample object : Rail Car # 2015 Sample number : 1114967
 Sample type : Submitted
 Sample submitted as : ULSD
 Marked : Rail Tank Car Rail Car # 2015 Submitted Sample

| NAME | METHOD | UNIT | RESULT |
|---------------------------------|-----------------------|---------|--------|
| Sulphur (S) | ASTM D 5453 | wt% | 0.0005 |
| Nitrogen | ASTM D 5762 | wt% | 0.0093 |
| Elemental analysis | ASTM D 5291 | | |
| Carbon | | wt% | 81.28 |
| Hydrogen | | wt% | 12.87 |
| Calculated Oxygen by Difference | Normalized Calculated | | |
| Calculated Oxygen | | wt % | 5.84 |
| Heat of Combustion-calculated | Calculated | | |
| Gross Heat of Combustion | | Btu/gal | 137137 |
| Net Heat of Combustion | | Btu/gal | 128517 |
| Heat of Combustion | ASTM D 240 | | |
| Gross Heat of Combustion | | Btu/lb | 19839 |
| Net Heat of Combustion | | Btu/lb | 18592 |

Signed by: Michael Oliver Tibay - Laboratory Supervisor
 Issued by: Saybolt LP
 Place and date of issue: Martinez - 10-17-2013

Precision parameters apply in the evaluation of the test results specified above. Please also refer to ASTM D3244 (except for analysis of RFG) and IP 367 with respect to the utilization of test data to determine conformance with specifications.

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Figure 10 – Saybolt October 2013 Fuel Test Results (Page 5 of 5)

NATIONAL RAILWAY EQUIPMENT CO.
 1100 SHAWNEE ST.
 P.O. BOX 1416
 62864, MT. VERNON
 United States
 229533001



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

Analysis Report

Report number : 13093/00006344.2/L/14 Submitted date : 05-08-2014
 Main Object : Rail Car # 2015 Sample submitted at : North Railways
 Report Date : 05-13-2014 Date received : 05-13-2014
 Date of issue : 05-13-2014 Date completed : 05-13-2014
 Sample object : Rail Car # 2015 Sample number : 1547161
 Sample type : Submitted
 Sample submitted as : ULSD
 Marked : Rail Car # 2015 ULSD Red Dye Submitted Sample NRE, Richmond Pacific RR

| NAME | METHOD | UNIT | RESULT |
|-------------------------------------|-------------|---------|-----------|
| Gravity API at 60 °F | ASTM D 4052 | °API | 39.4 |
| Cal.Density at 15°C | ASTM D 4052 | | |
| Density at 15 °C ¹ | | g/mL | 0.8276 |
| Sulphur (S) | ASTM D 5453 | ppm | 3.2 |
| Kinematic Viscosity at 40°C | ASTM D 445 | cSt | 2.332 |
| Cetane Index | ASTM D 4737 | | |
| Distillation 10 vol% recovered | | °C°F | 193.6/380 |
| Distillation 50 vol% recovered | | °C°F | 242.8/469 |
| Distillation 90 vol% recovered | | °C°F | 336.8/638 |
| Cetane Index (proc B) | | - | 49.2 |
| Cetane Index | ASTM D 976 | | |
| Distillation at 50% recovered | | °C°F | 242.8/638 |
| Cetane Index | | - | 48.8 |
| Heat of Combustion | ASTM D 240 | | |
| Gross Heat of Combustion | | Btu/gal | 136972 |
| Net Heat of Combustion | | Btu/gal | 128671 |
| Gross Heat of Combustion | | Btu/lb | 19851 |
| Net Heat of Combustion | | Btu/lb | 18648 |
| Aromatic/Polynuclear Aromatics | 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 |

Precision parameters apply in the evaluation of the test results specified above. Please also refer to ASTM D3244 (except for analysis of RFG) and IP 367 with respect to the utilization of test data to determine conformance with specifications.

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Figure 11 - Saybolt May 13, 2014 Fuel Test Results (Page 1 of 2)

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Attention of : Mr. S.S Sonni
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Analysis Report

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 Date of issue : 05-13-2014 Date completed : 05-13-2014
 Sample object : Rail Car # 2015 Sample number : 1547161
 Sample type : Submitted
 Sample submitted as : ULSD
 Marked : Rail Car # 2015 ULSD Red Dye Submitted Sample NRE, Richmond Pacific RR

| NAME | METHOD | UNIT | RESULT |
|--|-----------|-------|--------|
| Derived. Nitrogen ² | | wt% | 0.0045 |
| Derived. Sulfur ³ | | wt% | 0.0032 |
| Cal. Oxygen by difference ⁴ | | wt% | 3.75 |
| Distillation | ASTM D 86 | | |
| Initial boiling point | | °C | 169.6 |
| 5% Recovered | | °C | 187.8 |
| 10% Recovered | | °C | 193.6 |
| 15% Recovered | | °C | 199.8 |
| 20% Recovered | | °C | 205.4 |
| 30% Recovered | | °C | 216.6 |
| 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 | 336.8 |
| 95% Recovered | | °C | 364.4 |
| Final boiling point | | °C | 376.2 |
| Recovery | | vol % | 97.5 |
| Residue | | vol % | 1.5 |
| Loss | | vol % | 1.0 |

Remarks:

- 1 Density calculated form API Table 3.
- 2 Derived from ASTM 5762 Result
- 3 Derived form ASTM 5453 Result
- 4 Normalized Calculated

Signed by: Laura Nichols - Laboratory Manager
 Issued by: Saybolt LP
 Place and date of issue: Martinez - 05-13-2014

Precision parameters apply in the evaluation of the test results specified above. Please also refer to ASTM D3244 (except for analysis of RFG) and IP 367 with respect to the utilization of test data to determine conformance with specifications.

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Figure 12 - Saybolt May 13, 2014 Fuel Test Results (Page 2 of 2)

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

Analysis Report

Report number : 13093/00006528.1/L/14 Submitted date : 2014-10-22
 Main Object : Rail Car # 2015 Sample submitted at : North Railways
 Report Date : 2014-10-27 Date received : 2014-10-25
 Date of issue : 2014-10-27 Date completed : 2014-10-27
 Sample object : Rail Car # 2015 Sample number : 1921576
 Sample type : Submitted
 Sample submitted as : ULSD
 Marked : Rail Tank Car Rail Car # 2015

| NAME | METHOD | UNIT | SPECS | | RESULT |
|-------------------------------------|-------------|---------|-------|-----|--------|
| | | | Min | Max | |
| Gravity API at 60 °F | ASTM D 4052 | °API | | | 39.2 |
| Cal.Density at 15°C | ASTM D 4052 | | | | |
| Density at 15 °C ¹ | | g/mL | | | 0.8285 |
| Sulphur (S) | ASTM D 5453 | ppm | | | 7.89 |
| Kinematic Viscosity at 40°C | ASTM D 445 | cSt | | | 2.312 |
| Cetane Index | ASTM D 4737 | | | | |
| Distillation 10 vol% recovered | | °C | | | 197.9 |
| Distillation 50 vol% recovered | | °C | | | 241.9 |
| Distillation 90 vol% recovered | | °C | | | 333.9 |
| Cetane Index (proc A) | | - | | | 49.1 |
| Cetane index (proc B) | | - | | | 50.3 |
| Cetane Index | ASTM D 976 | | | | |
| Distillation at 50% recovered | | °C | | | 241.9 |
| Cetane Index | | - | | | 48.2 |
| Heat of Combustion | ASTM D 240 | | | | |
| Gross Heat of Combustion | | Btu/gal | | | 136825 |
| Net Heat of Combustion | | Btu/gal | | | 128669 |
| Gross Heat of Combustion | | Btu/lb | | | 19789 |
| Net Heat of Combustion | | Btu/lb | | | 18609 |
| Aromatic/Polynuclear Aromatics | ASTM D 5186 | | | | |
| Polynuclear Aromatics | | - | | | 1.5 |
| Total Aromatics | | - | | | 14.2 |
| Mono- Aromatics | | - | | | 12.7 |
| FIA (hydrocarbon types - corrected) | ASTM D 1319 | | | | |
| Saturates | | vol % | | | 85.9 |
| Olefins | | vol % | | | 0.9 |
| Aromatics | | vol % | | | 13.2 |
| Total | | vol % | | | 100 |
| Nitrogen | ASTM D 5762 | ppm | | | 48 |
| Sulphur (S) | ASTM D 5453 | ppm | | | 7.89 |

Uncertainties apply in the evaluation of the test results specified above. Please also refer to ASTM D3244 (except for analysis of RFG) and IP 367 with respect to the utilization of test data to determine conformance with specifications.

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Figure 13 -Saybolt Analysis Report 10-27-2014 –(Page 1 of 3)

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

Analysis Report

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 Report Date : 2014-10-27 Date received : 2014-10-25
 Date of issue : 2014-10-27 Date completed : 2014-10-27
 Sample object : Rail Car # 2015 Sample number : 1921576
 Sample type : Submitted
 Sample submitted as : ULSD
 Marked : Rail Tank Car Rail Car # 2015

| NAME | METHOD | UNIT | SPECS | | RESULT |
|--|-------------|------|-------|-----|--------|
| | | | Min | Max | |
| Elemental analysis | ASTM D 5291 | | | | |
| Carbon | | wt% | | | 76.99 |
| Hydrogen | | wt% | | | 12.93 |
| Derived. Nitrogen ² | | wt% | | | 0.48 |
| Derived. Sulfur ³ | | wt% | | | 0.08 |
| Cal. Oxygen by difference ⁴ | | wt% | | | 9.52 |
| Distillation | ASTM D 86 | | | | |

Uncertainties apply in the evaluation of the test results specified above. Please also refer to ASTM D3244 (except for analysis of RFG) and IP 367 with respect to the utilization of test data to determine conformance with specifications.

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Figure 14-Saybolt Analysis Report 10-27-2014 (Page -2 of 3)

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 Date of issue : 2014-10-27 Date completed : 2014-10-27
 Sample object : Rail Car # 2015 Sample number : 1921576
 Sample type : Submitted
 Sample submitted as : ULSD
 Marked : Rail Tank Car Rail Car # 2015

| NAME | METHOD | UNIT | SPECS | | RESULT |
|-----------------------|--------|-------|-------|-----|--------|
| | | | Min | Max | |
| Initial boiling point | | °C | | | 175.2 |
| 5% Recovered | | °C | | | 192.0 |
| 10% Recovered | | °C | | | 197.9 |
| 15% Recovered | | °C | | | 202.9 |
| 20% Recovered | | °C | | | 207.8 |
| 30% Recovered | | °C | | | 218.4 |
| 40% Recovered | | °C | | | 229.4 |
| 50% Recovered | | °C | | | 241.9 |
| 60% Recovered | | °C | | | 257.8 |
| 70% Recovered | | °C | | | 277.0 |
| 80% Recovered | | °C | | | 300.8 |
| 90% Recovered | | °C | | | 333.9 |
| 95% Recovered | | °C | | | 361.5 |
| Final boiling point | | °C | | | 375.4 |
| Recovery | | vol % | | | 98.0 |
| Residue | | vol % | | | 1.5 |
| Loss | | vol % | | | 0.5 |

- Remarks:**
- 1 Density calculated form API Table 3.
 - 2 Derived from ASTM 5762 Result
 - 3 Derived form ASTM 5453 Result
 - 4 Normalized Calculated

Signed by: Laura Nichols - Location Manager
 Issued by: Saybolt LP
 Place and date of issue: Martinez - 2014-10-27

Uncertainties apply in the evaluation of the test results specified above. Please also refer to ASTM D3244 (except for analysis of RFG) and IP 367 with respect to the utilization of test data to determine conformance with specifications.

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Figure 15- Saybolt Analysis Report 10-27-2014 –(Page 3 of 3)