GE Marine 6L250 EPA Tier 3 Development

Task #1 Report

for:

New Technology Research and Development Program

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Submitted by:

GE Transportation

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Abstract/Executive Summary

This project involves the prototype build and engine performance testing of US Environmental Protection Agency (EPA) Tier 3 compliant marine engines. In particular, it is a goal of this project to release a Tier 3 compliant engine ahead of the January 1, 2014, compliance deadline.

This task in particular provided for the initial component and technology development to allow for engine testing on the 6L250 engine platform. Computer aided design software packages have been leveraged to model the structure needed to modify the engine to meet EPA Tier 3 requirements, as well as the performance and emissions of the Tier 3 engine platform. In short this task provided the design steps necessary to move forward with engine testing and prototype component procurement.

Introduction/Background

The GE family of inline engines is US Environmental Protection Agency (EPA) Tier 2 certified. This project seeks to modify the current inline engine design such that it is capable of meeting the more stringent EPA Tier 3 guidelines. Given that the EPA guidelines on Tier 3 marine engines only apply to engines with a rated load of less than 2000 kilowatts, the inline engines are the engines in GE's portfolio that are subject to the Tier 3 regulations.

Project Objectives/Technical Approach

From the Grant Activities (Scope of Work):

> *"1.1. The objectives for this work are:*
>
> *1.1.1. Certify a marine 4-stroke six and eight cylinder engine rebuild kit to American Bureau of Shipping (ABS) class standards and EPA Tier 3 marine emission standards ahead of the 2014 EPA regulatory deadline."*

This report in particular is in regards to the initial structural and performance development of the 6L250 EPA Tier 3 certified engine platform.

Tasks

Task 1: Tier 3 System Design

From the Grant Activities (Scope of Work):

> *"2.1. Task Statement: The PERFORMING PARTY will complete the design work required to implement a new turbo design and an improved lube oil consumption package to meet the EPA Tier 3 and class society requirements. The PERFORMING PARTY will also model the engine using common standards and practices."*

Turbocharger mounting design

From the Grant Activities (Scope of Work):

> *"2.1.1.1. The PERFORMING PARTY will develop and produce prototype assemblies to mount and operate a Tier 3 turbocharger on the existing L250 engine platform. This design work will include computer analysis and structural testing of the prototype mounting components."*

The prototype design has been completed and modeled completely in a computer aided design environment. All parts have been procured as necessary, in accordance with Task 2 of the grant activities, and have been installed on the engine. Figure 1 displays the computer generated model of the

turbocharger mounting, while Figures 2 and 3 display the turbocharger actually mounted on the engine, utilizing the prototype mounting design.

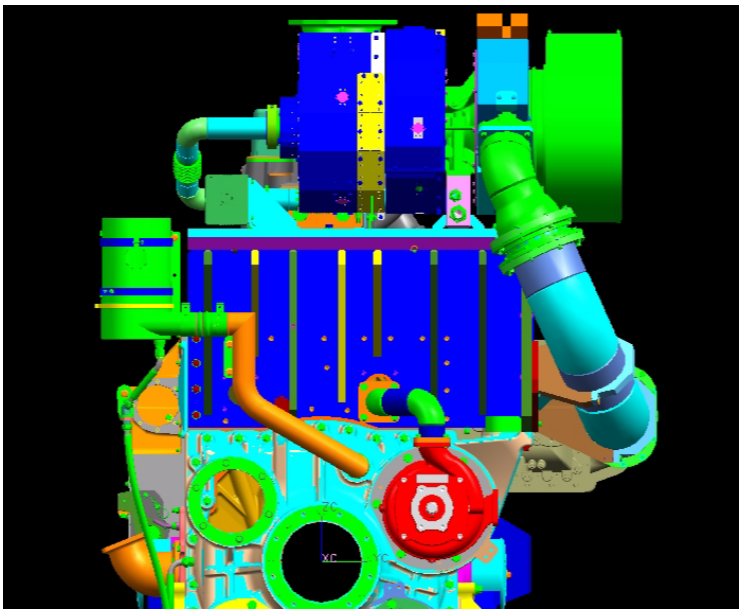

Figure 1: Computer generated model of 6L250 prototype turbocharger mounting solution

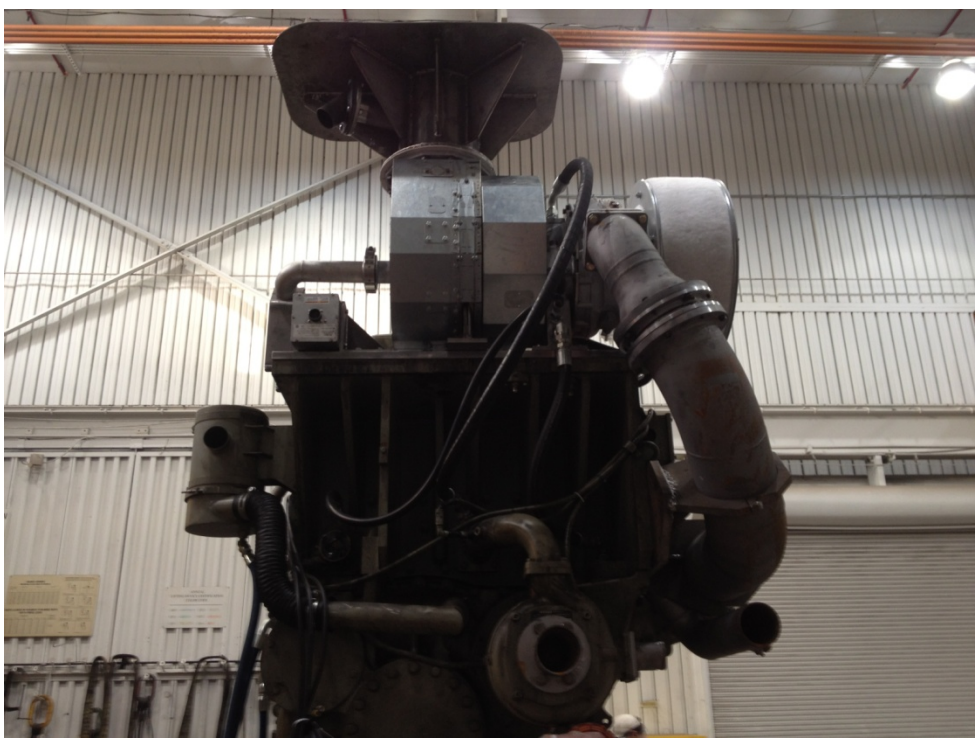

Figure 2: Front view of prototype 6L250 engine configured for performance testing

Figure 3: View of new turbocharger installed on the prototype 6L250 engine

Reduced lube oil consumption package integration

From the Grant Activities (Scope of Work):

> *"2.1.2.1. The PERFORMING PARTY will test and validate a reduced lube oil consumption package for the marine L250 family of engines."*

This hardware packaged has been leveraged from the GE Transportation locomotive engine program and will be tested on the 6L250 platform in accordance with Task 3 of the awarded grant.

Computer aided system modeling

From the Grant Activities (Scope of Work):

> *"2.1.3.1. The PERFORMING PARTY will model and predict the performance and emissions of the Tier 3 6L250 and 8L250 engine configurations. This data will be used to set expected values for the engine timing and performance, and save development time on the engine in the test cell."*

The performance and emissions modeling of the 6L250 and 8L250 engine configurations has been completed utilizing the computer modeling software package. Details of this modeling can be found in Appendix A. This data has been used to select the appropriate turbocharger configuration and model the expected engine operating conditions of the final engine configuration. The primary turbocharger matching results produced from the computer modeling efforts will be provided separately.

Component and system level design reviews

From the Grant Activities (Scope of Work):

> *"2.1.4.1. The PERFORMING PARTY will plan and prepare design reviews for each of the 8L250 and 6L250 engine configurations, to include all required additional components to retrofit the L250 engine family to meet EPA Tier 3 emissions levels."*

Per GE's standard engineering processes for new product development, technical design reviews covering the development of the marketing guide specifications, product functional specifications, system concept development, system requirements determination, and the development of the validation plan and verification strategy have been conducted and approved by the senior engineering staff. With regards to the program specific core strategies such as the turbocharger solution and its associated mounting strategy, technical reviews have been conducted covering the technical requirements review and the primary concept selection review. The concept selection review for the turbocharger mounting strategy was scheduled for the week of March 7, 2012. Once testing is underway, the validation review will be conducted for the turbocharger strategy which will be followed by a verification and production readiness review that will occur later in 2012. To date, all applicable reviews have been approved.

Reporting

From the Grant Activities (Scope of Work):

> *"2.1.5. Schedule: The PERFORMING PARTY shall complete this task within 7 months of the signed Notice to Proceed Date as issued by TCEQ.*
>
> *2.1.6. Deliverables: The PERFORMING PARTY shall submit a report to the TCEQ upon completion of this task. This report will include but is not limited to results of the initial design work and results of all design reviews."*

Formal design reviews for the 6L250 and 8L250 series production components will be completed as a part of Tasks 5 and 8, for the 6L250 and 8L250, respectively in accordance with the GE formal design review process, and marine class society submission requirements.

Discussion/Observations

Objectives vs. Results

All desired objectives have been met for this portion of the grant objectives. All prototype designs have been completed, as well as the computer modeling of the system. The complete series production structural analysis has not been completed; however this task is viewed as on track with respect to the desired production release of the engine system.

Critical issues

At this stage of the program, the only risk to the program is one of a scheduling push due to testing delays caused by test cell availability at GE's test facility. Any further delays in starting the tests may lead to push in the overall testing and certification of the engine platform. At this point, GE is tracking the issue very closely and does not expect the remaining grant activities to slide based upon the agreed program end date.

Technical and commercial viability of the proposed approach

All aspects of this project to date are deemed achievable and technically viable. Some activity is still to be undertaken to develop a serial production ready version of the hardware, however this task can be viewed as a modification of the prototype component designs, and as noted above is seen as on track with respect to the GE design guidelines.

Scope for future work

Future work is to involve the performance testing and compliance certification of the engine with the applicable governing bodies. For this task, much of the work performed can be leveraged for the 8L250 system design, and will be leveraged in the 8L250 prototype engine development and production.

Intellectual Properties/Publications/Presentations

The produced performance development data has been provided in Appendix A as confidential information.

Summary/Conclusions

The elements of this part of the grant activity focused on building a working prototype of the intended design per the performance modeling effort in order to test and validate a viable Tier 3 solution for GE's 6L250 and 8L250 engine platforms. The activities, as noted in the grant scope of work, will validate the initial system analysis and provide the data necessary to model and release the series production ready version of the engine platform.

Appendices

Appendix A: 6L250 and 8L250 Engine Configurations Performance and Emissions Computer Modeling

The information in this appendix was claimed by the grantee as Proprietary and/or Confidential. To view this information please contact the New Technology Research and Development program at:

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Or

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