

3RD QUARTERLY REPORT – PUBLIC
GTI PROJECT NUMBER 21873

**Project Title: Statistical Review and Gap
Analysis of LNG Failure Rate Table**

Contract Number: DTPH56-15-T-00008

Date of Report: 3rd Quarterly Report – June 30, 2016

For Quarterly Period Ending: June 30, 2016

Prepared for:

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Table of Contents

| | |
|--|----|
| Legal Notice | ii |
| Table of Contents..... | 1 |
| Funds and Work Completed this Quarterly Period | 2 |
| Results and Conclusions..... | 3 |
| Plans for Future Activity | 4 |

Funds and Work Completed this Quarterly Period

The following work was performed during this quarterly period.

Task 1. Form Technical Advisory Panel – GTI supplemented its prior work accomplishments on Task 1, as summarized by this additional accomplishment:

- GTI asked a representative of National Grid to join this project’s TAP, and received a positive response. National Grid is one of the largest investor-owned energy companies in the world (covering Massachusetts, New York, Rhode Island and the UK) and can add important insights to the TAP because it brings additional key experience.

Task 2. Review Literature and Data, and Prepare Final Bibliography – GTI completed Task 2 during this quarter, as summarized by these accomplishments:

- Submitted the Final Bibliography that summarizes final review of literature and data on June 30, 2016. It identified 50 references that appear to contain failure rate data relevant to PHMSA’s LNG Failure Rate Table, and identified 56 additional references relevant to analysis methodology.

Task 4. Contact Additional SMEs and Other Interested Parties – GTI completed Task 4 during this quarter, as summarized by these accomplishments:

- Leveraged major LNG events occurring in April 2016 for this task, namely the LNG18 conference in Perth, Australia and the meeting of the American Gas Association’s Supplemental Gas Technical Committee at AGA’s Operations Conference in Phoenix, AZ, in order to personally discuss available LNG equipment failure rate data with representatives of key organizations. In total, the project team contacted more than 40 individuals globally that represented a sampling of pipeline companies, operators of LNG facilities and related process facilities, LNG facility designers and builders, LNG equipment manufacturers, and others; this substantially exceeded the contract requirement to contact at least 15 Subject Matter Experts (SMEs) beyond the TAP and seek their input.
- Submitted the Summary of Findings from Additional SMEs Beyond TAP on June 30, 2016.

Task 5. Develop Integrated Database and Analyze Data – GTI completed Task 5 during this quarter, as summarized by these accomplishments:

- Developed an integrated database in Microsoft Excel format by applying the data found in literature search and as represented in the Framework Layout.
- Made further refinements to the Framework Layout and equipment protocols.
- Structured and performed a Bayesian Network analysis of data using AgenaRisk commercial software supplemented by a custom-generated software input/output script.
- Received comments from subcontractor CH-IV International Inc. regarding miscellaneous details of various reference documents.

- Received comments from subcontractor CH-IV International Inc. about draft versions of Preliminary Summary of Database and Analysis of Results.
- Submitted the Preliminary Summary of Database and Analysis of Results on June 30, 2016.

Task 9. Program Management – GTI continued Task 9 during this quarter, as summarized by these accomplishments:

- Performed overall project management and coordination activities.
- Prepared and submitted Monthly Reports, this Quarterly Report, and above-referenced reports.
- Communicated with DOT/PHMSA’s AOR, subcontractor CH-IV International Inc., and performed other Project Management activities.

Other: Peer Review #1 – Virtually Administered – GTI completed Peer Review #1 during this quarter. GTI prepared and submitted presentation materials, and presented results virtually on May 25, 2016.

The payable milestones completed during this quarter were:

1. Final Bibliography that Summarizes Final Results of Review of Literature and Data. Due to DOT within nine (9) months of the effective date of the Agreement. Completed on June 30, 2016.
2. Summary of Findings from Additional SMEs Beyond TAP. Due to DOT within six (6) months of the effective date of the Agreement. Completed on June 30, 2016.
3. Preliminary Summary of Database and Analysis of Results. Due to DOT within seven (7) months of the effective date of the Agreement. Completed on June 30, 2016.
4. Peer Review #1 – Virtually-Administered. Due to DOT within ten (10) months of the effective date of the Agreement. Completed on May 25, 2016.
5. Quarterly Report #3. Due to DOT within nine (9) months of the effective date of the Agreement. Completed on June 30, 2016.

Results and Conclusions

The Preliminary Results included 17 additional equipment failure rate data sources for PHMSA’s consideration, which significantly expanded upon the 12 failure rate data sources cited in the 2012 derivation of the LNG Failure Rate Table. Examples of the 17 additional equipment failure rate data sources considered in the Preliminary Results include equipment failure rate data produced by the Flemish Government’s LNE department, data contained in NFPA 59A 2013 and 2016 editions, and data produced by the International Association of Oil & Gas Producers (IOGP) and the European Gas Pipeline Incident Data Group (EGIG). The Preliminary Summary of Database and Analysis of Results summarizes the data sources applied in the Preliminary Results to each individual PHMSA Failure Rate Table category. There remains a paucity of LNG-specific or cryogenic-specific equipment failure rate data available, and thus a Bayesian Network statistical approach provides a useful way to analyze the available disparate data.

The Preliminary Results and estimates of mean failure rates for some equipment categories vary significantly depending on: the consideration and weighting given to specific references that appeared to contain some outlier data (three specific references were identified); the consideration and weighting of data deemed more directly sourced from or applicable to LNG service applications; interpretations and application of older LNG-specific data such as from several key references produced during 1979-1984; and the basis used to convert some failure rate data to a common basis. Sixteen variations of Preliminary Results were provided to PHMSA in order to help illustrate the impacts of analysis factors such as these.

The Preliminary Results generated by the project team are generally consistent with PHMSA's current LNG Failure Rate Table (depending on how the above factors are addressed, especially for certain equipment categories), although some notable differences were identified for review and discussion with PHMSA for categories such as failure of gaskets/flanges, expansion joints, and transfer loading arms, as well as some differences in cryogenic atmospheric storage tanks failure rates and some piping diameter category failure rates.

Estimated failure rate data for additional potential equipment categories or subcategories data in the Failure Rate Table were also generated for PHMSA's review and consideration.

The Preliminary Results are subject to the further refinement of the assumptions and interpretations identified in the Preliminary Summary of Database and Analysis of Results. The project team looks forward to discussing the preliminary results with PHMSA and the TAP and assessing next steps in Task 6.

Plans for Future Activity

Planned activities for the next quarter include:

- Review Preliminary Results with PHMSA and TAP.
- Begin and Complete Task 6 – Revisit/Finalize Framework, Protocols, and Data Analysis. Planned Task 6 activities are described in Section 6 of the Preliminary Summary of Database and Analysis of Results.
- Begin and Complete Task 7 – Develop Gap Analysis and Summarize Process Results
- Begin and Complete Task 8 – Develop Final Report with Recommendations
- Submit monthly reports and quarterly report.

End of Quarterly Report