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October 9, 2017
In reply, refer to:
CRC Project No. CM-137-17-1

Dear Prospective Bidder:

The Coordinating Research Council (CRC) invites you to submit a written proposal to provide services for "Review of LSPI" (CRC Project No. CM-137-17-1). A description of the project is presented in Exhibit A, "Statement of Work."

Please indicate by letter, fax, or email by **October 23, 2017** if you or your organization intends to submit a written proposal for this research program. CRC will answer technical questions regarding the Request for Proposal if they are submitted in writing. CRC will then return written answers to all of the bidders, along with a copy of the original questions.

A CRC technical group composed of industry representatives will evaluate your proposal. CRC reserves the right to accept or reject any or all proposals.

The reporting requirements will be monthly progress reports and a summary technical report at the end of the contractual period. The reporting requirements are described in more detail in the attachment entitled "Reports" (Exhibit B).

The proposal must be submitted as two separate documents. The technical approach to the problem will be described in part one, and a cost breakdown that is priced by task will be described in part two. The cost proposal document should include all costs associated with conducting the proposed program. The technical proposal shall not be longer than 10 pages in length (not including resumes). The schedule / timeline information should be included in the technical proposal.

CRC expects to negotiate a cost-plus fixed fee or cost reimbursement contract for the research program.

Contract language for intellectual property and liability clauses is presented in Exhibit C and in Exhibit D, respectively.

Important selection factors to be taken into account are listed in Exhibit E. CRC evaluation procedures require the technical group to complete a thorough technical evaluation before considering costs. After developing a recommendation based on technical considerations, the costs are revealed and the recommendation is modified as needed.

Electronic copies of the technical and cost proposals should be submitted to:

Chris Tennant
Coordinating Research Council
5755 North Point Parkway, Suite 265
Alpharetta, GA 30022

Phone: 678-795-0506
Fax: 678-795-0509
E-mail: ctennant@crcao.org

The deadline for receipt of your proposal is **November 9, 2017.**

Yours truly,

Chris Tennant
General Manager

EXHIBIT A
Statement of Work
Review of LSPI or Low Speed Pre-Ignition (aka Stochastic Pre-Ignition, SPI) Including the Superknock portion of the events, and Fuel Effects on LSPI and Superknock in Vehicle Light Duty Engines

Summary

Investigate through reviews of the academic, commercial and government literature and interviews with OEMs and suppliers, the factors associated with the onset and or severity of LSPI/SPI as related to current market fuels and engine design/hardware and engine lubricating oil. Identify critical technology gaps in understanding LSPI/SPI and suggest R&D efforts where CRC could contribute with possible future programs.

Background

Engine hardware for light-duty vehicles is changing rapidly in response to increasingly stringent requirements imposed by government regulations such as the DOT/NHTSA Corporate Average Fuel Economy (CAFE) standards and the EPA tailpipe GHG program as well as similar programs in California. This has contributed to a substantial increase in the new vehicle market share of turbocharged Gasoline Direct Injection (GTDI) engines [1]. Although GTDI engines have the ability to increase vehicle fuel economy, they can also be subject to LSPI/SPI, a potentially destructive form of sudden abnormal combustion typically associated with high cylinder pressures found in downsized, turbocharged engines.

Abnormal ignition, especially low speed/stochastic preignition (LSPI/SPI), in gasoline engines has been a phenomenon that has been reported for many decades, going back to at least the 1920s in the literature [2]. This was something initially noted by the CRC in 1954, and a document was created so that a common set of terms were used to discuss and communicate the nuances of normal and abnormal combustion [3]. At that time, engine manufacturers were testing designs that included both higher compression ratio and evaluating the use of turbochargers and superchargers for improved performance and economy. In the last 14 years, another abnormal combustion issue, low speed/stochastic preignition, has been observed and documented. This low speed/stochastic preignition issue has again shown up in the industry in response to the need for improved fuel economy as engine design change towards higher compression ratios and turbocharged engines, and manifested by way of changes in engine hardware, oil properties and fuel properties similar to changes since the 1950s. Quick resolution of the current low speed/stochastic preignition issue is required to minimize risk of engine hardware damage and enable utilization of advanced technologies to significantly improve vehicle fuel economy. Therefore, all aspects that can yield improvement need to be understood.

There have been various literature reviews and continued research in the area of LSPI/SPI and superknock (uncontrolled engine knocking after an LSPI/SPI event) to firmly identify the root causes and provide mitigation techniques for each aspect: engine hardware, oil, and fuel. At this time, this issue is still ongoing in the industry and an updated literature review will serve to clearly identify current learnings in preparation for project proposals in areas not currently being studied.

Objectives

Investigate through reviews of the academic, commercial and government literature and interviews with OEMs and suppliers, the factors associated with the onset and or severity of LSPI/SPI as related to current market fuels and engine design/hardware and engine lubricating oil. Identify critical technology gaps in understanding LSPI/SPI and suggest R&D efforts where CRC could contribute with possible future programs.

There are several tasks associated with this updated literature review.

The technical objective of the literature review is to include, specific to engine hardware and configurations, gasoline like fuels and fuel properties, and oils:

1. Outline the factors that have been shown to induce/produce low speed/stochastic preignition and superknock
2. Outline the factors that have been shown to affect the severity of the low speed/stochastic preignition and superknock
3. Identify how the factors produce the required chemical kinetics and physical system that promote the low speed/stochastic preignition and superknock events, and impact the severity of the events.
4. Identify gaps in the understanding of low speed/stochastic preignition and superknock
5. Propose and prioritize technical questions that could be addressed through projects around low speed/stochastic preignition and superknock that would help to further elucidate the causes and enable development of solutions.

The boundaries of the literature include the follow expectation. The contractor(s) will be expected to investigate these areas (low speed/stochastic preignition and fuel effects on low speed/stochastic preignition) of the literature published by interested parties such as OEMs, Tier 1 and Tier 2 suppliers to OEMs, government labs, independent contractors, consortia, and academia. The materials fall into various categories:

1. The open and published literature from 1990 forward.
2. To the extent permissible, obtain and summarize materials from symposia which normally publish their own materials, but not through open literature. The contractor does not need to disclose the source of specific information, other than in broad categories such as “OEM” or “Tier 1 supplier” and the like.

3. Suppliers, OEMs, and Government Organizations that are currently performing work that is not published or is not in the open literature, including planned work that is not currently in process
4. Unattributed materials from projects that will be shared with CRC only if the source agrees to disclosure.

Items that should be specifically noted from the studies include, but not limited to:

1. Engine Design and Hardware
    a. type of fuel injection architecture/components
    b. Compression ratio
    c. Engine architecture: combustion chamber, flow characteristics, bore-stroke ratio, rod ratio, crevice volume/ring pack design, etc.
    d. Forced Induction or Boosted Operation
    e. Combustion cycle (Otto, Miller, Atkinson)
2. Fuel Properties
    a. Oxygenates
    b. Composition/ Refinery Streams
    c. Octane number (AKI, RON, MON)
    d. Volatility Properties including Distillation Curve
    e. Other properties and correlations as outlined in the papers
3. Test Operating Parameters
    a. Engine Test Conditions
    b. Pre-conditioning before test
    c. Engine Test cycle
4. Oil Properties
    a. Base Oil Group
    b. Viscosity effects
    c. Contaminants (fresh vs used)
    d. Additives
    e. Impact and Correlation on SPI
5. Inter-relational effects between lubricants and fuels
6. Inter-relational effects among any of the above

Contractor Tasks

1. Identify and prepare detailed list of literature planned to be reviewed. Contractor will review this list with CRC Committee prior to deep dive analysis to confirm all significant materials are accounted for in data set.
2. Interview external organizations or ask them to prepare reports with information that they can provide with regard to the technical objective.
3. Compile the information into a report which meets the technical objectives of the project, outlining the factors, gaps in understanding, and proposed technical questions to address in next steps project proposals.

Literature Review should include the following sources, but not limited to these:

1. SwRI P3 and AEF Consortiums (to the extent possible/permissible - much of the data has not been published)
2. SwRI Internal research and any other additional client research that can be shared
3. FVV Consortium
4. Aachen Symposium, Baden-Baden Symposium
5. IAV Symposium- (2013, 2017) International Conference on Knocking in Gasoline Engines
6. FEV
7. IAV
8. NREL
9. ORNL
10. APL in Germany
11. AVL
12. API
13. Auto OEMs
14. Oil Companies
15. Additive Companies
16. Patent literature

References

1. Stacy C. Davis; Susan E. Williams; Robert G. Boundy; Sheila Moore. 2015 Vehicle Technologies Market Report

2. Chapman, E. and Costanzo, V., "A Literature Review of Abnormal Ignition by Fuel and Lubricant Derivatives," *SAE Int. J. Engines* 9(1):107-142, 2016, doi:10.4271/2015-01-1869.
3. CRC 278, "Terms for use in Otto Cycle Engine Combustion", Prepared by Special Panel on Nomenclature, Combustion Chamber Deposits Group, Motor Fuels Division, June 8, 1954.

EXHIBIT B

REPORTS

MONTHLY TECHNICAL PROGRESS REPORTS

The contractor shall submit a monthly technical progress report covering work accomplished during each calendar month of the contract performance. An electronic Microsoft® Word compatible file (<1 MB) of the monthly technical progress report shall be distributed by the contractor within ten (10) calendar days after the end of each reporting period. The report shall contain a description of overall progress, plus a separate description for each task or other logical segment of work on which effort was expended during the reporting period.

FINAL REPORT

The contractor shall submit to or distribute for CRC an electronic pdf-compatible copy transmittable via email) of a rough draft of a final report within thirty (30) days after completion of the technical effort specified in the contract. The report shall document, in detail, the test program and all of the work performed under the contract. The report shall include tables, graphs, diagrams, curves, sketches, photographs and drawings in sufficient detail to comprehensively explain the test program and results achieved under the contract. The report shall be complete in itself and contain no reference, directly or indirectly, to the monthly report(s).

Within thirty (30) days after receipt of the approved draft copy of the final report, the contractor shall make the requested changes and deliver to CRC thirty (30) hardcopies including a reproducible master copy of the final report. The final report shall also be submitted as an electronic copy in a pdf or pdf-convertible file format. The final report may be prepared using the contractor's standard format, acknowledging author and sponsors. An outside CRC cover page will be provided by CRC. The electronic copy will be made available for posting on the CRC website.

EXHIBIT C

INTELLECTUAL PROPERTY RIGHTS

Title to all inventions, improvements, and data, hereinafter, collectively referred to as ("Inventions"), whether or not patentable, resulting from the performance of work under this Agreement shall be assigned to CRC. Contractor X shall promptly disclose to CRC any Invention which is made or conceived by Contractor X, its employees, agents, or representatives, either alone or jointly with others, during the term of this agreement, which result from the performance of work under this agreement, or are a result of confidential information provided to Contractor X by CRC or its Participants. Contractor X agrees to assign to CRC the entire right, title, and interest in and to any and all such Inventions, and to execute and cause its employees or representatives to execute such documents as may be required to file applications and to obtain patents covering such Inventions in CRC's name or in the name of CRC's Participants or nominees. At CRC's expense, Contractor X shall provide reasonable assistance to CRC or its designee in obtaining patents on such Inventions.

To the extent that a CRC member makes available any of its intellectual property (including but not limited to patents, patent applications, copyrighted material, trade secrets, or trademarks) to Contractor X, Contractor X shall have only a limited license to such intellectual property for the sole purpose of performing work pursuant to this Agreement and shall have no other right or license, express or implied, or by estoppel. To the extent a CRC member contributes materials, tangible items, or information for use in the project, Contractor X acknowledges that it obtains only the right to use the materials, items, or information supplied for the purposes of performing the work provided for in this Agreement, and obtains no rights to copy, distribute, disclose, make, use, sell or offer to sell such materials or items outside of the performance of this Agreement.

EXHIBIT D

LIABILITY

It is agreed and understood that _____ is acting as an independent contractor in the performance of any and all work hereunder and, as such, has control over the performance of such work. _____ agrees to indemnify and defend CRC from and against any and all liabilities, claims, and expenses incident thereto (including, for example, reasonable attorneys' fees) which CRC may hereafter incur, become responsible for or pay out as a result of death or bodily injury to any person or destruction or damage to any property, caused, in whole or in part, by _____'s performance of, or failure to perform, the work hereunder or any other act of omission in connection therewith.

EXHIBIT E

PROPOSAL EVALUATION CRITERIA

1) Merits of proposed technical approach.
2) Previous performance on related research studies.
3) Personnel available for proposed study – related experience.
4) Timeliness of study completion.
5) Cost.