



**COORDINATING RESEARCH COUNCIL, INC.**

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**February 13, 2015**

In reply, refer to:

CRC Project No. AVFL-27

Dear Prospective Bidder:

The Coordinating Research Council (CRC) invites you to submit a written proposal to provide services for “**Heat of Vaporization Measurements of Ethanol/Gasoline Blends**” (CRC Project No. AVFL-27). A description of the project is presented in Exhibit A, “Statement of Work.”

Please indicate by letter, fax, or email by **March 9, 2015** 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 and government 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) including a description of CRC reporting standard template format.

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 element 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.

CRC expects to negotiate a fixed price or cost reimbursement contract for the study.

Contract language for intellectual property and liability clauses is presented in Exhibit C and in Exhibit D, respectively. Bidders are also advised that government funds may be used to support the research, and therefore certain government contract terms and conditions may apply.

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

Prospective contractors should provide in their bid (1) an explanation of their proposed measurement technique, (2) examples of previous results or literature on relevant samples, (3) a per-measurement cost estimate, (4) an anticipated schedule for testing and reporting, and (5) resumes for those who will be involved in the testing. Unless the bid states otherwise, the per-measurement cost estimate for Phase 1 testing will be assumed to apply to Phase 2 testing as well, if the contractor is selected for both Phases of testing.

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

Brent K. Bailey  
Coordinating Research Council  
5755 North Point Parkway, Suite 265  
Alpharetta, GA 30022

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Proposals for Phase 1 testing only are requested by **March 31, 2015** with contractor selection and notification in April 2015. Contractual negotiation with the CRC Office will follow the contractor's selection.

Yours truly,

Brent Bailey  
Executive Director

**Statement of Work**  
for  
**CRC Project Number AVFL-27**  
**Heat of Vaporization Measurements of Ethanol/Gasoline Blends**

**Background**

The heat of vaporization<sup>1</sup> (HOV, also symbolized as  $\Delta H_{\text{vap}}$ ) is the energy that is needed to completely convert a given quantity of a substance from a liquid to a gaseous state at a given temperature and pressure, usually measured at ambient conditions. For simple substances, the HOV can be calculated from the Clausius-Clapeyron equation by measuring the vapor pressure of the substance at two different temperatures but this approach is not as easy to apply to multicomponent, volatile blends, such as gasoline.

For liquid fuels in combustion engines, droplet vaporization and heat transfer have long been recognized as important factors for optimizing vehicle performance and emissions from gasoline engines [1]. Charge cooling of the injected air/fuel mixture occurs when liquid fuel is injected into the engine's intake air system and the fuel droplets begin to vaporize. The vaporization of the liquid droplets extracts energy from the hot intake system and reduces the temperature of the air/fuel mixture. A cooler air/fuel mixture is expected to increase the engine's volumetric efficiency and power output and improve knock resistance but too much charge cooling could result in vehicle driveability problems [2]. Knock typically occurs under conditions where the air/fuel charge has fully evaporated. In contrast, driveability issues typically occur when a significant portion of the charge has not evaporated and where the droplet composition is not representative of the whole fuel.

To understand the impact of fuel properties on these effects, the HOV is an important parameter because it provides a direct measure of the charge-cooling effectiveness of the fluid when it is vaporized. Generally accepted HOV values for hydrocarbon-only gasoline and for neat ethanol can be found in [2] but there are relatively few references for HOV measurements on low-level blends of ethanol and gasoline [3,4].

For this reason, the Coordinating Research Council (CRC) intends to conduct a research project to measure the HOV of various pure materials and gasoline blends using best available techniques. CRC invites qualified contractors to respond to this Statement of Work (SOW) with proposals that address the following objectives.

**Objective of Study**

The objective of this CRC project is to obtain more precise HOV data for multicomponent liquids in order to better understand the charge-cooling effectiveness of liquid fuels in combustion engines. Phase 1 of this project will assess different measurement techniques for

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<sup>1</sup> The Heat of Vaporization is also called the Latent Heat of Vaporization or the Molar Enthalpy of Vaporization.

obtaining HOV data on four samples, including pure compounds where HOV results already exist and on volatile multicomponent blends, like gasoline/ethanol blends. Phase 2 of this project will select some of the more promising techniques from Phase 1 and measure the HOV for a broader range of sample types.

The AVFL Project Panel will summarize relevant published literature of previous HOV measurements on hydrocarbon fuels and oxygenates, including neat ethanol, and blends of gasoline and ethanol. This information will be provided to the contractors selected for Phase 1 testing for their information and comments.

### **Scope of Phase 1 Testing**

The AVFL-27 Project Panel will provide sufficient sample volumes to those contractors selected for Phase 1 testing. Selected contractors will be asked to measure the HOV of each sample in duplicate and provide the average and individual reported values. The approximate sample volume needed to complete the requested HOV measurements should be stated by the contractor in the bid as well as any specific analytical data that is needed to complete the measurements.

The following four samples will be provided by the AVFL-27 Project Panel for Phase 1 testing:

1. A pure compound for which the HOV is already known
2. A blend of pure compounds, preferably including Sample #1
3. A market quality hydrocarbon-only gasoline
4. A market quality gasoline/ethanol blend

### **Contractor's Proposal Elements**

Prospective contractors should provide in their bid (1) an explanation of their proposed measurement technique, (2) examples of previous results or literature on relevant samples, (3) a per-measurement cost estimate, (4) an anticipated schedule for testing and reporting, and (5) resumes for those who will be involved in the testing. Unless the bid states otherwise, the per-measurement cost estimate for Phase 1 testing will be assumed to apply to Phase 2 testing as well, if the contractor is selected for both Phases of testing.

### **Deliverable**

The contractor will be expected to document their experimental approach, raw data for samples and any calibration materials, calculations, and results from Phase 1 testing in a formal report using CRC's standard report template. (See Exhibit B)

### **Scope of Phase 2 Testing**

Based upon the results of Phase 1, the Project Panel will then select one or more of the Phase 1 contractors and ask them to conduct HOV measurements on approximately 12 additional samples. These samples are expected to include a broader range of pure compound blends, hydrocarbon-only gasoline, neat ethanol, and various ethanol/gasoline blends.

The experimental approach and results from Phase 2 testing will also be documented in a formal report using CRC's standard report template. After the report on all Phase 1 and Phase 2 testing has been approved for publication by CRC, it will be made available through the CRC website ([www.crcao.org](http://www.crcao.org)). Contractors will be encouraged to subsequently publish their results in a peer-reviewed journal.

### **Schedule for Phase 2 Testing**

The start of Phase 2 will depend on the completion and analysis of results from Phase 1 but all testing and reporting on the first two Phases is expected to be completed by the end of 2015.

### **References**

1. Bauer, W-D., 'Heat transfer and mixture vaporization in intake systems of spark ignition engines', PhD Thesis, MIT (1997).
2. API Publication No. 4261, 'Alcohols and Ethers: a Technical Assessment of Their Application as Motor Fuels and Fuel Components', 3<sup>rd</sup> Edition, June 2001.
3. Balabin, R.M., Syunyaev, R.Z., and Karpov, S.A., 'Molar enthalpy of vaporization of ethanol-gasoline mixtures and their colloidal state', FUEL, 86, 323-327 (2007).
4. Kar, K., Last, T., Haywood, C., and Raine, R., 'Measurement of vapor pressure and enthalpies of vaporization of gasoline and ethanol blends and their effects on mixture preparation in an SI engine', SAE Int. J. Fuels Lubr., 1(1), SAE 2008-01-0317, 132-144 (2008).

## **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 draft 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).

**The draft report must have appropriate editorial review corrections made by the contractor prior to submission to CRC to avoid obvious formatting, grammar, and spelling errors. The report should be written in a formal technical style employing a format that best communicates the work conducted, results observed, and conclusions derived. Standard practice calls for a CRC Cover/Title Page, Contractor Title Page, Disclaimer Statement, Foreword/Preface, Table of Contents, List of Figures, List of Tables, List of Acronyms and Abbreviations, Executive Summary, Background, Approach (including a full description of all experimental materials and methods), Results, Conclusions, List of References, and Appendices as appropriate for the scope of the study. Incomplete draft reports or reports of poor quality requiring additional outside editorial review may have outside editorial services charged back to the project budget.**

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 fifteen (15) 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 of Contractor 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.