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February 14, 2019
In reply, refer to:
CRC Project No. AVFL-29-2

Dear Prospective Bidder:

The Coordinating Research Council (CRC) invites you to submit a written proposal to provide services for "Effect of DHA Development on PMI Variability" (CRC Project No. AVFL-29-2). A description of the project is presented in Exhibit A, "Statement of Work."

Please indicate by letter, fax, or email by **February 28, 2019** 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). 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.

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.

The technical and cost proposals should be submitted to:
Christopher J. Tennant Email: **ctennant@crcao.org**

The deadline for receipt of your proposal is **March 14, 2019**

EXHIBIT A

Statement of Work

Background

Fuel properties and composition may affect vehicle particulate matter (PM) emissions. Researchers have proposed various methods to predict the effect of fuel properties and composition on PM emissions, including the Particulate Matter Index (PMI) (SAE 2010-01-2115). PMI is calculated from the vapor pressure (VP) evaluated at 443K and double bond equivalent (DBE) of the individual fuel components as measured using ASTM D6729 Detailed Hydrocarbon Analysis (DHA) test method. DHA uses a gas chromatography (GC) method to measure the composition of thousands of chemical species present in gasoline. Based on a worldwide fuel survey reported by Honda (SAE 2010-01-2115), PMI for market gasolines ranges from 0.8 to 3.0, with a median value of 1.6.

Errors in DHA arise for several reasons including variability of the GC chromatogram trace itself, variability of peak integration, variability of calibration parameters, and variability of peak identification. Variability of peak identification may arise from peaks that are unidentified, generically identified, and/or misidentified. A generically identified peak is a component whose carbon number and/or hydrocarbon type is known (for example a C8 aromatic), but the specific isomer is unknown. Errors in DHA produce errors in PMI.

PMI increases for components with decreasing VP and increasing DBE. So heavier, less volatile components have higher PMI and components with more rings or pi bonds (double bonds) have higher PMI. The formula for DBE is shown below. The DBE of hydrocarbon types is shown in Table I.

$$DBE = C - H/2 + 1$$

Where DBE = Double Bond Equivalent
C = number of carbon atoms
H = number of hydrogen atoms

Table I. Double Bond Equivalent (DBE) of Hydrocarbon Functional Groups

Hydrocarbon Type	DBE
n-Paraffin	0
Isoparaffin	0
Cycloparaffin	1
Mono-Olefin	1
Mono-Aromatic	4
Di-Aromatic (fused rings)	7
Di-Aromatic (separate rings)	8

As shown in Table I, DBE is much higher for aromatics than for other hydrocarbon types. The combination of high DBE with low VP means heavy aromatics have a very significant effect on PMI.

Heavy aromatics are generally less well-characterized than lighter components in gasoline because there are more isomers of the heavier components, so each individual isomer of the heavy aromatics is present in lower concentration. In contrast, the peaks of lighter components are larger and easier to identify and calibrate. And it is easier to find neat component calibration samples of lighter components.

CRC did two studies to quantify and reduce errors in PMI calculation. AVFL-29 "Enhanced Speciation of Gasoline" was a study in which several methods including Mass Spectrometry (MS) were used to improve identification of unidentified peaks in DHA, along with acquisition and calibration for a range of substituted naphthalenes. Several gasoline samples were analyzed with varying heavy aromatics content and PMI levels. Many previously unknown and generically identified peaks were identified and several misidentified peaks were correctly identified. The AVFL-29 report was issued June 2018.

RW-107 "Assessment of Relative Accuracy of PMI and Related Methods" is a project comparing various methods of estimating fuel effects on PM emissions (some are based on DHA and others are not) and how well the various methods are able to predict PM emissions from vehicles in several studies reported in literature. In addition, for several gasoline samples of varying PMI level, DHA was performed using both standard DHA (based on the current ASTM D6729 test method) and enhanced DHA (as configured based on AVFL-29 project results). The RW-107 project is in the reporting stage. The current research is motivated by a concern that the enhanced DHA method, by correctly identifying more species (especially heavy aromatics) may result in different PMI results.

Based on discussions in the CRC AVFL Committee, there are many different variants of the standard DHA method (ASTM D6729 and D6730) in common use in the industry. All are GC-based methods, but there are many differences in the detailed methods. There are differences in instruments and chromatography columns. Many test labs have developed their own determination and reporting from the obtained chromatograms. Some use in-house methods using in-house proprietary software. Others use commercial software available from vendors. Even for companies using vendor software, many labs have done their own development work to better identify peaks of interest to their company. Some analysts manually check peak integration and component identification and correct any errors. Other analysts make little attempt to correct automatic peak integration. This produces a situation where nearly all DHA methods as practiced by test labs are different.

Objectives

The objective is to determine the magnitude of variability of DHA and PMI results as measured by various test labs in practice for a set of gasoline samples covering a wide range of PMI. A secondary objective is to determine which components contribute most to PMI variability.

Experimental Plan

Gasoline Test Samples

Obtain approximately six gasoline samples covering a wide range of PMI as shown in Table II. Although high PMI samples are expected to show the largest differences in PMI, samples representative of the entire PMI range (low, medium, and high) are desired. CRC will provide test samples to the contractor. The contractor will be responsible for shipping sample aliquots to the various participating labs for testing.

Table II. Gasoline Test Samples

Sample Type	PMI
Low PMI	0.8 to 1.3
Moderate PMI	1.3 to 2.0
High PMI	2.0 to 3.0

Test Labs and Test Methods

Analyze these samples for DHA at several labs using various implementations of DHA including;
1) Labs using the enhanced DHA method developed in project AVFL-29.
2) Commercial labs using standard DHA (ASTM D6729 or D6730).
3) CRC member company labs using in-house versions of DHA.
4) Other labs running DHA including National Laboratories.

Data Collection

Collect DHA and PMI results from each lab, and also calculate PMI for each reported DHA using the CRC PMI calculator tool. Ask each test lab to report PMI for each DHA using their normal calculation method, if any. Calculate variability (reproducibility?) of PMI results using statistical methods. Evaluate differences in DHA and PMI results and where the biggest differences originate. (Specifically, which components and/or component groups show the largest differences in concentration, and which components and/or component groups produce the largest differences in PMI?)

Statistical Analysis

It is anticipated that statistical analysis will be required for evaluation of test results. The contractor should propose whether they plan to use their own statistician or have one provided by CRC.

Lab Questionnaire

Each participating lab will be asked to complete a questionnaire describing modifications or improvements to the DHA method as practiced in their lab compared to the standard ASTM method. The questionnaire will be generic and designed to not disclose sensitive or proprietary information about lab techniques. The questionnaire is optional; Labs are encouraged to participate in the study even if they do not want to fill out any or all the questions on the questionnaire. The

questionnaire will be prepared by the contractor, with input and approval of the project Panel, and administered by CRC staff (if desired).

Sample Blinding

To better understand how the various DHA methods differ in practice, we want participating labs to analyze samples as "ordinary" samples without performing any special sample handling or special data analysis. The idea is to analyze samples using the normal lab technician and normal test procedure. For example, if the lab ordinarily has DHA performed by "Joe" the lab technician using automatic peak integration, do it the same way for these samples. (Don't bring in the Ph.D. principle investigator and do manual peak integration to improve the "accuracy" of the DHA because it is for a special project.) The samples don't necessarily need to be "blinded" unless the contractor thinks this is the best way to verify that the samples are tested in an ordinary manner. It may be necessary to first get sample analysis done as an ordinary sample, then later follow-up to gather additional information like questionnaire or raw chromatogram (if needed to achieve project objectives). In the project proposal, the contractor should explain the approach they plan to use to ensure that the DHA samples are analyzed as normal samples.

The origin of test and questionnaire results (which lab produced which results) will be known to the contractor and project Panel members, but all results will be blinded in the project final report that is released to the public. Upon request, CRC will disclose to individual companies/labs the identity of their own test results in the final report (i.e. ABC Company is "Lab A"), but not the origin of results from other labs.

Reporting

Write a final report on the project results. Include recommendations on how to improve DHA and PMI accuracy or consistency. Include insights learned from the questionnaires regarding the state of DHA development within the industry. (i.e. Is modification of the DHA method common? What types of test modifications are most common? Do test modifications seem to have a significant effect on variability of results? etc.)

<u>Deliverables</u>

A project report explaining the test methodology, DHA results for each sample, PMI calculations and results, statistical analysis of DHA and PMI results including variability (as reproducibility?), evaluation (a spreadsheet?) showing which components and/or component groups show the largest differences in concentration and which components and/or component groups produce the largest differences in PMI, a summary of project findings, a summary of lab questionnaire results and implications thereof, recommendations on how to improve DHA and PMI accuracy and variability within the industry, and recommendations for future studies.

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. Periodic conference calls may also be requested by CRC to update the technical committee overseeing the project.

FINAL REPORT

The contractor shall submit to CRC a draft final report. The report shall document the test procedure, document details of each test iteration, and explain any observations noted. The test data will be recorded and reviewed, and the final report will include a certification that the test procedures were followed, noting any exceptions. The detailed data will also be supplied electronically to CRC.

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 typically calls for a CRC 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.

Comments regarding the report shall be furnished by the CRC committee to the contractor within one (1) month after receipt of the draft copy. Additional rounds of review may be required.

Within thirty (30) days after receipt of comments, the contractor shall make the requested changes and submit an electronic copy of the draft final report in both Microsoft Word and Adobe pdf file format. Once accepted, the contractor shall deliver five (5) hard copies of the final report to CRC. 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.