



COORDINATING RESEARCH COUNCIL, INC.

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August 18, 2017

In reply, refer to:

CRC Project No. RW-107

Dear Prospective Bidder:

The Coordinating Research Council (CRC) invites you to submit a written proposal to provide services for “Assessment of the Relative Accuracy of the PM Index and Related Methods” (CRC Project No. RW-107). A description of the project is presented in Exhibit A, “Statement of Work.”

Please indicate by letter, fax, or email by **September 1, 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:

Amber Leland
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The deadline for receipt of your proposal is **September 18, 2017**.

Yours truly,

Amber Leland
Deputy Director

EXHIBIT A Statement of Work

Assessment of the Relative Accuracy of the PM Index and Related Methods

Background

The EPA, Honda, and others have confirmed that the PM Index (PMI) can reasonably predict the relative particulate-forming tendency of a gasoline.^{1,2,3,4,5} The PMI is a function of the vapor pressure and double bond equivalent (DBE) of each component of the fuel:

$$PM\ Index = \sum_{k=1}^n I_k = \sum_{k=1}^n \left(\frac{DBE_k + 1}{VP[443K]_k} \times Wt_k \right)$$

Where $DBE = \frac{(2C + 2 - H)}{2}$, “k” represents each component of the fuel, and $VP_{[443K]}$ can be estimated from the component’s boiling point.

The physical term, $VP_{[443K]}$, represents the fact that “heavier” components are more likely to participate in diffusion combustion, and therefore form particulates. The chemical term, DBE, represents the fact that particulate formation increases as the C/H ratio of the fuel increases. The only fuel analysis required to calculate a PM Index is a DHA (detailed hydrocarbon analysis). A typical method used for this purpose is ASTM D6730, or a variation thereof. In the case of unknown components encountered in the analysis, knowledge of the compound class and an estimate of the boiling point (from the chromatogram) is often sufficient to maintain the accuracy of the PM Index calculation. An effort is now underway (CRC AVFL-29) to identify more components in the DHA chromatogram, with the objective of improving the accuracy of the resulting PM Index.

However, performing the high-quality DHA required for PM Index determination may be beyond the capability of some laboratories. This has led to the search for potential alternatives to the original PM Index that do not require a DHA. Ford has developed an Oxygen Extended Sooting Index (OESI), which incorporates fuel smoke point measurements and various fuel volatility metrics.⁶ GM has developed the Particulate Evaluation Index (PEI) which is based on fuel aromatic content, and also the Particle and Soot Correlation Equation (PASCE), which uses E170 and the C/H ration of the fuel.^{7,8} JAMA has proposed a Simplified PM Index that uses only the volatility parameters of the fuel; one version of the equation uses E130 and E170, and another version uses only E150.⁹

These variations of the PM Index have all been developed using different vehicles and fuel matrices. In order to perform a thorough evaluation and comparison of the original PM Index and the variations thereof, a common set of fuel/vehicle data should be used. Such an evaluation is the objective of this project.

Objectives

1. Compare the performance of PM Index alternatives to the original PM Index, using datasets representing a variety of vehicle technologies and fuel formulations. The proposed metric would be the correlation coefficient resulting from a comparison of the PM Index alternative to actual (measured) particulate mass and particulate number. The contractor will choose the appropriate correlation coefficient—or other metric(s)—for this task. (Note that PM Indices do not predict PM or PN emissions; rather, they indicate the relative propensity of the fuel to form particulates. The slope of the trend line is related to the sensitivity of the vehicle to fuel formulation.)
2. Compare the performance of an enhanced PM Index to the original PM Index, where the enhanced Index is calculated using the results of the new DHA developed in AVFL-29.

Scope of Work

Overview

This project will not require test fuel preparation or vehicle testing. It involves only the analysis of existing data.

Step 1: Collection of PM Indices and alternatives to be evaluated and compared

- Original PM Index^{1,3}
- Enhanced PM Index
- OESI⁶
- PEI^{7,8}
- PASCE^{7,8}
- Simplified PM Index (E150 version)⁹
- Simplified PM Index (E130 & E170 version)⁹

It should be noted that published references to these indices do not always contain sufficient information to calculate the index value. If needed, the CRC will assist in gathering the required information. In cases in which this information is unavailable, the index in question can be removed from this list.

Step 2: Gathering of data required to calculate each index

The data required to calculate the various indices will include:

Fuel analyses:

- DHA. (Not required if the PM Index has already been calculated)
- ASTM D86 (fuel distillation), all available data points. (Data can be used to determine the “E” volatility parameter, where E_X is the % fuel volume distilled off at temperature X.)

Vehicle emission analyses:

- Particulate mass (gravimetric, per 40 CFR 1065)
- Particulate number (PMP protocol or similar)

- Note: It is acceptable to use Phase 1 of the FTP in place of the weighted average. (The precision of PM and PN measurements of Phases 2 and 3 is sometimes not acceptable; variation in the results can confound the comparison of PM indices.)

This is a partial list. The CRC will provide fuel analyses that are not yet published, such as those associated with E-94-3 and AVFL-29. In some cases, additional fuel analyses will be required. The contractor will request the CRC to provide such analyses. It is recognized that some fuel samples are no longer available, and therefore some indices cannot be evaluated on all fuels.

Source of data:

Source	Available Data	Vehicle Type	Fuel Samples Available for Additional Analyses?*
CRC E-94-2/3 ¹¹	Vehicles: 11 Fuels: 12	GDI	Yes
CRC E-89 / EPA EPAAct ^{5,11}	Vehicles: 15 Fuels: 27	PFI	No

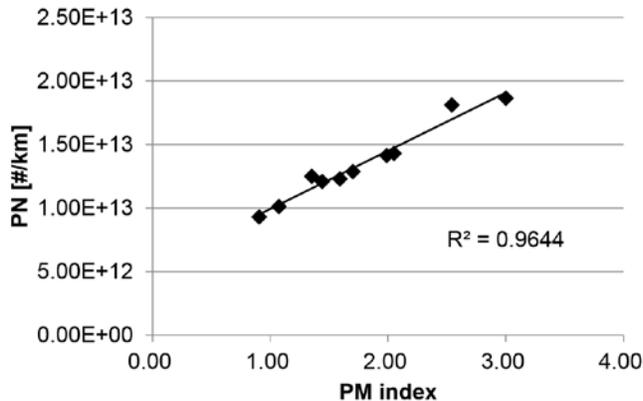
* Purpose for additional analyses:

- Enhanced PM Index requires newly-developed DHA
- May be required for the determination of alternative PM Indices. Smoke point is one example.

The CRC will provide guidance to the contractor regarding the specific fuel/vehicle sets to be included in this evaluation. For example, some fuels with high ethanol concentrations may be excluded, as may some vehicles with uncharacteristic particulate emission levels.

Step 3: Formatting results for the report

At a minimum, the results for each combination of vehicle and fuels should be presented in a simple scatter plot or similar. An example is shown below for measured particle number compared to the original PM Index.³ Note that a correlation of determination or similar should be shown on each chart.



If the plot seems bifurcated due to a fuel formulation difference, (e.g., E0 vs. E15), this can be indicated by multiple trend lines and variations in data-point colors. Note that each index should be compared with PM and PN data, for each combination of vehicle and fuels selected for the project.

References

1. Aikawa, K., Sakurai, T., Jetter, J., “Development of a Predictive Model for Gasoline Vehicle Particulate Matter Emissions,” SAE Technical Paper 2010-01-2115, 2010.
2. Leach, F., Stone, R., Richardson, D., “The Influence of Fuel Properties on Particulate Number Emissions from a Direct Ignition Spark Ignition Engine,” SAE Technical Paper 2013-01-1558, 2013.
3. Aikawa, K., Jetter, J., “Impact of Gasoline Composition on Particulate Matter Emissions from a Direct-Injection Gasoline Engine: Applicability of the Particulate Matter Index,” *International Journal of Engine Research*, vol. 15, no. 3, pp.298-306, 2014.
4. Sobotowski, R., Butler, A., Guerra, Z., “A Pilot Study of Fuel Impacts on PM Emissions from Light-Duty Gasoline Vehicles,” SAE Technical Paper 2015-01-9017, 2015.
5. Butler, A., Sobotowski, R., Hoffman, G., Machiele, P., “Influence of Fuel PM Index and Ethanol Content on Particulate Emissions from Light-Duty Gasoline Vehicles,” SAE Technical Paper 2015-01-1072, 2015.
6. Barrientos, E., Anderson, J., Mariq, M., Boehman, A., “Particulate Matter Indices using Fuel Smoke Point for Vehicle Emissions with Gasoline, Ethanol Blends, and Butanol Blends”, *Combustion and Flame* 167, 2016.
7. Chapman, E., Winston-Galant, M., Geng, P., Latigo, R., Boehman, A., “ Alternative Fuel Property Correlations to the Honda Particulate Matter Index (PMI),” SAE Technical Paper 2016-01-2250, 2016.
8. Chapman, E., Winston-Galant, M., Geng, P. Konzack, A., “Global Market Fuel Review using Fuel Particulate Emission Correlation Indices,” SAE Technical Paper No. 2016-01-2251.
9. JAMA, ACEA, “Fuel Quality Impact on PM Emission from Petrol DI Engine Vehicle, Executive Summary,” September 2016, available at: [https://circabc.europa.eu/webdav/CircaBC/GROW/wltp/Library/RDE-LDV/RDE%203/July%20to%20Sept%202016%20RDE%20Drafting%20Meetings/160829%20Executive%20summary%20-%20RDE%20heavy%20fuel%20impact%20on%20PM%20emissions%20\(JAMA-ACEA\).pdf](https://circabc.europa.eu/webdav/CircaBC/GROW/wltp/Library/RDE-LDV/RDE%203/July%20to%20Sept%202016%20RDE%20Drafting%20Meetings/160829%20Executive%20summary%20-%20RDE%20heavy%20fuel%20impact%20on%20PM%20emissions%20(JAMA-ACEA).pdf)
10. Morgan, P., Crawford, R., et al., “Evaluation and Investigation of Fuel Effects on Gaseous and Particulate Emissions on SIDI In-Use Vehicles,” CRC Project E-94-2, 2017, available at: <https://creao.org/publications/emissions/index.html>
11. U.S. Environmental Protection Agency, U.S. Department of Energy, Coordinating Research Council, “EPA/V2/E-89: Assessing the Effect of Five Gasoline Properties on Exhaust Emissions from Light-Duty Vehicles Certified to Tier 2 Standards,” EPA-420-R-13-004, 2013. Report and all related material available at: <https://www.epa.gov/moves/epactv2e-89-tier-2-gasoline-fuel-effects-study>

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.