COORDINATING RESEARCH COUNCIL, INC.
5755 NORTH POINT PARKWAY, SUITE 265
ALPHARETTA, GA 30022
TEL: 678/795-0506 FAX: 678/795-0509
WWW.CRCAO.ORG

October 12, 2023
In reply, refer to:
CRC Project No. AVFL-39-2/ E-139-2

Dear Prospective Bidder:

The Coordinating Research Council (CRC) invites you to submit a written proposal to provide services for CRC Project No. AVFL-39-2/ E-139-2 "Low Phosphorous Low Ash Gasoline Engine Oil to Meet Future Emission Requirements". A description of the project is presented in Exhibit A, "Statement of Work."

Please indicate your intention to bid at this link on or before **October 27, 2023** 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 at least one week before the proposal submission deadline here: Q & A Link. CRC will then return written answers to all of the bidders, along with a copy of the original questions. Questions submitted within a week of the deadline may not be answered before the proposal submission deadline.

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.

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

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

The deadline for receipt of your proposal is **November 13, 2023.**

Yours truly,

Amber B. Leland
Deputy Director

EXHIBIT A

STATEMENT OF WORK

CRC Project AVFL-39-2/ E-139-2
Low Phosphorous Low Ash Gasoline Engine Oil to Meet Future Emission Requirements

Background

Phosphorous is present in engine oil as zinc dialkyl dithiosphosphate (ZDDP) which is a very effective and affordable antiwear and antioxidant additive. Phosphorous is also known as a catalyst poison. Phosphorous (P) enters into the aftertreatment system when engine oil leaks past the piston rings or through the crankcase ventilation system and burns in the combustion chamber and leaves through the exhaust stream. Therefore, reduction in ZDDP level in engine oil to reduce the effect on exhaust aftertreatment, must be supplemented with other antiwear and antioxidant additive compound(s). There has been much research in developing supplemental antiwear additives but none have been readily accepted to replace ZDDP. The P level in engine oil remained at 800 ppm maximum since implementation of GF-4 oil in 2004. However, in GF-5 oils, P volatility index was introduced to limit P volatilizing from engine oil and poisoning catalyst and it was achieved by using higher molecular weight ZDDP. GF-6 oils maintained the same level of volatility index as it was in GF-5. P volatility index was "equivalent" to reducing the P level to 500 ppm.

The emission level is projected to be stricter in the future. The 2021 MY fleet avg requirement is 0.058 g/mi (NMOG + NOx). This number will be 0.03 g/mile in 2025 MY. GF-6 oils became available in May 2020 and it is not clear when potential GF-7 is targeted. By the time GF-7 is released, the emission standard is expected to be 0.03 g/mile (NMOG+NOx). In addition, the Particulate Matter (PM) standard is currently 3 mg/mile and EPA has proposed reducing it to 0.5 mg/mile starting model year 2027. A Gasoline Particulate Filter (GPF) may be required to meet this new PM standard. The knowledge gained through this investigation could be an enabler for defining GF-7 specification.

Objective

The main objectives of this proposal are to understand the effects of (a) lower phosphorous concentration on catalysts protection, and (b) ash levels acceptable for GPFs for meeting future emission levels.

Experimental Plan

We propose two separate tests; one for evaluating the effectiveness of lower phosphorous level in engine oil while meeting future emission requirements, and another test to evaluate the effectiveness of lower ash (lower than GF-6) oils on meeting future particulate matter requirement in exhaust gas.

For lower phosphorous engine oil, the evaluation requires two steps; the first step is catalyst aging representing 150,000 miles (as regulation requires) followed by the second step of emission

measurements. The catalyst aging procedure requires mixing a phosphorous additive, DMA-4 or tricresyl phosphate (TCP) in fuel. Although ZDDP (zinc dialkyl dithiophosphate) is commonly used in engine oil, it is not preferred due to issues related to solubility in fuel, injector clogging, in addition to Zn not contributing to poisoning. DMA-4 has been used in the past but availability has become an issue recently. Therefore, TCP could be a natural choice although both are accepted by Environmental protection Agency (EPA). The impact of phosphorous on catalyst is similar with all these additives and correlated with fleet study.

The aging can be done in an engine dyno with engine running conditions simulating thermal effects based on Standard Road Cycles (SRC). The aging cycle in engine consists of four steps; stoichiometric air-to-fuel ratio (AFR), rich, lean and exothermic conditions and the cycle is repeated. The purpose of the exothermic reactions is to generate heat by oxidizing CO and HC by supplying oxygen to get to the peak catalyst temperature. Following aging, the catalyst system is mounted on a vehicle and emission tests can be performed. For the test vehicle, it may be feasible to use a Ford F-150 Light Duty truck planned for use in E-141 "Post Tier 3 Vehicle and Fuels" project. The emission test results on dyno-aged catalysts are found to be similar to customer vehicle aged catalysts. For deeper understanding of ash deposit mechanisms and structure, following emission tests the catalysts can be analyzed using various analytical techniques (XRD, XRF, SEM etc.) to characterize the chemistry and morphology of ash deposits.

For GPF study, an engine dyno test can be run which consist of two steps; the first step is ash loading followed by the second step of measurement of filtration efficiency vs soot load at <500C and delta pressure measurement across GPF at a high engine power point >500C. The ash loading part consists of doping fuel with ZDDP (or other appropriate additive if fuel solubility of ZZDP is limiting as mentioned above) and detergent additives and run tests for sixty hours on a four-mode cycle. Another ash loading method is to run an engine with fuel doped with oil and perform FTP Bag 1 and Bag 2 cycles to consume ten gallons of fuel. The amount of ash deposited may be similar to that observed on a vehicle with 150,000 miles.

Include regeneration effects:

- Impact on back-pressure: measure how ash amount reduces back pressure and improves efficiency of GPF.
- Measure ash / monitor GPF
- Identify regen method: in cylinder method vs/ Exhaust fuel dump to increase temperature. If test vehicle is not originally equipped with a GPF and retrofit is required, GPF regeneration will be passive by default. Literature suggests regen happens automatically when exhaust temperature exceeds 600°C (Reference 1).
- Prefer the use of a current production engine.
- Which type of GPF – underfloor or close coupled. For regeneration, it may be more beneficial to pick close coupled due to higher temp from the exhaust.
- Some researcher papers indicate a break-in process for the GPF is necessary, so this is something we should consider.

Fuels should include E-10 fuel as mapped out in the NPRM. Indolene fuels are no longer of interest.

Test Cycles should include:

- FTP cycle at negative seven degrees Celsius.
- US06

Include the following features in the GPF testing program:

- Measure real-time Particle Number (PN) and particle size distribution.
- Measure GPF filtration efficiency using two identical measurement devices (like Micro Soot Sensor (MSS)) before and after the GPF.
- Real-time ash number and size distribution
- Elemental ash composition – Particulate Matter (PM) by filter with ICP-MS analysis or equivalent
- Ash loading – CT scan for distribution and density, pressure drop changes, and fuel economy effects of pressure drop.

Resources

It may be a good idea to involve an additive company to source additive components without which it may be difficult. Ford suggests Infineum because of a recent collaborative work in this area. Other additive companies are encouraged to participate. Collaboration with the test vehicle manufacturer (Ford if we use the F-150 proposed above) and Manufacturers of Emission Controls Association (MECA) may be desirable to specify and source appropriate catalyst and DPF test article components.

References

1) L. Chen, Y. Long, H. Tuo, R. Xu, Study on GPF Regeneration Factors and Extreme Environmental Regeneration Methods, E3S Web of Conferences **268**, 01001 (2021)

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 (Microsoft Word) 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).

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. Reports submitted to CRC shall be written with a degree of skill and care customarily required by professionals engaged in the same trade and /or profession.

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 ten (10) hardcopies including a reproducible master copy of the final report. The final report shall also be submitted as electronic copies in a pdf and Microsoft Word 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.