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July 17, 2018
In reply, refer to:
CRC Project No. A-114/ RW-111

Dear Prospective Bidder:

The Coordinating Research Council (CRC) invites you to submit a written proposal to provide services for "Characterizing Primary Organic Aerosol Emissions from In-Use Motor Vehicles," (CRC Project No. A-114/ RW-111). A description of the project is presented in Exhibit A, "Statement of Work."

Please indicate by letter, fax, or email by **August 1, 2018** 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.

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 B. 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 **August 17, 2018.**

Yours truly,

Amber B. Leland
Deputy Director

EXHIBIT A

Statement of Work

Coordinating Research Council Atmospheric Impacts Committee
Project A-114 / RW-111

Characterizing Primary Organic Aerosol Emissions from In-Use Motor Vehicles

Objective:

The goal of this project is to better connect existing detailed approaches for measuring the volatility of vehicular organic emissions with standard available methods. This goal will be accomplished via characterization of a reduced-complexity method of quantifying vapor-particle partitioning in vehicle exhaust. The proposed experiments and analyses will quantify the loss of particle mass as the emissions are systematically diluted in order to constrain the volatility of organic carbon emissions.

Background:

It has been shown that primary organic aerosol (POA) mass from combustion emissions evaporates as it is diluted to ambient conditions (Robinson et al., 2007; Grieshop et al., 2009; Huffman et al., 2009; Kuwayama et al., 2015). May et al. (2013) demonstrated the semivolatile partitioning of a large fleet of gasoline vehicles on chassis dynamometers and quantified the volatility profile of the emissions using a combination of thermodenuder and mass spectrometer analysis. Large scale model studies have also shown that treating POA compounds as semi-volatile has a significant impact on the average magnitude of emissions from combustion sources as well as on the spatiotemporal variability of organic aerosol (OA) concentrations, particularly in urban areas and close to sources (Robinson et al., 2007; Murphy et al., 2017). Although many chemical transport models (CTMs) now include POA semi-volatile partitioning, standard emission measurement procedures do not collect the information needed to inform gas/particle partitioning calculations (e.g. the response of emissions to dilution and/or heating).

Current vehicle emissions measurements report total hydrocarbons, non-methane organic compounds (NMOG), and particulate mass. However, in order to calculate OA partitioning, one needs to know how the emissions themselves respond to swings in, for example, the pollutant particle concentration. Without this information, many CTMs have relied on ambient OA measurements to constrain the total OA mass emitted from combustion sources like vehicles, and parameters vary widely depending on the model and the application. While there has been extensive recent work on the detailed measurement of POA volatility and composition, these scientific findings need to be connected to standard measurements and methods that are the most common source of data for emissions inventories and models like CMAQ. For example, if organic partitioning behavior can be accurately gathered and reported by changing a readily available parameter from a dynamometer study (e.g. CVS dilution factor), then the availability of volatility measurements should increase substantially, thereby improving our understanding of the

variability of this phenomenon across vehicle types, driving and environmental conditions, and fuel composition.

Previous studies have derived the POA volatility distribution using complicated models of evaporation, usually manifest by heating the emissions. The proposed experiments are unique because they will instead vary dilution in-line to create a similar effect. Gathering volatility information in this way has the potential to be very useful for quantifying low-volatility and semivolatile organic compounds (LVOCs and SVOCs), the majority of which are condensed when emitted during dynamometer testing. However, for some vehicles or higher volatility compounds (e.g. intermediate volatility organic compounds; IVOCs), sorbent tubes will be needed to collect the vapor mass so that it may be properly accounted for as it is a significant contributor to secondary PM formation.

Results from this study will be used to 1) confirm that varying dilution leads to organic evaporation behavior that is consistent with published volatility profiles and partitioning theory, 2) better understand the interpretation of existing emissions datasets where particle concentration and volatility information does not exist, 3) determine the accuracy and limitations of using dilution factor to quantify the volatility profile of individual vehicles during standard emissions measurement efforts, and 4) add to the growing body of data documenting the volatility profiles of individual vehicles by tier, model, and model year, etc.

Methodology:

The goal of this project is to quantify the volatility profile and particle concentration in exhaust emissions. Measurements will focus on exhaust physical properties and particulate and gas-phase concentrations. The contractor shall measure hydrocarbons by FID in addition to particulate mass concentration over conditions representative of three different exhaust dilution ratios. The contractor can perform these tests either by running three complete tests with full CVS dilution at three different dilution ratios, or by using partial flow dilution sampling to measure emissions at three different dilution ratios simultaneously. The partial flow dilution method is preferred both due to the reductions in the number of tests required as well as in test-to-test variability. The contractor shall also measure relative humidity and temperature at the point where the hydrocarbon emissions are measured. The exact dilution ratios will likely be dependent on the laboratory where the work is done, please suggest at least three dilution ratios that will work best for your site. The contractor will measure particulate mass by standard gravimetric filter and also will determine the elemental vs organic particulate ratio. During each test, semivolatile and intermediate volatility vapors shall also be collected using sorbent tubes. The collected samples would be shipped to EPA's Office of Research and Development laboratories for analysis by gas chromatography.

The study will consist of a total of twelve vehicle tests on four different vehicles or one test per each of four vehicles choosing to use partial flow dilution sampling. The vehicles should be chosen to be representative of the current on-road fleet with at least one vehicle representing GDI technology. CRC will provide one GDI vehicle (2013 Hyundai Santa Fe) for the study. The other three vehicles shall be a combination of post-2007MY PFI and GDI vehicles. The same fuel will be used for all testing and will be representative of a current commercially-available E10 fuel. Fuel analysis shall be performed to properly characterize bulk fuel properties including distillation, RVP, octane, ethanol content, specific gravity, sulfur concentration, and olefin and

aromatic content. If requested by CRC, the contractor shall provide and ship up to three 1-gallon samples of the fuel to CRC member companies for analysis. CRC and EPA should be consulted in the choice of vehicles and fuel.

- Three tests per vehicle at varying dilution ranges or one test per vehicle if exhaust sampled simultaneously at three different dilutions
- Unified Test Cycle for each test
- Analytical measurements – continuous modal wherever possible
    - Criteria Pollutants, Total Hydrocarbon, Carbonyls
    - $PM_{2.5}$ - continuous and gravimetric, Teflon filter with quartz backup for quantifying artifacts, bare quartz for speciation. Filters to be saved and shipped to EPA after on site analysis for further testing
    - Particle size
    - MSS if available
    - Sorbent tubes for speciation analysis to be sent to EPA
    - Temperature at each analyzer must be recorded during test
    - RH humidity must be measured during each test

Project Deliverables:

- Monthly status reports with project timeline for relevant tasks status.
- Final report suitable for journal publication.
- Recommendations for a reduced-complexity method of determining vehicle volatility profiles, or further work needed to refine the approach.
- Additional volatility profiles to continue to improve chemical transport models such as CMAQ, CAMx, WRF-Chem, and any other near-field, regional or global chemical transport model.
- All deliverables are due to CRC no more than one year from the date the contract is signed.

Utilization of Deliverable:

- EPA, States, Region, District, Autos/Oils, Science Community
- The insights gained from this work into the potential method for volatility quantification by dilution will lead to 1) more robust connections between air quality model predictions of organic aerosol (OA) and emissions measurements, 2) better interpretation of existing measurements where detailed volatility information is lacking, 3) guidance for development of future measurement methodologies, and 4) improved model inputs which will inform future vehicle control strategies and policy decisions.

Contact:

Amber Leland, Coordinating Research Council, (678) 795-0506, extension 106.

References:

Huffman, J., et al. (2009). *Environmental Science & Technology* **43**(14): 5351-5357.

Kuwayama, T., et al. (2015): *Environmental Science and Technology* **49** (3): 1569-1577.

May, A. A., et al. (2013). *Atmospheric Environment* **77**: 128-139.

Murphy, B. N., et al. (2017). *Atmos. Chem. Phys. Discuss.* doi:10.5194/acp-2017-193. Robinson, A. L., et al. (2007). *Science* **315**: 1259.

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.