



**COORDINATING RESEARCH COUNCIL, INC.**

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**June 10, 2021**

In reply, refer to:

CRC Project No. E-135

Dear Prospective Bidder:

The Coordinating Research Council (CRC) invites you to submit a written proposal to provide services for “Tier 3 GDI Vehicle Technology Effects on Particle Emissions Operating with Different Fuels,” (CRC Project No. E-135). A description of the project is presented in Exhibit A, “Statement of Work.”

Please indicate by letter, fax, or email by **June 25, 2021** 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. 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. In this case, we request the quotation be provided on a per-vehicle/ per-fuel basis as the CRC panel may request that additional vehicles or fuels may be added to the program. 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](mailto:aleland@crcao.org)

The deadline for receipt of your proposal is **July 14, 2021**.

Yours truly,

Amber B. Leland  
Deputy Director

## **STATEMENT OF WORK**

### **Tier 3 GDI vehicle technology effects on particle emissions operating with different fuels**

#### **Background**

Different new vehicle technologies geared towards Tier 3 compliance such as increasing fuel injection pressure and atomization have shown potential significant benefits to reduce particle emissions from gasoline direct-injection (GDI) engines. The expected vehicle technology trend is that as emissions regulations become more stringent more deployment of these technologies may be required. Furthermore, fuels containing a high proportion of heavy aromatics (C9+) compared to market average and certification fuels, characterized with a high particle matter index (PMI), have been found to generate higher particle emissions. Moreover, CRC projects E-94-2 and E-94-3 have indicated a potential link between an increase in particulate matter index (PMI) and ethanol content with increased PM emissions. Evaluation of interactions of fuel composition (i.e., PMI, aromatic content, and ethanol content) with different vehicle technologies used to meet Tier 3 emissions standards, such as higher injection pressure among others, and their effect on particle and gaseous emissions is of interest for future vehicle/fuel co-optimization to comply with upcoming emission regulations.

#### **Objective**

The purpose of this work is to improve understanding of fuel injection pressure impact as well as other technologies on tailpipe emissions from gasoline direct injected vehicles. The project will evaluate a specific fuel matrix comprised of fuels with low and high PMI, and different ethanol contents on vehicle(s) with different technology packages including different fuel injection pressures (e.g., 150-200 and 350+ bar).

#### **Project Management**

CRC and its project technical panel will provide management and oversight for this project. These entities are here after referred to collectively as the project sponsor.

#### **Design of Experiment**

##### Vehicles

Vehicle selection will be determined by the project sponsor. The project will require two Tier 3 light duty gasoline direct injection vehicles with injection pressures equal or higher than 200 bar (e.g., 350 bar). These vehicles should be compliant with Tier 3 US standards. The vehicles for testing will need to be purchased as part of this work, and de-greened based on the procedure highlighted below, also determined by the project sponsor.

Upon receipt of test vehicles, engine oil and filter should be changed according to the OEM recommendations. The fresh engine oil should be “de-greened” with an appropriate accumulation of mileage. Further guidance will be provided by the project technical panel.

Test vehicles shall be evaluated for malfunctions, OBD codes, etc. to ensure they are in proper working order prior to start of testing. Any issues should be raised with the CRC project technical panel.

Baseline emissions testing over a standard cold start Federal Test Procedure (FTP) using certification fuel required for that vehicle shall be performed to confirm that the vehicle emissions

system is performing properly. If the vehicle fails to perform properly, the CRC project panel shall be contacted for guidance.

The general quotation should be done on a per-vehicle/ per-fuel basis. The CRC project panel could request that additional vehicles be added to the program. To address this possibility, please provide a supplemental quote on a per-vehicle basis. This quote would cover all related program costs, but would exclude the vehicle purchase cost.

#### New Vehicle Purchase:

- Use market fuel: regular E10 87 AKI to put 4K miles on vehicle for break-in.
  1. This could be done on a track with a driver under a wide range of operation conditions to properly break the engine in.
  2. It could also be done on a mileage accumulation dynamometer (MAD) using a cycle that incorporates city and highway driving.
- On completion of the 4K miles the vehicle would have an oil and filter change using the prescribed engine oil from the owner's manual.
- Change fuel to proper certification fuel and conduct a cold start Federal Test Procedure (FTP) measuring tailpipe gaseous emissions and gravimetric filter type particulate matter (PM) emissions. The vehicle must meet EPA emission standards the vehicle was certified to. The road load chassis dynamometer coeff. from the EPA website should be used for testing.

#### Used Vehicle Purchase:

- Assuming the vehicle has greater than 4K miles the vehicle should have an oil and filter change using the prescribed engine oil from the owner's manual.
- Change fuel to proper certification fuel and conduct a cold start Federal Test Procedure (FTP) measuring tailpipe gaseous emissions and gravimetric filter type particulate matter (PM) emissions. The vehicle must meet the EPA emission standards the vehicle was certified to. The road load chassis dynamometer coeff. from the EPA website should be used for testing.

#### Fuels Blending and Testing

Two Summer fuels with one high and one low PMI as well as two Winter fuels with one low and one high PMI will be used for testing. Fuels will be provided by the project sponsor (available fuels from CRC E-122-2 project). In case further fuels and quantities are needed, the contractor will be required to obtain and test the fuels for specific fuel properties listed in Appendix A. CRC will guide the contractor on when and what terminal to acquire the fuel from in this case. The sponsor will provide detailed instructions for sampling the fuels in case further fuels and quantities are needed. The contractor's facility should be temperature and humidity controlled for storing the fuels. Additionally, Tier III certification fuel will be used for this project. Estimated drum quantities are shown below.

- 12 drums of Winter high PMI E10
- 12 drums of Winter low PMI E10
- 12 drums of Summer high PMI E10
- 12 drums of Summer low PMI E10
- 3 drums of Tier III certification fuel

- 2 drums of ethanol to be splash blended on fuels to obtain E15. Ethanol will be blended in Summer high and low PMI fuels.

Chassis Dynamometer Test Procedure

1. Prepare each of the vehicles by performing a single oil drain and fill and filter change meeting the OEM specifications and recommendations (follow degreasing procedures previously described depending if vehicle is new or used). No additional oil changes should occur unless mileage is accumulated, reaching the recommended oil drain interval.
2. Drain existing fuel from the vehicle. Flush with the test fuel using appropriate fuel change procedures, provided by the CRC technical panel. Fill tank with nominally 40% of fuel tank volume of test fuel. It may be challenging to completely drain the existing fuel in some vehicles, due to the tank design, therefore a tank flush procedure with the next test fuel will be provided.
3. Add “optional” costs and lead times (separate from main costs) for consideration of oil changing and cleaning injectors when switching fuels.
4. Equip the vehicle with a “scan tool,” and configure the device to continuously record the following parameters in real time:

Absolute Throttle Position (%)
Relative Throttle Position (%)
Absolute Throttle Position B (%)
Commanded Throttle Actuator Control (%)
Intake Manifold Absolute Pressure (kPa)
MAF (g/s)
Ignition Timing Advance Cyl. #1 (Deg)
Bank 1 - Sensor 1 lambda (Wide Range O2S)
Absolute Load Value (%)
Engine RPM (RPM)
Vehicle Speed (mph) (km/hr)
Calculated LOAD Value (%)
Engine Coolant Temperature (°C)
Commanded Evaporative Purge (%)
Bank 1 - Sensor 1 O <sub>2</sub> Voltage (v)
Intake Air Temp (°C)
Commanded Equivalence Ratio

Note: Any MIL lights and codes should be noted

5. One LA92 test cycle shall be run as a prep cycle (no emissions testing since vehicles have previously been baseline evaluated) followed by a soak time of at least eight hours, but no more than 24 hours, before running the LA92 emissions test cycle. Specific test protocols will be provided by the CRC technical panel.
6. While on the LA92 test cycle the following should be monitored:

- Tailpipe gaseous emissions (including NH<sub>3</sub>)
  - Particulate matter emissions (PM and PN). PM should be measured with gravimetric filter method and microsoot sensor.
  - Particle size distribution (please quote as “optional” and separate)
  - For particle measurements please specify if catalytic stripper can be used for removal of semivolatiles.
  - GHG emissions – CO<sub>2</sub>, N<sub>2</sub>O, and methane
  - For FTIR (NH<sub>3</sub> and H<sub>2</sub>O) data consideration for collecting raw spectra at 1hz should be included in proposal.
7. Proposals should include a list of equipment and protocols for measurement of the desired emissions.
  8. Note any drivability issues. Drivability is not a focus of this program, but obvious issues should be noted. Examples include long crank times, rough idle, hesitation/stumble, etc. Note any instances of MIL illumination. In some cases, the MIL may go out after an engine stop/start event; such “temporary” MILs should also be recorded.
  9. Run two additional tests, repeating the initial test procedure, on the same fuel before moving to the next test fuel. Testing order protocol will be agreed upon initiation of the project.
  10. Check to see if the test results are within the test protocol before moving to the next fuel. A potential to have 25% of the testing run a forth test should be included in the budget. An outline of the prep and test procedure will be provided by the CRC technical panel.

### **Project Schedule**

As part of proposal submission, the contractor should include a schedule for the tasks outlined above, along with an overall estimate on the timing to complete all of the tasks/testing.

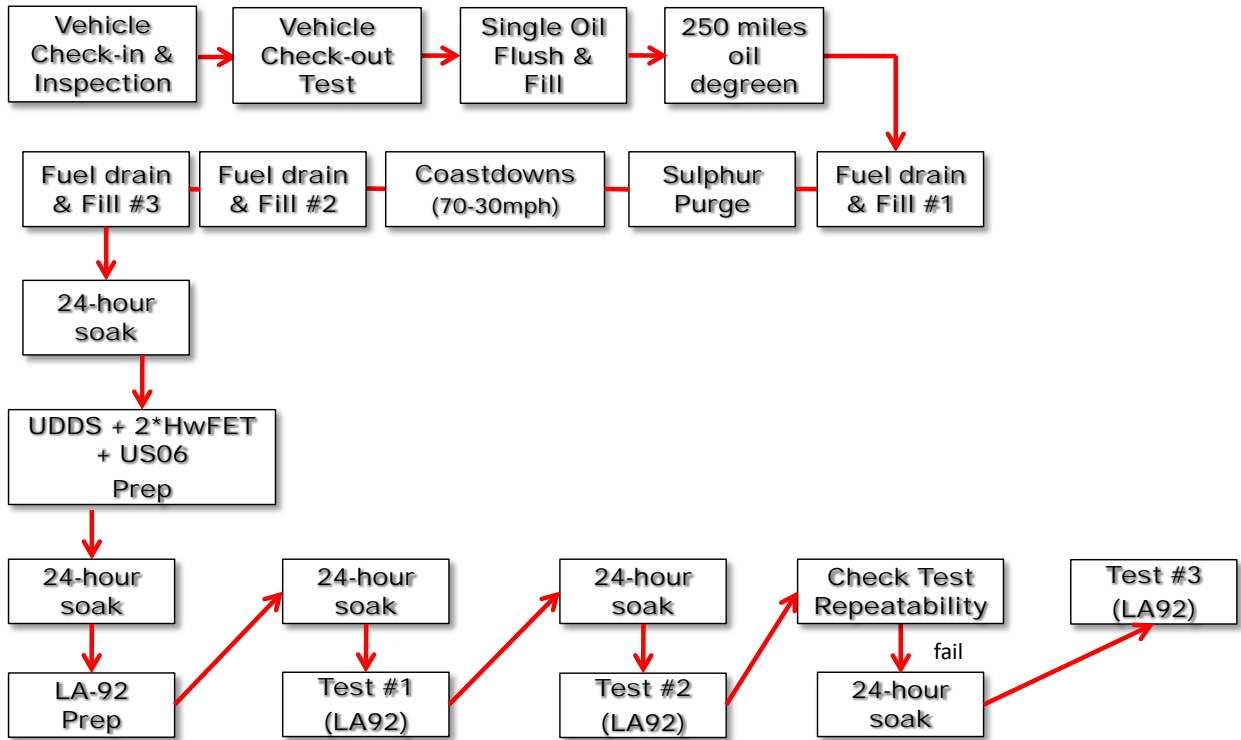
### **Deliverables**

The contractor should submit monthly reports in addition to the draft and final reports. Monthly reports should contain all data acquired during the report month, including data from the OBD scan tool, when appropriate. Emission test results and driveability notes should also be included. These reports should be accompanied by monthly calls to discuss progress contained in the reports and input feedback for the CRC technical panel, including a kick-off call. Depending on the final program schedule, the contractor may be requested to issue an interim report. This interim report would be structured in format of a final report, and would address all vehicles that had completed testing to that point.

**Appendix A: Fuel test methods**

	<b>Methods</b>
RON	D2699
MON	D2700
AKI	(R+M)/2
Sensitivity	R-M
Aromatic, vol%	D6729
PMI Honda Eq	PMI Tool
RVP @ 100°F, psi	D5191
Ethanol, vol%	D4815
Sulfur, ppm w/w	D5453
Benzene, vol%	D6729
Olefins, vol%	D6729
Distillation, IBP °F	D86
Distillation, 5% °F	D86
Distillation, 10% °F	D86
Distillation, 20% °F	D86
Distillation, 30% °F	D86
Distillation, 40% °F	D86
Distillation, 50% °F	D86
Distillation, 60% °F	D86
Distillation, 70% °F	D86
Distillation, 80% °F	D86
Distillation, 90% °F	D86
Distillation, 95% °F	D86
Distillation, DP °F	D86
Recovery, vol %	D86
Residue, vol %	D86
Loss, vol%	D86
DI Index	D4814
C10+ Aromatics, vol%	D6729
Existent Gums washed, mg/100 ml	D381
Unwashed Gums, mg/100 ml	D381
Specific Gravity @ 60°F	D4052
Density @ 60°F, g/ml	D4052
API Gravitiy	D4052
Net Heating Value, MJ/kg	--
Carbon, wt. %	--
Hydrogen, wt.%	--
Oxygen, wt.%	--

## Appendix B: Prep and Test Procedure





## **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.