



**COORDINATING RESEARCH COUNCIL, INC.**

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**April 25, 2024**

In reply, refer to:

CRC Project No. E-141

Dear Prospective Bidder:

The Coordinating Research Council (CRC) invites you to submit a written proposal to provide services for “Post Tier 3 Vehicle and Fuels Evaluation” (CRC Project No. E-141). 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 **May 13, 2024** 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

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The deadline for receipt of your proposal is **May 31, 2024**

Yours truly,

Amber B. Leland  
Deputy Director

Form Links:

Intention to Bid:

<https://form.asana.com/?k=IdnxN4m7VYymCW2k-LXdZA&d=1109089988204036>

Question and Answers:

<https://form.asana.com/?k=SkZ4dzE7oKIGgmnLhnTJ5Q&d=1109089988204036>

## EXHIBIT A

### CRC Project Statement of Work

#### “Post Tier 3 Vehicle and Fuels Evaluation”

**CRC Project Number: E-141**

#### **Background**

In April 2023, EPA released their NPRM multi-pollutant proposal with increased stringency on PM emissions (0.5 mg/mi). PMI of regular gasoline in the market may have decreased in the past 12 years, as well as improvements made to vehicle technologies and calibration for Tier 3 and future Tier 4 standards to meet regulations.

#### **Objective**

Evaluate the latest vehicle technology sets with current range of market fuel effects on particulate and gaseous emissions for production Tier 3 certified vehicles typical of the US market. Evaluations will be conducted under Tier 4 proposed regulation conditions and special attention to vehicles evaluated under the CA ACC II program (1 mg/mi PM std). The project will leverage knowledge from the national PMI survey (RW-121), which is currently still in progress as of late 2023.

#### **Scope of Work**

##### Vehicles

Vehicle selection will be determined by the project sponsor. The project will require at least one US spec light-duty gasoline vehicle with add-on GPF, example shown as Option A in the table below. See reference for an example of EPA’s multi-pollutant NPRM study with GPF added to the vehicle. Proposals should include tasks for modifying the vehicle for GPF application as well as required de-greening of the GPF. The second vehicle will be another US spec light-duty gasoline vehicle with wall-guided direction injection and an example is shown below as Option B. A third vehicle which is already owned by the CRC and has a hybrid powertrain will be provided and shown as Option C. Two vehicles will be purchased and a total of 3 vehicles will be used for testing.

The vehicles that need to be procured are shown below in Table 1:

**Table 1: Vehicles to be Procured.**

	Option A w/GPF	Option B	Option C
<b>Vehicle ID</b>	<b>F-150</b>	<b>Civic</b>	<b>Prius PHEV</b>
<b>Model Year</b>	2021	2022	2019
<b>Displacement [L]</b>	3.5L V6	1.5L I4	1.8L I4
<b>Bore [mm]</b>	92.5	73	80.5
<b>Stroke [mm]</b>	86.6	89.5	88.3
<b>GDI Pressure [bar]</b>	150	200	n/a
<b>Power [hp]</b>	400	180	71 (ICE) / 121 (combined)
<b>Torque [lb-ft]</b>	500	177	
<b>Turbocharged?</b>	Yes	Yes	No
<b>Turbocharger details</b>	Twin	Single	N/A
<b>Cylinder Deactivation?</b>	No	No	No
<b>EGR</b>	Yes	Yes	Yes
<b>Valves per Cylinder</b>	4	4	4
<b>Valvetrain Configuration</b>	4	4	4
<b>Emission Cert Level</b>	Tier 3 Bin 50	Tier 3 Bin 30	Tier 3 Bin 30
<b>Equivalent Test Weight (lbs)</b>	5500	3250	3625
<b>Compression Ratio</b>	10.5:1	10.3:1	13:1
<b>Fuel Grade Recommended in Owner's Manual</b>	Regular min 87	Min 87 w/no Sport mode Min 91 w/Sport mode	Regular min 87
<b>Start / Stop</b>	Yes	Yes	Yes
<b>Hybrid? (BSG)</b>	No	No	Yes
<b>Aftertreatment Configuration</b>	Three-way Catalyst (Post Turbo)	Three-way Catalyst (Post Turbo)	Three-way Catalyst (Close Coupled)
<b>Fuel system specifics (injector design)</b>	Direct, Side-mounted, multi-hole solenoid Injection + PFI	Direct, Side-mounted, multi-hole solenoid Injection	PFI
<b>Transmission Type</b>	Automatic	Automatic	Automatic, e-CVT

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 on a dynamometer. 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 emission testing over a standard cold start 25°C 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 FTP testing will be repeated for each vehicle at the end of testing to look for vehicle drift and confirm emissions system performance.

We ask the contractor to provide historical emissions test data from a vehicle that is tested repeatably using the same fuel and test conditions to demonstrate good test cell repeatability (e.g., test cell drift data vehicle). In addition provide weekly, or at a frequency approved by the project panel, background PM emission tunnel blanks during the duration of the testing.

Fuels

Fuels will be provided by the project sponsor. The contractor’s facility should be temperature and humidity controlled for storing the fuels. Contractor will provide an estimate of the quantity of fuel needed to complete the program with respect to the test matrix, fuel change flushing, and re-test backup quantity. Comparisons of test fuels will be made to the certification/baseline fuel in the report analysis. Not all fuels will be run with all test cycles, the test matrix is indicated in the section specifying test cycles. Contractor to suggest test schedule that will optimize both fuel changes and experimental design.

**Table 2: Anticipated fuel test matrix**

Fuel Number	Fuel Name	Description
1	<u>Cert Fuel</u>	<u>Tier 3 regular certification gasoline</u>
2	<u>Cold Cert Fuel</u>	<u>Tier 3 cold regular certification gasoline</u>
3	<u>Test Fuel M-1</u>	<u>Test gasoline</u>
4	<u>Test Fuel M-2</u>	<u>Test gasoline</u>
5	<u>Test Fuel A</u>	<u>Test gasoline</u>
6	<u>Test Fuel B</u>	<u>Test gasoline</u>
7	<u>Test Fuel C</u>	<u>Test gasoline</u>
8	<u>Test Fuel D</u>	<u>Test gasoline</u>
9	<u>Test Fuel E</u>	<u>Test gasoline</u>
10	<u>Test Fuel F</u>	<u>Test gasoline</u>

Test Cycles

Table 3 summarizes the fuels which shall be used for each test cycle. Each test cycle shall be run five times per fuel. The appropriate certification fuel shall be run at the beginning and end of all other fuel testing.

**Table 3: Fuels to be used for each test cycle**

Test cycles	Test fuel number	
	Warm (25°C)	Cold (-7°C)
<u>LA92</u>	1,3,5-10	2-6
<u>RTS95x2</u>	1,3,5-10	
<u>FTP</u>	1	2

## Chassis Dynamometer Test Procedure

1. Prepare each of the vehicles by performing a single oil drain, fill, and filter change meeting the OEM specifications and recommendations. A 250 mile de-greening procedure should be performed on each vehicle to break-in the new oil. No additional oil changes should occur unless mileage is accumulated, reaching the recommended oil drain interval.
2. If the GPF fitted to the GPF enabled vehicle is new, de-greening of the GPF should be performed. The contractor should suggest a method.
3. 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.
4. Equip the vehicle with a “scan tool,” and configure the device to continuously record the following parameters in real time:

**Table 4: Recording Parameters**

Absolute Throttle Position (%)
Relative Throttle Position (%)
Absolute Throttle Position B (%)
Commanded Throttle Actuator Control (%)
Intake Manifold Absolute Pressure (kPaA)
MAF (g/s)
Ignition Timing Advance Cyl. #1 (Deg)
Bank 1 - Sensor 1 lambda (Wide Range O2S)
Absolute Load Value (%)
Short Term Fuel Trim - Bank 1 (%)
Short Term Fuel Trim - Bank 2 (%)
Long-term Fuel trim Bank 1 (%)
Long-term Fuel trim Bank 2 (%)
Engine RPM (RPM)
Vehicle Speed (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. Before the start of the test procedure, one FTP test cycle (three phase for gasoline vehicles, four phase for hybrid vehicle, both conducted with appropriate preconditioning prior to the emissions sampled FTP) using certification fuel should be done to compare emissions and ensure the vehicle is meeting expected emissions standards and no vehicle faults are detected.
6. One LA92 test cycle (first two phases) 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 (three phases). For any HEV vehicles in the program, a battery State of Charge (SOC) setting procedure will be required and accomplished during the soak period. Specific test protocols will be provided by the CRC technical panel. This shall be done at 25°C for the fuels 1, 3 and 5-10, and at -7°C for fuels 2-6. See table above for test cycle & fuels for each.
7. After the LA92 test cycles at 25°C (not for cold testing at -7°C), run a RTS95 warm prep without emissions testing and directly after run another RTS95 with emissions testing after a 2 minute idle (e.g., LA92, RTS95-2min Idle-RTS95).
8. While on the LA92 and RTS95 test cycles the following should be monitored:
  - Tailpipe gaseous emissions (NO<sub>x</sub>, CO, CO<sub>2</sub>, THC, CH<sub>4</sub>, N<sub>2</sub>O, NH<sub>3</sub>)
  - Particulate matter emissions (PM by gravimetric filter method and total particle number PN)
  - Particle size distribution
  - Modal PM with AVL MSS or equivalent (GPF equipped vehicle will need pre+post GPF modal PM)
9. Proposals should include a list of equipment and protocols for measurement of the desired emissions.
10. 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.
11. Run a second test, repeating the initial test procedure, on the same fuel before moving to the next test fuel.
12. Check to see if the two test results are within the test protocol before moving to the next fuel. If the first two tests do not agree within test protocol, a third test will be run. A potential to have 25% of the testing run a third test should be included in the budget. An outline of the prep and test procedure will be provided by the CRC technical panel.
13. At the conclusion of testing after all the test fuels have been run, each vehicle should re-run cert fuel with the five replicates of the LA-92 and RTS-95 test cycles, as well as a single FTP test cycle to check for any vehicle drift from the beginning to the end of the program and to confirm the vehicle is still meeting emissions.

## **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. Contractor should put timeline in terms of per-vehicle and per-fuel testing as additional fuels may be added on to the study for select vehicles. Pricing should be provided on a per test cycle basis including FTP-75 with prep, LA-92 with prep, -7°C LA-92 with prep, and RTS-95x2. Cost for fuel changes should be indicated in the proposal.

## **Analysis**

Contractor shall compile and analyze the test results, including the following:

### General Analysis

- Identification of any outlier or invalid data points, using statistical analysis or best industry practices.
- Analysis and comparison of any redundant measurements to ensure data quality, such as integrated modal vs. cumulative results, tailpipe vs. tunnel, PM vs. PN, EEPS vs. CPC, etc.
- Determine variability, including test-to-test, vehicle-to-vehicle, and fuel-to-fuel, and assess if test-to-test variability meets acceptable industry standards.
- Presentation of existing contractor data if available demonstrating long-term drift / repeatability in emissions measurements based on repeat measurements from the same vehicle over a 6-12 month or longer period.
- Compilation of all fuel properties into a unified table in XLS or MATLAB format, including bulk properties and component group totals (e.g. C10 aromatics) from DHA.
- Summary of emissions test results (cumulative and by phase) in XLS format.

### Fuel Property Analysis and Correlation

- Identification of co-linearities and property groupings in fuel properties, for example using Pearson correlation coefficient and partial component analysis.
- Use of regularization with cross validation to perform feature (fuel property) selection to identify and down-select features to be used for prediction of tailpipe emissions from fuel properties and detailed composition, for example LASSO regularization. An appropriate regularization technique should be used to select the features which best correlate with emissions, among many features with multiple collinearities. The method should also be able to identify if no fuel specific effects are observed among properties considered, or if the predictive power of one feature is indistinguishable from another due to collinearity and test-test variability.



- Construction of predictive models of tailpipe emissions for each vehicle from fuel properties identified from regularization, in the case that any significant fuel property effects are observed which exceed overall test variability.

### Statistical Analysis to Support Conclusions

Contractor to propose appropriate statistical methods to answer the following questions based on the data collected in this project:

- What percentage of tailpipe emissions variability can be attributed to each of the following:
  - Random test to test variability
  - Variability due to different test cycles
  - Variability due to different soak temperature
  - Variability due to different vehicle technology
  - Variability due to different fuel properties
- Do the test results demonstrate the existence of any universal predictors of tailpipe emissions (i.e.: those which consistently correlate with emissions across all vehicles and test cycles studied in this work), and which can accurately predict tailpipe emissions from fuel properties on either a relative or absolute basis?
- Do the test results demonstrate that vehicle technology can consistently be correlated to higher or lower emissions across all test fuels, test cycles, and soak temperatures?
- In general, can any of the three key fuel properties considered in this work (D86 distillation, PMI, or back-end distillation (D86 FBP or SimDist T99)) be said to consistently have a greater impact on emissions than the other properties at a statistically significant level?
- To what extent can tailpipe emissions be reduced or increased with each of the following:
  - Fuel formulation collectively relative to the baseline fuel
  - Fuel formulation individually for each key property (PMI, overall distillation, and back-end distillation)
  - Vehicle technology
  - Test cycle
  - Soak temperature

### **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. The final report should thoroughly document the analysis conducted including assumptions, sources of error, or selection of methods which could alter the findings significantly. The final report should be a stand-alone document, not referring to any monthly or interim reports. The final report should be in CRC standard report format, not presentation format.

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.

A robust analysis of fuel and vehicle results is a key deliverable from this project. The contractor will submit an outline of the proposed approach to analyzing results once testing as progressed far enough to develop such an approach. Further, an “easy to digest” executive summary is another key deliverable of the final report.

The final deliverable should include an excel worksheet with the compiled emissions results for each vehicle, fuel and each valid test cycle. The compiled test results should additionally indicate the date the test was run, the driver, and the energy economy rating or similar metric for the test.

Upon request contractor shall make the full test report available for each individual test cycle.

Upon request contractor shall provide the time-aligned modal data for all modal measurement devices, including emissions and OBD measurements.

## **References**

NRPM GPF study: See figures 14 and 15, with supporting text.

[Proposed Rule: Multi-Pollutant Emissions Standards for Model Years 2027 and Later Light-Duty and Medium-Duty Vehicles \(pdf\)](#)

## **Cost Estimate**

Contractor should put pricing in terms of per test cycle, with indicated setup or change-over charges for each vehicle or fuel change as Vehicles and fuels may be added or removed to the study based on pricing received or initial results.

## Appendix A

### FUEL CHANGE PROCEDURE

1. Drain vehicle fuel completely via fuel rail whenever possible.
2. Turn vehicle ignition to RUN position for 30 seconds allowing fuel level reading to stabilize. Confirm the return of fuel gauge reading to zero.
3. Turn ignition off. Fill fuel tank to 40% with next test fuel in sequence. Fill-up fuel temperature must be less than 50°F.
4. Start vehicle and execute catalyst sulfur removal procedure described in Appendix B. Apply side fan cooling to the fuel tank to alleviate the heating effect of the exhaust system. Engine oil temperature in the sump will be measured and recorded during the sulfur removal cycle.
5. Perform four (4) vehicle coast downs from 70 to 30 mph, with the last two (2) measured. The vehicle will be checked for any obvious and gross source of change in the vehicle's mechanical friction if the individual run fails to meet the following repeatability criteria: 1) maximum difference of 0.5 seconds between back-to-back coastdown runs from 70 to 30 mph; and 2) maximum  $\pm 7$  percent difference in average 70 to 30 mph coastdown time from the running average for a given vehicle.
6. Drain fuel and refill to 40% with test fuel. Fill-up fuel should be at approximately 50°F.
7. Drain fuel again and refill to 40% with test fuel. Fill-up fuel should be at approximately 50°F.
8. Soak vehicle for at least 12 hours to allow fuel temperature to stabilize to the test temperature.

## **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.