



**COORDINATING RESEARCH COUNCIL, INC.**

1 CONCOURSE PARKWAY, SUITE 800  
ATLANTA, GA 30328  
TEL: 678/795-0506 FAX: 678/795-0509  
[WWW.CRCAO.ORG](http://WWW.CRCAO.ORG)

**February 23, 2026**

In reply, refer to:  
CRC Project No. E-149

Dear Prospective Bidder:

The Coordinating Research Council (CRC) invites you to submit a written proposal to provide services for “**Effect of Engine Deposits on Tailpipe Emissions of New-Technology Vehicles**” (CRC Project No. E-149). 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 **March 9, 2026** 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 intended 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).

Key contract language examples are presented in Exhibits B, C, D, and E. CRC must adhere to standard contract language with minor adjustments only in extraordinary circumstances. **Failure to agree to these contract clauses as written may result in the project being awarded to another contractor.**

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. The cost proposal should include clearly shown contingency budget for replicate tests as needed based on repeatability criteria. Optional tasks should be shown as separate cost items for consideration. A 3<sup>rd</sup> document is requested for quality control data to demonstrate test cell repeatability, which will be considered by the panel alongside the technical proposal. As stated in the Deliverables section of the

Statement of Work, this would consist of historical emissions test data from a vehicle that is tested repeatably using the same fuel and test conditions.

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  
1 Concourse Parkway, Suite 800  
Atlanta, GA 30328

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 **March 25, 2026**

Yours truly,

Amber B. Leland  
Deputy Director

## EXHIBIT A

### STATEMENT OF WORK

#### “EFFECT OF ENGINE DEPOSITS ON TAILPIPE EMISSIONS OF NEW-TECHNOLOGY VEHICLES”

CRC Project Number: E-149

#### Background

State and federal emission regulations regarding particulate matter (PM) continue to ratchet down, presenting a challenge for automotive OEMs. In response, OEMs have released multiple new models that produce certification results below 0.5 mg/mi. Engine deposits (injector, combustion chamber, etc.) are known to cause PM emissions to increase [1, 2, 3]. However, this effect has not been studied in new-technology vehicles, especially those designed to meet the latest PM emission targets.

#### Objectives

The key objectives of this project are as follows:

- Determine the emission and performance effects of maintaining combustion chambers (and injectors) in a clean condition, by comparing with engines that have accumulated deposits.
- Conduct detailed characterization of particulate matter (PM) emissions and the relationship with engine deposit accumulation, based on changing fuel severity. This would include measurement of PM mass (by filter and Micro Soot Sensor), number, and size distribution.
- Collect data during the deposit accumulation cycle that can provide insight into the amount of deposit formation; e.g., injector pulse width and fuel trim. Correlate these data with measured emissions.

Ideally, the results of this project will provide data that help address questions such as:

- Does this problem still exist for the latest vehicle technology? If so, to what extent? That is, how should “clean up” be defined for new-technology engines? (Note that actual additive testing will not be performed in this phase of the project.)
- Could EPA-mandated IUVP (in-use emissions verification [4]) testing be more challenging for vehicles designed to meet ultra-low PM standards? For example, a vehicle might have routinely been fueled with gasoline containing the Lowest Additive Concentration (LAC). The LAC is recommended by various regulatory agencies, but this low level of detergency can sometimes *increase* deposits [5].
- Do current vehicle emission certification rules allow procedural variability that could significantly affect emissions levels, particularly by allowing poor control of

deposits? For example, the regulations contain no specification for the fuel used to “de-green” vehicles for 4k miles prior to emission certification testing.

## **Scope of Work**

### Overview

The program will conduct vehicle emission testing to study the influence of engine carbon deposits on criteria emissions and fuel economy. A small fleet of vehicles will be tested for tailpipe emissions after their engines have been mechanically cleaned of deposits. Testing will be repeated after equilibration with a market-representative fuel. “Dirty-up” cycles will then be conducted using an appropriate deposit-forming test fuel, with deposit formation monitored using fuel trim and injector pulse width data. Emission tests will be conducted at a pre-determined endpoint.

### Details

#### **Vehicles**

- 3 GDI, 1 PFI, and 1 GDPI with emissions certification results spanning the range from <0.5mg/mi to near 3mg/mi. (GDPI = Combined Direct and Port Fuel Injection.)
- It is preferred that most test vehicles have conventional drivetrains, considering the added complexity of testing full hybrid (FHEV) drivetrains.
- New or low-mileage in-use vehicles are acceptable. The former would require de-greening procedures prior to the initial as-received emission tests. [6]

#### **Driving Cycles**

- Deposit equilibration: 50% to 70% highway, with the remainder urban. To be performed on a mileage accumulation dynamometer.
- Deposit accumulation: 2000 RPM steady state on a mileage accumulation dynamometer
- Emission testing: RTS 95 (aka RTS Aggressive)

#### **Fuels**

- Certification fuel: EPA or CARB.
- Equilibration fuel: Any market fuel conforming to Top Tier guidelines. Note that the same batch of fuel must be available for the entirety of the program.
- Deposit accumulation fuel (HF2208 or similar) [7, 9] The CRC project panel is open to suggestions for this fuel.
- Note that proper procedures should be followed whenever changing fuels, to avoid carry-over effects.

**Emission Data** NMOG, NO<sub>x</sub>, CO, CO<sub>2</sub>, FE. Sample collection/analysis via bag and tailpipe modal techniques.

- PM:
  - Gravimetric filters
  - MSS (Micro-soot sensor) MSS data should also be acquired approximately every 500 miles during the equilibration and deposit accumulation cycles and reported to the CRC project panel immediately.
  - EEPS (Engine Exhaust Particle Sizer) or similar instrument capable of real-time (sec x sec) number concentration and size distribution [8]. Solid particles down to 10nm should be measured.
  - Details such as specific instruments, methods, and calibration procedures should be noted in the proposal.
  - Optional Task: In addition to PM sampling and measurement at the tailpipe, perform the MSS and EEPS analyses on engine-out samples, that is, pre-catalyst.

**Vehicle Parameters** to be recorded throughout the equilibration and deposit accumulation cycles, and during all emission tests. All are available through the vehicles' CAN service port.

- Injector pulse width (IPW)
- Short-term fuel trim (STFT)
- Long-term fuel trim (LTFT)
- See Table 2 in Reference 9 for other parameters to be monitored. Note that this reference refers to an engine dyno test; not all parameters on the list will be appropriate for a chassis dyno test. Data that cannot be acquired through the CAN bus are not needed. The proposal should include a list of parameters that will be monitored for this project.

Procedure (see figure)

1. Perform standard mechanical and safety inspection on all vehicles. Check OBD system for active/pending codes.
  - a. Perform a compression and leak down check on all cylinders [9]. Note if leak down check presents any leak at the intake valve(s) by listening at throttle body, or exhaust valve(s) by listening at exhaust pipe, or crankcase by listening at the dipstick location.
    - i. A leak down result on any cylinder >15% will require panel review and potential to reject the test vehicle.

2. Perform emission testing using the certification fuel. Confirm stability by performing at least 2 tests. Share results of the second test with the project panel before proceeding. If further repeat testing is deemed necessary, share the rationale with the project panel.
3. Bring engine internals to a mechanically clean condition via walnut shell blasting and/or chemical cleaning and/or ultrasonic cleaning.
  - a. Perform a compression and leak down check on all cylinders [9]. Note if leak down check presents any leak at the intake valve(s) by listening at throttle body, or exhaust valve(s) by listening at exhaust pipe, or crankcase by listening at the dipstick location.
  - b. Optional task: Project panel may request procurement and replacement of injectors and spark plugs.
  - c. Optional task: Remove and disassemble cylinder head(s) to mechanically clean combustion chamber, valve seat/tulip/stem region, and intake + exhaust ports.
4. Perform emission testing using the certification fuel, using the protocol in Step 2.
5. Fuel vehicle with the equilibration fuel and accumulate miles until the IPW and LTFT stabilize. This could take a few thousand miles or more. Solicit advice from the project panel regarding an appropriate stabilization point.
6. Perform emission testing using the certification fuel, using the protocol in Step 2.
7. Fuel vehicle with deposit accumulation (“dirty-up”) gasoline. Perform mileage accumulation on the dyno until both an IPW shift greater than 5% and a 5-10% LTFT shift are achieved. Note that this could take up to 60 hours or more to achieve. Notify project panel if the IPW and LTFT shifts are proceeding at an unexpected pace; i.e. too slowly or too quickly.
8. **Optional Tasks:** Perform emission testing using the *deposit accumulation fuel* at three points: (1) Upon initial fill; (2) After deposit accumulation; (3) After in-cylinder engine inspection. A single emission test is sufficient in each case.
9. Perform visual inspection via borescope to confirm and document deposit formation. Inspection should include in-cylinder through the spark plug hole to observe piston crown, valve surfaces, injector surface, and rotation of engine to capture intake and exhaust valve tulip regions for all cylinders.
10. Change back to certification fuel and perform emission testing, using the protocol in Step 2.

## Deliverables

Standard CRC contracting requests monthly reports, a Final Report, and all related project data as described in Exhibit B. Deliverables for this project will include:

1. 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). It is assumed that drift will be monitored and reported using such a vehicle throughout the course of the program. In addition provide weekly, or at a frequency approved by the project panel, background PM emission tunnel blanks during the duration of the testing.
2. Project Kick-Off Call: During this call, the CONTRACTOR will lead the meeting with the CRC project panel to review project plans.
3. Photos of Fuels upon delivery/ shipment
4. Presentation of Final or Draft Results at a CRC workshop or similar event at the selection of the panel.

### **Notes re: Cost Quotation**

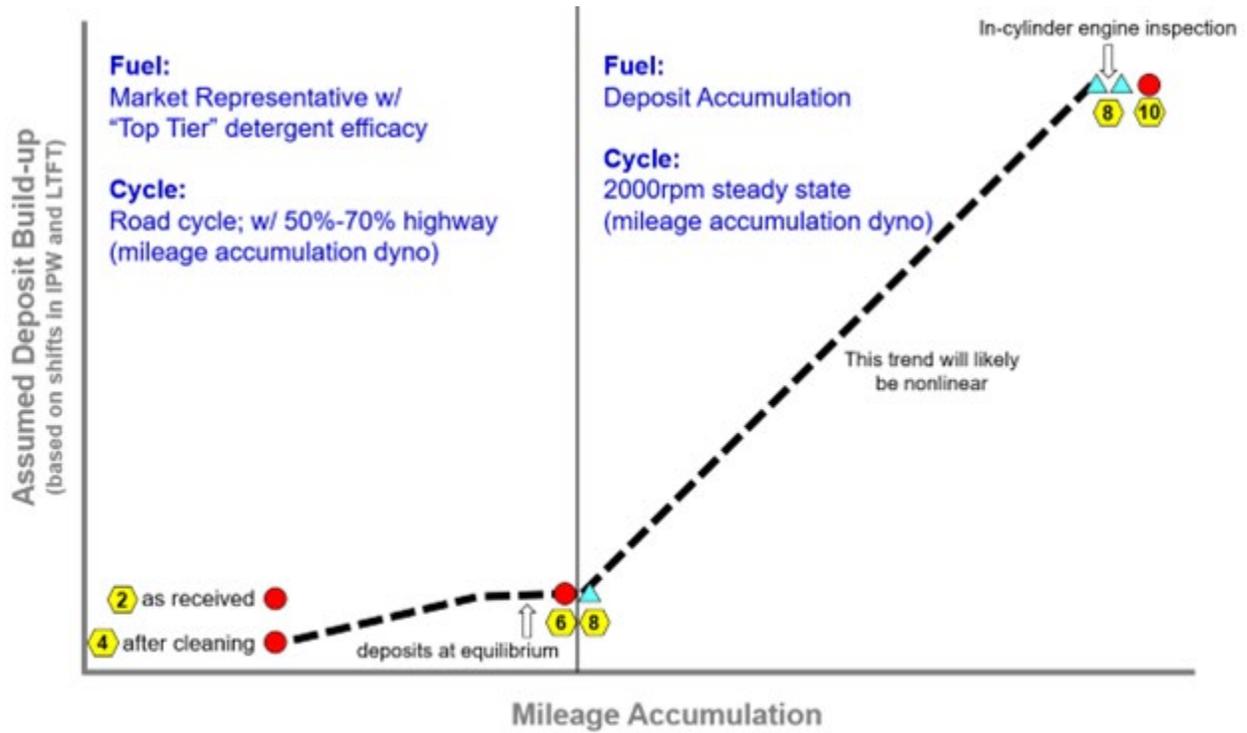
- The contractor will arrange test vehicle procurement and logistics. Please include these costs as separate line items in the cost proposal. Test vehicle selection will be proposed by the contractor and final vehicle selection will be approved by the CRC project panel.
- An approximate per-vehicle itemization should be included, such that the project panel can estimate the cost of adding or deleting test vehicles.
- Any task listed as “optional” in the Procedure section should be quoted separately.

### **References**

1. Wen, Y., Wang, Y., Fu, C., Deng, W. et al., "The Impact of Injector Deposits on Spray and Particulate Emission of Advanced Gasoline Direct Injection Vehicle," SAE Technical Paper 2016-01-2284, 2016, doi:10.4271/2016-01-2284
2. Pilbeam, J.J., Xu, H., Liu, H., and Thomson, A.R., "New CEC Gasoline Direct Injection Fuels Test - Comparison of Deposits and Spray Performance from New and Used Injectors," SAE Technical Paper 2019-28-2392, 2019, doi:10.4271/2019-28-2392.
3. Kuo, C.-H., Smocha, R., Loeper, P., Mukkada, N. et al., "Aftermarket Fuel Additives and their Effects on GDI Injector Performance and Particulate Emissions," SAE Technical Paper 2022-01-1074, 2022, doi:10.4271/2022-01-1074
4. Code of Federal Regulations, Title 40, Chapter I, Subchapter C, Part 86, Subpart S, 86.1846-01.

5. Raj Mohan, V.R., Nelson, E., Reitz, J., Kensler, J. et al., "Evaluation of Gasoline Additive Packages to Assess Their Ability to Clean Up Intake Valve Deposits in Automotive Engines," SAE Technical Paper 2019-01-0261, 2019, doi:10.4271/2019-01-0261.
6. Code of Federal Regulations, Title 40, Chapter I, Subchapter C, Part 86, Subpart G, 86.608-98.
7. DuMont, R., Evans, J., Feist, D., Studzinski, W. et al., "Test and Control of Fuel Injector Deposits in Direct Injected Spark Ignition Vehicles," SAE Technical Paper 2009-01-2641, 2009, doi: 10.4271/2009-01-2641.
8. Badshah, H. and Khalek, I., "Solid Particle Emissions from Vehicle Exhaust during Engine Start-Up," SAE Int. J. Engines 8(4):2015, doi:10.4271/2015-01-1077.
9. Reilly V., Moravec, A., Ciaravino J., "TOP TIER GDI Fuel Injector Deposit Test Method," version 2, January 2025.

# Image of E-149 Test Program



- # Step # in "Procedure" section of SOW
- Emission test w/ certification fuel
- ▲ Emission test w/ deposit accumulation fuel (optional)

- Test Vehicles**
- 3 GDI
  - 1 GDPI
  - 1 PFI
- Based on proportion of new vehicle fleet in 2024  
EPA Trends Report

## **EXHIBIT B**

### **REPORTING AND DELIVERABLE REQUIREMENTS**

#### **MONTHLY TECHNICAL PROGRESS REPORTS**

CONTRACTOR shall submit a technical progress report covering work accomplished during each month of the contract performance. 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. Periodic conference calls may also be requested by CRC to update the technical committee overseeing the project.

#### **FINAL REPORT**

CONTRACTOR shall submit to CRC a draft final report within thirty (30) days after completion of the technical effort specified in the contract. The *Draft Final Report* shall be reviewed and returned to CONTRACTOR with comments no later than forty-five (45) days thereafter. The report shall document, in detail, all of the work performed under the contract including data, analyses, and interpretations, as well as recommendations and conclusions based upon results obtained. The report shall include tables, graphs, diagrams, curves, sketches, photographs, and drawings in sufficient detail to comprehensively explain the results achieved under the contract. The report shall be complete in itself and contain no reference, directly or indirectly, to the monthly progress reports and should be suitable for publication in the peer-review literature. Additional rounds of review may be required prior to acceptance of the Final Report. If applicable, data from the research shall be provided in a format suitable for releasing to the public along with the final report.

The draft report must have appropriate editorial review corrections made by 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 report structure that includes:

- CRC Title Page and Disclaimer Statement (both provided by CRC)
- 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 (may also include Recommendations if CRC requests them)
- List of References

- Appendices as appropriate for the scope of the study.

Incomplete draft reports or reports of poor quality requiring additional outside editorial review may have outside editorial services charged back to the project budget.

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

***NOTE: This example language describes CRC's preferred approach to IP. There are alternative clauses to IP that can be used if necessary. All approaches require unlimited royalty-free access to any IP generated by CRC-funded research for CRC and its members.***

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**

### **RELATIONSHIP OF PARTIES**

It is agreed and understood that CONTRACTOR is acting as an independent contractor in the performance of any and all work hereunder, and to the extent caused by CONTRACTOR, CONTRACTOR shall be solely liable and responsible for the payment of all legal claims for damages made by its employees or agents, or by another person or persons, on account of any property damage or on account of personal injury sustained or suffered by, or on account of the death, of any person or persons, or on account of any other legal claims arising or growing out of CONTRACTOR's negligence in the performance of the agreement; and CONTRACTOR undertakes to indemnify CRC against any such liability.

## **EXHIBIT E**

### **KEY PERSONNEL REQUIREMENTS**

Certain skilled experienced professional and/or technical personnel are essential for successful performance by CONTRACTOR of its obligations and work under this Agreement. These personnel are persons whose resumes were submitted for evaluation of the Proposal and are identified by CRC as "Key Personnel". CRC awards contracts based on several requirements and the reputation and experience of Key Personnel are a significant requirement. CONTRACTOR agrees that CONTRACTOR will not remove or replace any Key Personnel from the contract work without compliance with paragraphs (a) and (b) hereof.

(a) If any Key Personnel for whatever reason becomes, or is expected to become, unavailable for work under this Agreement (or any specific Project) for a continuous period exceeding thirty (30) work days, or is not expected to perform the work hours and volume of work indicated in the proposal or initially anticipated, the CONTRACTOR shall immediately notify CRC and shall, subject to the concurrence of CRC, promptly replace such Key Personnel with personnel of at least substantially equal ability and qualifications acceptable to CRC.

(b) All requests for approval of substitutions of Key Personnel hereunder must be in writing to CRC and provide a detailed explanation of the circumstances necessitating the proposed substitutions. Requests for substitution must contain a complete resume for the proposed substitute Key Personnel, and any other information requested by CRC needed to approve or disapprove the proposed substitution. CRC will evaluate such requests and notify CONTRACTOR of approval or disapproval thereof in writing. CRC is not responsible for, and shall not be charged, any fees or other costs related to such replacement Key Personnel's performance of the services until the replacement Key Consultant has obtained the same proficiency and knowledge regarding the services as the former Key Personnel.

(c) If CRC determines that suitable and timely replacement of Key Personnel who have been reassigned, terminated or have otherwise become unavailable for the contract work is not reasonably forthcoming or that the proposed replacement Key Personnel would impair the successful completion of the contract or the services ordered, at the option of CRC, (i) the

Agreement (in whole or in part related to the applicable contract work) may be terminated by CRC or (ii) the contract price or fixed fee may be equitably adjusted downward to compensate CRC for any resultant delay, loss, or damage, in an amount acceptable to CRC

## **EXHIBIT F**

### **CRC POLICIES**

It is understood that CONTRACTORS agree to follow CRC policies and procedures, including meeting attendance, project participation, and Anti-trust policies. A copy of these policies can be made available upon request.

It is understood that the major purpose of the work performed by CONTRACTOR is to obtain information that may be made available to industry and the public through publications or otherwise. Any announcement or publication of work under this agreement by CONTRACTOR shall be subject to review and approval by CRC and its committee members and shall recognize and give credit in the text and on the title pages to the cooperation of the CRC. This applies (but is not limited to) conference presentations, journal articles, and social media posts.

## **EXHIBIT G**

### **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.