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July 24, 2020
In reply, refer to:
CRC Project No. CM-136-18-1

Dear Prospective Bidder:

The Coordinating Research Council (CRC) invites you to submit a written proposal to provide services for "Port Fuel Injection (PFI) Intake Valve Deposit (IVD) Test Development" (CRC Project No. CM-136-18-1). A description of the project is presented in Exhibit A, "Statement of Work."

Please indicate by letter, fax, or email by **August 8, 2020** 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). 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.

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 (not including resumes). **The schedule / timeline information should be included in the technical proposal.**

CRC expects to negotiate a cost-plus fixed fee or cost reimbursement contract for the research program.

The technical and cost proposals should be submitted to:
Christopher J. Tennant Email: **ctennant@crcao.org**

The deadline for receipt of your proposal is **August 21, 2020**

EXHIBIT A
Statement of Work

"Port Fuel Injection (PFI) Intake Valve Deposit (IVD) Test Development"

CRC Project Number: CM-136-18-1

Background

Current test methods used to demonstrate effectiveness of gasoline detergent additives to reduce Intake Valve Deposits (IVD) in Port Fuel Injection (PFI) engines include:

- ASTM D5500 – This test uses a 1985 model BMW car operated on a prescribed test cycle performed on a test track or public road. This test method is used by the U.S. Environmental Protection Agency (EPA) to certify gasoline detergent additives.

- ASTM D6201 – This test uses a 1994 model Ford inline 4-cylinder engine from a Ford Ranger truck operated on prescribed test cycle on an engine dynamometer.

These test vehicles, engines and associated test fuels have become increasingly outdated, difficult to obtain replacement parts, and not representative of modern vehicle/engine/fuel technology. It is desirable to replace these outdated tests with modern test engines and fuels.

This work is a continuation of the American Chemistry Council Fuel Additives Task Group (FATG) IVD Test Consortium's development of the GM LE9 Ecotec 2.4L engine test stand.

Objective

Develop a new engine-based test method suitable to replace existing ASTM D5500 test method for demonstrating effectiveness of gasoline detergent additives. We will conduct an engine test program to develop a final test fuel specification, test parameters, operating conditions, engine hardware requirements, and recommendations for pass / fail criteria. The work will result in an ASTM test methodology for IVD measurement and be acceptable to the EPA and potentially CARB for use in their Lowest Additive Concentration (LAC) certification test programs. This work will be completed in the Prove-out Phase of the CRC test development project. There will a follow up Precision Phase of the project to define the repeatability and reproducibility of the test method once the Prove-out Phase is complete. The overall development project is expected to consist of three Prove-Out phases and one Precision phase.

- Phase 1 – Prove-Out Test Cycle
- Phase 2 – Prove-Out Test Fuel
- Phase 3 – Prove-Out Detergent
- Phase 4 – Precision

This Request for Proposal is soliciting response for the first three Prove-Out phases only. Phase 4 Precision will be bid separately at a later time.

It is our intention that CRC, Contract Labs, Fuel Additive Suppliers, Specialty Fuel Suppliers and the Regulatory Agencies work in collaboration to achieve the objectives of this work. Our project team has formed around five workstreams; Engine Test Development, Data Analysis, Test Fuel, Additives, and EPA / CARB Engagement. We have the expectation that the contract

labs will actively participate in the technical discussions of the workstreams and be a contributor to the success of this effort.

Scope of Work

1. ***Engine Test Development***
   Goal: identify the right engine test cycle and test fuel so that sufficient deposits will be generated and can be controlled with the use of Deposit Control Additives (DCA).

   Please review the attachment *1. PFI IVD Test Plan Development* for an overview of our draft engine test develop plan. We encourage you to provide any feedback to the plan in your response to the RFP.

   When the details of the Engine Test Development Plan are finalized, the successful bidder will work with CRC's Statistician to develop the test sequencing for each phase of the Test Plan

   Minimum requirements:
   a. Respond with the minimum number of tests required for each phase in the Test Plan
   b. Work with CRC's Statistician to develop the test sequencing for each phase of the Test Plan
   c. Provide a timeline for each phase of the Test Plan
   d. Provide a per test cost (excluding fuel and additive).

2. ***Data Analysis***
   Goal: Collect data to develop conclusions about specific test runs. Collect enough data to enable troubleshooting of problems encountered and offer guidance on sources of variability and ways to reduce variability.

   Please review attachment *2a. Test Data Requirements* and *2b. Fuel Test Requirements* for the data collection requirements. Please suggest if there are data requirements, such as those related to the engine build, which may not need to be collected on every test and provide the technical reasoning.

   Minimum requirements:
   a. Affirmatively validate that you can meet all metric, parameters and data collection requirements.
   b. Provide sample photos which meet the Test Data Requirements. These should be representative of the photos that your lab will submit with each test result.
   c. Recommend methods for quantifying IVD morphology and volume. Provide a quotation for measuring IVD volume and morphology as a separate optional add-on cost.
   d. Provide a plan to retain and store post-test valves, photos, and fluid retain samples (fuel, used lubricant). Suggested retain sample volumes are 1 liter for

fuels and 500 ml for used lubricants. Post-run analysis of fuels and used lubricants is not anticipated unless needed for troubleshooting purposes.

e. Provide statistical analysis on data to determine the relevance of the results, or to validate troubleshooting assumptions.

3. ***Test Fuel***

Goal: CRC will establish a range of parameters based on analysis of current market fuels and help specify fuels for each phase of the Test Plan. At the end of the Prove-out phase we will have a validated Test Fuel specification.

It is expected that the successful bidder will work with the CRC Test Fuels workstream and specialty fuel suppliers to arrange for the different fuels required throughout the Test Plan to be delivered to your lab site.

Minimum requirements:

a. Costs to procure, store and test the fuel are to be included in the proposal
b. Costs to purchase and transport the fuel to the lab facility should be billed at actual costs (cost plus contract time) to CRC.
c. All fuel blending decisions require review with the CRC Test Fuel workstream. In order to maximize fuel storage stability, we will consider antioxidant treatment immediately after blending. For specific recommendations about which additive, treat rate and blending procedure, we should consult with an additive manufacturer or the fuel blender. After blending, fuel should be packaged in epoxy-lined drums and nitrogen-blanketed.
d. Provide a fuels storage, testing, and handling plan for the duration of the project. Fuel must be stored in climate-controlled room-temperature storage (at minimum) or refrigerated cold storage (preferred). Fuel drums should not be opened until they are ready for use so as not to disturb the nitrogen blanket.

4. ***Fuel Additives***

Goal: Test a range of fuel additive types and treat rates to verify the test engine's ability to discriminate IVD performance with and without DCA and relative scale of the IVD by varying DCA treat rates.

The successful bidder with work with the ACC FATG Director, Chemical Products & Technology Division, and CRC to ensure proper custody of blind samples of EPA certified widely used market general additives. It is expected that an additive custody protocol will be developed and followed by the contract lab.

The contract lab will coordinate with ACC FATG on appropriate safeguards for additive treat rates (LAC and 2.5x LAC), which may include a non-disclosure agreement with the ACC and/or additive companies.

5. ***EPA and CARB Engagement***

Goal: Align with EPA and CARB on the test program and milestone results, such that they will be accepting of the GM LE9 test method in their LAC certification programs.

The Contract lab Project Lead is expected to generate status reports and participate in engagements with EPA or CARB. Depending on circumstances, this may require travel to EPA or CARB facilities.

Schedule

A detailed schedule is required with your response to the RFP.

It is expected that the required equipment, facilities, and personnel are dedicated to the CRC project through its duration. Any changes to the most expedient execution of the project timeline must be provided in writing and approved by CRC.

Deliverables

In addition to the CRC standard contract deliverables, the successful bidder will also continue to support the development of the ASTM test method, including modifications to the current draft test method.

Periodic status update calls and data reports as needed to monitor and facilitate project progress, periodic written status reports (monthly), and a written final report at the end of each test phase (Phase 1, 2 and 3) are required. When requested, data should be made available at the end of each test.

In order to document our learning, a project briefing report is required for each troubleshooting effort or course correction. This will provide us with guidance on how to proceed with the test program. We expect this to be a collaborative effort with the CRC / Contract Lab team to minimize waste and maximize efficiency.

References

As available, please provide a narrative of your experience with the below tests, including your view on how the IVD test results compare relative to each other:

- GM LE9 2.4L test stand
- ASTM D6201 Ford 2.3L test stand
- ASTM D5500 BMW 318i vehicle test

Attachment 1

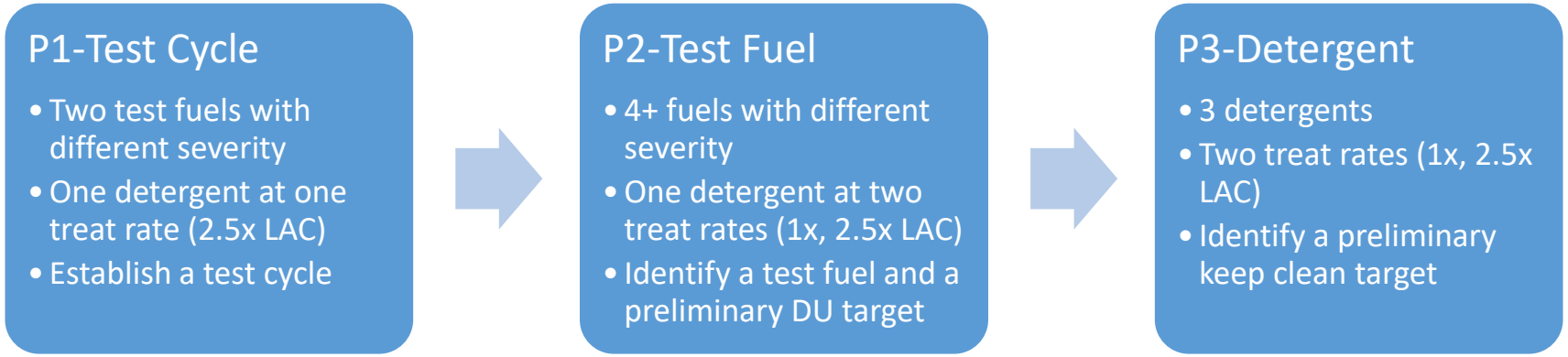
CRC CM-136-18-1
PFI IVD Test Plan Development (Draft)

July 23, 2020

Engine Testing Workstream

Prove-out Phase Test Plan Outline

- Goal: identify the right engine test cycle and test fuel so that sufficient deposits will be generated and can be controlled by detergent
  - Check the detergent response through out the prove-out phase to prevent generating deposits hard to control
- Test includes three phases:



P1-Test Cycle

- Goal: optimize the engine cycle to generate sufficient and treatable deposits
  - Adopt deposit per cylinder as target to be comparable with historical tests
  - Dirty up to more than 300 mg without detergent and less than 100 mg with detergent are good initial targets with sufficient separation
- Test variables
  - Intake air temperature: air temperature (33^{o}C vs. 42^{o}C)
  - Stage 2 loading: intake valve temperature (MAP 60 kPa and variations, main control knob)
  - Stage 1/2 duration: time (4 min. + 8 min.)
- Other considerations:
  - Explore means to ensure intake valve rotation to reduce test variation, including measurement techniques to validate rotation of valves.
  - Build in tests to check variation from engine head
- Test Fuels: To be specified by the CRC Test Fuel workstream, and will be within a range of:
  - Top Tier E10 Test fuel (e.g., Haltermann HF2075)
  - 65th percentile fuel (e.g., Haltermann HF-0034) blended with 10 vol% fuel grade ethanol
  - It is desired that the test fuel produces results can be correlated with ACC FATG data
- Result: an engine cycle for further validation

P2-Test Fuel

- Goal: understand today's market fuel change and its impact on intake valve deposit formation
  - Design test fuels based on today's market fuel analysis
  - Fuel properties impact on deposit formation and detergent response
- Test variables
  - Define today's 65th percentile fuel and beyond
  - Fuel properties impact: aromatic and olefin content
- Other things to consider: market fuel vs special blends
- Each fuel will be tested without detergent, 1x, and 2.5x LAC (on one DCA).
- Result:
  - Recommend a test fuel correlated to today's market fuel with sufficient and treatable deposits
  - Recommend a preliminary dirty up target

P3-Detergent

- Goal: verify mainstream detergent with acceptable response
  - Should be at least three detergents to representing widely used EPA certified additives
  - Check the response at 1.x and 2.5x LAC treat rate
- Test detergents in the recommended fuel
  - Keep clean tests: 3 detergents X 2 treat rates
- Result: recommend a preliminary keep clean target

Attachment 2a. Test Data Requirements

CRC Project Number: CM-136-18-1
PFI IVD Test Development

Test Data Collection Minimum Requirements:

1. All information below is required for each run performed in the test order as specified in the Test Plan or associated Design of Experiments.
2. Details about engine parts used in build engine and especially the head. – part #, serial #, lot #, mfg. source, mfg. date, etc.
3. Metrics/parameters
    a. Intake valves must all have same finish – anodized or smooth
    b. Intake valve springs must have same spring tension when installed.
        i. Adjustment to the same tension may be done by adjusting spring tension by shimming (preferred) or by "cherry picking" springs from different spring kits.
        ii. Spring tension measured, recorded, and within service spec. – for each intake valve spring according to position in the head.
    c. Intake valve seats smooth within service spec.
    d. Intake and exhaust valve stem-guide clearances measured, recorded, and within service spec according to position in head – before and after test
    e. Intake and exhaust valve seat widths measured, recorded and within service spec according to position in head
    f. Measure intake valve lift, clearance, lift profile and lift duration – before and after test?
    g. Conduct a compression leak down test and record individual cylinder compression pressures and calculate leak down (%).
    h. Measure head air flow – before and after test.
    i. Log engine operating data thought to affect IVD rate and especially intake valve temperature – IAT, Intake Air Pressure, Intake Air Humidity, MAP, speed, load, ignition timing advance, lambda, fuel flow, fuel temperature, oil T, coolant T, exhaust T, test time, etc. At least 1 Hz data rate.
    j. Report Minimum, Average and Maximum values along with Standard Deviation for requested engine operating data.
    k. Measure and report fuel injector flow rates and ensure all are within service specification.
    l. CRC ratings for intake valve tulip, intake port, intake head runner, piston top and cylinder head.

m. Valve weight before and after – recorded for each valve according to position within head (valve number, cylinder number, head number if more than one head is used.)
n. IVD mass, volume, morphology, porosity, photo, etc.
    i. Measurement methods for volume, morphology, and porosity need to be defined.
    ii. High definition digital photos of the intake valves showing different perspectives. For example, 4 front valves lined up for photo from the side and individual valve photos taken from above, looking down the valve stem or offset from the valve stem.
        1. Care must be taken with photographs to control lighting, exposure, color and angle to enable valve-to-valve and run-to-run comparisons. Include length scale reference in photos. Color calibration should be conducted for every group shooting. Picture resolution should be sufficient to demonstrate deposit details. Unprofessional "snapshots" with inferior photo equipment are not sufficient! Digital photos are desirable to facilitate CRC project team member inspection.
o. High definition digital photos of combustion chambers, piston tops, intake ports and intake runners for each cylinder.
p. Measure and record piston top and cylinder head deposit thickness according to an agreed upon pattern.
q. Scrape, weigh and record piston top and cylinder head deposits and provide total combustion chamber deposit weights.
r. During the Phase 1 Prove-out of the test cycle, provide an agreed to methodology to observe valve rotation. This could include borescope photos and marking a reference point on the valve.
s. Measure and record initial oil fill and end of test oil weight. Provide oil consumption rate in grams/hour. Retain a 500 ml end of test lubricant oil sample.
t. Provide fuel usage in gallons and/or kilograms.
u. Record of unscheduled shutdowns and maintenance and comments related to the test.
v. Details of test fuels and additives composition and identification including requested fuel analyses – requirements to be listed by Test Fuels and Additives Workstreams. Retail a minimum 1 liter sample of fuel from the end of test.

Attachment 2b. Fuel Test Requirements

Fuel Blend Analysis

Test	Test Method	Alternative Test Method
Distillation	ASTM D86	
Density @ 15 oC	ASTM D4052	
Vapor Pressure, psi	ASTM D5191	ASTMD323 / 6378
Oxygen , wt%	ASTM D4815	ASTM D5599 / 8071
Nitrogen, ppm wt.	ASTM D4629	
Ethanol , vol%	D4815	ASTM D5845 / 5599 / 8071
Sulfur, ppm wt.	ASTM D5453	ASTM D7039 /2622 /4045
Aromatic, vol%	ASTM D5769	ASTM 5580 /8071
Olefins, vol%	ASTM D6550	ASTM D6729 / 8071 /6839
Saturates, vol%	Calc	
Existent gum, unwashed	ASTM D381	
Existent gum, washed	ASTM D381	
Water by Karl Fischer, ppm wt.	ASTM E1064	
Oxidation Stability, minutes	ASTM D525	
NACE Corrosion Test, rating	TM0172-2001	
Research Octane	ASTM D2699	
Motor Octane	ASTM D2700	
R+M/2	Calc	
Sensitivity	Calc	
Net Heat of Combustion	ASTM D240	
PONA	ASTM D6729 / 6730	
Paraffins		
Isoparaffins		
Olefins		
naphthenes		
Aromatics		

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. Periodic conference calls may also be requested by CRC to update the technical committee overseeing the project.

FINAL REPORT

The contractor shall submit to CRC a draft final report. The report shall document the test procedure, document details of each test iteration, and explain any observations noted. The test data will be recorded and reviewed, and the final report will include a certification that the test procedures were followed, noting any exceptions. The detailed data will also be supplied electronically to CRC.

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

Comments regarding the report shall be furnished by the CRC committee to the contractor within one (1) month after receipt of the draft copy. Additional rounds of review may be required.

Within thirty (30) days after receipt of comments, the contractor shall make the requested changes and submit an electronic copy of the draft final report in both Microsoft Word and Adobe pdf file format. Once accepted, the contractor shall deliver five (5) hard copies of the final report to CRC. 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.