**COORDINATING RESEARCH COUNCIL, INC.**
3650 MANSELL ROAD, SUITE 140
ALPHARETTA, GA 30022
TEL: 678/795-0506 FAX: 678/795-0509
www.crcao.org

**March 16, 2012**
In reply, refer to:
CRC Project No. CM-138-12-1

Dear Prospective Bidder:

The Coordinating Research Council (CRC) invites you to submit a written proposal to provide services for the **Risk Analysis/Hazard Assessment of High Ethanol Content Fuels at the Service Station** (CRC Project No. CM-138-12-1). A description of the project is presented in Exhibit A, "Statement of Work." This request for proposal is being issued in anticipation of funding being available in the near future.

Please indicate by letter, fax, or email by **March 30, 2012** whether or not 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 and government 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 25 pages in length.

CRC expects to negotiate a fixed price contract for the research program.

Contract language for intellectual property and liability clauses is presented in Exhibit C and in Exhibit D, respectively. Bidders are also advised that government funds may be used to support the research, and therefore certain government contract terms and conditions may apply.

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 proposal and the cost proposal should be submitted to:

Dr. Christopher J. Tennant
Coordinating Research Council
3650 Mansell Road, Suite 140
Alpharetta, GA 30022

Phone: 678-795-0506
Fax: 678-795-0509
E-mail: ctennant@crcao.org

The deadline for receipt of your proposal is **April 13, 2012.**

Yours truly,

Dr. Christopher J. Tennant
Deputy Director

## EXHIBIT A

## STATEMENT OF WORK

### Risk Analysis/Hazard Assessment of High Ethanol Content Fuels at the Service Station

### Background

The U. S. Department of Energy supports efforts to increase the use of ethanol-rich transportation fuels such as "E85". Furthermore, the mission of the U.S. DOE's Clean Cities program is to advance the energy, economic, and environmental security of the United States by supporting local decisions to adopt practices that reduce the use of petroleum in the transportation sector. However, infrastructure compatibility and safety have historically been one of the most difficult deployment hurdles to address when introducing a new transportation fuel. The proximity of self-serve fuel dispensers and underground storage tanks to the consumer elevates concerns regarding potential unintended consequences. The physical and chemical properties of ethanol-rich fuels are different from those of conventional transportation fuels, therefore it is critical that we evaluate the situation to ensure safety.

Today, according to NFPA (National Fire Protection Association) data, there are over 5000 fires per year at filling stations. These fires cause on average annually 2 deaths and 48 fire injuries. 61% of the fires are to vehicles, and the most common type of material ignited is gasoline. (see NFPA report, dated April 2011 Fire at US Service Stations) The small number of accidents and fire fatalities recorded for higher ethanol fuel blends in the distribution system is due more to the small number of stations currently selling high ethanol content fuels. The Renewable Fuel Standards requirements to vastly increase the amount of ethanol-containing fuels into the marketplace will rapidly increase the opportunity for an unintended consequence to occur, potentially. Therefore, a probalistic risk assessment (PRA) model-based approach is required rather than relying the limited historical data.

In addition to testing that led to UL-listing of dispensers[1], NREL undertook the testing described three reports[2,3,4] to assess the difference in headspace flammability between typical summertime gasolines that have an accepted level of safety, and these new high-ethanol content fuel blends. The results apply to vehicle fuel tanks as well as aboveground and underground storage tanks. These projects evaluated the effects of ambient temperature and fuel formulation on the headspace vapor flammability of ethanol/gasoline blends. When a fuel tank is partially filled with liquid fuel, the remaining space (i.e., the "headspace") is filled with fuel vapors and air. Depending on the degree of tank filling, fuel type, and ambient temperature, the fuel vapors can be flammable or non-flammable. Vapors in fuel tanks containing pure gasoline generally are too rich (i.e., the ratio of fuel vapor to air is too high) to be flammable except when ambient temperatures are extremely low. However, fuels containing high percentages of ethanol blended with gasoline can be less volatile than pure gasoline and thus can produce flammable headspace vapors at common ambient temperatures. The above studies also are intended to provide knowledge to support the refinement of fuel ethanol volatility specifications, and to show the potential consequences of using fuels that do not comply with such specifications. Additional analysis[5] has been conducted based upon these experimental results and published data for pure compounds.

## ANALYSIS/ASSESSMENT PROGRAM

### Objective

A risk analysis/hazard assessment is required to fully judge the safety implications, if any, of the introduction of these new fuel blends into the hands of the public. It is also necessary to understand potential risks posed to fuel handlers all along the distribution chain, including pipeline and terminal operators, as well as tanker truck drivers (who are loading and unloading the fuel). Eventually this analysis may evaluate terminal storage tanks, tanker trucks and rail cars, the focus of the current effort will be service station tanks (both USTs and ASTs) along with vehicle fuel tanks.

The purpose of this analysis is to determine the incremental change in risk due to a change in fuel. The benchmark will be the currently accepted public safety level of the terminal blender making an E10 (10 vol% ethanol blended into a base gasoline where the resulting vapor pressure is appropriate for the season and geographic location) blend, the tanker truck driver loading/blending/delivering the blend and, ultimately, for this analysis, the consumer dispensing E10 into their own vehicles at self-serve refueling stations.

The blends to be investigated include E10, which will be the baseline for comparison, E51 (51 vol% denatured ethanol in gasoline (conventional and California)), E83 and E98. A range of temperatures/ambient conditions shall be proposed for consideration by the RA/HA (Risk Assessment/Hazard Analysis) Ad Hoc group, to span the extremes of the most dangerous but plausible, conditions.

This analysis will not consider materials compatibility per se, unless directly related to a failure mode that would cause or allow a spark of sufficient energy to enter the headspace above ethanol gasoline blends. Nor will we consider toxicity, environmental impacts (groundwater or air quality).

### Approach

Using the data generated by NREL and others as well as analyses provided by Reddy (and possibly others) and the expertise that resides in the RA/HA Ad Hoc Group regarding all aspects of fuel delivery and dispensing at public service stations, a formal quantitative risk assessment will be conducted.

The intended audience is the safety community, i.e., NFPA, AHJs (Authorities Having Jurisdiction), Fire Marshalls, UL (Underwriter's Laboratory), safety officers at fuel marketing companies, petroleum equipment installers/maintainers, etc.

The project should answer these six key questions:

1. Define Scenarios, what can go wrong? What are the Hazards?
2. How bad can it be? What are the consequences?
3. How likely is it to happen? What is the frequency?
4. How do the consequence and frequency combine? What is the risk?
5. Is the current level of risk (for E10) tolerable, considering the existing safeguards?
6. If not, what additional barriers are needed to reduce or manage the risk?

We are interested in reviewing the events that fall in these general classes:

1. Hardware or human failure that may result in the electrostatic ignition of a flammable tank headspace (UST, AST, LD or MD vehicle tank) and in potential follow-on work Truck, Rail Tank Car, Marine barge.

2. Human error resulting in release of a flammable tank headspace in the presence of an ignition source.

3. Accidental impact on hardware resulting in release of flammable headspace in the presence of an ignition source.

4. Catastrophic hardware failure leading to instantaneous release of flammable headspace in the presence of an ignition source.

5. Degradation hardware failure resulting in a gradual release of flammable headspace in the presence of an ignition source.

6. Nonflammable headspace fires (area fires, pool fire, brush fire) which results in release of flammable headspace in the presence of an ignition source.

**TASKS**

1. The subcontractor shall survey the literature provided[6-9] and any other sources of data regarding headspace flammability for handling flammable liquids germane to the analysis as well as other case studies of explosions[10, 11] of this nature that have occurred, been investigated for root cause and documented. This literature survey shall review codes, preventative barriers and incidents in Sweden and Germany that have aggressive requirements in this area.

2. The subcontractor shall investigate available techniques to determine what gasoline-ethanol blends can create and hold sufficient static during product transfers activities which promote static generation, e.g., nozzle flow velocities during vehicle refueling, truck/rail/marine loading rates, product transfers into tanks, product transfers/drops into underground storage tanks, vapor velocities out of vessel vents during these events, product velocities during overfill/overflow events, etc., in are more hazardous than E10 transfers.

3. Primary fire and explosion hazards shall be defined, first at the service station but in possible follow-on work, across the entire distribution system, over a range of possible ambient temperatures. In consultation with the RA/HA team, the scenarios of greatest concern regarding potential danger and fatalities to the public as well as to workers in the distribution system shall be the focus of the remainder of the study. The system shall be described as far as relevant to this analysis, i.e., only components or subsystems relevant to the use of liquid fuel and contributing to fire hazards should be considered.

4. The subcontractor shall work with the RA/HA team to define possible service station accident scenarios and then narrow the choices to approximately six for further analysis by covering a range

of possibilities. Scenarios will be described in detail. The subcontractor will evaluate the event consequences and estimate the frequencies and consequently, and the event impacts.

A qualitative risk analysis approach following standard PRA techniques will be applied to help identify scenarios. Use fault tree analyses and event tree modeling techniques to describe scenarios. Use of Center for Chemical Process Safety (**CCPS**)[12] guidelines for this matrix is acceptable. For example, at a service station, the scenarios (not ranked) included might be:

- Fire during a fuel hose drop hose/truck/UST connect
- Disconnect (static)
- Fire inside UST (static)
- Fire inside UST (electrical short pump/sensor)
- Surface/Area (brush/forest) Fire overwhelms tank vents/tanks
- Spill/pool fire at dispenser flash back to UST/to P/V vents
- Spill/pool fire during fuel drop flash back to UST/to P/V vents
- Lighting strike on UST vents
- Lighting strike on UST with EVR Phase I systems
- Stage II/nozzle fire flash back to vehicle tank/to UST
- Loss of containment from meter/hose/nozzle spill fire/flashback to UST
- Failure of legacy P/V, vapor fire flash back to UST

5. We ask the bidder to outline tools and processes they feel they need to develop the quantitative risk model, however we suggest consideration of the following steps (or propose a different, but sound approach that will yield the same or better results):

The subcontractor shall use the above effort to develop a consequence vs. frequency risk matrix, in consultation with the RA/HA group, that can be use to facilitate a semi-quantitative risk analysis. A format consistent with DOD MIL-STD-882D Appendix A STANDARD PRACTICE FOR SYSTEM SAFETY is acceptable. Frequency should be quantified using historic records of similar events, generic failure data for basic components, fault and event tree analysis. Engineering judgment and simple fire analysis should be used to evaluate consequences.

MIL Std 882
Appendix A tables

6. A formal quantitative risk assessment will be conducted. The bidder should identify the suite of models that will be used. The above pre-work will allow proper selection of scenarios to be recommended to the RA/HA Ad Hoc group for modeling. Uncertainties in failure and consequence date should be propagated. Sensitivity and importance analysis shall be performed. A risk summary table for each scenario will be produced comparing the risk of baseline E10 to E51, E83, and E98. The absolute risk calculation shall be compared to the risk for the same scenarios using E10.

7. The subcontractor shall determine the adequacy of any existing safequards[13, 14] on current fuel handling/dispensing systems (such as P/V valves, lack of flame arrestors) as well as determine whether or not today's fleet of flex fuel vehicles (FFVs) have/need flame arrestors in their filler

necks. The subcontractor shall answer: Are vapor return lines or other hardware in the filler neck on any kind of tank sufficiently protective?

**Project Schedule**

**Deliverables**

1. Monthly (approx.) conference calls with RA/HA team
2. Reports
    a. Summary of literature review
    b. Brief report on static hazard with ethanol blends
    c. Fault Trees and Event Trees
    d. FEMA study (if used)
    e. Results and Risk summary from quantitative model risk review
        i. Include details on report on source model, dispersion models, fire/explosion models as applicable and any data files from models used
        ii. Include a discussion on Uncertainties, and sensitivities in the model
        iii. Provide an outline of suggest additional preventative barriers
        iv. Finally, provide a discussion comparing the risk of high ethanol content fuels vs. baseline E10

**Monthly Progress Reports**

**Final Report**

**IP** - [intention is to provide info. in the open literature]

**References**


1. **Dispensing Equipment Testing with Mid-Level Ethanol/Gasoline Test Fluid**
   Publication Type: Subcontract Report (no. 10807)
   Authors: Boyce, K and Chapin, J. T., Publisher: NREL
   Publisher: NREL
   Publication Date: November 2010
   http://www.afdc.energy.gov/afdc/ethanol/publications.html
2. **Experimental and Modeling Study of the Flammability of Fuel Tank Headspace Vapors from High Ethanol Content Fuels,**
   Publication Type: Subcontract Report (PDF 1.3 MB)
   Authors: D. Gardiner, M. Bardon, and G. Pucher, Nexum Research Corporation
   Publisher: NREL
   Publication Date: 2008
3. **Experimental and Modeling Study of the Flammability of Fuel Tank Headspace Vapors from Ethanol/Gasoline Fuels, Phase 2: Evaluations of Field Samples and Laboratory Blends**
   Publication Type: Subcontract Report (PDF 1.4 MB)
   Authors: D. Gardiner, M. Bardon, and M. LaViolette, Nexum Research Corporation

Publisher: NREL
Publication Date: 2010

4. **Experimental and Modeling Study of the Flammability of Fuel Tank Headspace Vapors from Ethanol/Gasoline Fuels; Phase 3: Effects of Winter Gasoline Volatility and Ethanol Content on Blend Flammability; Flammability Limits of Denatured Ethanol**
   http://www.nrel.gov/docs/fy11osti/52043.pdf
5. **CRC Report No. 661, Mathematical Prediction of Flammability of Ethanol-Containing Fuels (CRC Project no. CM-138-11-2), August 2011.**
   http://www.crcao.org/reports/recentstudies2011/CRC%20661/CRC%20661.pdf

6. **Gasoline Container Vapor Flammability, Manuscript no. HAZMAT-D-11-03174, B. E. Elias, R. G. Zalosh, and A. S. Rangwala, Worcester Polytechnic Institute, Worcester, MA 01609, also presented at Yokohama, Japan, September 5-10, 2010 (ISH-074).**


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7. **Comparative Fire Risk of Motor Vehicle Fuels: Gasoline versus Ethanol; S. E. Dillon, A. R. Carpenter, and R. A. Ogle; AIChE, Process Safety Progress, Volume 28, Issue 2, pages 171–178, June 2009.** http://onlinelibrary.wiley.com/doi/10.1002/prs.10284/pdf

8. **National 2010-2011 Survey of E85; CRC Project E-85-2**
   **Publication Type: Report**
   **Authors:** Teresa L. Alleman
   **Publisher: NREL**
   **Publication Date: December 2011**
   http://www.nrel.gov/docs/fy12osti/52905.pdf

9. **Intermediate Ethanol Blends Infrastructure Materials Compatibility Study: Elastomers, Metals, and Sealants**
   **Publication Type: Report no. 10861**
   **Authors:** Kass, M.; Theiss, T.; Janke, C.; Pawel, S.; Lewis, S.
   **Publisher: NREL**
   **Publication Date:** March 2011
   http://www.afdc.energy.gov/afdc/ethanol/publications.html

10. **U.S. Chemical Safety and hazard Investigation Board Case Study, Barton Solvents, Static Spark Ignites Explosion Inside Flammable Liquid Storage Tank (No. 2007-06-I-KS).**


Barton-Valley Center CS.pdf

11. **U.S. Chemical Safety and hazard Investigation Investigation Report, Methanol Tank Explosion and Fire, Bethune Point Wastewater Treatment Plant, City of Daytona Beach, Florida, January 11, 2006 (Report No. 2006-03-I-FL, March 2007).**


Bethune_Report.pdf

12. **Fundamental Concepts of Risk Assessment and Risk Criteria, 2009 Copyright, Center for Chemical Process Safety/AIChE.**

13. **Literature Review of the Usefulness and Efficacy of Flame Arresters and Pressure/Vacuum Valves with Gasoline-Ethanol Blends, Final Report, SWRI Project No. 01.15417.01.001, American Petroleum Institute Contract No. 2009-104505, Report Date July 2, 1010, Prepared for American Petroleum Institute.**

SwRI Final Report - Efficacy of Flame Arre

14. **Testing the Functionality of Stage I Vapor Recovery and Overfill Prevention Components, Ken Wilcox Associates, Inc., prepare for American Petroleum Institute, September 2011.**

KWA API Final Report.pdf

# 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. Thirty-five (35) hardcopies or one 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 thirty-five (35) hardcopies (or one hardcopy and one electronic pdf-compatible 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).

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 fifty (50) hardcopies including a reproducible master copy of the final report. The final report shall also be submitted as an electronic copy in a pdf or pdf-convertible 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 of Contractor 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.