Department of Energy
Argonne Site Office
9800 South Cass Avenue
Argonne, Illinois 60439

SEP 2 6 2014

Dr. Peter B. Littlewood
Director, Argonne National Laboratory
President, UChicago Argonne, LLC
9700 South Cass Avenue
Argonne, IL 60439

Dear Dr. Littlewood:

SUBJECT: NATIONAL ENVIRONMENTAL POLICY ACT (NEPA) DETERMINATION FOR ARGONNE NATIONAL LABORATORY (ARGONNE)

The Argonne Site Office (ASO) has approved the following as a categorical exclusion (CX) under Appendix B (to 10 CFR Part 1021, Subpart D, Integrated DOE NEPA Implementing Procedures, December 1996), Category B 3.6 "Small-scale research and development, laboratory operations, and pilot projects" applicable to:

- Methods to Measure, Predict, and Relate Friction, Wear, and Fuel Economy (ASO-CX-307)

Therefore, no further NEPA review is required. However, if any modification or an expansion of the scope is made to the above project, additional NEPA review will be necessary.

Enclosed please find a copy of the approved Environmental Review Form (ERF) for the project. If you have any questions, please contact Kaushik Joshi of my staff at (630) 252-4226.

Sincerely,

Joanna M. Livengood

Joanna M. Livengood
Manager

Enclosure:
As Stated

cc: J. Stauber, ANL, w/encl.
W. Brocker, ANL, w/encl.
G. Fenske, ANL, w/encl.
M. McKown, SC-CH, w/encl.
P. Siebach, SC-CH, w/encl.
K. Joshi, ASO, w/encl.

Argonne NATIONAL LABORATORY

Environmental Review Form for Argonne National Laboratory

Project/Activity Title: Methods to Measure, Predict, and Relate Friction, Wear, and Fuel Economy

ASO NEPA Tracking No. ASO-CX-307 **Type of Funding**: FOA

B&R Code ______

Identifying number: ______ WFO proposal # ______ CRADA proposal # ______

Work Project # ______ ANL accounting # (item 3a in Field Work Proposal) ______

Other (explain) FOA DE-0000991

Project Manager: George Fenske Signature: George Fenske Date: 9-23-14

NEPA Owner: William Brocker Signature: William Brocker Date: 9-23-14

ANL NEPA Reviewer: Joel Stauber Signature: Joel V Stauber Date: 9/23/14

I. Description of Proposed Action:

Correlation of labscale friction and wear data with engine/vehicle fuel efficiency and durability data. Perform labscale tests at Argonne to provide input data (friction and wear) for computer simulation of engine friction and wear. Validation of simulation data will be performed by Ricardo Inc at their site.

II. Description of Affected Environment:

All research activities will be performed indoors using existing labscale test equipment located in the D-wing Tribology Facilities in building 212 located on the Argonne site. Building 212 occupies approximately 150,000 sq ft of lab space. The tribology facilities in 212 occupy approximately 10,000 sq ft, or 6-7 % of the building 212 lab space.

III. Potential Environmental Effects: (Attach explanation for each "yes" response. **See Instructions for Completing Environmental Review Form**)

A. Complete Section A for all projects.

1. Project evaluated for Pollution Prevention and Waste Minimization opportunities and details provided under items 2, 4, 6, 7, 8, 16, and 20 below, as applicable — Yes X No ___

   The activities will fully conform with the criteria defined in the ANL specific site-wide categorical exclusions for bench-scale research and development in established facilities.

2. Air Pollutant Emissions Yes X No ____

Limited quantities (< 100 milliliters) of solvents (e.g. ethanol and acetone) will be used to clean laboratory samples (steel). Waste solvents will be segregated into waste containers for disposal by Argonne Waste Management Office.

The activities will fully conform with the criteria defined in the ANL specific site-wide categorical exclusions for bench-scale research and development in established facilities.

3. Noise Yes ____ No X

4. Chemical/Oil Storage/Use Yes X No ____

Commercial engine lubricants will be used in the friction and wear tests at quantities < 1 milliliter per test. Lubricants will be stored in combustible cabinets per ANL policy. Solvents such as ethanol and acetone (at quantities < 100 milliliter per test) will be used to clean samples before and after each test. Waste solvents will be segregated in ANL approved waste accumulation containers and disposal by Argonne Waste Management personnel.

The activities will fully conform with the criteria defined in the ANL specific site-wide categorical exclusions for bench-scale research and development in established facilities.

5. Pesticide Use Yes ____ No X

6. Polychlorinated Biphenyls (PCBs) Yes ____ No X

7. Biohazards Yes ____ No X

8. Effluent/Wastewater (If yes, see question #12 and contact Gregg Kulma (FMS-SEP) at 2-9147 or gkulma@anl.gov Yes ____ No X

9. Waste Management

   a) Construction or Demolition Waste Yes ____ No X

   b) Hazardous Waste Yes X No ____

Commercial engine lubricants will be used in the friction and wear tests at quantities < 1 milliliter per test. Lubricants will be stored in combustible cabinets per ANL policy. Solvents such as ethanol and acetone (at quantities < 100 milliliter per test) will be used to clean samples before and after each test. Waste solvents will be segregated in ANL approved waste accumulation containers and disposal by Argonne Waste Management personnel.

The activities will fully conform with the criteria defined in the ANL specific site-wide categorical exclusions for bench-scale research and development in established facilities.

c) Radioactive Mixed Waste — Yes ____ No X

d) Radioactive Waste — Yes ____ No X

e) PCB or Asbestos Waste — Yes ____ No X

f) Biological Waste — Yes ____ No X

g) No Path to Disposal Waste — Yes ____ No X

h) Nano-material Waste — Yes ____ No X

10. Radiation — Yes ____ No X

11. Threatened Violation of ES&H Regulations or Permit Requirements — Yes ____ No X

12. New or Modified Federal or State Permits — Yes ____ No X

13. Siting, Construction, or Major Modification of Facility to Recover, Treat, Store, or Dispose of Waste — Yes ____ No X

14. Public Controversy — Yes ____ No X

15. Historic Structures and Objects — Yes ____ No X

16. Disturbance of Pre-existing Contamination — Yes ____ No X

17. Energy Efficiency, Resource Conserving, and Sustainable Design Features — Yes ____ No X

B. For projects that will occur outdoors, complete Section B as well as Section A.

18. Threatened or Endangered Species, Critical Habitats, and/or other Protected Species — Yes ____ No ____

19. Wetlands — Yes ____ No ____

20. Floodplain — Yes ____ No ____

21. Landscaping — Yes ____ No ____

22. Navigable Air Space — Yes ____ No ____

23. Clearing or Excavation — Yes ____ No ____

24. Archaeological Resources Yes____ No____

25. Underground Injection Yes____ No____

26. Underground Storage Tanks Yes____ No____

27. Public Utilities or Services Yes____ No____

28. Depletion of a Non-Renewable Resource Yes____ No____

C. For projects occurring outside of ANL complete Section C as well as Sections A and B.

29. Prime, Unique, or Locally Important Farmland Yes____ No____

30. Special Sources of Groundwater (such as sole source aquifer) Yes____ No____

31. Coastal Zones Yes____ No____

32. Areas with Special National Designations (such as National Forests, Parks, or Trails) Yes____ No____

33. Action of a State Agency in a State with NEPA-type Law Yes____ No____

34. Class I Air Quality Control Region Yes____ No____

IV. **Subpart D Determination: (to be completed by DOE/ASO)**

Are there any extraordinary circumstances related to the proposal that may affect the significance of the environmental effects of the proposal? Yes____ No_X_

Is the project connected to other actions with potentially significant impacts or related to other proposed action with cumulatively significant impacts? Yes____ No_X_

If yes, is a categorical exclusion determination precluded by 40 CFR 1506.1 or 10 CFR 1021.211? Yes____ No____

Can the project or activity be categorically excluded from preparation of an Environment Assessment or Environmental Impact Statement under Subpart D of the DOE NEPA Regulations? Yes_X_ No____

If yes, indicate the class or classes of action from Appendix A or B of Subpart D under which the project may be excluded. Appendix B, B3.6 Small-scale research and development, laboratory operations, and pilot projects

If no, indicate the NEPA recommendation and class(es) of action from Appendix C or D to Subpart D to Part 1021 of 10 CFR.

ASO NEPA Coordinator Review: Kaushik Joshi

Signature: [signature] Date: 9-24-2014

ASO NCO Approval of CX Determination:

The preceding pages are a record of documentation that an action may be categorically excluded from further NEPA review under DOE NEPA Regulation 10 CFR Part 1021.400. I have determined that the proposed action meets the requirements for the Categorical Exclusion identified above.

Signature: [signature] Date: 9/24/2014

Peter R. Siebach
Acting Argonne Site Office NCO

ASO NCO EA or EIS Recommendation: NOT APPLICABLE

Class of Action: ______________________

Signature: ______________________ Date: ______________

Peter R. Siebach
Acting Argonne Site Office NCO

Concurrence with EA or EIS Recommendation: NOT APPLICABLE

CH GLD: ______________

Signature: ______________________ Date: ______________

ASO Manager Approval of EA or EIS Recommendation: NOT APPLICABLE

An ☐ EA ☐ EIS shall be prepared for the proposed ______________ and

__________ shall serve as the document manager.

Signature: ______________________________________ Date: ______________________

Dr. Joanna M. Livengood
Manager

Argonne NATIONAL LABORATORY

VERIFICATION OF NEPA APPROVAL

Release of Funds is Contingent on Approval

A. DESCRIPTION

Name of project or activity Methods to Measure, Predict, and Relate Friction, Wear, and Fuel Economy

Division ES Project Manager/or Project Investigator George Fenske (name)

Identifying numbers (enter all that apply):

	WFO proposal number		LDRD number
	CRADA proposal number		B&R Code
	Field Work Proposal (enter the number in		Item 3a on the FWP)
ES1414	Other (explain) DE-FOA-0000991		

CONTINUE

B. APPROVAL FOR OFFICE ACTIVITIES (If not applicable, GO TO Section C.)

The activity(s) described above will be wholly confined to conducting "office work" (e.g. program planning, management and administration; information gathering; information/data analysis; preparation and dissemination of reports; modeling; conceptual design; software development).

For any off-site or on-site activities ANL personnel will not be responsible for directing or conducting: laboratory work, field sampling, geophysical or geological characterization, installation of field instruments, drilling or digging, or any other activities with potential for disturbing the existing ecological/environmental conditions.

Project Manager ________ (name) (signature) (mm/dd/yyyy)

Environ. Compl. Rep. ________ (name) (signature) (mm/dd/yyyy)

STOP if Section B is applicable.

C. APPROVAL FOR OTHER ACTIVITIES (Complete either item 1 or 2.)

1. ☒ The activities will fully conform with the criteria defined in the ANL-specific site-wide categorical exclusions for bench-scale research and development in established facilities.

2. ☐ Other applicable NEPA documentation has been approved by (check all that apply):

☐ NEPA Owner ☐ ANL NEPA Coordinator ☐ DOE-ASO

Most recent approval ________ (date) (ANL determination or ASO number)

Environ. Compl. Rep. Bryan Wozny (name) Bryan M. Wozny (signature) 03/24/2014 (mm/dd/yyyy)

NEPA Owner Will Brocker (name) Will Brocker (signature) 03/25/2014 (mm/dd/yyyy)

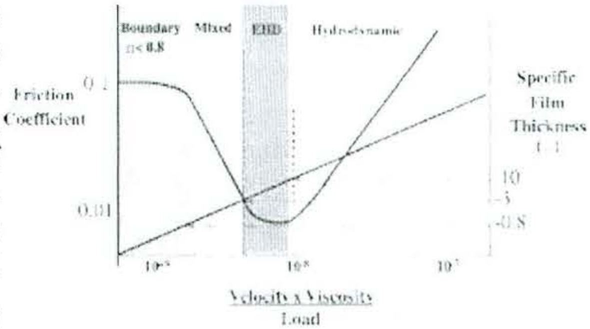
Methods to Measure, Predict, and Relate Friction, Wear, and Fuel Economy

Technology Description

• The proposed technology, including its basic operating principles

Friction forces and wear performance in engines and other driveline components can be calculated from equations that capture the understanding of the fundamental physics involved. However, accuracy of the results is dependent on measurement or estimation of the friction coefficient used in the calculations. For contacting surfaces in any component system (piston ring or skirt and liner; bearings; gears, etc.) the friction coefficient is a function of lubricant viscosity, relative speed, surface properties and load, which is captured in a Stribeck curve.

For a given set of operating conditions the curve provides a friction coefficient which can be used to calculate FMEP (Friction Mean Effective Pressure). FMEP is a quantification of losses due to friction during engine operation. It combines all types of friction losses from asperity or boundary friction (caused by metal to metal contact) to hydrodynamic friction (caused by viscous losses) and mixed regimes between. Once FMEP is quantified, whether predicted or measured, it can be used to calculate friction impacts on fuel economy.



Typical Stribeck Curve

In this program Ricardo will use existing computer models to specify relevant Stribeck conditions (speed and load) for light duty and heavy duty OEM engines (one or more of each). ANL and EMA will make careful measurements of friction and wear using high-precision lab-scale test rigs as a function of surface and lubricant properties over a range of operating temperatures, loads, and speeds typical of engine (or other) components. The data generated will be used, with some processing, as input to Ricardo's codes to improve correlations between model FMEP predictions and measurements of FMEP in full scale engine or driveline tests.

FMEP is difficult to measure directly in an operating engine. It is equal to the difference between IMEP (Indicated Mean Effective Pressure), which is the theoretical amount of power the engine can produce from the amount of fuel burned, and BMEP (Brake Mean Effective Pressure), which is the amount of power delivered by the crankshaft. Because FMEP is the relatively small difference between two relatively large numbers, accuracy can be poor when determining FMEP by calculating IMEP and subtracting measured BMEP. It can be measured directly in motored tests, but they lack some of the physical realities (temperatures, combustion forces, etc.) of fired engines. Methods to calculate FMEP from well verified models are needed.

The "technology" developed in this project will be FMEP maps as a function of load and speed which, when coupled with IMEP, can be used with suitable weighting factors to predict fuel consumption for any user-specified driving cycle. The lab-scale rig data will be used to predict wear loads (cycle averaged as a function of speed and load) to compare with wear-load-sliding distance calculations. Lubricant effects will be evaluated in terms of both friction losses and wear performance. The models will be used to predict fuel savings and wear, as validated with engine dyno tests by Ricardo and Navistar using an off-the-shelf high viscosity lubricant and a friction-modified low-viscosity synthetic lubricant. Engine tear-down tests at INL will provide data on engine component wear in fleet-tested vehicles.

• The proposed technology's target level of performance

The target level of performance is to simulate/correlate friction, FMEP, and fuel economy in the three different Stribeck regimes – boundary, mixed, and hydrodynamic. Previous work by ANL and Ricardo showed that reductions in asperity friction on key HD diesel engine components can lead to reduced fuel consumption between 0.43% and 0.81% as measured over a simulated FTP cycle. It was later shown that reductions in hydrodynamic friction, by using lower viscosity lubricants, could reduce FTP-cycle fuel consumption between 1% and 4.8%. We will develop correlations that verify these levels of improvement and make predictions for other engines (both heavy and light duty) and extend the method to other driveline components (e.g., gear systems).

• The current state-of-the-art (Include key shortcomings, limitations, and challenges)

The input parameters and correlations for modeling component dynamics (pistons, rings, valves, crankshaft bearings, etc.) need to be improved in order to accurately predict the subtle but important effects of advanced lubricant technologies (e.g. friction modifiers and novel base fluids) on fuel economy and engine life. The current state of the art is the FEI analysis for sequence 6D tests where FEI = a + b* viscosity + c* HTHS + d* asperity friction. We need more flexibility, including the ability to cover a wider set of conditions – from a large HDDE to a small SI engine. Also, very little correlation on wear or scuffing load exists.

• How the proposed technology will overcome the shortcomings, limitations, and challenges

The proposed work will provide the lab-scale fundamental data (open source), model correlations, and full scale verifications to enable more accurate predictions of friction coefficient and wear for a wider range of engines, lubricants, and operating conditions than currently exists. We also plan to extend the approach to sliding and rolling friction in gears.

• Potential impact the proposed project would have on the relevant field and application

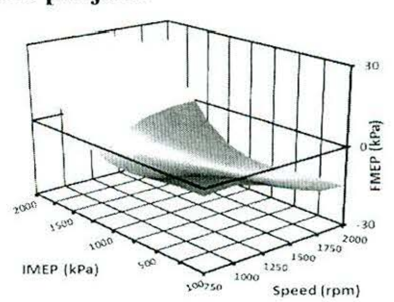
As a result of this work predicting friction reductions and fuel economy benefits will be made more accurately, for more engines, at more conditions, and with more confidence. It would provide more than the 'simple' sequence 6d correlations, would be more flexible, and would allow those with sufficient knowledge the ability to use a well defined set of protocols to generate data on friction and wear and to predict FMEP maps. The impact of this technology will be measured in fuel economy improvements enabled by low-friction components (material, surface finish, design, or coatings) and lower viscosity lubricants, whose use can be exploited because of improved wear predictions. We are seeking OEM support for geared system tests.

• The key technical risks/issues associated with the proposed technology development plan

The key technical risk involves acquiring meaningful friction and wear data from full-scale engine (or transmission) tests. Such data are difficult to collect because of the large forces involved and the harsh operating environments that are difficult to reproduce outside the actual hardware. While the rig tests and models can be run with low risk, the collection of accurate, full-scale friction loss or fuel economy data at a reasonable expense is difficult and risky.

• The impact that EERE funding would have on the proposed project.

EERE funding will enable collection of accurate data on friction with a wider variety of lubricants and operating conditions, collection of new wear data, collection of open and accessible full-engine data, and generation of data relevant to geared systems. The data will make models more accurate when predicting ΔFMEP for changes in system design, operation, or lubricants. (Example at right)



Delta FMEP - 20WT (40 WT Baseline)

Addendum

• Show the Principal Investigator and Project Team have the skill and expertise needed

George Fenske – Section Manager of the Argonne Tribology Section; over 30 years' experience investigating friction, wear, and lubrication properties of materials and coatings using advanced lab-scale equipment, and characterizing surfaces with x-rays and electron microspcopy.

Aaron Matthews – Masters of Engineering degree in Engine Systems (UWM) with 4years experience in engine design and consulting at Navistar and Argonne. Currently is a PI on the Ricardo/Argonne CRADA investigating parasitic friction losses in engines.

Nicholas Demas – Ph.D. in Mechanical Engineering (UIUC) with 12 years' experience investigating the impact of advanced materials, lubricants, and surface texture on friction and wear; lead PI on multiple Argonne projects that utilize our advanced lab-scale test rigs.

Diana Dascalescu – Mechanical Product Manager at Ricardo Software. M.Sc. in Mechanical Engineering (UIUC) and French Engineer Diploma (Paris) with over six years of experience in complex mechanical system simulation and tribology, including friction and wear prediction

Steve Gravante – B.S. in Engineering (UIUC); 20+ years engine development work at Navistar

• Show the Team has experience and ability to perform tasks of similar risk/complexity

Argonne Tribology Section has multiple DOE EERE projects on the development and evaluation of advanced lubricants, additives, and coatings to improve tribological performance. The Section has 30 years of experience in testing and characterization of tribological systems using our 20+ test rigs. We investigate tribological performance under a wide range of environments.

Ricardo has been supporting Argonne's Tribology Section with friction predictions and analysis for almost 10 years using our proven commercial codes VALDYN, PISDYN, and RINGPAK, which were designed for detailed component analysis. Ricardo has deep technical expertise for analyzing and designing engines and transmissions, and has first class test facilities for both.

INL manages DOE's Advanced Vehicle Testing Activity and has collected over 100,000,000 miles of driving data from a multitude of vehicle types in real-world conditions. INL Operations makes its buses available for fuel economy, mileage accumulation, and other petroleum reduction studies and supports buses with a 60,000 square foot maintenance and repair facility.

• Show the Team has worked together on prior projects or programs

ANL and Ricardo - multiple projects on the impact of tribological parameters on engine friction:

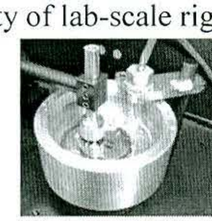
- Impact of Low Friction Coatings on Fuel Consumption – 3-year collaboration using dynamic codes to model impact of asperity friction and lubricant viscosity on FMEP in diesel engine
- DOE/DOD Collaboration – CRADA to model impact of tribological parameters on FMEP

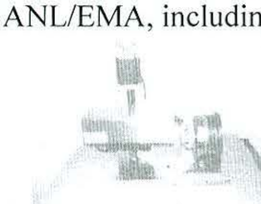
• Show the Team has adequate access to equipment/facilities needed to execute the effort

Friction and wear data will be obtained from a variety of lab-scale rigs at ANL/EMA, including:


Reciprocating ring-on-liner


Ring-on-liner


Pin-on-disc


Ring Profile Tracer

Advanced surface characterization techniques will be used at ANL and EMA to examine post-test specimens from lab-scale and engine tear-down components to correlate wear mechanisms. Ricardo Software simulates these friction behaviors: VALDYN – valvetrain interfaces; PISDYN – piston skirt in liner, wrist pin bearings; RINGPAK – rings/liner; ENGDYN – journal bearings