DOE-ID NEPA CX DETERMINATION
Idaho National Laboratory

CX Posting No.: DOE-ID-INL-17-059

SECTION A. Project Title: NASA/INL Transient and Irradiation Testing for Nuclear Thermal Propulsion Fuels Development and Qualification

SECTION B. Project Description and Purpose:

The purpose of this revision is to clarify and address additional project scope.

Under the authority of the Atomic Energy Act of 1954, the Department of Energy's (DOE's) mission includes meeting the nuclear material needs of other federal agencies. DOE has supplied materials for radioisotope power systems as the source of electric power and heat for the National Aeronautics and Space Administration (NASA) and national security missions for over 50 years. DOE's role in these missions reflects established ongoing cooperation between DOE and NASA to ensure that radioisotope power system production capabilities are maintained and coordinated to meet NASA mission requirements.

The National Aeronautics and Space Administration (NASA) Space Technologies Mission Directorate has been authorized by Congress to continue to develop Nuclear Thermal Propulsion (NTP) systems for the peaceful exploration of the solar system and beyond by both manned and unmanned missions. NTP systems rely on a very high temperature once-through / open gas-cooled fission reactor to provide thermal energy and hence excite the coolant (H_2) that also serves as the propellant. This heated propellant is exhausted through a converging-diverging nozzle to provide propulsive thrust. The fuel systems adopted by NASA's NTP program are hexagonal-prismatic in geometry and feature multiple internal flow channels that serve as integral heat exchange surfaces, through which the hydrogen gas is passed and heated. NASA is currently examining a number of candidate nuclear fuel compositions including ceramic-metallic (cermet), and (U, Zr) C-graphitic composite fuels that may be able to be operated at the required temperatures of interest.

Operation of NTP systems require that fuel systems maintain their geometric integrity and core coolable geometry and retain the fissile constituents of the fuel at very high temperatures and power densities for mission life duration. Since NTP reactor systems will be started following a period in long-lived earth orbit, during which system readiness checkout can be performed, the initial temperature of the fuel will be at cryogenic, space cold temperatures. At these temperatures, many of the candidate fuel systems are below their material ductile-to-brittle transition temperatures (DBTT). This material attribute compounds the challenge of thermally driven stresses within the fuel matrix, and if the ramp rate to full operating temperature and/or power is too great, these attributes could result in stress-cracking of the fuel matrix and/or claddings. Therefore, candidate NTP fuels must be tested under prototypical fission heating conditions to demonstrate they can meet the rigors implied by the fuel design specifications. Similarly, the power/temperature ramp-rate failure thresholds attributed to incipient cracking, fissile material loss and Fuel-Coolant Interactions (FCI) with the propellant (e.g., hydride formation) must be understood in order to bound operational performance margins and inform NASA's mission design activities.

The purpose of Phase I of the proposed action is to determine the feasibility of developing a simplified first test (SIRIUS-1) to study NASA NTP fuel specimens at peak design operating temperatures when subjected to a prototypical start up ramp rate. To determine experiment feasibility, Idaho National Laboratory (INL) will perform conceptual design for an irradiation test vehicle and experiment life-cycle planning. Phase I activities will be performed at INL's Engineering Research Office Building (EROB), the Materials and Fuels Complex (MFC), subcontracted fabrication facilities if necessary, and NASA facilities in Huntsville, AL and Washington, D.C.

Additional phases of the proposed action are contingent upon the feasibility of developing the SIRIUS-1 experiment. If the determination is made to proceed with the SIRIUS-1 experiment following Phase I, additional analysis under the National Environmental Policy Act (NEPA) will be conducted. It is anticipated Phase II would address preliminary and final design of the SIRIUS-1 experiment, fabrication of an irradiation test capsule and transient irradiation calibration test specimens, performance of transient irradiation calibration tests, fabrication of fuel specimens, assembling irradiation test experiment, performing transient testing at the Transient Reactor Test Facility (TREAT), developing data reports, conducting neutron radiography examination and post-irradiation examinations (PIE), developing examination reports, and developing and executing a test specimen disposal plan.

The following tasks comprise Phase I of the proposed action:

TASK 0: TREAT Capabilities Scoping Study

A capabilities and NTP test scoping study will be executed and documented in a report. The study will examine the range of tests that could be executed at TREAT and identify the post irradiation examination and testing activities that are applicable to NTP fuels. The study will consider the NTP fuel materials of importance to NASA and DOE that could be tested to make preliminary calculations of ramp rates, hold time and temperatures that could be achieved in both static capsule and flowing loop testing.

The following task comprise Phase II of the proposed action:

Task 1: SIRIUS-1 Static Capsule Test Conceptual Design and Design and Issue Functional and Operational Requirements (F&OR)

INL will develop and issue Functional and Operational Requirements (F&OR) based on notional test conditions and fuel specimen composition and specifications provided by NASA. INL will create sketches of potential irradiation test specimens and test specimen fixtures as positioned in SIRIUS-1 test capsule. The sketches will be used to develop computer models for performing neutronic, thermal, and structural calculations. The developed models will then be used to perform neutronic, thermal, and structural analyses to determine if the SIRIUS-1 experiment meets the desired test response. Design options for the SIRIUS-1 experiment will be evaluated as modeling results become available to determine preferred design. After evaluation, a decision will be made whether or not to proceed with the experiment. If the experiment is determined to be feasible, issuance of the F&OR completes Phase I.

Task 2: Develop SIRIUS-1 Post-Irradiation Examination (PIE) Plan

A PIE plan for the SIRIUS-1 experiment will be developed.

Task 3: SIRIUS-1 Capsule Prototype Fabrication and Assembly with Mock-Up Test Specimens

INL or an INL subcontractor will fabricate the prototype components to assemble into a completed mock-up assembly of the SIRIUS-1 capsule. The capsule prototype will include all necessary thermal protection materials and mock-up test specimens. This activity will facilitate design assembly concurrence.

Task 4: Develop Phase II Experiment Execution Plan

An Experiment Execution Plan (EEP) will be developed for subsequent Phase II tasks for designing, fabricating, irradiating, and performing PIE on the SIRIUS-1 experiment. The following experiment life-cycle activities will be addressed by Phase II:

1. Finalize and issue EEP
2. Perform preliminary design
3. Perform final design
4. Fabricate SIRIUS-1 irradiation test capsule
5. Fabricate SIRIUS-1 transient irradiation calibration test specimens
6. Perform SIRIUS-1 transient irradiation calibration tests
7. Fabricate SIRIUS-1 fuel specimens
8. Assemble SIRIUS-1 irradiation test
9. Conduct SIRIUS-1 transient tests
10. Develop SIRIUS-1 transient test data reports
11. Perform SIRIUS-1 neutron radiography examinations
12. Perform SIRIUS-1 post-irradiation specimen examinations
13. Develop SIRIUS-1 examination reports
14. Develop and execute SIRIUS-1 test specimen disposal plan.

Following Phase II, studies on cryogenically cooled specimen tests in flowing H_2 may be pursued. Phase III (SIRIUS-2) activities are anticipated to include the following:

1. Finalize and issue EEP
2. Perform preliminary design
3. Perform final design
4. Fabricate SIRIUS-2 irradiation test loop
5. Fabricate SIRIUS-2 transient irradiation calibration test specimens
6. Perform SIRIUS-2 transient irradiation calibration tests
7. Fabricate SIRIUS-2 fuel specimens
8. Assemble SIRIUS-2 irradiation test
9. Conduct SIRIUS-2 transient tests
10. Develop SIRIUS-2 transient test data reports
11. Perform SIRIUS-2 neutron radiography examinations
12. Perform SIRIUS-2 post-irradiation specimen examinations
13. Develop SIRIUS-2 examination reports
14. Develop and execute SIRIUS-2 test specimen disposal plan.

This environmental checklist analyzes the environmental impacts and aspects, and project work activities for Phase I specifically related to static capsule test conceptual design, development of functional and operating requirements, development of a PIE plan, and prototype fabrication and assembly with mock-up test specimens to facilitate design concurrence. Subsequent Phases (II and III) require additional NEPA analysis as specific activities are defined (e.g. waste profile and volume, air emissions, etc.).

If Phases II and III of the project are implemented, irradiated sample segments and PIE remnants would be stored after PIE with other similar DOE-owned irradiated materials and experiments at MFC, most likely in the HFEF or the Radioactive Scrap and Waste Facility (RSWF). Ultimate disposal of the irradiated sample segments and PIE remnants would occur along with similar DOE-owned irradiated materials and experiments currently at MFC which are generated from other research and development activities. Categorizing the material as waste is supported under DOE Order (O) 435.1, Att. 1, Item 44, which states "…Test specimens of fissionable material irradiated for research and development purposes only…may be classified as waste and managed in accordance with this Order..."

To complete proposed work activities, it is necessary for the project to use the HFEF hot cell which contains both defense and nondefense related materials and contamination. Project materials will come into contact with defense related materials. It is impractical to clean out defense related contamination, and therefore, waste associated with project activities is eligible for disposal at the Waste Isolation Pilot Plant (WIPP). National Environmental Policy Act (NEPA) coverage for the transportation and disposal of waste to WIPP are found in Final Waste Management Programmatic Environmental Impact Statement [WM

PEIS] (DOE/Environmental Impact Statement [EIS]-0200-F, May 1997) and Waste Isolation Plant Disposal Phase Supplemental EIS (SEIS-II) (DOE/EIS-0026-S-2, Sept. 1997), respectively. The 1990 Record of Decision (ROD) also stated that a more detailed analysis of the impacts of processing and handling transuranic (TRU) waste at the generator-storage facilities would be conducted. The Department has analyzed TRU waste management activities in the Final Waste Management Programmatic Environmental Impact Statement (WM PEIS) (DOE/EIS-200-F, May 1997). The WM PEIS analyzes environmental impacts at the potential locations of treatment and storage sites for TRU waste; SEIS-II addresses impacts associated with alternative treatment methods, the disposal of TRU waste at WIPP and alternatives to that disposal, and the transportation to WIPP.

SECTION C. Environmental Aspects or Potential Sources of Impact:

Air Emissions

This activity at MFC machine shop may create a small amount of emissions during prototype fabrication. Irradiation activities at TREAT and PIE at Hot Fuel Examination Facility and Irradiated Materials Characterization Laboratory may also contribute to radioactive emissions.

Generating and Managing Waste

No waste generation is expected in Phase I of this project other than typical office waste.

Phase II will likely generate cutting oils, scrap steel from fabrication activities. At the end of Phase I, the test activities for Phases II and III will be identified. The activities will determine what waste streams may be generated.

Releasing Contaminants

As described in the air emissions section above, radioactive air emissions are anticipated as a result of irradiation activities associated with this project.

Using, Reusing, and Conserving Natural Resources

All material would be reused and/or recycled where economically practicable. All applicable waste would be diverted from disposal in the landfill when possible. Project personnel would use every opportunity to recycle, reuse, and recover materials and divert waste from the landfill when possible. The project would practice sustainable acquisition, as appropriate and practicable, by procuring construction materials that are energy efficient, water efficient, are bio-based in content, environmentally preferable, non-ozone depleting, have recycled content, and are non-toxic or less-toxic alternatives. New equipment will meet either the Energy Star or Significant New Alternatives Policy (SNAP) requirements as appropriate (see https://sftool.gov/greenprocurement).

SECTION D. Determine Recommended Level of Environmental Review, Identify Reference(s), and State Justification: Identify the applicable categorical exclusion from 10 Code of Federal Regulation (CFR) 1021, Appendix B, give the appropriate justification, and the approval date.

For Categorical Exclusions (CXs), the proposed action must not: (1) threaten a violation of applicable statutory, regulatory, or permit requirements for environmental, safety, and health, or similar requirements of Department of Energy (DOE) or Executive Orders; (2) require siting and construction or major expansion of waste storage, disposal, recovery, or treatment or facilities; (3) disturb hazardous substances, pollutants, contaminants, or Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)-excluded petroleum and natural gas products that pre-exist in the environment such that there would be uncontrolled or unpermitted releases; (4) have the potential to cause significant impacts on environmentally sensitive resources (see 10 CFR 1021). In addition, no extraordinary circumstances related to the proposal exist that would affect the significance of the action. In addition, the action is not "connected" to other action actions (40 CFR 1508.25(a)(1) and is not related to other actions with individually insignificant but cumulatively significant impacts (40 CFR 1608.27(b)(7)).

References: 10 CFR 1021, Appendix B, B3.6, "Small-scale research and development, laboratory operations, and pilot projects"

Final Environmental Impact Statement for the Waste Isolation Pilot Plant (DOE/EIS-0026, October 1980) and Final Supplement Environmental Impact Statement for the Waste Isolation Pilot Plant (SEIS-I) (DOE/EIS-0026-FS, January 1990)

Final Waste Management Programmatic Environmental Impact Statement [WM PEIS] (DOE/EIS-0200-F, May 1997) and Waste Isolation Plant Disposal Phase Supplemental EIS (SEIS-II) (DOE/EIS-0026-S-2, Sept. 1997)

Justification: Project activities are consistent with 10 CFR 1021, Appendix B, B3.6, "Siting, construction, modification, operation, and decommissioning of facilities for small-scale research and development projects; conventional laboratory operations (such as preparation of chemical standards and sample analysis); and small-scale pilot projects (generally less than 2 years) frequently conducted to verify a concept before demonstration actions provided that construction or modification would be within or contiguous to a previously disturbed or developed area (where active utilities and currently used roads are

readily accessible). Not included in this category are demonstration actions, meaning actions that are undertaken at a scale to show whether a technology would be viable on a larger scale and suitable for commercial deployment."

The impacts of transporting and disposing of waste resulting from defense activities that was placed in retrievable storage pursuant to a 1970 Atomic Energy Commission policy (see Section 1.2) and TRU waste that was reasonably expected to be generated by ongoing activities and programs was analyzed in DOE/EIS-0026 (October 1980) and the Final Supplement Environmental Impact Statement for the Waste Isolation Pilot Plant (SEIS-I) (DOE/EIS-0026-FS, January 1990).

NEPA coverage for the transportation and disposal of waste to WIPP are found in DOE/EIS-0200-F (May 1997) and Waste Isolation Plant Disposal Phase Supplemental EIS (SEIS-II) (DOE/EIS-0026-S-2, Sept. 1997), respectively. The 1990 ROD also stated that a more detailed analysis of the impacts of processing and handling TRU waste at the generator-storage facilities would be conducted. DOE has analyzed TRU waste management activities in DOE /EIS-200-F (May 1997). The WM PEIS analyzes environmental impacts at the potential locations of treatment and storage sites for TRU waste; SEIS-II addresses impacts associated with alternative treatment methods, the disposal of TRU waste at WIPP and alternatives to that disposal, and the transportation to WIPP. (SEIS-II also includes potential transportation between generator sites.)

Is the project funded by the American Recovery and Reinvestment Act of 2009 (Recovery Act) ☐ Yes ☒ No

Approved by Jason Sturm, DOE-ID NEPA Compliance Officer on: 10/23/2017