DOE-ID NEPA CX DETERMINATION
Idaho National Laboratory

CX Posting No.: DOE-ID-INL-19-090

SECTION A. Project Title: FINESSE Experiment

SECTION B. Project Description and Purpose:

Pressure vessel manufacturing and assembly presents rate-limiting challenges for constructing new advanced nuclear power systems. Using current methods qualified by the Nuclear Regulatory Commission (NRC) requires forging heavy components, machining these components to specifications, and conventional arc welding, and these processes take more than two years to complete. The proposed project investigates using electron beam (EB) welding and powder metallurgy with hot isostatic pressing (PM-HIP) to reduce vessel fabrication time and cost.

EB welding reduces embrittlement and produces weld in a fraction of the time as conventional nuclear arc welding processes. In addition, using PM-HIP base materials enables reactor component fabrication near-net shape, which reduces reliance on machining and joining, simplifies component inspections, and further reduces production time. The combination of EB welding and PM-HIP could enable the production of high-quality pressure vessel components with no evidence of a weld seam or heat affected zone (HAZ) after a solution anneal, quench, normalization, and tempering (SQNT) treatment.

This project assesses EB weld performance, safety, and structural and mechanical integrity on PM-HIP pressure vessel steel under service-relevant irradiation conditions. Specifically, the proposed action focuses on PM-HIP pressure vessel steel A508 containing autogenous single-pass EB welds. Samples undergo post weld heat treatment (PWHT), SQNT, or no heat treatment then INL irradiates the specimens in the Advanced Test Reactor (ATR) to a maximum fluence of 0.5 dpa at 300°C.

EB welding utilizes a high energy electron beam as the heat source to melt the materials being joined. EB welding is performed under vacuum conditions, where the electrons can be accelerated to gain enough kinetic energy. These conditions also minimize contaminants in the weld, inherently reducing embrittlement. The narrow, high intensity electron beams produce localized welding with rapid heating and cooling, resulting in a small and often non-detectable heat affected zone (HAZ), and with weld centerline grain structures consistent with those of the base metal.

EB weld speed and power are critical process parameters that significantly affect the weld microstructure, microchemistry, and defect formation. INL must also optimize the PWHT to attain desired mechanical performance. Researchers have optimized EB weld parameters and designed a SQNT treatment of 1120°C solution anneal, water quench, 870°C normalization, and 650°C tempering. These conditions eliminate the EB weld HAZ, with weld centerline grain structures identical to those in the base metal. A 607°C post-weld heat treatment also exhibits promising microstructural results.

Following irradiation in ATR, INL ships experiment components from the ATR canal to the Hot Fuels Examination Facility (HFEF) at the Materials and Fuels Complex (MFC) using the BEA Research Reactor (BRR) cask or equivalent. Post irradiation examination (PIE) will take place at the Center for Advanced Energy Studies (CAES) / Irradiated Materials Characterization Laboratory (IMCL) and Westinghouse. Shipments of irradiated experiment material to off INL locations would be shipped in Type A packages. Typically, Type A packages are used to transport radiopharmaceuticals (radioactive materials for medical use) and certain regulatory qualified industrial products.

PIE uses scanning electron microscopy (SEM) to investigate grain and phase structure, transmission electron microscopy (TEM) to measure dislocation loops and voids, and atom probe tomography (APT) to quantify irradiation-induced nano-precipitates. Small-scale mechanical tests, including nanoindentation and shear punch testing, evaluate irradiation effects on elastic properties and hardness. The proposed action also carries out fracture toughness testing on miniature specimens from all regions of the weld (centerline, HAS, and base metal) using computed tomography (CT). Fracture testing informs quantitative fracture toughness, qualitative fracture mode, and the irradiation-induced ductile-to-brittle transition temperature (DBTT) shift. Microstructure and small-scale mechanical tests enable researcher understanding of the mechanisms that induce DBTT shift. Researchers use experimental results to validate GRIZZLY cohesive zone and crystal plasticity models for pressure vessel DBTT, enabling code case development.

All irradiated samples deemed to have research value will be placed in the NSUF sample library located at HFEF upon conclusion of the project. Low level waste (LLW) generated during PIE would likely be transferred to the Nevada National Security Site. It is expected that all generated wastes would be managed under current BEA waste management plans and procedures.

SECTION C. Environmental Aspects or Potential Sources of Impact:

Air Emissions

The proposed action has the potential to generate radiological and chemical emissions from ATR and PIE facilities. An Air Permit Applicability Determination (APAD) may be required.

Irradiation activities in the ATR are not modifications in accordance with Idaho Administrative Procedures Act (IDAPA) 58.01.01.201 and 40 Code of Federal Regulation (CFR) 61 Subpart H. ATR radionuclide emissions are sampled and reported in accordance with Laboratory Wide Procedure (LWP)-8000 and 40 CFR 61 Subpart H. All experiments are evaluated by Environmental Support and Services staff. All radionuclide release data (isotope specific in curies) directly associated with any future irradiation will be calculated and provided to the Environmental Support organization and evaluated in additional NEPA analysis as required.

All radionuclide release data associated with future PIE needed for completion of the proposed tasks will be recorded as part of the HFEF continuous stack monitor. PIE examination in HFEF is not a modification in accordance with Idaho Administrative Procedures Act (IDAPA) 58.01.01.201 and 40

Code of Federal Regulation (CFR) 61 Subpart H.

Minor releases of radioactive material are expected from analytical efforts at CAES. These potential emissions would be covered by the radioactive material license for the CAES facility.

Generating and Managing Waste

Small amounts of office, industrial, and low-level radioactive waste are anticipated. All Solid Waste will be managed by INL Waste Generator Services. Waste generated at CAES will be managed according to CAES procedures.

Releasing Contaminants

Chemicals will be used and submitted to chemical inventory lists with associated Safety Data Sheets (SDSs) for approval prior to use. The Facility Chemical Coordinator will enter these chemicals into the INL Chemical Management Database. All chemicals will be managed in accordance with laboratory procedures. When dispositioning surplus chemicals, project personnel must contact the facility Chemical Coordinator for disposition instructions.

Although not anticipated, there is a potential for spills when using chemicals. In the event of a spill, notify Environmental Staff. If Environmental Staff cannot be contacted, report the release to the Spill Notification Team (208-241-6400). Clean up the spill and turn over spill cleanup materials to WGS.

Type A packages must demonstrate their ability to withstand a series of tests without releasing the contents. Regulations require that the package protect its contents and maintain enough shielding under conditions normally encountered during transportation to protect the public, transportation workers, and the environment from potential exposure to radiation during transportation.

Using, Reusing, and Conserving Natural Resources

All materials will be reused and recycled where economically practicable. All applicable waste will be diverted from disposal in the landfill where conditions allow.

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 to subpart D, items B3.6, "Small-scale research and development, laboratory operations, and pilot projects"

Final Site-Wide Environmental Impact Statement for the Continued Operation of the Department of Energy/National Nuclear Security Administration Nevada National Security Site and Off-Site Locations in the State of Nevada (DOE/EIS-0426, December 2014).

Justification: The proposed R&D activities are consistent with CX 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); 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 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 environmental impacts of transferring LLW from the INL Site to the Nevada National Security Site were analyzed in the 2014 Final Site-Wide Environmental Impact Statement for the Continued Operation of the Department of Energy/National Nuclear Security Administration Nevada National Security Site and Off-Site Locations in the State of Nevada (DOE/EIS-0426) and DOE's Waste Management Programmatic EIS (DOE/EIS-200). The fourth Record of Decision (ROD) (65 FR 10061, February 25, 2000) for DOE's Waste Management Programmatic EIS established the Nevada National Security Site as one of two regional LLW and MLLW disposal 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: 01/21/2020