

DOE-ID NEPA CX DETERMINATION

SECTION A. Project Title: Development of a High-fidelity Flow Boiling Database for Validation of High-void-fraction Flow Regime Models– University of Michigan

SECTION B. Project Description

The University of Michigan (UM) proposes to develop a comprehensive, high-resolution, multiphase computational fluid dynamics (MCFD) validation-grade flow boiling database from rod-bundle geometry simulating current light water reactor (LWR) fuel designs by taking advantage of the instrumentation and facilities developed by the research team. In addition, the applicability of the data through initial evaluations of selected test cases using Nek-2P, the MCFD component of the NEAMS toolkit, boiling closure models will be studied and demonstrated for two-phase flow simulations. The following specific project scope is proposed: 1) Perform detailed and systematic uncertainty quantification for the instruments developed in the research team's labs and other two-phase instruments that will be employed in this project, including X-ray radiography, high-speed imaging, Particle Image Velocimetry (PIV) and Planar Laser-Induced Fluorescence (PLIF) techniques, gamma densitometer, wire-mesh sensor, conductivity probe, and hot-film anemometry, to determine the applicable ranges (void fraction and flow regimes) and associated measurement uncertainties for each selected measurement technique; 2) Experimentally investigate the flow boiling from subcooled boiling to film boiling over a wide void fraction range in a tubular and a rod-bundle test section up to 6.89 MPa pressure; and 3) Validate and improve boiling-related closure models in the Nek-2P code using the acquired high-resolution flow boiling database. These closure models can potentially be applied to other MCFD codes.

SECTION C. Environmental Aspects / Potential Sources of Impact

An existing water boiling test facility at the University of Michigan will be used to perform water flow boiling experiments. Two instrumentation systems based on radiation are planned to be used for acquiring void fraction data: 1) A gamma densitometer system acquired from Berthold Technologies. It includes a sealed gamma source (Cs-137 of 20 mCi), installed in a sealed container made of SS 316L; and 2) A high-speed X-ray radiography system developed by the co-PI Prof. Manera's group. The system consists of an X-ray tube, a generator, and an imaging detector. Radioactive Material Use (existing): 1) Gamma source: Cs-137 of 20 mCi; and 2) X-ray source: generated by a VADIAN G-1092 X-ray tube and a 65-kW Indico IQ generator (150 kV, 800 mA). The UM PI and research partners have procedures in place to handle the gamma and X-ray sources.

SECTION D. Determine the Level of Environmental Review (or Documentation) and Reference(s): Identify the applicable categorical exclusion from 10 CFR 1021, Appendix B, give the appropriate justification, and the approval date.

Note: 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, including requirements of DOE orders; 2) require siting and construction or major expansion of waste storage, disposal, recovery, or treatment facilities; 3) disturb hazardous substances, pollutants, contaminants, or CERCLA-excluded petroleum and natural gas products that pre-exist in the environment such that there would be uncontrolled or unpermitted releases; 4) adversely affect environmentally sensitive resources. In addition, no extraordinary circumstances related to the proposal exist which would affect the significance of the action, and the action is not "connected" nor "related" (40 CFR 1508.25(a)(1) and (2), respectively) to other actions with potentially or cumulatively significant impacts.

References: 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). For purposes of this category, "demonstration actions" means actions that are undertaken at a scale to show whether a technology would be viable on a larger scale and suitable for commercial deployment. Demonstration actions frequently follow research and development and pilot projects that are directed at establishing proof of concept.

Justification: The activity consists of an investigation to develop a comprehensive, high-resolution, high-quality water flow boiling database of high void fractions that will support the development and validation of Nek-2P and other MCFD codes for potential industry applications.

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

Approved by Jason Anderson, DOE-ID NEPA Compliance Officer, on 09/17/2021.