

DOE-ID NEPA CX DETERMINATION

Idaho National Laboratory

SECTION A. Project Title: High Power and High Temperature Heat Pipes for Small and Modular Reactors

SECTION B. Project Description and Purpose:

Revision 1:

Revision 1 changes the ECP to a first tier to address the offsite testing at Advanced Cooling Technologies, Inc. (ACT). of components fabricated at the INL. This revision also identifies known scope of Phase II of the project which was mentioned in the original ECP. Phase II of the project will include printing porous SST wicks, which are essentially small tubes with porous walls for pore size, permeability and porosity characterization at ACT and INL. The testing at ACT will use sodium, whereas the characterization at INL will be performed using SEM and the X-ray microscope at IMCL (no working fluids, no waste or emissions). Items sent to ACT will be returned to the INL after completion of testing.

Original:

Advanced Cooling Technologies, Inc. (ACT) is a developer and manufacturer of heat pipes, pumped liquid and two-phase loops, and thermal storage devices. ACT's products have been used in applications from spacecraft thermal management to medical surgery temperature control, at temperatures ranging from -150 to 1,100°C. ACT was awarded a Phase I Small Business Innovation Research (SBIR) award for Funding Opportunity Number: DE-FOA-0002146 Topic 37. Advanced Technologies for Nuclear Energy, Subtopic: Small Modular Reactor Capabilities, Components, and Systems. ACT reached out to Idaho National Laboratory (INL) to assist with developing advanced wick architectures for high power and high temperature heat pipes for small and modular reactors.

INL is currently performing research in the areas of nuclear energy and advanced manufacturing of microreactor components and systems. Heat pipes provide a means of transporting heat from the reactor core to the power conversion system. However, there are currently no licensed nuclear reactors in the U.S. that rely upon heat pipes as a primary means of transporting heat from a reactor core. This technology needs further development to ensure acceptable performance and safety of heat pipe cooling systems. The ACT recognized the INL's expertise and requested INL's assistance with the project.

ACT has proposed to develop high performance wicks for thermosyphons and integrate them in nuclear reactor applications. The specific technical objectives of the Phase I DOE SBIR program are listed below:

- Develop two preliminary wick configurations that would separate working fluid vapor flow from liquid flow and eliminate the traditional flooding limitation to enhance the thermosyphon performance. This will be done by initial wick design and coupon testing and model validation. It is expected that a new performance limit will be introduced – the liquid return limit, which is significantly higher and will compete with the entrainment limit.
- Develop plans for manufacturing to optimize the relationship between wick performance and fabrication cost.
- Develop a mathematical model for both wick configurations and validate the model with all the coupons and heat pipe prototypes developed during Phase I. The process will start early in the program and it will be carried an iterative fashion tightly linked to the other tasks. In the end, the format of the mathematical model will allow it to extend the capabilities of Sockeye (the heat pipe code currently being written in the MOOSE framework). The incorporation of this specific sub-model will be carried by the MOOSE staff.
- Develop prototypes compatible with nuclear reactor applications for both hot and cold ends of the conversion system. The hot end would be alkali metal thermosyphons while the cold end would potentially be water (or one of toluene, pentane or methanol) thermosyphons (or single-phase pumped loop). In the role of consultant, INL will provide guidance during the relevant to nuclear reactor prototype development. Fabrication of the prototypes will occur at the Energy Innovation Laboratory (EIL) and the INL Research Center (IRC). Prototypes may be 3D printed in EIL C-314 using off-the-shelf stainless steel resins. The printed prototypes would be subjected to a binding/debinding process using furnaces at the IRC. These prototypes will be provided to ACT for testing at their facility.

The success of Phase I technical objectives will demonstrate high performance wicks for thermosyphons to be used in microreactor applications. A path for advanced development of the thermosyphons and their modeling and design tools in Phase II will be shown at the end of Phase I. Prototypes for irradiation testing that will be further performed by INL will be also developed in Phase II.

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Task No.	Tasks	Contractor Role/Responsibilities	Participant/Sponsor Role/Responsibilities	Task Duration
1	Proposed Concept Wick Architecture Generation	Consult on system design and fabrication	Generate and analyze two wick configurations/architectures	Months 1-4
2	Mathematical Model Development	Provide technical input for the heat pipe modeling effort	Develop an experimentally validated sub-model for these wick designs will be provided for incorporation into the MOOSE heat pipe code, Sockeye.	Months 2-5
3	Water Based Reduced Scale Advanced Wick Prototype Development	Assist with wick design for arterial and annular water (or one of methanol, toluene or pentane)-copper/Monel reduced scale heat pipes	Develop, build and test water-copper/Monel reduced scale heat pipes with arterial and annular wicks	Months 5-7
4	Sodium Based Reduced Scale Advanced Wick Prototype Development	Assist with wick design for arterial and annular sodium-stainless steel reduced scale heat pipes	Develop, build and test sodium-stainless steel reduced scale heat pipes with arterial and annular wicks	Months 6-8
5	Full Scale Prototype Development	Provide design requirements in terms of actual geometry (total length, diameter, evaporator size, condenser size, NCG reservoir size and location) temperature of operation power to be transported	Fabricate sodium-filled heat pipe prototype	Months 7-9
6	Reporting	Provide input for reports	Prepare two quarterly reports and a Final report	Months 3,6,9

SECTION C. Environmental Aspects or Potential Sources of Impact:

Air Emissions

Operation of the furnaces will generate air emissions covered by existing APADs for IRC.

Discharging to Surface-, Storm-, or Ground Water

N/A

Disturbing Cultural or Biological Resources

N/A

Generating and Managing Waste

Scrap metal will be recycled to the extent practicable. Laboratory furniture that is no longer needed will be repurposed elsewhere or sent to excess. All Solid Waste will be managed by WGS.

Releasing Contaminants

Although not anticipated, there is a potential for spills when using chemicals. In the event of a spill, notify facility 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.

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Using, Reusing, and Conserving Natural Resources

All applicable waste will be diverted from disposal in the landfill when possible. Project personnel will use every opportunity to recycle, reuse, and recover materials and divert waste from the landfill when possible. The project will 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 SNAP requirements as appropriate (see <http://www.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 to subpart D, items B3.6, "Small-scale research and development, laboratory operations, and pilot projects"

Justification: The proposed activities are consistent with the categorical exclusion, 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."

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:1/27/2021