DOE-ID NEPA CX DETERMINATION
Idaho National Laboratory

CX Posting No.: DOE-ID-INL-22-020 R1

SECTION A. Project Title: X-Wave Self-Powered Wireless Sensor System Irradiation R1

SECTION B. Project Description and Purpose:

Revision 1

X-Wave Innovations Inc(XII) is preparing to meet this critical need by developing the innovative self-powered, wireless sensor system (SPWSS). Through Phase I and Phase II programs, This SBIR Phase IIB program is a continuation of Phase I and Phase II programs under the same title. The goal of this Phase IIB project is to refine the prototype sensor system such that it is in a good position for commercialization. The Phase I sensor has been kept at INL for Phase II project use. No new sensor will be created. After all testing is finished, the sensor from Phase I (sample) will be sent to XII. This project work will only involve gamma radiation and will be examined by INL radiological services before release to XII. XII and its partners developed a SPWSS prototype. The prototype exploits the advantages of both surface acoustic wave (SAW) sensor technology and bulk acoustic wave (BAW) data communication technology to provide simultaneous measurements of temperature, pressure, humidity, gas species, etc. inside stainless-steel dry storage canisters and wirelessly transmit measurement data through the thick stainless-steel walls without direct connection. The internally installed SAW and BAW sensors are powered by a thermoelectric device that harvests electrical energy from heat generated by the nuclear fuel. Therefore, the time-interval between two fully charged (or discharged) states of the capacitor that triggers the measurements correspond to the radiation level or temperature of the fuel.

In the current Phase IIB program, the focus will be to fine-tune the SPWSS system with improved hardware and software and integrate it with a dry-storage cask system as an entry showcase for commercialization. Specifically, to improve, validate, and calibrate the measurement sensitivity and accuracy of the SPWSS system, and if necessary, expand its sensing capabilities for fission gases (e.g., Kr 85). Systematic experiments will be conducted to verify and validate the SPWSS measurement results, including irradiation testing at INL. At the end of this phase, there should be a fully functional SPWSS system ready for commercialization as a turnkey product for passive, remote, and long-term monitoring of internal conditions of nuclear fuel dry-storage casks. XII will conduct the activities for fine-tuning the SPWSS at the same time INL is performing the irradiation testing.

INL will do the irradiation testing for the developed SAW sensor and BAW transducers by exposing them to a significant quantity of gamma radiation to ensure sensor survival in dry nuclear cask. Setup work will be done in the Measurement Sciences Lab, EIL Room B-114. Gamma irradiation will be conducted at the Advanced Test Reactor(ATR) gamma tube. Total dose is not defined and will be dependent on available irradiation time. Deliverables will be provided to XII from INL and will include collected data from test sensors and total irradiation dose. A small amount of soldering flux (milliliter) and isopropanol (centiliter) will be used at the Measurement Sciences Laboratory(MSL) in EIL along with a few cleaning wipes. Mixed waste may be generated rom possible contamination. The sensor being tested will not become radioactive but will be analyzed after irradiation to check for contamination. ATR radiological technicians will check for contamination that might be transferred from the tube to the test piece with the use of a few(<0.5 kg) cloth wipes and anti-contamination PPE.

Original ECP

INL will provide access to X-Wave Innovations for neutron and gamma irradiation testing of sensor components consisting of sensing unit, wireless power system, ultrasonic communication devices. The sensor unit will be assembled in easy to handle aluminum container and will be provided for irradiation. The total weight of the assembly will be around 4 kg.

Neutron irradiation is to be performed at the NRAD reactor located in the Hot Fuel Examination Facility (MFC-785) at the Materials and Fuels Complex (MFC). Neutron irradiation is expected to take one 24-hour cycle in NRAD to reach desired fluence and is anticipated to start in April, 2022. Waste materials will include sensor components exposed to neutron radiation and may include Al 6061, 316 or 304 stainless steel, LiNbO3, Cr(20nm)/Au(500nm) thin film (adhered to the LiNbO3), alumina, machinable oxide ceramics, aluminum, fused quartz, and tungsten. All components irradiated in NRAD will be considered low level radioactive waste to be disposed of using in-place procedures.

Gamma irradiation is to be performed using a Co-60 gamma irradiator located at either the Energy Innovation Laboratory (IF-688) building in REC or Fuels and Applied Science Building (MFC-787) at MFC, depending on availability. Gamma irradiation is expected to take two to four weeks and is anticipated to start in April, 2022. Gamma irradiation is not expected to produce any waste materials or emissions and the test samples may be returned to X-Wave for further study. The project has the potential to generate mixed waste.

SECTION C. Environmental Aspects or Potential Sources of Impact:

Air Emissions

Small amounts of isopropanol will evaporate.

There will be no air emissions from the gamma irradiation at ATR, as the tube is open to atmosphere within the canal area and the air in the tube is static.

Discharging to Surface-, Storm-, or Ground Water

NA

Disturbing Cultural or Biological Resources

FASB (MFC-787) is over 50 years old. However, no structural or aesthetic changes will be made to the building.

Generating and Managing Waste

Small amounts of soldering flux, isopropanol, and general industrial waste(cleaning wipes) will be used at EIL for setup.

No generation of radiological waste is expected for the work being performed at ATR. Anti-contamination PPE will be used and disposed of properly along with a generation of cloth wipes from performing swipes of the sensor from Radiological technician personnel. Gamma irradiation at EIL/ FASB is not expected to produce any waste materials or emissions and the test samples may be returned to X-Wave for further study.

Waste materials will include sensor components exposed to neutron radiation and may include Al 6061, 316 or 304 stainless steel, LiNbO3, Cr(20nm)/Au(500nm) thin film (adhered to the LiNbO3), alumina, machinable oxide ceramics, aluminum, fused quartz, and tungsten. All components irradiated in NRAD at HFEF will be considered low level radioactive waste to be disposed of using in-place procedures. The project also has the potential to generate mixed waste at NRAD.

Releasing Contaminants

When chemicals are used during the project there is the potential for spills that could impact the environment (air, water, soil).

Using, Reusing, and Conserving Natural Resources

Project description indicates materials will need to be purchased or used that require sourcing materials from the environment. Being conscientious about the types of materials used could reduce the impact to our natural resources.

Equipment will be returned to X-Wave.

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:

B3.6 "Small-scale research and development, laboratory operations, and pilot projects"

Justification:

B3.6 Small-scale research and development, laboratory operations, and pilot projects. 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 L. Anderson, DOE-ID NEPA Compliance Officer on: 6/22/2023