Harvest Materials from the NRU Reactor – Implementation Phase (Leads: R. DeAbreu & W. Li)

Objectives:

1. Extract material and components from NRU for R&D collaborations and programs.
2. Establish collaborations with external partners and pursue research opportunities using NRU materials of mutual interest.

Federal Stakeholders:

- Canadian Nuclear Safety Commission
- Natural Resources Canada

Completed:

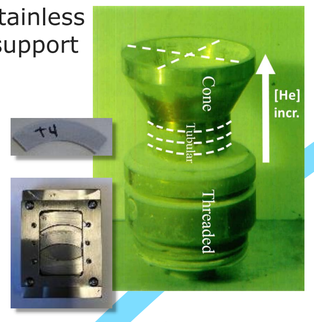
- ✓ Development of work plans for extraction of high-value NRU materials and components
- ✓ Extraction of gamma-irradiated copper tubing (NWMO waste container) and three 304 stainless steel header cups (weldability collaboration study)
- ✓ Creation of relational database of NRU harvest materials and components
- ✓ Engagement of several organizations for potential research collaborations

Oak Ridge National Laboratory (United States)

304 Stainless Steel Lower Header Cups

To study weldability of 304 stainless with high helium content to support power reactor life extension, specifically of reactor vessel.

Scope: Fabricate coupons & holders; perform welding trials on irradiated material varied helium concentration using laser-beam welding; examine post-weld microstructure.



Expected Outcomes: Assessment of repair techniques of highly irradiated materials

Nuclear Research and Consultancy Group (Netherlands)

Aluminum Alloy 5052 from Iodine-125 Rod

To study fracture toughness of irradiated Al-5052 to support research reactor life extension, specifically of reactor vessel.

Scope: Machine test specimens (CT and Charpy) from I-125 rod, perform tests at NRG, and analyze test data.

Expected Outcomes: Joint research publication; CNL develops expertise in Charpy testing

Side-grooved compact toughness (CT) specimen

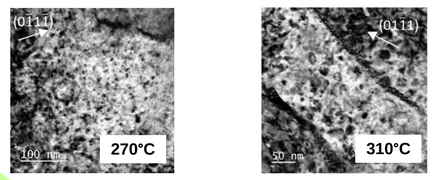
Queen's University (Canada)

Inconel X-750 Tie Rod; Zr-2.5Nb Loop Liner Tubes

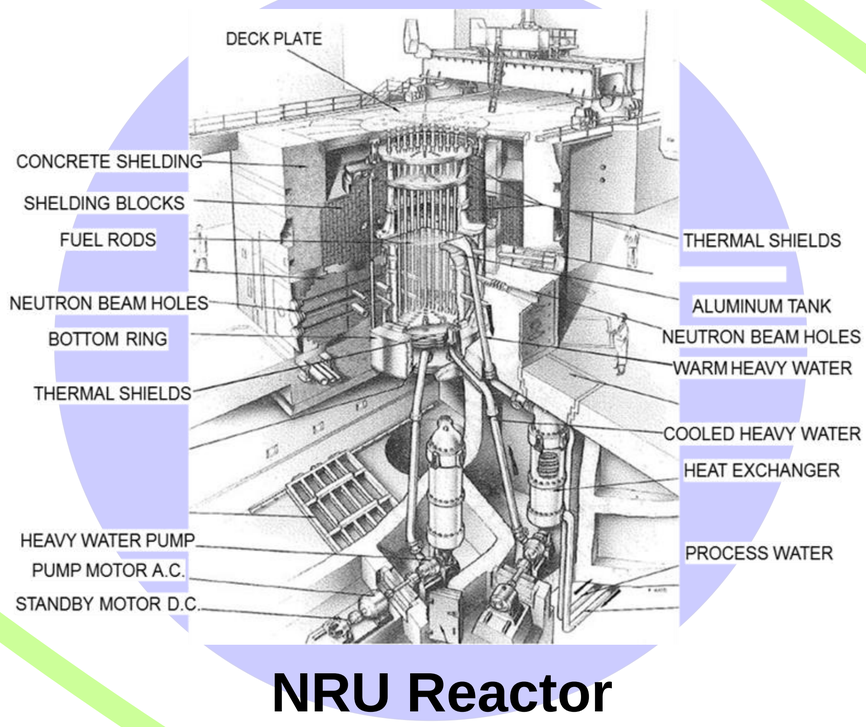
To determine the effect of neutron irradiation and irradiation temperature on the mechanical properties and microstructure of in-core materials.

Scope: Fabricate samples and perform post-irradiation examination (TEM, XRD) and testing (nanohardness) on irradiated materials.

Expected Outcomes: Joint research publications; development of highly qualified personnel (HQP)



Zr-2.5Nb pressure tube microstructure at 2.5e25 n·m^{-2}·(E > 1 MeV)



NRU Reactor

Nuclear Waste Management Organization (Canada)

Copper Tubing from Upper Service Space

To study the effects of elevated levels of gamma radiation on copper to support NWMO's used nuclear fuel container design for Canada's safe long-term used-fuel management.

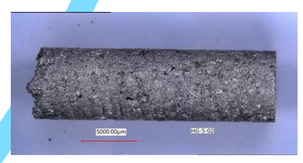
Scope: Perform metallographic analysis and surface oxide characterization.

Expected Outcomes: Increased confidence in container safety case; closer CNL-NWMO relationship

Oak Ridge National Laboratory (United States)

Graphite Cores from Thermal Column

To study microstructural degradation of graphite irradiated at low temperatures (20–230°C).

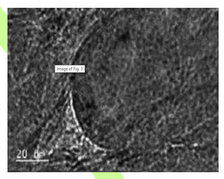


Applications:

Graphite-moderated Gen IV reactors; structural graphite in British advanced gas-cooled reactors (AGRs)

Scope: Perform microstructural characterization of neutron-irradiated graphite using Brunauer–Emmett–Teller (BET) and Transmission Electron Microscopy (TEM).

Expected Outcomes: Joint research publication; CNL gains expertise in graphite for SMR applications



Graphite microstructure (TEM) [https://doi.org/10.1016/j.carbon.2018.08.039]

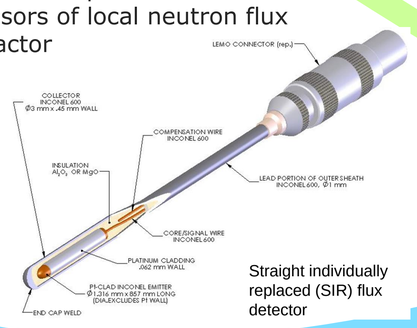
CANDU Owners Group (Canada)

Self-Powered NRU Loop Flux Detectors

To develop an objective guideline for failure prediction for CANDU flux detectors, which are used as sensors of local neutron flux and level indicators of the CANDU reactor safety/shut-down system.

Scope: Study the degradation and failure mechanisms of the NRU SIR flux detector and their correlation with detector signals.

Expected Outcomes: Potential COG R&D project



Straight individually replaced (SIR) flux detector

Massachusetts Institute of Technology (United States)

Aluminum Alloy 5052 from Iodine-125 Rod; Inconel X-750 Tie Rod; Zr-2.5Nb Loop Liner Tubes

To assess neutron embrittlement of in-core materials.

Scope: Supply neutron-irradiated Al 5052, Zr-2.5Nb and Inconel X-750 with associated characterization info, provide CNL's expertise on irradiation damage mechanisms, and advance development of new real-time NDE technique and instrument (transient gradient spectroscopy).

Expected Outcomes: Development of novel NDE technique

Publications:

- C.D. Judge et al., Microstructural Characterization of Proton Irradiated 304L SS at 100°C and 360°C, 19th International Conference on Environmental Degradation of Materials in Nuclear Power Systems – Water Reactors, Boston, Massachusetts, 2019 August 18-22.
- M.A. Mattucci, Nano-Mechanical Testing of Proton Irradiated 304L SS at 100oC and 360°C to Support IASCC, 19th International Conference on Environmental Degradation of Materials in Nuclear Power Systems – Water Reactors, Boston, Massachusetts, 2019 August 18-22.