[Form 2 (to be reported to Committee on Countermeasures for Contaminated Water Treatment and to be disclosed to public)

Technology Information	
Area	4 – Management of contaminated water inside the buildings
Title	4-1 – Technologies to block water inside the buildings
Submitted by	Candu Energy Inc., SNC-Lavalin, Atomic Energy of Canada Ltd., Canadian Nuclear Partners

1. Overview of Technologies (features, specification, functions, owners etc.)

We are proposing the following technologies:

Technology 1: Locating and repairing large leak sources from inside of the structures. Significant discontinuities (i.e. gaps around the penetrations, construction joints, cracks, etc.) are to be located using remote camera. Depending on the location, type and size of discontinuities, repairs can be done remotely using materials that have proven field performance and can be applied under water if it is not possible to pump out water for such a time as to execute repair. Methods to be used will be similar to conventional methods of crack injection, patching and joint sealant replacement but performed using robotic manipulators. Locating and repairing large discontinuities in structures can significantly minimize in leakage of water.

Technology 2: Identifying suitable areas inside buildings, based on geometry, leakage data, and results of camera inspection and filling those areas with the material that will significantly reduce the amount of water leaking into the buildings. The type(s) of material to be used will depend on the environmental conditions (i.e. temperature and radiation) and geometry of the space (confinement). Materials such as concrete, cementitious grout and polyurethane may be considered. Depending on the velocity of water in-leakage, a combination of fast-setting expanding and slower setting filling materials may be used.

2. Notes (Please provide information if possible)

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The Candu consortium has an assortment of remotely controlled robotic technologies that can operate in high radiation fields. The team have customized these technologies to successfully conduct remote activities (e.g. welding, NDE) on research and operating reactors in extreme radiation fields. The approach is to use engineering and robotic solutions to tackle tough project in high radiation fields. The consortium has some robots in its fleet that are ready for use; however, those would have to be customized for these particular applications.
The Candu consortium has extensive experience related to designing and applying tooling for remote operation in radioactive environment. Few examples are provided below.

- A project that required cutting of Pressure Tube (PT) and End Fitting (EF) sections located in the spent fuel bay was recently completed. The tooling was capable to transfer the equipment from the dry storage to the spent fuel bay. Work included the transfer of the equipment from

the flask to the platform, performing the inspection and marking of the cut locations, performing underwater cutting of the PT and EF sections. The system was equipped with an onboard filtering system that would catch all the cutting chips in a filtering unit and recycle the water back into the fuel bay. The cutting system was composed of a hydraulic motor and a cutting wheel driven by hydraulic pump located outside the fuel bay. The project was a success and all the necessary inspection and the cuts were performed within the schedule.

- We developed tooling for underwater camera inspections of spent fuel transfer structures in areas with accessibility constraints (due to geometry and radiation) at a nuclear research facility. Inspections to locate discontinuities in concrete were performed remotely, underwater using camera and recording equipment.
- Corrosion of the aluminum reactor vessel had thinned the wall and caused perforation in several areas and the vessel wall was corroded in a few places from the outside. The nearest human access was 30 ft above the repair site with access through a 4.75 inch diameter hole, also repair of irradiated aluminum made this repair a complex challenge. It was recognized early in the program that a variety of remote tools would be required to execute such a complex repair. One of the main custom tools produced was a complex remote welding tool to apply weld deposit on the inner surface of the reactor vessel. For the areas of perforation, aluminum patching plates were used. We successfully developed, build, deployed and used the tooling to effect repairs.
- The Calandria Inspection Tool (CVIT) was developed to perform inspections of the inside of the reactor vessel via an operator on the tooling platform located outboard of the reactor face. The CVIT tool consists of two RAD tolerant cameras, 1 colour with zoom capability, and 1 black and white. Initial inspections performed found debris located inside of the Calandria requiring the development of a Debris Removal Tool (DRT). Both tools are approximately 20 feet long and have articulating and telescoping arms. These tools can cover a 360 ° rotation and 100° arm flexion and are controlled by manual operations from operators located on the reactor platforms. The DRT has interchangeable scoops with the ability to pick up large items such as swab cloths, and the dexterity to pick up small items such as wires.

The Candu consortium has in-depth knowledge of materials that can be used for effective waterproofing of the structures and are qualified for use in radioactive environment with elevated temperatures. The Candu consortium is working with a few manufacturers of concrete repair materials with proven track record of application in nuclear industry.

The Candu consortium has extensive experience with inspecting and waterproofing structures both above ground as well as underground. Few examples of recently completed projects include:

- Replacement of degraded concrete and protective coating for Reactor Building and Auxiliary structures at NPP suffering degradation due to moisture exposure;
- Application of waterproofing coating for spent fuel canisters;
- Injection of cracks in spent fuel canisters;
- Injection of leaking areas of the underground nuclear facility;
- Installing and waterproofing viewing ports for camera inspections of underground waste storage facility;

- Numerous Condition Assessments of structures including Spent Fuel Bays, Spent Resin Tanks, Fuel Transfer Structures, Reactor Buildings, Calandria Vaults, and Waste Storage Facilities;
- Assessment of liners and coatings in the Reactor Building of Point Lepreau Generating Station and of containment liners for Wolsong 1 and Embalse;
- Assessment of effects of elevated temperatures and radiation on properties of concrete of nuclear safety related structures.

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- possibly submerged operation
- un-manned operations will require performing inspection and repairs using robotic manipulator
- possible interference of the high radiation with the robotic manipulator electro-magnetic fields
- long-term performance of materials in severe environment

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SNC Lavalin, CANDU Energy Inc., AECL and OPG maintain IP and some patent rights on remote tooling they have developed.