[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	4-2 – Technologies for soil improvement
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 No. 1: A soil improvement technology - soil grouting using chemical grout. It features direct injection of liquid grout into the soil under low pressure. The grout is inorganic, which makes it durable under elevated radiation. After injection, the grout reacts and solidifies the soil thus decreasing the soil permeability. The grout does not contaminate the ground water. The technology is applicable in granular soils. The required grouting wells are drilled by using the horizontal directional drilling method.

The advantages of this technology are:
a) The closure distance is selected so that no close access to the building is needed. Therefore, the debris and narrow spaces will not prevent grouting operations;
b) Un-manned grouting operations may not be needed if the well heads are at appropriate distances from the Reactor Building;
c) By using low pressure for the grout, the soil is not displaced, which implies that the underground lines will not break. Also, by using directional drilling, the underground lines will be bypassed by the wells.

Technology No. 2: A technology for filing the inter-building gaps with slurry or grout. The purpose of this technology is to tap the face (entrance) of the inter-building gaps from inside the buildings (e.g. Reactor Building, Turbine Building, Radiation Waste Treatment Building, Underground Storage Facility Building or Service Building) by filling the gap with impermeable material. First, the wall between the buildings is drilled at the building corner (where the gap face is). Then the gap filling material (extruded polystyrene) is either vacuum cleaned, if the material is pellets, or dissolved, if the material is solid foam. Finally, the clear gap is filled with slurry or cement grout.

In order to avoid working in a submerged condition on the base slab floor, the operations can be done on a floor above the base slab.

2. Notes (Please provide information if possible)

- *Technology readiness level (including cases of application, not limited to nuclear industry, time line for application)*

Technology No. 1 is readily available. Case applications (by SNC-Lavalin Inc.) include :

i) Hydropower Sector – Rock grouting, foundation grouting, grouting of concrete dams to reduce the

permeability or to create water-tight facilities operating under very high hydraulic heads;

ii) Mining Sector – Installation of grout curtains to create containment facility for mine waste (chemistry consideration), grouting for filling in unexpected voids within the mine waste containment areas, grouting for foundation improvement and making hydraulic barriers for surface runoff collection, water storage and tailings dams, and for groundwater flow management and control;

iii) Infrastructure Sector – Ground improvement, foundation improvement, shallow anchorage for foundation supports;

iv) Nuclear Sector – hydraulic barrier for contaminated water (concept design).

Technology No. 2 application must be un-manned. The conventional equipment for this technology is readily available; however it must be adapted to self-propelled robotic manipulators.

Candu Energy Inc. (Candu) has an assortment of remotely controlled robotic technologies that can operate in high radiation fields. The company has used these technologies to successfully conduct remote activities like welding or non-destructive examination for operating reactors. Candu has some robots in its fleet that are ready for use with some customization for the soil improvement technologies proposed above.

Case applications of remote operation technologies by Candu include:

i) Underwater cutting of Pressure Tubes (PT) and End Fittings (EF) in the spent fuel bay. Work included transfer of equipment, performing the inspection and marking of the cut locations, performing underwater cutting. The technology featured an onboard filtering system that would catch all the cutting chips in a filtering unit and recycle the water back into the spent fuel bay;

ii) Remote inspection of spent fuel transfer structures with accessibility constraints and high radiation. Inspections to locate discontinuities in concrete were performed remotely and underwater by using camera and video recording equipment;

iii) Complex remote welding tool to repair perforation in an aluminum reactor vessel. The challenges of delivering the weld from a height of 30 ft and through a 4.75 inch diameter hole were met successfully;

iv) Development of Reactor Inspection Tool for inspections of the inside of the reactor vessel and Debris Removal Tool for pickup of large items such as swab cloths as well as small items such as wires. Both tools have articulating and telescoping arms that can cover 360° rotation and 100° arm flexion and are controlled by remote operations.

- *Challenges*

For Technology No.1:

- Pre-project geotechnical investigation – it must be performed under the same limitations as the grouting technology;
- Robotic manipulators may be needed for servicing the grouting equipment

For Technology No.2:

- Un-manned operations will require construction of self-propelled robotic manipulators;
- Interference of the high radiation with the robotic manipulator command lines/chains.