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

Technology Information	
Area	2 – Treatment of Contaminated Water
Title	2-2 - Requirements for treatment technologies
Submitted by	Candu Energy Inc., SNC-Lavalin, Atomic Energy of Canada Ltd., Canadian Nuclear Partners

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

Candu Energy Inc, Atomic Energy of Canada Ltd and SNC Lavalin are proposing a feasibility study for tritium mitigation technologies, taking into consideration the wastewater treatment requirements, to select the best available technology to minimize, as far as practicable, the impact on the environment (including worker dose, public dose and non-human biota dose) whilst taking into account a wide range of factors, including cost-effectiveness, technological status, operational safety, social and environmental factors, and schedule.

The following tritium mitigation technologies will be assessed:

- Technology No. 1: Wastewater pretreatment and evaporation with dispersion into the atmosphere
- Technology No. 2: Wastewater pretreatment and controlled discharge to the sea
- Technology No. 3: Disposal of tritiated wastewater in deep geologic formations

Technology No. 1: Wastewater pretreatment and evaporation with dispersion into the atmosphere

Description

The evaporation of the wastewater could be achieved by using a forced-circulation type liquid waste evaporator. A liquid waste evaporator (LWE), a forced-circulation type evaporator, is used at the Waste Treatment Centre at the Chalk River Laboratories for treatment of radioactive liquid waste. The LWE is comprised of a heater (shell and tube heat exchanger), a flash tank and a recirculation pump.

Technology No. 2: Wastewater pretreatment and controlled discharge to the sea

Description

We are proposing to evaluate the existing discharge structures as part of the feasibility study. This involves structural evaluation and dispersion and environmental evaluation. Construction of a new, deep-water discharge will also be evaluated as part of the study. One potential technology is presented below.

The wastewater could be pre-mixed with sea water (1/100 ratio) using a water jet eductor and discharged into the sea using a diffuser to improve dispersion of contaminants over a large surface avoiding sensitive areas. A diffuser like the Darlington Condenser Cooling Water discharge could be used for dispersion of wastewater into the sea. The design of the Darlington diffuser minimizes thermal and flow effects of the station cooling water discharge by dispersing the water over a large area in the aquatic environment. The diffuser consists of a cement lined tunnel underneath the lake bottom with 90 periscoped exit ports, each 0.6 m wide, protruding just above the lake bottom from the tunnel along a distance of 700 to 1600 m offshore. The ports are spaced 10 m apart with water being discharged at depths from 10 to 12 m along the length of the 900-m diffuser. The Darlington diffusers are located in an inshore lake water zone with low densities of fish.

Technology No. 3: Disposal of tritiated wastewater in deep geologic formations

Description

One other approach for mitigation of tritium in wastewater is to store it underground in a deep suitable geologic formation where it will be isolated from the general environment and human consumption for an extended period of time. Tritium reduction will be achieved by natural decay (tritium half-life is 12.5 years) in a safe environment. This waste mitigation approach is known as deep-well injection disposal which is used on a large scale by the petrochemical industry in the USA since 1950. Petrochemical industries produce substantial quantities of saline formation brines from drilling. Currently, more than 1.1 billion m^3 of brine are injected yearly into approximately 175,000 wells in the USA.

To achieve a tritium reduction of 99% (or Decontamination Factor of 100), as defined in the wastewater treatment requirement, the wastewater has to be stored in a suitable geologic formation where it will be isolated from the general environment and human consumption for at least 80 years. (Note: In terms of groundwater movement at depth, 80 years is a very short time).

Candu Energy, AECL , SNC Lavalin and OPG Expertise in Heavy Water, Tritium Removal and Tritium Management Technologies

Candu Energy, AECL, SNC Lavalin and OPG (Candu consortium) have extensive experience in evaluating, developing and deploying heavy water production technology, detriation technology and tritium management technology that could be applied to Fukushima's tritium issues:

- Decontaminating heavy water in CANDU reactors by extracting the tritium:
  The Candu consortium designed the Wolsong Tritium Removal Facility in Korea, and has performed feasibility studies for multiple reactor operators.
- Decontaminating light water by extracting tritium:
  The Candu consortium is actively involved in design work for ITER.
  The consortium has designed a system to treat spent-fuel-bay water.
  The consortium has conducted feasibility studies on groundwater decontamination for various clients.
- Decontaminating air streams in power plants by removing HTO vapour:
  This technology is part of every standard CANDU reactor.
- Decontaminating solid waste by stripping tritiated water:
  Used by some facilities to simplify subsequent processing of the waste.
- Evaporation of tritium-contaminated water, with solidification of any solids:
  Designed and operated by the Candu consortium, it is a robust process for dealing with complex wastes.

Other expertise in tritium management include:

- Environmental monitoring and assessment, including environmental risk assessment

- Public and environmental dose modeling and assessment, including pathways analysis
- Health physics evaluations and programs
- Occupational monitoring, assessment and protection
- Effluent and waste monitoring and control for all tritiated species (gaseous, liquid and solid)
- Equipment and plants for removing tritium from gases, liquids and solids
- Repair, decontamination and decommissioning of tritiated facilities
- Long-term management of tritiated wastes
- Commercial applications of tritium

2. Notes (Please provide information if possible)

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

- *Challenges*

- *Others (referential information on patent if any)*

Technology No. 1: Wastewater pretreatment and evaporation with dispersion into the atmosphere

Benefits

The forced- circulation type liquid waste evaporator (LWE) is a proven technology and commonly used to treat various types of radioactive liquid waste generated in nuclear power plants. The forced-circulation type evaporator is designed to overcome problems such as fouling and corrosion and to increase the decontamination factor. The combination of high tube-side velocity and lack of phase change on the heat exchange surface effectively eliminates salting and scale formation, making system cleaning an infrequent operation.

Issues/Challenges

A pretreatment of feedwater to the LWE may be required to reduce the concentration of radionuclides (Cs-134, Cs-137 and Sr-90). Operating cost (energy consumption) is high since large amount of wastewater (at least 400 m^3/day) must be evaporated.

Radionuclides will be released into the atmosphere which may have an impact on public dose, worker dose and non-human biota dose. A public, worker and environmental dose modeling and assessment, including pathways analysis must be performed to implement the pretreatment and/or evaporation solutions. The Candu consortium has extensive experience in such dose modeling and assessments, and Canada has developed some of the most advanced models and modelling software for tritium in the world. AECL, in particular, is a world leader in evaluating tritium impacts on the public and environment.

Project Examples of Application and Readiness

A large-scale liquid waste evaporator (LWE), a forced-circulation type evaporator, is used at the Waste Treatment Centre at the Chalk River Laboratories for treatment of radioactive liquid waste.

Intellectual Property/Patent Aspects

AECL

Technology No. 2: Wastewater pretreatment and controlled discharge to the sea

Benefits

The pre-mixing step is a simple process which only requires large pumps and could be implemented over a short period of time.

Issues/Challenges

This process would require large pumps (40 000 m^3/day). The construction cost for the diffuser is very high. A simpler diffuser modified to sea condition could be designed.

A pretreatment of wastewater prior to pre-mixing and discharge into the sea may be required to reduce the concentration of radionuclides (Cs-134, Cs-137 and Sr-90). Radionuclides will be released into the sea which may have an impact on public and non-human biota doses. A public and environmental dose modeling and assessment, including pathways analysis must be performed to implement the pretreatment and/or environmental discharge with diffuser solutions. The Candu consortium has extensive experience in such dose modeling and assessments, and Canada has developed some of the most advanced models and modelling software for tritium in the world. AECL, in particular, is a world leader in evaluating tritium impacts on the public and environment.

Project Examples of Application and Readiness

There are deep-water discharges at Darlington (Ontario, Canada) and Qinshan (China). The Candu consortium has extensive experience with such structures.

Intellectual Property/Patent Aspects

No specific patent issues

Technology No. 3: Disposal of tritiated wastewater in deep geologic formations

Benefits

This approach has the advantages of low cost and low energy consumption provided a suitable storage location is available. Pre-treatment might be required to remove Sr-90 which has a long half-life (28.1 years).

Issues/Challenges

Regulatory approval by various agencies (for siting, construction, operation, monitoring, reporting, decommissioning and post-closure).

The project proponent must demonstrate that “No Migration” of the tritiated wastewater will occur outside of the formation into which it is injected. Extensive geologic evaluation/testing (e.g., structural and stratigraphic geology, hydrogeology, and seismicity of the region and well site, etc.) and groundwater modelling will be required to identify a suitable geologic formation for the long-term storage of tritiated wastewater. A public, worker and environmental dose modeling and assessment, including pathways analysis must be performed to implement the deep-well-injection disposal solution.

Extensive monitoring will be required for the operating site.

Project Examples of Application and Readiness

Currently, 123 Class I hazardous waste wells (i.e., wells injecting hazardous waste below the lowest aquifer containing a potential source of drinking water) are operating in the USA Most of these wells are found in Texas (64) and Louisiana (17). Another 221 facilities comprising 350 Class I wells injecting nonhazardous waste are also in operation, most of which are found in Florida (122) and Texas (49). In the USA, deep injection well depths range from 520 to 2,740 meters.

Intellectual Property/Patent Aspects

Injection technology dependant