Canadian Nuclear Safety Commission
Commission canadienne de sûreté nucléaire

CMD 24-H2.38

File / dossier : 6.01.07
Date: 2023-11-20
Edocs: 7170849

Oral presentation

Written submission from Dennis LeNeveu

In the Matter of the

Ontario Power Generation Inc.

Applicability of the Darlington New Nuclear Project environmental assessment and plant parameter envelope to selected reactor technology

Commission Public Hearing

January 2024

Exposé oral

Mémoire de Dennis LeNeveu

À l'égard d'

Ontario Power Generation Inc.

Applicabilité de l'évaluation environnementale et de l'enveloppe des paramètres de la centrale à la technologie de réacteur sélectionnée pour le projet de nouvelle centrale nucléaire de Darlington

Audience publique de la Commission

Janvier 2024

BWRX-300 Comments

By

D.M. LeNeveu, M.Sc. formerly the vault model developer for the Probabilistic Risk Assessment of Canadian concept for High Level Nuclear Waste Disposal

Nov. 19, 2023

A new environmental assessment for the BWRX-300 boiling water reactor, which was not adequately covered by the previous 2011 EA, must be completed. The 2011 EA was conducted by comparing four large "pressurized water reactors" each with a primary and secondary cooling loop, each with auxiliary boilers and a different arrangement as to the ultimate heat sink. Since cooling the nuclear fuel is a key component of reactor safety, any reactor with fundamentally different cooling arrangements has to be considered as a fundamentally different design from a safety perspective and so it needs its own EA. A new EA for BWRX-300 must include decommissioning operational waste management and disposal. A new EA must include a comprehensive loss of coolant safety analysis (LOCA) including all measures to mitigate the risk such as specification of reactor waste chemistry to minimize corrosion.

The first BWR was built in 1957.[1] There are about 440 BWR operational reactors in the world with most over 1000 MW.[2]

A total of four BWRX-300 reactors are planned. It would appear OPG is attempting to capitalize on the recent promotional effort for small modular reactors (SMR). The boiling waste reactor is not new technology. However the BWRX-300 is a relatively small reactor that has not been build before and will suffer from lack of economy of scale. Four BWR reactors of 300 MW each would be inefficient compared to a large BWR reactor of 1200 MW for which the technology has been proven. The risks associated with four small reactors may be larger than one large reactor. OPG has not made a viable case of the desirability of building four small relatively inefficient reactors. The BWRX-300 requires enriched fuel not produced in Canada and is a foreign reactor design. It would be far more beneficial for Canada to build a two unit CANDU. The advantages would be a Canadian built and fuelled reactor with established technology and a waste disposal concept that has received technical approval by the Seaborn Panel.

The only apparent advantage of the BXRX-300 is a claim for passive safety with no requirement for emergency coolant. This claim has not been established. The coolant pools are said to provide enough passive cooling for 72 hours. There are no detailed calculations or documents to verify this claim. Surely a large break of the pressure vessel or coolant system could result in rapid loss of all coolant in less than 72 hours.

For example, a publication by USNRC Technical Training Center on BWRs describes a high pressure coolant injection (HPCI) system required for a large coolant leakage event.[3] The BWRX-300 specifications do not include an HPCI. Stress corrosion cracking has been identified as one of the potential causes for a loss of coolant. In some cases the water chemistry is altered in BWRs by the addition of hydrogen to mitigate stress corrosion cracking.[4] To mitigate the increased shutdown dose rates seen with HWC due to cobalt-60 release, several plants, including the majority of US BWRs, inject Depleted Zinc Oxide (DZO). Other chemical additions may be beneficial. There should be a thorough study of the chemistry requirements for the BWR coolant. There needs to be a separate independent analysis of the safety of the BWRX-300 with respect to loss of coolant event (LOCA).

Activation product production and handling has been omitted from the BWRX-300 reports. The entire suite of activation products inventories as a function of time must be determined. All operational activation product and fission product removal systems in the reactor system must be clearly specified. The operational doses from the maintenance of the clean up systems must be determined. The quantity or the operational wastes such as ion exchange resins, the radionuclide inventory in the wastes, the storage of the wastes and the long term disposal methods must be specified. Of particular concern is the accumulation of gamma emitting fission products and activation products such as Co-60, Sr90, Cs137 in the steam generators and other components that require maintenance. The maintenance cost would be far more than in CANDU or PWR reactors where the steam generators are in an isolated secondary coolant loop. The BWRX-300 has only one coolant loop. The costs and consequences of the radiation protection measures to limit worker exposure must be specified.

Of particular concern in the BWRX-300 is the production of C14 primarily from 14N(n,p)14C, 17O(n,α)14C, and 13C(n,γ)14C reactions listed in order of decreasing neutron cross section.[5] There will large amounts of C14 generated in the coolant, the control rods and in the concrete of the biological shield. The C14 production from the nitrogen content of the coolant has been not been evaluated. The oxygen in the cooling water and steam will generate large amounts of C14. Presumably most of the C14 will be removed from the coolant through the use of ion exchange resins. An unspecified quantity of C14 will enter the off gas system and may be subsequently released to the atmosphere. The operational doses consequence to workers and the public must be determined for C14 and other airborne emissions such as tritium. Tritium may be produced from the boron injection system, any lithium content and somewhat from the natural deuterium content of the light water.[6] Chlorine is a minor constituent in most materials. Cl-36 activation in steel, control rods and other components from 15Cl(n,γ)16Cl must be determined. The quantity of all the activation products that would be generated from all sources must be determined. The measures and costs of operational methods and the waste disposal consequences of these activation products must be specified.

The EA for the BWRX-300 must include a comprehensive waste management study that includes all costs. The final disposal of all the operational waste products such as ion exchange resins must be included. The studies on the disposal of used CANDU fuel are not applicable to the used BWRX-300 enriched fuel that would have a higher burn-up and heat generation. Studies must be completed on the size and requires spacing of used fuel containers and many other aspects of used fuel disposal. One major advantage of building a new CANDU is the used fuel disposal studies have been largely completed.

There is one end of life report NK054-PLAN-00960-00007-R000 on decommissioning of the BWRX-300 reactor that simply lists a series of procedures with no determination of does consequence for and radiation protection measures that must be taken. Many activation products especially C-14 will be entrained in the concrete that must be considered during decommissioning. The cost of decommissioning and waste management is omitted and must be factored in to a proper EA.

A comparative cost benefit analysis is required for building four BWRX-300 reactors where alternatives such as a two unit CANDU reactor and renewable wind and solar powered installations with storage backup or gird interconnections to other power sources are compared. For instance new grid connections to Quebec Hydro could provide a relatively cheap and reliable backup for renewable energy. Decommissioning and waste management costs of the BWRX-300 must be included in such a necessary cost benefit study.

References

1. Description of boiling water reactors, Alfonso Prieto-Guerrero, Gilberto Espinosa-Paredes, in Linear and Non-Linear Stability Analysis in Boiling Water Reactors, 2019, https://www.sciencedirect.com/topics/earth-and-planetary-sciences/boiling-water-reactor#:~:text=The%20development%20of%20the%20boiling,levels%20up%20to%20100%20MWt

2. Plans For New Reactors Worldwide (Updated November 2023), https://world-nuclear.org/information-library/current-and-future-generation/plans-for-new-reactors-worldwide.aspx#:~:text=Today%20there%20are%20about%20440,10%25%20of%20the%20world's%20electricity

3. Boiling Water Reactor Systems, USNRC Technical Training Center, https://www.nrc.gov/docs/ML1209/ML120970422.pdf

4. Office for Nuclear Regulation, Chemistry of operating civil nuclear reactors, Jan. 2019, https://www.onr.org.uk/operational/tech_asst_guides/ns-tast-gd-088.pdf

5. OSTI.GOV Technical Report: Carbon-14 production in nuclear reactors, Jan 1, 1997, https://www.osti.gov/biblio/7114972

6. OSTI.GOV Technical Report: Sources of tritium, Dec.1, 1980 https://www.osti.gov/biblio/6867774