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Licensing Status and Issues of BWRX-300

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1. Introduction

The innovative Small Modular Rector (i-SMR) has been under development with plans to apply for Standard Design Approval (SDA) in 2026.

Innovative designs of i-SMR incorporating design features such as multiple modules, passive safety systems, non-safety class electrical power, and radiation source terms different from traditional method are currently underway. Therefore, it is necessary to establish a regulatory stance on how these design features should be considered in safety reviews for Standard Design Approval (SDA), Construction Permits (CP), and Operating Licenses (OL). In the previous studies, safety issues and exemptions resulting from the innovative design features of NuScale under 10 CFR 50.12 were examined. In addition, the applicability of these items to the domestic legal and technical standards framework was reviewed, and related exmption directives for the application of exemption and exception are being prepared.

This study examines the licensing status and key issues including exemptions of the BWRX-300, the fastest developing light-water type SMR in major SMR-developing countries such as the U.S. and Canada, to identify key considerations for i-SMR licensing reviews.

2. BWRX-300 Design Overview

The BWRX-300, developed by GE Hitachi Nuclear Energy (GEH), is a 300 MWe (870 MWth) boiling water reactor with a design life of 60 years. It is based on the design characteristics and licensing experience of the 1,520 MWe Economic Simplified Boiling Water Reactor (ESBWR).

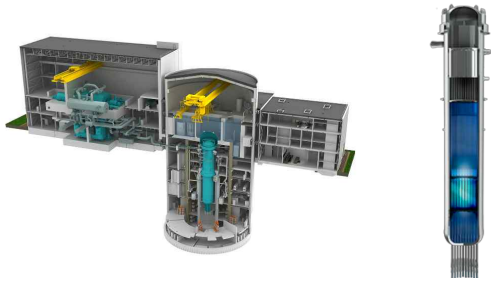

Fig. 1. Schematics of BWRX-300 Power Plant and RPV

BWRX-300 uses Low-Enriched Uranium (LEU) fuel assemblies and supports 12~24 month fuel cycle to enhance fuel efficiency and minimize radioacitive waste It includes a high chimney in Reactor Pressure Vessel (RPV) to enhance efficient natural circulation for core cooling, with in-core flow generated by natural circulation. The Isolation Condenser System (ICS) is installed to ensure decay heat removal for at least 7 days during design basis accidents. Unlike the ESBWR, the BWRX-300 eliminates Safety Relief Valves (SRVs) and utilizes a high-capacity ICS to relieve overpressure and provide emergency core cooling.

3. BWRX-300 Licensing Status

3.1. Overview

The BWRX-300 is undergoing licensing and design feasibility reviews in various forms worldwide. In the UK, the ONR has conducted a Generic Design Assessment (GDA) with Step 2. In Canada, a construction permit application was submitted to the CNSC in October 2022 and approved in April 2025. In the U.S., 10 Topical Reports (TRs) or White Papers have been submitted to the USNRC. The construction permit application was submitted to the USNRC in May 2025.

This study focuses on the licensing status, including exemption applications, and key issues related to the construction permit application in U.S., a country with good data accessibility.

3.2. Exemption Applications

3.2.1. Exemption from Simultaneous Submission of Application Documents[1]

According to 10 CFR 2.101(a)(5), both the Environmental Report (ER) under 10 CFR 50.30(f) and the Preliminary Safety Analysis Report (PSAR) under 10 CFR 50.34(a) must be submitted simultaneously when applying for a CP. The Tennessee Valley Authority (TVA) sought to apply for an SMR CP at the Clinch River site in Tennessee and proposed a partial submission approach, submitting the ER first and the PSAR later. In November 2023, the NRC officially granted an exemption to allow the PSAR to be submitted separately from the ER, recognizing an exception to 10 CFR 2.101(a)(5) at TVA's request.

This exemption was granted to enhance procedural efficiency for new SMRs, considering project characteristics, the need for phased reviews, and early

environmental reviews. The exemption met the requirements of 10 CFR 50.12 and was deemed not essential to achieving the purpose of "streamlining nuclear power plant licensing procedures."

Consequently, the first part of the application was submitted as an ER in April 2025, referencing ESP-006, followed by the PSAR.

3.2.2. Exemption for Pre-Construction Restrictions [2]

Under USNRC regulations (10 CFR 50.10(c)), major construction work such as excavation and foundation work on a reactor facility cannot be conducted before a formal CP is approved. However, applicants may request an exemption for limited early activities if necessary for the project schedule.

TVA requested an exemption to perform early excavation at the BWRX-300 Reactor Building (RB) site before formal CP approval. The USNRC granted a partial exemption, allowing limited early civil works (site preparation, grading, foundation excavation) under the condition that they would not adversely affect the safety review or future safety evaluations.

3.2.3. Exemption/Variance Requests at Construction Permit Application [3]

When submitting the PSAR, TVA included Enclosure 4, "Exemptions and Variances (Public Version)," in the CP application for the Clinch River Nuclear Site, summarizing the contents of exemptions and variances.

One exemption request was to apply ASTM E185-21, Standard Practice for Surveillance Program Design for Reactor Pressure Vessels," for the BWRX-300 RPV surveillance program. The purpose of the material surveillance program required by 10 CFR 50 Appendix H is to monitor changes in fracture toughness of ferritic materials in the RPV beltline region due to exposure to neutron irradiation and thermal environment. Surveillance capsules containing specimens are periodically retrieved to obtain toughness test data, with ASTM E185-82 typically used as a reference. TVA requested to apply the E185-21 standard instead, as the E185-82 schedule is unrealistic for the 60~80 year target lifespan of BWRX-300, being based on an initial low-close 40-year assumption. TVA argued that E185-21 reflecting the latest research, reduces uncertainties in fracture toughness measurement, and is suitable for long-term service. This request met the legal requirements of 10 CFR 50.12 and was demonstrated to pose no undue risk to public health and safety or to security and protection.

The variances included requests to NRC to approve changes reflecting differences between actual design parameters and those assumed in the Early Site Permit (ESP) or SSAR, such as changes to site elevation, groundwater level, and changes in the assumed reactor thermal output (from 800 MWt to 870 MWt).

4. Major Review Items and Issues for BWRX-300

TVA submitted 10 TRs or White Papers on specific topics for the BWRX-300 design to the USNRC. For some topics, such as containment evaluation methodology, the USNRC and CNSC jointly reviewed and issued joint review reports. The following section outlines the key issues discussed on BWRX-300 that may be relevant to i-SMR licensing reviews.

4.1. Source Term Evaluation Methodology [4]

BWRX-300 applies a Risk-Informed, Performance-Based (RIPB) approach and mechanistic source term evaluation to present an innovative approach to radioactive material release conditions (source term), Emergency Planning Zone (EPZ) / Exclusion Area Boundary (EAB) / Low Population Zone (LPZ) size, and radiological release evaluation during accidents.

It was evaluated that, unlike existing large reactors, BWRX-300 is designed such that internal events during normal operation do not lead to core melt or large releases of radioactive materials. All event categories (Anticipated Operational Occurrence, Design Basis Accident, Design Extension Condition (DEC)) were considered in source term evaluation based on the likelihood of occurrence. Analyses were performed based on actual release locations, pathways, and timing of radioactive material release for major accident scenarios.

The USNRC is reviewing the adequacy of this mechanistic approach, event occurrence frequency and release selection methods, scenario validity, consistency with major accident evaluation criteria, system reliability, and verification of release impact.

4.2. Safety Strategy [5][6]

BWRX-300 adopts passive safety systems and simplified safety systems compared to conventional BWR/ESBWR, introducing innovative concepts such as replacement/elimination of major safety systems. The safety strategy includes justifications for minimizing safety systems, implementation of Defense-in-Depth (D-in-D) objectives during accidents, safety measures and accident response procedures in Design Basis Condition (DBC) and DEC, deterministic safety analyses, and human factors assessments.

The USNRC requested experimental data and performance verifications, and is reviewing the design and simplification of the passive system based on demonstration test data and additional analyses, focusing on system reliability and availability.

4.3. Steel-Plate Composite Containment/Structural Design [7][8]

The BWRX-300 adopts a simplified Steel-Plate Composite (SC) containment and structural design

compared to conventional reactors. The SC containment consists of central concrete and side steel plates and is an innovative design applied to enhance structural strength, seismic performance, radiation shielding efficiency, and construction efficiency. The design was evaluated for stability, seismic, external loads, site conditions, and soil-structure interaction analysis.

5. Conclusion and Summary

This study reviewed the design characteristics of the BWRX-300 for which TVA applied for a CP to the USNRC. It also reviewed licensing status including exemption and variance requests granted by the USNRC. The key issues were also identified discussed on BWRX-300 that may be relevant to i-SMR licensing reviews.

It is expected that continuously monitoring the BWRX-300 construction permit status, resolving key issues such as passive safety systems and source term evaluation, and using these insights to prepare domestic responses will enable efficient and effective licensing of i-SMR construction and operation.

Acknowledgements

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