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Non-Proprietary Information

BWRX-300 Darlington New Nuclear Project (DNNP) GNF2 Fuel Design, Qualification, and BWR Fuel Licensing

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0	All	Originally Issued as Proprietary Version NEDC-33977P Revision 0
1	All	Initial Issues as Non-Proprietary Version

1.0 INTRODUCTION

This report presents GNF2 fuel design and qualification information for application to the GE Boiling Water Reactor X-300 (BWRX-300) and describes the industrial norm for BWR fuel qualification and licensing (i.e., regulatory approval). The objective is to illustrate that standard BWR fuel regulatory requirements are adequate to assure compliance to the Canadian Nuclear Safety Committee's (CNSC's) regulatory requirements pertaining to fuel, as specified in REGDOC 2.5.2, "Design of Reactor Facilities: Nuclear Power Plants," (Reference 8-1).

The GNF2 fuel design is the result of over 50 years of design, fabrication, and operational experience. As the process for designing BWR fuel is mature, many of the methodologies developed to meet design and licensing requirements were established decades ago. These methodologies have been documented in various Licensing Topical Reports (LTRs) that were submitted to the US Nuclear Regulatory Commission (NRC) on an as-needed basis. In addition, Global Nuclear Fuels-America, LLC (GNF) developed a fuel licensing framework, in concert with the NRC, titled the General Electric Standard Application for Reactor Fuel, GESTAR II, NEDE-24011-P-A-31, (Reference 8-2). This licensing framework defines all the requirements and approved methods for designing BWR fuel pertaining to safety. In the development of a new fuel product, once GNF shows compliance to the GESTAR II requirements (which include the process for implementing a new fuel design in reload quantities), the fuel is considered licensed in the US for generic BWR application. This report is a summary of a report submitted to the CNSC as part of the Vendor Design Review Process in Reference 8-3.

GNF's design methodology is comprised of analysis methods, irradiated performance data and engineering tests that are underpinned by the entire evolution of BWR fuel. GNF2 fleet-wide fuel performance is directly applicable to the BWRX-300. The principal difference between the BWRX-300 and BWR/2-6 & Advanced Boiling Water Reactor (ABWR) is that the BWRX-300 exhibits lower flows and has a higher power-to-flow ratio as it is a natural circulation reactor. This primarily affects one thermal limit Critical Power Ratio (CPR); however, fuel hardware performance (e.g., corrosion/oxidation characteristics, dimensional stability, fuel rod hermiticity, etc.) is evaluated to be the same.

The BWRX-300 has been designed to receive commercially available BWR fuel compatible with N-lattice geometries (e.g., ABWR). The GNF2 fuel mechanical design for BWRX-300 is identical to that applicable to the ABWR. The only mechanical design differences as compared to BWR/4-6 are minor geometry differences to the channel spacers & fastener that interface with the top guide and do not affect fuel performance.

NOTE: GNF2 for application to BWR/2-3 reactors is slightly shorter in axial extent, but otherwise the same.

2.0 GNF FUEL BUNDLE DESIGN DESCRIPTION

GNF has extensive experience designing and fabricating nuclear fuel for BWR applications. The basic design of fuel rods held together in a square array by spacers, connected to lower and upper tie plates for handling and surrounded by a channel box has not changed in the over 50 years since Oyster Creek began operation in 1969; although innovative improvements have been made to increase power and burnup capabilities and decrease failure probability.

The GNF2 has been in reload production since 2008 with over 100 reloads. 106 full reloads of GNF2 have been licensed and inserted into BWRs in the US, Spain, Switzerland, Germany, Sweden, and Finland. This adds up to the operation of over 22,000 GNF2 bundles. GNF2 is very similar to the previous GNF fuel design called GE14, that had ~37,200 bundles operate in 200 cycles (1-2 years in length) over a more than 20-year time period. Table 2-1 provides a summary of the GNF2 design as compared to the GE14 design (GNF2's predecessor). It should be noted that any references to BWR/4-6 plants herein also apply to BWRX-300 as the fuel designs are essentially the same. A summary of the fuel reliability and operational experience with a focus on GNF2 is provided in Appendix A of GE Hitachi Nuclear Energy, BWRX-300 Fuel Design and Qualification, (Reference 8-3). A schematic of the GNF2 fuel assembly is shown in Figure 2-1. The GNF2 design consists of 92 fuel rods and two large central water rods that occupy eight (8) fuel rod locations contained in a 10x10 array (i.e., 100 lattice locations). Fourteen (14) fuel rod locations are occupied by Part Length Fuel Rods (PLRs). Part length rods provide several benefits: 1) reduced 2-phase pressure drop that improves stability, 2) more efficient H/U ratio axially, and 3) lower core reactivity in the cold shutdown condition. Eight PLRs are located on the bundle periphery and terminate just past the top of the 6th spacer (indexed from the bottom) and are designated as long part length fuel rods (LPLR). An additional six PLRs are located adjacent to the central water rods and terminate just past the top of the 3rd spacer and are designated as short part length fuel rods (SPLR). Eight peripheral fuel rods are used as tie rods. The GNF2 lattice arrangement is shown in Figure 2-2. The rods are spaced and supported by the upper and lower tie plates and eight spacers (sometimes referred to as grids) over the length of the fuel rods. The channel, which encompasses the bundle, hangs from the upper tie plate and creates a slip seal over the lower tie plate. This seal controls leakage flow without the need for any additional sealing components (i.e., finger springs).

The fuel rods consist of high-density ceramic UO_2 or (UO_2+Gd_2O_3) fuel pellets stacked within Zircaloy-2 cladding. The cladding has an inner zirconium liner for resistance to PCI-SCC (stress-corrosion enhanced pellet cladding interaction). The fuel rod is evacuated and backfilled with helium during the final welding of the upper end plug. Fuel rod dimensions are given in Table 2-1.

Additional details on the fuel assembly and component designs are provided in NEDC-33940P, "GNF2 Fuel Assembly Mechanical Design Report for BWRX-300," (Reference 8-7).

A discussion of the new GNF2 design features, as compared to GE14, is also described in NEDC-33270P, Revision 11, "GNF2 Advantage Generic Compliance with NEDE-24011-P-A (GESTAR II)," August 2020 (Reference 8-6).

The key features affecting in-reactor performance are:

- All Alloy X-750 grid type spacers with Flow Wings. The GNF2 spacer design evolved from an expansive developmental program that included substantial thermal hydraulic testing. The GNF2 spacer exhibits reduced hydraulic resistance (i.e., pressure drop) than the GE14 Zircaloy-ferrule spacer due to reduced material thickness deriving from improved material performance. Also, the Flow Wings (long, tapered tabs on the top of the spacer) improve droplet deposition while operating that translates to improved critical power. Also, Alloy X-750 is resistant to hydrogen pickup for improved robustness at EOL.

- GNF2 fuel rod design. The GNF2 fuel rod is comprised of the same materials as GE14. Owing to the GNF's vast BWR fuel operating experience, [[

  ]]. Note that the bundle heavy metal mass varies with nuclear design due to the presence of gadolinia burnable absorber. Also, the fuel rod power rating (e.g., thermal-mechanical operating limit, or TMOL) [[
  ]].

- PLR arrangement. Two lengths of PLR were established for GNF2 that results in a more efficient axial H/U ratio. The efficiency benefit is [[
  ]]. Also, the PLRs are located adjacent to the other regions of the BWR lattice that are, essentially, solid water (e.g., the intra-assembly bypass gap and the water rods). This has a flux trap effect in the cold shutdown condition and the core reactivity is substantially reduced [[ ]]. This has the composite effect of increasing Cold Shutdown Margin (CSDM) and provides the nuclear designer with abundant flexibility in developing the core nuclear design of any cycle. Essentially, GNF2 removes CSDM as a significant design constraint.

Pertaining to safety, the following is noted:

- The improved droplet deposition characteristics of the GNF2 spacer increases margin to Boiling Transition (i.e., CPR) that pertains to safety. Also, the all-Alloy X-750 material of the GNF2 spacer is largely resistant of hydrogen pickup resulting in improved tolerance of post-operation discharged fuel handling.
- The continual evolution of debris filtration in the Lower Tie Plate (LTP) reduces the frequency of debris fret cladding perforations during operation.
- The arrangement of part length rods results in a less reactive core in the cold condition that translates into increased CSDM.
- The introduction of NSF as standard channel material largely mitigates control blade interference arising from channel distortion.
- The overall reduction in assembly pressure drop results in lower stability decay ratios and promotes increased natural circulation flow when applied to the BWRX-300.

Some of the key tests that are performed when developing any new BWR fuel design are listed below. Note that that the specific design changes of a new design will influence the breadth of testing and some types of testing may not be required (e.g., only single-phase hydraulic testing would be required for a new debris filter LTP):

- Full scale thermal hydraulic testing (e.g., critical power and pressure drop) at both steady-state and transient conditions
- Single phase hydraulic testing of the Orifice/LTP when significant design modifications are made
- Flow Induced Vibration (FIV) testing (note that the BWR is evaluated as not susceptible to flow-induced fretting damage)

- Spacer seismic testing
- Myriad manufacturing tests
- Transportation testing
- Testing to assure poolside examination can be performed on the new fuel design
- Poolside fuel examination for performance confirmation

The engineering tests described above were completed for GNF2 prior to the first reload applications that began operation in 2008. The thermal hydraulic test conditions encompass the BWRX-300, and the test results are either directly applicable (e.g., critical power data at specified coolant mass flux) or bounding (e.g., hydrodynamic forces are greater in forced circulation BWRs pertaining to FIV).

There have been two hardware retrofits to GNF2 pertaining to the spacer (i.e., grid) and the Defender filter. Both modifications were motivated to further reduce the likelihood of a debris fretting condition and derived from operating experience. During poolside examinations of GNF2, it was observed [[ ]]. The Defender filter with these design enhancements is named Defender-plus. Defender-plus, in concert with the [[ ]] in the GNF2 spacer, are named GNF2.02 and is standard equipment. These design changes, and associated operating experience, are described in Appendix A of (Reference 8.3).

Table 2-1: GE14 and GNF2 Dimensions

Fuel Assembly	GE14	GNF2
Total number of fuel rods	92	No Change
Full length	78	No Change
Partial length	14 total, Single Length	14 total, Two Lengths
Long Part Length Rod (LPLR)	14	8
Short Part Length Rod (SPLR)	0	6
Lattice Array	Figure 2-2	Figure 2-2
Rod to rod pitch (cm)	1.295	No Change
Number of water rods	2	No Change
Typical Assembly weight (kgU)	178	185
BWR/4-6 and BWRX-300 Full Length Rod (mm)	[[	]]
Long Part Length Rod (LPLR) (mm)	[[	]]
Short Part Length Rod (SPLR) (mm)	N/A	1507
Fuel Rod		
Cladding material	Zr-2 with zirconium inner liner. An additional option of non-liner clad is available.	Zr-2 with zirconium inner liner.
Typical BWR/4-6 and BWRX-300 Assembly active fuel length (mm)	3810	No Change
LPLR Active Fuel Length (mm)	2134	2591
SPLR Active Fuel Length (mm)	N/A	1372
Cladding tube diameter, outer (cm)	[[	
Cladding tube wall thickness (cm)		
Pellet diameter, outer (mm)		
Fuel Pellet Density (PD) standard		
Fuel column Geometric Stacking Factor (GSF) standard		
Helium Backfill Pressure BWR/4-6		
Fuel column stack density (g/cc)		]]
Water Rod		
Cladding material	Zirc –2	No Change
Cladding diameter, outer (cm)	[[	
Cladding wall thickness (cm)		]]
Spacer		

Fuel Assembly	GE14	GNF2
Number of spacers	8	No Change
Material	Zircaloy-ferrule and bands with Alloy X-750 springs	Alloy X-750
[1] Gd_2O_3 Concentration (GC), percent by weight		

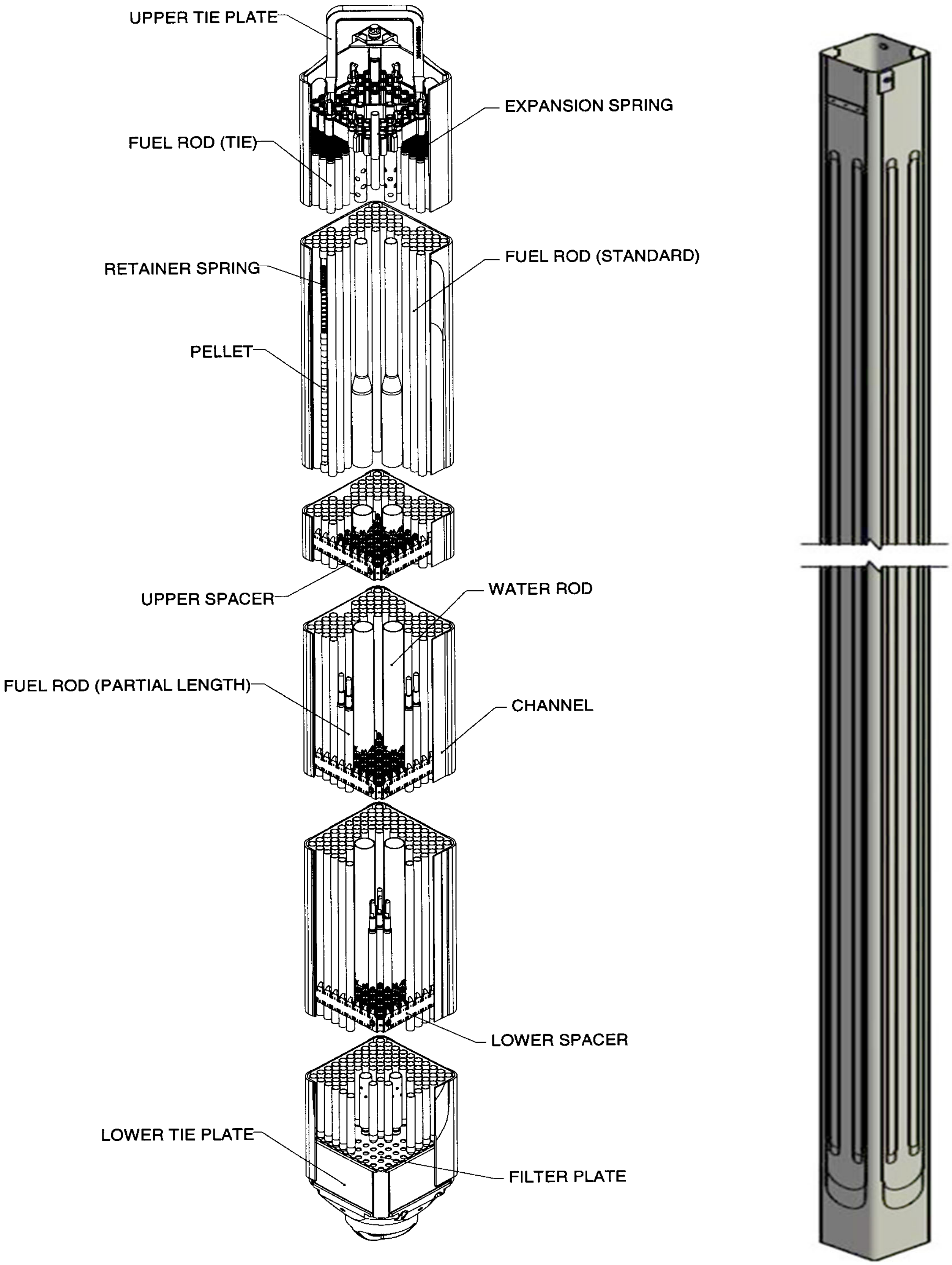

Figure 2-1 GNF2 Fuel Assembly

Figure 2-1 GNF2 Fuel Assembly

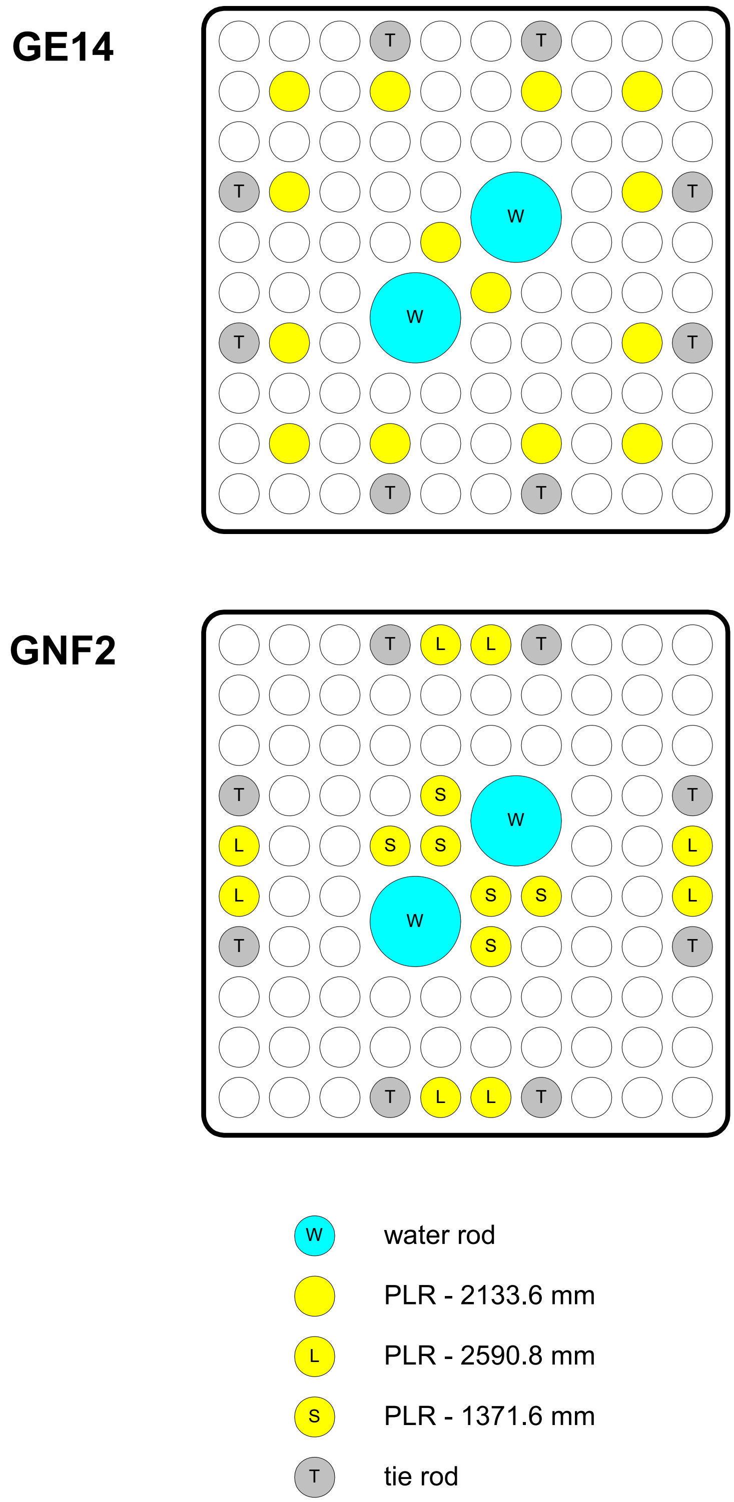

Figure 2-2: Lattice Arrangement

3.0 GNF2 FUEL QUALIFICATION

A status of “qualified” pertaining to a BWR fuel assembly can be interpreted as the engineering design, analysis, testing and lead assembly irradiation & surveillance has been completed sufficiently to achieve regulatory approval for generic BWR application. Note that generic regulatory approval is necessary for fuel application but does not constitute regulatory completeness. Generic regulatory approval corresponds to those aspects that are common for fuel application to all BWRs (i.e., generic). The requirements associated with generic BWR fuel application govern fuel mechanical, fuel rod thermal mechanical, bundle thermal hydraulic and certain nuclear dynamic parameters that influence core transient response. Further discussion pertaining to BWR fuel licensing is provided in Section 4.0.

GNF2 achieved a status of fully qualified for generic BWR application in the US in 2007 and has approximately 15 years of successful operating experience in most BWR types in a wide range of reactor water chemistries and operational strategies (e.g., annual cycle control cell core, two-year conventional core control rod sequencing). For application to the BWRX-300 in Canada, the final step is to affirm compliance to CNSC’s general requirements and achieve regulatory approval.

4.0 BWR FUEL AND RELOAD LICENSING

Licensing BWR fuel and reactor cores is introduced in (Reference 8-4) and comprised of three domains:

- Generic Fuel Requirements (i.e., generic licensing under GESTAR)
  - Methods applicability
  - Lead assembly demonstration for new fuel designs
  - Nuclear dynamic parameters (e.g., Doppler, void, moderator temperature, power)
  - Fuel rod and assembly thermal mechanical requirements
  - Thermal hydraulic correlations
  - Reported in a New Fuel Compliance Report, (Reference 8-6)
- Plant and fuel dependent, but cycle indpendent
  - Established by the design and licensing basis evaluations in the Final Safety Analysis Report (FSAR)
  - Design Basis Accidents (DBAs) (e.g., Loss-of-Coolant-Accident (LOCA))
  - Introduced in (Reference 8-5)
- Cycle specific analyses (i.e., reload licensing as prescribed in GESTAR)
  - Spans the potentially limiting Anticipated Operational Occurrences (AOOs)
  - Establishes core operating limits that are cycle dependent (e.g., Operating Limit Minimum Critical Power Ratio (OLMCPR))
  - Confirms applicability of generic evaluations
  - Culminates in the Supplemental Reload Licensing Report (SRLR) for every cycle that serves as technical input to the Core Operating Limits Report (COLR)

In most jurisdictions where a GE BWR operates, a country specific regulatory framework has been adopted (i.e., approved by the regulatory authority) that governs the fuel and cycle specific thermal limits governing the reactor core. This is referred to as the GESTAR, which can be considered an approved licensing process (i.e., approved by the cognizant authority) to govern reactor core configurations and new fuel assembly designs. GESTAR establishes the methods and requirements that assure conformance with regulatory requirements for BWR cores (i.e., reload licensing) as well as new fuel assembly designs.

The new fuel licensing requirements established in GESTAR span fuel mechanical, fuel rod thermal mechanical, nuclear and thermal hydraulic domains and constitute the Generic Requirements. The reload licensing requirements in GESTAR are established to identify the limiting AOOs that are evaluated to construct cycle specific operating limits (e.g., OLMCPR). The requirements in GESTAR assure safe operations over decades of experience. To adopt a GESTAR framework in Canada, the requirements stipulated in the governing regulatory documents must be addressed in the country specific supplement and the GESTAR framework approved by CNSC.

5.0 COMPLIANCE WITH CNSC REGULATORY REQUIREMENTS

The compliance of the GNF2 fuel design with CNSC requirements is provided in 9.0, Appendix A.

6.0 SUMMARY AND CONCLUSION

GNF2 has features used in previous GNF fuel design dating back to the early 1990s including PCI-resistant barrier cladding, high performance spacers, water rods, part length rods, thick corner/thin wall channel, and customized bundle nuclear designs. The GNF2 design is a 10x10 array with 92 fuel rods (eight of which are LPLR, and six are SPLR) and two large central water rods. Since full reloads of GNF2 were inserted in the mid-2000s, over 22,000 GNF2 fuel assemblies have operated. Besides the US, GNF2 is licensed to operate in Switzerland, Germany, Spain, Sweden, and Finland. In addition to the US, GESTAR has been adopted in Mexico, Spain, Switzerland, and Taiwan as the BWRs are of the GE type.

(References 8-3 and 8-6) provide evidence that the GNF2 fuel design for application within the GE Boiling Water Reactor X-300 (BWRX-300) is compliant to the CNSC regulatory requirements for Focus Area 4, as specified in REGDOC 2.5.2, Design of Reactor Facilities: Nuclear Power Plants (1). As such, the GNF2 fuel assembly is evaluated to meet CNSC requirements governing nuclear fuel and may be approved for generic use in BWRs in Canada. The adequacy of the BWRX-300 reactor, fueled with GNF2, is addressed in the plant Preliminary Safety Analysis Report (PSAR).

7.0 ACRONYMS, DEFINITIONS, AND SYMBOLS

7.1 Acronyms

Acronym	Explanation
ABWR	Advanced Boiling Water Reactor
AOO	Anticipated Operational Occurrence
BWR	Boiling Water Reactor
BWRX-300	GE Boiling Water Reactor X-300
CNSC	Canadian Nuclear Safety Commission
COLR	Core Operating Limits Report
CSDM	Cold Shutdown Margin
DBA	Design Basis Accidents
DEC	Design Extension Condition
GE	General Electric Company
GESTAR II	General Electric Standard Application for Reload Fuel
LOCA	Loss-Of-Coolant-Accident
LTP	Lower Tie Plate
LTR	Licensing Topical Report
NRC	U.S. Nuclear Regulatory Commission
OLMCPR	Operating Limit Minimum Critical Power Ratio
PCI	Pellet Cladding Interaction
PLR	Part Length Rod
PSA	Probabilistic Safety Analysis
SRLR	Supplemental Reload Licensing Report

7.2 Definitions

Term	Definition
delta-Keff	Change in neutron multiplication
GC	Gadolinia concentration
H/U ratio	Hydrogen to uranium ratio
UO2 or (UO2+Gd2O3)	Uranium Dioxide (Uranium dioxide with gadolinia as burnable absorber)

7.3 Symbols

Symbol	Definition
atm	Atmospheres
cm	Centimeter
g/cc	Grams per cubic centimeter
KgU	Kilograms of uranium
mm	Millimeter
Zirc	Zircalloy

8.0 REFERENCES

8-1 Canadian Nuclear Safety Commission, REGDOC 2.5.2, Design of Reactor Facilities: Nuclear Power Plants, May 2014.

8-2 GE Hitachi Nuclear Energy, NEDE-24011-P-A-31, Standard Application for Reactor Fuel (GESTAR II), November 2020.

8-3 GE Hitachi Nuclear Energy, 006N1887, Revision A, BWRX-300 Fuel Design and Qualification.

8-4 GE Hitachi Nuclear Energy, 006N2726, Revision A, BWRX-300 Reactor Core Nuclear Design.

8-5 GE Hitachi Nuclear Energy, 006N2656, Revision A, BWRX-300 Deterministic Safety Analysis.

8-6 GE Hitachi Nuclear Energy, NEDC-33270P, Revision 11, GNF2 Advantage Compliance with Amendment 22 of NEDE-24011-P-A (GESTAR II), August 2020.

8-7 GE Hitachi Nuclear Energy NEDC-33940P, Class II (Proprietary), GNF2 Fuel Assembly Mechanical Design Report for BWRX-300, August 2022.

9.0 APPENDIX A: BWRX-300 FUEL DESIGN AND QUALIFICATION – COMPLIANCE MATRIX

9.1 Purpose

The compliance matrix contained herein maps the evidence of compliance for BWRX-300 GNF2 fuel to the applicable regulatory requirements in REGDOC 2.5.2 Version 1.

Fuel Design and Qualification – Compliance Matrix			
Clause	**Title**	**GEH Conformance Statement**	**GEH Conformance Summary and Reference**
REGDOC 2.5.2, Section 7.13.1	Seismic Design and Classification	**The BWRX-300 design currently complies with the cited regulatory document section as written** The design authority shall ensure that seismically qualified SSCs important to safety are qualified to a Design Basis Earthquake (DBE) and ensure that they are categorized accordingly. This shall apply to: (1) SSCs whose failure could directly or indirectly cause an accident leading to core damage, (2) SCCs restricting the release of radioactive material to the environment, (3) SCCs that assure the subcriticality of stored nuclear material, (4) SSCs such as radioactive waste tanks containing radioactive material that, if released, would exceed regulatory dose limits.	See Section 4.1.12 of 006N1887 Revision A
REGDOC 2.5.2, Section 8.1	Reactor Core	**The BWRX-300 design currently complies with the cited regulatory document section as written** The anticipated upper limit of possible deformation or other changes due to irradiation conditions shall be evaluated. These evaluations shall be supported by data from experiments, and from experience with irradiation. The design shall provide protection against those deformations, or any other changes to reactor structures that have the potential to adversely affect the behavior of the core or associated systems.	See Section 4.1.1 of 006N1887 Revision A
REGDOC 2.5.2, Section 8.1	Reactor Core	**The BWRX-300 design currently complies with the cited regulatory document section as written** The reactor core and associated structures and cooling systems shall: (1) withstand static and dynamic loading, including thermal expansion and contraction, (2) withstand vibration (such as flow-induced and acoustic vibration), (3) ensure chemical compatibility, including service-related contaminants, (4) meet thermal material limits, and (5) meet radiation damage limits	See Section 4.1.2 of 006N1887 Revision A
REGDOC 2.5.2, Section 8.1.1	Fuel Elements, Assemblies and Design	**The BWRX-300 design currently complies with the cited regulatory document section as written** Fuel assembly design shall include all components in the assembly, such as the fuel matrix, cladding, spacers, support plates, movable rods inside the assembly etc. The fuel assembly design shall also identify all interfacing systems.	See Section 4.1.3 of 006N1887 Revision A
REGDOC 2.5.2, Section 8.1.1	Fuel Elements, Assemblies and Design	**The BWRX-300 design currently complies with the cited regulatory document section as written** Fuel assemblies and the associated components shall be designed to withstand the anticipated irradiation and environmental conditions in the reactor core, and all processes of deterioration that can occur in operational states.	See Section 4.1.4 of 006N1887 Revision A
REGDOC 2.5.2, Section 8.1.1	Fuel Elements, Assemblies and Design	**The BWRX-300 design currently complies with the cited regulatory document section as written** The fuel shall remain suitable for continued use after AOOs.	See Section 4.1.11 of 006N1887 Revision A

Fuel Design and Qualification – Compliance Matrix			
Clause	**Title**	**GEH Conformance Statement**	**GEH Conformance Summary and Reference**
REGDOC 2.5.2, Section 8.1.1	Fuel Elements, Assemblies and Design	**The BWRX-300 design currently complies with the cited regulatory document section as written** At the design stage, consideration shall be given to long-term storage of irradiated fuel assemblies after discharge from the reactor.	See Section 4.1.5 of 006N1887 Revision A
REGDOC 2.5.2, Section 8.1.1	Fuel Elements, Assemblies and Design	**The BWRX-300 design currently complies with the cited regulatory document section as written** Fuel design limits shall be established to include, as a minimum, limits on fuel power or temperature, limits on fuel burnup, and limits on the leakage of fission products in the reactor cooling system. The design limits shall reflect the importance of preserving the fuel matrix and cladding, as these are first and second barriers to fission product release, respectively.	See Section 4.1.6 of 006N1887 Revision A
REGDOC 2.5.2, Section 8.1.1	Fuel Elements, Assemblies and Design	**The BWRX-300 design currently complies with the cited regulatory document section as written** The design shall account for all known degradation mechanisms, with allowance being made for uncertainties in data, calculations, and fuel fabrication.	See Section 4.1.7 of 006N1887 Revision A
REGDOC 2.5.2, Section 8.1.1	Fuel Elements, Assemblies and Design	**The BWRX-300 design currently complies with the cited regulatory document section as written** Fuel assemblies shall be designed to permit adequate inspection of their structures and components prior to and following irradiation.	See Section 4.1.8 of 006N1887 Revision A
REGDOC 2.5.2, Section 8.1.1	Fuel Elements, Assemblies and Design	**The BWRX-300 design currently complies with the cited regulatory document section as written** The requirements for reactor and fuel assembly design shall apply in the event of changes in fuel management strategy, or in operating conditions, over the lifetime of the plant.	See Section 4.1.9 of 006N1887 Revision A
REGDOC 2.5.2, Section 8.1.1	Fuel Elements, Assemblies and Design	**The BWRX-300 design currently complies with the cited regulatory document section as written** Fuel design and design limits shall reflect a verified and auditable knowledge base. The fuel shall be qualified for operation, either through experience with the same type of fuel in other reactors, or through a program of experimental testing and analysis, to ensure that fuel assembly requirements are met.	See Section 4.1.10 of 006N1887 Revision A
REGDOC 2.5.2, Section 8.1.1	Fuel Elements, Assemblies and Design	**The BWRX-300 design currently complies with the cited regulatory document section as written** In DBAs, the fuel assembly and its component parts shall remain in position with no distortion that would prevent effective post-accident core cooling or interfere with the actions of reactivity control devices or mechanisms. The design shall specify the acceptance criteria necessary to meet these requirements in DBAs.	See Section 5.5 of 004N9787 Revision C

Fuel Design and Qualification – Compliance Matrix			
Clause	**Title**	**GEH Conformance Statement**	**GEH Conformance Summary and Reference**
REGDOC 2.5.2 Section 8.12.1	System-Specific Requirements –Fuel Handling and storage / Handling and storage of non-irradiated fuel	**The BWRX-300 design currently complies with the cited regulatory document section as written** The design of the fuel handling and storage systems for non-irradiated fuel shall: 1. ensure nuclear criticality safety 2. permit appropriate maintenance, periodic inspection, and testing of components important to safety 3. permit inspection of non-irradiated fuel 4. prevent loss of or damage to the fuel 5. meet Canada's safeguards requirements for recording and reporting accountancy data, and for monitoring flows and inventories related to non-irradiated fuel containing fissile material	Handling and storage systems of non-irradiated fuel are interfacing systems with the fuel design and are, thus, considered in the fuel design (see Section 4.1.3 of 006N1887 Revision A). For compliance to the system requirements see Sections 2.1 and 3.6 of 005N9751 Revision A.
REGDOC 2.5.2 Section 8.12.2	System-Specific Requirements –Fuel Handling and storage / Handling and storage of irradiated fuel	**The BWRX-300 design currently complies with the cited regulatory document section as written** The design of the handling and storage systems for irradiated fuel shall: 1. ensure nuclear criticality safety 2. permit adequate heat removal in operational states, DBAs and Design Extension Conditions (DECs) 3. permit inspection of irradiated fuel 4. permit periodic inspection and testing of components important to safety 5. prevent the dropping of irradiated fuel in transit 6. prevent unacceptable handling stresses on fuel elements or fuel assemblies 7. prevent the inadvertent dropping of heavy objects and equipment on fuel assemblies 8. permit inspection and safe storage of suspect or damaged fuel elements or fuel assemblies 9. provide proper means for radiation protection 10. permit adequate identification of individual fuel modules 11. facilitate maintenance and decommissioning of the fuel storage and handling facilities 12. facilitate decontamination of fuel handling and storage areas and equipment when necessary 13. ensure implementation of adequate operating and accounting procedures to prevent loss of fuel	Handling and storage systems of irradiated fuel are interfacing systems with the fuel design and are, thus, considered in the fuel design (see Section 4.1.3 of 006N1887 Revision A). For compliance to the system requirements see Sections 2.1 and 3.6 of 005N9751 Revision A.

Fuel Design and Qualification – Compliance Matrix			
Clause	**Title**	**GEH Conformance Statement**	**GEH Conformance Summary and Reference**
		14. include measures to prevent a direct threat or sabotage to irradiated fuel 15. meet Canada's safeguards requirements for recording and reporting accountancy data, and for monitoring flows and inventories related to irradiated fuel containing fissile material	
REGDOC 2.5.2 Section 8.12.3	System-Specific Requirements –Fuel Handling and storage / Detection of failed fuel	**The BWRX-300 design currently complies with the cited regulatory document section as written** The design shall provide a means for allowing reliable detection of fuel defects in the reactor, and the subsequent removal of failed fuel, if action levels are exceeded.	This requirement is similar to the requirement in 8.1.1 that says: "Fuel design limits shall be established to include limits on the leakage of fission products in the reactor cooling system." The conformance summary for this requirement is provided in Section 4.1.6 of 006N1887 Revision A. The leakage of fuel will be detected by dose monitors and actions defined based on dose limits. This is covered in Focus Area 13, Radiation Protection, submittal in Package 4 scheduled for January 7, 2022. A summary of the GNF experience with failed fuel is provided in Appendix A of 006N1887 Revision A. GNF has extensive experience helping utilities detect failed fuel and manage operations after detection.