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GLOBAL NUCLEAR FUELS

FUEL BUNDLE DESIGNS

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1. INTRODUCTION AND SUMMARY

This document contains fuel bundle–specific information for General Electric and Global Nuclear Fuels fuel bundles that have been designed and analyzed per the requirements described in Reference 1. The fuel designs contained in this document have received specific USNRC review and approval or have been shown to meet the USNRC approved fuel licensing acceptance criteria documented in Reference 1. A detailed description of these designs is given in Section 2.

Individual fuel bundles meeting these specifications are listed the following historical and current references.

"GE Fuel Bundle Designs," NEDE–31152P, Supplement 1, June 2000
"GE Fuel Bundle Designs," NEDE–31152P, Supplement 2, April 2001
"GE Fuel Bundle Designs," NEDE–31152P, Supplement 3, November 2002
"GE Fuel Bundle Designs," NEDE–31152P, Supplement 4, September 2003
"GNF Fuel Bundle Designs," NEDE–31152P, Supplement 5, May 2007
"GNF Fuel Bundle Designs," NEDE–31152P, Supplement 6, May 2007

Any new fuel bundle designs designed and analyzed with the fuel rod thermal–mechanical performance model described in Reference 1 will be included in future revisions to this document.

2. FUEL DESIGNS

The fuel designs presently covered in this report include:

(1) Prepressurized 8x8 Retrofit (P8x8R) and Prepressurized 8x8 Retrofit with barrier cladding (BP8x8R);

(2) GE8 and GE8B – also designated as GE8x8E (non–barrier) and GE8x8EB (barrier option);

(3) GE9B – also designated as GE8x8NB;

(4) GE10 – also designated as GE8x8NB–1 (interactive channel – C–lattice plants), GE8x8NB–2 (offset lower tie–plate only – D–lattice plants) and GE8x8NB–3 (interactive channel with offset lower tie plates – D–lattice plants);

(5) GE11.

(6) GE13.

(7) GE12.

(8) GE14

(9) GNF2

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2.1 FUEL ASSEMBLY DESCRIPTION

The fuel assembly (Figure 2–1) consists of a fuel bundle and a channel, which surrounds it. Fuel assembly parameters for each fuel bundle type are given in Tables 2–1 through 2–8. The P8x8R and BP8x8R fuel bundles contain 62 fuel rods and two water rods. The GE8/8B fuel designs provide for the use of more than two water rods. Details of this design option are presented in Subsection 2.1.2. The GE9B and GE10 fuel bundles contain 60 fuel rods and one large centrally located water rod. The rods in the above fuel designs are placed in an 8x8 lattice array. The GE11 and GE13 fuel designs are comprised of 74 fuel rods and two large central water rods in a 9x9 lattice array. Eight of these fuel rods are part length rods (see Subsection 2.1.1). The GE12 and GE14 fuel is comprised of 92 fuel rods and two large central water rods in a 10x10 lattice array. Fourteen of these fuel rods are part length rods. The rods of all bundle types are spaced and supported by the upper and lower tie plates, as well as fuel rod spacers. The lower tie plate has a nosepiece that has the function of supporting the fuel assembly in the reactor. The upper tie plate has a handle for transferring the fuel bundle from one location to another. The identifying assembly serial number is engraved on the top of the handle. No two assemblies bear the same serial number. A boss projects from one side of the handle to aid in ensuring proper

fuel assembly orientation (see Figure 2–2). Finger springs, located between the lower tie plates and the channel, are utilized to control the bypass flow through that flow path. Finger springs are not used in GNF2. Like the GE12 and GE14 fuels, the GNF2 fuel is also comprised of 92 fuel rods, including 14 part length rods, and two large central water rods in a 10x10 lattice array. However, the 14 part length rods in GNF2 consist of two types of different length: 8 long part length rods and 6 short part length rods.

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A schematic representation of this axial zoning of uranium enrichment and gadolinia concentration and number of gadolinia rods for the GE8 through GNF2 fuel designs is shown in Figures 2–3 through 2–5. [[

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2.1.1 Fuel Rods

Three types of fuel rods are used in all of the fuel bundle designs included in this report: tie rods, standard rods, and part length rods. The tie rods in each bundle have lower end plugs, which thread into the lower tie plates and threaded upper end plugs that extend through the upper tie plates. A nut and locking tab are installed on the upper end plug of the tie rods to hold the fuel bundle together. These tie rods support the weight of the bundle during fuel handling operations. [[ ]] In the GE11, GE12, GE13, GE14 and GNF2 fuel designs the third type of fuel rod, called a part length rod, is used. There are 8 part length rods in the GE11 and GE13 fuel designs and 14 part length rods in the GE12, GE14 and

GNF2 fuel designs. [[

]] The location of these rods are shown in Figures 2–6 through 2–8.

During operation, the fuel assembly is supported by the lower tie plate. [[

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Each fuel rod consists of high-density ceramic uranium dioxide fuel pellets stacked within Zircaloy cladding that is evacuated, backfilled with helium to a specified pressure and sealed with Zircaloy end plugs welded on each end. For the barrier fuel designs, the cladding consists of the same Zircaloy base material with the innermost part of the cladding replaced by a thin zirconium liner. [[

]] The barrier fuel designs include BP8x8R, GE8B, GE9B, GE10, GE11, GE12, GE13, GE14, and GNF2.

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Adequate free volume is provided within each fuel rod in the form of a pellet–to–cladding gap and a plenum region at the top of the fuel rod to accommodate thermal and irradiation expansion of the UO_2 and the internal pressures resulting from the helium fillgas, impurities, and gaseous fission products liberated over the design life of the fuel. [[

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2.1.2 Water Rods

The P8x8R and BP8x8R fuel bundles contain two water rods. GE8/8B fuel designs provide for the use of more than two water rods. The GE9B and GE10 fuel designs contain one large centrally located water rod. This is increased to two large central water rods for the GE11, GE12, GE13, GE14, and GNF2 fuel designs. A dimensional description of the water rods is included in Tables 2–1 through 2–8.

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2.1.3 Other Fuel Assembly Components

The primary function of the fuel spacer is to provide lateral support and spacing of the fuel rods. The P/BP8x8R and GE8/8B fuel designs utilize an egg–crate spacer. The ferrule spacer design is used for the GE9B through GE11 and in the GE 13 and GE14 fuel designs. The GE12 fuel design optionally employs either a ferrule or a unit cell spacer. There are seven (7) spacers in

the fuel designs through GE11. GE12, GE13 and GE14 have an eighth spacer. In the GE11, GE12 and GE13 fuel design, the top two spacers do not have ferrules above the part length fuel rods, and the GE14 fuel design has no ferrules above the part length fuel rods in the top three spacers. Finger springs are employed to control the bypass flow through the channel–to–lower tie plate flow path. These finger spring seals, which are located between the lower tie plate and the channel, provide control over the flow through this path due to channel wall deflections by maintaining a nearly constant flow area as the channel wall deforms. GNF2 uses 8 grid type spacers, consisting of Alloy X-750. Finger springs are not used in GNF2.

The upper and lower tie plates support the weight of the fuel and position the rod ends during operation and handling. Two alternate path bypass flow holes are located in the lower tie plate (Figure 2–1). These holes are drilled to augment flow in the bypass region. A similar design is used for GE11, GE12, GE13 and GE14. There is an optional *Debris Filter* lower tie plate available for GE11, GE12 and GE13 fuel.

The debris filter lower tie plate is standard for the GE14 design. This debris filter lower tie plate is very similar to the regular tie plate except for the upper portion, or the grid plate. [[

]] The Debris Filter lower tie plate is standard for the GNF2 designs. The Debris Filter types available for GNF2 are: the Integral Debris Filter LTP, the Debris Shield LTP, and the Defender LTP.

2.1.4 Channels

The channel is open at the bottom [[

]] The channel fastener springs and the channel spacer buttons position the upper end of each fuel assembly in a four–bundle cell in the corners of the cell against the top guide beams. At the top of the channel, two diagonally opposite corners have welded tabs, one of which supports the weight of the channel from a threaded raised post on the upper tie plates. The channel is attached using the threaded channel fastener assembly, which also includes the fuel assembly positioning spring. Channel–to–channel spacing is provided by means of spacer buttons located on the upper portion of the channel adjacent to the control rod passage area.

For the P/BP8x8R through GE9B fuel designs, the channels have a uniform thickness of 80 or 100 mils for BWR2–5 plants and 120 mils for BWR6 plants. The channels for the GE10 options 1 and 3 (GE10–1,3), GE11, GE12, GE13, GE14 and GNF2 fuel designs have, in most cases, thinner sides and thicker corners. Channel dimensions for all fuel designs are given in Tables 2–1 through 2–8.

The BWR Zircaloy fuel channel performs the following functions:

(1) Forms the fuel bundle flow path outer periphery for bundle coolant flow.

(2) Provides surfaces for control rod guidance in the reactor core.

(3) Provides structural stiffness to the fuel bundle during lateral loadings applied from fuel rods through the fuel spacers.

(4) Minimizes, in conjunction with the finger springs and bundle lower tie plates, coolant bypass flow at the channel/lower tie plates interface. Finger springs are not used in GNF2.

(5) Transmits fuel assembly seismic loadings to the top guide and fuel support of the core internal structures.

(6) Provides a heat sink during loss–of–coolant accident (LOCA).

(7) Provides a stagnation envelope for in–core fuel sipping.

Table 2–1
FUEL ASSEMBLY DESIGN SPECIFICATIONS For The P/BP8x8R FUEL DESIGN
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Table 2–2
FUEL ASSEMBLY DESIGN SPECIFICATIONS FOR THE GE8/8B FUEL DESIGN

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Table 2–3
FUEL ASSEMBLY DESIGN SPECIFICATIONS FOR THE GE9B & GE10 FUEL DESIGNS

	GE9B or GE10–1,3	GE9B	GE10–1
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Table 2–4
FUEL ASSEMBLY DESIGN SPECIFICATIONS FOR THE GE11 FUEL DESIGN

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Table 2–5
FUEL ASSEMBLY DESIGN SPECIFICATIONS FOR THE GE12 FUEL DESIGN

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Table 2–6
FUEL ASSEMBLY DESIGN SPECIFICATIONS FOR THE GE13 FUEL DESIGN

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Table 2–7
FUEL ASSEMBLY DESIGN SPECIFICATIONS FOR THE GE14 FUEL DESIGN

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Table 2–8
FUEL ASSEMBLY DESIGN SPECIFICATIONS FOR THE GNF2 FUEL DESIGN

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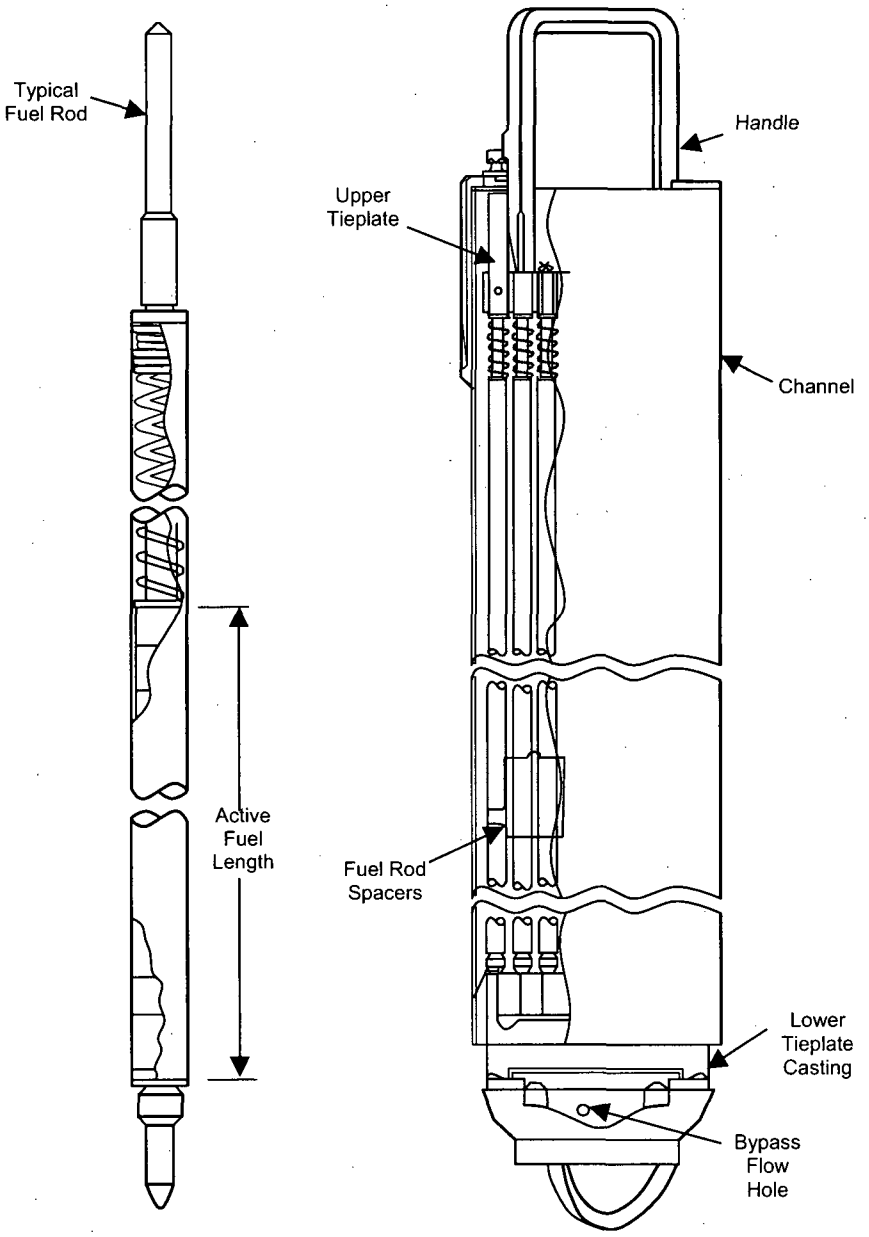

Figure 2–1. Typical GE BWR Fuel Assembly

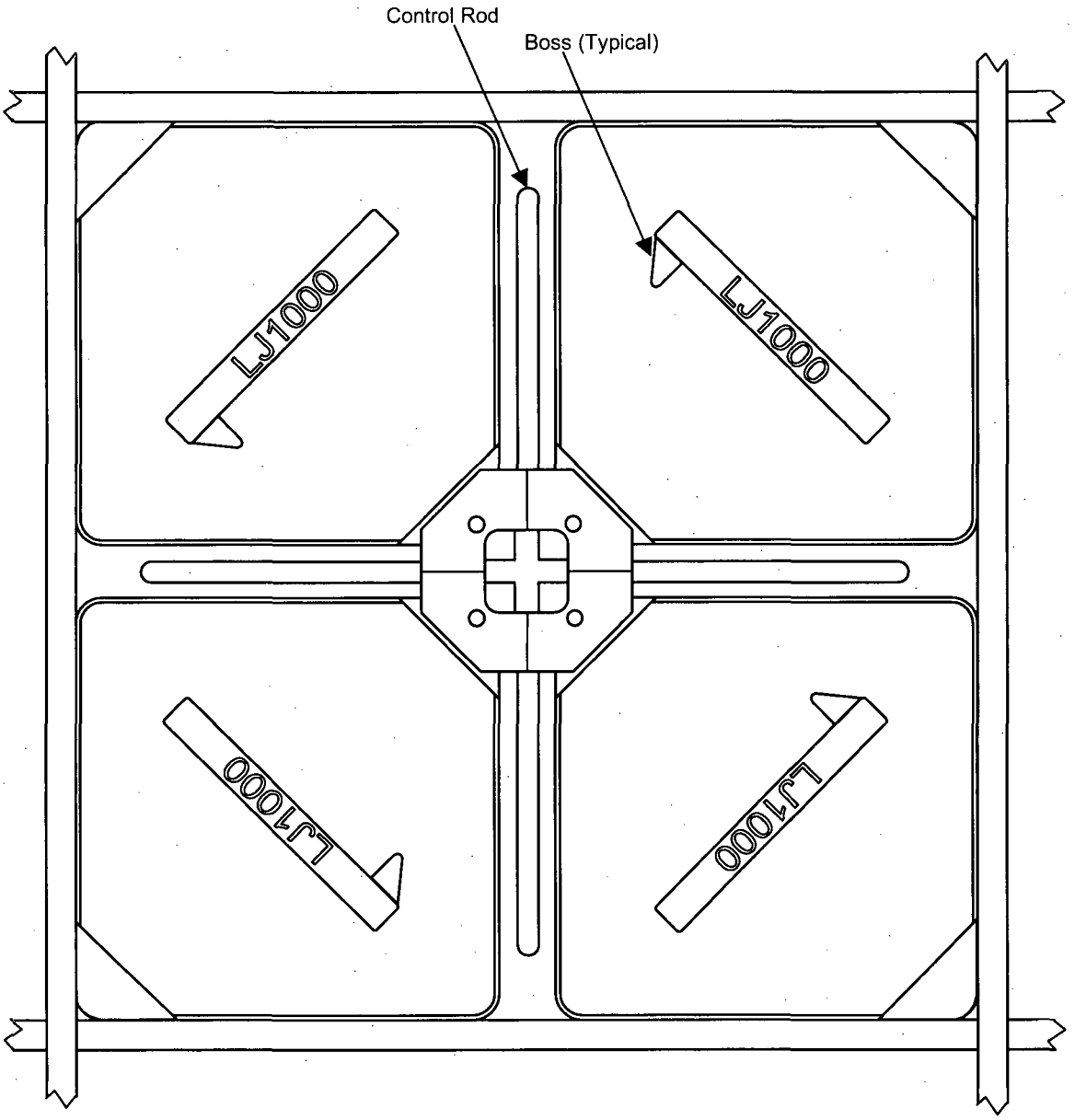

Figure 2–2. Typical Core Cell

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Figure 2-3. Illustration of Axial Zoning in GE8 Through GE10 Fuel Designs

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Figure 2–4. Illustration of Typical Axial Zoning in GE11, GE12, GE13 and GE14 Fuel Designs

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Figure 2–5. Illustration of Typical Axial Zoning in GNF2 Fuel Design

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Figure 2–6. GE11/13 Part Length Rod Locations

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Figure 2–7. GE12/14 Part Length Rod Locations

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Figure 2–8. GNF2 Part Length Rod (PLR) Locations

3. ANALYSES

GESTAR II (Reference 1) provides the basis for the design and analysis of the fuel designs described in Section 2. The generic analyses for fuel designs licensed under the GESTAR II fuel licensing criteria are documented in fuel bundle specific reports. These compliance reports are transmitted to the USNRC to establish completion of the GESTAR II requirements and are incorporated by reference into GESTAR II. The GEXL critical power correlations used for the fuel bundles described in Section 2 and in the Supplements to this report are correlations which have been specifically approved by the USNRC or have been derived using the criteria in Subsection 1.1.7 of Reference 1. Critical power correlations that have received specific USNRC review and approval as well as those that were derived using the criteria in reference 1 are included by reference in GESTAR II.

4. REFERENCES

1. "General Electric Standard Application for Reactor Fuel," NEDE–24011–P–A, most recent revision.