Global Nuclear Fuel

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Subject: Part 21 60-Day Final Report Notification: GNF3 Raised Water Rod (SC-22-04 Revision 2)

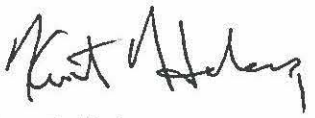
This letter provides Global Nuclear Fuel's (GNF) final report regarding a 10 CFR Part 21 evaluation. This is the final report for Reference 1.

One GNF3 bundle with a raised water rod was found during core verification. The GNF3 bundle was in its first cycle of operation. The water rod remained constrained within the envelope of the fuel bundle, which was discharged to the spent fuel pool for examinations. The examinations concluded that no fuel leaks were present, and all hardware was intact with no visible wear or damage. The cause was identified as the water rod not being rotated into its proper orientation during assembly.

The information required for this GNF Final Report Notification per §21.21 (a)(2) is attached as Enclosures 1 through 4.

Please contact Dr. Brian Moore, General Manager of Core and Fuel Engineering (brian.moore@gnf.com) if there are any questions.

Sincerely,



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References

1. Global Nuclear Fuels, M220124, Revision 1, Part 21 60-Day Interim Report Notification: GNF Raised Water Rod (SC-22-04 R1)

Enclosures:

Summary Letter

1. Final Report
2. List of Potentially Affected Plants
3. Recent GE Hitachi Nuclear Energy 10 CFR Part 21 Communications
4. GNF's Assessment of 06.07 Scope of Operability Determinations

cc: E Lenning, NRC
L Dudes, NRC Region II Administrator
J. Giessner, NRC Region III Administrator
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L Trosman, GEH Wilmington, NC
B Moore, GNF Wilmington, NC
PLM Specification 007N3317 Revision 2

Global Nuclear Fuel

10 CFR Part 21 Communication

SC 22-04 R2 *November 30, 2022*

To: *Affected and Potentially Affected Plants (Enclosure 2)*

Subject: *GNF3 Raised Water Rod – Final Notification*

[X]	**Reportable Condition [21.21(d)]**	[ ]	**60 Day Interim Report [21.21(a)(2)]**
[ ]	**Transfer of Information [21.21(b)]**	[X]	**Safety Information Communication**

Summary:

One GNF3 bundle with a raised water rod was found during core verification at a US-based nuclear power plant. The GNF3 bundle was in its first cycle of operation. The water rod remained constrained within the envelope of the fuel bundle, which was discharged to the spent fuel pool for examinations. The examinations concluded that no fuel leaks were present, and all hardware was intact with no visible wear or damage. The cause was identified as the water rod not being rotated into its proper orientation during assembly.

It is determined that GNF3 bundles fabricated between March 1, 2021, and August 1, 2022, that have not already undergone an enhanced fuel receipt inspection may be susceptible to an infrequent occurrence of this defect.

Analysis of the susceptible GNF3 population concludes that the subject condition has not created a potential for a Substantial Safety Hazard (SSH) nor contributed to exceeding a Safety Limit, as defined in the Technical Specifications of a license for operation issued under 10 CFR Part 50. However, if the condition were to go uncorrected and a bundle with an unlocked water rod were operated beyond a single cycle, it has the potential to contribute to the exceedance of a Technical Specification Safety Limit for bundle critical power and create a potential for a SSH due to a potential loss of structural integrity under design basis loads (i.e., coolability cannot be assured).

GNF has completed the evaluation of the condition described above and determined that the subject condition is reportable under 10 CFR Part 21(d).

Please contact Dr. Brian Moore, General Manager of Core and Fuel Engineering (brian.moore@gnf.com) if there are any questions.

Issued by:

Kent Halac, Safety Evaluation Program Manager Delegate
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Background

During a mid-cycle outage at a US-based BWR/6, a first cycle GNF3 bundle (designated "GEX290") was discovered to have a raised water rod during core verification inspection (Figure 1).

After the GEX290 discovery, a second GNF3 bundle was found with a water rod not rotated during fabrication oversight with interim additional quality control verification during manufacturing. This GNF3 bundle did not leave GNF's manufacturing facility and the condition was corrected.

During the bundle assembly process for GNF3 fuel products, the water rod is locked into place via manual rotation of the water rod engaging a proprietary mechanism in the Lower Tie Plate (LTP). A number of spacers are distributed axially where each spacer is engaged by a set of tabs on the water rod that positively locate each spacer for height and separation.

The primary functions of the spacers are to hold the fuel rods in their proper locations and to improve fuel performance during operation by mixing the water such that the fuel rods maintain the water film responsible for the heat transfer out of the rod and into the coolant. The relevant metric for this thermal-hydraulic behavior and associated limit is the critical power of the assembly, which varies throughout operation of the core.

Figure 2 shows a photo taken during the outage at the discovery of the raised water rod and the unengaged water rod tabs.

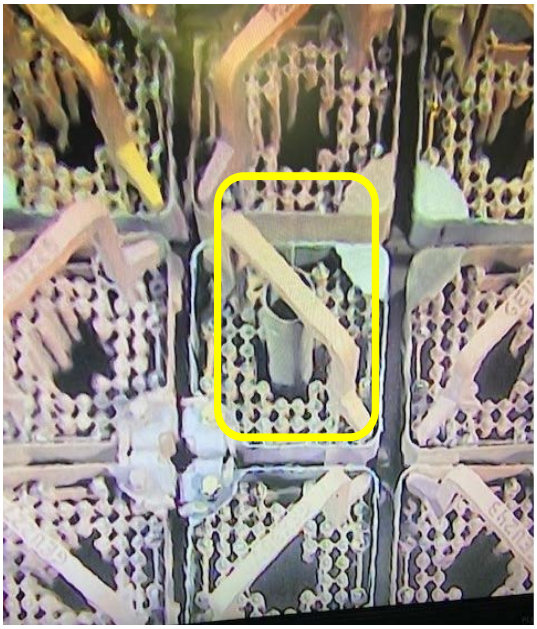

Figure 1: Raised Water Rod

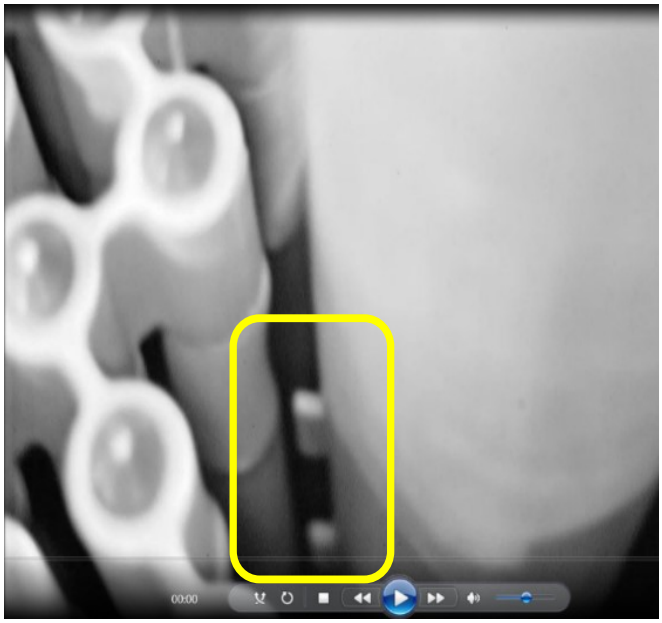

Figure 2: Closeup of Spacer 8 Water Rod Tab

After the initial discovery, further inspection of bundle GEX290 indicated that the water rod capture mechanism in the LTP was never engaged. The cause was identified as the water rod not being rotated into its proper orientation during bundle assembly due to human error.

Until March 2021, the bundle assembly process involved at least three individuals: two operators and a Quality Control (QC) inspector. From March 1, 2021, the QC inspector function was replaced with each operator as the designated quality checker for the other operator. QC inspectors continued to perform quality inspections during final inspection (after the bundle is assembled); however, a check of the WR

orientation was not explicitly required in the final inspection procedure. On August 1, 2022, because of the GEX290 discovery, QC inspectors at final inspection were required to perform an in-process check for water rod orientation and the QC procedure was updated to assure clarity of the water rod inspection requirement. In addition, fuel receipt inspectors were instructed to assure proper water rod orientation (spacers engaged with water rod tabs) as part of their receipt inspection.

Discussion

Based on the water rod installation process and the root cause analysis that was performed, a probability of the water rod being improperly installed and not being detected by inspections was calculated based on industry accepted human reliability analyses methods for the various time periods described above. The conclusion from the reliability analyses was that the susceptible population consists of GNF3 bundles manufactured between March 1, 2021, and August 1, 2022, that have not already undergone additional inspection(s) to confirm water rod orientation. Within this population, while unlikely, it cannot be precluded that a bundle within a reload may have an unlocked water rod. As added confirmation that this condition is isolated, none of the past GNF3 fuel inspections (including for fuel failures) have identified such a condition.

Currently, the susceptible population does not include any bundles operating beyond their first cycle of operation. For a GNF3 bundle with an unlocked water rod operating in its first cycle, analysis shows insignificant impact to operation. During this single cycle irradiation period, normal operation hydraulic lift forces are sufficient to overcome the weight of an unlocked (and misoriented) water rod and the spacer spring friction restraining forces, given the relaxation of the spacer springs on the water rod. The spacers, which are normally fixed in place by the tabs on the water rod, are held in place by spacer spring forces. That spring force also experiences relaxation, but there is margin to the point where spacers can initially lift (i.e., where drag forces overcome friction and gravity) including both the drag forces for anticipated operational occurrence conditions and the uncertainties in the methodology used to calculate the associated forces.

If an unlocked water rod is raised up through the upper tie plate, but within the envelope of the fuel assembly, there is a change in the location of moderator within the lattice, and an effect of the altered geometry on the hydraulic resistance of the spacers, water rod exit, and upper tie plate. The net impact of the changes in local loss characteristics and void fraction reduction on bundle flow is insignificant.

Analyses of isolated instances of GNF3 assemblies with an unlocked and raised water rod established the potential impact of the subject condition on mechanical performance (including seismic events), thermal margins, transients, LOCA, and core stability. All analyses demonstrated acceptable performance for first cycle operation for bundles with the raised water rod condition.

At some irradiation time after an initial cycle of operation, spring forces on the spacers undergo sufficient relaxation that it is not possible to conclude that they remain at their initial axial locations. Spacers and their location are sufficiently important to critical power performance and to providing structural support for the fuel rods that margin to fuel mechanical or Tech Specification safety limits cannot be shown if such a condition were to exist.

Actions that GNF has already taken since the discovery of the condition include the following:

- GNF initiated Condition Report (CR) 40108 on July 27, 2022, to document this issue. The initiation of this CR under GNF's corrective action program prompted a 10 CFR Part 21 evaluation.
- A formal root cause analysis was performed on this issue per the GNF corrective action program to identify root causes and contributing causes. Due to the root cause analysis completion date going

beyond 60 days from the Part 21 evaluation initiation, GNF issued a 60-Day Interim Notification in accordance with 10 CFR Part 21.21(a)(2).

- After the apparent cause (that the water rod was not rotated during bundle assembly) was determined, on August 1, 2022, GNF manufacturing released QCII-5.2.8 Rev. 103 for final bundle inspection of GNF3 bundles to include looking down the upper tie plate opening to ensure the water rod tabs are aligned in the proper direction.
- For GNF3 bundles that were built and packed but not yet installed in reactor or spent fuel pool, QCII-0032 was updated for new fuel receipt to include an inspection of the water rod tab orientation prior to insertion into operation in the reactor.
- On September 8, 2022, QN-02484 was released to implement an additional check during the bundle build process for the final bundle inspectors to verify that the water rod is rotated prior to proceeding to the next step.

Conclusions

Analysis of the susceptible GNF3 population concludes that the subject condition has not created a potential for a Substantial Safety Hazard (SSH) nor contributed to exceeding a Safety Limit, as defined in the Technical Specifications of a license for operation issued under 10 CFR Part 50. However, if the condition were to go uncorrected and a bundle with an unlocked water rod were operated beyond a single cycle, it has the potential to contribute to the exceedance of a Technical Specification Safety Limit for bundle critical power and create a potential for a SSH due to a potential loss of structural integrity under design basis loads (i.e., coolability cannot be assured).

Recommended Actions

The following action is recommended for licensees when receiving GNF3 fuel.

- Receipt inspection of the GNF3 fuel should be augmented to include visual inspection for the proper water rod orientation. GNF has already provided supplemental instructions to inspection procedures to be used during new fuel receipt of GNF3 fuel bundles at licensees' facilities. These instructions provide a receipt inspection method for licensees to independently verify that the GNF3 water rod is in the correct orientation prior to insertion of the bundle in the fuel pool. These inspections have already been undertaken at some plants to disposition some or all of the susceptible population as being unaffected.

The following action is recommended for licensees with GNF3 fuel in the remaining susceptible population.

- Inspection of the GNF3 susceptible population should be performed prior to the second cycle of operation to identify if any bundles in that population have an unlocked water rod and take appropriate corrective action. This recommendation only applies to bundles that were not receipt inspected for an unlocked WR.

Enclosure 2

List of Potentially Affected Plants

BWR Plants and Associated Facilities

	Utility	Plant
X	Constellation Energy Generation	Clinton
	Constellation Energy Generation	Dresden 2-3
X	Constellation Energy Generation	FitzPatrick
X	Constellation Energy Generation	LaSalle 1
	Constellation Energy Generation	LaSalle 2
X	Constellation Energy Generation	Limerick 1
	Constellation Energy Generation	Limerick 2
	Constellation Energy Generation	Nine Mile Point 1
X	Constellation Energy Generation	Nine Mile Point 2
X	Constellation Energy Generation	Peach Bottom 2-3
	Constellation Energy Generation	Quad Cities 1-2
X	Detroit Edison Co.	Fermi 2
	Energy Northwest	Columbia
X	Entergy	Grand Gulf
X	Entergy	River Bend
	Entergy	Pilgrim
	FirstEnergy Nuclear Operating Co.	Perry 1
	Florida Power & Light	Duane Arnold
	Holtec International	Oyster Creek
	Nebraska Public Power District	Cooper
	NorthStar Group Services	Vermont Yankee
	Northeast Utilities	Millstone
	PPL Susquehanna LLC	Susquehanna 1-2
	Progress Energy	Brunswick 1-2
	PSEG Services Corp.	Hope Creek
X	Southern Nuclear Operating Co.	Hatch 1-2
	Tennessee Valley Authority	Browns Ferry 1-3
	Xcel Energy	Monticello

Non-Domestic BWR Plants

	Utility	**Plant**
_____	BKW-FMB, Ltd	Mühleberg
_____	Chubu Electric Power Co.	Hamaoka 1-4
_____	Chubu Electric Power Co.	Hamaoka 5
_____	Chugoku Electric Power Co.	Shimane 1-2
_____	Chugoku Electric Power Co.	Shimane 3
_____	Comision Federal de Electricidad	Laguna Verde 1-2
_____	Forsmark Kraftgrupp AB	Forsmark 1-3
_____	Hokuriku Electric Power Co.	Shika 1
_____	Hokuriku Electric Power Co.	Shika 2
_____	Iberdrola SA	Cofrentes
_____	Japan Atomic Power Co.	Tokai 2
_____	Japan Atomic Power Co.	Tsuruga 1
_____	Kernkraftwerk Gundremmingen GmbH	Gundremmingen B, C
_____	Kernkraftwerk Brunsbuettel GmbH	Brunsbuettel
_____	Kernkraftwerk Kruemmel GmbH	Kruemmel
_____	Kernkraftwerk Philippsburg	Philipsburg
_____	Kernkraftwerk Leibstadt AG	Leibstadt
_____	Kraftgrupp AB	Forsmark
_____	Kraftgrupp AB	Ringhals 1
_____	Nuclenor SA	Santa Maria De Garoña
_____	OKG Aktiebolag	Oskarshamn 1-3
_____	Taiwan Power Company	Chinshan 1-2
_____	Taiwan Power Company	Kuosheng 1-2
_____	Taiwan Power Company	Lungmen 1-2*
_____	Teollisuuden Voima Oy	Olkiluoto 1-2
_____	Tokyo Electric Power Company	Fukushima Daiichi 1-6
_____	Tokyo Electric Power Company	Fukushima Daini 1-4
_____	Tokyo Electric Power Corporation	Kashiwazaki 1-5
_____	Tokyo Electric Power Corporation	Kashiwazaki 6-7
_____	Tohoku Electric Power Company	Higashidori 1
_____	Tohoku Electric Power Company	Onagawa 1-3

US PWR Plants

	Utility	**Plant**
_____	AmerenUE	Callaway
_____	Arizona Public Service	Palo Verde 1-3
_____	Constellation Energy Generation	Braidwood 1-2
_____	Constellation Energy Generation	Byron 1-2
_____	Constellation Energy Generation	Calvert Cliffs 1-2
_____	Constellation Energy Generation	Fort Calhoun
_____	Constellation Energy Generation	Ginna
_____	Constellation Energy Generation	Three Mile Island 1
_____	Dominion	Kewaunee
_____	Dominion	Millstone 2
_____	Dominion	Millstone 3
_____	Dominion	North Anna 1-2
_____	Dominion	Surry 1-2
_____	Duke Energy Corporation	Catawba 1-2
_____	Duke Energy Corporation	Crystal River 3
_____	Duke Energy Corporation	McGuire 1-2
_____	Duke Energy Corporation	Oconee 1-3
_____	Duke Energy Corporation	Robinson
_____	Duke Energy Corporation	Shearon Harris
_____	Entergy	Arkansas Nuclear One 1-2
_____	Entergy	Indian Point 2-3
_____	Entergy	Palisades
_____	Entergy	Waterford 3
_____	FirstEnergy Nuclear Operations Co.	Beaver Valley 1-2
_____	FirstEnergy Nuclear Operating Co.	Davis-Besse
_____	Florida Power & Light	Seabrook
_____	Florida Power & Light	St. Lucie 1-2
_____	Florida Power & Light	Turkey Point 3-4
_____	Florida Power & Light	Point Beach 1-2
_____	Indiana Michigan Power Corp	D C Cook 1-2
_____	Northern States Power	Prairie Island 1-2
_____	Pacific Gas & Electric Co.	Diablo Canyon 1-2
_____	PSEG Nuclear LLC	Salem 1
_____	PSEG Nuclear LLC	Salem 2
_____	South Carolina Electric & Gas Co.	Summer
_____	South Texas Project Nuclear Operating Co.	South Texas Project 1-2
_____	Southern California Edison Co.	San Onofre 2-3
_____	Southern Nuclear Operating Co.	Farley 1-2
_____	Southern Nuclear Operating Co.	Vogtle 1-2
_____	Tennessee Valley Authority	Sequoyah 1-2
_____	Tennessee Valley Authority	Watts Bar 1
_____	Tennessee Valley Authority	Watts Bar 2
_____	TXU Electric Generation Co.	Comanche Peak 1-2
_____	Wolf Creek Nuclear Operating Corp.	Wolf Creek

Enclosure 3 – Recent GE Hitachi Nuclear Energy 10 CFR Part 21 Communications

The following is a list of recent 10 CFR Part 21 communications that GE Hitachi Nuclear Energy (GEH) and Global Nuclear Fuel (GNF) have provided to affected licensees as Reportable Conditions (RC), Transfers of Information (TI), 60-Day Interim Reports (60 Day) and/or Safety Information Communications (SC).

Number	Ref.	Subject	Date
SC 22-01	PRC 22-01	Inadequately sized / rated equipment used to perform dedication testing on a safety related transformer	5/26/2022
SC 22-02	PRC 22-03	Design Change Implemented by Manufacturer Impacts Qualification	6/8/2022
SC 22-03	PRC 22-02	Updated Lifetime Limits for Marathon-C+ Control Rods	6/16/2022
SC-22-04	PRC 22-04	Part 21 60-Day Interim Report Notification: GNF3 Raised Water Rod (SC-22-04)	9/28/2022
SC 22-04	**PRC 22-04**	**GNF3 Raised Water Rod – Final Notification**	**11/30/2022**

Enclosure 4

GNF's Assessment of 06.07 Scope of Operability Determinations

Item	Point to Address	GNF Assessment
a.	Possible elements of an operability determination include:	
(1)	The SSC affected by the condition,	Fuel assemblies with the potential condition are affected. Specifically, GNF3 fuel produced between March 1, 2021, and August 1, 2022, are the susceptible population.
(2)	The extent of condition for all similarly affected SSCs,	There are no other affected SSCs.
(3)	The current licensing basis requirements or commitments established for the affected SSC,	The current licensing basis requirement is the SSC's ability to perform its specified safety function (i.e., operate within defined Specified Acceptable Fuel Design Limits or SAFDLs).
(4)	The specified safety function(s) performed by the affected SSCs,	In general, most SSCs (e.g., control blades, safety relief valves, etc.) have a function that protects nuclear fuel assemblies, which are the SSCs of concern. As long as fuel is operated within applicable limits, such as the Technical Specification Safety Limit MCPR and thermal-mechanical limits, fuel cladding integrity is maintained.
(5)	The effect or potential effect of the condition on the affected SSC's ability to perform its specified safety function(s), and	The condition does not have a significant effect on the SSC's ability to perform its specified safety function (i.e., operate within SAFDLs). Operability is not challenged for bundles in the susceptible population for their first cycle of operation. However, if uncorrected, the condition could result in reduced margin to the Technical Specification Safety Limit MCPR if a limiting Anticipated Operational Occurrence (AOO) were to occur.
(6)	Whether there is a reasonable assurance of operability, including the basis for the determination and any compensatory measures put in place to establish or restore operability.	Implementation of the recommended actions is enough to assure that fuel can be operated as normal. The recommended measures assure adequate margin for operability.

Item	Point to Address	GNF Assessment
b.	The following things should be considered when reviewing operability determinations:	
(1)	Design basis events are plant-specific, and plant-specific TS, bases, and safety evaluations may contain plant-specific considerations related to operability,	Plant-specific safety evaluations are unaffected by this issue. Recommended actions will preserve the existing TS and bases as well as assure adequate margin to the existing TS and bases.
(2)	An SSC's operability requirements are based on safety analyses of specific design basis events for one mode or specified condition of operation and may not be the same for other modes or conditions of operation; therefore, all applicable modes and conditions of operation should be considered,	Recommended actions will assure conformance to existing bases, which includes all applicable licensed modes of operation. The recommended actions will assure adequate margin to the existing limits and bases, which includes all applicable modes of operation.
(3)	The operability requirements for an SSC encompass all necessary support systems (per the TS definition of operability) regardless of whether the TS explicitly specifies operability requirements for the support functions,	The recommended actions will assure adequate margin to the existing bases and TS requirements.
(4)	In order to evaluate conditions, it is assumed in the OD that the design basis event occurs. The occurrence of multiple simultaneous design basis events should be considered only to the extent that they are required as a part of the plant's CLB, and	The recommended actions will assure adequate margin to limits and supports conformance to the plant's CLB including the design basis events.
(5)	Compensatory measures may be established to restore or maintain operability of an SSC. See section 06.08 of this IMC for additional guidance on compensatory measures.	The identified recommended action assures adequate margin to support operation.