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M210077

U.S. Nuclear Regulatory Commission
Attn: Document Control Desk
Washington, DC 20555-0001

Subject: 10 CFR Part 21.21(d)-Reportable Condition: Fuel Support Side Entry Orifice Meta-Stable Flow for 2 Beam Locations in the BWR/6 Reactors

Reference 1 provided a GE Hitachi Nuclear Energy's (GEH) interim report regarding a 10 CFR Part 21 evaluation of hydraulic loss coefficients for certain fuel bundles as a function of location, which can result in a local overprediction of Minimum Critical Power Ratio (MCPR) margin.

Pursuant to 10 CFR 21.21(d), this letter provides the GEH final report for the Fuel Support Side Entry Orifice Meta-Stable Flow for 2 Beam Locations in the BWR/6 Reactors reportable condition. The basis for reportability is that the change in Minimum Critical Power Ratio associated with this issue could contribute to the exceeding of a safety limit, as defined in the technical specifications of a license for operation issued under 10 CFR Part 50. Enclosure 1 identifies the potentially affected plants, Enclosure 2 contains the reporting information, Enclosure 3 provides additional details of the evaluation, and Enclosure 4 provides information to assist plants that may desire to perform an operability determination.

Please contact me if there are any questions.

Sincerely,

Michelle P. Catts

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Safety Evaluation Program Manager
GE Hitachi Nuclear Energy Americas LLC

References:

1. Letter from M. P. Catts (GEH) to Document Control Desk (USNRC), Subject: Part 21 60-Day Interim Report Notification: Side Entry Orifice Hydraulic Loss Coefficient (SC 21-04 RO), April 19, 2021.

Enclosures:

1. US BWR Plants Potentially Affected
2. Reportable Condition per §21.21(d)
3. Description of Evaluation
4. Assessment of 06.07 Scope of Operability Determinations (OD)

cc: E. Lenning, USNRC NRR/DORL/LLPB
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PLM Spec 006N6786 R0

US BWR Plants Potentially Affected

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

RC – Reportable Condition

Reportable Condition per §21.21(d)

(i) Name and address of the individual or individuals informing the Commission.

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(ii) Identification of the facility, the activity, or the basic component supplied for such facility which fails to comply or contains a defect.

Input to GNF's core monitoring system potentially contains a defect.
See Enclosure 1 for a list of potentially affected U.S. plants

There are currently no US ABWR plants in operation that would potentially be affected by this evaluation. The potential error in the core monitoring system does not affect the NRC certified design of the ABWR or the GEH ABWR design certification renewal application currently under review. The unique core support structure design of the BWR6 and ABWR is not shared by earlier BWR plants or the ESBWR.

(iii) Identification of the firm constructing the facility or supplying the basic component which fails to comply or contains a defect.

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(iv) Nature of the defect or failure to comply and the safety hazard which is created or could be created by such defect or failure to comply.

The potentially underpredicted hydraulic loss coefficients for 2-beam locations are included in the databanks (input) applied to GNF core monitoring system for the BWR/6 customers identified in Enclosure 1. This potential defect could contribute to the exceeding of a safety limit, as defined in the technical specifications of a license for operation issued under 10 CFR Part 50.

(v) The date on which the information of such defect or failure to comply was obtained.

A Potential Reportable Condition evaluation was initiated by a GNF employee in accordance with 10 CFR Part 21 and GEH procedures on February 18, 2021.

(vi) In the case of a basic component which contains a defect or fails to comply, the number andlocation of these components in use at, supplied for, being supplied for, or may be suppliedfor, manufactured, or being manufactured for one or more facilities or activities subject to theregulations in this part.

Core monitoring system is applied to surveil fuel assemblies during operation. The potentially defective input to the system is a GEH product for BWR/6 customers. The four affected US plants are identified in Enclosure 1.

(vii) The corrective action, which has been, is being, or will be taken; the name of the individual or organization responsible for the action; and the length of time that has been or will be taken to complete the action.

Affected plants should review “Recommended Actions” in Enclosure 3 and if actions are elected to be implemented in core monitoring updates should contact their GNF account representative for schedule and delivery dates.

(viii) Any advice related to the defect or failure to comply about the facility, activity, or basic component that has been, is being, or will be given to purchasers or licensees.

Advice for affected BWR/6 customers is provided in the “Recommended Actions” in Enclosure 3.

For non-affected plants (See Enclosure 1), there are no recommended actions. GNF recognizes that other non-GNF fueled plants, safety analysis methodologies, and core monitoring systems may have different design bases and address the subject issue by other means.

(ix) In the case of an early site permit, the entities to whom an early site permit was transferred.

Not Applicable.

Description of Evaluation

Background

In 2020, GEH issued a Reportable Condition notification [Reference 1], as well as a safety information communication to inform plants that may have been similarly affected but were not GEH customers. The subject of these communications was the hydraulic loss coefficient used to calculate the pressure loss and flow rate into the Side Entry Orifice (SEO) at the fuel bundle entrance in BWR/6 plants. The SEO loss coefficient was underpredicted for some fuel bundle locations, which could result in an overprediction of MCPR margin in core monitoring applications. The overprediction was a result of not originally including in the assessment flow area restrictions associated with instrument support structures in the cross beams (structural supports underneath the core plate) in BWR/6 plant designs.

The issue evaluated here is a result of follow-on actions from the 2020 Reportable Condition [Reference 1] to further characterize the flow phenomena at other SEO locations. It has been discovered that the 2-beam (corner) fuel bundle locations have the potential for a meta-stable behavior resulting in higher SEO losses.

Discussion

The BWR/6 and ABWR plant designs are similar in that they have supporting cross beams that form a grid structure underneath the core plate. The orientation of SEOs relative to the beams produces the different losses due to differences in upstream flow areas. While the ABWR shares these similarities with the BWR/6 in this area, it has differences in design features in the vicinity of the SEO, as well as different orifice diameters compared to the BWR/6. These variations influence the SEO flow patterns and have the potential for meta-stable pressure losses for the BWR/6. These meta-stable losses have been determined not to apply to the geometry of the ABWR plant design.

BWR/2-5 plants built by GE have a different core support structure that is more open so that multiple SEO losses are not applied to evaluations for those plants. The ESBWR core support plate design is also different, and this issue is not applicable. The SEO loss coefficients for different beam configurations are applied in core monitoring applications for GNF customers; there are no ABWRs or ESBWRs operating or being monitored at this time in the United States.

The BWR/6 SEO inlet loss area dependency is well known. GE evaluated full-scale tests of different SEO configurations in the late 1980s. In 2002 it was discovered that modern GNF fuel designs (10x10 fuel), which have critical power performance that is more flow-dependent than prior generations, are more sensitive to this loss coefficient and changes were incorporated into core monitoring databanks to address the issue. In 2020, it was discovered at the IRM/SRM locations have more restrictive inlet flow areas and this was incorporated as an additional change in loss coefficient into core monitoring databanks. From the 2020 discovery, there were follow-on actions to further characterize the losses for the SEO configurations; it was found that meta-stable pressure losses may exist under some conditions for the 2-beam locations of the BWR/6

plant design. Random behavior of the interacting flow patterns in the lower plenum at the two beam locations may be possible that result in higher SEO pressure losses, which could lead to a situation where the actual SEO hydraulic loss at affected locations is higher than previously calculated. For US BWR/6 plants, the potential increase in the SEO loss for these locations has been evaluated to be bounded by a value approximately 1.9 times the current loss value (design basis). The frequency at which these higher-pressure losses may occur has not been determined. Figure 1 shows a diagram of the geometry of interest (not to scale). The SEO locations are designated A, B, C, D or D′ and the dashed lines are lines of symmetry. The 2-beam location corresponds to C on Figure 1.

Because the frequency at which meta-stable losses may occur has not been determined, the four US-based BWR/6 plants were evaluated using a bounding loss coefficient (1.9 times the current loss value) at the 2-beam location. Results show the potential MCPR impact at limiting locations can be greater than 0.01 and will vary by plant and power/flow condition. The MCPR impact is greater than the 0.01 criterion that GEH has historically applied for reporting that a Technical Specification (TS) Safety Limit (as found in TS 2.1) could have been exceeded as defined under 10 CFR Part 21. The value of 0.01 represents a level of significance beyond numerical roundoff errors and uncertainties.

As opposed to CPR, other limits, such as fuel rod linear heat generation rate or bundle planar average heat generation rate, are more strongly dependent on power, and less on flow and are therefore evaluated as being not significantly impacted.

Conclusions

The MCPR impact is greater than 0.01 due to possible meta-stable losses at the 2-beam locations. If not addressed, the condition could occur at a limiting bundle location and reduce transient margin. This could result in exceeding the SLMCPR (as found in TS 2.1) which is a reportable condition.

GEH recognizes that licensees will need to perform operability evaluations. To assist licensees in an assessment of Section 3.01 of Reference 2, “Scope of Operability Determinations,” is provided as Enclosure 4. As long as no limiting transient event as analyzed in the unit reload evaluation had occurred while the unit operating limit MCPR (OLMCPR) was exceeded due to implementation of the penalty described in this SC, it can be concluded that the SLMCPR was not exceeded. In other words, with no transient occurrence, the transient protection would not be needed, and therefore the margin between SLMCPR and OLMCPR would be more than enough to accommodate the penalty evaluated in this communication.

Recommended Actions

For affected plants that use GNF core monitoring systems, an action can be implemented, such as a penalized Operating Limit MCPR (OLMCPR) or an administrative MCPR penalty, in the core monitoring system. This measure would assure the limiting locations’ MCPR values are greater than the penalized OLMCPR or, if an MCPR penalty is used instead, assuring that the limiting

locations are less than the Maximum Fraction of Limiting CPR (MFLCPR) limit minus the penalty (e.g., $MFLCPR_{limit}$ = 1.00 - 0.05 = 0.95). Only the 2-beam locations require a penalized OLMCPR or an administrative MCPR penalty, but these may be applied to all core locations, which is conservative and acceptable. Note that this recommended measure was developed on a standalone basis conservatively applying the higher loss coefficient (giving largest CPR impact) at all 2 beam locations and does not supplant any existing MFLCPR limit reductions established for other purposes.

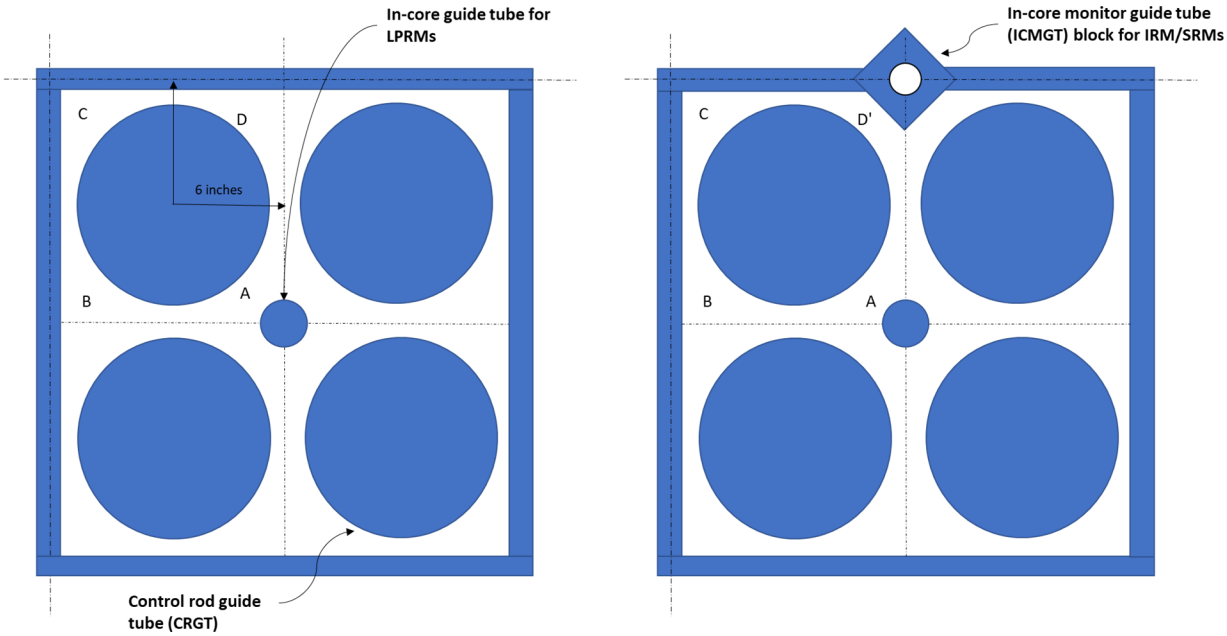

Figure 1 Illustrations of BWR/6 interior (central core) cells with surrounding support beams (not to scale)

References

1. ML 20176A432 (M200087), Subject: Non-Conservative BWR/6 Side Entry Orifice (SEO) Loss Coefficients, June 24, 2020.
2. ML19273A878, NRC Inspection Manual Chapter 0326, Operability Determinations, effective date 10/01/2019.

Assessment of 06.07 Scope of Operability Determinations

Item	Point to Address	GEH Assessment
a.	Possible elements of an OD include:	
(1)	The SSC affected by the condition,	Fuel assemblies are affected by the potentially degraded condition. The core monitoring system is provided to surveil fuel during operation and assure that applicable safety limits are met.
(2)	The extent of condition for all similarly affected SSCs,	There are no other affected SSCs.
(3)	The CLB requirements or commitments established for the affected SSC,	Core monitoring system provides a means to assure that fuel is operated in a manner that conforms to applicable safety limits and CLBs.
(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 a fuel is operated within applicable limits, such as the Technical Specification Safety Limit MCPR or SLMCPR, 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	If a fuel assembly were operated beyond the Operating Limit MCPR (OLMCPR), then an event with a single failure has the potential to contribute to exceeding the SLMCPR.
(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.	The identified compensatory measures are expected to be effective so that the fuel assemblies can be operated and monitored within applicable limits. Implementation of the recommended corrective action is enough to maintain the core monitoring system with the appropriate limits so that fuel can be operated as normal. The recommended interim measure assures adequate margin for operability.
b.	The following things should be considered when reviewing ODs:	
(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. Corrective action will maintain the capability to monitor and will preserve the existing TS and bases. The recommended interim measure will 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,	Corrective action will maintain the capability for appropriately monitoring the existing limits and conformance to the existing bases, including all applicable licensed modes of operation. The recommended interim measure will assure adequate margin to the existing limits and bases, which includes all applicable modes of operation.

Item	Point to Address	GEH Assessment
(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 core monitoring system is applied to support fuel operation. Corrective action will maintain the capability of the computer system to appropriately monitor to the existing bases and TS requirements. The recommended interim measure 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	Corrective action will maintain the capability of the core monitoring system to appropriately monitor fuel assemblies, to support conformance to the plant's CLB. The recommended interim measure will assure adequate margin to limits and supports conformance to the plant's CLB.
(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 corrective action is all that is required to maintain the capability of the core monitoring system. The identified interim measure assures adequate margin to support operation.