HITACHI

10 CFR Part 21 Communication

SC 23-01 Revision 1
007N7348

July 26, 2023

To: **BWR Customers Identified on Attachment 1**

Subject: **Failure of the CRD Collet Retainer Tube/Outer Tube Weld**

☒ **Reportable Condition [21.21(d)]**

☐ **60 Day Interim Report [21.21(a)(2)]**

☐ **Transfer of Information [21.21(b)]**

☒ **Safety Information Communication**

Reference: **A. Part 21 60-Day Interim Report Notification: Failure of the CRD Collet Retainer Tube/Outer Tube Weld (SC-23-01), GEH Letter M230057, April 27, 2023**

Summary:

GE Hitachi Nuclear Energy (GEH) has completed the 10CFR Part 21 evaluation of the failure of the Control Rod Drive (CRD) collet retainer tube fillet weld on a CRD recently removed from a domestic plant. The weld failure allowed for movement of the retainer tube up the outside of the Cylinder, Tube and Flange (CTF) assembly's outer tube and spacer, which movement adversely affected the CRD's operation.

Based upon the completed evaluation GEH has determined that the condition described herein is a reportable condition as defined by 10CFR Part 21. This is the follow-up to the Part 21 60-Day Interim Report Notification in Reference A.

Please contact me if there are any questions.

Michelle P. Catts

Issued by:

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Background

During removal of a Control Rod Drive Mechanism (CRDM) from a domestic plant in February 2023, it was discovered that a 360° failure of the collet retainer tube fillet weld had occurred, and the retainer tube had displaced approximately 1.125" from its original position. This retainer tube is part of the CRD 919D258G003 Cylinder, Tube and Flange (CTF) assembly. The function of this assembly (see Figure 1) is to react to the applied hydraulic loads so that the collet fingers can be retracted from the index tube and allow the CRD to be moved for control rod positioning or scram.

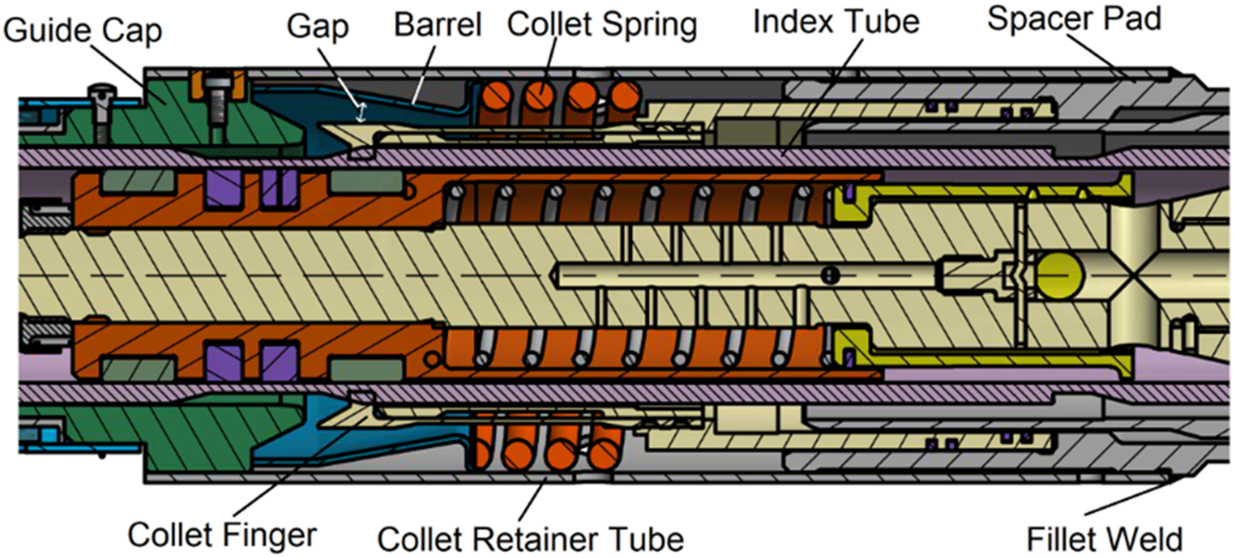

Figure 1
Upper Section of CRDM Assembly

The failed CTF was manufactured and delivered to the domestic customer in 1982. In 1992 the CTF assembly was installed as part of the CRDM into the reactor. After installation, the associated CRDM operated without significant performance issues until August 2021. During routine control rod exercising, the control rod would not withdraw from position 46 to 48. This was the first observed symptom indicating that significant movement, or separation, of the retainer tube had occurred. The plant operator took steps to fully insert the control rod using elevated drive water differential pressure (DP), and maintained the control rod fully inserted until the next refuel outage per the plant Technical Specifications.

In December 2011, inspection of another G003 CTF assembly revealed a 360° failure of the collet retainer tube fillet weld, with ≈0.15" axial displacement of the collet retainer tube (Reference 1). This event was the first known occurrence of a weld failure allowing for some movement of the retainer tube, on any CTF assembly observed by GEH. In this case, the CRDM continued to perform normally, including the scram function, while in service. As part of the evaluation of the failure, GEH concluded that even if a complete weld fracture were to occur, displacement of the upper tube would be sufficiently limited by the design dimensions and joint configuration and therefore the condition of the 360° crack would not result in a substantial safety hazard. This conclusion was supported by push tests performed on four CTF assemblies which measured the force required to separate the retainer tube from the outer tube with the fillet weld no longer intact. Three of these assemblies were CTFs discovered to have partially cracked while installed, and the fourth was a sample manufactured to simulate worst case conditions. The push tests found that the force required to mechanically separate the retainer tube after complete weld failure was significantly greater than the force applied during typical drive operation including abnormal operation when drive water differential pressure (DP) may be significantly increased to assist with control rod withdrawal. The recent CTF assembly failure for which the collet retainer tube displaced > 0.15" is the second occurrence where any movement of the retainer tube was detected, and the first occurrence where normal operation of the CRD was affected.

Evaluation

The collet retainer tube and fillet weld design in question is applicable to all 919D258G002 and G003 CTF assemblies because the collet retainer tube material, part configuration and fillet weld design are similar for both assemblies. GEH provides these CTF assemblies to operating GEH BWRs (BWR/2-6's). Since 1977, more than 5000 of these G002 and G003 CTF assemblies have been manufactured and many are approaching 40 years of service or greater.

Collet Retainer Tube Fillet Weld Crack Formation History

Each CRDM undergoes a routine rebuild at a frequency determined by each utility. While this frequency varies from plant to plant, the BWROG CRD System Improvement Committee (Reference 2) recommends exchanging and rebuilding [[ ]] of CRDs each refuel outage when on a typical 2-year fuel cycle, to maintain acceptable CRD performance. During these rebuilds, the collet retainer tube and its welds are inspected per recommendations in SIL 139 and the applicable supplements (References 3 - 9). This inspection consists of the use of liquid dye penetrant (PT) examination to detect linear indications (cracks), all CTF assemblies that exhibit these indications are rejected and removed from service. Since GEH began refurbishing CRD assemblies for domestic customers, approximately [[ ]] CTF assemblies (G002 and G003) have been PT inspected by GEH. Of these a total of [[ ]] assemblies have been rejected for linear indications related to this fillet weld.

A more detailed analysis of the rejection rate for the years 2007 through 2022 for CTF assemblies inspected by GEH at the Wilmington Field Services Center (WFSC) is shown in Table 1. Note that the number inspected and the number with linear indications shown in Table 1 differs from the totals above. Table 1 data does not include data from earlier inspections performed at GEH's CRDM rebuild facility located in Memphis, Tennessee, which is no longer in operation[1]. Based on available information, [[ ]] CTF assemblies were rejected for linear indications identified during PT examinations performed at the Memphis facility.

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[1] The GEH joint venture was formed in 2007. GEH performs CRDM rebuild and inspection at the WFSC in Wilmington, NC.

Year	**Number Inspected**	**Number with Linear Indications**	**Rejection Rate (%)**
2007	[[		
2008			
2009			
2010			
2011			
2012			
2013			
2014			
2015			
2016			
2017			
2018			
2019			
2020			
2021			
2022			
Total			]]

Table 1
WFSC CTF Assembly Inspection Reject Rate

It is apparent that variability exists in the year-to-year rates, however the average rejection rate is [[ ]] and there is not an apparent increasing rate over time.

GEH has evaluated available operational data for all [[ ]] of the rejected CTF assemblies including time in-service, last known core location, and history of high temperature operation. The time in-service varied widely from [[ ]] years to [[ ]] years, the core locations were randomly dispersed and included interior control rods and peripheral control rods, and there was not a consistent history of high temperature operation. As a result, no unique operating characteristic has been found to identify CTF assemblies that are more likely to develop linear indications. However, the CTF assembly inspection results demonstrate that the number of in-service G002 and G003 CTF assemblies with any degree of cracking, much less 360 degree circumferential cracking, is very low.

Cause of Crack Formation and Propagation in the Weld

For the 2011 event, GEH determined that fillet weld geometry with incomplete fusion at the bottom of the retainer tube (Figure 2), can create creviced areas with high stress concentrations which were shown to be points of fatigue (crack) initiation. Fracture analysis of samples from the failed CTF assembly found evidence of fatigue crack initiation (in the creviced areas) and crack propagation. GEH concluded that thermal and mechanical cycling caused crack propagation.

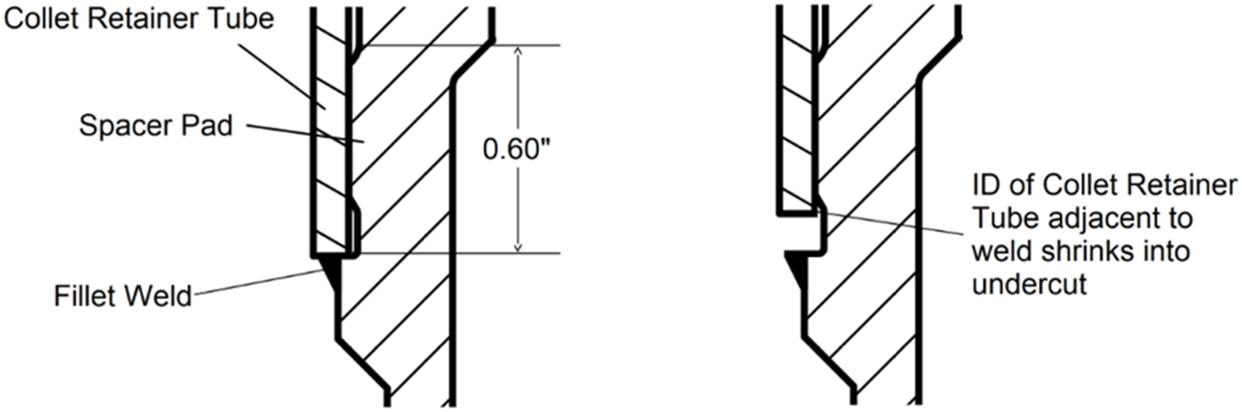

Figure 2
Retainer Tube to Spacer Detail

For the February 2023 event, GEH performed similar inspections and fracture analysis on the separated CTF assembly. The inspections found that the fillet weld geometry was such that there was incomplete fusion across the bottom of the retainer tube, and at some locations the weld had fused with only ≈30% of the bottom of the retainer tube. At these locations, the weld size did not meet the weld size requirement and did not achieve complete root fusion as required by the weld process specification. The fracture analysis similarly found evidence of fatigue crack initiation in the creviced areas which propagated through a weld ligament adjacent to the bottom of the retainer tube and not through the weld throat.

As part of the investigation into why a limited number of CTF assemblies have experienced these linear indications, GEH performed destructive inspection of another CTF removed from the plant which had the separated CTF assembly. This CTF assembly had also been in-service since 1992, was installed at a core location adjacent to the failed CTF assembly and had not developed linear indications at the retainer tube weld. Sectioning of this CTF assembly at the weld found that the weld was fully fused to the root of the weld, and in many locations, fused beyond the root and to the ID of the retainer tube.

Therefore, when the retainer tube to spacer fillet weld does not meet the weld size requirement and does not achieve complete root fusion, crevices of sufficient size are created at the root of the weld, forming areas of stress concentration. Then, when exposed to cyclic loading conditions, fatigue (crack) initiation can occur at the high stress areas.

Cause of Collet Retainer Tube Separation After Weld Failure

Normally a tensile load is applied to the weld due to the compression of the collet piston spring. Then during control rod withdrawal, the collet piston actuates further compressing the spring, and further increasing the tensile load at the weld. Therefore, separation is most likely to occur during an attempt to withdraw a control rod. However, because a tensile load always exists due to the spring compression, it is possible that separation could occur without an attempt to withdraw the control rod.

As previously discussed, after the 2011 event in which a 360° weld failure allowed ≈0.15” of retainer tube movement, GEH had concluded that further separation was not expected to occur (Reference 1). The above-described push tests and inspections of a sampling of other CTF assemblies found that weld shrinkage of the bottom of the retainer tube into the ≈0.15” wide circumferential relief groove machined into the spacer, directly underneath the root of the weld joint, effectively locks the retainer tube onto the spacer (see Figure 2). Therefore, for the retainer tube to be able to move relative to the spacer beyond 0.15” the shrunken tube had to be diametrically stretched out of the relief groove. The force required for this further movement was measured and found to be significantly greater than the force applied during typical drive operation including abnormal operation when drive water DP may be significantly increased to assist with control rod withdrawal. Inspection of the components after the retainer tube was pushed off the spacer found galling indications and deep scratches across the surface of the spacer pad.

For the 2023 event, the retainer tube moved >0.15” and at some point, completely separated. GEH has performed detailed inspections of the subject CTF assembly components at the GEH Vallecitos Nuclear Center. It appears that, after weld failure, movement of the retainer tube was at first limited, similar to the 2011 event. Apparently then, with repeated cycling (e.g., control rod withdrawals), the retainer tube walked along the spacer. As shown on Figure 2, a pad exists on the spacer which forms the interference fit with the shrunken ID of the retainer tube. It is expected that upward movement of the retainer tube would be restrained until tube movement approaches 0.6”, where interference no longer exists, and separation occurs. GEH has not identified any unique characteristics of this CTF assembly which make it different from the four samples used for the push test in 2011. However, it is recognized that the push tests were performed at room temperature which is different than the in-service environment. Analysis of the expected thermal expansion of the thin-walled collet retainer tube with respect to the spacer under in-service operating conditions, found that the interference between the two components would be significantly reduced. As the interference decreases, the retainer tube is more likely to walk up the spacer with each withdrawal attempt. Therefore, GEH cannot assure that similar separation will not occur after weld failure on in-service CTF assemblies because weld shrinkage of the bottom of the retainer tube may not be sufficient in all cases.

Effect of Collet Retainer Tube Separation on Operation of the CRDM

During normal control rod insertion (not scram) pressure is applied to the under-piston area of the CRDM drive piston connected to the bottom of the index tube. This pressure exerts an upward force which results in upward movement of the index tube and control rod. Normally during insertion, the collet piston stays in the latched (down and seated) position and the collet fingers ratchet in and out of the index tube notches as the tube moves up. However, with separation, significant narrowing of the gap (see Figure 1) between the collet fingers and the barrel and spring occurs, which prevents the fingers from freely disengaging from the notches. When this occurs, friction opposing rod insertion is created which also exerts an upward force on the collet fingers and piston. With the collet spring no longer compressed because of separation, this upward force allows upward movement of the fingers with respect to the barrel and spring, thus widening the gap. This action allows the fingers to sufficiently clear the index tube notches which permits rod insertion. Note that without this upward movement of the collet piston, the gap size would be insufficient for the fingers to clear the notches which would lock them in place and prevent rod insertion. For the recent event, the movement of the retainer tube was such that the positioning of the barrel, spring and collet fingers allowed the fingers to clear the notch allowing for insertion of the control rod, although only at elevated drive water DP (325 psid).

In SIL-139 Supplement 2, GEH described tests performed in 1975 that simulated separation of the collet retainer tube and stated that these tests found that at normal reactor operating pressure and temperature the test drive would not insert, withdraw, or scram. During this test separation or displacement of the retainer tube was set at the expected (nominal) value, however the insert test was performed only at 250 psid and 285 psid. At both differential pressures, notching inward was unsuccessful. The 1975 test results are consistent with the symptoms observed during the recent event. That is, for the recent event the control rod would not insert at 250 psid, however when pressure was increased to 325 psid, the rod did insert slowly. The 1975 tests also found that at cold, 0 psig reactor conditions, the test drive would insert at 250 psid drive water DP, and scram. The mechanism by which normal insertion in the cold, depressurized condition is successful, while the hot, pressurized condition is not successful is not fully understood. It is possibly related to the change in the retainer tube movement, and therefore the positioning of the collet fingers with respect to the barrel and spring, which occurs with thermal expansion of the CRD housing relative to the CRDM. It is also important to note that the tests found that in the cold, depressurized condition, when abnormally high drive water DP was applied during attempts to withdraw the control rod, it was possible to drive the collet piston out of the operating cylinder to key the piston in the unlocked position by the expanding piston ring. When this occurred, it allowed the test drive to drift down to the fully withdrawn position.

As discussed above, testing found that retainer tube separation could prevent scram in a hot, pressurized reactor. This is because during scram with the reactor pressurized, the underside of the collet piston is depressurized, and reactor pressure applies a significant downward force on the collet piston. This downward force could be sufficient to prevent the upward movement of the collet fingers which occurs during normal control rod insertion, effectively locking the fingers into the notches, thus preventing scram. During a cold, depressurized scram, the downward force does not exist, therefore scram is unopposed.

Therefore, when collet retainer tube separation occurs, control rod insertion will likely be possible with the assistance of increased drive water DP. However, GEH is unable to conclude that insertion will be possible in all cases. Additionally, scram function may not be available in the hot, pressurized condition.

Collet Retainer Tube Separation Detectability

The safety significance of a CTF assembly with >0.15” separation of the retainer tube is reduced if the failure is promptly detected, and operators take action to maintain the plant in a safe condition. As discussed above, separation is most likely to occur during an attempt to withdraw the control rod. Should separation occur during startup, or during normal rod positioning for operation, the condition will be readily detectable because rod withdrawal will no longer be possible and insertion capability will, as a minimum, be degraded. Should separation occur during control rod exercising, required by plant Technical Specifications, it will be readily detectable if the separation occurs when the withdraw signal is first applied. However, it is possible that separation could occur when the control rod is not moving, or when the CRDM to control rod coupling check is being performed when the control rod is fully withdrawn. In these cases, the separation would go undetected until the next attempt to exercise the affected control rod.

Conclusions

The weld that secures the collet retainer tube in place on GEH's 919D258G002 and G003 CTF assemblies is susceptible to crack initiation and propagation when the weld does not meet the specified size requirement around the circumference and when the weld does not achieve complete root fusion, as specified in the assembly drawing's weld process specification. Under these conditions, crevices of sufficient size increase the stress concentration to a point where crack initiation is possible. Then, when exposed to cyclic loading conditions, fatigue (crack) initiation can occur at the areas of incomplete root fusion. GEH has not yet identified a non-destructive means by which to differentiate welds which meet specification (i.e., fillet weld with complete root fusion) from welds which do not meet specification. Additionally, GEH has not identified a specific CTF assembly in-service time at which crack initiation then subsequent weld failure can occur. However, because cyclic loads initiate then propagate the weld crack, and the number of these cycles increases over time, the probability of retainer tube separation occurring on a susceptible CTF (i.e., a CTF with an incomplete weld) is expected to increase as in-service time increases.

Inspections performed on this weld on thousands of CRDMs removed from service as part of the normal rebuild cycle, indicates that for the total in-service population, approximately 1% have been found with linear indications (cracks) of any length at the weld surface. Of those found with cracks, only four were found to have a 360° crack and, of those, only two allowed for any movement of the collet retainer tube. In the 2011 event, the retainer tube displaced ≈0.15", and during the 2023 event the retainer tube displaced ≈1.125". When the allowed displacement is limited to ≈0.15", there is no discernable effect on the performance of the affected control rod. However, it cannot be assured that displacement will be limited in this way. When separation occurs, and the retainer tube displaces 1.125" as seen in the more recent event, the ability to insert or scram the control rod is degraded, and in some cases, may not be possible.

Should separation occur on an in-service CTF assembly, it should be readily detectable allowing operators to take action to maintain the plant in a safe condition. However, it is possible that the separation could occur and go undetected until the time when the control rod is exercised as required by plant Technical Specifications. Assuming the strongest rod stuck out, the failure of a additional control rod to insert due to a separated collet retainer tube may result in an affected plant to not be able to achieve cold shutdown. Therefore, GEH concludes that the potential for a substantial safety hazard exists, and this is a reportable condition under 10CFR Part 21.

As part of the root cause analysis, GEH is continuing to evaluate corrective actions.

Probabilistic Analysis of the Condition

Assuming the failure rates for BWR CRDMs remain constant for the BWR plants, the following probabilistic analysis is performed to investigate the risk effect to the BWR plant with the identified condition, which demonstrates negligible effect to plant risk.

The reactivity control function is modeled for all BWR Probabilistic Risk Analysis (PRA) models. Per NUREG/CR-5500 Vol. 3 (INEL/EXT-97-00740), Reliability Study: General Electric Reactor Protection System (RPS), 1984 – 1995, a low RPS unavailability estimate (2.6E-6) has been developed, which is mostly attributable to lower failure probabilities for the Common-Cause Failure (CCF) events. Control rod and control rod drive failures contribute 10% to the total RPS unavailability. While the control rod failure criterion of the model was chosen to be one-third (or more) of the control rods failing to insert, the failure from individual control rods is demonstrated to be negligible in their contribution to the total RPS failure probability. The identified condition is only associated with a single CRDM. Table 1 data shows no obvious degradation trending. Therefore, based on the foregoing and pending confirmation with the ongoing root cause analysis, the identified condition does not result in increased failure probability for the CCF events associated with reactivity control.

Although the failure probability for an individual control rod has negligible contribution to the total RPS unavailability, the effect to failure rate of Hydraulic Control Unit (HCU), which includes the CRDM is also investigated for completeness. Per INL/EXT-21-65055, which is the 2020 update to the industry-average performance for components and initiating events at U.S. commercial nuclear power plants, the pooling group HCU with a failure mode of FTOP (failure to operate) has gathered 19 failures out of the total 1.347×10^9 running hours. These data have been gathered during a period covering 2006 – 2020 using Reliability and Availability Data System (RADS) from 10,425 components at 35 plants. The calculated failure rate for HCU FTOP has a mean value of 1.45E-8. The identified condition will fit into the category of HCU FTOP data set; therefore, the generic failure rate could be updated to about 1.520E-8/hour ($20.5 / 1.347 \times 10^9$) from 1.45E-8/hour without accounting for other industry failure data and the additional running hours since 2020. Nevertheless, the potential increase in the failure rate is not significant.

Recommended Actions

The recommendations below are intended to further reduce the probability of collet retainer tube separation on in-service CRDMs, and to help ensure actions taken by operators will not result in inadvertent rod withdrawal should separation occur.

1. Limit use of elevated drive water differential pressure to when excessive collet piston seal leakage is preventing the collet mechanism from actuating during attempts to notch out from position 00. Specifically, elevated DP may be used to allow for unlatching after it has been confirmed that the control rod is inserting as expected, and the withdrawal stall flow has been confirmed to be high (significantly above trend) due to suspected collet piston seal leakage. It is recognized that other issues may prevent normal control rod insertion. Use of elevated drive water DP to assist with rod insertion is not limited by the above recommendation.
2. If a control rod fails to insert or withdraw with normal drive water DP (250 to 265 psid), recognize that these are potentially symptoms of a separated collet retainer tube on the CTF assembly.
3. Review SIL 139 and its supplements (References 3-9) and ensure recommendations provided in these SILs are adequately addressed in plant procedures.
4. When prioritizing CRDMs for rebuild, consider elapsed time since last inspection of each CTF assembly, and plant specific G002 and G003 PT examination failure rates. Those

CRDMs with CTF assemblies with the greatest in-service time should be given priority consistent with Reference 2.

References

1. SC 12-13, Failure of CRD Collet Retainer Tube/Outer Tube Weld
2. BWROG-TP-08-019 R2, Control Rod Drive (CRD) System Improvement Committee, Standard for Selecting CRDs to Exchange During Refuel Outages
3. SIL-139, Control Rod Drive Collet Retainer Tube Cracking
4. SIL-139 Supplement 1, Revision 1, CRD Collet Retainer Tube Inspection Reports
5. SIL-139 Supplement 2, Control Rod Drive Collet Retainer Tube Cracking
6. SIL-139 Supplement 3, Control Rod Drive Collet Retainer Tube Cracking
7. SIL-139 Supplement 4, Control Rod Drive Collet Retainer Tube Cracking
8. SIL-139 Supplement 5, Revision 1, Control Rod Drive Collet Retainer Tube Cracking
9. SIL-139 Supplement 6, Control Rod Drive Collet Retainer Tube Cracking

Attachment 1
List of Potentially Affected Plants

BWR Plants and Associated Facilities

	Utility	Plant
X	Detroit Edison Co.	Fermi 2
X	Energy Northwest	Columbia
X	Entergy	Grand Gulf
X	Entergy	River Bend
X	Entergy	Pilgrim
X	Entergy	Vermont Yankee
X	Constellation	Nine Mile Point 1-2
X	Constellation	Clinton
X	Constellation	Dresden 2-3
X	Constellation	FitzPatrick
X	Constellation	LaSalle 1-2
X	Constellation	Limerick 1-2
X	Constellation	Oyster Creek
X	Constellation	Peach Bottom 2-3
X	Constellation	Quad Cities 1-2
X	Energy Harbor	Perry 1
X	Nextera Energy Resources	Duane Arnold
X	Nebraska Public Power District	Cooper
X	Talen Energy	Susquehanna 1-2
X	Duke Energy - Progress	Brunswick 1-2
X	Public Service Enterprise Group Incorporated	Hope Creek
X	Southern Nuclear Operating Co.	Hatch 1 - 2
X	Southern Nuclear Operating Co.	Pooled Equipment Inventory Co.
X	Tennessee Valley Authority	Browns Ferry 1-3
X	Xcel Energy	Monticello

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US PWR Plants

	Utility	**Plant**
______	AmerenUE	Callaway
______	Arizona Public Service	Palo Verde 1-3
______	Entergy	Arkansas Nuclear One 1-2
______	Entergy	Indian Point 2-3
______	Entergy	Palisades
______	Entergy	Waterford 3
______	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
______	Constellation	Braidwood 1-2
______	Constellation	Byron 1-2
______	Constellation	Calvert Cliffs 1-2
______	Constellation	Fort Calhoun
______	Constellation	Ginna
______	Constellation	Three Mile Island 1
______	Energy Harbor	Beaver Valley 1-2
______	Energy Harbor	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

	Utility	**Plant**
______	TXU Electric Generation Co.	Comanche Peak 1-2
______	Wolf Creek Nuclear Operating Corp.	Wolf Creek

Attachment 2 – 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 23-01	PRC 23-01	Failure of the CRD Collet Retainer Tube/Outer Tube Weld	4/27/2023
SC 21-04 Revision 2	PRC 21-04	Fuel Support Side Entry Orifice Meta-Stable Flow for 2 Beam Locations in the BWR/6 Reactors	7/05/2023
SC 23-01 Revision 1	PRC 23-01	Failure of the CRD Collet Retainer Tube/Outer Tube Weld	7/26/2023

Attachment 3 GEH's Assessment of SC 23-01 Scope of Operability Determinations

Item	Point to Address	GEH Assessment
a.	Possible elements of an OD include:	
(1)	The SSC affected by the condition,	The 919D258G002 and 919D258G003 Cylinder, Tube and Flange (CTF) assemblies which are a component of the Control Rod Drive Mechanism (CRDM)
(2)	The extent of condition for all similarly affected SSCs,	All BWR CRDMs with 919D258G002 and 919D258G003 CTF assemblies could be affected.
(3)	The CLB requirements or commitments established for the affected SSC,	The CRDM will fully insert a control blade during a scram.
(4)	The specified safety function(s) performed by the affected SSCs,	The CRDMs will scram or fully insert the control blades to assure the reactor is shut down and maintained shut down under all conditions.
(5)	The effect or potential effect of the condition on the affected SSC's ability to perform its specified safety function(s), and	Circumferential cracking could result in separation of the collet retaining tube from the CTF assembly. Following separation, the scram or fully insert functions may not be available.
(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.	There have only two reported instances in the history of more than 5000 919D258G002 and 919D258G003 CTF assemblies in operation where a complete 360-degree circumferential collet retainer tube weld crack allowed for any movement of the collet retainer tube. In one event, after the weld failed displacement of the retainer tube was constrained to ~0.15" which did not adversely affect CRD operation. In the other event, the retainer tube separated > 1" which did affect operation. With separation the ability to insert the control rod was maintained, although use of elevated drive water differential pressure was required. However, when separation occurs the ability to scram or insert a control blade may not be available. Services Information Letter (SIL) 139 and its supplements provide recommendations to detect and mitigate the probability of a CTF to collet tube separation. All CRDMs removed for rebuild are dye penetrant tests (PTs) at the weld. When a linear indication is detected, the CTF is scrapped. The industry has observed an ≈1%

Item	Point to Address	GEH Assessment
		linear indication (crack) rate on CRDMs that have been removed from service to be rebuilt. Both the SIL 139 recommendations and CRDM rebuild PT checks minimize the possibility of widespread cracks and therefore potential separation events occurring in CRDMs in operation.
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,	BWR plants perform control rod surveillances in accordance with the plant's Technical Specifications (TS). These surveillances will detect operational issues with control rods including a separated collet retainer tube. Normally, a control rod that fails a required TS surveillance will be fully inserted and disarmed. In the event a control rod cannot be inserted, TS require the control rod to be declared stuck and actions taken to ensure the plant can be shut down and remain shut down under all conditions.
(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,	Technical Specifications define the control rod operability requirements and applicable modes.
(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,	Not applicable, no support systems are affected.
(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	It is assumed in the design basis that the reactor will be shut down under all conditions with the Strongest Rod Out (SRO). This additional potential could result in another rod not being able to scram or fully insert.

Item	Point to Address	GEH Assessment
(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.	Compensatory measures not required. See recommendations in SC 23-01 Revision 1 to minimize probability of a separation event