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

Shearon Harris Nuclear Power Plant, Unit 1
Docket No. 50-400/Renewed License No. NPF-63

Subject: IWB-3142.4 Analytical Evaluation Performed to Accept ASME Section XI Code
Case N-885 Identified Hard Facing Indications

Ladies and Gentlemen:

Pursuant to the 2007 Edition through the 2008 Addenda of the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code, Section XI, IWB-3144(b), Duke Energy Progress, LLC (Duke Energy), is submitting an analytical evaluation performed to accept ASME Code Case N-855 identified hard facing indications on the upper core plate alignment keys at 0 degrees and 180 degrees during the 26th refueling outage (H1R26) for Shearon Harris Nuclear Power Plant, Unit 1 (HNP), in the fall of 2025. The October 2025 analytical evaluation for the hard facing indications was performed as a corrective action in accordance with the 2007 Edition through the 2008 Addenda of the ASME Boiler and Pressure Vessel Code, Section XI, IWB-3142.4 and is contained in the Enclosure.

This submittal contains no regulatory commitments. Should you have any questions regarding this submittal, please contact Sarah McDaniel at (984) 229-2002.

Sincerely,

A handwritten signature in black ink, appearing to read "Chad Kidd", written in a cursive style.

Chad Kidd
General Manager of Nuclear Engineering

Enclosure: Core Barrel Upper Core Plate Alignment Keys Analytical Evaluation of H1R26 Hard Facing Indications

cc: NRC Senior Resident Inspector, HNP
NRC Project Manager, HNP
NRC Regional Administrator, Region II

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Enclosure

**Core Barrel Upper Core Plate Alignment Keys Analytical Evaluation of H1R26 Hard
Facing Indications**

Shearon Harris Nuclear Power Plant, Unit 1

Docket No. 50-400

Renewed Facility Operating License No. NPF-63

Introduction

During Reactor Vessel Section XI, CC N-885 VT-3 examination of the Core Barrel Upper Core Plate Alignment Keys, hard facing (Stellite) indications were observed on both the 0 degree and 180-degree locations, as identified by nuclear condition report (NCR) 2572339. The 0-degree key has a total of 4 indications with 3 on the left side and 1 on the right side. The 180-degree key has 1 indication on the right side. On both keys the indications are bound within the hard facing (Stellite) material and do not propagate into base material. A review of the 2018 data was inconclusive in determining if the indications existed previously. Advancements in camera technology and industry OE have contributed to the discovery of these indications.

An engineering evaluation was completed to accept damaged Core Barrel Upper Core Plate Alignment Keys hard facing (Stellite) documented in Framatome Indication Notification Report (INR)-H1R26-01. The 0 key has a total of 4 indications with 3 on the left side and 1 on the right side. The 180 key has 1 indication on the right side.

Engineering Evaluation

An engineering evaluation was completed to accept the indications identified on the Upper Core Plate (UCP) alignment keys documented in INR-H1R26-01.

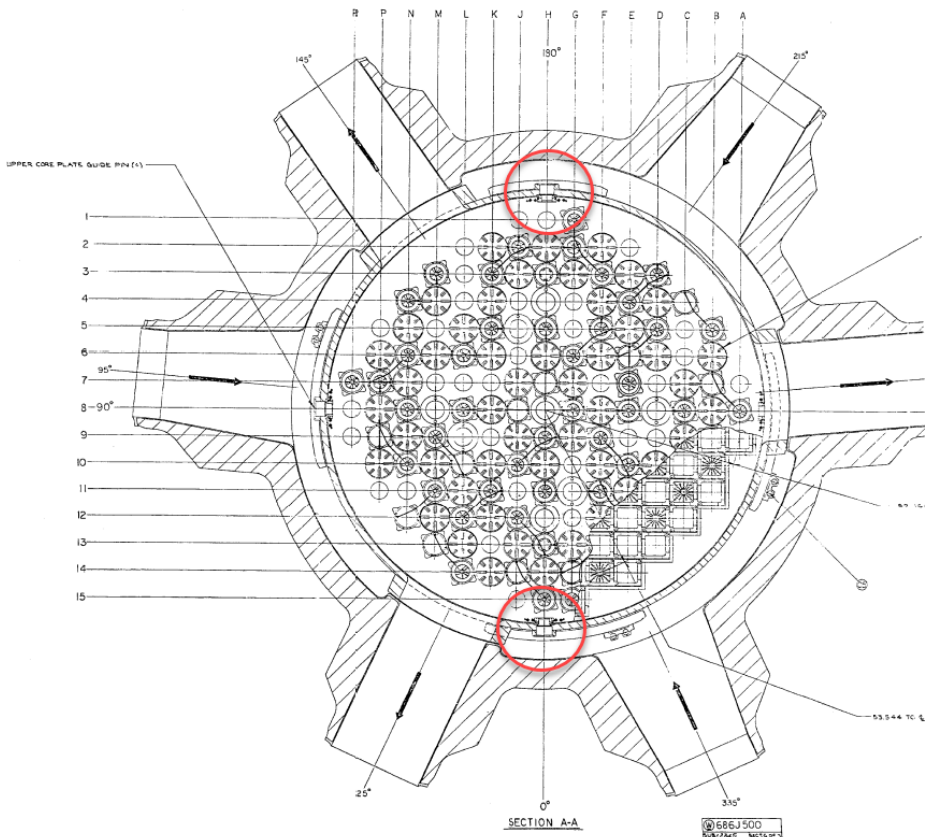
Basic Exam Requirements:

The UCP Alignment Pin VT-3 visuals are performed under ASME Section XI, Code Case N-885. The Section XI exams on this component are also credited in MRP-227, Revision 1-A as Item W15.

Exam History:

- The UCP Alignment Pins receive a VT-3 visual in accordance with ASME Section XI each interval (approximately every 10 years).
- Similar Stellite hard facing indications were identified on the Robinson Nuclear Plant (RNP) UCP Alignment Pins in R2R33 (NCR 02450925), as well as the Catawba Nuclear Station (CNS) Radial Keys in C1R28 (NCR 02531825).
- As noted in the problem description, during the H1R26 exams, the UCP Alignment Pins at 0 degrees and 180 degrees were reported with small linear indications requiring evaluation.

The UCP Alignment Pins referenced in this AR are identified by their azimuthal location. A map of the affected UCP alignment pins is shown below for reference.



ASME Code Acceptance Criteria

As noted above, examination of the UCP alignment pins was performed in accordance with ASME Section XI, Code Case N-885. Table 1 of Code Case N-885 indicates the acceptance standard for B13.40 items to be IWB-3520.2, which requires the requirements of IWB-3142 to be met prior to continued service. Section IWB-3142.1(b) allows a component whose visual examination detects relevant conditions to be acceptable for continued service if it meets the requirements of IWB-3142.4, Acceptance by Analytical Evaluation.

The ASME Section XI code of record currently in effect for Shearon Harris Nuclear Power Plant, Unit 1 (HNP), is the 2007 Edition through 2008 Addenda. The below disposition of indications was developed to meet the requirements of IWB-3142.4 and is considered the evaluation analysis for the observed conditions of Stellite surface cracking on the HNP UCP Alignment Pins.

Disposition of Indications:

The upper internals to lower internals alignment is provided through keyways (UCP insert and UCP alignment pins) in the outer edges of the UCP. The keyways contain customized inserts that provide the required alignment gaps at the alignment pins in the lower internals. This alignment is needed for the installation of the upper internals into the lower internals, and the UCP inserts and UCP alignment pins limit any torsional rotation or translation of the UCP during operation. Therefore, the UCP alignment pins serve a core support function as defined in ASME Section XI. UCP alignment pins and inserts are hard faced with a Stellite material on the mating contact surfaces to mitigate wear during operation.

Stellite surfaces on reactor internals interfacing components are known within the industry to be susceptible to cracking during heating and cooling cycles due to the low ductility and high hardness of the hard facing material. Furthermore, multiple occurrences of Stellite surface cracking have been identified on PWR reactor internals components in recent years and determined to not impact the intended purpose of the associated component. Among these instances include Stellite surface cracking identified on two UCP Alignment Pins at RNP during R2R33 in Fall 2022 (NCR 02450925). As documented in NCR 02450925, an assessment of the cracking identified on the Stellite surfaces of the UCP alignment pins at RNP was performed by Westinghouse in vendor document CPL-RV010-TM-CJ-000001 (RNP Calculation RNP-R/MECH-1393 – Reference [1]) meeting the requirements of ASME Section XI, IWB-3142.4. Based on similarities in material (hard facing Stellite surfaces on Type 304 stainless steel), component function / ASME designation (removable core support structure), and associated nature of the cracking observed, the arguments made for acceptability of the RNP UCP alignment pin Stellite surfaces as documented within CPL-RV010-TM-CJ-000001 may be applied to the HNP UCP alignment pin Stellite surface cracking as discussed further below.

Stellite surface cracking was more recently identified on CNS, Unit 1, Lower Radial Support Keys during C1R28 in Fall 2024 and evaluated in NCR 02531825.

Observations of Stellite Cracking

As noted above, Stellite cracking is a known phenomenon in PWR reactor internals components. Furthermore, the Electric Power Research Institute (EPRI) has recognized the use of Stellite in reactor internals components but concluded that these materials do not need to be included in the EPRI Materials Degradation Matrix (MDM) (Reference [2]) since the associated degradation does not present a structural integrity issue.

Also as identified within Reference [1], there have been instances of Stellite surface cracking at other Westinghouse-designed plants besides RNP and the plant was able to disposition the indications and continue operation without repair or replacement; therefore the Stellite surface cracking indications identified at the RNP UCP alignment pins (R2R33), the CNS, Unit 1, radial support keys (C1R28), nor the HNP UCP alignment pins (H1R26) are unique or the leading instance of this phenomenon.

As stated in INR-H1R26-01, the specific indications identified during the VT-3 visual examinations of the UCP alignment pins were three indications on the left side of the 0-degree key, one indication on the right side of the 0-degree key, and one indication on the right side of the 180-degree key. Below are noteworthy observations of the indications described in INR-H1R26-01:

- All indications may be characterized as “perpendicular” to the axis of the UCP alignment pin hard facing, are oriented horizontally (parallel to each other), and do not change direction.
- All indications are bound within the Stellite material and do not propagate into the base material.

Review of videos from the last 10-year ISI examination did not identify these linear indications as the quality of the camera technology was not the same at that time. Therefore, it is not known when these indications initiated and whether growth has arrested, or if they have been growing during operation. However, the observed linear indications (perpendicular to the axis of the UCP alignment pin) are not oriented in a way that would promote growth during plant operation as there are no direct tensile stresses expected

which would open the indications. Growth of these linear indications is not expected due to loads from removal and installation activities, primarily due to the infrequency of these loads (approximately twice per reload cycle).

It is noted in INR-H1R26-01 that the linear indications observed are bound within the Stellite material and do not propagate into the base material, however consideration is given into the likelihood that the observed indications could extend into the base material of the UCP alignment pins. As noted in Reference [1], Stellite weld overlays have significantly higher hardness and lower ductility than austenitic stainless steel base metal. The base material of the UCP alignment pins at HNP is 304 stainless steel (Reference [3]). Thermal expansion coefficient differences between the Stellite layer and Type 304 stainless steel base material cause differential stresses on the weld metal, and the low ductility and high hardness of the hard facing Stellite overlay makes it prone to cracking during heating and cooling cycles. As also documented in Reference [1], investigation into instances of cracking in Stellite hard facing surfaces in BWR components revealed that cracks blunted when they reached the more ductile base metal below the Stellite overlay. The high ductility of the Type 304 stainless steel base material of the HNP UCP alignment pins is expected to support a similar crack blunting effect. Additionally, as noted in Reference [1], even if a sharp flaw is maintained, the cracking should have relieved the local residual stresses from welding removing a driver for continued cracking, and the high resistance to stress corrosion cracking of the Type 304 base metal is expected to prevent growth due to environmental effects. Therefore, it is not expected that the linear indications observed on the Stellite surfaces would be likely to extend into the base material of the UCP alignment pin and continue growing during plant operation.

Wear Considerations

An additional consideration to be addressed is whether or not the indications observed on the UCP alignment pins could cause accelerated wear degradation of the contact surfaces. Based on the images provided in INR-H1R26-01, the linear indications observed had a generally tight appearance without evidence of noticeable material loss. The hard facing Stellite material on either side of the indications is expected to have maintained its material properties, including wear resistance, and spalling and loss of pieces of the hard facing material is considered unlikely. It is expected that continued inspections in accordance with ASME Section XI will adequately monitor the UCP alignment pin surfaces for indications of changes in wear over time.

Generic Industry Justification for Return to Service (PWROG-24021-P)

In addition to the above arguments which supported the Stellite cracking assessment for the RNP UCP alignment pins (R2R33) and also apply to this assessment of the Stellite cracking observed on the HNP UCP alignment pins (H1R26), a generic industry assessment of the risks of Stellite surface cracking and a generic justification for return to service for Westinghouse and Combustion Engineering plants was recently developed within the PWR Owner's Group (PWROG-24021-P – Reference [4]). This industry document was reviewed for applicability to the linear indications identified on the UCP alignment pins during H1R26. Table 6-1 of PWROG-24021-P, which is shown below, provides acceptance criteria and the associated identified conditions that are and are not covered by the generic assessment:

Table 6-1: Conditions Covered Under This Evaluation

Acceptance Criteria	Conditions Covered	Conditions Not Covered
Crack Growth into Base Metal	Perpendicular Cracking through Stellite surface and inclusive of cracks that extend into the HAZ	- Crack Growth into Corner - Parallel Cracking - Perpendicular Crack Turning Parallel - Perpendicular Crack Extending Beyond HAZ - Delamination - Other unexpected cracking conditions
Material Spalling	- Minor flaking and/or chipping of Stellite - Stellite surface loss: ≤5% (2-Loop) ≤10% (3-Loop) ≤30% (4-Loop)	- Stellite surface loss: ≥5% (2-Loop) ≥10% (3-Loop) ≥30% (4-Loop) - Other unexpected spalling conditions

From review of INR-H1R26-01 and as discussed above, all of the indications of Stellite cracking on the HNP UCP alignment pins were perpendicular through the Stellite surface, had little or no surface loss due to material spalling or wear, and did not meet any of the "Conditions Not Covered" per Table 6-1 of PWROG-24021-P. Therefore, the linear indications identified on the HNP UCP alignment pin Stellite surfaces have met the identified acceptance criteria and are applicable to the assessment performed generically for the industry within PWROG-24021-P. Consistent with the assessment performed for the RNP UCP alignment pins in Reference [1] and its applicability to the HNP 1 UCP alignment pins as discussed above, PWROG-24021-P assesses crack growth mechanisms, crack growth into base metal, material property comparison of Stellite and base metal, thermal expansion, material property impacts on crack propagation, hypothetical cracking scenarios, material spalling, and susceptibility for loose parts. Below are some key excerpts from the generic industry assessment in PWROG-24021-P which apply to the HNP UCP alignment pin indications:

"By design, the hard facing material is far less ductile than the base metal; thus, it would be reasonable to assume any minor cracking would fail to propagate far beyond the end of the hard facing, especially since there is not significant loading on these interfaces that would propagate the cracks."

"Stellite is a cobalt based material with a matrix containing dispersing carbides; such a microstructure results in a material with high hardness and tensile strength, but low ductility. There are multiple studies which analyze this microstructure; they collectively show that cracking of Stellite coated steels tend to occur only in regions of higher carbide concentration, due to their brittle nature. Additionally in these studies, cracks observed on the hard face did not cross over to the base metal. The higher ductility of the stainless steel, or similar metal, can accommodate the stresses more effectively and have a blunting effect on crack propagation."

"The base metal can better accommodate thermal stresses by yielding more prior to cracking, which would slow a crack from propagating beyond the hardened region."

“Perpendicular cracks... would not impact the function of the component as the bearing surface remains relatively smooth and the functionality of the interfaces (radial restraint) as a whole are not impacted. ...Additionally, for perpendicular cracks contained to the Stellite surface or extending into the HAZ, there is no propagation mechanism that would extend the crack into the base metal.”

“Similarly, since there is likely no tensile stress to grow the crack, there is minimal concern for stress corrosion cracking (SCC) to expand the gap.”

“Because of the combination of the small size and brittle nature of the Stellite, it is likely that any loose parts would be extremely fine and continue to break apart over time. As such, wedging would not be an issue as the fragments would be too small to cause damage or become impacted.”

“Note that bounded indications will not require re-inspection for the duration of the inspection interval as defined in Section XI of the ASME Code.”

PWROG-24021-P acknowledges that while the cause of Stellite cracking is not fully understood, mechanical loadings/stresses on the interfacing components are a contributing factor as well as differences in the coefficient of thermal expansion between the Stellite surface material and stainless steel base material which can cause a mismatch in thermal stresses during operations as each part expands and shrinks differently during cycles of heating and cooling. However, as indicated in the various excerpts provided above, PWROG-24021-P determined that surface Stellite cracking is not expected to propagate into base material, though in the unlikely scenario that it did, the higher ductility of the stainless steel base metal is expected to have a blunting effect which would preclude further crack propagation from occurring. This is consistent with the observations from H1R26 in which the cracking indications were reported to be bound within the Stellite material and do not propagate into the base material.

Based on the generic industry assessment performed within PWROG-24021-P and applicability of the Stellite cracking observed on the HNP UCP alignment pin surfaces during H1R26, the acceptance criteria of PWROG-24021-P has been met and therefore return to service is justified for HNP. The indications on the UCP alignment pins will not impact their function.

Successive Examinations

As noted above, the disposition of indications performed herein is considered the evaluation analysis per ASME Section XI, IWB-3142.4. The UCP alignment pins have been evaluated as acceptable for continued service, as CPL-RV010-TM-CJ-000001 (Reference [1]) and PWROG-24021-P (Reference [4]) both provide assurance the indications on the UCP alignment pins will not impact their intended functions. From an engineering analysis perspective, these indications do not require re-inspection for the duration of the inspection interval. Therefore, aside from ASME Section XI requirements, re-inspection of the UCP alignment pins is not required until the next ISI interval per this evaluation. Assignment #2 has been added to this NCR for the HNP ISI Program Manager to assess re-inspection of the UCP alignment pins in regard to this evaluation and ASME Section XI requirements and update the HNP ISI plan accordingly.

Summary:

During the H1R26 VT-3 visual examination of the four UCP alignment pins at HNP in accordance with ASME Section XI Code Case N-885, four relevant indications were identified on the 0° UCP alignment pin and one relevant indication was identified on the 180-degree UCP alignment pin, all of which were bound within the Stellite surface material. An evaluation was performed meeting the requirements of ASME Section XI, IWB-3142.4 which concluded:

- The indications on the UCP alignment pin Stellite surfaces do not propagate into the base material. In the unlikely scenario that the indications were to progress, they are expected to blunt and stop propagating when they reach the more ductile Type 304 stainless steel base material of the UCP alignment pins.
- Similar indications in Stellite hard facing material have been observed in reactor internals components at other plants and justified for continued service.
- The analytical evaluations performed in CPL-RV010-TM-CJ-000001 and PWROG-24021-P are both applicable to the H1R26 UCP Alignment Pin indications.
- Continued operation with the linear indications on the UCP Alignment Pins at 0 degrees and 180 degrees is justified. The indications on the UCP alignment pins will not impact their function. Installation and operation of the upper internals will be maintained even with the reported indications.
- Aside from ASME Section XI requirements, re-inspection of the UCP alignment pins is not required until the next ISI interval per this evaluation. Assignment #2 has been added to this NCR for the HNP ISI Program Manager to assess re-inspection of the UCP alignment pins in regard to this evaluation and ASME Section XI requirements and update the HNP ISI plan accordingly.

References

1. Westinghouse document CPL-RV010-TM-CJ-000001 (RNP Calculation RNP-R/MECH-1393), "Assessment of Indications on the Upper Core Plate Alignment Pins for H.B. Robinson Unit 2," December 7, 2022 (Agency-wide Documents Access and Management System (ADAMS) Accession No. ML23089A212)
2. EPRI Materials Degradation Matrix, Revision 5. EPRI, Palo Alto, CA: 2024. 3002030559.
3. Materials Reliability Program: Screening, Categorization, and Ranking of Reactor Internals Components for Westinghouse and Combustion Engineering PWR Design (MRP-191, Revision 2). EPRI, Palo Alto, CA: 2018. 3002013220. (ADAMS Accession No. ML19081A060)
4. PWROG-24021-P, Revision 1, "Stellite Surface Indication Assessment for Westinghouse and Combustion Engineering Designed Plants", October 2025 (ADAMS Accession No. ML25321A033)