UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

July 25, 2014

Mr. Oscar A. Limpias
Vice President-Nuclear and CNO
Nebraska Public Power District
72676 648A Avenue
Brownville, NE 68321

SUBJECT: COOPER NUCLEAR STATION – LICENSE RENEWAL COMMITMENT REVIEW RE: CORE PLATE HOLD DOWN BOLT INSPECTION PLAN AND ANALYSIS (TAC NOS. ME9550 AND MF3557)

Dear Mr. Limpias:

By letter dated January 16, 2012, as supplemented by letters dated July 3, 2013, October 1, 2013, and May 19, 2014, Nebraska Public Power District (NPPD, the licensee) submitted a plant-specific analysis report of the core plate hold-down bolts for Cooper Nuclear Station (CNS). Portions of the letters dated January 16, 2012, and July 3, 2013, contain sensitive unclassified non-safeguards information (proprietary) and, accordingly, have been withheld from public disclosure.

By letter dated March 25, 2010, as a supplement to the CNS facility operating license renewal application (LRA) dated September 24, 2008, the licensee committed to submit to the U.S. Nuclear Regulatory Commission (NRC), at least 2 years prior to the period of extended operation (PEO), a complete proprietary version of an analysis of the core plate rim bolts that demonstrates their adequacy considering potential loss of pre-load through the PEO.

The NRC staff completed the review of the licensee's core plate hold-down bolt stress analysis, as well as the licensee's information and commitments regarding inspection of the core plate hold-down bolts, and the responses to requests for additional information. Based on the enclosed staff evaluation, the staff concludes that the licensee's core plate hold-down bolt inspection plan and analysis will provide an acceptable level of quality and safety.

The NRC staff has determined that the staff evaluation for the subject review contains proprietary information pursuant to Title 10 of the *Code of Federal Regulations*, Section 2.390. Proprietary information is indicated in the staff evaluation by text enclosed within brackets. Accordingly, the NRC staff has also prepared a non-proprietary, publicly-available version of the staff evaluation, which is provided in Enclosure 1. The proprietary version of the staff evaluation is provided in Enclosure 2.

Enclosure 2 to this letter contains Proprietary Information. Upon separation from Enclosure 2, this letter is DECONTROLLED.

If you have any questions regarding this approval, please contact the CNS Project Manager, Andrea George, at 301-415-1081.

Sincerely,

Peter Bamford for

Michael T. Markley, Chief
Plant Licensing Branch IV-1
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket No. 50-298

Enclosures:
1. Non-Proprietary Staff Evaluation
2. Proprietary Staff Evaluation

cc w/encl 1: Distribution via Listserv

ENCLOSURE 1

STAFF EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RELATED TO LICENSE RENEWAL CORE PLATE BOLTS COMMITMENT REVIEW

NEBRASKA PUBLIC POWER DISTRICT

COOPER NUCLEAR STATION

DOCKET NO. 50-298

Proprietary information pursuant to Section 2.390 of Title 10 of the *Code of Federal Regulations* has been redacted from this document.

Redacted information is identified by blank space enclosed within double brackets.

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

STAFF EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

CORE PLATE HOLD DOWN BOLT INSPECTION PLAN AND ANALYSIS

NEBRASKA PUBLIC POWER DISTRICT

COOPER NUCLEAR STATION

DOCKET NO. 50-298

1.0 INTRODUCTION

1.1 Application

By letter dated January 16, 2012 (Reference 1), as supplemented by letters dated July 3, 2013 (Reference 2), October 1, 2013 (Reference 3), and May 19, 2014 (Reference 4), Nebraska Public Power District (NPPD, the licensee) submitted a complete proprietary report, "Cooper Nuclear Station Core Plate Bolt Stress Report" (Reference 5). This report was submitted in accordance with License Renewal Commitment NLS2009100-1, Revision 1, as documented in NUREG-1944, "Safety Evaluation Report Related to the License Renewal of Cooper Nuclear Station," dated October 2010 (Reference 6). The licensee report included the stress analysis of the CNS core plate hold-down bolts that demonstrates their adequacy considering potential loss of pre-load through the period of extended operation (PEO). The licensee agreed to provide this analysis at least 2 years prior to entering the PEO. The licensee submitted the supplements to its original report in response to the NRC staff's requests for additional information (RAIs), dated May 24, 2013 (Reference 7), September 20, 2013 (Reference 8), and April 21, 2014 (Reference 9).

The NRC staff completed the review of the licensee's core plate hold-down bolt inspection plan and analysis, as supplemented by NPPD, including the CNS core plate bolt stress analysis report (the analysis report) prepared by GE Hitachi (GEH) Nuclear Energy Americas LLC.

1.2 Core Plate Assembly

The core plate assembly, located inside the boiling-water reactor (BWR) reactor pressure vessel, consists of a perforated stainless steel (SS) plate reinforced by stiffener beams and supported on the perimeter by a circular rim. Stiffener beams are welded to the core plate to carry the pressure loads from design basis loss-of-coolant accident (LOCA) events. The pressure loading from the LOCA causes compressive stresses in the lower edges of the stiffener beams. Cross ties or stabilizer beams are added between the stiffener beams to prevent flange buckling by providing lateral support.

The core plate rim is bolted to a ledge on the core shroud by SS studs which prevent vertical movement. The rim hold-down bolts attach the core plate to the core shroud. The stabilizer beams or rods also provide support for in-core housing monitors. The core plate assembly provides lateral support for the fuel bundles, control rod guide tubes, and in-core instrumentation during seismic events and provides vertical support for the peripheral fuel assemblies. The core plate is positioned on the shroud ledge by four vertical aligner pins. The seismic and other dynamic loads are shared between the friction load of the shroud to rim bolt connection, and the shear resistance of the aligner pins. During seismic events, the core plate provides lateral support for the core to prevent misalignment that could affect the insertion of the control rods. The critical number of intact hold-down bolts required to prevent lateral displacement during a seismic event is unique to each plant, and can be determined from a plant-specific analysis. Even if hold-down bolt failures result in significant core plate movement, preventing the insertion of control rods, the plant can still be brought to a safe shutdown condition using the standby liquid control (SLC) system. Core plates experience tensile stresses and have stress concentrations in the threaded regions. GEH has also determined that core plate bolt stress relaxation occurs due to thermal and irradiation effects.

2.0 REGULATORY EVALUATION

Title 10 of the *Code of Federal Regulations*, paragraph 54.21(a)(3) requires that for each component within the scope of license renewal, as defined in 10 CFR 54.4, and subject to aging management review according to the criteria of 10 CFR 54.21(a)(1) (typically described as long-lived, passive components), applicants for license renewal must demonstrate that the effects of aging will be managed adequately so that the intended function(s) will be maintained consistent with the current licensing basis (CLB) for the PEO.

The regulations in 10 CFR 54.21(c)(1) require an evaluation of time-limited aging analyses (TLAAs), as defined in 10 CFR 54.3. 10 CFR 54.3 states that [TLAAs], for the purposes of this part, are those licensee calculations and analyses that:

(1) Involve systems, structures, and components within the scope of license renewal, as delineated in § 54.4(a);

(2) Consider the effects of aging;

(3) Involve time-limited assumptions defined by the current operating term, for example, 40 years;

(4) Were determined to be relevant by the licensee in making a safety determination;

(5) Involve conclusions or provide the basis for conclusions related to the capability of the system, structure, and component to perform its intended functions, as delineated in § 54.4(b); and

(6) Are contained or incorporated by reference in the CLB.

The regulations in 10 CFR 54.21(c)(1) require that for each TLAA, the licensee shall demonstrate that:

(i) The analyses remain valid for the period of extended operation;

(ii) The analyses have been projected to the end of the period of extended operation; or

(iii) The effects of aging on the intended function(s) will be adequately managed for the period of extended operation.

3.0 TECHNICAL EVALUATION

3.1 Licensee's Basis for Acceptance of Core Plate Hold Down Bolt Stress Analysis

In its letter dated January 16, 2012, the licensee submitted its plant-specific analysis of the core plate bolts intended to fulfill the requirements of the license renewal commitment described in Section 1.1 of this staff evaluation. The analysis report was included as Attachment 1 to the licensee's letter dated January 16, 2012. The licensee described the core bolt stress analysis, load cases, load combinations, and results from the plant-specific analysis.

The licensee described the method of evaluation of stress relaxation of the core plate bolts in Section 5.0 of the analysis report. The licensee's evaluation is based on proprietary data generated by GEH. The licensee presented Figure 5-1 of the analysis report, which shows a mean design curve fit to the plotted data, designated the **[[ ]]**. Additionally, In Figure 5-2 of the analysis report, the licensee also provided data from the Electric Power Research Institute (EPRI) report, "BWRVIP-99-A: BWRVIP Vessel and Internals Project, Crack Growth Rates in Irradiated Stainless Steels in BWR Internal Components," dated October 2008 (Reference 10), for Type 304/316/348 wedge-loaded double cantilever beam (DCB) specimens in a BWR environment. The data are for higher fluence levels (4.4 to 6 $\times 10^{20}$ n/cm^2) (over five times higher than that predicted for the top of the CNS bolts). This data shows stress relaxation levels clustered between 28 percent and 38 percent for DCB specimens fabricated from 304/316/348 SS.

In Section 6.0 of the analysis report, the licensee discussed loads considered in the stress analysis for the core plate bolts, load combinations (Normal/Upset, Emergency, and Faulted), and the effects of temperature and fluence on preload. Section 7.0 of the analysis report included a structural analysis, including three loading scenarios, while Section 8.0 included the stress analysis results for all loading conditions and assumptions for all three scenarios, compared to American Society of Mechanical Engineers (ASME) allowable stress values.

3.2 NRC Staff Evaluation

3.2.1 Stress Analysis of Cooper Nuclear Station Core Plate Bolts

The core plate bolt stress analysis report does not state explicitly what type of analysis was performed to demonstrate that the CNS core plate hold-down bolts (core plate bolts) will remain structurally adequate throughout the PEO, considering a potential loss of preload. By letter dated July 3, 2013, in response to the NRC staff's RAI NP-1 dated May 24, 2013, the licensee stated that the stress analysis performed was not based on finite element analysis (FEA), but is still consistent with the approach used in BWRVIP-25, "BWR Vessel and Internals Project BWR Core Plate Inspection and Flaw Evaluation Guidelines," Appendix A (Reference 11), and used linear elastic calculations. The licensee stated that differences with Appendix A are listed in the analysis report, Section 8.1. However, the analysis performed for CNS core plate bolts calculated the shear loads on the core plate aligner pins using a different method than that used in BWRVIP-25 due to the variance in aligner pin configurations. In the NRC staff's RAI NP-4 dated May 24, 2013, the NRC staff asked the licensee to describe the method used to calculate the shear loads for the CNS core plate aligner pins and provide a technical justification for this deviation from BWR VIP-25, which demonstrates that the alternative method provides an accurate means to evaluate the shear stresses imposed on the aligner pins.

In the licensee's July 3, 2013, response to RAI NP-4, the licensee stated that the aligner pin configuration of CNS (Figures NP-4.1 and NP-4.2, Reference 6, proprietary) is different than the plant used in the BWRVIP-25, Appendix A, example (Figure NP-4.3 (proprietary) in the licensee's letter dated July 3, 2013). Although both include four assemblies and resist load mainly in shear, the CNS aligner pins are horizontal instead of vertical. For both configurations, the most limiting direction of applied horizontal load will engage at least three of the four aligner pin assemblies.

As stated by the licensee in its response to RAI NP-4, in BWRVIP-25, Appendix A, the maximum horizontal load noted on a single pin is **[[** **]]** (by FEA calculation), out of approximately **[[** **]]** kips total horizontal load. The ratio of the worst pin load to the total horizontal load is **[[** **]]** The aligner pin diameter, noted in Appendix A, is **[[** **]]** The maximum pure shear of one pin was calculated as **[[** **]]** The three remaining pins resisted the rest of the load.

Continuing the discussion in RAI NP-4, the licensee stated that for CNS, the horizontal load is **[[** **]]** Using the same ratio of pin load to total load as the BWRVIP-25, Appendix A, calculation **[[** **]]** results in a shear stress of **[[** **]]** However, due to the difference in aligner pin configuration, a more conservative calculation was performed **[[** **]]** as shown in Table 8-1 of the analysis report. Based on the above, the NRC staff concludes that the proposed response is acceptable.

3.2.1.1 <u>Loads and Load Combinations</u>

Section 8.1 of the analysis report provides the results of the stress analyses of the CNS core plate bolts for three distinct scenarios which are described in Section 7.2 of the report. For each scenario, the bolt stress levels were compared against applicable allowable stress values prescribed by the ASME Boiler and Pressure Vessel Code (ASME Code), depending on the service level considered (i.e., Normal, Upset, Emergency, or Faulted). The construction of the core plate results in an uneven distribution of the resultant horizontal and vertical loads supported by the core plate bolts. However, the results presented in Section 8.1 of the analysis report do not specify whether these results apply to the limiting CNS core plate bolt(s).

In RAI NP-5 dated May 24, 2013, the NRC staff asked the licensee to confirm that the results presented in Section 8.1 of the analysis report correspond to the limiting core plate bolt(s) (i.e., those which support the greatest horizontal and/or vertical loads) and demonstrate that these limiting core plate bolt(s) meet the applicable ASME Code allowable stress values. If the results presented in the analysis report do not correspond to the limiting core plate bolts, the staff asked the licensee to show the results of the stress analyses for the limiting core plate bolt(s) which demonstrate that the stresses induced in the limiting core plate bolts meet the applicable ASME Code allowable stress values.

In its July 3, 2013, response to RAI NP-5, the licensee stated that the evaluation supporting the analysis report did not calculate individual core plate bolt stresses, which would have required the development of an FEA model or very detailed hand calculations. Rather, a conservative alternative approach was used that determined the average stress values, consistent with the example presented in BWRVIP-25, Appendix A, and also consistent with industry practice when demonstrating ASME Code compliance for linear elastic analyses. Using the BWRVIP-25, Appendix A, approach provided conservative results, which bounded the individual bolt stresses, assuring the actual individual bolt stresses were below the ASME Code allowable stress values. The licensee stated that this approach provided reasonable and conservative assurance that all of the bolts will meet all postulated design basis loading conditions. The CNS evaluation applied the same methodology as BWRVIP-25, Appendix A, by using the average stress for the core plate bolt analysis.

Additionally, in its July 3, 2013, response to RAI NP-5, the licensee stated that Figure A-3 in BWRVIP-25, Appendix A, shows a specious variation in core plate bolt force. Variation exists **[[** **]]** However, this figure only depicts forces from externally-applied vertical loads. The total load on a core plate bolt includes the fluence and thermally relaxed preload plus a portion of the external loads. Figure A-3 does not include the internal forces due to preload and assumes the entirety of the external load is carried by the bolts. If the **[[** **]]** internal force is added to the bolts (due to the preload), the **[[** **]]** maximum variation in bolt vertical force is reduced by more than half. This still assumes that the entire external load is transferred to the bolts.

In its response to RAI NP-5, the licensee also stated that joint-to-fastener participation effects were also not included in Figure A-3 **[[** **]]** Realistically, the majority of the externally-applied vertical load will reduce the clamping force on the clamped components (i.e., the core plate rim) with a smaller portion of the load increasing the force in the fastener (i.e., the core plate bolt). **[[** **]]** Therefore, the already-reduced variation discussed above will be further reduced. This will bring the variation of bolt force shown in BWRVIP-25, Appendix A, down **[[** **]]** such that the total bolts force is lower than that used in the Membrane Stress (P_m) calculation.

For CNS, the variation is even smaller because [[

]]

Based on the above, the NRC staff concludes that the proposed response is acceptable.

3.2.2 Loss of Preload for the Core Bolts

The details regarding the licensee's calculation of the projected loss of preload for the core plate hold-down bolts due to neutron irradiation corresponding to 54 effective full power years (EFPY) are discussed in Section 5.0 of the analysis report. As discussed in Section 5.0, the licensee selected the [[

]]

The NRC staff conducted its review of the applicant's evaluation of stress relaxation of the core plate bolts using the guidance of the BWRVIP-25 report. Appendix B to BWRVIP-25 provides an evaluation of the potential loss of preload in BWR core plate bolts that is intended to be bounding for all BWRs. However, because the staff has not previously approved a calculated or estimated plant-specific value for the core plate bolt neutron fluence, the staff requested in RAI P-1 dated May 24, 2013, that the licensee provide the details of the neutron fluence evaluation that was used to determine projected irradiation-induced loss of preload for the core plate bolts.

In its July 3, 2013, response to RAI P-1, the licensee stated that a fast neutron fluence evaluation was performed by TransWare Enterprises, Inc., for CNS using the BWRVIP Radiation Analysis Modeling Application (RAMA) methodology. The licensee indicated that the RAMA neutron fluence methodology has been reviewed by the NRC and subsequently given generic approval for determining fast neutron fluence in BWR reactor pressure vessels (RPVs), as well as RPV internal components that include the core shroud and top guide. For application of the RAMA methodology to the core shroud and top guide, the licensee referenced the NRC staff's approval of BWRVIP-145-A, "BWR Vessel and Internals Project Evaluation of Susquehanna Unit 2 Top Guide and Core Shroud Material Samples Using RAMA Fluence Methodology," October 2009 (Reference 12). The licensee provided the range of neutron fluence values calculated for the bounding core plate hold-down bolt (peak azimuthal location).

The NRC staff notes that the RAMA neutron fluence methodology has only been generically approved by the NRC for determining projected neutron fluence for the RPV. As stated in the safety evaluation accompanying BWRVIP-145-A, "[i]t should be noted that the RAMA fluence methodology is based on the guidance of RG 1.190 ["Calculational and Dosimetry Methods for Determining Pressure Vessel Neutron Fluence"], which was developed specifically for reactor pressure vessels, in order to satisfy GDCs [10 CFR Part 50, Appendix A, "General Design Criteria of Nuclear Power Plants"] 14, 30, and 31 pertaining to reactor coolant pressure boundaries. Since reactor vessel internals are not reactor coolant pressure boundary components, GDCs 14, 30 and 31 do not apply to the reactor vessel internals." The NRC staff does note that RAMA's application to the core shroud and top guide components has received limited approval by the NRC staff for those cases where the licensee has demonstrated on a plant-specific basis that the calculational results are generally conservative for the intended application, as discussed in the staff's safety evaluation for BWRVIP-145-A.

The RAMA methodology has not been approved by the NRC staff for neutron fluence projections for the core plate hold-down bolts because it has not been benchmarked based on analysis irradiated core plate hold-down bolt material specimens. The staff notes, however, that there are substantial margins available for 54 EFPY core plate bolt stress relaxation values, based on the stress analysis results provided in the analysis report. Therefore, given the conservatisms assumed in the licensee's fluence calculation, in concert with the staff's findings regarding the consistency of the licensee's calculated core plate bolt preload reduction compared to results provided in Appendix B of BWRVIP-25 (discussed below), the staff concludes that the licensee's application of the RAMA methodology is adequate for the core plate bolt stress relaxation analysis. Therefore, the staff concludes that the proposed response is acceptable.

BWRVIP-25, Appendix B states that a **[[** **]]** reduction in preload due to **[[** **]]** should be expected for a 40-year plant life. However Appendix B of BWRVIP-25 does not provide the range of neutron fluence values corresponding to this reduction in preload. In order the verify that the licensee's projected loss of preload is consistent with the BWRVIP generic evaluation for loss of preload in BWR core plate bolts from Appendix B of BWRVIP-25, the staff issued RAI P-2 dated May 24, 2013, requesting that the licensee provide the neutron fluence range on which the loss of preload range from the BWRVIP-25, Appendix B is based.

In its July 3, 2013, response to RAI P-2, the licensee provided the neutron fluence range that was used to calculate the loss of preload range from BWRVIP-25. Based on the discussion of a similar RAI response in Section 3.2.1 of its evaluation for the Vermont Yankee Nuclear Power Station (VYNPS) core plate hold-down bolt stress relaxation analysis dated March 28, 2012 (Reference 13), the NRC staff noted that the neutron fluence range used in the BWRVIP-25 analysis represents an **[[** **]]** The staff compared the neutron fluence range for the limiting core plate bolt at CNS (as provided in the licensee's response to RAI P-1) with the neutron fluence values used for the BWRVIP-25 analysis and determined that it is bounded by the maximum neutron fluence value used for the analysis of core plate bolt stress relaxation in BWRVIP-25. The staff also compared the total projected loss of bolt preload for CNS, due to the combined effects of neutron irradiation-induced stress relaxation at 54 EFPY and thermal-induced stress relaxation, with the range of values for reduction in preload specified in BWRVIP-25 and concludes that the licensee's results are consistent with what would be expected from the BWRVIP-25 generic evaluation. Furthermore, the staff has approved licensees' use of the [[ ]] for calculating projected loss of preload due to neutron irradiation based on comparison these results to other industry data for irradiation-induced stress relaxation, as documented in Section 3.2.1 of its March 28, 2012, evaluation for the VYNPS core plate hold-down bolt stress relaxation analysis. Therefore, the staff concludes that the licensee's projected loss of preload due to irradiation effects is consistent with BWRVIP-25 and is acceptable. Therefore, the staff concludes that the proposed response is acceptable.

The NRC staff concludes that the licensee's evaluation of the projected loss of preload for the CNS core plate hold-down bolts due to irradiation-assisted stress relaxation was appropriately determined because: a) the licensee appropriately estimated the peak neutron fluence for the bolts at end of life using methods that are adequately conservative for this application, and b) the licensee's projection of loss of preload based on the peak bolt fluence is generally consistent with what would be expected based on the BWRVIP-25 generic analysis.

3.2.3 <u>Inspection Plan for the Core Plate Hold-Down Bolts</u>

For certain core plate configurations, specifically those that do not have lateral restraint wedges installed to prevent lateral displacement of the core plate, the BWRVIP-25 report provides inspection criteria for the core plate hold-down bolts to ensure that an adequate number of bolts are intact to prevent lateral displacement of the core plate during a seismic event.

Appendix C, "Response to BWRVIP Applicant Action Items," of the CNS License Renewal Application (LRA) dated September 24, 2012 (Reference 14), indicates that lateral restraint wedges are not installed. Therefore, the core plate hold-down bolts are relied upon to provide for lateral restraint of the core plate. Based on the fact that lateral restraint wedges are not installed at CNS, inspection of the core plate hold-down bolts would need to be performed in accordance with BWRVIP-25 guidelines. The licensee noted in Appendix C of the LRA that the BWRVIP-25-required inspections have been deferred until the technology for performing the inspections in accordance with BWRVIP-25 guidelines is available. To date, no techniques have been developed for performing core plate hold-down bolt inspections in accordance with BWRVIP-25 guidelines. The NRC staff's evaluation of the licensee's interim inspection plan for the core plate hold-down bolts, to be implemented until the BWRVIP revises its guidance for core plate hold-down bolt inspection and evaluation, is addressed herein.

By letter dated May 24, 2013, the NRC staff issued RAI P-3 requesting that the licensee provide details regarding previous inspections of the core plate hold-down bolts, as well as its plan for performing future bolt inspections.

In its July 3, 2013, response to RAI P-3, the licensee stated that NPPD performed VT-3 visual examinations of 48 of the core plate hold-down bolts from the top side of the bolts in the spring of 2000 with no recordable indications. The licensee further stated that in 2010 the BWRVIP issued interim guidance to the BWR fleet requiring plants to develop and submit a technical justification for deviating from the inspection guidelines of BWRVIP-25. The licensee stated that a "Deviation Disposition" from the BWRVIP-25 guidelines was provided to the BWRVIP and the NRC in 2011 because no techniques are currently available to perform inspections of the bolts in accordance with the BWRVIP-25 guidelines. The licensee indicated that the Deviation Disposition from the BWRVIP-25 guidelines provided technical justification for not following the inspection criteria of BWRVIP-25 and included interim inspection guidance.

NPPD's BWRVIP-25 deviation was submitted to the NRC by letter dated April 20, 2011 (Reference 15). The licensee's deviation letter states that the core plate hold-down bolts have a relatively low susceptibility to cracking based on field experience and fabrication practices. The deviation letter also states that, should some cracking occur in several of the bolts, the consequences are mitigated by redundancy in the bolting and associated alignment hardware. The NRC staff noted that the deviation letter contains no specific information regarding the bolt fabrication practices and how they may preclude the occurrence of stress-corrosion cracking (SCC) in the core plate hold-down bolts. The staff also noted that the deviation lacks sufficient inspection guidance; the deviation states only that the licensee will perform VT-3 visual inspections of the core plate hold-down bolts from above the core plate on a periodic basis to ensure that significant degradation is not occurring. No inspection frequency or inspection sample size is specified in the deviation letter.

The licensee explained in its July 3, 2013, RAI response that the BWRVIP-25-required volumetric examinations of the core plate hold-down bolts are not feasible because the techniques for ultrasonic testing of the bolts from above the core plate are not available. The licensee also stated that meaningful enhanced VT-1 visual examinations of the bolts from below the core plate are not feasible because access to the bolt threads would require disassembly of the RPV internals. The licensee noted that Section 3.2.5 of BWRVIP-47-A, "BWR Vessel and Internals Project, BWR Lower Plenum Inspection and Flaw Evaluation Guidelines" (Reference 16), states that removing or dismantling RPV internal components for the purpose of performing inspections is not warranted to assure safe operation. However, the licensee stated that NPPD performs inspections to the extent practical from below the core plate in accordance with BWRVIP-47-A guidelines if access is made available due to maintenance activities not part of normal refueling operations. The licensee stated that results of these inspections are provided to the BWRVIP and then forwarded by the BWRVIP to the NRC.

In its July 3, 2013, RAI response, the licensee indicated that, based on the above limitations associated with implementation of the BWRVIP-25 inspection criteria, future inspections of the core plate hold-down bolts will consist of VT-3 visual examinations of 25 percent of the bolts from the top side of the bolts every 10-year inservice inspection interval, consistent with the BWRVIP interim guidance. The licensee also stated that VT-3 visual examinations from the top side are considered reasonable to detect loosened and rotated bolts due to a combination of vibration and failure of the welds on the locking device.

Based on the above, the NRC staff concludes that the licensee's deviation from the BWRVIP-25 requirements for ultrasonic examination of the core plate hold-down bolts and interim inspection plan to perform a VT-3 visual examination of the bolts with only a 25 percent sample every 10-year inservice inspection interval, does not provide adequate assurance of core plate hold-down bolt structural integrity. This level of inspection would likely reveal if there was widespread failure of the bolts but could miss partially cracked bolts or a small number of failed bolts. The staff's determination is based on the inherent limitation in the VT-3 visual examination method for detecting cracking, the need for assurance that a sufficient number of bolts are intact, and the inadequate statistical assurance of bolt integrity provided by a 25 percent inspection sample. Considering these issues, the staff determined that the licensee must propose a more comprehensive inspection plan to provide adequate assurance of core plate hold-down bolt structural integrity during the PEO.

During a September 19, 2013, clarification call with the licensee, the NRC staff communicated its concerns regarding the licensee's proposed inspection plan to conduct a VT-3 visual examination of 25 percent of the bolts every 10-year ISI interval. As documented in its teleconference e-mail summary and RAI dated September 20, 2013 (Reference 8), the NRC staff indicated that this inspection plan provides insufficient assurance of component integrity and requested additional information regarding the inspection criteria.

By letter dated October 1, 2013 (Reference 3), the licensee provided a supplemental RAI response, wherein the licensee provided a new commitment related to the performance of inspections for the core plate hold-down bolts. The commitment states:

> Until the NRC endorses the revised inspection guidance of BWRVIP-25, NPPD will perform VT-3 inspections on the top side of a 50% sample of the Core Plate Hold Down Bolts every other refueling outage.

The licensee noted that the above inspection plan is the same as that approved by the NRC staff in its March 28, 2012, evaluation for the core plate hold-down bolts at VYNPS.

Based on the above, the NRC staff determined that additional information would be required to make a finding regarding the adequacy of performing a VT-3 visual examination of 50 percent of the core plate hold-down bolts every other refueling outage. The staff noted that its approval of this inspection plan at VYNPS was based, in part, on its determination that the licensee adequately demonstrated that its core plate hold-down bolts would have a low susceptibility to intergranular stress-corrosion cracking (IGSCC). This determination is documented in Section 3.2.2 the staff's March 28, 2012, safety evaluation for the VYNPS core plate hold-down bolt inspection plan and stress analysis. The staff's determination regarding IGSCC susceptibility at VYNPS was based on the fact that the VYNPS core plate hold-down bolts are not sensitized, the bolts were procured to a specification prohibiting cold forming operations after solution heat treatment, and there were no instances of IGSCC of these bolts in the BWR fleet at that time.

Based on the above criteria for VYNPS, the NRC staff issued RAI-2 by letter dated April 21, 2014, requesting that NPPD provide information regarding the fabrication practices for the core plate hold-down bolts at CNS, as they relate to IGSCC susceptibility. The staff also requested in RAI-2 that the licensee indicate whether any instances of SCC have been observed for these bolts at CBS or other U.S. BWRs, based on operating experience in the domestic BWR fleet to date.

In its May 19, 2014, response to RAI-2, the licensee stated that the CNS core plate hold-down bolts were fabricated from non-sensitized Type 304 annealed SS. The original material specification required this austenitic SS material to be solution heat treated following the cold roll threading process. In addition, the licensee stated that the procurement specification also limited the as-fabricated material surface hardness, thus limiting the amount of cold work introduced as part of the thread forming process. The licensee noted that the machined threads were liquid honed to a matte finish to remove any burrs or residual surface roughness, and the upper nut thread surfaces were electrolyzed to minimize the potential for galling during assembly. The licensee stated that CNS, as well as the domestic BWR fleet, has not observed any instances of SCC based on inspections performed to date. The licensee emphasized that non-welded Type 304 SS material in the solution annealed condition has shown to be highly resistant to IGSCC initiation in BWR applications. The licensee concluded that, based on manufacturing process controls and inspection history, susceptibility to IGSCC is considered low for the core plate hold-down bolts at CNS.

The NRC staff determined that the licensee's response to RAI-2 is acceptable because the licensee confirmed that the core plate hold-down bolts at CNS are not sensitized, and the bolts were not subjected to cold working after solution heat treatment. The staff also noted that the core plate hold-down bolts have a low preload, which would further decrease susceptibility to IGSCC. These factors, in concert with the lack of any core plate hold-down bolt failures in the BWR fleet, demonstrate reasonable assurance that the core plate hold-down bolts should have low susceptibility to IGSCC. Additionally, the staff found that the susceptibility of the core plate hold-down bolts to irradiation-assisted stress-corrosion cracking (IASCC) is low because the peak neutron fluence level for the bolts is below the range at which IASCC can typically begin to be an issue in BWRs (5×10^{20} n/cm^2, E > 1.0 MeV). Further, the staff determined that VT-3 visual examination of the bolts from the top side should readily detect loosened and rotated bolts due to a combination of vibration and failure of the welds on the locking device. Finally, in accordance with BWRVIP-47-A, inspections of opportunity when access to the lower plenum is possible due to maintenance should provide additional assurance that core plate bolts are intact since it should be possible to view the threaded portion of the bolts from below the lower plenum region. Based on the above factors, the staff determined that VT-3 visual examinations would be adequate for conducting interim bolt inspections, provided that the 50 percent inspection sample provides adequate statistical assurance of the integrity of the overall bolt population.

To verify the adequacy of a 50 percent VT-3 visual inspection sample, the NRC staff performed an independent statistical evaluation of the probable number of cracked bolts in the overall population given that no cracked bolts are found in the 50 percent sample. The staff used a hypergeometric distribution, which can be used as the basis for a sampling scheme (a hypergeometric experiment) that samples a population for attributes without replacement and which satisfies the following conditions, as described in NUREG-1475, "Applying Statistics," Revision 1, March 2011 (Reference 17):

- The sampled population is finite;
- Once an item is selected, it cannot be selected again;

- The size of the population is known;
- The number of items with the attribute of interest is known;
- Each item in the sample is drawn at random.

The NRC staff concluded that if no cracked bolts are present in the 50 percent sample, the probability of having 10 percent or more cracked bolts in the overall population is less than 1 percent. The staff noted that having 10 percent of the bolts cracked would not result in the ASME Code allowable stresses being exceeded based on the margins given in the analysis CNS analysis report. The staff concludes that this probability provides adequate statistical assurance of the integrity of the overall core plate hold-down bolt population. Therefore, RAI-2 is resolved.

The NRC staff also notes there are several conservatisms in the core plate bolt stress analysis that make it even less likely that the ASME Code allowable stresses for the bolts would be exceeded. First, as noted in Section 3.1 of this staff evaluation, **[[**

]] Second, for the stress evaluations that were performed in accordance with BWRVIP-25, Appendix A, Scenarios 1 and 3, **[[**
]]

Based on its review of the information submitted by the licensee supporting low susceptibility to IGSCC and IASCC for the CNS core plate hold-down bolts, and the margins present in the CNS core plate bolt stress analysis, as supported the NRC staff's statistical evaluation, the staff concludes that the licensee's proposal to perform a VT-3 visual examination of 50 percent of the core plate hold-down bolts every other refueling outage to be acceptable until the BWRVIP revises its guidance for core plate hold-down bolt inspection and evaluation.

4.0 CONCLUSION

The NRC staff reviewed the licensee's analysis report, as supplemented, for completion of the license renewal commitment, NLS20091001, Revision 1, and concludes that it is acceptable based on the following:

1. The analysis uses plant-specific loading and geometry for CNS.
2. The analysis takes credit for a conservative amount of friction between the core plate rim and the shroud ledge.
3. The analysis used the pre-load in the secondary stress calculation.
4. An additional bending load due to the bending of core plate rim is added to the core plate bolts.

5. The analysis calculates the shear loads on the aligner pins using a different method due to having a different aligner pin configuration.

With respect to the stress analysis of the core plate bolts, including the preload relaxation due to thermal effects and fluence for a 60-year life, the NRC staff concluded that the licensee's evaluation is acceptable. This is based on the determination that the core plate bolts satisfy the ASME Code criteria for the applicable loads and load combinations. The methodology and assumptions utilized in the stress analysis were reasonable and consistent with BWRVIP-25. Therefore, the NRC staff concludes that there is reasonable assurance that the CNS core plate bolts are structurally acceptable for 60-year plant life, in accordance with 10 CFR 54.21 (a)(3), and that this information meets license renewal commitment, NLS20091001, Revision 1.

With respect to the inspection plan proposed by the licensee for the core plate bolts, the NRC staff concludes that the licensee's inspection plan, as modified by the commitment contained in the Attachment to the licensee's letter dated October 1, 2013, is acceptable. Specifically, the licensee committed to perform VT-3 inspections on the top side of a 50 percent sample of the CNS core plate bolts every other refueling outage, effective 30 days after the issuance of this staff evaluation, until the NRC endorses revised inspection guidance contained in BWRVIP-25.

5.0 REFERENCES

1. Van Der Kamp, David, Nebraska Public Power District, letter to U.S. Nuclear Regulatory Commission, "Completion of License Renewal Commitment NLS2009100-1 (Revision 1), Core Plate Hold Down Bolt Analysis, Cooper Nuclear Station Docket No. 50-298 License No. DPR-46," dated January 16, 2012 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML12031A248).

2. Limpias, Oscar, Nebraska Public Power District, letter to U.S. Nuclear Regulatory Commission, "Response to Request for Additional Information Regarding Core Plate Hold Down Bolt Stress Analysis," dated July 3, 2013 (ADAMS Accession No. ML13190A030).

3. Limpias, Oscar, Nebraska Public Power District, letter to U.S. Nuclear Regulatory Commission, "Supplemental Information Related to Response to Request for Additional Information Regarding Core Plate Hold Down Bolt Stress Analysis," dated October 1, 2013 (ADAMS Accession No. ML13283A010).

4. Limpias, Oscar, Nebraska Public Power District, letter to U.S. Nuclear Regulatory Commission, "Response to Nuclear Regulatory Commission Follow-Up Request for Additional Information Regarding Fulfillment of License Renewal Commitment No. NLS2009100-1, Revision 1, for the Core Plate Hold-Down Bolts at Cooper Nuclear Station," dated May 19, 2014 (ADAMS Accession No. ML14143A366).

5. GEH Nuclear Energy Americas LLC, NEDO-33674P – Revision 0, "Cooper Nuclear Station Core Plate Bolt Stress Analysis," October 2011, (Enclosures to Reference 1, ADAMS Accession Nos. ML12231A250 – Proprietary, withheld under 10 CFR 2.390, and ML12231A249 – Non-Proprietary).

6. U.S. Nuclear Regulatory Commission, NUREG-1944, "Safety Evaluation Report Related to the License Renewal of Cooper Nuclear Station," October 2010 (ADAMS Accession No. ML103070009).

7. Wilkins, Lynnea, U.S. Nuclear Regulatory Commission, letter to Oscar A. Limpias, Nebraska Public Power District, dated May 24, 2013, "Cooper Nuclear Station - Request for Additional Information Re: Core Plate Hold Down Bolt Stress Analysis (TAC No. ME9550)" (ADAMS Accession Nos. ML13133A077 – Proprietary, withheld under 10 CFR 2.390, and ML13133A080 – Non-Proprietary).

8. Wilkins, Lynnea, U.S. Nuclear Regulatory Commission, email to David Van De Kamp, Nebraska Public Power District, "Cooper - Request for Additional Information Regarding Core Plate Hold Down Bolt Stress Analysis (ME9550)," dated September 20, 2013 (ADAMS Accession No. ML13263A130).

9. George, Andrea, U.S. Nuclear Regulatory Commission, email to David Van De Kamp, Nebraska Public Power District, "Request for Additional Information – License Renewal Core Hold-Down Bolts Commitment Review (TAC No. MF3557)," dated April 21, 2014 (ADAMS Accession No. ML14111A274).

10. Electric Power Research Institute, "BWRVIP-99-A: BWRVIP Vessel and Internals Project, Crack Growth Rates in Irradiated Stainless Steels in BWR Internal Components," October 2008 (ADAMS Accession No. ML091620165 – Proprietary, withheld under 10 CFR 2.390).

11. Electric Power Research Institute, "BWRVIP-25: BWR Vessel and Internals Project BWR Core Plate Inspection and Flaw Evaluation Guidelines," TR-107284, December 1996 (Proprietary, withheld under 10 CFR 2.390. Not publicly available.).

12. Electric Power Research Institute, "BWRVIP-145NP-A: BWR Vessel and Internals Project Evaluation of Susquehanna Unit 2 Top Guide and Core Shroud Material Samples Using RAMA Fluence Methodology," October 2009 (ADAMS Accession No. ML100260948).

13. Wilson, George A., U.S. Nuclear Regulatory Commission, letter to Entergy Nuclear Operations, Inc., "Core Plate Hold Down Bolt Inspection Plan and Analysis - Vermont Yankee Nuclear Power Station (TAC No. ME6248)," dated March 28, 2012 (ADAMS Accession No. ML120760152).

14. Minahan, Stewart B., Nebraska Public Power District, letter to U.S. Nuclear Regulatory Commission, "Appendix C, Response to BWRVIP Applicant Action Items" (ADAMS Accession No. ML083030243); included with the Cooper Nuclear Station License Renewal Application dated September 24, 2012 (ADAMS Package Accession No. ML083030227).

15. Van Der Kamp, David, Nebraska Public Power District, letter to U.S. Nuclear Regulatory Commission, "Deviation from BWRVIP-25 Inspection Requirements," dated April 20, 2011 (ADAMS Accession No. ML11116A202).

16. Electric Power Research Institute, "BWRVIP-47-A, "BWR Vessel and Internals Project, BWR Lower Plenum Inspection and Flaw Evaluation Guidelines" (Proprietary, withheld under 10 CFR 2.390. Not publicly available.).

17. U.S. Nuclear Regulatory Commission, NUREG-1475, "Applying Statistics," Revision 1, March 2011 (ADAMS Accession No. ML11102A076).

Principal Contributors: D. Hoang
C. Sydnor

Date: July 25, 2014

If you have any questions regarding this approval, please contact the CNS Project Manager, Andrea George, at 301-415-1081.

Sincerely,

/RA by PBamford for/

Michael T. Markley, Chief
Plant Licensing Branch IV-1
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket No. 50-298

Enclosures:
1. Non-Proprietary Staff Evaluation
2. Proprietary Staff Evaluation

cc w/encl 1: Distribution via Listserv

DISTRIBUTION:
PUBLIC
LPL4-1 r/f
RidsAcrsAcnw_MailCTR Resource
RidsNrrDeEmcb Resource
RidsNrrDeEvib Resource
RidsNrrDorlDpr Resource
RidsNrrDorlLpl4-1 Resource
RidsNrrPMCooper Resource
RidsNrrLAJBurkhardt Resource
RidsRgn4MailCenter Resource
DHoang, NRR/DE/EMCB
CSydnor, NRR/DE/EVIB

ADAMS Accession Nos.: Proprietary ML14190A005; Non-proprietary ML14190A004
*Via Memo **Previously concurred

OFFICE	NRR/DORL/LPL4-1/PM	NRR/DORL/LPL4-1/LA**	NRR/DE/EMCB/BC*	NRR/DE/EVIB/BC*	NRR/DORL/LPL4-1/BC
NAME	AGeorge (FLyon for)	JBurkhardt	MMcMurtray	SRosenberg	MMarkley (PBamford for)
DATE	7/24/14	7/9/14	1/23/14	6/20/14	7/25/14

OFFICIAL RECORD COPY