UNITED STATES
NUCLEAR REGULATORY COMMISSION
REGION IV
1600 E. LAMAR BLVD
ARLINGTON, TX 76011-4511

November 22, 2017

Mr. John Dent, Jr., Vice President-Nuclear
and Chief Nuclear Officer
Nebraska Public Power District
Cooper Nuclear Station
72676 648A Avenue
P.O. Box 98
Brownville, NE 68321

SUBJECT: COOPER NUCLEAR STATION – NRC POST-APPROVAL LICENSE RENEWAL INSPECTION REPORT 05000298/2017008

Dear Mr. Dent:

On November 2, 2017, a U.S. Nuclear Regulatory Commission (NRC) inspector completed a Post-Approval Site Inspection for License Renewal at the Cooper Nuclear Station. The enclosed report documents the inspection findings, which were discussed with you and other members of your staff.

The NRC inspector did not identify any findings of significance or violations of more than minor significance.

This letter and its enclosure will be made available for public inspection and copying at http://www.nrc.gov/reading-rm/adams.html and at the NRC Public Document Room in accordance with 10 CFR 2.390, "Public Inspections, Exemptions, Requests for Withholding."

Sincerely,

/RA/

Gregory E. Werner, Chief
Engineering Branch 2
Division of Reactor Safety

Docket: 50-298
License: DPR-46
cc w/enclosure: Electronic Distribution

Enclosure:
NRC Inspection Report 05000298/2017008
w/ Attachment: Supplemental Information

U.S. NUCLEAR REGULATORY COMMISSION

REGION IV

Docket:	05000298
License:	DPR-46
Report:	05000298/2017008
Licensee:	Nebraska Public Power District
Facility:	Cooper Nuclear Station
Location:	72676 648A Ave Brownville, NE
Dates:	February 21 – November 2, 2017
Inspector:	G. Pick, Senior Reactor Inspector
Approved By:	Gregory E. Werner, Chief Engineering Branch 2 Division of Reactor Safety

SUMMARY

IR 05000298/2017008; 02/21/2017 – 11/02/2017; Cooper Nuclear Station; Post-Approval Site Inspection for License Renewal

The inspection activities described in this report were performed between February 21 and November 2, 2017, by an inspector in the NRC's Region IV office. No findings of significance were identified.

The significance of inspection findings is indicated by their color (Green, White, Yellow, or Red) using Inspection Manual Chapter 0609, "Significance Determination Process," dated April 29, 2015. Their cross-cutting aspects are determined using Inspection Manual Chapter 0310, "Aspects within the Cross-Cutting Areas," dated December 4, 2014. Violations of NRC requirements are dispositioned in accordance with the NRC Enforcement Policy. The NRC's program for overseeing the safe operation of commercial nuclear power reactors is described in NUREG-1649, "Reactor Oversight Process," dated July 2016.

A. NRC-Identified Findings and Self-Revealing Findings

None

B. Licensee-Identified Violations

None

REPORT DETAILS

4. OTHER ACTIVITIES (OA)

4OA5 Phase 3 Inspection Activities (IP 71003)

Phase 3 Inspection activities are performed after the licensee enters the period of extended operation. The period of extended operation is the additional 20 years beyond the original 40-year licensed term. Cooper Nuclear Station began the period of extended operation on January 18, 2014.

The inspector performed this inspection to evaluate whether the licensee completed outstanding actions required to comply with the license renewal license condition and commitments and effectively implemented outstanding actions related to aging management programs.

The inspector closed Commitments 29, 33, 34, 35, and 41 during this inspection.

a. Inspection Scope

During this in-office inspection, the inspector evaluated the licensee actions related to commitments not closed during the Phase 2 license renewal inspection (Inspection Report 05000298/2013008 (ADAMS ML13352A313)).

The inspector reviewed program documents, design calculations, inspection results, engineering reports, updated safety analysis report change reports and corrective action documents. The inspector interviewed licensee personnel, including the program owners and design engineers during several teleconferences to discuss the technical resolution related to the commitments. In addition, reviewers from the office of Nuclear Reactor Regulation and office of Nuclear Regulatory Research assisted in independent assessments of these commitments, particularly, the corrosion rates for the wetted portions of the torus.

b. Observations

1. B.1.37 Thermal Aging and Neutron Irradiation Embrittlement of Cast Austenitic Stainless Steel - Commitment 29 (NLS2009100-3)

The Thermal Aging and Neutron Irradiation Embrittlement of Cast Austenitic Stainless Steel aging management program managed the reduction of fracture toughness resulting from thermal aging combined with radiation embrittlement to prevent any loss of intended function of reactor vessel internal components. This program evaluated cast austenitic stainless steel components in the reactor vessel internals and required non-destructive examinations as appropriate. The licensee committed to use the NRC acceptance and approval of an industry technical evaluation as specified in this commitment.

Commitment 29 specified:

> "NPPD will confirm there are no cast austenitic stainless steel materials with greater than 25 percent ferrite or provide a flaw evaluation methodology for cast austenitic stainless steel internal components with greater than 25 percent ferrite for staff review and approval. This will be provided at least two years prior to the period of extended operation. NPPD expects to implement this commitment by a generic analysis sponsored by the Boiling Water Reactor Vessel and Internals Project (BWRVIP) in collaboration with EPRI."

During the previous inspection, the inspectors could not evaluate this commitment because the licensee continued to await approval of BWRVIP-234, "Thermal Aging and Neutron Embrittlement Evaluation of Cast Austenitic Stainless Steels," dated December 2009. Because the licensee commitment specified that they would await acceptance and approval of the generic analysis, the inspectors provided a chronology and considered it appropriate for the licensee to extend the completion date for this commitment. The licensee indicated that they would implement the appropriate corrective actions if they exceeded 25 percent ferrite in their cast austenitic stainless steel components. The licensee tracked completion of this commitment by Condition Report CNSLO-2011-00258.

During this inspection, the inspector determined that NRC had issued a final safety evaluation report for BWRVIP-234 on June 22, 2016 (ML16096A002). The inspector reviewed the Cooper Nuclear Station Vessel Internals Program, Section 12.25, "VIP-234, Thermal Aging and Neutron Embrittlement Evaluation of Cast Austenitic Stainless Steels," and the fluence evaluation performed after issuance of the safety evaluation report. The BWRVIP-234 analysis demonstrated that the reactor vessel internal components did not exceed 20 percent ferrite and the fluence values, except for the orificed fuel support plate, did not exceed 6×10^{20} n/cm^2. The fluence evaluation demonstrated that the orificed fuel support plate is in compression and does not have the tensile stress necessary to propagate intergranular stress corrosion cracking. During a teleconference, the inspector determined that the licensee did not plan to conduct nondestructive examinations of these components based on the low susceptibility to thermal aging and neutron embrittlement. The inspector identified no concerns with the licensee evaluations or planned actions.

Based on review of the actions implemented related to Commitment 29, the inspector determined the licensee had met Commitment 29. The licensee effectively evaluated the susceptibility of their internal cast austenitic stainless steel components to intergranular stress corrosion cracking. This commitment is closed.

2. <u>B.1.10 Containment Inservice Inspection - Commitments 33, 34, and 35</u>

The Containment Inservice Inspection aging management program managed the loss of material and cracking for the primary containment and its integral attachments. The program used the ASME Boiler and Pressure Vessel Code, Section XI, 2001 Edition, through the 2003 Addenda. Visual inspections monitored for loss of material from the steel containment shells and their integral attachments; containment hatches and

airlocks; moisture barriers; and pressure retaining bolting. The licensee inspected surfaces for evidence of flaking, blistering, peeling, discoloration, and other signs of distress. The commitments that remained open related to recoating the wetted portion of the torus, removing sludge from the wetted portion until the recoating occurred and evaluating the rate of corrosion and demonstrating the torus would remain functional until the next inspection.

Commitment 33

Commitment 33 specified:

> "NPPD will recoat the wetted portion of the CNS torus within 3 years after entering the period of extended operation."

During the previous inspections, the inspectors verified that the licensee had budgeted this item for implementation in 2016 during Refueling Outage 29 that would restore the zinc-based coating to an original condition. This commitment arose because NRC identified the need to arrest corrosion and prevent torus structural failure or through wall leakage caused by deep pitting. The licensee continued to evaluate available options related to managing the effects of aging of the submerged portions of the torus (pressure suppression chamber). The inspectors determined that the general surface corrosion rate had not exceeded 5 mils per year. The licensee attributed this to the nitrogen-inerted atmosphere decreasing the amount of available oxygen for generating corrosion products, the reduced conductivity because of the reduced amount of particulates, and removal of the corrosion products that reduced the ability of particulates to create concentration cells.

During this inspection, the inspector determined that the licensee had rescinded this commitment related to recoating their torus based on the results of two-year cleaning and inspecting. Instead of recoating the torus as a preventive measure, which would have provided the added protection of a sacrificial anode coating, the licensee decided to continue their periodic maintenance and monitoring program through the end of the period of extended operation, as described in commitments 34 and 35 reviews.

The licensee established a method to monitor and maintain the condition of their torus by conducting frequent cleaning and inspections. The licensee had incorporated the inspection requirements, acceptance criteria, and coating/repair criteria into their containment inservice inspection program. Because the licensee had established a periodic cleaning and inspection plan to manage the effects of aging, the inspector identified no concerns with the repeal of this commitment. This commitment is closed.

Commitment 34

Commitment 34 specified:

> "NPPD will remove sludge and inspect the wetted portion of the torus every refueling outage from now until the torus is recoated."

During the previous inspection, the inspectors verified that the licensee removed sludge and corrosion products prior to inspecting the torus during two earlier outages. The licensee identified a decreased number of pits exceeding the established thresholds since they began desludging and cleaning the torus each outage. The inspectors determined that the licensee tracked future sludge removal activities with Condition Reports LO 2010-0259-005 and LO 2010-0259-006.

During this inspection, the inspector determined that the licensee modified this commitment to specify

> "NPPD will remove sludge and inspect the wetted portion of the torus every refueling outage from now until the end of the period of extended operation."

Specifically, the licensee implemented cleaning and inspection each 2-year outage of the wetted portions of the pressure suppression chamber. The inspector reviewed the inspection reports for the cleaning and inspection activities performed in 2014 and 2016. The inspector determined that the amount of sludge being removed had decreased significantly from approximately 2000-3000 pounds to a little more than 500 pounds for the most recent inspections, as listed in Table 1, "Amount of Sludge Removed."

Table 1, Amount of Sludge Removed

Outage	Year	Filter Weight (lbs)
RE22	2005	1964
RE24	2008	3120
RE26	2011	493
RE27	2012	510
RE28	2014	540
RE29	2016	530

The inspector determined that the water clarity continued to improve and the number of identified pits exceeding acceptance criteria had continued to decrease. The inspector determined that the periodic maintenance and monitoring provided an appropriate method and frequency that significantly decreased the amount of sludge accumulation. The inspector determined that the need to recoat the torus related to managing aging effects and preventing leakage from occurring in the torus as specified in the original commitment and accepted by the safety evaluation report was not needed so long as the licensee continued to periodically clean (remove sludge) and inspect the torus.

The licensee initiated actions to revise their commitment to clean and internally inspect the torus every four years because the amount of sludge being removed had stabilized, as well as the general corrosion of the torus internals had remained constant (refer to the Commitment 35 discussion below). The licensee established an ultrasonic testing grid on the exterior of their torus at the test patches to enable them to monitor the condition of the inspection plates and evaluate corrosion of the torus without entering the containment. The inspector determined that the licensee initiated actions to inspect the

test patches each outage. The licensee assigned the test patches containment inservice inspection identification numbers that will allow them to schedule and track the ultrasonic tests.

Because of their decision to decrease the frequency of their cleaning and inspection activities for the internal of the torus from two to four years, the inspector requested that personnel in the Division of Engineering in the Office of Nuclear Reactor Regulation assist in the review of the licensee's basis. The reviewer independently evaluated a corrosion rate based upon the licensee's data and determined that the licensee had established a conservative corrosion rate. The licensee described that they would initiate corrective actions if their exterior evaluation identified indications of deep pitting or the corrosion rate deviated significantly from what they predicted.

Based on review of the actions implemented related to Commitment 34, the inspector determined the licensee had met Commitment 34. The licensee established a program to periodically monitor and maintain the effects of aging of the wetted portions of their torus. This included (1) inspecting the test patches each refueling outage to allow for trending and (2) cleaning and inspecting the interior of the torus every four years. This commitment is closed.

Commitment 35

Commitment 35 specified:

> "NPPD will complete an analysis following each torus inspection that demonstrates that the projected pitting of the torus up to the time that the torus is recoated, will not result in reduction of torus wall thickness below minimum acceptable values."

During the previous inspection the inspectors reviewed calculations and inspection reports to assess the corrosion rate and actions taken by the licensee. The licensee calculated that the torus corroded between 1-2 mils per year since the previous inspection in 2011. The licensee determined that they could have up to 16 mils per year corrosion and still monitor/inspect the torus every 2 years through 2020.

During this inspection, the inspector determined that the licensee modified this commitment to specify:

> "NPPD will complete an analysis following each torus inspection that demonstrates that the projected pitting of the torus up to the next inspection interval, will not result in reduction of torus wall thickness below minimum acceptable values."

The inspector reviewed Calculation NEDC 94-214, "Evaluation of Torus Shell Corrosion and the Impact to Structural Integrity of the Torus," Revision 9, to determine the change in the general corrosion rate in the torus based upon the actual inspection data from the reference plates in Bays 6 and 9. Based upon corrosion rates, the licensee determined the time until the torus wall would reach minimum acceptable thickness according to their design calculation and the ASME code. The licensee also used this calculation to

verify that the torus wall has sufficient material such that operation could continue until the next outage without risk of structural failure. This revision was based upon the data obtained during Refueling Outage RE29 in 2016. The licensee calculated that the torus corroded approximately 4.67 mils per year for Bay 6 and 2.62 mils per year for Bay 9. The licensee assumed 16 mils/year corrosion rate to reach the minimum thickness of 31.25 mils in two years or 8 mils/year corrosion rate to reach the minimum thickness of 31.25 mils in four years.

The inspector verified that this calculation demonstrated significant margin existed in the torus shell thickness. The amount of margin allowed the licensee to use preventive measures (cleaning and inspecting) to manage the effects of aging. Because of their intention to decrease the frequency of their cleaning and inspection activities for the internal of the torus, the inspector requested that personnel in the Division of Engineering in the Office of Nuclear Reactor Regulation assist in the review of the licensee's basis. The reviewer independently evaluated a corrosion rate based upon the licensee's data and determined that the licensee had established a conservative corrosion rate. The licensee described that they would initiate corrective actions if their exterior evaluation identified indications of deep pitting or the corrosion rate deviated significantly from what they predicted.

From review of the data, the inspector verified that cleaning and inspecting (i.e., monitoring and maintaining) had demonstrated that the effects of aging could be managed. The inspector identified no concerns with the planned actions because (1) NRC independently confirmed the predicted corrosion rate; (2) the corrosion rate had remained constant; (3) the planned inspections would occur prior to the first action level; and (4) the licensee established additional monitoring from the exterior of the torus.

Based on review of the actions implemented related to Commitment 35, the inspector determined the licensee had met this commitments and had developed a method that would ensure wastage of the wetted portion of their torus would not exceed the minimum thickness between internal inspections. This commitment is closed.

3. <u>B.1.20 Assessment of Cast Austenitic Stainless Steel Components - Commitment 41</u>

This aging management commitment related to verifying the condition of the main steam and reactor recirculation nozzles because they contained cast austenitic stainless steel.

During the last inspection, the inspectors determined that one of six criteria addressed in Calculation 13-012, "Flaw Tolerance Evaluation for Reactor Recirculation Flow Element," Revision 0, discussed the amount of ferrite contained in the main steam and reactor recirculation nozzles. The inspectors recognized that the amount of ferrite discussed in Calculation 13-012 had a similar basis as the cast austenitic stainless steel components discussed in Commitment 29 and addressed by BWRVIP-234. Consequently, the inspectors determined that the licensee had inappropriately excluded these flow nozzles from being visually or volumetrically examined. Consequently, the licensee initiated a new commitment that specified:

> "NPPD will confirm that the reactor recirculation and main steam line flow restrictor CASS materials are either: (a) not greater than 25 percent

ferrite, (b) will perform a flaw tolerance evaluation, or (c) will perform a qualified visual or volumetric examination. This will be completed within 3 years after entering the period of extended operation."

During this inspection, the inspector determined that the licensee had performed evaluations that demonstrated that one of the reactor recirculation nozzles exceeded 20 percent ferrite. The inspector reviewed the flaw tolerance evaluation and the licensee's evaluation related to meeting the conditions in BWRVIP-234. In addition, the inspector consulted with a materials engineer in the Office of Nuclear Reactor Regulation, Division of Engineering. For the reactor recirculation flow element that exceeded the ferrite content, the inspector determined that the flow element would not experience significant degradation because the: (1) neutron fluence would remain less than 1.0×10^{17} n/cm^2; (2) maximum tensile stress did not exceed 5 ksi; and (3) material fracture toughness exceeded the value considered to cause significant degradation.

Based on review of the actions implemented related to Commitment 41, the inspector determined the licensee had met Commitment 41. Further, the licensee effectively evaluated the potential degradation of their reactor recirculation nozzle that could have been subject to loss of fracture toughness caused by the combined effects of thermal and irradiation embrittlement. This commitment is closed.

4OA6 Meetings, Including Exit

The inspector presented the inspection results on November 2, 2017, to Mr. J. Dent, Vice President Nuclear and Chief Nuclear Officer and other members of the licensee staff. The licensee acknowledged the NRC inspection observations. The inspector retained no proprietary information and verified that no proprietary information was documented in this report.

SUPPLEMENTAL INFORMATION

KEY POINTS OF CONTACT

Licensee

T. Barker, Manager, Engineering Programs and Components
L. Bray, Licensing Specialist
D. Buman, Director, Nuclear Safety Assurance
J. Dent, Vice President Nuclear and Chief Nuclear Officer
K. Dia, Director, Engineering
J. Jackson, Civil Design Engineer
T. McClure, ISI Programs Engineer
J. Shaw, Licensing Manager

NRC

A. Prinaris, Structural Engineer, Office of Nuclear Reactor Regulation
P. Purtscher, Senior Materials Engineer, Office of Nuclear Regulatory Research

COMMITMENTS

The inspector closed Commitments 29, 33, 34, 35 and 41 in this inspection report.

Commitments previously closed include:

NRC closed Commitments 4, 26, 27, and 28 in Inspection Report 05000298/2012008.

NRC closed Commitments 1, 2, 3, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 30, 31, 32, 36, 37, 38, 39, and 40 in Inspection Report 05000298/2013008.

DOCUMENTS REVIEWED

Condition Reports (CR-CNS-)

LO 2010-059-006
LO 2010-059-010

Calculations

Number	Title	Revision/Date
13-012	Flaw Tolerance Reactor Recirculation Flow Element	April 24, 2013
NEDC 94-214	Evaluation of Torus Shell Corrosion and the Impact to Structural Integrity of the Torus	7, 8 and 9
NPP-FLU-004-R-001	Cooper Nuclear Station Fluence Evaluation Update at EOC 28	0

Calculations

Number	Title	Revision/Date
NPP-FLU-004-R-002	Cooper Nuclear Station Vessel Internal CASS Fluence Evaluation	0

Letters

Number	Title	Date
	Summary of the July 15, 2014, Meeting with the Electric Power Research Institute on Items Related to Cast Austenitic Stainless Steel and the Materials Reliability Program -227-"A Pressurized Water Reactor Internals Inspection and Evaluation Guidelines	September 9, 2014
BWRVIP 2015-025	Project No. 704 – Summary of Industry Position on Screening Criteria for Thermal and Irradiation Embrittlement for PWR and BWR Reactor Internals Fabricated of Cast Austenitic Stainless Steel	March 9, 2015
NLS2015083	Rescission of License Renewal Commitment to Recoat the Torus	September 29, 2015
	Cooper Nuclear Station – Acknowledgement of Regulatory Commitment Change Regarding the Torus Recoating	November 5, 2015

Miscellaneous Documents

Number	Title	Revision/Date
	Final Safety Evaluation of the BWRVIP-234: Thermal Aging and Neutron Embrittlement Evaluation of Cast Austenitic Stainless Steel for BWR Internals (TAC No. ME5060)	June 22, 2016
	Cooper Nuclear Station Fourth Ten-year Interval Inservice Inspection Program and Second Ten-year Interval Containment Inservice Inspection Program	2.1
	Cooper Nuclear Station Fifth Ten-year Interval Inservice Inspection Program and Third Ten-year Interval Containment Inservice Inspection Program	0

Miscellaneous Documents

Number	Title	Revision/Date
	Cooper Nuclear Station Vessel Internals Program	20.6
Engineering Report ER 2014-05	Corrosion Evaluation of Cooper Nuclear Station Mark 1 Torus	0
Engineering Report ER 2017-03	Review of Transware RPV Fluence Evaluation and Internal CASS Fluence Evaluations per NPP-FLU-004-R-001 and-002, Revision 0	0
Final Engineering Report NUC2012108	Reactor Torus Filtration and Desludging, IWE Examination, Coating and Corrosion Inspection and Coating Repair	0
Final Engineering Report NUC2014106	Reactor Torus Desludging, IWE Examination, Coating Inspection and Coating Repair	0
LO-2013-0555-001	LICLO: NLS2013100, New License Renewal Commitment (Commitment NLS2013100-01): Confirm that the reactor recirculation and main steam line flow restrictor CASS materials are either not greater than 25 percent ferrite, or will perform a flaw tolerance evaluation, or will perform a qualified visual or volumetric examination.	
NUREG 1944	Safety Evaluation Report Related to the License Renewal of Cooper Nuclear Station	October 2010
USAR Change Request 2014-019	Revise Updated Safety Analysis Report, Section V-2.3.3.2 to reflect the conclusions of Engineering Report 2014-05	April 2015

COOPER NUCLEAR STATION – NRC POST-APPROVAL LICENSE RENEWAL INSPECTION REPORT 05000298/2017008 DATED NOVEMBER 22, 2017

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■ SUNSI Review By: GAP/rdr		ADAMS ■ Yes ☐ No	■ Publicly Available ☐ Non-Publicly Available		■ Non-Sensitive ☐ Sensitive	Keyword: NRC-002
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