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

April 25, 2016

Mr. Shane M. Marik
Site Vice President and Chief Nuclear Officer
Omaha Public Power District
Fort Calhoun Station
9610 Power Lane, Mail Stop FC-2-4
Blair, NE 68008

SUBJECT: FORT CALHOUN STATION, UNIT NO. 1 – REQUEST FOR ADDITIONAL INFORMATION RE: REVISE CURRENT LICENSING BASIS TO USE AMERICAN CONCRETE INSTITUTE ULTIMATE STRENGTH REQUIREMENTS (CAC NO. MF6676)

Dear Mr. Marik:

By letter dated August 31, 2015, as superseded by letter dated December 23, 2015 (Agencywide Documents Access and Management System (ADAMS) Accession Nos. ML15243A167 and ML15363A042, respectively), Omaha Public Power District submitted a license amendment request to revise the current licensing basis to use American Concrete Institute (ACI) ultimate strength requirements at Fort Calhoun Station, Unit No. 1.

The U.S. Nuclear Regulatory Commission staff has reviewed the information provided in your application and determined that additional information is required in order to complete its formal review of your request. The enclosed questions were provided to E. Matzke of your staff on April 13, 2016, and discussed with E. Matzke, S. Queen, et al., of your staff in a telecon on April 22, 2016. Please provide a response to the enclosed questions within 45 days of the date of this letter. If you have any questions, please contact me at 301-415-2296 or via e-mail at Fred.Lyon@nrc.gov.

Sincerely,

CFLyon

Carl F. Lyon, Project Manager
Plant Licensing Branch IV-1
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket No. 50-285

Enclosure:
Request for Additional Information

cc w/encl: Distribution via Listserv

REQUEST FOR ADDITIONAL INFORMATION

LICENSE AMENDMENT REQUEST

OMAHA PUBLIC POWER DISTRICT

FORT CALHOUN STATION, UNIT NO. 1

DOCKET NO. 50-285

By letter dated August 31, 2015, as superseded by letter dated December 23, 2015 (Agencywide Documents Access and Management System (ADAMS) Accession Nos. ML15243A167 and ML15363A042, respectively), Omaha Public Power District submitted a license amendment request (LAR) to revise the current licensing basis to use American Concrete Institute (ACI) ultimate strength requirements at Fort Calhoun Station, Unit No. 1 (FCS). The LAR intends to revise the FCS Updated Safety Analysis Report (USAR) to change the structural design methodology for Class I structures at FCS with several exceptions. The exceptions are the containment structure (cylinder, dome, and base mat), the spent fuel pool, and the foundation mats. No change to the current licensing basis code of record is proposed for these structures.

The U.S. Nuclear Regulatory Commission (NRC) staff has reviewed the information provided in the application and determined that additional information is required in order to complete its formal review of the request.

RAI-1 Item 1 of the proposed changes in the LAR requests to replace the working stress design (WSD) method with the ultimate strength design (USD) method for normal operating/service loading conditions. The LAR proposes to apply this change to new designs or re-evaluations of existing Class I structures at FCS other than the containment structure, the spent fuel pool, and the foundation mats for all Class I structures.

a. The proposed load combinations do not include operating thermal load and operating piping/equipment reaction loads. Please provide justification for excluding these relevant design load conditions considering the requirements of the FCS licensing basis Code of record ACI 318-63, "Building Code Requirements for Reinforced Concrete," the ACI 349-97, "Code Requirements for Nuclear Safety Related Concrete Structures" (Reference 6.11 in the LAR), the guidance in Regulatory Guide (RG) 1.142, Revision 2, "Safety-Related Concrete Structures for Nuclear Power Plants (Other than Reactor Vessels and Containments)" (Reference 6.22 in the LAR), and NUREG-0800, Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants: LWR Edition" (SRP) Section 3.8.4, "Other Seismic Category I Structures" (Reference 6.12 in the LAR).

Enclosure

RAI-2 Footnote 4 in Section 2.1 of the LAR states the following: "Soil dynamic pressure and hydrodynamic pressure loading shall be accounted, where applicable in accordance with the current licensing basis."

a. Considering soil dynamic pressure and hydrodynamic pressure loadings in the design of soil/water retaining structural components has been an established design practice. As such, they should be considered for the design of new Class I structures and the evaluation of existing FCS Class I structures to maintain consistency with the proposed changes in this LAR. Thus, using the term "current licensing basis" appears redundant and unclear in the context of footnote 4 and in the context of this LAR which requests to change the current licensing basis.

   i. Please discuss the intent of the term "current licensing basis" in the context of this LAR and footnote 4.

   ii. Please confirm that soil dynamic pressure and hydrodynamic pressure loadings were considered in the original design of the FCS Class I structures.

   iii. The mark-up of the USAR, Section 5.11 does not include a statement relative to consideration of soil dynamic pressure and hydrodynamic pressure loadings. Please discuss the reason for excluding this relevant information from the USAR mark-up.

RAI-3 Item 3 of the proposed changes in this LAR requests to use higher reinforcing steel yield strength values for the containment internal structure (CIS) that includes the reactor cavity and compartment (RC&C) walls and the CIS beams, slabs, and columns.

Section 3.3 of the LAR references DIT-SA-13-005, "Use of Higher Reinforcement Yield Strength for Operability Calculations," and states that

> Quality records show that there were 115 heat code samples used in the construction of the CIS. Some of the heat code yield stress values could not be identified and 105 of the 115 samples are known. Based on 105 samples specifically used for CIS, the 95% confidence level is equal to 44.45 ksi. As a result, the current design steel yield strength (i.e. 40 ksi) is increased to 44 ksi with high confidence for the RC&C and for CIS.

In addition, Section 2.10 of the LAR states that the FCS quality program during plant construction contained detailed procedures for controlling installation of reinforcing steel bars and included signoffs for each delivery, reinforcing steel test data, and the location where the steel reinforcement was placed in the Class I structures.

a. Please provide statistical analysis information, including mean, standard deviation and coefficient of variation for each individual bar size on a heat-by-heat basis, as well as for all bar sizes (entire 105 samples population).

The response should demonstrate random sampling plan was implemented, traceability of the bars to their respective heats, and traceability to the location where the reinforcing steel bars were placed in the RC&C and the CIS beams, slabs, and columns.

b. Considering the design deficiencies of CIS beams (shear and/or flexure interaction ratios greater than one), as summarized in Table 8 of the LAR, please provide justification for proposing to use the yield strength associated with the 95 percent confidence level for the entire 105 samples of reinforcing steel population rather than using 95 percent confidence level for individual bar size(s) corresponding to the shear and flexural reinforcing steel bars.

RAI-4 Items 2 and 3 of the proposed changes in this LAR requests to use higher concrete compressive strength and higher reinforcing steel yield strength values using analysis of historical test data for a limited number and specific areas of Class I structures. The language in the new Sections 5.11.3.8, "Concrete Compressive Strength," and 5.11.3.9, "Steel Reinforcing Capacity," included in the USAR mark-up in the LAR, gives an appearance that using analysis of historical test data as described in Sections 5.2.6 and 5.2.2.1 could be generically used for the FCS. In addition, these new sections appear to be redundant because Sections 5.2.6 and 5.2.2.1 of the LAR already describe the proposed changes.

a. Please clarify the language and discuss the intent of new Sections 5.11.3.8 and 5.11.3.9 included in the USAR mark-up.

b. The term "capacity" in the title of Section 5.11.3.9 and the term "steel reinforcing capacity allowable stress" in the proposed language of Section 5.11.3.9 are not consistent with the request in the LAR which relates to "reinforcing steel yield strength." Please clarify.

RAI-5 Item 3 of the proposed changes in this LAR requests to use higher concrete compressive strength (f'c) determined based on cylinder break test data for the Auxiliary building (above Elevation 1007) and the CIS. The containment structure, intake structure, spent fuel pool, reactor cavity floor, and concrete around the reactor vessel will continue to use the f'c currently specified in the design basis documents.

a. Measured strengths of laboratory cured cylinders may be significantly different from the in-place strengths because it is difficult, and often impossible, to have identical bleeding, consolidation, and curing conditions for concrete in laboratory-cured cylinders and concrete in structures. In addition, the properties of concrete may vary with elevation due to differences in placing and consolidation procedures, segregation, and bleeding. The ACI 318-63 (FCS Code of record), Section 504(a) indicates that additional test specimens cured

entirely under field conditions may be required by the Building Official to check the adequacy of curing and protection of concrete.

i. Please provide cylinder break test data for the Auxiliary building and the CIS for specimens cured under field conditions during the original construction of the FCS, if available.

ii. Considering the variabilities noted above, please provide a discussion to justify the request regarding the use of cylinder break test data of laboratory-controlled samples alone without performing an in-situ field test to establish a valid correlation between the statistical evaluation and the as-built concrete strength.

b. Please provide ACI 318-63, Section 504(c) strength test data analysis, and the 95 percent confidence level statistical analysis information. The response should demonstrate that random sampling plan was implemented, and traceability of the samples to their respective structure and the location where the concrete was placed.

RAI-6 Please provide a discussion and a sample of quantitative data regarding reconciliation of bond and reinforcing steel anchorage requirements of ACI 318-63, when using higher concrete compressive strength, against the as-installed shear and flexural reinforcing steel arrangement.

RAI-7 The footnote for Table 7 of the LAR indicates that the application of actual concrete compressive strength in lieu of the original specified design values is not allowed where structures undergo prolonged exposure to high radiation, excessive moisture, or harsh chemicals. Table 7 of the LAR indicates that the increased compressive strength of concrete will not be used for reactor cavity floor and concrete around the reactor vessel.

a. Please provide a discussion and the rationale for requesting to allow increased compressive strength for the reactor cavity walls and other compartment walls relative to the footnote for Table 7.

RAI-8 According to Section 2.7 of the LAR, it is the NRC staff's understanding that (1) FCS currently inspects the Auxiliary building per procedures SE-PM-AE-1001, Auxiliary Building Structural Inspection, and the CIS in accordance with procedure SE-PM-AE-1004, Containment Building Structural Inspection; (2) each procedure has an inspection frequency of 3 years with caveats to increase or decrease the frequency as accumulated inspection findings warrant, but shall not exceed 5 years; and (3) a review of the results from recent inspections did not identify any significant structural deterioration that would invalidate the use of the current licensing basis or proposed licensing basis items requested by this LAR.

Considering the brevity of the above statements in the LAR:

a. Please provide a general description of the FCS inspection program for the Auxiliary building and the CIS. The response should, as a minimum, identify and discuss the industry standard(s) used to develop the FCS inspection procedures, current inspection frequency, the scope and the method of inspection, and the criteria used for classification of inspection findings.

b. Please discuss the highlights of findings of the last three inspections of the Auxiliary building and the CIS, and any corrective actions taken to disposition them.

c. Please discuss the definition of "significant structural deterioration" noted in Section 2.7 of the LAR. Also, discuss the threshold where an inspection finding (crack, etc.) will be designated as "significant structural deterioration".

RAI-9 Section 2.0 of the LAR states that in 2012, two latent engineering errors were discovered during preparations for a planned extended power uprate of FCS and a detailed extent of condition concluded that several concrete beams in the CIS do not meet the current design basis. In addition, Section 2.8 (Table 8) of the LAR provides summary of analysis results for CIS beams. The LAR does not discuss the operating experience that prompted for structural re-evaluation of intake structure, Auxiliary building, and the RC&C walls.

a. Please provide a discussion regarding the operating experience (design deficiencies, etc.) that prompted the RC&C structural re-evaluation and the proposed request to use the limit state design method.

b. Please provide a discussion regarding the operating experience (design deficiencies, etc.) that prompted the intake structure and Auxiliary building structural re-evaluation and the proposed requests in the LAR.

RAI-10 Item 4 of the proposed changes in this LAR requests to use the limit state design method for evaluating the RC&C walls, including the use of dynamic increase factors (DIF) for impulsive loads, according to equations in commentary of Appendix C of ACI 349-97.

Section 2.9 of the LAR attempts to perform a gap analysis of ACI 318-63 (FCS Code of record) to ACI 349-97. Section 2.9.4 of the LAR states the following: "Based on the comparison of ACI 349-97 Code and the dissimilarities to ACI 318-63 it has been determined that use of DIF as described in ACI 349-97 and RG 1.142 would be advantageous for re-evaluation of the RC&C. Use of the USD methodology is adequate to evaluate the RC&C."

Section 3.4 of the LAR states the following:

> The request to allow the inclusion of the Limit Design Method is required because there is no equivalent method in the ACI 318-63 Code. The

original design of the reactor cavity and compartment walls (RC&C walls) was based on the limit state of the reinforced concrete structure. Design forces and moments at the limit state, which were used to determine sizes and placements of reinforcing bars (rebar), cannot be replicated by any form of linear finite element analysis, herein called the Linear Design Method. They can only be computed by using non-linear (or step-wise linear) finite element analysis, herein called the Limit Design Method. While the Limit Design Method is able to reasonably reproduce the original design forces and moments at the limit state by simulating load redistribution behavior, the Linear Design Method is not.

Please provide further clarification on the following items:

a. Contrary to Section 3.4 of the LAR where it is requested to allow the use of the limit design methodology, the conclusion of Section 2.9 of the LAR states that the use of the USD methodology is adequate to evaluate the RC&C. Please clarify.

b. Section 3.4 of the LAR states that when the limit design method is applied, where flexure controls design of the RC&C walls, rotations of the walls in any yield zone must be less than the rotational capacity of the zone, as expressed by Equations 3.4.1 and 3.4.2 in Section C.3.4 of ACI 349R-97, Appendix C (ACI 349-97 Commentary).

   The NRC staff notes that the premise of using the provisions of the ACI 349, Appendix C and the limit state design methodology hinges upon the member ductility at critical section(s) and consideration of limited plastic hinge rotation.

   i. Please provide information related to ductility of the RC&C walls and reconciliation of reinforcing steel detailing requirements of ACI 349-97.

   ii. The LAR does not discuss/justify an appropriate acceptance criterion/limit for the rotational capacity of yield (plastic) hinge. Please clarify.

   iii. Partial adoption of a more up-to-date code (ACI 349) is not consistent with the industry practice. Please provide justification.

c. It is the NRC staff's understanding that finite element analysis is used for the RC&C walls structural re-evaluation. Please provide a discussion relative to the application of the limit state design methodology as it relates to the RC&C walls and the applicable load combinations. The response should, as a minimum, include the description of (1) RC&C finite element model/analysis (element type, stress-strain relationship of concrete and reinforcing steel, type of nonlinearity associated with the RC&C wall analysis, incremental and iterative procedures used in the analysis, computer software, benchmarking and model validation, etc.); and (2) how the transverse shear forces and twisting moments, in addition to bending moments, are taken into account.

d. Please provide the pertinent RC&C force/moment demand versus capacity for individual load cases (e.g., seismic loads, compartmental pressurization) prior and subsequent to the application of limit state design methodology and identify critical load combinations and the areas of high demand.

e. The inelastic deformation/rotational capability of RC&C walls, adequate shear resistance in critical sections, and adequate reinforcement anchorage length to support the use of limit state design methodology have not been discussed in the LAR. Please provide a discussion with quantitative data related to these items.

f. Considering the statement in Section 3.4 of the LAR, it is the NRC staff's understanding that the request to use limit state design methodology is being proposed for all load combinations applicable to the RC&C walls including the normal/service load combinations. The ACI 349 Code and NRC staff guidance (SRP Section 3.8.3, "Concrete and Steel Internal Structures of Steel or Concrete Containments," and Section 3.8.4), referenced in this LAR, require elastic design for service load and seismic load conditions. Therefore, the request to use limit state design methodology for all load combinations has not been technically justified in this LAR. Please provide further information to demonstrate that this request is consistent with the industry codes/standards and the NRC staff regulatory guidance.

g. Considering the methodology of limit state design and formation of plastic hinge:

   i. Please discuss the effects of change in stiffness on the dynamic characteristics of the RC&C walls, which may affect (1) the level of accelerations induced in the RC&C structure due to seismic loading; and (2) the structural response of the RC&C walls to the impulse loading due to compartmental pressurization.

   ii. Please justify that the additional deformation/rotation, crack formation, and stiffness degradation of the RC&C wall structure, resulting from such an analysis approach, does not adversely affect those safety-related structures, systems, or components adjacent to or supported from the RC&C walls, including the component support anchorages.

RAI-11 According to RG 1.142 (Reference 6.22 in the LAR), Regulatory Position 10.6, increase in the material strength (i.e., DIF) could be realized only when the material is subjected to very high strain rates of loading, normally associated with impactive/ impulsive loadings. Section 3.4 of the LAR is not clear relative to the application of DIF to various load combinations. Please clarify.

RAI-12 Section 2.9.2 of the LAR states that special seismic requirements for steel reinforcing detailing of ACI 349-97, Chapter 21 adds special detailing provisions for seismic that are not related to impactive or impulsive conditions.

Section 21.2.1.1 of ACI 349-97 states that the reinforcing bar detailing requirements of Chapter 21 shall be the design practice for nuclear plants within the purview of this code. In addition, the ACI 349-97 Commentary (Section R21.2) provides a discussion regarding the intent of Chapter 21.

Considering the above, the NRC staff does not consider the statement in Section 2.9.2 of the LAR consistent with the intent of ACI 349 Code. Please provide further clarification regarding the statement in Section 2.9.2 of the LAR.

RAI-13 The mark-up of the USAR, Section 5.11 indicates changes to Section 5.11.3.2, "Operating Basis Load Combinations for Class I Steel Structures," and Section 5.11.3.3, "Design Basis Load Combinations for Class I Steel Structures." The scope of the LAR is related to concrete structures and the proposed changes to Section 5.11.3.2 and Section 5.11.3.3 are not discussed in the LAR. These changes are considered outside the scope of the submitted LAR and will not be reviewed. Please discuss and clarify this inconsistency in the LAR submittal.

RAI-14 The mark-up of the USAR, Section 5.11.3.6 indicates that the use of DIF for RC&C comply with ACI 349-97, Appendix C. RG 1.142 has not been incorporated in this mark-up as discussed in the LAR. Please clarify.

April 25, 2016

Mr. Shane M. Marik
Site Vice President and Chief Nuclear Officer
Omaha Public Power District
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9610 Power Lane, Mail Stop FC-2-4
Blair, NE 68008

SUBJECT: FORT CALHOUN STATION, UNIT NO. 1 – REQUEST FOR ADDITIONAL INFORMATION RE: REVISE CURRENT LICENSING BASIS TO USE AMERICAN CONCRETE INSTITUTE ULTIMATE STRENGTH REQUIREMENTS (CAC NO. MF6676)

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Sincerely,
/RA/
Carl F. Lyon, Project Manager
Plant Licensing Branch IV-1
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Docket No. 50-285

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Request for Additional Information

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ADAMS Accession No. ML16104A287 *email dated **Previously concurred

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