December 12, 2001

MEMORANDUM TO: Ledyard B. Marsh, Acting Deputy Director
Division of Licensing Project Management
Office of Nuclear Reactor Regulation

FROM: Geoffrey E. Grant, Director
Division of Reactor Projects

SUBJECT: TASK INTERFACE AGREEMENT (TIA 2001-15)
EVALUATION OF D.C. COOK CONTAINMENT STRUCTURE
CONFORMANCE TO DESIGN BASIS REQUIREMENTS

References: See attached page

The Region and NRR staff have been involved in the assessment of D.C. Cook Unit 1 and 2 containment structural issues since March 2000. The operability of the D.C. Cook Unit 1 and 2 containment structures was reviewed by NRR staff as a part of the Manual Chapter 0350 process. Following the restart of both Units, the licensee continued to perform transient mass distribution (TMD) and structural calculations to determine conformance with the design basis. The licensee made a presentation to NRR staff on June 11, 2001, regarding their determination that containment structures met design basis requirements. However, during the meeting the licensee did not provide detailed information regarding calculation assumptions, and Unit 2 walkdowns to verify as built dimensions used in the calculations had not been completed. The licensee completed the walkdowns in September 2001, and finalized their calculations in late November 2001.

Region III requests that NRR verify that the D.C. Cook Unit 1 and 2 containment structures meet design basis requirements. Specifically, Region III requests that NRR review licensee TMD, and structural calculations to determine that the licensee utilized appropriate methodologies, assumptions, and inputs in determining that containment structures comply with design basis requirements.

Background

Containment Description

The D.C. Cook Unit 1 and 2 containments are reinforced concrete structures consisting of a vertical cylinder, hemispherical dome and a flat base. The interior is divided into three volumes; a lower volume which houses the reactor and reactor coolant system (RCS), an intermediate volume housing the energy absorbing ice bed in which steam is condensed, and an upper volume which accommodates the air displaced from the other two volumes during a loss-of-coolant accident (LOCA).

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The condensation of steam in the ice bed limits the containment pressure to values substantially below those for a comparable dry-type containment under the same conditions. The containment vessel, including all its penetrations, is a low leakage steel shell designed to contain the radioactive material that may be released from the reactor core following a design basis LOCA. Additionally, the containment and shield building provide shielding from the fission products that may be present in the containment atmosphere following accident conditions.

The lower compartment is divided into a number of subcompartments formed by equipment and internal structures. The containment pressure responses within these subcompartments were analyzed by the licensee using the TMD computer code developed by Westinghouse. The code provides a means of computing pressures, temperatures, heat transfer rates, and mass transfer rates as a function of time and location throughout the containment.

Containment Structural Deficiencies

In early 1999, during the Expanded System Readiness Reviews the licensee identified that certain containment structural calculations could not be located and other calculations did not meet the current licensee standards for technical and/or administrative attributes. The licensee performed a revision to the Westinghouse Transient Mass Distribution (TMD) analysis; this analysis resulted in an increase in the predicted pressure loading on some structural components in the Unit 2 containment. Since the TMD analysis load changes impact a variety of containment structures, an extent of condition evaluation was performed by the licensee for Unit 1 containment and similar conditions were identified. The revised TMD analyses outputs were then reviewed to determine their impact on the structural evaluations. It was as a result of reviewing the TMD analysis outputs that licensee personnel identified design pressures impacting certain internal structures were inconsistent with design basis margins.

In March 2000, while making cosmetic repairs to Unit 2 containment walls the licensee identified that some concrete had been removed from the top of some of the lower containment subcompartment walls, also called Fan-Accumulator (F/A) Room walls. In addition, the licensee subsequently identified concerns regarding grout strength, cut rebar, rebar location, and rebar cover. Similar conditions were also identified in the Unit 1 containment. The licensee documented these issues in their corrective action program.

In May 2000, during an evaluation of concrete structures in the D.C. Cook Unit 2 containment, the licensee determined that a condition outside the design basis of the plant existed. Based upon simplified evaluations, some containment internal concrete subcompartment structural elements, specifically, certain walls and floors, did not meet the design pressure load factor margin of 1.5 as described in the D.C. Cook Unit 1 and 2 UFSAR. The simplified structural evaluations included the results of revised postulated pressure loads derived from the containment TMD analysis. As explained in the UFSAR, having a design pressure load factor margin of 1.5 means that these structures are expected to be able to withstand, without failure, a fifty percent increase in pressure load above the worst-case pressure postulated in an area.

Operability Containment Structures

The Manual Chapter 0350 panel designated the Unit 1 and Unit 2 containment structural deficiencies as issues which required review prior to the restart of the respective Unit. Specifically, Restart Action Matrix items 2.3, “Evaluate Licensee Corrective Actions for Containment Internal Structural Walls,” 8.1, “Reconstitution of Assumptions and Methodology for Transient Mass Distribution (TMD)” for Unit 1, and R.2.13.3, ”Operability of Degraded Unit 2 CEQ Fan Room Concrete Wall”, and R.3.17, “Changes in Input Assumptions and UFSAR for TMD Analysis”, for Unit 2, were initiated to track the inspection of these issues. The MC 0350 panel coordinated inspections and NRR staff reviews to assess the adequacy of licensee corrective actions, and to validate that the containment structures were operable prior to plant restart. In addition, several public meetings were held to discuss the status of licensee corrective actions associated with these issues.

Under the cognizance of the MC 0350 panel the operability of the Unit 1 and 2 containment structures was evaluated by NRC staff. The NRR staff reviewed the operability calculations for the affected containment structures with the following results.

In the operability evaluations, the licensee examined applicable Updated Final Safety Analysis Report (UFSAR) load combinations and determined that the combinations containing design basis accident (DBA) pressure loadings were governing. The licensee designated C = 1.5 P1 as the limiting load-factored design combination, where C is the capacity and P1 is the pressure due to main steamline break (MSLB). The licensee’s operability criterion was C > 1.0 P1, as the effects of dead load (DL) and thermal loading (T) associated with MSLB were very small. For the operability determinations, the NRR staff considered the licensee’s selection of the criterion, (i.e.), reasonable and acceptable when taken in context with the inherent conservatism in the TMD analysis. In each of the operability evaluations of containment structures for Units 1 and 2, the licensee concluded that the structures in question met the operability criterion, $C \geq 1.0P1$.

The NRR staff noted that for the Unit 1 ice condenser support slab the licensee used a concrete strength of 5220 psi based on 90-day strength. However, the NRR staff determined that an as-built strength of 4424 psi based on 28-days concrete cylinder strength data should have been utilized. Based upon information provided by the licensee, the NRR staff determined that the licensee had not provided adequate justification for the use of 5220 psi based on the 90-day concrete strength. Using the 28-days strength and without using the dynamic increase factor, the NRR staff verified during the independent audit that the safety margin was about 1.07 which was acceptable for the operability of Unit 1.

Regarding the Fan/Accumulator (F/A) walls in the Unit 1 and Unit 2 containments the NRR staff reviewed the condition of the degraded walls. The staff reviewed the results of licensee walkdowns which identified voids at the top of some of the walls, inadequate grout installation, and discrepancies in concrete cover and spacing of rebar. These discrepencies were indicative of non-conformance with the design-basis requirements. The NRR staff reviewed licensee calculations related to the operability of the F/A walls.

The NRR staff noted that because of discrepancies identified at the top of the walls, the licensee assumed that the connection of the affected F/A walls to the slab above was free in their operability calculations, even though the localized weak areas in the walls were excavated and regrouted with high strength grout. The top joints for the other unaffected F/A walls were considered pinned in the licensee's calculations, since these walls were built monolithic with the slab. The NRR staff concluded that the licensee's approximations to account for the degraded condition of the walls was reasonable and conservative for the operability of the F/A walls in the Unit 1 and Unit 2 containments.

The NRR staff noted that the licensee evaluated the adequacy of Unit 1 and 2 containment F/A walls using a 90-day concrete strength of 5262 psi, based on the concrete pour data. The NRR staff did not consider the use of 5262 psi concrete reasonable. However, the NRR staff evaluated the operability of the affected walls using the 28-day concrete strength of 4424 psi concrete and determined that this satisfied the criteria of $C \geq 1.0P1$.

The staff noted that the licensee had used the revised TMD analysis to develop the time history of the differential pressure resulting from a main steam line break (MSLB), which was applied to the walls as an impulsive load. The licensee developed a generic dynamic load factor (DLF) relationship corresponding to the natural period of vibration (T) of a structure, based on the applied time-history. The licensee had also utilized a dynamic increase factor (DIF) in determining the strength of materials as a result of the rapid strain rates associated with a dynamic load, using Appendix C of ACI 349. The NRR staff found the licensees use of DLF was consistent with current industry practice. However, considering the almost static response of the structure to the applied differential pressure load, the use of DIF, in this case, was not adequately justified by the licensee and, therefore, was not accepted by the NRR staff.

The NRR staff concluded the impact of the use of 5262 psi vs. 4424 psi concrete strength in the operability calculations for the most limiting F/A wall was not significant, and that eliminating the DIF did not appreciably change the load factor used for calculating the moment, but the load factor associated with the shear transfer calculations changed. Although the NRR staff took exception to the licensee's assumptions regarding concrete strength and the use of the DIF, the NRR staff determined that the Unit 1 and Unit 2 containment walls met the operability criteria of $C \geq 1.0P1$. As a result, the related MC 0350 restart action matrix items were closed.

Restoration of Containment Structures to Design Basis

On June 28, 2000, the licensee submitted Licensee Event Report (LER) 316/2000-003-00, "Containment Internal Concrete Structures Do Not Meet Design Load Margins." The LER contained two commitments:

1. A review of containment internal structures will be performed prior to Unit 1 startup to determine the extent of condition, repairs to structural elements will be made where applicable, and critical calculations will be reconstituted or evaluations performed to document operability of the Unit 1 structures.

2. The final course and schedule for long-term corrective and preventive actions to restore and maintain the design pressure load factors for the internal containment concrete structural elements in both units will be determined prior to Unit 1 startup.

In letters dated October 15, 2000, and May 9, 2001, the licensee communicated to the NRC the status of corrective actions related to demonstrating that Unit 1 and 2 containment structures could meet their design basis requirements. During the June 11, 2001, public meeting at Headquarters between the licensee and NRR management and staff, the licensee stated that D.C. Cook containment structures were in compliance with the design basis. The licensee based this conclusion on their extensive transient mass distribution calculations and structural analysis. The licensee stated that the methods used to reach their conclusions were consistent with licensed codes and methods; therefore, no licensing basis changes were needed. In addition, the licensee determined that no modifications were warranted since all design basis requirements were met. The only actions remaining after the June 11, 2001 meeting involved the validation by the licensee during the next refueling outage of Unit 2 containment parameters that were utilized in the transient mass distribution and structural calculations.

Since the June 11, 2001, meeting, the licensee has conducted walkdowns to confirm as-built Unit 2 containment parameters that were utilized in the TMD and structural calculations. The licensee stated that the results of the walkdown confirmed that the parameters utilized in the calculations were the same as, or conservative to, the values used in the calculations.

Action Requested

Due to the significant number of structural deficiencies and design basis non-conformances that had been identified at D.C. Cook in the past two years, Region III requests that NRR verify that the D.C. Cook Unit 1 and 2 containment structures have been restored to compliance with design basis requirements. Specifically, Region III requests that NRR review licensee transient mass distribution (TMD), and structural calculations to determine that the licensee utilized appropriate methodologies, assumptions, and inputs in determining that containment structures comply with design basis requirements. In particular the following design basis calculation attributes should be validated:

1) Concrete strength utilized in structural calculations

2) Reinforcing steel material strength used in structural calculations

3) Unit 2 design inputs that were obtained by the licensee subsequent to the June 11, 2001, meeting were consistent or conservative with respect to the values utilized in the TMD and structural calculations.

4) If utilized, was the use of a dynamic increase factor (DIF), adequately justified by the licensee.

5) If utilized, did the licensee properly apply yield line theory analysis in structural calculations.

6) The methodology and assumptions utilized by the licensee to perform transient mass distribution analysis and structural calculations was consistent with licensed code requirements.

This issue was discussed during a conference call on December 6, 2001, with the NRR Senior Project Manager and Regional Branch Chief.

Given the numerous discussions between NRR and Region III about this issue and its potential significance, Region Ill requests an expedited response.

cc: J. Dyer, RIII

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REFERENCES:

(1) Letter, Stang to Powers, dated June 12, 2000, Subject: Donald C. Cook - Summary of June 1, 2000, Public Meeting Regarding Containment Subcompartment Walls

(2) Letter, Rencheck to Document Control Desk, dated June 28, 2000, Subject: Operating License DPR-74, Docket No. 50-316

(3) Memo, Black to Grobe, dated June 9, 2000, Subject: Donald C. Cook Nuclear Plant, Unit 2 - Closeout of Restart Action Matrix Issues Dealing with Generic Letter 91-18 Operability Evaluations

(4) Letter, Stang to Powers, dated October 13, 2000, Subject: Donald C. Cook - Summary of September 27, 2000, Public Meeting Regarding Update on Containment Structures

(5) Letter, Rencheck to Document Control Desk, dated October 15, 2000, Subject: Donald C. Cook Nuclear Plant Units 1 and 2 Resolution of Containment Structural Issues

(6) Letter, Rencheck to Grant, dated November 18, 2000, Subject: Donald C. Cook Nuclear Plant Units 1 and 2 Resolution of Containment Structural Issues

(7) Memo, Stang to Grant, dated November 28, 2000, Subject: Donald C. Cook Nuclear Plant, Unit 1 - Closeout of Restart Action Matrix Issue 2.3/8.1 Dealing with Generic Letter 91-18 Operability Evaluations (TAC Nos. MB0286 and MB0287)

(8) Letter, Grant to Powers, dated February 21, 2001, Subject: Summary of the February 15, 2001, D.C. Cook Public Meetings

(9) Memo, Stang to Indiana Michigan Power Company, dated June 28, 2001, Subject: Donald C. Cook Nuclear Power Plant - Summary of June 11, 2001, Public Meeting Regarding Containment Structural Issues