October 6, 2003

MEMORANDUM TO: Anthony J. Mendiola, Chief
Project Directorate Section III-2
Division of Licensing Project Management

FROM: Kamal A. Manoly, Chief ***/RA/***
Civil and Engineering Mechanics Section
Mechanical and Civil Engineering Branch
Division of Engineering

SUBJECT: LICENSE AMENDMENT RELATED TO HEAVY LOADS HANDLING DRESDEN NUCLEAR POWER STATION, UNITS 2 AND 3

References:

1. Letter from K. R. Jury of Exelon to U. S. NRC, "Request for License Amendment Related to Heavy Loads Handling," dated February 26, 2003

2. Letter from U. S. NRC to J. L. Skolds of Exelon, "DNPS, Units 2 and 3 "Request for Additional Information Regarding Heavy Loads Handling Amendment Request," dated May 23, 2003

3. Letter from Exelon, "Dresden Nuclear Power Station Units 2 and 3" to USNRC - Additional information regarding request for license amendment related to load handling. Dated June 12, 2003

4. Letter from Exelon to NRC - Additional information regarding request for license amendment related to load handling - Dated September 11, 2003

By letter dated February 26, 2003, (Reference 1), Exelon Generation Company (EGC, the licensee) requested a license amendment for Dresden Nuclear Power Station (DNPS), Units 2 and 3. The purpose for the amendment request was to allow the licensee to move shield plugs weighing greater than 110 tons with the Unit 2/3 reactor building crane during power operation.

In Reference 2, the NRC staff requested additional information regarding the proposed change. By letters dated June 12 and September 11, 2003, (References 3 and 4) the licensee provided its response to the staff's questions. In addition, the licensee provided an addendum to the load drop analysis provided in Reference 1.

The Mechanical and Civil Engineering Branch (EMEB) has completed its review of the applicable areas, within EMEB's review responsibility, of the referenced submittals. Our safety evaluation is provided in the attachment.

Attachment: As stated

Contact: J. R. Rajan, EMEB 415-3306 Y. S. Kim, EMEB 415-2729

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SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION
RELATED TO AMENDMENT **NO. xxx** TO
FACILITY OPERATING LICENSE NOS. DPR-19 AND DPR-25
EXCELON GENERATION COMPANY
DRESDEN NUCLEAR POWER STATION
DOCKET NOS. 50-237 AND 50-249

1.0 INTRODUCTION

By letter dated February 26, 2003, (Reference 1), Exelon Generation Company (EGC, the licensee) requested a license amendment for Dresden Nuclear Power Station (DNPS), Units 2 and 3. The purpose for the amendment request was to allow the licensee to move shield plugs (or blocks) weighing greater than 110 tons with the Unit 2/3 reactor building crane during power operation.

In Reference 2, the NRC staff requested additional information regarding the proposed change. By letters dated June 12 and September 11, 2003, (References 3 and 4) the licensee provided its response to the staff's questions. In addition, the licensee provided an addendum to the load drop analysis in which the lifting of the shield plugs was restricted to a height of one foot.

2.0 REGULATORY EVALUATION

The reactor building overhead crane meets the single-failure criteria stated in NUREG-0612 for heavy loads of 110 tons. The NRC has approved the use of the reactor building overhead crane during power operations to lift a total load up to 116 tons for removal and installation activities for the reactor shield plugs prior to and during Unit 3 refueling outage D3R17.

Section 9.1.5, "Overhead Heavy Load Handling Systems," of NUREG-0800, "NRC Standard Review Plan," references the guidelines of NUREG-0612, "Control of Heavy Loads at Nuclear Power Plants," and NUREG-0554, "Single-Failure-Proof Cranes for Nuclear Power Plants," for implementation of these criteria in the design of overhead heavy load handling systems.

In order to meet the single-failure-proof requirements of NUREG-0544 and the guidelines of NUREG-0612, the licensee has utilized design acceptance criteria consistent with DNPS Safety Analysis Report (SAR). Standards and guides which have been used for determining allowable stress limits and other acceptance criteria are consistent with industry practice and have previously been accepted by the staff for similar applications.

NUREG-0612, Sections 5.1.4 (2) and 5.1.5 (1) (c), requires that a load drop analysis should conform to the guidelines of Appendix A of NUREG-0612, if the crane is not Single Failure Proof (for the specific load movement). The licensee stated that the guidelines in Appendix A of NUREG-0612 will be followed as applicable to the present load drop analysis.

Reference 5 provides general guidelines and formulations for the evaluation of impactive and impulsive loads. Reference 8 provides ductility requirements for reinforced concrete structures. Reference 10 provides structural design criteria for DNPS.

ATTACHMENT

3.0 TECHNICAL EVALUATION OF STRUCTURAL IMPACTS

A load drop analysis has been performed in Reference 11 for handling the top layer of the Units 2 and 3 reactor cavity shield plugs weighing up to 116 tons for the designated safe load path. The analytical results demonstrate that a postulated load drop will not affect any safety-related equipment since there will be no scabbing or perforation of the refueling floor, and the overall response of the floor system will be acceptable. Extension of the methodology is not approved for application of other heavy loads or load paths.

The load drop analysis used the following key assumptions and methods:

- The weight of the dropped top half-layer reactor cavity shield plug is considered to be 116 tons, including the slings and other rigging used to lift the cavity shield plug, and excluding the weight of the crane load block. The maximum drop height for the 116 ton shield plug is assumed to be 1' - 0" above the floor.

- The overall adequacy of the impacted structural elements is determined by calculating the total strain energy in the impacted elements corresponding to an allowable ductility limit, and comparing this energy to the impact energy imparted to the impacted elements.

- The kinetic energy of the reactor cavity shield block at impact is conservatively assumed to be transferred entirely to the impacted structural elements.

- The energy absorption of the impacted elements is calculated using constructed elasto-plastic load-deflection diagrams of the structural elements. The ductility limit is determined using Reference 8, Appendix C, Section C.3, and the area under the load-deflection diagram up to the applicable ductility limit is used as the measure of the energy absorption capacity of the elements.

- The shear failure load is estimated using Reference 9. The shear failure load is at least 1.20 times the flexural resistance load in order to use the flexural mode of failure to calculate the strain energy. Otherwise, the ductility ratios given in Reference 8, Section C.3.7 or C.3.9 are used.

- The calculation uses the actual concrete compressive strength, as noted in station documents.

- The potential for scabbing of the underside of the refueling floor is investigated based on drop of the cavity shield block when one or two of the three lift points of the lifted cavity shield block fail. The calculation is based on the local damage equations given in Reference 5.

The calculation has been revised to consider that the entire kinetic energy of a postulated dropping plug is absorbed by the structure and/or the equipment that is impacted. This is a more conservative approach than assuming that some energy is dissipated during an impact.

Various accident scenarios are addressed in Reference 11 and are evaluated in detail later. The maximum weight of the plug, which can be safely lifted to a clear height of 1'-0" above the floor, is determined by equating the “Total Drop Energy Before Impact” to the “Target Energy Capacity”. The least value of the lifted weight from all scenarios was determined to be the governing weight of the reactor shield plug.

The licensee used an energy method to demonstrate the adequacy of the impacted structural elements (beams, slabs, columns, and walls) under the drop of the shield plugs. The licensee calculated an impact energy of a plug using the equation, $E_{iE} = P \times H$, where P and H are defined as plug weight and drop height, respectively. The licensee did not consider any energy dissipation during the impact in the calculation of the impact energy. The licensee also calculated a strain energy, which is the area under the load-deflection curve of a structural element, as an energy absorbing capacity of a structural element using the equation, $E_{SE} = R \times [0.5 \times \Delta_e + (\mu \times \Delta_e - \Delta_e)]$, where R, μ and Δ_e are defined as yield resistence, allowable ductility ratio and elastic deformation of a structural element in Reference 11. The licensee compared the calculated impact energy to the strain energy, and concluded that the impacted structural element is adequate to support the drop of a shield plug if the impact energy is smaller than the strain energy. This energy approach is acceptable to the staff because: (1) the strain energy indicates the larger capacity of the structural element to absorb the impact energy without sustaining structural damage if the strain energy is larger than the impact energy, and (2) energy dissipation was not considered during the impact in order to calculate a conservative impact energy.

The designated safe load path, hoisting height restrictions, and the maximum weight of the reactor cavity shield block and rigging are described in applicable procedures. When handling the top layer of shield blocks weighing more than 110 tons, crane controls incorporate travel limits and hoisting height restrictions.

According to the licensee, the following load drop scenarios envelope all potential load drops of the reactor shield plugs on the reactor cavity and on relevant floors. The load movements are limited to the areas shown in the application (Reference 1). The licensee analyzed the following five different load drop conditions (Reference 4):

(1) shield plug drop during initial lift from unit 3 cavity and during laydown on top of unit 2 shield plugs;
(2) full drop of a shield plug on a single column;
(3) full drop of a shield plug on a system of two adjacent slabs with a beam between the slabs;
(4) full drop of a shield plug on two adjacent columns; and
(5) full drop of a shield plug on a wall at column row 44.

The licensee provided the results of the impact analyses in Reference 11. The results show that all calculated impact energies (except one load drop condition in Scenario 2, which is discussed below), are smaller than the corresponding strain energies. This demonstrates that the structural elements are capable of handling a shield plug weight of up to 110 tons dropping from a height of up to 1 foot above the floor without sustaining structural damage.

Scenario 1 consists of all cases of the drop of a shield plug on the reactor cavity. In the governing condition, the top layer plug is postulated to drop on the two middle and the two bottom layer plugs. The top layer plug may drop over the middle layer plugs situated in the reactor cavity, while being lifted one foot above the floor or a drop height of 3'-0". The “Total

Impact Energy" for a plug weighing 116 tons (232 kips), dropping from 3'-0", without considering the dissipation of the energy due to the impact is determined to be 696 kip-ft. and the maximum weight that can be safely dropped from a height of 3'-0" is calculated to be 194.82 tons. Since this is greater than the weight of the heaviest shield plug, the results of this Scenario are acceptable.

Due to the large area of impact, scabbing on the underside of the refueling floor slab is not expected to occur if the shield plug drops due to failure above the crane hook. However, if one or two of the three lift parts of the plug fail, it may cause an impact at the plug corner with a small impact area and may result in scabbing. The evaluation of the potential scabbing of the refueling floor slab is based on an assumption that a piece of broken plug weighing 10,000 lbs. dropping from a height of 2'-6" (30") impacts the concrete floor slab area of 1 sq. ft. The evaluation shows that this condition will result in scabbing only if the thickness of the floor slab is 13.708" or less. Since the floor slab thickness is 18", no scabbing will result.

In Scenario 2, the full drop of a shield plug on a single column from a height of one foot is analyzed. In the evaluation for this scenario in Reference11, a conservative assumption was made to simplify the calculation. It is assumed that the entire mass of the dropped shield block is centered on top of the column and dropped from a one-foot height.

The Unit 3 middle and bottom layers weighed less than 110 tons and the Unit 2 layers are expected to weigh at or below 110 tons. Since the single failure proof capacity of the crane is not exceeded when lifting these plugs, a load drop analysis is not warranted for these plugs. With regard to top layer shield plugs, the movement path for the top layer plugs has been restricted by the design of crane limit switches, which shall limit the movement of the crane hook (center of gravity of the plug) as shown in References 3 and 4. The path shows that the center of gravity of the shield plugs will not pass near the center of the column along Row M. The center of gravity of the shield plugs will be a minimum of 12'-5" from columns along Row M. Accordingly, Scenario 2 does not apply.

In Scenario 3, 4 and 5, the maximum weights that can be safely dropped from a height of 1'-0 to have the "Total Impact Energy" value equal to the "Net Available Strain Energy" value are determined to be 237.5, 139.44 and 317.5 tons respectively. Since all these weights are greater than the heaviest shield plug, the results of Scenarios 3,4 and 5 are acceptable.

4.0 CONCLUSION

Based on its review as discussed above, the staff concludes that the weight of the top layer plug may safely be as high as 139.44 tons. The refueling floor system elements (including the slabs, columns, beams and walls) that were evaluated in this amendment, are conservatively capable of handling a shield plug weight of up to 139.44 tons dropping from a height of up to 1'-0" above the floor without sustaining any structural damage to the building elements with no scabbing of the floor slab.

REFERENCES

(1) Letter from K. R. Jury (Exelon Generation Company, LLC) to U. S. NRC, “Request for License Amendment Related to Heavy Loads Handling,” dated February 26, 2003

(2) Letter from U. S. NRC to J. L. Skolds (Exelon Generation Company, LLC), “Dresden Nuclear Power Station, Units 2 and 3 - Request for Additional Information Regarding Heavy Loads Handling Amendment Request,” dated May 23, 2003

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(4) Letter from EGC to NRC - Additional information regarding request for license amendment related to load handling - Dated September 11, 2003

(5) Second ASCE Conference on “Civil Engineering and Nuclear Power, Volume V: Report of the ASCE Committee on Impactive and Impulsive Loads”, September 1980, Knoxville, Tennessee

(6) NUREG-0612 “Control of Heavy Loads at Power Plants”

(7) “Roark’s Formulas for Stress and Strain”, 6th Edition, by W. C. Young

(8) ACI 349-97 “Code Requirements for Nuclear Safety Related Concrete Structures”

(9) ACI 318-99 “Building Code Requirements for Structural Concrete”

(10) TDBD-DQ-01 “Topical Design Basis Document - Quad Cities Units 1 & 2 and Dresden Units 2 & 3 - Structural Design Criteria”

(11) Calculation DRE02-0064 (Rev 0, 0A, 0B), “D2/3 Load Drop Evaluation of the Reactor Shield Plugs.”