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U. S. Nuclear Regulatory Commission
ATTN: Document Control Desk
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Dresden Nuclear Power Station, Units 2 and 3
Facility Operating License Nos. DPR-19 and DPR-25
NRC Docket Nos. 50-237 and 50-249

Subject: Additional Information Regarding the Request for License Amendment Related to Heavy Loads Handling

Reference: 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

In the referenced letter, Exelon Generation Company (EGC), LLC, requested a change to Facility Operating License Nos. DPR-19 and DPR-25 for Dresden Nuclear Power Station (DNPS), Units 2 and 3. The proposed change will allow DNPS to revise the Updated Final Safety Analysis Report to include a description of a load drop analysis performed for handling reactor cavity shield blocks weighing greater than 110 tons with the Unit 2/3 reactor building crane during power operation.

In a teleconference on July 7, 2003, involving Mr. L. W. Rossbach, other members of the NRC, Mr. A. R. Haeger, and other members of EGC, and during a subsequent communication on July 21, 2003, the NRC requested additional information regarding this proposed change. The attachments to this letter provide the requested information.

Should you have any questions concerning his letter, please contact Mr. Allan R. Haeger at (630) 657-2807.

I declare under penalty of perjury that the foregoing is true and correct. Executed on the 25th day of July 2003.

Respectfully,

Terrence W. Simpkin

Terrence W. Simpkin
Manager, Licensing
Mid-West Regional Operating Group

A001

Attachment

cc: Regional Administrator – NRC Region III
NRC Senior Resident Inspector – Dresden Nuclear Power Station
Office of Nuclear Facility Safety – Illinois Department of Nuclear Safety

Attachment
Additional Information Regarding Request for License Amendment Related to Heavy Loads Handling

Question 1
Design Input number 4 on page 9 of Calculation No. DRE02-0064, Rev. 0, states that the "shield plug weight of 116 Tons (232 kips) is based on actual weighing of the top layer of shield plugs by Dresden Station on September 20, 2002." Attachment C of Calculation No. DRE02-0064, Rev. 0, gives the actual weights of the Dresden Unit 3 shield plugs but states that the Unit 2 shield plugs have not been accurately weighed. Section 4 of Attachment 1 to the submittal states that the Unit 2 shield blocks are believed to weigh less than or equal to 116 tons based on a review of the dimensional drawings. Section 4 of Attachment 1 also states that Exelon will verify the weight of each piece of the top layer of the Unit 2 shield blocks.

Describe how Exelon will verify the weights of the top layer of the Unit 2 shield blocks and state when this verification will be done.

Response
The weights of the top layer of the Unit 2 shield blocks will be obtained using the same methodology as was used for obtaining the weights of the top layer of the Unit 3 shield blocks.

The weights of the top layer of the Unit 3 shield blocks were obtained on September 20, 2002, by using the 200-ton capacity load cell shackle. The rigging connected to the three attachment points of the shield block was hung from the 200-ton load cell shackle. The 200-ton load cell shackle in turn was supported from the main hook of the reactor building crane. When the crane hook is lifted up, the 200-ton load cell supports the full load of the shield block. The weights of the two Unit 3 top layer shield blocks were found to be 112.9 tons and 114.9 tons.

Exelon Generation Company, LLC (EGC) will use same methodology with a similar type of load cell to obtain the weights of the Unit 2 top layer shield blocks. The task of weighing the top layer shield blocks will be performed before the start of refueling outage D2R18 in early October 2003.

Question 2
Methodology number 7 on page 6 of Calculation No. DRE02-0064, Rev. 0, states that: "The impact energy to be absorbed by the overall deflection of the impacted structural elements is less than the total kinetic energy of load drop. Some kinetic energy is dissipated during the impact. This loss, which can be computed by equating the momentum of the entire system before and after impact, is most conveniently taken into account by multiplying the available kinetic energy by a factor."

Appendix A, Section 1(7) of NUREG-0612 recommends that the analysis should postulate the "maximum damage" that could result, i.e., the analysis should consider that all energy is absorbed by the structure and/or equipment that is impacted.

Justify using lower impact energy than the total kinetic energy, which is inconsistent with the NUREG-0612 guidance.

<u>Response</u>
EGC understands that Item 7 in section 1 of Appendix A to NUREG-0612 refers to considering the "maximum damage," not the maximum missile energy. For the conditions being evaluated, the missile (dropped block) weight is considerable (block weight is 116 tons). In this case, the missile weight will force the barrier and the missile to move together. The condition of plastic impact of simple impact analysis is therefore considered applicable. Because of this, the initial kinetic energy of the missile will not be conserved in the impact process. As item 1(7) of Appendix A requires, the maximum energy consistent with this movement of missile and barrier together is considered in the calculation.

The calculation uses equations from Section 15.4 of calculation Reference 3 (i.e., the textbook of Roark's equations), because these equations conveniently address various impact scenarios: mass striking a column or a column with a tip mass, mass striking a beam or a beam with additional mass at the center, etc. In addition, these equations yield energy reduction factors comparable to plastic impact results.

The assumption of plastic impact is also considered applicable based on Bechtel Power Corporation Topical Report 9A, "Design of Structures for Missile Impact," Revision 2, which discusses, in Section 3.1, the conditions of plastic and elastic impact. This reference states the following.

> "Plastic impact is characterized by the missile remaining in contact with the target, subsequent to impact. In an elastic impact, the missile and target remain in contact for a very short period of time, and then disengage due to elastic interface restoring forces. An elastic missile impact is rarely encountered in nuclear plant design. For example, based on information available, a plastic collision can be considered for all postulated tornado-generated missiles."

The topical report goes on to describe equations for treating plastic impact. This topical report was accepted by the NRC in Reference 1, although the statements quoted above are not specifically discussed in the NRC's acceptance.

Appendix A to this attachment describes in more detail the derivation of equations for plastic impact and shows the portion of the pre-impact energy that is transmitted to the supporting structure.

<u>Question 3</u>
Confirm that the 0.36 Tons value given in Attachment C of Calculation No. DRE02-0064, Rev. 0, accounts for the weight of the rigging for the concrete shield plugs, including special lifting devices used, if any.

<u>Response</u>
Attachment D to Calculation No. DRE02-0064, Rev. 0A shows the weight of the rigging for lifting the concrete shield blocks. This weight includes the weight of the slings and shackles normally used to lift the concrete shield blocks. No other special lifting devices are used for lifting the concrete shield blocks.

<u>*Question 4*</u>
The acceptance criteria given on page 7 of Calculation No. DRE02-0064, Rev. 0, state that: "After local damage effects are ruled out, the acceptable drop height is based on the ability of the impacted structural elements to absorb the remaining kinetic energy after loss due to impact is taken into account." However, Assumption number 1 on page 8 of Calculation No. DRE02-0064, Rev. 0, states that: "Hard missile impact is assumed. Energy lost in the deformation of the dropped plug itself is ignored, which is conservative."

Explain how and in what pathways the energy is lost.

<u>Response</u>
The response to this question is explained in the response to Question 2 above.

<u>*Question 5*</u>
Figures 1 through 3 of Attachment B of Calculation No. DRE02-0064, Rev. 0, show safe load paths with height restrictions for moving of shield blocks.

a. Confirm that there are no equipment or structures on the safe load paths which may interfere with the height restrictions.

b. What are the safety-related equipment located below the floor of safe load paths?

<u>*Response*</u>
a. There are no obstructions on the analyzed load paths that will interfere with the height restrictions. The only items that protrude above the refuel floor in the analyzed load path are the bolts at the three removable pedestal support locations shown in the decontamination pit area between Columns 43-44 and L-M (Drawing B-208, previously provided). These bolts protrude five inches above the refuel floor level and hence do not interfere with the twelve-inch height restriction.

b. The safety-related Unit 2 and Unit 3 isolation condensers are located on the floor at Elevation 589'-0". This floor is immediately below the refuel floor at Elevation 613'-0". These are the only major pieces of safety-related equipment on Elevation 589"-0" under the load paths. In addition, there are runs of piping, conduit and ductwork, as well as valves and other miscellaneous items under the load path below the refueling floor. Some of these items are supported below the refueling floor slab.

   Other safety-related equipment is located below the analyzed load path on elevations below 589'-0". A comprehensive list of these items is not provided. Given the large size of the reactor shield blocks, the analyzed load path for the movement of the shield blocks is the only practical path available.

<u>*Question 6*</u>
Page 39 of Calculation No. DRE02-0064, Rev. 0, states that perforation of the floor slab at Elevation 613' due to impact by the dropped shield plug is not possible for three reasons. Reason number 1 is that both plug and slab are made of reinforced concrete

and may suffer local crushing at the impacted surface during impact. Reason number 2 is that the impact area is large which reduces the impact intensity.

a. *Reason number 1 is inconsistent with Appendix A, Section 1(7) of NUREG-0612, which recommends that the analysis should postulate the "maximum damage" that could result, i.e., the analysis should consider that all energy is absorbed by the structure and/or equipment that is impacted. Justify using Reason number 1 which is inconsistent with NUREG-0612 recommendations.*

b. *Reason number 2 is inconsistent with Appendix A, Section 1(1) of NUREG-0612, which recommends to consider for any load drop analysis that the load is dropped in an orientation that causes the most severe consequences. The impact area is significantly reduced for a tilted drop. Justify using Reason number 2 which is inconsistent with the NUREG-0612 recommendation.*

Response

Pages 39 and 40 of the calculation discuss the potential for perforation of the floor or scabbing due to penetration of the missile into the slab. This portion of the calculation supplements the other portions of the calculation, which address the structural effects of a load drop. The methodology used for pages 39 and 40 is therefore necessarily different from that of the remainder of the calculation.

The argument on page 39 of the calculation addresses the situation where the entire block drops vertically and the entire surface of the block makes contact with the floor slab. But for a worse case, the block falls tilted, and one corner hits the floor. The scabbing calculation on page 40 addresses this hypothetical worst-case scenario using an impact area of one square foot. The calculation uses a method designed to determine the minimum depth of slab required to ensure that there will be no scabbing and is based on weight, drop height, and impact area. The calculation (page 40) shows that there will be no scabbing. Hence there will be no perforation as well. The method used does not depend on assumptions regarding energy lost due to deformation.

Question 7

Using a weight of the top layer shield plug with lifting apparatus of 116 tons (232 kip) and a drop height of one foot gives a potential energy of 232 kip-ft. Scenario 2 of Calculation No. DRE02-0064, Rev. 0, uses an impact energy of 109 kip-ft when dropping a top layer shield plug one foot on top of a concrete column. This 53 percent reduction in the amount of the potential energy transmitted to the column was derived using reference 3 of Calculation No. DRE02-0064, Rev. 0. If the actual impact energy is higher by just 10.4 percent of 0.53, the calculated load drop energy will exceed the 121.759 kip-ft absorption capacity of the column.

a. *What is the accuracy of the referenced methodology for determining such energy losses?*

b. *How do you account for the balance of the potential energy?*

Response

a. Given plastic impact, as Appendix A shows, the results depend on the mass ratio of the missile and target. Any inaccuracy in the calculation is associated with the determination of the effective mass of the impacted component. The calculation uses the effective masses from the Roark text.

The specific condition referred to in the question is part of scenario 2. In the evaluation for this scenario an extremely conservative assumption was made to simplify the calculation. It was assumed that the entire mass of the dropped shield block is centered on top of the column and dropped from a one-foot height.

Column M-47 is part of the grid of columns located at about 24'-6" on centers in the east-west direction and about 25'-6" on centers in the north-south direction. The columns are connected in both directions with beams. The shield block (dropped mass) is a half circular disc with a radius of about 21'-6".

Considering the shield block center of gravity and Column M-47 center are the same, the ends of the shield block in the long direction (diameter direction) will be not more than 3 or 4 feet away from the adjacent columns. In the short direction one end (curved side) will be about 9 feet away from the adjacent third column. If the shield block is oriented at 45-degree angle relative to the beam grid, additional columns and slabs will be involved in the impact resistance.

Based on the above layout description, no matter what the orientation of the dropped shield block, only part of the dropped mass will be engaged in the impact with column M-47. On this basis, a substantial margin exists in the referenced calculation for column M-47 for scenario 2.

In addition, for the other scenarios in the calculation involving the top layer of shield blocks, substantial margin exists. Scenario numbers 3, 4, and 5 are calculated based on a 2'-6" drop height. However, for the top layer of shield blocks the height restriction is 1'-0". This provides a substantial margin for these scenarios.

b. Refer to the response to Question 2 above. Because the impact is considered to be plastic impact, energy is dissipated and the two masses move off at the same velocity. Therefore, for plastic impact, energy is not conserved.

References

1. Letter from U. S. Atomic Energy Commission to J. V. Morowski (Bechtel Power Corporation), dated November 25, 1974

Appendix A

DISCUSSION OF ENERGY TRANSMITTED TO A SPRING SUPPORTED MASS WHEN A SECOND MASS DROPS FROM A HEIGHT ABOVE

Refer to the idealized condition shown in Figure A-1. A falling object of mass, m, drops onto a stationary mass, M, that is spring supported. Using standard impact analysis as contained in Section 13.13 of Reference 1, the ratio of the energy transmitted to the supporting spring to the pre-impact falling object energy is calculated.

Figure A-1 (a) shows the condition just before impact:

The velocity of mass (m) is v_0, and the velocity of mass (M) is zero.

Figure A-1 (c) shows the condition of velocities of the two bodies just after impact. The post impact velocity of mass (m) is v_1, and the post impact velocity of the mass (M) is V_1. Using the standard analysis detailed in Reference 1, the post impact velocities are determined in terms of v_0 and a coefficient of restitution (e). The coefficient of restitution is the ratio of post impact relative velocity to the pre-impact relative velocity. In this case, the coefficient of restitution is

$$e = \frac{V_1 - v_1}{v_0} \qquad (1)$$

If we consider the system of two masses as a unit, at the moment of impact, there are no external impulsive forces acting on the system; therefore, momentum is conserved. Equating the momentum of system before and after impact, we have the second needed equation. This is:

$$m \cdot v_0 + M \cdot 0 = m \cdot v_1 + M \cdot V_1 \qquad (2)$$

Solving Equations (1) and (2) for the post impact velocities V1 and v1, we have:

$$V_1 = \frac{R \cdot (1 + e)}{1 + R} \cdot v_0 \qquad (3)$$

$$v_1 = \frac{R - e}{1 + R} \cdot v_0 \qquad (4)$$

Where,

$$R = \frac{m}{M} \qquad (5)$$

Note from Equations (3) and (4) that when the restitution coefficient (e) is zero, the velocities V_1 and v_1 are equal, and the two masses move together. This is the so called condition of plastic impact. The actual value of (e) depends on the impacting material, and the way the two objects can become tangled together or forced to move together because of an external force such as weight, etc.

Energy Imparted to the Spring

The spring absorbs the post impact kinetic energy of the mass to which it is connected.

For plastic impact (e) is zero, and by virtue of discussion, following Equation (5), the masses M and m both are connected to the spring, and

$$E_{spring\_e\_zero} = 0.5 \cdot (M + m) \cdot V_1^2$$

$$E_{spring\_e\_zero} = \frac{R}{1 + R} \cdot \left(0.5 \cdot m \cdot v_0^2\right) \qquad (6)$$

Equation 6 will always result in energy transmitted to the spring that is less than the pre-impact kinetic energy.

Reference

1. F.P. Beer and E.R. Johnston, Jr., Vector Mechanics for Engineers—Statics and Dynamics, Sixth Edition, 1997, McGraw-Hill Companies, Inc.

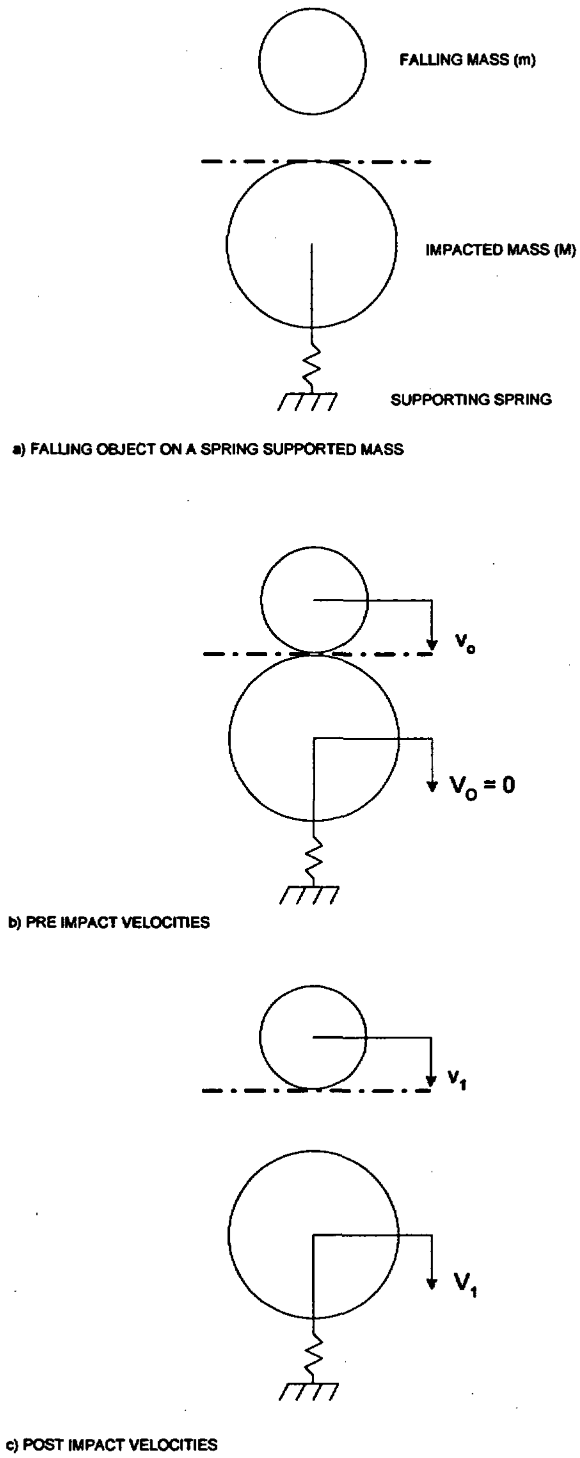

Figure A-1 Idealized Load Drop Case Considered