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RS-02-065

April 12, 2002

United States Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, D.C. 20555-0001

Braidwood Station, Units 1 and 2
Facility Operating License Nos. NPF-72 and NPF-77
NRC Docket Nos. STN 50-456 and STN 50-457

Byron Station, Units 1 and 2
Facility Operating License Nos. NPF-37 and NPF-66
NRC Docket Nos. STN 50-454 and STN 50-455

Subject: Hot Leg Switchover Confirmatory Analysis Supporting Uprated Power Operations at Byron and Braidwood Stations

References: See Attachment 1

In Reference 1, we submitted proposed changes to Facility Operating License Nos. NPF-72, NPF-77, NPF-37 and NPF-66, and Appendix A, Technical Specifications (TS), for Braidwood Station, Units 1 and 2, and Byron Station, Units 1 and 2, respectively. The proposed changes would revise the maximum power level specified in each unit's license and the TS definition of rated thermal power. As part of this "power uprate" analysis, a calculation was performed to confirm the value of the maximum allowable time in which operators must direct some Emergency Core Cooling System (ECCS) recirculation flow to the Reactor Coolant System hot legs (i.e., Hot Leg Switchover (HLSO)) during a Loss of Coolant Accident scenario in order to prevent boron precipitation in the reactor core.

In References 2 and 3, we provided additional information regarding the HLSO calculation. In summary, References 2 and 3 provided justification for maintaining the HLSO time at the current value of 8.5 hours.

In Reference 4, we acknowledged that after review of the HLSO time analysis, the NRC indicated that a HLSO time of 8.5 hours was acceptable for operation of Byron Station and Braidwood Station under uprated power conditions for a period of 18 months from the date of issuance of the power uprate license amendment. Subsequently, a HLSO time confirmatory analysis would be performed using an analysis model acceptable to the NRC. This analysis would be submitted to the NRC by June 1, 2002, and either justify the 8.5 hour HLSO time or establish a new HLSO time consistent with the new analysis model.

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In Reference 5, the NRC issued Amendment 113 for Braidwood Station and Amendment 119 for Byron Station approving the license amendment request addressed in Reference 1. These license amendments contain a License Condition that states the following:

> "The licensee shall submit to the NRC a confirmatory analysis using a model acceptable to the NRC justifying the value of 8.5 hours for the time of switchover to hot leg injection following a loss-of-coolant accident (Safety Evaluation Section 3.1.3); or recalculate the switchover time using the currently accepted methodology."

As noted above, this confirmatory analysis is to be submitted to the NRC by June 1, 2002. Attachment 2 provides the requested analysis. In summary, the confirmatory analysis model remains the same as that previously submitted in Reference 1 and subsequently approved in Reference 5, with the exception of three items: 1) all ECCS subcooling assumptions have been removed and a value of 212 °F is assumed for ECCS water temperature, whereas the existing analysis credited ECCS subcooling to 170°F; 2) the existing decay heat assumption, which used the American Nuclear Society (ANS) Standard, "Decay Energy Release Rates Following Shutdown of Uranium-Fueled Thermal Reactors," 1971, for a finite operating time with no margin, has been changed to the 1971 ANS Standard for an infinite operating time with a 20% uncertainty factor, which is consistent with 10 CFR 50, Appendix K, "ECCS Evaluation Models;" and 3) a boron measurement uncertainty of 25 ppm is used instead of the overly conservative value of 50 ppm assumed in the previous analysis. Based on this analysis, the HLSO time has been revised to 6.0 hours.

Procedure revisions addressing the revised HLSO time will be implemented within 30 days after receiving NRC approval of the attached HLSO reanalysis.

Should you have any questions or concerns regarding this information, please contact Mr. J. A. Bauer at (630) 657-2801.

Respectfully,

K. A. Aniger for

Keith R. Jury
Director – Licensing
Midwest Regional Operating Group

cc: Regional Administrator – NRC Region III
NRC Senior Resident Inspector – Braidwood Station
NRC Senior Resident Inspector – Byron Station

ATTACHMENT 1

References

1. Letter from R. M. Krich (Commonwealth Edison Company) to U.S. NRC, "Request for a License Amendment to Permit Uprated Power Operations at Byron and Braidwood Stations," dated July 5, 2000

2. Letter from R. M. Krich (Exelon Generation Company, LLC) to U.S. NRC, "Additional Information Supporting the License Amendment Request to Permit Uprated Power Operations at Byron and Braidwood Stations," dated March 26, 2001

3. Letter from R. M. Krich (Exelon Generation Company, LLC) to U.S. NRC, "Additional Information Supporting the License Amendment Request to Permit Uprated Power Operations at Byron and Braidwood Stations," dated April 5, 2001

4. Letter from R. M. Krich (Exelon Generation Company, LLC) to U.S. NRC, "Additional Information Supporting the License Amendment Request to Permit Uprated Power Operations at Byron and Braidwood Stations," dated April 16, 2001

5. Letter from G. F. Dick (U.S. NRC) to O. D. Kingsley (Exelon Generation Company, LLC), "Issuance of Amendments; Increase in Reactor Power, Byron Station, Units 1 and 2, and Braidwood Station, Units 1 and 2," dated May 4, 2001

ATTACHMENT 2

Hot Leg Switchover Reanalysis
Byron and Braidwood Stations

Background

In Reference 1, Exelon Generation Company, LLC (Exelon) submitted proposed changes to Facility Operating License Nos. NPF-72, NPF-77, NPF-37 and NPF-66, and Appendix A, Technical Specifications (TS), for Braidwood Station, Units 1 and 2, and Byron Station, Units 1 and 2, respectively. The proposed changes would revise the maximum power level specified in each unit's license and the TS definition of rated thermal power. As part of this "power uprate" analysis, a calculation was performed to confirm the value of the maximum allowable time in which operators must direct some Emergency Core Cooling System (ECCS) recirculation flow to the Reactor Coolant System (RCS) hot legs (i.e., Hot Leg Switchover (HLSO)) during a Loss of Coolant Accident (LOCA) scenario in order to prevent boron precipitation in the reactor core.

In References 2 and 3, Exelon provided additional information regarding the HLSO calculation. In summary, References 2 and 3 provided justification for maintaining the HLSO time at the current value of 8.5 hours.

In Reference 4, Exelon acknowledged that after review of the HLSO time analysis, the NRC indicated that a HLSO time of 8.5 hours was acceptable for operation of Byron Station and Braidwood Station under uprated power conditions for a period of 18 months from the date of issuance of the power uprate license amendment. Subsequently, a HLSO time confirmatory analysis would be performed using an analysis model acceptable to the NRC. This analysis would be submitted to the NRC by June 1, 2002, and either justify the 8.5 hour HLSO time or establish a new HLSO time consistent with the new analysis model.

In Reference 5, the NRC issued Amendment 113 for Braidwood Station and Amendment 119 for Byron Station approving the license amendment request addressed in Reference 1. These license amendments contain a License Condition that states the following:

> "The licensee shall submit to the NRC a confirmatory analysis using a model acceptable to the NRC justifying the value of 8.5 hours for the time of switchover to hot leg injection following a loss-of-coolant accident (Safety Evaluation Section 3.1.3); or recalculate the switchover time using the currently accepted methodology."

In the Reference 5 Safety Evaluation Report (SER), the NRC identified two assumptions in the HLSO analysis that needed further justification. These two issues are noted below.

Subcooled ECCS Water Assumption

The pre-power uprate HLSO calculation credited ECCS water subcooling to 170°F. The HLSO calculation submitted in support of the power uprate amendment maintained the ECCS subcooling assumption. During the course of the approval process as documented in the Reference 5 SER, the NRC expressed concerns over the validity of the ECCS subcooling assumption with respect to the interaction of the ECCS water with the steam generated in the core.

Decay Heat Assumption

Although not discussed in detail in the Reference 5 SER, the NRC expressed reservation over the decay heat assumption that was used in the power uprate HLSO calculations (i.e., the American Nuclear Society (ANS) Standard, "Decay Energy Release Rates Following Shutdown or Uranium-Fueled Thermal Reactors," 1971, for a finite operating time with no margin).

Although the ECCS subcooling and decay heat issues were not fully resolved, the NRC provided a conditional approval of the 8.5 HLSO time with the stipulation that a reanalysis be performed to address the issues raised in the SER. This reanalysis is presented below.

HLSO Reanalysis Methodology

The methodology used in the HLSO reanalysis is unchanged from that conditionally approved in Reference 5 except for the three items noted below.

ECCS Water Temperature Assumption

The water/boric acid solution in the vessel is assumed to be at atmospheric conditions, at a temperature of 212°F, i.e., no credit is taken for ECCS water subcooling.

Decay Heat Assumption

The decay heat generation rate is based on the 1971 ANS Standard for an infinite operating time with a 20% uncertainty factor, which is consistent with 10 CFR 50, Appendix K, "ECCS Evaluation Models." The decay heat generation includes a 1.02 core power multiplier to address instrumentation uncertainty consistent with 10 CFR 50, Appendix K, Section I.A.

Boron Concentration Uncertainty Assumption

The reanalysis assumed a boron concentration measurement uncertainty of 25 ppm instead of the overly conservative value of 50 ppm assumed in the previous analysis. The value of 25 ppm for the boron measurement uncertainty is consistent with the Institute for Nuclear Power Operations (INPO) guidelines (i.e., INPO-88-021, "Guidelines for Chemistry at Nuclear Power Stations", Revision 1, September 1991). Exelon Chemistry procedure, CY-AA-130-200, "Quality Control," follows this INPO guideline. The performance check done for the boron titration equipment at both Byron and Braidwood Stations bounds the 25 ppm uncertainty value.

Summary – Results and Conclusions

The Byron Station and Braidwood Station Power Uprate HLSO reanalysis addressed the two issues raised by the NRC in Reference 5, (i.e., the use of ECCS subcooling and the use of reactor core decay heat assumptions different than that specified in 10 CFR 50, Appendix K). In the HLSO reanalysis, all ECCS subcooling assumptions were removed and the decay heat assumption specified in 10 CFR 50, Appendix K (i.e., 1971 ANS Standard for a infinite operating time with a 20% uncertainty factor) was used. The reanalysis also assumed an RCS boron concentration measurement uncertainty of 25 ppm instead of the overly conservative value of 50 ppm assumed in the previous analysis. All other aspects of the calculation remain the same as the previous Byron Station and Braidwood Station Power Uprate HLSO analysis discussed in Reference 1. The results of the reanalysis yielded a HLSO time of 6.0 hours.

A HLSO time of 6.0 hours will preclude reactor core boron precipitation for post-LOCA scenarios for the uprated power conditions, assuming no ECCS subcooling, decay heat as prescribed by 10 CFR 50, Appendix K, and all other assumptions consistent with the methodology approved in Reference 5. The available ECCS flows at HLSO were shown to be sufficient to provide core cooling for a HLSO time of 6.0 hours as detailed below. The acceptance criteria of 10 CFR 50.46, "Acceptance criteria for emergency core cooling systems for light-water nuclear power reactors," relative to core coolable geometry and long-term cooling, continue to be met at uprated power conditions.

HLSO Minimum Flow Requirement Results

The minimum flow requirements were calculated at the HLSO time to ensure that sufficient flow exists in the hot leg recirculation flow configuration at Byron and Braidwood Stations to stop the buildup of boron in the reactor vessel and to ensure adequate core cooling is maintained. For the large-break LOCAs, the minimum required flow delivered to the hot legs must equal or exceed 1.3 times the calculated core boiloff rate; and the minimum required flow delivered to the cold legs, must equal or exceed 1.2 times the calculated core boiloff rate. As noted in Table 1, the available flow exceeds the minimum flow requirement for each case.

In the event of a small hot leg break where RCS pressure can remain high, there are two means of demonstrating the adequacy of flow at the HLSO time. Credit may be taken for operator action to cool down and depressurize the RCS, using steam generator power operated relief valves (PORVs), prior to entering the hot leg recirculation mode. Alternatively, it may be demonstrated that available flows at high pressures meet or exceed the calculated core boiloff rate, which is known to be conservative relative to the actual maximum calculated flow through the break. Core boiloff rates at high RCS pressures are calculated to determine the minimum required flow delivered to both the hot and cold legs for a small hot leg break.

A revised set of hot leg recirculation minimum required flows were calculated at uprated power conditions for a HLSO time of 6.0 hours. Table 1 provides the required ECCS flow rates for the different accident break locations at the HLSO time.

Table 1

ECCS Minimum Required Flow Rates

Byron and Braidwood Stations, Uprated Power to 3586.6 MWt

Break Location and Size	ECCS Flow Spilling Assumption	Source of Flow to Meet Criteria	Pressure at Delivery Location	Required Flow at 6.0 hr HLSO Time (lbm/s)	Available Flow (lbm/s)
Cold Leg Large Break	One Cold Leg Spills to Containment Pressure.	Total Hot Leg Flow. (No lines spilling.)	0 psig	49.2 (1.3 × boiloff)	≥ 49.2
Hot Leg Large Break	One Hot Leg Spills to Containment Pressure.	Total Cold Leg Flow. (No lines spilling.)	0 psig	45.5 (1.2 × boiloff)	≥ 45.5
Small Break	One Hot Leg Spills to RCS Pressure.	Total of Hot and Cold Leg Delivered Flow.	1300 psia	36.9[1,2]	≥ 36.9

[1] Based on 1.0 x boiloff which greatly exceeds maximum break flow rates for break cases of one inch or smaller.

[2] This flow must be met where credit is not taken for operation of steam generator PORVs to depressurize RCS prior to HLSO.

References

1. Letter from R. M. Krich (Commonwealth Edison Company) to U.S. NRC, "Request for a License Amendment to Permit Uprated Power Operations at Byron and Braidwood Stations," dated July 5, 2000

2. Letter from R. M. Krich (Exelon Generation Company, LLC) to U.S. NRC, "Additional Information Supporting the License Amendment Request to Permit Uprated Power Operations at Byron and Braidwood Stations," dated March 26, 2001

3. Letter from R. M. Krich (Exelon Generation Company, LLC) to U.S. NRC, "Additional Information Supporting the License Amendment Request to Permit Uprated Power Operations at Byron and Braidwood Stations," dated April 5, 2001

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