

December 12, 2016

MEMORANDUM TO: Stephen S. Koenick, Acting Chief  
Plant Licensing Branch I-2  
Division of Operating Reactor Licensing  
Office of Nuclear Reactor Operation

FROM: Eric R. Oesterle, Chief */RA/*  
Reactor Systems Branch  
Division of Safety System  
Office of Nuclear Reactor Regulation

SUBJECT: SAFETY EVALUATION FOR LIMERICK GENERATING  
STATION, UNITS 1 AND 2, PROPOSED LICENSE AMENDMENT  
TO REVISE THE TECHNICAL SPECIFICATIONS TO ADDRESS  
THE HIGH-PRESSURE COOLANT INJECTION OPERABILITY  
REQUIREMENT UNDER LOW REACTOR PRESSURE  
CONDITIONS (TAC NOS. MF7555, AND MF7556.)

By letter dated April 4, 2016 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML16095A275), Exelon Generation company, LLC (the licensee) submitted a License Amendment Request (LAR) for Limerick Generating Station, Units 1 and 2. The proposed changes modify the High Pressure Coolant Injection (HPCI) system and Reactor Core Isolation Cooling (RCIC) system actuation instrumentation Technical Specifications (TSs) by adding a footnote indicating that the injection functions of drywell pressure - high (HPCI only) and manual initiation (HPCI and RCIC) are not required to be operable under low reactor pressure conditions.

The staff of the Reactor Systems Branch (SRXB) has reviewed the LAR and found that it is acceptable. The SRXB staff provides its bases for approval in the Enclosure. This effort completes the SRXB review of the LAR under TAC Nos. MF7555, and MF7556.

Enclosure:  
Safety Evaluation

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**SAFETY EVALUATION FOR LIMERICK GENERATING STATION,**  
**UNITS 1 AND 2, PROPOSED LICENSE AMENDMENT TO**  
**REVISE THE TECHNICAL SPECIFICATIONS TO ADDRESS THE**  
**HIGH-PRESSURE COOLANT INJECTION OPERABILITY**  
**REQUIREMENT UNDER LOW REACTOR PRESSURE CONDITIONS**  
**TAC NOS. MF7555 AND MF7556**

**1.0 INTRODUCTION**

By letter dated April 4, 2016 Agencywide Documents Access and Management System (ADAMS Accession No. ML16095A275), Exelon Generation company, LLC (the licensee) submitted a License Amendment Request (LAR) for Limerick Generating Station (LGS), Units 1 and 2. The proposed amendment would revise the Technical Specifications (TSs), Appendix A of renewed Facility Operating License. NPF-39 and NPF-85 for LGS, Units 1 and 2, respectively. Both of LGS units are General Electric (GE) Boiling-Water-Reactors (BWRs 4) Mark II design.

**2.0 PROPOSED CHANGE**

The proposed changes modify the High Pressure Coolant Injection (HPCI) system and Reactor Core Isolation Cooling (RCIC) system actuation instrumentation TS by adding a footnote indicating that the injection functions of drywell pressure-high (HPCI only) and manual initiation (HPCI and RCIC) are not required to be operable under low reactor pressure conditions.

**3.0 REGULATORY EVALUATION**

The U.S. Nuclear Regulatory Commission uses the following requirements and guidance documents in evaluating the licensee's amendment request:

Title 10 of the *Code of Federal Regulations* (10 CFR), Section 50.36, "Technical Specifications," in which the Commission established its regulatory requirements related to the contents of the TS. Specifically, 10 CFR 50.36(c)(2) states, in part, "Limiting conditions for operation are the lowest functional capability or performance levels of equipment required for safe operation of the facility."

Criterion 13 - Instrumentation and control. Instrumentation shall be provided to monitor variables and systems over their anticipated ranges for normal operation, for anticipated operational occurrences, and for accident conditions as appropriate to assure adequate safety, including those variables and systems that can affect the fission process, the integrity of the reactor core, the reactor coolant pressure boundary, and the containment and its

**ENCLOSURE**

associated systems. Appropriate controls shall be provided to maintain these variables and systems within prescribed operating ranges.

#### **4.0 SYSTEMS DESIGN**

The LGS HPCI system (GE BWR 4 Technical Manual, ML023010606 and LGS Updated Final Safety Analysis Report (UFSAR) Revision 18, Chapters 6 and 15) is a single-train system that provides a reliable source of high-pressure coolant for cases where there is a loss of normal core coolant inventory. The HPCI system consists of a steam turbine-driven pump, valves and valve operators, and associated piping, including that from the normal and alternate pump suction sources and the pump discharge up to the penetration of the main feedwater line. The steam turbine-driven pump includes all steam piping from the main steam line penetration to the turbine.

The HPCI system is actuated by either a low reactor water level or a high drywell pressure. Initially the system operates in an open loop mode, taking suction from the Condensate Storage Tank (CST) and injecting water into the Reactor Pressure Vessel (RPV) via one of the main feedwater lines. When the level in the CST reaches a low-level setpoint, the HPCI pump suction is aligned to the suppression pool. To maintain RPV level after the initial recovery, the HPCI system is placed in manual control, which may involve controlling turbine speed, diverting flow through minimum-flow or test lines, cycling the injection Motor-Operated Valve, or complete stop-start cycles. The HPCI system is also manually used to help control RPV pressure following a transient.

The HPCI system provides coolant to the reactor vessel following a Small-Break-Loss-Of-Coolant Accident (SBLOCA) until reactor pressure is below the pressure at which the low-pressure coolant injection systems, i.e., the Core Spray (CS) system or the Low-Pressure Coolant Injection mode of the Residual Heat Removal system, maintain core cooling. The HPCI system is also capable of providing sufficient coolant to the reactor vessel to prevent actuation of the Automatic Depressurization System (ADS) and ensure that the reactor core remains covered in the event of a small pipe break with a break size of one-inch diameter or less. The RCIC system is designed to ensure that sufficient reactor water inventory is maintained in the reactor vessel to permit adequate core cooling in the event of a loss of normal feedwater flow.

The HPCI and RCIC systems (GE BWR 4 Technical Manual, ML023010606, and LGS UFSAR Revision 18, Chapters 6 and 15) consist of a steam driven turbine, pump assembly and associated system piping, valves, controls and instrumentation. HPCI and RCIC system controls automatically start the systems from the receipt of a reactor vessel low water level signal (Level 2). In all actuation modes, the systems are prevented from operating above Level 8 (high reactor vessel water level). In addition, the HPCI system is designed to automatically start on primary containment (drywell) high pressure. Primary containment high pressure is an indication that a breach of the nuclear process barrier has occurred inside the drywell.

Reactor vessel low water level (LGS LAR, ADAMS Accession No. ML16095A275, and LGS UFSAR Revision 18, Chapter 6 and 15) is monitored by four level sensors that sense the difference between the pressure of the water column in a constant reference leg, which is independent of reactor water level and density, and the pressure of the water column in the

variable leg which varies linearly with the reactor vessel water level but is dependent on the reactor water density.

The licensee in its LAR (ADAMS Accession No. ML16095A275) states that, these four-wide range reactor vessel water level sensors that provide the HPCI and RCIC low water level actuation signals also provide the HPCI and RCIC high reactor vessel water level trip signals. Each sensor is connected to a trip unit and the four trip units are connected in a one-out-of-two twice logic to automatically shut down the HPCI and RCIC systems. High water level in the reactor vessel indicates that the HPCI and RCIC systems have performed satisfactorily in providing makeup water to the reactor vessel and core cooling requirements are satisfied. The reactor vessel high water level setting that shuts down HPCI and RCIC (+54 inches of water level or Level 8) is near the top of the steam separators and is sufficient to prevent gross moisture carry over to the HPCI and RCIC turbines.

## **5.0 TECHNICAL EVALUATION**

### **4.1 Effect of HPCI and RCIC Unavailability on Plant Operation and Safety**

The HPCI and RCIC are technically not available (LGS LAR, ADAMS Accession No. ML16095A275) when the indicated reactor vessel water level is above Level 8 (+54 inches of water level), the HPCI and RCIC systems are not needed under normal operating conditions when the reactor vessel water level is at some steady high level, and are only needed during a loss of level transient, such as Loss-Of-Coolant Accident (LOCA) when the level has decreased to Level 2. For Limerick, the Level 2 setpoint is -38 inches from instrument zero, which is below the minimum level above which HPCI and RCIC are technically unavailable due to the wide range off calibration condition at the lowest applicable reactor steam dome pressure of 150 psig. The staff performed an independent review of GE BWR 4 design documentation, and LGS UFSAR Revision 18, Chapters 6 and 15 to confirm that the licensee's analysis results indicating that the highest wide range off-calibration condition, corresponding to the lowest applicable dome pressure of 150 psig, is not large enough to prevent the Level 2 actuation. In addition, both the Level 8 trip and the Level 2 actuation for the HPCI and RCIC systems come from the same wide range instrumentation, so the Level 8 trip clears before the level reaches the Level 2 actuation, regardless of the off-calibration conditions.

The HPCI and RCIC are systems designed (GE BWR 4 Technical Manual, ML023010606, and LGS UFSAR revision 18, Chapters 6 and 15) to mitigate events such as LOCA or loss of feedwater flow, and assure that the reactor vessel water level stays high enough to provide adequate core cooling. The HPCI and RCIC are only required to inject water into the reactor when the reactor vessel water level decreases to Level 2. For LGS, the Level 2 setpoint is -38 inches from instrument zero. Because the HPCI and RCIC level trips initiate from the same wide range level instrumentation, the Level 8 trip clears and the HPCI and RCIC systems are available when the Level 2 actuation occurs, regardless of the off-calibration condition. Therefore, availability of HPCI and RCIC systems, after Level 2 actuation occurs, ensures adequate core cooling.

The licensee stated in its amendment request (LGS LAR, ADAMS Accession No. ML16095A275) that their analyses results show that, once the reactor vessel water level reaches Level 2, due to the HPCI and RCIC actuation logics that are designed to automatically

trigger HPCI and RCIC injection. Depending upon the accident scenario and size of break, this injection could start to raise the water level inside the reactor, so the HPCI and RCIC trip logic is designed to automatically trip HPCI and RCIC if the reactor vessel water level reaches Level 8 to protect the turbine. The systems stay in the tripped configuration when the indicated level is above Level 8. If this level decreases below Level 8, the Level 8 trip signal is lifted, and when the level reaches Level 2, the HPCI and RCIC trip logic automatically clears the Level 8 trip and the actuation logic starts HPCI and RCIC injection. Thus, if the break is such that the HPCI and RCIC systems can provide enough water to raise the reactor vessel water level above Level 2, the HPCI and RCIC trip/actuation logic is designed to allow the system to automatically maintain level between Level 2 and Level 8 with no operator intervention. If the break is such that HPCI and RCIC cannot provide enough water to maintain level, then the low-pressure Emergency Core Cooling Systems (ECCSs) are initiated when the indicated reactor vessel water level drops to Level 1 (-129 inches from instrument zero). Once the low-pressure systems are initiated, HPCI and RCIC are not needed, although they would continue to inject unless the reactor vessel water level recovered sufficiently to initiate the Level 8 trip. The staff review of LGS UFSAR Revision 18, Chapter 7, related to HPCI Initiating Circuits, confirms that the HPCI actuation logics are initiated in a manner to provide design makeup water flow to prevent core uncover, and to protect the turbine.

#### 4.2. HPCI and RCIC Function at Low Pressure

The BWR 4 design consists of emergency core cooling high pressure pumping system that delivers its flow to vessel annulus. The function of the HPCI and RCIC systems (GE BWR 4 Technical Manual, ML023010606, and LGS UFSAR revision 18, Chapters 6 and 15) is to provide make-up coolant at high reactor pressure conditions to prevent core uncover when the reactor vessel water level is low. The licensee in its LAR (ADAMS Accession No. ML16095A275) states that the functional pressure range at LGS for the HPCI and RCIC overlaps the operational range of the low-pressure systems as well as the safety and relief valve overpressure setpoints. While these systems are primarily designed to operate at near rated operating conditions, they are also capable to function near the low end of their operating pressure range to mitigate coolant losses from decay heat RCIC and small leaks or vessel line breaks (HPCI). This capability is consistent with the requirements of 10 CFR, section 50.36 as discussed in Section 2 of this safety evaluation.

##### 4.2.1 The consequences of off-calibration of the wide range level instrumentation at low pressure:

For the licensing basis LOCA analysis as documented in LGS UFSAR ECCSs, Sections 1.2.4.2.13, 6.3.3.7 and Table 6.3-5, the licensee states that HPCI system, which is most effective for small breaks, is disabled by the limiting assumed single failure and therefore, for this case, the off-calibration of the wide range level instrumentation and the delay of HPCI injection at low pressure are of no consequence. The licensee also states that for the case where the HPCI system is credited in the LOCA analysis, the consequences of off-calibration of the wide range level instrumentation at low pressure is not significant because the mass of water that provides the core cooling is unaffected by the density differences and so the core cooling analysis results would not be significantly affected. For larger break sizes, where the vessel depressurizes faster, the mitigation capability of HPCI is minimal. The staff performed review of the LGS UFSAR Revision 18, Chapters 6, and 15 to confirm the licensee

determination that the consequences of off-calibration of the wide range level instrumentation at low pressure are not significant, and does not affect the core cooling analysis results.

For the licensee analysis for loss of feedwater flow at rated conditions following a reactor scram, shows that (LGS LAR ADAMS, Accession No. ML16095A275) the mitigation by the RCIC and HPCI systems is demonstrated to be effective in preventing core uncover and actuation of the ADS. But because there is no wide range off-calibration condition at rated pressure, the low pressure wide range level off-calibration behavior is not of concern for the short-term. However, for the long-term mitigation following the event, as the vessel is depressurized, the RCIC and HPCI systems maintain the level consistent with the wide range level indication. The LGS UFSAR Revision 18 Chapter 01, references a BWR owner group (BWROG) transmittal evaluation results of for the BWR 4 plants the worst case transient is loss of feedwater event. The results of the studies indicate that the core remains covered during the entire course of the transient either to RCIC operation or automatic or manual depressurization permitting low pressure inventory makeup, even with failure of the HPCI system. Therefore, based on the review of the BWROG analysis results, the staff agrees with the license that there would be no core cooling or core uncover concerns. As such, the consequences of wide range reactor vessel water level off-calibration do not lead to a more severe reactor condition when low pressure conditions are considered. The effect of pressure on water density results in comparable mass inventory above the lower instrument tap; therefore, the wide range off-calibration condition has a minimal effect on the reactor water inventory available for core cooling. This capability is consistent with Criterion 13, i.e., the LGS Units 1 and 2 provide appropriate control to monitor reactor water content that can be used to cool the core as required.

#### 4.3 HPCI Specific to the High Drywell Pressure Initiation Function

For a LOCA event initiating at low reactor pressures, HPCI automatically actuates and injects into the vessel when the wide range indicated level reaches the Level 2 low-low level initiation setpoint, with or without the presence of the high drywell pressure actuation. Therefore, for a LOCA event initiating at low reactor pressures, the HPCI system performs in a manner that is consistent with the HPCI actuation assumptions in the ECCS-LOCA analysis of record (LGS UFSAR Revision 18, Chapters 6 and 15). Therefore, automatic actuation of the HPCI system on the high drywell pressure signal is not required to satisfy HPCI system safety functions.

## 6.0 CONCLUSION

The staff finds that the licensee used methods consistent with regulatory requirements identified in Section 3 above. Therefore, the proposed addition of a footnote to TSs indicating that the injection functions of drywell pressure-high (HPCI only) and manual initiation (HPCI and RCIC) are not required to be operable under low reactor pressure conditions complies with GDC13 and 10CFR50.36 and is acceptable.