



Order No. EA-12-049

RS-14-210

August 28, 2014

U.S. Nuclear Regulatory Commission  
ATTN: Document Control Desk  
Washington, DC 20555-0001

Limerick Generating Station, Units 1 and 2  
Facility Operating License Nos. NPF-39 and NPF-85  
NRC Docket Nos. 50-352 and 50-353

Subject: Third Six-Month Status Report in Response to March 12, 2012 Commission Order  
Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-  
Design-Basis External Events (Order Number EA-12-049)

References:

1. NRC Order Number EA-12-049, "Issuance of Order to Modify Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events," dated March 12, 2012
2. NRC Interim Staff Guidance JLD-ISG-2012-01, "Compliance with Order EA-12-049, Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events," Revision 0, dated August 29, 2012
3. NEI 12-06, "Diverse and Flexible Coping Strategies (FLEX) Implementation Guide," Revision 0, dated August 2012
4. Exelon Generation Company, LLC's Initial Status Report in Response to March 12, 2012 Commission Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events (Order Number EA-12-049), dated October 25, 2012
5. Exelon Generation Company, LLC Overall Integrated Plan in Response to March 12, 2012 Commission Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events (Order Number EA-12-049), dated February 28, 2013 (RS-13-022)
6. Exelon Generation Company, LLC First Six-Month Status Report in Response to March 12, 2012 Commission Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events (Order Number EA-12-049), dated August 28, 2013 (RS-13-123)
7. Exelon Generation Company, LLC Second Six-Month Status Report in Response to March 12, 2012 Commission Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events (Order Number EA-12-049), dated February 28, 2014 (RS-14-012)

8. NRC letter to Exelon Generation Company, LLC, Limerick Generating Station, Units 1 and 2 – Interim Staff Evaluation Relating to Overall Integrated Plan in Response to Order EA-12-049 (Mitigation Strategies) (TAC Nos. MF0847 and MF0848), dated January 10, 2014

On March 12, 2012, the Nuclear Regulatory Commission (“NRC” or “Commission”) issued an order (Reference 1) to Exelon Generation Company, LLC (EGC). Reference 1 was immediately effective and directs EGC to develop, implement, and maintain guidance and strategies to maintain or restore core cooling, containment, and spent fuel pool cooling capabilities in the event of a beyond-design-basis external event. Specific requirements are outlined in Attachment 2 of Reference 1.

Reference 1 required submission of an initial status report 60 days following issuance of the final interim staff guidance (Reference 2) and an overall integrated plan pursuant to Section IV, Condition C. Reference 2 endorses industry guidance document NEI 12-06, Revision 0 (Reference 3) with clarifications and exceptions identified in Reference 2. Reference 4 provided the EGC initial status report regarding mitigation strategies. Reference 5 provided the Limerick Generating Station, Units 1 and 2 overall integrated plan.

Reference 1 requires submission of a status report at six-month intervals following submittal of the overall integrated plan. Reference 3 provides direction regarding the content of the status reports. References 6 and 7 provided the first and second six-month status reports, respectively, pursuant to Section IV, Condition C.2, of Reference 1 for Limerick Generating Station. The purpose of this letter is to provide the third six-month status report pursuant to Section IV, Condition C.2, of Reference 1, that delineates progress made in implementing the requirements of Reference 1. The enclosed report provides an update of milestone accomplishments since the last status report, including any changes to the compliance method, schedule, or need for relief and the basis, if any. The enclosed report also addresses the NRC Interim Staff Evaluation Open and Confirmatory Items contained in Reference 8.

This letter contains no new regulatory commitments. If you have any questions regarding this report, please contact David P. Helker at 610-765-5525.

I declare under penalty of perjury that the foregoing is true and correct. Executed on the 28<sup>th</sup> day of August 2014.

Respectfully submitted,



James Barstow  
Director - Licensing & Regulatory Affairs  
Exelon Generation Company, LLC

Enclosure:

1. Limerick Generating Station, Units 1 and 2 Third Six-Month Status Report for the Implementation of Order EA-12-049, Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events

cc: Director, Office of Nuclear Reactor Regulation  
NRC Regional Administrator - Region I  
NRC Senior Resident Inspector – Limerick Generating Station, Units 1 and 2  
NRC Project Manager, NRR – Limerick Generating Station, Units 1 and 2  
Ms. Jessica A. Kratchman, NRR/JLD/PMB, NRC  
Mr. Jack R. Davis, NRR/DPR/MSD, NRC  
Mr. Eric E. Bowman, NRR/DPR/MSD, NRC  
Mr. Jeremy S. Bowen, NRR/DPR/MSD/MSPB, NRC  
Mr. Robert L. Dennig, NRR/DSS/SCVB, NRC  
Mr. John D. Hughey, NRR/DPR/MSD/MSPB, NRC  
Director, Bureau of Radiation Protection – Pennsylvania Department of Environmental  
Resources  
R. R. Janati, Chief, Division of Nuclear Safety, Pennsylvania Department of Environmental  
Protection, Bureau of Radiation Protection

**Enclosure**

**Limerick Generating Station, Units 1 and 2**

**Third Six-Month Status Report for the Implementation of Order EA-12-049, Order  
Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-  
Design-Basis External Events**

(11 pages)



Limerick Generating Station, Units 1 and 2 Third Six Month Status Report  
for the Implementation of FLEX  
August 28, 2014

**Enclosure**

**Limerick Generating Station, Units 1 and 2 Third Six Month Status Report for the Implementation of Order EA-12-049, Issuance of Order to Modify Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events**

**1 Introduction**

Limerick Generating Station, Units 1 and 2 developed an Overall Integrated Plan (Reference 1 in Section 8), documenting the diverse and flexible strategies (FLEX), in response to NRC Order EA-12-049 (Reference 2). This enclosure provides an update of milestone accomplishments since submittal of the last status report, including any changes to the compliance method, schedule, or need for relief/relaxation and the basis, if any.

**2 Milestone Accomplishments**

The following milestone(s) have been completed since the February 28, 2014 status report (Reference 7) and are current as of August 01, 2014.

- A contract has been awarded for the purchase of the portable FLEX generators.

**3 Milestone Schedule Status**

The following provides an update to Attachment 2 of the Overall Integrated Plan (Reference 1). It provides the activity status of each item, and whether the expected completion date has changed. The dates are planning dates subject to change as design and implementation details are developed.

The need for relief/ relaxation on site implementation of Order EA-12-049 is provided in Section 5 of this enclosure.

**Milestone Schedule**

**Site: Limerick Generating Station**

<b>Activity</b>	<b>Target Completion Date</b>	<b>Activity Status</b>	<b>Revised Target Completion Date</b>
Submit 60 Day Status Report	October 2012	Complete	
Submit Overall Integrated Plan	February 2013	Complete	
Contract with National SAFER Response Center	October 2012	Complete	
<b>Submit 6 Month Updates:</b>			
Update 1	August 2013	Complete	
Update 2	February 2014	Complete	
Update 3	August 2014	Complete with	

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Activity	Target Completion Date	Activity Status	Revised Target Completion Date
		this submittal	
Update 4	February 2015	Not Started	
Update 5	August 2015	Not Started	
Update 6	February 2016	Not Started	
Update 7	August 2016	Not Started	Not required based on April 2016 second unit live date
Submit Completion Report	April 2016	Not Started	
<b>Modification Development &amp; Implementation:</b>			
Unit 1 Modification Development (All FLEX Phases)	February 2015	Started	
Unit 1 Modification Implementation (All FLEX Phases)	April 2016	Started	
Unit 2 Modification Development (All FLEX Phases)	March 2014	Started	November 2014 (Mod implementation not affected)
Unit 2 Modification Implementation (All FLEX Phases)	April 2015	Started	
<b>Procedures:</b>			
Create Site-Specific Procedures	April 2015	Started	
Validate Procedures (NEI 12-06, Sect. 11.4.3)	February 2015	Not Started	
Create Maintenance Procedures	April 2015	Not Started	
Perform Staffing Analysis	November 2014	Not Started	
Storage Plan and Construction	April 2015	Started	
FLEX Equipment Acquisition	April 2015	Started	
Training Completion	April 2015	Started	
National SAFER Response Center Operational	December 2014	Started	

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Activity	Target Completion Date	Activity Status	Revised Target Completion Date
Unit 1 FLEX Implementation	April 2016	Started	
Unit 2 FLEX Implementation	April 2015	Started	
Full Site FLEX Implementation	April 2016	Started	

#### **4 Changes to Compliance Method**

There are no changes to the FLEX strategies identified at this time.

#### **5 Need for Relief/Relaxation and Basis for the Relief/Relaxation**

This section provides a summary of needed relief/relaxation only. The specific details will be submitted in a separate document.

NRC Order EA-12-049 requires implementation of Mitigation Strategies to include procedures, guidance, training, and acquisition, staging, or installing of equipment needed for the strategies. The Overall Integrated Plan (Reference 1) provided the Limerick Generating Station response to NRC Order EA-12-049. Reference 4 identifies that delays in implementing the Hardened Containment Vent System as required by NRC Order EA-13-109 will also affect implementation of the Mitigation Strategies Order EA-12-049 actions.

The Overall Integrated Plan (Reference 1) enclosure describes the Limerick Generating Station Mitigation Strategies that are based on venting the containment using the Hardened Containment Vent System. It also describes that a modification to install a Hardened Containment Vent System (HCVS) is required. Thus, the Limerick Generating Station NRC Order EA-12-049 response provided in Reference 1 was premised on installation and use of a Hardened Containment Vent System as required by NRC Order EA-12-050.

Upon issuance of NRC Order EA-13-109, the NRC staff changed technical and schedule requirements applicable to the Hardened Containment Vent System and rescinded the requirements of NRC Order EA-12-050.

As a result, full compliance to the Mitigation Strategies required by NRC Order EA-12-049 and described in Reference 1 for Limerick Generating Station Units 1 and 2 will not be achieved until compliance to NRC Order EA-13-109 is achieved. Relief/relaxation from the NRC Order EA-12-049 IV.A.2 requirements is required.

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Limerick Generating Station will be in compliance with the aspects of the Reference 1, Unit 1 and Unit 2 Mitigation Strategies that do not rely upon a Hardened Containment Vent System unless otherwise described.

Limerick Generating Station submitted the request for relaxation to the NRC by letter dated February 26, 2014 (Reference 8). The NRC approved the Limerick relaxation request for full compliance of NRC Order EA-12-049 by letter dated April 15, 2014 (Reference 9).

## 6 Open Items from Overall Integrated Plan and Draft Safety Evaluation

The following tables provide a summary of the open items documented in the Overall Integrated Plan or the Draft Safety Evaluation (SE) and the status of each item.

Section Reference	Overall Integrated Plan Open Item	Status
Sequence of Events (p. 8)	The times to complete actions in the Events Timeline are based on operating judgment, conceptual designs, and current supporting analyses. The final timeline will be time validated once detailed designs are completed and procedures developed.	Started
Sequence of Events (p. 7) Installed Phase 1 Equipment (p.37)	Initial evaluations were used to determine the fuel pool timelines. Formal calculations will be performed to validate this information during development of the spent fuel pool cooling strategy detailed design.	Complete with this submittal – Calculation LM-0708 documents fuel pool heat up time lines and has been posted on the eportal.
Sequence of Events (p. 7)	Analysis of deviations between Exelon's engineering analyses and the analyses contained in BWROG Document NEDC-33771P, "GEH Evaluation of FLEX Implementation Guidelines" and documentation of results was not completed and submitted with the Overall Integrated Plan (Reference 1).	Completed (Reference 4)
Identify how strategies will be deployed in all modes (p. 11)	Transportation routes will be developed from the equipment storage area to the FLEX staging areas. An administrative program will be developed to ensure pathways remain clear or compensatory actions will be implemented to ensure all strategies can be deployed during all modes of operation.  Identification of storage areas and creation of the administrative program are open items.	Started Storage Building locations for equipment have been identified and travel routes to point of use determined. A contract has been established for construction.

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Identify how the programmatic controls will be met (p. 12)	An administrative program for FLEX to establish responsibilities, and testing & maintenance requirements will be implemented.	Started. A corporate fleet-wide program has been developed and a template for site programs is in review.
Sequence of Events (p. 9)	Additional work will be performed during detailed design development to ensure Suppression Pool temperature will support RCIC operation, in accordance with approved BWROG analysis, throughout the event.	Started
Portable Equip Phase 2 (p. 50)	Complete an evaluation of the spent fuel pool area for steam and condensation.	Started
Installed Equip Phase 1 (p.47)  Portable Equip Phase 2 (p. 49)	Evaluate the habitability conditions for the Main Control Room and develop a strategy to maintain habitability.	Started Habitability conditions within the MCR and other areas of the plant will be maintained with a tool box approach limiting the impact of high temperatures with methods such as supplemental cooling, personnel rotation and/or availability of fluids. Preliminary analysis indicates that actions in the main control room will not be required until after at least 6 hours post event; this guidance will be included in site procedures.
Installed Equip Phase 1 (p.47)  Portable Equip Phase 2 (p. 50)	Develop a procedure to prop open battery room doors upon energizing the battery chargers to prevent a buildup of hydrogen in the battery rooms.	Started

Item Number	Interim Staff Evaluation Open Items / Confirmatory Actions	Status
Open Item 3.1.1.2.A	NEI 12-06 states that if power is required to move or deploy the equipment (e.g., to open	Complete with this submittal – the storage

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	the door from a storage location), then power supplies should be provided as part of the deployment. The Integrated Plan did not address whether or not power would be required to move or deploy equipment and thus this evaluation must be completed satisfactorily.	building design will not require power to open doors or move or deploy equipment. Debris removal/deployment vehicles will be stored in each robust structure.
Open Item 3.1.1.3.A	The licensee did not address actions to be taken if key instruments were lost due to a seismic event, as specified in NEI 12-06, section 5.3.3. Verify that this activity is completed satisfactorily.	Started
Open Item 3.1.2.2.A	Further review is required regarding how the licensee will address NEI 12-06 Section 6.2.3.2 deployment considerations 2, 4, 5, and 8 with respect to transient floods. This review shall include an applicable procedure review.	Complete (Reference 7)
Open Item 3.2.3.A	With regard to maintaining containment, the implementation of Boiling Water Reactor Owners Group (BWROG) Emergency Procedure Guideline (EPG)/Severe Accident Guideline (SAG), Revision 3, including any associated plant-specific evaluations, must be completed in accordance with the provisions of NRC letter dated January 9, 2014.	Started
Open Item 3.2.4.2.C	With regard to elevated temperatures in general, the licensee should provide an evaluation of the impact of elevated temperatures, as a result of loss of ventilation and/or cooling, on electrical equipment being credited as part of the ELAP strategies (e.g., electrical equipment in the RCIC pump rooms).	Complete – calculation LM-0689 previously posted on eportal documents that the currently proceduralized ventilation actions during an SBO are adequate to maintain RCIC temperatures below the EQ room limits during an ELAP event.
Open Item 3.4.A	The licensee should provide details that demonstrate the minimum capabilities for offsite resources will be met, per NEI 12-06 Section 12.2.	Started
Confirmatory Item 3.1.1.4.A	With regard to offsite resources, confirm that the licensee develops a plan that will address the logistics for equipment transportation, area set up, and other needs for ensuring the equipment and commodities to sustain the site's coping strategies.	Started

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Confirmatory Item 3.1.5.2.A	The licensee stated that the design of the storage facilities will include provisions to ensure the equipment storage facilities are not impacted by high temperatures. Confirm that this is evaluated appropriately.	Started
Confirmatory Item 3.2.1.1.A	Benchmarks must be identified and discussed which demonstrate that Modular Accident Analysis Program (MAAP) is an appropriate code for the simulation of an ELAP event at LGS, consistent with the NRC endorsement of the industry position paper on MAAP.	Complete with this submittal - LG-MISC-015, "Use of MAAP in support of FLEX Implementation" has been posted on the eportal. This information is also included as Attachment 1.
Confirmatory Item 3.2.1.1.8	Confirm that the collapsed reactor pressure vessel level remains above Top of Active Fuel and the reactor coolant system cool down rate is within technical specifications limits.	Complete with this submittal - LG-MISC-015, "Use of MAAP in support of FLEX Implementation" has been posted on the eportal. This information is also included as Attachment 1.
Confirmatory Item 3.2.1.1.C	Confirm that MAAP is used in accordance with Sections 4.1, 4.2, 4.3, 4.4, and 4.5 of the June 2013 position paper.	Complete with this submittal - LG-MISC-015, "Use of MAAP in support of FLEX Implementation" has been posted on the eportal. This information is also included as Attachment 1.
Confirmatory Item 3.2.1.1.D	Confirm that, in using MAAP, the licensee identifies and justifies the subset of key modeling parameters cited from Tables 4-1 through 4-6 of the "MAAP Application Guidance, Desktop Reference for Using MAAP Software, Revision 2" (Electric Power Research Institute Report 1 020236).	Complete with this submittal - LG-MISC-015, "Use of MAAP in support of FLEX Implementation" has been posted on the eportal. This information is also included as Attachment 1.
Confirmatory Item 3.2.1.3.A	The licensee stated that the "times to complete actions in the events timeline are based on ... current supporting analyses." Confirm that the final timeline is validated once detailed designs are completed and procedures are developed.	Future 6 month update

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Confirmatory Item 3.2.1.4.A	The licensee stated that the detailed design will determine containment heat-up rate and the subsequent impacts on RCIC operation and the need for any modifications. Confirm that this evaluation is completed satisfactorily.	Started
Confirmatory Item 3.2.1.4.8	The licensee identified two RCIC room switch set points that were above the predicted maximum temperature but pointed out that the "RCIC Equipment Room Delta Temperature High" setpoint was below that temperature at 109 °F. It is not clear whether or not any of the setpoints would have an adverse impact on the planned use of the RCIC as a mitigation strategy. Thus, further clarification is needed for this issue.	Complete (Reference 7)
Confirmatory Item 3.2.1.4.C	Because the Integrated Plan makes reference to use of the Phase 3 equipment as backup, the Integrated Plan should address the guidance of NEI 12-06 regarding site procedures for Phase 3 implementation. The licensee addressed this concern during the audit response and stated that LGS would ensure connection capabilities of the Phase 3 offsite equipment to site systems and would develop any procedural guidance required for those connections. Confirm that the connections for the Phase 3 equipment have been properly determined, once the details are finalized.	Complete with this submittal. The hose connections and electrical connections selected as part of the LGS modifications are compatible with the Phase 3 equipment provided by the National SAFER Response Center. This will allow National SAFER Response Center equipment to be connected to the LGS connection points.
Confirmatory Item 3.2.1.7.A	The licensee stated that LGS plans to abide by the generic resolution for refueling and cold shutdown conditions. The licensee stated that a review is in progress to develop a plan to address potential plant specific issues associated with implementing the generic approach. Confirm that this evaluation is completed satisfactorily.	Future 6 month update
Confirmatory Item 3.2.1.8.A	The licensee stated that the final design of the FLEX pump suction will determine if additional screens are required. Confirm that the potential for entrained debris as a result of extreme external hazards (e.g., suspended solids especially during flood conditions, or from high wind debris) in the cooling water from the spray pond is addressed.	Complete with this submittal – Calculation LM-0706 documents this review and has been posted on the eportal.



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Confirmatory Item 3.2.1.8.8	Insufficient technical information is presented or referenced in the Integrated Plan to confirm the ability of the portable FLEX pumps to deliver the required flow through the system of FLEX hoses, couplings, valves, elevation changes, etc. for the configurations described. Confirm that these evaluations are completed and documented.	Complete with this submittal – Calculation LM-0706 documents this review and has been posted on the eportal.
Confirmatory Item 3.2.2.A	The licensee stated that formal calculations will be performed to validate the timing required for supplying cooling water to the spent fuel pool. Confirm that these calculations are performed, with acceptable results.	Complete with this submittal – Calculation LM-0708 documents this review and has been posted on the eportal.
Confirmatory Item 3.2.4.2.A	It was not clear from the information presented in the Integrated Plan what analysis or technical basis was used to conclude that the battery room temperature rise is inconsequential. Also, no discussion was presented to address possible low temperature effects. Confirm the adequacy of the battery room ventilation to protect the batteries from the effects of elevated or lowered temperatures.	Started - Preliminary analysis shows forced battery room ventilation actions will not be required for approximately 24 hours after the event.
Confirmatory Item 3.2.4.2.8	The licensee stated that battery room ventilation will be addressed through procedure changes and that the proposed methods of ventilation, open doors and fans, will be confirmed during the detailed design process. Confirm that this is completed satisfactorily.	Started - Based on the computations noted above, proceduralized actions are being developed to address battery room ventilation.
Confirmatory Item 3.2.4.4.A	Confirm that the proposed communications upgrades in the licensee's communications assessment are completed as planned.	Future 6 month update
Confirmatory Item 3.2.4.5.A	The licensee stated that keys for access to the plant are available to security, the shift manager and to the radiation protection group. The licensee further stated that plant areas requiring access as part of the FLEX response, will be evaluated to determine if sufficient keys are available or if additional keys will be required. Confirm that this evaluation is completed.	Future 6 month update

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Confirmatory Item 3.2.4.6.A	According to the licensee, habitability conditions will be evaluated and a strategy will be developed for the main control room. Confirm that the strategy and associated support analyses are completed.	Started - Preliminary analysis and review indicates that actions will not be required during the first 6 hours post event.
Confirmatory Item 3.2.4.6.B	With regard to the fuel building habitability, the licensee acknowledged that the evaluation of the spent fuel pool area for steam and condensation has not yet been performed. Confirm that this evaluation is completed, and its resulting conclusions satisfactorily addressed.	Started
Confirmatory Item 3.2.4.8.A	The Integrated Plan did not provide information regarding the technical basis for the selection and size of the FLEX generators to be used in support of the coping strategies. Confirm that this evaluation is satisfactorily completed.	Complete with this submittal – generators have been ordered, ECR 14-0019, while not finalized at this time, has been completed sufficiently to confirm generator sizing.
Confirmatory Item 3.2.4.1 0.8	The licensee stated minimum limit for the dc bus voltage is 105 volts. More information is needed to understand if this minimum voltage provides for sufficient operating voltages at the device terminals to ensure proper operation in support of the strategies.	Complete (Reference 7)
Confirmatory Item 3.2.4.10.C	Although the licensee addressed the potential adverse impact from load shedding on main generator hydrogen control, the licensee needs to address any other potential adverse impacts to mitigation strategies resulting from the load shed plan.	Started

## 7 Potential Draft Safety Evaluation Impacts

There are no potential impacts to the Draft Safety Evaluation identified at this time.

## 8 References

The following references support the updates to the Overall Integrated Plan described in this enclosure.

1. Limerick Generating Station Units 1 and 2, "Overall Integrated Plan in Response to March 12, 2012 Commission Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events (Order Number EA-12-049)," dated February 28, 2013 (RS-13-022).

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2. NRC Order Number EA-12-049, "Issuance of Order to Modify Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events," dated March 12, 2012.
3. NRC Order EA-13-109, "Issuance of Order to Modify Licenses with Regard to Reliable Hardened Containment Vents Capable of Operation Under Severe Accident Conditions," dated June 6, 2013.
4. Limerick Generating Station Units 1 and 2, "First Six-Month Status Report in Response to March 12, 2012 Commission Order Modifying Licenses with Regard to Requirements for Mitigating Strategies for Beyond-Design Basis External Events (Order Number EA-12-049)." Dated August 28, 2013 (RIS 13-123).
5. Limerick Generating Station Units 1 and 2, "Interim Staff Evaluation Relating to Overall Integrated Plan in Response to Order EA-12-049 (Mitigating Strategies)" dated January 10, 2014.
6. NEI 12-06, "Diverse and Flexible Coping Strategies (FLEX) Implementation Guide," Revision 0, dated August 2012
7. Limerick Generating Station Units 1 and 2, "Second Six-Month Status Report in Response to March 12, 2012 Commission Order Modifying Licenses with Regard to Requirements for Mitigating Strategies for Beyond-Design Basis External Events (Order Number EA-12-049)." Dated February 28, 2014 (RIS 14-012).
8. Limerick Generating Station Units 1 and 2, "Request for Relaxation from NRC Order EA-12-049, "Order Modifying Licenses With Regard To Requirements For Mitigation Strategies For Beyond-Design-Basis External Events." Dated February 26, 2014 (RS-14-044)
9. Limerick Generating Station, Units 1 and 2 –Relaxation of Certain Scheduler Requirements for Order EA-12-049 "Issuance of Order to Modify Licenses with regard to Requirements for Mitigation Strategies for Beyond Design Basis External Events." Dated April 15, 2014

## **9 Attachments**

1. Attachment 1- LG-MISC-015, "Use of MAAP in support of FLEX Implementation"

STATION: Limerick

UNIT(S) AFFECTED: Unit 1 and 2

TITLE: Use of MAAP In Support of FLEX Implementation

**SUMMARY** (Include UREs incorporated):

MAAP 4.0.6 calculations (LG-MISC-012-R2) were performed to estimate the containment pressure and temperature response to a variety of extended Station Blackout (SBO) events. The NRC has requested that some additional information be provided relating to the use of MAAP for FLEX analysis as part of the periodic update to the plants response to EA-12-049. The attached information is being provided to include in the next update to EA-12-049.

☐ Review required after periodic Update☒ Internal RM Documentation☐ External RM Documentation

Electronic Calculation Data Files: N/A

**Method of Review:** ☒ Detailed ☐ Alternate ☐ Review of External DocumentThis RM documentation supersedes: N/A in its entirety.

Prepared by: Jeff Gabor

Print

Sign

Date

Reviewed by: Gary Hayner

Print

Sign

Date

Approved by: Brandon Irvin

Print

Sign

Date

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## 1.0 PURPOSE AND SCOPE

The purpose of the included information is to respond to NRC questions relating to the use of MAAP in support of the plant's response to EA-12-049. The MAAP analysis is documented separately in LG-MISC-012-R2.

## 2.0 REQUESTED INFORMATION ON THE USE OF MAAP

In response to the letter of October 3, 2013 from Jack Davis (NRR) to Joe Pollock (NEI), the following responses have been developed regarding the use of the Modular Accident Analysis Program (MAAP) for estimating accident progression timing in support of the Overall Integrated Plan for Limerick Generating Station.

- (1) From the June 2013 position paper, benchmarks must be identified and discussed which demonstrate that MAAP4 is an appropriate code for the simulation of an ELAP event at your facility.***

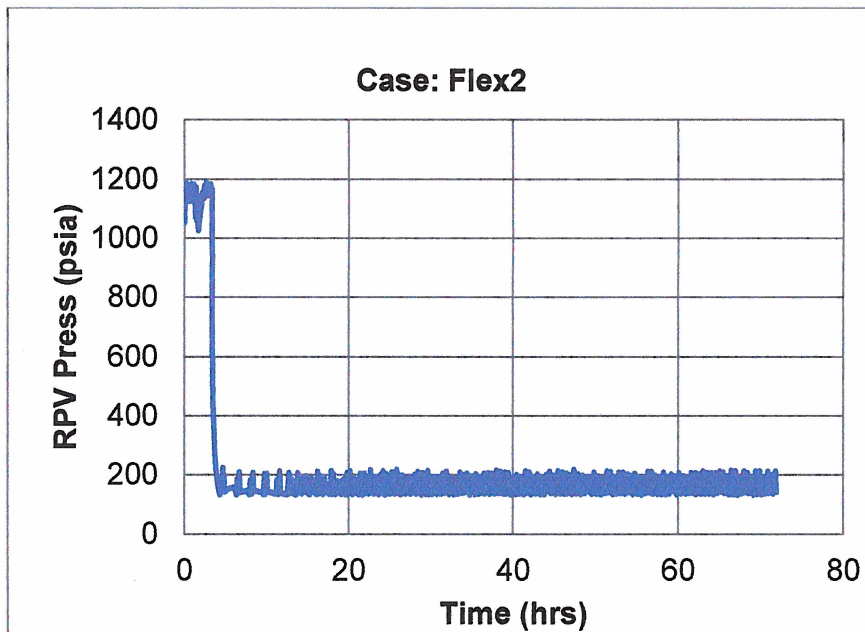
### **Response to Item 1:**

Generic response has been provided in EPRI Technical Report 3002002749, "Technical Basis for Establishing Success Timelines in Extended Loss of AC Power Scenarios in Boiling Water Reactors Using MAAP4 - A Guide to MAAP Thermal-Hydraulic Models".

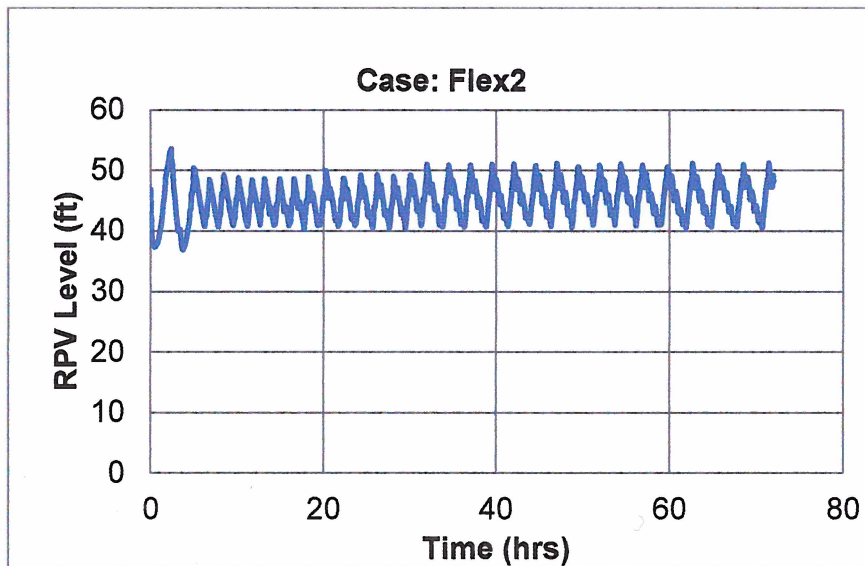
- (2) The collapsed level must remain above Top of Active Fuel (TAF) and the cool down rate must be within technical specification limits.***

### **Response to Item 2:**

Attachment 1A of the Limerick Integrated Plan (Feb 2013) states that the operators would commence a cooldown of the RPV at 20 min per E-1, SBO procedure. A controlled cooldown is identified in the SBO procedures, however, it is authorized to exceed 100 °F/hr if plant conditions require a rapid cooldown. For the MAAP analysis used to simulate the plant response, a single SRV was assumed to be opened to perform the cooldown. The following plot of the RPV pressure from the MAAP analysis confirms this cooldown.



For the representative MAAP run (Case Flex 2), RPV water level remains well above Top of active fuel (TAF) for the duration of the analysis. The plot below shows that the lowest RPV level, calculated by MAAP, was approximately 38 ft above the bottom of the reactor vessel. TAF is located at 30.5 ft for Limerick Units 1 and 2. As shown in the following plot, the collapsed RPV water level remains approximately 8' above TAF.



- (3) MAAP4 must be used in accordance with Sections 4.1, 4.2, 4.3, 4.4, and 4.5 of the June 2013 position paper.***

**Response to Item 3:**

MAAP analysis performed for Limerick was carried out in accordance with Sections 4.1, 4.2, 4.3, 4.4, and 4.5 of the June 2013 position paper, EPRI Technical Report 3002001785, "Use of Modular Accident Analysis Program (MAAP) in Support of Post-Fukushima Applications". Preparation and Review of the MAAP analysis is conducted under engineering training certification guide ENANRM08.

- (4) In using MAAP4, the licensee must identify and justify the subset of key modeling parameters cited from Tables 4-1 through 4-6 of the "MAAP4 Application Guidance, Desktop Reference for Using MAAP4 Software, Revision 2" (Electric Power Research Institute Report 1020236). This should include response at a plant-specific level regarding specific coding options and parameter choices for key models that would be expected to substantially affect the ELAP analysis performed for that licensee's plant. Although some suggested key phenomena are identified below, other parameters considered important in the simulation of the ELAP event by the vendor / licensee should also be included.***

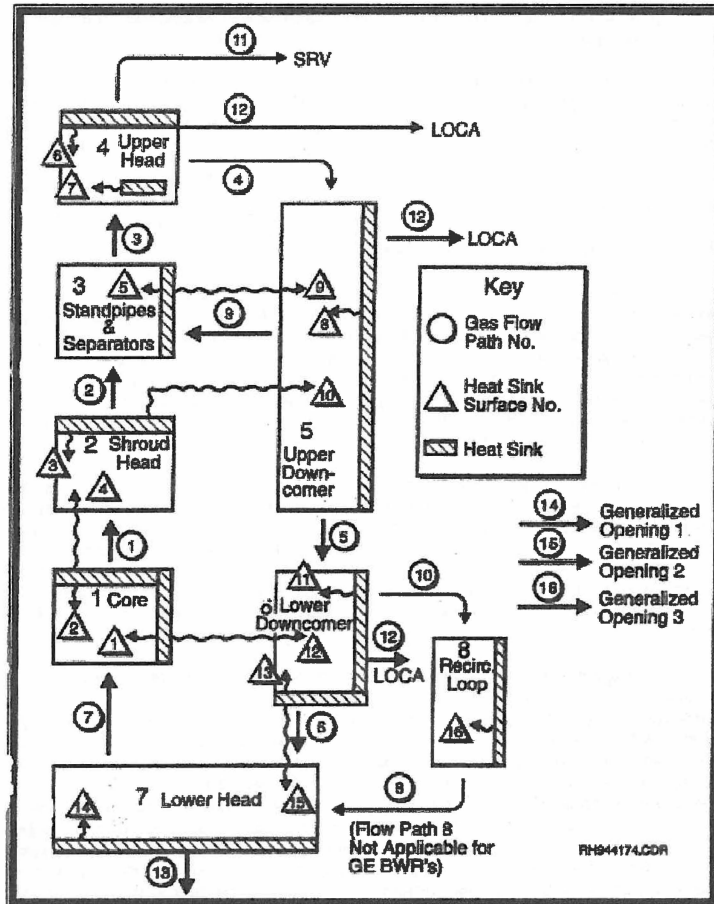
- a. Nodalization***
- b. General two-phase flow modeling***
- c. Modeling of heat transfer and losses***
- d. Choked flow***
- e. Vent line pressure losses***
- f. Decay heat (fission products / actinides / etc.)***

**Response to Item 4:**

- a. The reactor vessel nodalization is fixed by the MAAP code and cannot be altered by the user, with the exception of the detailed core nodalization. The Limerick MAAP 4.0.6 parameter file divides the core region into 7 equal volume



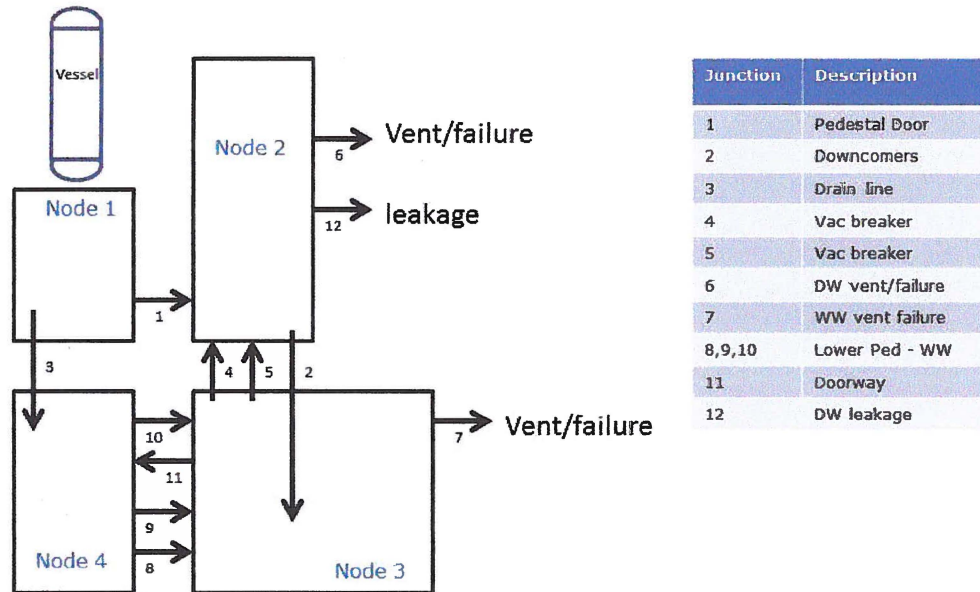
radial regions and 28 axial regions. The axial nodalization represents 25 equal-sized fueled nodes, 1 unfueled node at the top, and 2 unfueled nodes at the bottom. The figure below, taken from the MAAP User's Manual, illustrates the vessel nodalization scheme.



Containment nodalization is defined by the user. The standard nodalization scheme (as recommended in the MAAP4.0.6 sample parameter file) is used in the Limerick MAAP 4.0.6 parameter file and represents the following individual compartments:

1. Reactor pedestal region
2. Drywell
3. Wetwell (main pool)
4. Wetwell (under pedestal)

The figure below illustrates the Limerick MAAP containment nodalization along with an identification of containment flow junctions.



General two-phase flow from the reactor vessel is described in the EPRI Technical Report 3002002749. In the case of the scenario outlined in the integrated plan, flow can exit the RPV via the open SRV(s) and from the assumed recirculation pump seal leakage. Flow from the SRV(s) will be single-phase steam and flow from the recirc pump seal will be single-phase liquid due to the location of the break low in the RPV with RPV level maintained above TAF. Upon exiting the RPV, the seal leakage will flash a portion of the flow to steam based on saturated conditions in the drywell, creating a steam source and a liquid water source to the drywell. As described in the EPRI Technical Report 3002002749, "Technical Basis for Establishing Success Timelines in Extended Loss of AC Power Scenarios in Boiling Water Reactors Using MAAP4 - A Guide to MAAP Thermal-Hydraulic Models", there are two MAAP parameters that can influence the two-phase level in the RPV – FCO (void concentration factor) and FCHTUR (churn-turbulent critical velocity coefficient). The following table confirms that the parameter values match the recommended values as outlined in the EPRI Technical Report 3002002749.

PARAMETER NAME	VALUE USED IN LIMERICK MAAP ANALYSIS	EPRI RECOMMENDED VALUE
FCO	1.5248	1.5248
FCHTUR	1.53	1.53

b. Modeling of heat transfer and losses from the RPV are described in the EPRI Technical Report 3002002749. The MAAP parameters that control these processes, as defined in the EPRI report, are provided below with the values selected to represent Limerick.

PARAMETER NAME	VALUE USED IN MAAP ANALYSIS	COMMENT
QC0 – not-thru-insulation heat transfer from RPV during normal operation.	3.753E6 BTU/hr	Plant specific value based on drywell heat removal to coolers during normal operation. Typical values range between 1-2 MW.
FINPLT – number of plates in reflective insulation	8	Plant-specific value
XTINS – average reflective insulation thickness	0.3346 ft	Plant-specific value

At the request of the NRC, the following information, as used in the MAAP analysis, is provided.

PARAMETER DEFINITION	PARAMETER NAME IN MAAP	PARAMETER VALUE IN MAAP
Power level, MWth	QCR0	3517 MWT
Initial CST water volume, gal	VCST0 (ft3)	146,887 gal
Initial CST water temperature, F	HCST (enthalpy)	110 °F
Initial suppression pool water mass, lbm	Calculated from input	7,658,000 lbm
Initial suppression pool water level, ft	XWRB0(i), where i is node number for wetwell	23 ft
Initial suppression pool water temperature, F	TWRB0(i), where i is node number for wetwell	95 °F
Drywell free volume, ft3	VOLRB(i), where i is node number for drywell	243,580 ft <sup>3</sup> (does not include upper pedestal)
Wetwell free volume, ft3	VOLRB(i) – volume of suppression pool water from initial pool mass	158,253 ft <sup>3</sup>

PARAMETER DEFINITION	PARAMETER NAME IN MAAP	PARAMETER VALUE IN MAAP
Containment vent pressure, psia	Refer to MAAP analysis document	27 psia
RCIC max flow rate, gpm	WVRCIC	600 gpm
Max FLEX pump flow rate, gpm	Refer to MAAP analysis document	NA
Lowest set SRV flow rate, lb/hr	Derived from SRV area, ASRV	933,028 lbm/hr Ref: UFSAR Table 3A-3 area 0.0993 ft <sup>2</sup>
Lowest set SRV pressure, psia	PSETSV	1184.7 psia
Recirc pump seal leakage, gpm	Value that was used to define LOCA area, ALOCA	36 gpm
Total leakage used in the transient, gpm	Value that was used to define LOCA area, ALOCA	36 gpm

c. Choked flow from the SRV and the recirculation pump seal leakage is discussed in the EPRI Technical Report 3002002749. The parameters identified that impact the flow calculation are listed below with input values identified.

PARAMETER NAME	VALUE USED IN MAAP ANALYSIS	EPRI RECOMMENDED VALUE
ASRV – effective flow area for relief valve	0.0993 ft <sup>2</sup> (based on rated flow at pressure)	Plant-specific value
ALOCA – seal leakage area	5.7E-4 ft <sup>2</sup> (36 gpm at normal conditions)	Plant-specific value
FCDBRK – discharge coefficient for seal leakage	0.75	0.75

d. Vent line pressure loss can be represented in two ways. The actual piping flow area can be input along with a discharge coefficient (FCDJ). An alternative method would be to calculate the effective flow area given the estimated piping losses, and input a loss coefficient of 1.0. For the Limerick analysis, the vent area is input based on a 10" diameter pipe and a discharge coefficient of 0.75 was selected.

e. The decay heat calculation in MAAP is discussed in the EPRI Technical Report 3002002749. Input parameters used to compute the decay heat are

identified in the EPRI report and are listed in the following table along with their values used in the Limerick analysis.

PARAMETER NAME	VALUE USED IN MAAP ANALYSIS	EPRI RECOMMENDED VALUE
FENRCH – normal fuel enrichment	0.0385	Plant-specific value
EXPO – average exposure	34672.4 MW-day/ton	Plant-specific value
FCR – total capture rate of U-238 / total absorption rate	0.323	Plant-specific value
FFAF – total absorption rate / total fission rate	2.30	Plant-specific value
FQFR1 – fraction of fission power due to U-235 and PU-241	0.510	Plant-specific value
FQFR2 – fraction of fission power due to PU-239	0.405	Plant-specific value
FQFR3 – fraction of fission power due to U-238	0.085	Plant-specific value
TIRRAD – average effective irradiation time for entire core	30816 hours	Plant-specific value

***(5) The specific MAAP4 analysis case that was used to validate the timing of mitigating strategies in the integrated plan must be identified and should be available on the ePortal for NRC staff to view. Alternately, a comparable level of information may be included in the supplemental response. In either case, the analysis should include a plot of the collapsed vessel level to confirm that TAF is not reached (the elevation of the TAF should be provided) and a plot of the temperature cool down to confirm that the cool down is within tech spec limits.***

**Response to Item 5:**

The MAAP analysis performed in support of the Limerick Integrated Plan is documented in calculation LG-MISC-012 Rev. 2 and is available on the ePortal site. Case Flex 2 was the specific MAAP run selected to represent the scenario as described in Attachment 1A of the integrated plan.