ENCLOSURE 7

Preliminary Emergency Planning Zone Determination Analysis Technical Report

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Technical Report

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Approval

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REVISION HISTORY

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1 PURPOSE & SCOPE

1.1 Purpose

The purpose of this report is to apply the methodology outlined in TerraPower Topical Report "Plume Exposure Pathway Emergency Planning Zone Sizing Methodology" [1] and the criteria within Regulatory Guide (RG) 1.242, Revision 0, "Performance-Based Emergency Preparedness for Small Modular Reactors, Non-Light-Water Reactors, and Non-Power Production or Utilization Facilities" [2] to establish the site-specific plume exposure pathway (PEP) emergency planning zone (EPZ) size for the Kemmerer plant site. TerraPower Topical Report "Plume Exposure Pathway Emergency Planning Zone Sizing Methodology," hereafter referred to as the EPZ Sizing Methodology, contains the PEP EPZ sizing methodology for which U.S. Nuclear Regulatory Commission (NRC) approval is sought. This methodology provides an approach for determining a PEP EPZ size based on the area within which public dose, as defined in Title 10 of the Code of Federal Regulations (10 CFR) 20.1003, "Definitions", is projected to exceed 10 mSv (1 rem) total effective dose equivalent (TEDE) over 4 days (96 hours) from the release of radioactive materials from the facility, considering accident likelihood and source term, timing of the release sequence, and meteorology. In addition, it addresses the consideration of the area in which predetermined, prompt protective measures are necessary.

1.2 Scope

The PEP EPZ methodology uses the approach laid out in Appendix A, General Methodology for Establishing Plume Exposure Pathway Emergency Planning Zone Size, of RG 1.242, as well as supporting information from NUREG-0396, "Planning Basis for the Development of State and Local Government Radiological Emergency Response Plans in Support of Light Water Nuclear Power Plants" [3]. This report is based on the following technical considerations:

- Methodology is designed to be structured and repeatable,
- Risk-informed methods are used to determine the spectrum of release sequences to be evaluated, including internal, external, and seismic events, and
- Analysis of uncertainties.

This PEP EPZ methodology is based upon numerical inputs from probabilistic risk assessment (PRA) methodologies, source term, and radiological consequences. The associated uncertainty with each input will be quantified within their own respective assessments, however, the overall uncertainty will be addressed in the PEP EPZ analysis submitted for the operating license application.

2 SUMMARY

The results of this analysis show that the dose consequences of events associated with Kemmerer Unit 1 meet the criteria established within the EPZ Sizing Methodology to show that the boundary of the EPZ can be set at the exclusion area boundary (EAB).

3 TERMS, ACRONYMS, AND DEFINITIONS

Acronym	Term
BDBE	beyond design basis event
CFR	Code of Federal Regulations
DBA	design basis accident
DBE	design basis event
DBHL	design basis hazard level
DID	defense-in-depth
EAB	exclusion area boundary
EPA	U.S. Environmental Protection Agency
EPZ	emergency planning zone
EVHM	Ex-Vessel Handling Machine
F-C	frequency-consequence
HAA	Head Access Area
IVS	In-Vessel Storage
LBE	licensing basis event
LTA	Lead Test Assembly
MACCS	MELCOR Accident Consequence Code System
NRC	U.S. Nuclear Regulatory Commission
OQE	Other Quantified Events
PEP	Plume Exposure Pathway
PRA	probabilistic risk assessment
rem	Roentgen equivalent man
RG	Regulatory Guide
SCG	Sodium Cover Gas System
SFP	Spent Fuel Pool
SPS	Sodium Processing System
TEDE	total effective dose equivalent
ULOF	Unprotected Loss of Flow
ULOHS	Unprotected Loss of Heat Sink

4 BACKGROUND

RG 1.242 identifies one acceptable method for establishing the EPZ boundary. The EPZ Sizing Methodology used this guidance to create a methodology that meets the guidance and is specific to the Natrium design; the report was submitted to the NRC for approval.

5 ASSUMPTIONS REQUIRING VERIFICATION AND OPEN ITEMS

5.1 Assumptions Requiring Verification

There are no specific assumptions for this report. Assumptions for the inputs can be found within their associated references.

6 INPUTS

6.1 Design Inputs

The inputs required to complete the outlined methodology are the results of the PRA analysis risk integration that informed the licensing basis event (LBE) selection process. This provides the list of associated events that need to be included for assessment within this methodology.

Additionally, source terms need to be quantified to properly assess the doses from the events. The associated source terms for the events that feed directly into the radiological consequence model are quantified.

Radiological consequences for EPZ sizing evaluation are developed using MELCOR Accident Consequence Code System (MACCS). The sources terms and the list of events are used to quantify the dose results necessary to meet the requirements outlined within RG 1.242 and the EPZ Sizing Methodology. Within this radiological consequence analysis was the use of site-specific meteorological data in addition to meteorological collected at the Naughton coal plant site as a surrogate until two years of site-specific data can be collected for the final EPZ sizing calculation.

7 DISCUSSION

The primary analysis for the quantification of radiological consequences was performed utilizing the methodology outlined in the EPZ Sizing Methodology. Some bounding analyses were performed to assess whether a specific 4-day release was needed for quantification or if a bounding analysis could be performed utilizing calculated 30-day results. As such some source terms will not have calculated 4-day releases as it was assumed that if the release could not exceed the criterion specifications in the EPZ Sizing Methodology in 30-days it would not exceed them in 4 days.

Additionally, external events and events involving the transfer of spent fuel to dry cask storage are not used to develop LBEs. These events are beyond the scope of the PSAR and are not mapped to an LBE. External events are generally addressed using design basis hazard levels (DBHL). Only the seismic DBHL has phenomena not covered by other design basis accident (DBA) evaluations and an assessment was performed on its impacts. As such only a seismic DBA was assessed using a bounding event.

8 RESULTS

The PRA identified a list of events from full power, low power, refueling, and shutdown operations. The events cover the full spectrum of likely accident scenarios that can occur from the specific reactor design.

As stated in section 7, external events have not been incorporated into the PRA at this point in the design process beyond a scoping level analysis to give a general idea of the risks posed by specific external events. However, a specific conservative surrogate seismic event was used in this analysis to bound the dose consequences from seismic events. The surrogate other quantified event (OQE) is representative of the likely damage resulting from a seismic scenario, and evaluating the dose from the bounding event "VD – vessel damage" resulting in failed vessel assemblies would bound the dose associated with the seismic event.

These PRA events, including the seismic OQE, were used to identify the source terms associated with each event that would be used in the radiological dose consequence analysis. The analysis followed the methodology in the EPZ Sizing Methodology to ensure that events were selected in accordance with the EPZ methodology. All quantified source terms generated from the PRA at its current design stage ensure incorporation of the expanded event selection criteria outlined within the EPZ Sizing Methodology.

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An assessment of cliff-edge events was conducted looking at events down to the frequency of 1E-8 per reactor-year.

Three evaluations were performed for evaluating potential cliff-edge impacts as summarized below:

- Evaluation of frequency and dose margins for all LBEs using 95th percentile values
- Evaluation of frequency and dose margins for OQEs with 95th percentile frequencies in the beyond design basis event (BDBE) region
- Evaluation of highest consequence event quantified in the PRA model

The first evaluation involved evaluating the frequency and dose margins for all LBEs against the frequency-consequence (F-C) Target using 95th percentile values. All LBEs demonstrate adequate margin to the F-C Target.

The second evaluation involved evaluating the frequency and dose margins for OQEs with 95th percentile frequencies in the BDBE region. [[

]] (a)(4) All OQEs in this subset show adequate margin to the F-C target.

The final evaluation involved identifying the highest consequence event sequence modeled in the PRA. [[

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Based on the review of LBE categorization and risk significance determination for both mean and 95th percentile values, no events required cliff-edge consideration.

The source terms for the events needed for the EPZ sizing assessment were evaluated using MACCS. Events that fit the specific criterion were evaluated against each set of criterion requirements.

For the evaluation of events, first the events were assessed at the 30-day boundary doses. If the events do not exceed the criterion levels of 1 rem for the mean TEDE and 5 rem for the 95th percentile TEDE, then it is recognized that a 4-day dose would also not exceed these levels. This bounding evaluation was performed for all events to assess the exact source terms that needed to be specifically evaluated for the 4-day dose. The results of this evaluation are provided below with the specific methodology and MACCS specifics used to perform the calculations.

Table 8-1 through Table 8-9 represent calculations of the radiological consequence analysis performed for the generated source terms and are compared to the criteria identified in the EPZ Sizing Methodology to identify an adequate size of the PEP EPZ boundary.

Table 8-1: LBE Analysis Source Term Listing Information and 30-Day TEDE Results

Event Category	Source Term Name	Source Term Description (Limiting Case)	Mean 30-day EAB TEDE Dose [rem]	95th Percentile 30-day EAB TEDE Dose [rem]	Screening (In/Out)
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Event Category	Source Term Name	Source Term Description (Limiting Case)	Mean 30-day EAB TEDE Dose [rem]	95th Percentile 30-day EAB TEDE Dose [rem]	Screening (In/Out)
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9 CONCLUSIONS

As represented by the radiological consequence analysis outlined within this report, all events meet the established criteria outlined in EPZ Sizing Methodology to set the PEP EPZ boundary at the EAB for the Kemmerer site.

10 REFERENCES

[1] TerraPower LLC, NAT-3056, "Natrium Topical Report: Plume Exposure Pathway Emergency Planning Zone Sizing Methodology," Rev. 1, 2023.

[2] U.S.NRC, "Regulatory Guide 1.242, Performance-Based Emergency Preparedness for Small Modular Reactors, Non-Light-Water Reactors, and Non-Power Production or Utilization Facilities", Rev. 0.

[3] US.NRC and US.EPA, NUREG-0396 & EPA 520/1-78-016, "Planning Basis for the Development of State and Local Government Radiological Emergency Response Plans in Support of Light Water Nuclear Power Plants.", 1978.

[4] American Society of Mechanical Engineers, ASME/ANS RA-S-1.4-2021, "Probabilistic Risk Assessment Standard for Advanced Non-Light Water Reactor Licensing Basis Development.".

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