Emergency Planning and EPZ Sizing Methodology

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Outline

- Purpose and Review Request
- Overview SOLO Safety Basis - Containment Design
- Applicable Regulatory Guidance for EPZ Sizing Characterization
- Approach to EPZ Sizing Definition for SOLO
- Conclusions

Purpose and Review Request

- To engage NRC staff in a pre-submittal meeting for the White Paper related to the SOLO Microreactor Emergency Planning Zone (EPZ) Size definition
  - Provide an overview of the SOLO MMR containment design and safety features
  - Describe the proposed approach for establishing EPZ sizes for SOLO MMR design
  - Describe the impact on emergency planning based on EPZs smaller than those for LWRs
- TINN is requesting NRC review and feedbacks
  - To justify applicability of the LWR pre-existing licensing basis for SOLO implementation
  - Obtain input from the NRC, regarding the acceptability of the proposed approach for establishing EPZ sizes for the plume exposure and ingestion pathways

Applicable Regulations and Regulatory Guidance

The following documents can be applied:

- Part of 10 CFR §50 and §100 related to the EPZ size definition in terms of dose rates limits
- Regulatory guide 1.183 Revision 1 (RG 1.183 Rev.1) related to dose calculation methodology
- Regulatory guide 1.145 Revision 1 (RG 1.145 Rev.1) related to determination of site-specific relative concentrations
- EPA-400-R-92-001 "Manual of Protective Action Guides for Nuclear Incidents" related to dose limits for public and ingestion pathway for food and water protection
- NUREG-0396 related to planning for emergency preparedness around nuclear power facility

SOLO MMR Safety Basis - Containment Design

1. Functional Containment Approach in the SOLO MMR

- **Integrated Radiological Containment (IRC):**
  - The IRC serves as the functional containment boundary in the SOLO MMR, providing a radiological barrier that prevents the release of radioactive materials under normal and accident conditions.
  - The IRC is structurally designed to withstand pressure transients and thermal loads during postulated accidents.
- **Monolith as Structural Protection:**
  - The Monolith, a robust concrete biological shield, surrounds the IRC and protects it from external hazards such as seismic events, external missiles, and other off-normal conditions.
  - The Monolith also serves as a heat loss and decay heat removal system, passively dissipating heat in normal and accident scenarios, maintaining containment integrity.
- **IRC+Monolith** are functionally equivalent to a “double-containment” barrier:
  - The SOLO MMR employs a dual-barrier containment strategy composed of the IRC, which provides a sealed boundary for fission products, and the Monolith, which serves as a structural and radiological shield as well as a passive heat removal system.

SOLO MMR Safety Basis - Containment Design

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SOLO MMR Safety Basis - Containment Design

3. Containment Monitoring and Control Systems

- **Instrumentation and Control (I&C) for Containment Monitoring**:
  - I&C systems provide continuous monitoring of pressure, temperature, and radiation levels inside the containment boundary.
  - Real-time data allows for prompt detection of deviations from normal operating conditions, ensuring that containment integrity is maintained.
- **Reactor Protection System (RPS) Interface**:
  - The RPS interfaces with containment systems to initiate automatic protective actions that prevent containment breaches and mitigate the consequences of off-normal events.

4. Containment Boundary Qualification and Structural Resilience

- **Seismic and External Hazard Qualification**:
  - The Monolith and IRC are structurally qualified to withstand seismic and external dynamic loads, preventing breach of the containment boundary.
  - Containment systems are tested and qualified under extreme accident scenarios to ensure long-term structural resilience.

SOLO MMR EPZ sizing

There are several aspects of the SOLO MMR design that are important to establishing the appropriate EPZ sizes. These considerations are:

- the potential for a severe core damage accident and the potential for a large offsite release of radioactive material
- how a large offsite release is prevented through application of defence-in-depth
- the characteristics of the limiting release applied to establishing the EPZ (e.g., content and magnitude of release, timing of release)
- how uncertainties and experience with the design and technology are taken into account

Establishing the size of the EPZ is critical to determining the appropriate level of emergency planning for the SOLO MMR.

SOLO MMR EPZ sizing

Regulatory basic 10 CFR 50.34 (1)(i): “*The safety features that are to be engineered into the facility and those barriers that must be breached as a result of an accident before a release of radioactive material to the environment can occur. Special attention must be directed to plant design features intended to mitigate the radiological consequences of accidents. In performing this assessment, an applicant shall assume a fission product release from the core into the containment assuming that the facility is operated at the ultimate power level contemplated. The applicant shall perform an evaluation and analysis of the postulated fission product release, using the* ***expected demonstrable containment leak rate*** *and any fission product clean up systems intended to mitigate the consequences of the accidents, together with applicable site characteristics, including site meteorology, to evaluate the offsite radiological consequences. Site characteristics must comply with part 100 of this chapter. The evaluation must determine that:*

(1) An individual located at any point on the boundary of the ***exclusion area*** *for* ***any 2 hour period*** *following the onset of the postulated fission product release, would not receive a radiation dose in excess of* ***25 rem*** *total effective dose equivalent (TEDE).*

(2) An individual located at any point on the outer boundary of the ***low population zone****, who is exposed to the* ***radioactive cloud*** *resulting from the postulated fission product release (****during the entire period of its passage****) would not receive a radiation dose in excess of* ***25 rem*** *total effective dose equivalent (TEDE).*”

SOLO MMR EPZ sizing

Regulatory basic 10 CFR 50.47 (c)(2): "*Generally, the **plume exposure pathway EPZ** for nuclear power plants shall consist of an area about 10 miles (16 km) inradius and the ingestion pathway EPZ shall consist of an area about 50 miles (80 km) in radius. The exact size and configuration of the EPZs surrounding a particular nuclear power reactor shall be determined in relation to local emergency response needs and capabilities as they are affected by such conditions as demography, topography, land characteristics, access routes, and jurisdictional boundaries. **The size of the EPZs also may be determined on a case-by-case basis for gas-cooled nuclear reactors and for reactors with an authorized power level less than 250 MW thermal.** The plans for the ingestion pathway shall focus on such actions as are appropriate to protect the food ingestion pathway.*"

SOLO MMR EPZ sizing

Regulatory basic RG 1.145 Rev.1: *"Accordingly, this guide provides an acceptable methodology for* ***determining site-specific relative concentrations (χ/Q)*** *and should be used in determining values for the evaluations discussed in … and Regulatory Guide 1.4, "Assumptions Used for Evaluating the Potential Radiological Consequences of a Loss of Coolant Accident for Pressurized Water Reactors."*

1.3.1 Releases Through Vents or Other Building Penetrations

This class of release modes includes all ***release points or areas that are effectively lower than two and one-half times the height of adjacent solid structures*** *(Ref. 9). Within this class, two sets of meteorological conditions are treated differently, as follows:*

a. During neutral (D) or stable (E, F, or G) atmospheric stability conditions when the windspeed at the ***10-meter level*** *is* ***less than 6 meters per second****, horizontal plume meander may be considered. χ/Q values may be determined through selective use of the following set of equations for ground-level relative concentrations at the plume centerline: "*

$$\chi/Q = \frac{1}{\bar{U}_{10}(\pi\sigma_y\sigma_z + A/2)} \quad (1)$$

$$\chi/Q = \frac{1}{\bar{U}_{10}(3\pi\sigma_y\sigma_z)} \quad (2)$$

$$\chi/Q = \frac{1}{\bar{U}_{10}\pi\Sigma_y\sigma_z} \quad (3)$$

where

χ/Q *is relative concentration, in sec/m^3 ,*

π *is 3.14159.*

$\bar{U}_{10}$ *is windspeed at 10 meters above plant grade, in m/sec,*

σ_y *is lateral plume spread, in m, a function of atmospheric stability and distance (see Fig. 1),*

σ_z *is vertical plume spread, in m, a function of atmospheric stability and distance (see Fig. 2),*

Σ_y *is lateral plume spread with meander and building wake effects, in m, a function of atmospheric stability, windspeed $\bar{U}_{10}$, and distance [for distances of 800 meters or less, $\Sigma_y = M \sigma_y$, where M is determined from Fig. 3; for distances greater than 800 meters, $\Sigma_y = (M - 1) \sigma_{y800m} + \sigma_y$], and*

A *is the smallest vertical-plane cross-sectional area of the reactor building, in m^2. (Other structures or a directional consideration may be justified when appropriate.)*

SOLO MMR EPZ sizing – Public Dose Limits

Several tables in the manual (EPA-400-R-92-001) provide PAGs based on the **potential radiation dose to the public**. For the purpose of the White Paper, the distance at which the following doses will not be exceeded will be used to establish the plume exposure EPZ:

- **1 rem** total effective dose equivalent (TEDE). TEDE is the sum of the effective dose equivalent (EDE) from external radiation exposure to the plume and the committed effective dose equivalent (CEDE) from inhalation of radioactive material in the plume.
- **5 rem** committed dose equivalent (CDE) to the thyroid. CDE is determined from inhalation of iodine radioisotopes in the plume. Typically, I-131 is used as the limiting radioisotope of iodine.

Establishing the **ingestion pathway** EPZ will rely on PAGs associated with the intermediate phase (e.g., days up to about one year beyond the early phase). The “preventive” PAGs for the **protection of food and water** and the exposure of population, provided in Chapter 3 and 6 of the manual, that can be applied for the ingestion EPZ are:

- **0.5 rem** TEDE
- **1.5 rem** CDE to the thyroid

The methodology for SOLO MMR EPZ sizing

The methodology proposed for SOLO EPZ sizing will entail the following:

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- Evaluate offsite dose consequences for each accident scenario and determine the distance at which the lower limit EPA PAGs are met

SOLO MMR design target: Limit EPZ sizes to the SOLO operational boundary (the Monolith outside boundary)

SOLO MMR Emergency Planning

Regulatory basic NUREG-0396 : *"APPENDIX III RELATED ISSUES CONSIDERED BY THE TASK FORCE*

B. Issue: Is there a need to plan beyond the Low Population Zone?

Commentary

The Low Population Zone (LPZ) is determined in accordance with the requirements of NRC Reactor Siting Criteria, 10 CFR Part 100(5). While the consequences of postulated design basis accidents would be expected to be substantially lower than the guideline values of 10 CFR Part 100, there are three reasons why some planning beyond the LPZ is useful:

First, if an accidental release were as severe as the design basis releases analyzed for purposes of 10 CFR Part 100, doses could be above the Protective Action Guide (PAG) levels beyond the LPZ. In this instance, the responsible officials should take reasonable and practical measures to reduce exposures to individuals beyond the LPZ.

Second, the deposition of radioactivity, and its subsequent uptake in foodstuffs such as milk products could be significant beyond the LPZ even if the plume exposure pathway doses did not exceed the PAG level at the LPZ outer boundary, because of the reconcentration of certain radionuclides in the food chain. Emergency protective measures in that situation should be taken to minimize exposures from the food chain via the ingestion pathway.

Third, there is a very small probability that releases larger than those from design basis accidents used in evaluating the acceptability of the reactor site could occur which could have consequences substantially in excess of the PAG levels outside the LPZ outer boundary. As discussed in Issue "A" the Task Force concluded that such larger accidents should be considered in developing the basis on which emergency plans are developed.

The Task Force considered these factors in establishing the size of the emergency planning zone."

For SOLO MMR design: No specific Emergency Plan is needed for the area outside the LPZ since the dose limits for public were assumed to be met at the SOLO operational boundary**.**

White Paper Table of Contents

Conclusions

- Applicable regulatory guidance for EPZ sizing characterization was reviewed for SOLO MMR
- SOLO MMR design target: Limit EPZ sizes to the SOLO operational boundary (the Monolith outside boundary)
- A methodology to comply with regulatory guidance was outlined in this white paper

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White Paper Submittal Schedule

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Questions

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Thank You!

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