

A Study on Licensing Requirements for a Non-Light Water Micro-Reactor in Korea

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1. Introduction

In Korea, small modular reactors (SMRs) have been studied for more than 20 years. Recently, a non-Light Water Micro Reactor (non-LWMR) based on a Molten Salt Reactor (MSR) is being studied. Therefore, new licensing requirements for non-LWMR should be prepared in Korea. Since the US licensing requirements for non-LWMR or non-LWR are currently well established, they would be a good reference model to follow. In the USA, there are several pre-application documents for non-LWRs such as KP-FHR [1], Xe-100 [2] and eVinci [3], etc. Among the illustrative non-LWRs, eVinci is the only micro reactor that requires an additional document such as "Transportation and Packaging".

For the light water reactors, the core damage frequency (CDF) is a good risk metric from the regulatory point of view. However, for the non-LWR, especially for MSR or High Temperature Gas Cooled Reactor (HTGR), the CDF is not a good risk metric because it is not an acceptable concept to have a core damage. Therefore, for non-LWRs, meeting the frequency consequence (F-C) target is an important regulatory requirement as described in NEI 18-04 [4] and Regulatory Guide (R.G.) 1.233 [5].

The regulatory requirements for non-LWMR are the same as for non-LWR, and it requires additional documentation such as "Transportation and Packaging". In addition to the F-C target requirement, there are other regulatory requirements. These are discussed in detail in the next section.

2. Regulatory Requirements of Non-LWMRs

As mentioned in section "1. Introduction", the regulatory requirements for non-LWRs in the U.S. also apply to non-LWMRs. Only the "Transportation and Packaging" documentation is additionally required for non-LWMRs.

The primary regulatory requirements for non-LW SMRs are the site boundary Emergency Planning Zone (EPZ) and the F-C target requirement proposed by NEI 18-04 [4]. These are also essential requirements for the design of non-LWMRs. In addition, there are many other regulatory requirements that apply to the non-LWRs and non-LWMRs. These requirements are discussed in this section.

2.1 F-C Target

The F-C target is shown in the illustrative example as shown in Fig. 1. The event sequences of a non-LWMR should be located below or to the left of the F-C target. We can understand that the safety goal of early fatality is satisfied if the F-C target is satisfied. However, since the following other safety goal of latent cancer fatality cannot be represented in the F-C target, it should be checked separately.

"The average individual risk of latent cancer fatalities within 10 miles of the EAB shall not exceed 2×10^{-6} /plant-year based on the mean estimates of frequencies and consequences to ensure that the NRC safety goal for latent cancer fatality risk is met" [4].

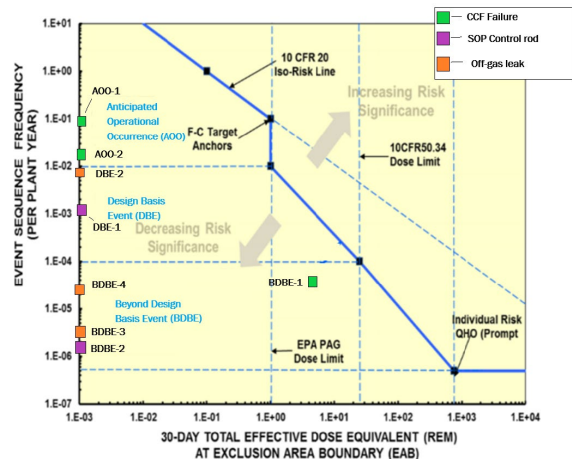


Fig. 1. MSRE accident sequences and Frequency-Consequence Target of R.G. 1.233

2.2 EPZ Setup Methodology of R.G. 1.242

R.G. 1.242 [6], which clarifies the "less" and "more" severe accidents mentioned in NUREG-0396 [7], determines the EPZ distance. For non-LWMRs, the EPZ distance could be the same as the site boundary or the Low Population Zone (LPZ), and the EPZ distance is the determining factor between them.

2.3 Regulatory Analysis

The regulations in 10 CFR should be reviewed to confirm the applicable requirements to establish the framework for the regulatory authority to review and license the non-LWMR designs.

2.4 Principal Design Criteria (PDC)

Non-LWMRs are required to describe the PDC [8] in their preliminary safety analysis report supporting a construction permit application. The General Design Criteria (GDC) in 10 CFR 50, Appendix A, provide the minimum requirements for a plant's PDC. There are SFR design criteria (DC) and MHTGR-DC. A MSR-DC will be completed in soon.

2.5 Mechanistic Source Term Verification and Validation

In the F-C curve, the correct consequence can be derived by the Mechanistic Source Term (MST). An MST computer code and its verification by experiment are necessary and important.

2.6 Safety Analysis Report (SAR)

Instead of the conventional SAR, a new format SAR [9] can be prepared that fully utilizes the results derived from the NEI 18-04 approach for non-LWMR license basis development.

2.7 Transportation and Packaging

Micro-reactors are expected to have power levels on the order of tens of megawatts thermal, and they can be fabricated in a factory, and moved to a fixed site for deployment. Thus, this requirement is necessary for non-LWMRs.

2.8 Operations and Remote Monitoring

If non-LWMRs have remote monitoring and control, or autonomous reactor operations, this requirement should be mentioned.

of latent cancer fatality which is not represented in the F-C target should be reviewed. For a short site boundary, meeting the EPZ requirement is critical.

Acknowledgement

This work was supported by Korea Research Institute for defense Technology planning and advancement(KRIT) grant funded by the Korea government(DAPA(Defense Acquisition Program Administration)) (KRIT-CT-22-017, Next Generation Multi-Purpose High Power Generation Technology(Liquid Fueled Heat Supply Module Design Technology), 2022)

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- [9] NEI, Technology Inclusive Guidance for Non-Light Water Reactors (Safety Analysis Report Content for Applicants Using the NEI 18-04 Methodology), NEI 21-07, Rev 0-B

3. Conclusions

Many regulatory requirements for non-LWMRs are discussed. First of all, the risk-informed, performance based guidance for non-LWMR licensing basis development (i.e., F-C target requirement) is a backbone in licensing requirement. A SAR is required for construction permit and operating license, and the SAR format for non-LWMRs may change to include the results that satisfy the F-C target requirement. In addition, even if the F-C Target is met, the safety goal