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Revision Log

Revision	Description of Changes
0	Initial Issue.

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Executive Summary

This white paper is intended to facilitate discussion with the NRC on appropriate methods for demonstrating compliance with GDC 33 Reactor Coolant Makeup. The design of the SMR-160 normal reactor coolant makeup methods through the Chemical and Volume Control System, in addition to safety-related makeup methods through the Passive Core Makeup Water System, is also presented for NRC familiarization. Recent NRC-approved designs are also discussed with respect to GDC 33 compliance for additional context. This white paper will also provide the opportunity for the NRC to ask any questions on the SMR-160 design. Follow on revisions to this white paper could result from discussions between Holtec and the NRC.

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1.0 INTRODUCTION

1.1 Purpose

The purpose of this white paper is to give a high-level overview of Holtec's design of the SMR-160 normal and safety-related reactor coolant makeup methods, specifically in the context of 10 CFR 50 Appendix A General Design Criteria (GDC) 33.

1.2 Objective

The objective of this whitepaper is to obtain feedback from the NRC staff on GDC 33 and understand how it applies to the SMR-160 reactor coolant makeup design.

1.3 Abbreviations

ADS	Automatic Depressurization System
CVCS	Chemical and Volume Control System
GDC	General Design Criterion
LOCA	Loss of Coolant Accident
PCCS	Passive Core Cooling System
PCMWS	Passive Core Makeup Water System
PCMWT	Passive Core Makeup Water Tank
RCPB	Reactor Coolant Pressure Boundary
RCS	Reactor Coolant System
SAFDL	Specified Acceptable Fuel Design Limit

2.0 NRC REGULATIONS

10 CFR 50 Appendix A [1] General Design Criteria 33, Reactor coolant makeup, states:

A system to supply reactor coolant makeup for protection against small breaks in the reactor coolant pressure boundary shall be provided. The system safety function shall be to assure that specified acceptable fuel design limits are not exceeded as a result of reactor coolant loss due to leakage from the reactor coolant pressure boundary and rupture of small piping or other small components which are part of the reactor coolant pressure boundary. The system shall be designed to assure that for onsite electric power system operation (assuming offsite power is not available) and for offsite electric power system operation (assuming onsite power is not available) the system safety function can be accomplished using the piping, pumps, and valves used to maintain coolant inventory during normal reactor operation.

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3.0 SMR-160 REACTOR COOLANT MAKEUP DESIGN AND COMPARISON TO OTHER RECENT DESIGNS

3.1 SMR-160

The Passive Core Cooling System (PCCS) is designed to perform emergency core cooling during design basis events. The Passive Core Makeup Water System (PCWMS), which consists of two accumulators for medium pressure water injection and two Passive Core Makeup Water Tanks (PCMWT) for low pressure water injection, is the PCCS subsystem that provides safety-related makeup water during design basis events. Automatic Depressurization System (ADS) valves in the PCCS perform timely depressurization of the Reactor Coolant System (RCS) to allow for safety-related water injection.

The SMR-160 is designed to provide normal makeup to the RCS through two parallel charging pumps located in the Chemical and Volume Control System (CVCS). Each charging pump is sized to provide sufficient makeup commensurate with a 3/8-inch equivalent break size in the reactor coolant pressure boundary (RCPB). Breaks in the RCPB below this size threshold are therefore considered a leak, and not a loss-of-coolant accident (LOCA) that would require PCCS actuation, for the SMR-160.

The CVCS does not have safety-related functions related to emergency core cooling and the inlet to the CVCS from the RCS will isolate on receipt of a safety signal to prevent letdown. The CVCS outlet to the RCS utilizes a series of swing check valves and stop check valves to prevent backflow from the RCS into the CVCS, but also allow the nonsafety-related charging pumps to provide makeup, if available, in a defense-in-depth capacity.

In the event of leakage or a break in the RCPB up to the equivalent of a 3/8-inch pipe break, the CVCS charging pumps will provide makeup to allow the plant to shut down without relying on PCCS. Should charging pumps not be available, the RCS will slowly drain. The large RCS water volume to power ratio, which is inherent in the SMR-160 design given the large steam generator and pressurizer, is capable of keeping the core within specified acceptable fuel design limits (SAFDL). Assuming the largest leakage flow rate from the 3/8-inch break size, the volume of the pressurizer would decrease over approximately 1 hour before initiating a reactor trip or safety signal on low pressurizer level or high containment pressure. PCCS would then provide emergency core cooling, including safety-related makeup water injection from the PCMWS.

3.2 NuScale

NuScale also makes use of nonsafety-related charging pumps in a CVCS to provide makeup during normal operations. However, during off-normal operations such as a small break in the RCPB when the CVCS is not available, the Emergency Core Cooling System actuates to ensure core cooling as maintained and SAFDLs are met. There is no injection of an external supply of coolant into the reactor. Therefore, NuScale requested an exemption from GDC 33 as it cannot demonstrate verbatim compliance with the regulation [2] [3]. The NRC finds that the

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NuScale design meets the underlying purpose of GDC 33 via the Emergency Core Cooling System, which ensures SAFDL protection by maintaining core inventory and coolability [4].

3.3 AP1000

Like SMR-160 and NuScale, AP1000 also uses nonsafety-related charging pumps in a CVCS to provide coolant makeup during normal operations. During off-normal operations such as small breaks in the RCPB when the CVCS in not available, Core Makeup Tanks are used for safety-related coolant injection. The inlet to these tanks is normally open to the RCS cold leg, but valves in the vessel injection discharge line prevent coolant from circulating during normal operating conditions. This allows the coolant in the tanks to cool and become denser relative to the RCS cold leg. Upon receipt of a safety signal during a small break in the RCPB, the valves actuate and allow warmer coolant to recirculate the denser inventory of the CMTs into the core without a pump, resulting in a net increase of coolant mass available in the RCS while the system is still at a high pressure [5]. All signals that align the CMTs for injection also initiate a reactor trip [6]. The NRC finds that passive systems, presumably referring to the CMTs, satisfy GDC 33. However, the nonsafety-related charging pumps in the CVCS are designed with the capability to provide makeup to the RCS following accidents such as small breaks in the RCPB [7].

4.0 REFERENCES

[1] 10 CFR 50 Appendix A, "General Design Criteria for Nuclear Power Plants".

[2] NuScale Power, LLC, "Final Safety Analysis Report, Chapter 9 Auxiliary Systems," Revision 5, July 2020.

[3] NuScale Power, LLC, "Exemptions," Revision 5, July 2020.

[4] U. S. Nuclear Regulatory Commission, "NuScale Final Safety Evaluation Report, Chapter 9 Auxiliary Systems," August 2020.

[5] Westinghouse, "AP1000 Design Control Document, Chapter 6 Engineered Safety Features, Section 6.3 Passice Core Cooling System," Revision 19, June 2011.

[6] Westinghouse, "AP1000 Design Control Document, Chapter 7 Instrumentation and Controls, Section 7.3 Engineered Safety Features," Revision 19, 2011.

[7] U. S. Nuclear Regulatory Commission, "Final Safety Evaluation Report Related to Certification of the AP1000 Standard Design (NUREG-1793, Initial Report), Chapter 9 Auxiliary Systems," September 2004.

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