UNITED STATES
NUCLEAR REGULATORY COMMISSION
ADVISORY COMMITTEE ON REACTOR SAFEGUARDS
WASHINGTON, DC 20555 - 0001

July 8, 2022

MEMORANDUM TO: Ronald G. Ballinger, Lead
SHINE License Application Review Subcommittee
Advisory Committee on Reactor Safeguards

FROM: Jose A. March-Leuba, Member
Advisory Committee on Reactor Safeguards

Jose A. March-Leuba
Digitally signed by Jose A. March-Leuba
Date: 2022.07.08 14:23:32 -04'00'

SUBJECT: INPUT FOR ACRS REVIEW OF SHINE OPERATING LICENSE - SAFETY EVALUATION FOR CHAPTER 6, ENGINEERED SAFETY FEATURES, SECTION 6B.3 "CRITICALITY SAFETY"

In response to the Subcommittee's request, I have reviewed the Nuclear Regulatory Commission (NRC) staff's safety evaluation report (SER) with no open items, and the associated section of the applicant's final safety analysis report (FSAR), for Chapter 6, Section 6b.3 "Criticality Safety." The following is my recommended course of action concerning further review of this chapter and the staff's associated safety evaluation.

Background

Chapter 6, Section 6b.3 of the SER documents the staff's review of the SHINE nuclear criticality safety (NCS) program. The applicant is licensing the facility under 10 *Code of Federal Regulations* Part 50, which assumes that some components (e.g., the core in power reactors) are critical; the safety of the facility is ensured by verifying that, for all design basis events, both the fuel and radioisotope releases maintain margin to acceptance criteria. SHINE assumes the target solution vessel (TSV) may reach criticality and documents its safety evaluation in Chapters 4 and 13 of the FSAR. For every other component in the facility, SHINE has committed to implement the more stringent criticality safety requirements of 10 CFR Part 70, which requires a 0.06 margin to criticality under all conditions. This commitment for non-TSV components is the subject of Section 6b.3.

Nuclear criticality is always an important safety consideration in all facilities containing fissile material. The SHINE facility requires special consideration because normal operation involves frequent batch operations with flow of fissile solution between containers of different geometries. Historically, criticality events have been more frequent in this type of facilities. The SHINE FSAR is aware of these potential vulnerabilities and protects against criticality by the combination of double-contingency administrative controls and the use of favorable-geometry containers.

The NCS program is designed to maintain fissile materials throughout the facility (outside the TSV) in a subcritical state during normal and credible abnormal conditions. It is consistent with applicable ANSI/ANS standards as endorsed by Regulatory Guide 3.71, Revision 3, "Nuclear

Criticality Safety Standards for Fuels and Materials Facilities," and nuclear criticality safety requirements of applicable sections of 10 CFR Part 70. The Program outlines organizational roles and responsibilities, training requirements, methods for nuclear criticality safety evaluations, and application of conservative criticality safety controls to systems and processes. It will be executed by qualified staff using written procedures.

The basis for the NCS evaluation is ensuring that all facility components (excluding the TSV) have a favorable geometry, where criticality is not possible. Some components (e.g., feed tanks) do not have favorable geometry; these are never intended to hold uranium solution and backflow is prevented by safety valves. Calculations are performed with the Monte Carlo code MCNP and evaluated nuclear data files (ENDF)/B-VII cross section libraries. To ensure favorable geometry, SHINE performs a spectrum of calculations to determine the optimal concentration and moderation. SHINE has validated their methods against a number of critical uranium solutions experiments. The calculational methods and input decks are maintained under configuration control.

Parameters important to NCS are maintained according to specifications using different instrumentation, which includes manual sampling to verify the solution concentration. When required, manual samples are collected in duplicate using diverse methods. Availability of instrumentation required by the NCS program is enforced by technical specifications.

SER Summary

The SER documents the staff's evaluation of the applicant's design for compliance with applicable regulations and standards. The NRC staff evaluated the descriptions and discussions of the SHINE's NCS Program for all components except the TSV. Based on the above determinations, the NRC staff found that the descriptions and discussions of SHINE's NCS Program are sufficient and meet the applicable regulatory requirements and guidance, and acceptance criteria, for the issuance of an operating license.

Concerns

I did not identify any specific deficiencies or concerns in my review.

Recommendation

As lead reviewer for SHINE Chapter 6, Section 6b.3, I concur with the staff's evaluation that the NCS Program is likely to be adequate to prevent criticality accidents outside the TSV. No further actions are required.

References

1. U.S. NRC, "Auxiliary Systems," Chapter 6, Section 6b.3, Staff Safety Evaluation Report, April 28, 2022 (ML22131A291).

2. SHINE Technologies, LLC, Application for Operating License, Supplement 14, Revision to the Final Safety Analysis Report, Chapter 6, Engineered Safety Features, January 26, 2022 (ML22034A641).

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Package No: ML22164A908
Accession No: ML22175A188 Publicly Available Y Sensitive N
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