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ANS

Nuclear Safety Criteria and Design Process for Sodium Fast Reactor Nuclear Power Plants

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An American National Standard

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American National Standard Nuclear Safety Criteria and Design Process for Sodium Fast Reactor Nuclear Power Plants

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Foreword

(This foreword does not contain any requirements of American National Standard "Nuclear Safety Criteria and Design Process for Sodium Fast Reactor Nuclear Power Plants," ANSI/ANS-54.1-2020, but is included for informational purposes.)

The overarching purpose of this standard is to define criteria to be satisfied for providing reasonable assurance that sodium fast reactor (SFR) nuclear power plants are designed so that they can be operated with adequate protection of the public health and safety and acceptable environmental impacts as defined by the national regulator. This purpose is achieved through the identification of applicable safety requirements from the U.S. Nuclear Regulatory Commission (NRC), industrial codes and standards, and other published guidance and professional engineering practices. It is also the purpose of this standard to define requirements for the acceptable use of probabilistic risk information in support of the design process (i.e., risk-informed design criteria). These latter requirements using risk information are optional in nature.

This standard defines safety objectives; sodium fast reactor design criteria (SFRDCs); selection criteria for licensing-basis events; and criteria for the classification of structures, systems, and components (SSCs) that can be used by designers and regulators of SFR nuclear power plants. It is intended to provide the necessary guidance to the designer in order to "bridge" the existing light water reactor (LWR)–focused general design criteria (GDCs) contained in Appendix A to 10 CFR 50 and other regulatory requirements to the development of their respective principal design criteria, while retaining the underlying safety principles of the GDCs. This standard builds on a U.S. Department of Energy (DOE)–sponsored Idaho National Laboratory report and a new NRC regulatory guide, which are discussed below.

This standard is intended to establish the details in support of the approach for licensing and regulation of SFR nuclear power plants. As with other standards that have been developed by standards development organizations, it is anticipated that this standard will be reviewed by the national nuclear regulator who will, in turn, use it as input for issuance of regulatory guidance specific for this class of reactors.

This standard applies to all SFR nuclear power plants, irrespective of level of power production and energy end use. It also applies to configurations in which there are one or more reactor units (modules) on a site. It is intended to apply to all fuel types. The heat transport system is not restricted to a particular configuration, and thus, this standard applies to loop, pool, hybrid, or other arrangements. This standard also pertains to on-site storage of spent fuel prior to its removal for recycling or long-term storage.

This standard does not directly address plant security design requirements or criteria. However, it does note the importance of integrating security into the design of the reactor to alleviate the possibility of conflicts between design and security requirements. The NRC has recently published draft security design considerations for advanced reactors. Once finalized by the NRC, these should be considered in conjunction with the safety design criteria and requirements contained in this standard. Security design requirements, including design-basis threats, are design elements to be brought into the plant design process to address licensing requirements of the national nuclear regulator. In general, both deterministic and risk-informed approaches may be considered in the plant security design process as provided by the national nuclear regulator. It is anticipated that various safety features and inherent safety characteristics together with the use of the risk-informed nuclear safety process described herein will effectively support plant security design.

The risk-informed process embedded in the requirements of this standard is voluntary rather than mandatory. It represents a departure from the approach used by professional communities familiar with traditional, deterministic LWR design processes. These communities include nuclear plant architect/engineer, nuclear licensing, and risk assessment professionals. This process presents an opportunity to extend traditional use of probabilistic risk assessment as applied to LWRs to SFRs and to incorporate risk insights early in the design process.

In addition, to designers, regulators, and the risk community, this standard provides a tool for plant operators who use design processes to maintain licensed plant designs. Some uses of this standard, such as identifying SSCs that require special treatment, apply beyond initial plant design, procurement, and construction into operations. Use of this standard for that purpose also allows plant owner/operators to specify special treatments over the life of the plant for procurement, application, testing, and maintenance commensurate with risk. This standard documents an established process that nuclear design organizations can use to develop nuclear safety designs. It is anticipated that sponsors of SFR designs will develop further specific designs with design-dependent standards that integrate these risk-informed characteristics.

An earlier version of this standard, ANS-54.1-1989, "General Safety Design Criteria for a Liquid Metal Reactor Nuclear Power Plant," was issued in 1989 and withdrawn in 1999 due to waning interest in SFRs, although two LWR counterparts, ANS-51.1/N18.2-1971, "Nuclear Safety Criteria for the Design of Stationary Pressurized Water Reactor Plants," and ANS-52.1-1978, "Nuclear Safety Criteria for the Design of Stationary Boiling Water Reactor Plants," were completed and approved much earlier (1971 and 1978, respectively). Those standards were subsequently updated in 1983, adding new risk-based classifications. However, along with the earlier ANS-54.1 standard, all remained essentially deterministic compilations of the state-of-the-art design from that era. Revived interest in SFRs spurred by the DOE and several industrial organizations, including the development in the industry of certain small modular reactor designs, has motivated the development of this new standard. Other, more detailed implementation standards are envisioned for detailed designs.

The working group that has prepared this standard was formed in 2010, and a reasonably complete draft was ready in 2014, but at that time the working group decided to put its completion in abeyance until an important effort being undertaken by the DOE and then by the NRC to develop new, broad recommendations for design criteria had reached fruition. When the DOE effort produced a useful report in late 2014, INL/EXT-14-31179, "Guidance for Developing Principal Design Criteria for Advanced (Non-Light Water) Reactors," followed by the NRC's publication of its Regulatory Guide 1.232, "Guidance for Developing Principal Design Criteria for Non-Light-Water Reactors," the working group resumed its work and completed the draft standard in 2018, beginning the American Nuclear Society's committee approval process. As noted, the SFRDCs in this standard build upon the above-cited DOE and NRC work.

Use of this standard does not supersede the responsibility to review and apply the top-level safety criteria of the regulatory authorities in the country in which the user plans to license, build, and operate a SFR. This standard may also be used to support the preparation of a SFR safety analysis report for the purpose of licensing. When used for licensing, this standard does not provide the only basis for establishing the safety and design criteria. The designer must also assess the applicability of the existing body of technical licensing requirements and guidance for nuclear plant licensing in the particular country of application. In this regard, the designer determines the applicability, partial applicability, or nonapplicability of these licensing requirements. The designer may also use this standard and other supporting standards to determine what additional licensing technical requirements are required for important technical design and safety aspects that are not addressed by the existing body of technical licensing requirements and guidance.

This standard might reference documents and other standards that have been superseded or withdrawn at the time this standard is applied. A statement has been included in the references section that provides guidance on the use of references.

This standard incorporates the concepts of generating risk-informed insights and performance-based requirements.

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