ANS Standards Activities Related to Sodium-Cooled Small Modular Reactors

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INTRODUCTION

Several sodium-cooled fast reactors (SFRs) have been designed and built in the United States. These include the Experimental Breeder Reactors I and II, the Fermi 1 Reactor, the Southwest Experimental Fast Oxide Reactor, the Fast Flux Test Facility, and the Clinch River Breeder Reactor (design only). A previous American Nuclear Society (ANS) 54.1 standard focusing on design criteria for liquid-metal reactors was issued in the 1970s but was withdrawn in 1989 when the support for the technology decreased. New designs of SFRs are being proposed as advanced small modular reactors (SMRs). They can be used for (1) electricity production, (2) process heat, (3) actinide waste disposition, and (4) resource utilization.

ANS 54.1 STANDARD

To support the development and licensing of this next generation of SMRs, an ANS standard (new ANS 54.1) is under development. The new standard defines the safety criteria and design process for an SFR.

The new ANS 54.1 Standard Working Group consists of US, Japanese, and French representatives from industry, national laboratories, consulting firms, utilities, and the Nuclear Regulatory Commission. It has 12 members, 4 technical experts, and 2 ANS associates. The chairman is Dr. G. F. Flanagan, and the vice chairman is Mr. R. Budnitz. Work on the standard was initiated in February 2010. The working group has a draft standard currently in the review process and is planning to have a draft standard available for balloting in early 2012.

The standard defines the safety objectives and general design criteria (similar to those of 10 CFR Part 50, Appendix A) for an SFR. It is also intended to define the requirements for use of technically adequate probabilistic risk information in support of design decisions, including the scope and quality of a probabilistic risk assessment (PRA). It is generic for any type of SFR design and power level, including both pool and loop designs, and metal or ceramic fuel types and includes consideration of spent fuel storage.

The standard defines qualitative regulatory and public risk requirements as well as high-level safety objectives for this type of reactor. These objectives include requirements for core damage frequency or an equivalent metric, large release frequency, 24 h containment integrity, risk management, and simplified offsite protective measures.

ANS 54.1 defines the high-level safety functions needed to accomplish key safety objectives. These functions include plant protection, core heat removal, reactivity control, maintenance of coolant inventory, residual heat removal, containment of radioactive material, containment heat removal, prevention/ mitigation of energetic core-disruptive phenomena, and response to station blackout.

It also addresses the analysis criteria necessary to meet these safety functions, including such areas as use of design codes and standards, reliability assurance of passive systems, technical adequacy of the PRA and safety analysis tools, treatment of mechanistic source terms, and treatment of uncertainties.

The design criteria are organized by safety function. Wherever possible, the general design criteria incorporated in 10 CFR Part 50, Appendix A, are used with minor wording changes to address SFR-specific design considerations. In addition, several new design criteria were added to address unique SFR issues such as sodium fires, recriticality, energetic reactions, passive safety, and spent fuel storage.

The standard also addresses risk-informed methods for selecting licensing basis events and categorization of systems, structures, and components in terms of their safety class and risk significance.