Regulation of Waste Streams from Small Modular Reactors and Advanced Reactors - 14061

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ABSTRACT

The U.S. Nuclear Regulatory Commission (NRC) is currently preparing for the submittal of several design certification applications for light-water, small modular reactors (SMRs). Additionally, over the long term, the NRC is strategically thinking about how it would approach the review of an application for a non-light-water reactor design. There are currently three light water reactor SMR vendors that are conducting pre-application interactions with the NRC, and a fourth one that has announced their intent to submit a design certification application but has not yet started interactions. These interactions include meetings to discuss technical issues as well as the agency's development of guidance to aid in the effective and efficient review of these new designs. The management of both low-level and high-level waste from these types of facilities will need to be addressed in regulatory requirements to ensure that public health and safety are protected.

INTRODUCTION

Reactor designers are currently developing a number of small light-water reactor (LWR) and non-LWR designs employing innovative solutions to technical nuclear power issues. These small modular reactor (SMR) designs could be used to replace older coal-fired generating stations, for generating electricity in isolated areas, or producing high-temperature process heat for industrial purposes. The U.S. Nuclear Regulatory Commission (NRC) expects to receive design certification applications for some of these designs for staff review beginning in the spring of 2014.

The NRC has developed its current regulations on the basis of experience gained over the past 40 years from the design and operation of large light-water reactor facilities. Now, to facilitate the near-term licensing of new reactor designs that differ from the current generation of large LWR facilities, the NRC staff seeks to resolve key safety and licensing issues and develop a regulatory infrastructure to support licensing review of these unique reactor designs. The management of both low-level and high-level waste

from these types of facilities will need to be properly addressed to ensure that regulatory requirements are met and that public health and safety are protected.

DISCUSSION

Small Light-Water Reactors

There are currently three light water reactor SMR vendors that are conducting pre-application interactions with the NRC. These vendors are B&W, Westinghouse, and NuScale, each of which are proposing reactors that are less than 300 MWe, can be mainly constructed in a factory and then transported to the site location, and have several passive safety features. The pre-application interactions include multiple meetings to discuss technical issues as well as the agency's development of Design Specific Review Standards (DSRS), which are technology-specific guidance that will aid in the effective and efficient review of these new designs.

The DSRS serves the same purpose and function as a Standard Review Plan for SMR applications. In order to generate the DSRS, the NRC first reviewed the current Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants: LWR Edition (NUREG-0800), which provides guidance to the NRC staff on what should be evaluated when reviewing license applications. The staff then developed new review guidance based on the SRP, where appropriate, to make it more performance-based and technology-specific and to ensure that these new reactor designs were properly assessed against the NRC requirements. Drafts of the DSRS's are released for public comment, and then finalized for use by both the applicant and the staff. It is important to note that the waste stream regulatory requirements (e.g., 10 CFR Part 20) for these new designs have not been revised; only the guidance that indicates how the regulations can be met has been revised to be more performance-based and technology-specific. The regulatory requirements remain the same as for other reactor designs.

The draft DSRS for B&W was released for public comment in May 2013. Several sections address waste handling and storage, and will provide guidance to the NRC staff on what to focus on when reviewing the proposed waste management systems for the SMR, which may be different than current systems because of unique approaches within the technical design. For example, Section 11.4 addresses the solid waste management system and Section 9.1.2 addresses new and spent fuel storage. In addition, the Appendix to Section 11.4 is titled "Design Guidance for Temporary Storage of Low-Level Radioactive Waste."

The DSRS for the solid waste management system for the mPower design addresses the systems that manage liquid, wet, and dry solid wastes, produced during normal operation and anticipated operational occurrences. It provides guidance for reviewing the design features that are necessary for collecting, handling, processing, and storing of wastes in facilities that are part of the nuclear island (e.g., radioactive waste building) or in other buildings (e.g., detached radioactive waste storage facility). Failure of the waste management system should not compromise any safety-related system or component, nor should it prevent the safe shutdown of the plant. However, the failure of specific subsystems or components may have some impacts on the means to control and monitor liquid effluent and gaseous releases and in complying with NRC regulations, and as such may have a direct impact on public health and safety. Therefore, the DSRS directs the reviewers to conduct a more detailed review than other non-safety related systems.

In July of 2013, the NRC staff sent to the Commission for consideration a revision to the waste disposal regulations in 10 CFR Part 61, “Licensing Requirements for Land Disposal of Radioactive Waste” (SECY-13-0075). This proposed rule, if approved by the Commission, will revise several requirements including: 1) updating the existing technical analysis requirements for protection of the general population (i.e., the performance assessment) to include a 10,000 year compliance period; 2) adding a new site-specific technical analysis for the protection of intruders with a 10,000 year compliance period and a dose limit of 500 mrem/yr; and 3) adding a requirement to assess impacts past 10,000 years for long-lived waste, such as depleted uranium. Part 61 would continue to apply to all low-level radioactive waste disposal licensees and license applicants that are regulated by the NRC or the Agreement States; therefore, these requirements would apply to the licensees of light-water SMRs. Any unique waste streams from these facilities would have to be evaluated by the licensee under Part 61 to determine the appropriate disposal approach. It is expected that the NRC staff will assess the licensee’s evaluation to determine whether it adequately protects public health and safety, and will issue additional guidance if needed.

As for spent fuel, several of the SMR designs will likely include fuel that is the same composition and enrichment as current operating reactors, but with significantly shorter fuel rods. This fuel design may require transportation and cask vendors to revise their designs to handle the different length of spent fuel. The vendors that have been interacting with the NRC recently plan to handle their spent fuel in the same manner as large light water reactors, with spent fuel pools and eventual dry cask storage. Although the fuel design may be shorter, the SRP was not revised to produce a DSRS for mPower for this section because the applicant has not identified any fuel features that

are so unique that they cannot be evaluated under the current SRP. If such features are identified during the application review, the staff will revise its approach appropriately.

Section 9.1.2 of the SRP addresses the capability of the new and spent fuel storage facilities to maintain the fuel in a safe and subcritical array during all anticipated operating and accident conditions. The NRC reviewers review areas such as the quantity of fuel to be stored, the effects of design loads and forces on the storage racks and storage vault, the capability to withstand natural phenomena such as tornados, and the ability to detect spent fuel pool liner leaks. It is important to note that any lessons-learned from the accident at Fukushima Dai-ichi will be addressed for SMRs using the same approach that will be used for large light waster reactors.

Non-Light Water Reactors

The term “non-LWR” encompasses a broad variety of reactor technologies and design concepts. It includes, for example, fast-spectrum-neutron and thermal-spectrum-neutron designs; solid-fuel and liquid-fuel designs; heavy-water, gas, and liquid- metal cooled designs; accelerator-driven reactors; and other technologies. Multiple non-LWR designs are being considered worldwide, with several undergoing design and development. In some cases, such designs are operational outside the U.S. In this country, several designs of non-LWR plants were constructed and operated for commercial, governmental, or test purposes in prior decades. However, at the present time, no non-LWR plant is in commercial operation in the U.S. Any advanced reactor design that uses fuel that differs significantly from the current type (zirconium-clad, low-enriched uranium dioxide) will require the evaluation of technical and regulatory approaches to the licensing of fuel fabrication, transportation, storage, and waste disposal operations.

The NRC is not currently conducting any pre-application interactions with designers of these types of reactors; as a result, the agency does not currently have detailed information regarding the types and amounts of low-level radioactive waste that would result from these types of reactors. However, Part 61 applies to all low-level radioactive waste disposal licensees and license applicants that are regulated by the NRC or the Agreement States; therefore, these requirements would apply to the licensees of non-light-water designs, including the changes currently being proposed in the revision to Part 61. Any unique waste streams from these facilities would have to be evaluated by the licensee under Part 61 to determine the appropriate disposal approach. It is expected that the NRC staff will assess the licensee’s evaluation to determine whether it adequately protects public health and safety, and will issue additional guidance if needed.

For spent fuel from non-light-water reactors, it is possible that current LWR transportation packages and storage cask designs may need to be modified to accommodate new and spent fuel for advanced LWR and non-LWR designs. Also, existing packages and cask designs may require additional testing before certification, taking into account spent fuel analysis or the new designs. New transportation package and storage cask designs would likely be needed for some non- LWR fuels. Furthermore, an updated security assessment may be required to address or bound the new fuel assembly designs.

Transportation requirements for spent nuclear fuel in NRC regulations are broad enough to address any type of radionuclide or fissile material and are not specific to any fuel type. The NRC currently issues certificates of compliance for transportation packages to transport fresh and spent power reactor and research reactor fuel that may be similar to advanced LWR and some non-LWR fuels. However, for non-LWR reactor fuel, the NRC will need to prepare for shipping these fuels on a larger scale, in addition to preparing for the review and approval of new types of fuel designs. Other challenges may face the NRC with respect to licensing or certifying transportation packages for these reactors. For example, some reactor designers have expressed interest in shipping modular reactors as fully fueled units, and some reactor designs may use nonradioactive hazardous materials that may also need to be shipped, such as sodium for SFRs.

Spent nuclear fuel storage regulations in 10 CFR Part 72 are generally broad enough to address new types of fuel associated with advanced reactor designs. However, minor modifications may be necessary to address new design features from any new class of cask storage technologies associated with advanced reactor fuels. The NRC would need to evaluate the adequacy of new storage cask designs for onsite storage of advanced LWR and non-LWR fuel designs and any other radioactive components not previously reviewed as part of the current LWR technology. The NRC would consider how cask designs may be affected by different discharge and loading operations, since discharged fuel may not be housed in traditional spent fuel pools. Other challenges may involve stacking spent fuel for non-LWRs during refueling operations, as well as detecting, segregating, and processing damaged fuel.

For spent fuel and high-level waste disposal, the NRC staff expects that the use of a risk-informed, performance-based framework would provide adequate flexibility to accommodate geologic disposal of alternate waste forms arising from non-LWR fuel cycles.

CONCLUSIONS

For the future licensing reviews of small modular reactors and advanced non-light-water reactor designs, the NRC expects that the current regulations regarding both low-level waste and spent fuel management are broad enough that they can be applied to the waste from these new types of designs. The NRC encourages all potential applicants, during the design process, to consider the waste streams that will be generated by their facilities in order to provide early identification of any unique issues. During the licensing review process, the NRC will evaluate the estimated waste streams to confirm that their management and disposal are conducted in such a way as to protect public health and safety.