

CHAPTER 12, "RADIATION PROTECTION," OF THE KHNP'S APR1400 DCD

NRC Audit Team

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1.0 SUMMARY

On August 10, 2015, through August 14, 2015, the U.S. Nuclear Regulatory Commission (NRC) staff conducted an audit of the Advanced Power Reactor (APR) 1400 source term calculations. The plan for the audit is available in the Agencywide Documents Access and Management Systems under accession number ML15208A492. During the audit, the NRC staff reviewed the applicant's calculations via the applicant's Electronic Reading Room. The objective of the audit was to review the applicant's radiation source term calculations to determine if they were consistent with the guidance provided in NUREG-0800, Chapter 12, and that the assumptions used in developing the source terms were appropriate, and that the calculations were adequate. Specifically, the staff reviewed the applicant's source terms used for radiation shielding and zoning, equipment qualification, and airborne activity concentrations to ensure they were based on adequate assumptions and an assumed 0.25 percent failed fuel fraction, as specified in the SRP.

2.0 BASIS

The NRC staff issued Request for Additional Information (RAI) 7856, Question 12.02-2, requesting that the applicant provide the methods, models, and assumptions used as the basis for the source terms in final safety analysis report (FSAR) Section 12.2.

The regulatory basis for the audit was to ensure that the requirements of Title 10 of the *Code of Federal Regulations* (10 CFR) 52.47(a)(5) and 10 CFR Part 50, Appendix A, General Design Criteria (GDC) 61 are met. 10 CFR 52.47(a)(5) requires that the FSAR contain the kinds and quantities of radioactive material and the means for controlling and limiting radioactive effluents and radiation exposures within the limits set forth in 10 CFR Part 20. GDC 61 requires, in part, that the fuel storage and handling, radioactive waste, and other systems which may contain radioactivity be designed to assure adequate safety under normal and postulated accident conditions, with suitable shielding for radiation protection, and with appropriate containment, confinement, and filtering systems.

The audit was needed in order for the staff to evaluate the methods, models, and assumptions used by the applicant to develop the radiation sources during normal operation and for staff to conclude that the radioactive source terms are acceptable for use in the shielding analysis, determining airborne concentrations, equipment qualification, and other aspects in FSAR Chapters 11 and 12. Therefore, the staff began auditing the material.

3.0 OBSERVATIONS AND RESULTS

During the audit, the staff reviewed the applicant's radiation source term information for radiation sources in the plant in order to ensure that the in plant radiation sources were adequate and consistent with the criteria in the Standard Review Plan (SRP) 12.2.

The DAMSAM code was used by the applicant to calculate the design basis reactor coolant system (RCS) source terms used as the starting basis for the other plant source terms. The DAMSAM code calculates RCS concentrations based on key core and RCS parameters. While the staff did not perform a detailed review of the DAMSAM code, the code methodology appeared similar to the methodology used in other codes to calculate RCS source terms and the resulting source terms from the DAMSAM code were consistent with similar pressurized water reactor (PWR) designs. Therefore, the RCS source terms were considered acceptable. The staff's review consisted mostly of the source terms downstream of the RCS.

The sources downstream of the RCS were calculated using the Shield-APR code and the DIJESTER code. These codes use the RCS radionuclide concentrations calculated with the DAMSAM code, along with operational parameters (such as flow rates, decontamination factors, holdup times, etc.) to calculate the radionuclide source terms of major plant components, to determine the radiation shielding, zoning, and equipment qualification requirements for equipment in different areas. In reviewing the Shield-APR code manual, the staff noted that the Shield-APR code did not appear to consider the buildup of radionuclide daughter progeny within each of the source terms it was calculating. The applicant later verified that the Shield-APR code did not consider daughter progeny, except for Ba-137m, which was considered to have the same activity as its parent Cs-137. It is reasonable to assume that Ba-137m has the same activity as Cs-137 in the different component source terms because these radionuclides would be in equilibrium and would be expected to have approximately the same activity. However, not considering the daughter progeny of other radionuclides could result in an underestimation of the radionuclide concentrations in components.

The staff did not review the DIJESTER code as part of the audit. The DIJESTER code was used only to determine the radionuclide inventory of the liquid waste management system components. While the staff did not review the code, the staff's confirmatory calculations indicated that the liquid waste management system source terms do appropriately consider radionuclide daughters and are calculated appropriately, when the appropriate assumptions are made for each component.

The staff also reviewed the applicant's calculation packages for calculating the source terms for some of the individual components in the plant. This included the assumptions made in calculating the source terms and/or the input parameters into the source term codes. Many of the assumptions made for individual components were appropriate. However, many of the liquid tanks located throughout the plant were only considered to be filled to a fraction of its total capacity in calculating the source terms. For example, the chemical and volume control system Holdup Tank was only considered to be filled to 12.5 percent of the tanks total volume. This was also confirmed by reviewing the applicant's response to Request for Additional Information (RAI) 7856, which was being reviewed at approximately the same time as the audit material. Since NUREG-0800 indicated that the plant zoning (and therefore, the source terms and plant shielding) should be based on the maximum source terms, the staff determined that the assumptions made for these tanks was inadequate.

It was also unclear to the staff, if some of the assumptions made for calculating airborne radioactivity were reasonable or appropriate. Therefore, the staff asked numerous questions related to airborne radioactivity source terms, which are being tracked in the staff's FSAR.

Other audit findings included that the calculation package for the liquid waste management system was based on an average RCS concentration of 44 percent since the liquid waste management system receives inputs from numerous waste streams. While the assumptions made were reasonable for long term liquid waste management system operation and the cumulative radionuclide building in demineralizers over time, they were not appropriate for the monitor tank source term, since those tanks could be filled with RCS activity concentrations processed over a short period of time.

As a result of the audit, the staff issued several RAIs. Some of these include: 1) RAI 8247, Question 12.02-15, requesting the applicant to provide additional source term assumptions in the FSAR; 2) RAI 8247, Question 12.02-17, requesting the applicant to update the monitor tank source term, based on the liquid waste management system processing full RCS activity fluid and to provide additional information on the liquid waste management system source terms in the FSAR; 3) RAI 8420, Question 12.02-22, requesting the applicant to revise the source terms of various tanks in the plant to consider the tanks filled to their full capacity, as well as other source term questions; 4) RAI 8090, Question 12.02-13, and RAI 8420, Question 12.02-23, requesting the applicant to update the source terms to include the contribution of daughter progeny or to justify not including them.

These RAIs, as well as other RAIs related to in-plant radiation sources, are being tracked under Section 12.2 of the staff's safety evaluation report.

4.0 CONCLUSION

As indicated above, the staff had numerous RAIs related to source terms. The results of the staff's review of these RAI responses, as well as any changes made to the source term calculations and associated FSAR information, will be documented in Section 12.2 of the staff's SER.