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Rankings of Nuclide Importance in Spent Fuel for Shielding Applications

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ABSTRACT

The radionuclide characteristics of light-water-reactor (LWR) spent fuel play key roles in the design and licensing activities for radioactive waste transportation systems, interim storage facilities, and the final repository site. Several areas of analysis require detailed information concerning the time-dependent behavior of radioactive nuclides including (1) neutron/gamma-ray sources for shielding studies, (2) fissile/absorber concentrations for criticality safety determinations, (3) residual decay heat predictions for thermal considerations, and (4) curie and/or radiological toxicity levels for materials assumed to be released into the ground/environment after long periods of time. The crucial nature of the radionuclide predictions over both short and long periods of time has resulted in an increased emphasis on thorough validation for radionuclide generation/depletion codes.

Current radionuclide generation/depletion codes have the capability to follow the evolution of some 1600 isotopes during both irradiation and decay time periods. Of these, typically only 10 to 20 nuclides dominate contributions to each analysis area. Thus a quantitative ranking of nuclides over various time periods is desired for each of the analysis areas of shielding, criticality, heat transfer, and environmental

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dose (radiological toxicity). These rankings should allow for validation and data improvement efforts to be focused only on the most important nuclides.

This study investigates the relative importances of the various actinide, fission-product, and light-element isotopes associated with LWR spent fuel with respect to three analysis areas: shielding (dose rate fractions), curies (fractional curies levels), and decay heat (fraction of total watts). Rankings are presented for up to six different burnup/enrichment scenarios and at decay times from 2 to 100,000 years. Ranking plots for each of these analysis areas are presented, as well as summary tables. Summary rankings are presented in terms of high (greater than 10% contribution to the total), medium (between 1% and 10% contribution), and low (less than 1% contribution) for both short- and long-term cooling. When compared with the expected measurement accuracies, these rankings show that most of the important isotopes can be characterized sufficiently for the purpose of radionuclide generation/depletion code validation in each of the analysis areas. Because the main focus of this work is on the relative importances of isotopes associated with LWR spent fuel, some conclusions may not be applicable to similar areas such as high-level waste (HLW) and nonfuel-bearing components (NFBC).