NEUP Nuclear Energy University Program

U.S. Department of Energy

Gamma irradiation effects on the mechanical behavior of seismic protective devices

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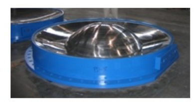
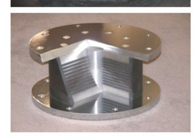
Program: PS R+D

ABSTRACT: Seismic isolation and damping devices are being considered for supporting and protecting safety-class equipment in some advanced reactor designs, wherein the devices will be placed close to the reactor vessel and exposed to gamma radiation. Such use of seismic protective devices is not addressed in current nuclear codes and standards such as ASCE 4-16 and ASCE 43-19, and by NUREG/CR-7253, which assume the devices to be installed below a reinforced concrete basemat that provides effective shielding from gamma and neutron radiation. There are no data to characterize the effect of prolonged gamma irradiation on the mechanical behavior of these safety-related devices and this project closes that gap.





This project will investigate the effect of gamma radiation of different cumulative doses on the mechanical (seismic) behavior of four protective devices: three isolators and one 3D viscodamper: see right. Three each of the four devices, two non-bonded elastomeric bearings, and cover-rubber samples will be subjected to cumulative gamma doses, preliminarily set to 1, 5, and 10 MGy, in the Foss irradiator at the Idaho National Laboratory. Pre-irradiation seismic testing will be performed on each device at the University at Buffalo (UB) to establish baseline, *global* mechanical properties needed for seismic response calculations (e.g., stiffness, damping, hysteresis). These tests will be repeated at UB after irradiation to characterize changes in these global mechanical properties as a function of increasing gamma dose. Post-irradiation experiments (PIE) at INL will utilize Raman spectroscopy and x-ray diffraction to understand physical changes at the *material* level, as a function of gamma dose, for the tested elastomers and steels, noting that changes will likely diminish with distance from the irradiated surface. The PIE at INL will complement the mechanical testing at UB to enable a re-compounding of the tested elastomers for increased gamma resistance, if needed. The work flow is organized around eight overlapping tasks. The data from the pre- and post-irradiation testing at UB and the PIE at INL will be used to a) update numerical models for protective devices in the DOE code MASTODON to account for gamma-related damage, b) underpin revisions to codes and standards, and guidelines, to accommodate gamma radiation exposure of seismic protective devices, and c) guide decisions regarding the choice of isolator and damper type based on expected gamma dosage, shielding if needed, and inspection and maintenance protocols.

The multidisciplinary team is composed of civil/structural/nuclear engineers specialized in advanced reactor design, earthquake engineering, seismic protective systems, and analysis and modeling (Whittaker, Bolisetti, Spencer, Carmichael, Peres), and radiation chemists and material scientists (Horne, Copeland-Johnson, Khanolkar, and Pu). The team will be supported by an advisory board, drawn from engineering consultancies, contractors, nuclear utilities, and advanced reactor developers, to provide additional domain expertise, broad insights, and industry connections.

Project deliverables will include reports, publications in the archival literature, presentations at ANS and ASCE meetings, and conference papers. The project will graduate one PhD students at UB. Active engagement is planned with consultants, industry, utilities, reactor developers, DOE and NRC.