

Study into the effects of radiation exposure on seismic integrity claims for a neutron detector

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ABSTRACT

The Centronic IN35D neutron detector is to be used in nuclear reactors to monitor the neutron flux from the core. Main structural components of the detector are manufactured from aluminium alloys, although other materials are also used. The detector will be irradiated by neutrons, which could have detrimental effects on the structural integrity of the detector. This is especially important for seismic events, and the detector must adhere to seismic integrity standards. The unirradiated detector passes these tests, but they have not been completed on the irradiated detector.

The main degradation mechanism for metal and ceramic materials when irradiated with neutrons is for vacancies to form in the crystal structure. This causes the materials to become embrittled and so more easily undergo brittle fracture. Research has shown that all materials can undergo embrittlement at high neutron fluences, but only nickel alloys and PTFE will undergo embrittlement at the fluences present for the operating conditions. Aluminium undergoes an increase in tensile strength of 90 to 95 MPa when irradiated at a fluence of 1×10^{21} thermal neutrons cm^{-2} . The fluence the detector is subjected to is 2.4×10^{18} neutrons cm^{-2} . Therefore, irradiation embrittlement effects are minimal.

The detector must undergo seismic qualification before use. Recommended seismic qualification testing methods for the nuclear industry exist. The neutron detector should remain fully functional during and after a design basis earthquake. Due to the small change in mechanical properties of the materials used in manufacturing the detector, it is unlikely that the irradiated detector would fail seismic integrity tests. However, due to the safety features of the neutron detector, seismic integrity tests must be completed, and a quantitative assessment of embrittlement data would not be satisfactory. Therefore, it has been recommended that testing on a similar detector be completed to qualify the Centronic IN35D neutron detector for seismic integrity claims.

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