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## International Multi-Modal Spent Nuclear Fuel Transportation Test: The Transportation Test Triathlon

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Can Spent Nuclear Fuel withstand the shocks and vibrations experienced during normal conditions of transport? This question was the motivation for the multi-modal transportation test conducted in June–October 2017. In this project the US Department of Energy (DOE) (through Sandia National Laboratories and Pacific Northwest National Laboratory) collaborated with the Equipos Nucleares SA, SME (ENSA), Empresa Nacional de Residuos Radiactivos S.A. (ENRESA), and ENUSA Industrias Avanzadas, SA SME (ENUSA) of Spain and Korea Radioactive Waste Agency (KORAD), Korea Atomic Energy Research Institute (KAERI), and Korea Electric Power Corporation Nuclear Fuel (KEPCO NF). The ENSa UNiversal (ENUN) 32P dual-purpose rail cask containing three surrogate PWR assemblies (the assemblies did not contain radioactive fuel) and 29 dummy assemblies (concrete masses) was instrumented with accelerometers and strain gauges. The basket, cask, cradle, and transportation platform were also instrumented. The accelerations and strains were measured during heavy-haul truck, ship, and rail transport, handling operations, and controlled rail tests at the Transportation Technology Center, Inc. (TTCI), a railroad testing and training facility in Pueblo, Colorado. During the test, 40 accelerometers, 37 strain gauges, and three Global Positioning System channels were used to collect 6 terabytes of data over the 54-day, 7-country, 12-state, and 8,500 miles of travel. While strains and accelerations have been measured on the exterior of transportation and storage containers, these measurements have never been collected on the fuel inside the container. The greatest strains and accelerations were observed during the testing at TTCI, specifically during the coupling test. Water transport strains and accelerations were the lowest and heavy haul and rail transport strains and accelerations were comparable. The handling tests were somewhat higher than the most extreme rail tests, except coupling. The observed strains were well below the yield points for spent nuclear fuel cladding demonstrating that the fuel can withstand the shocks and vibrations experienced during normal conditions of transport.

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#### Country or International Organization

United States of America

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