
A Comprehensive Assessment and Development of Impact Limiters for Transportation Casks

PI: Luis Ibarra – University of Utah

Collaborators: Chen Wang – University of Utah, Elmar Eidelpes – Idaho National Laboratory, Sven Bader – ORANO Federal Services LLC.

Program: Topic Area 6: Storage and Transportation Research.

ABSTRACT:

This research will develop efficient and cost-effective impact limiters, using engineered materials, for transportation casks that minimize vibration of cask internals during off-normal conditions and hypothetical accident scenarios. Transportation casks are expected to include impact limiters to significantly reduce damage to the cask internal components. However, studies are very limited, or non-existing, regarding the optimal materials and dimensions for these components. In addition, substantial knowledge gaps remain in understanding the dynamic performance of casks internals when using impact limiters. This study will first select the materials that, in addition to shock absorbing capabilities, exhibit resistance to environmental factors, particularly to thermal and irradiation exposure, exhibit stable characteristics, and can be scalable for manufacturing at a reasonable cost. Durability is also an important characteristic to be evaluated under the expectation that impact limiters could be reused many times. The closest existing material candidates will be experimentally modified using lab-scale samples for rapid development of new materials that adjust to the unique impact limiter demands. The materials tests will consist of thermomechanical characterizations at a condition that mimic in-field application, chemical resistance, fire retardancy, accelerated aging study to environmental (e.g., UV light and heat). For vibration testing, a drop hammer will be used to control dynamic loading on the scaled specimens, whereas measuring the isolation capabilities of different materials. Thereafter, the optimal design of impact limiter design will be manufactured for a scaled cask that will be subjected to several impact loading conditions to measure the stresses and strains in surrogate fuel rod cladding placed inside the scaled canister.

In parallel, finite element (FE) simulations will investigate the behavior of transportation casks when subjected to accident loading conditions. Current impact limiters are not optimized in terms of the best materials and dimensions for preventing damage to casks and their internals. For instance, the limiters should be sufficiently thick to prevent damage from most potential direct impacts in the unprotected central cask region. The cask mechanical performance will then be evaluated for several traditional and novel impact limiter configurations when exposed to accident loading conditions. The database generated from FE simulations and experimental tests will be utilized to identify the main contributors to damage of cask internal by applying machine learning methods. The experimental tests and numerical simulations will ensure that the proposed materials and impact limiter design drastically reduce the accelerations of the cask internals, without increasing other hazards, or significantly increasing costs. The impact limiters, for instance, should not increase the temperature of the cask internals, and should offer sufficient fire resistance to prevent damage to the cask during accidents that lead to high-temperature conditions.

The team has expertise on structural mechanics, spent nuclear fuel (SNF) rod performance, thermosetting polymers, thermal analysis, experimental testing under dynamic loading, nonlinear analysis, FE modeling, probabilistic risk assessment, and machine learning methodologies. The project will fund at least three graduate students and several undergraduate students who will collaborate in the FE modeling, experimental data processing, and fragility analyses.