Dynamic Simulation of Bulk Tritium Shipping Package Subjected to Internal Pressure and Sequential Impacts -ABSTRACT

The shipping packages of radioactive materials must meet the criteria for the Hypothetical Accident Conditions (HAC) specified in the Code of Federal Regulations Title 10 part 71 (10CFR 71). The scenarios of the HAC conditions occur sequentially; namely, the package first falls to a rigid surface by 30 feet, is then crushed by a 1100-pound steel plate falling 30 feet, and finally falls 40 inches to impact a bar. This paper presents a numerical technique to simulate the structural responses of the Bulk Tritium Shipping Package (BTSP) during the HAC scenarios. In addition, the BTSP containment vessel experiences the closure torque load and is also pressurized to 500 psi before the package is subjected to the sequential HAC impact loads.
The preload resulting from closure tightening is simulated by using a quasi-static approach together with the application of a uniaxial load in the connector element which links thread region of the bolt with that of the flange. After the bolt force reaches the desired value, the torque is removed and the bolt is locked to the flange. This technique of torque load simulation provides much more accurate results than the conventional method which uses the equivalent thermal load to present the body force resulting from the torque.
The structural response of the containment vessel to the internal pressure is modeled using the surface-based fluid cavity available in the ABAQUS finite-element computer program. The hydrodynamic material model which provides the volumetric strength of the air filling the containment vessel is provided by the ideal gas equation of state.
The cumulative damages of the package resulting from the sequential impacts together with the torque load and the internal pressure are predicted using the explicit integration method in the ABAQUS. The analytical results are compared with the results of the same package subjected to the same torque load and impacts except that the internal pressure is absent. The effect of the internal pressure in the containment vessel on structural responses is explored.