COMPUTATION OF NUCLEAR CONTAINMENT VESSEL RESPONSE TO IMPACT USING THE PISCES CODES

D.L. ORPHAL, N.K. BIRNBAUM
Physics International Company, San Leandro, California 94577, U.S.A.

SUMMARY

PISCES is a system of explicit finite difference computer codes. The codes solve the fundamental partial differential equations of continuum mechanics using the difference formulations of Wilkins and Noh. The PISCES system is composed of seven codes. PISCES 1DL, PISCES 2DL, and PISCES 3DL are written in the Lagrangian reference frame. PISCES 1DL and 2DL are used for geometries with one or two independent space variables. PISCES 3DL is for asymmetric geometries. PISCES 1DE, 2DE, and 3DE are analogous codes written in the Eulerian reference frame. PISCES 2DELEK is a two-dimensional code utilizing dynamically coupled Eulerian and Lagrangian grids. All the PISCES codes are capable of modeling complex geometries, time- and space-dependent boundary conditions, and space-dependent initial conditions. There are no restrictions with respect to equations of state or constitutive model.

PISCES 2DL was used to compute the response of a spherical steel containment vessel to impact on a concrete slab. The impact velocity of the hollow sphere was 392 feet per second. The steel shell had a diameter of two feet and a thickness of 5/8 inch. A linear equation of state and a strain-hardening yield model were used to describe the 304 stainless steel. Experimental data showed no impact damage to the steel-reinforced concrete target. Therefore the target was modeled with a linear equation of state and a simple Von Mises yield condition for convenience. The interaction between the sphere and target was modeled using a slide line logic with void opening and closing. The computation was performed to a time of 3 milli-seconds at which time permanent deformation was essentially complete. The computed final shell deformation compared well with available framing camera data. For example, at a time of 3 milliseconds following impact the PISCES computation showed a diametrical reduction of 4.6842 inches along the impact axis. The shell recovered from the experiment had a diametrical reduction of 4.6875 inches. Additional comparison between the computational results and experimental data are made.

Similar calculations were performed for a spherical nuclear waste container. The waste container structures studied were made of two concentric 304 stainless steel spheres. The inner sphere had an inner radius of 24 inches and a thickness of 2 inches. The outer steel shell had an inner radius of 29 inches and a thickness of one inch. The inner steel sphere was modeled as containing nuclear waste products with a nominal density of 3 682 gm/cm³. The volume between the two steel shells contained lithium hydride. Selected computational results will be presented for waste container package impact on a steel faced concrete slab at velocities ranging from 400 to 1055 feet per second.