ANALYSIS OF MECHANICAL HCDA CONSEQUENCES WITH ARES FOR DEMONSTRATION OF PRIMARY CONTAINMENT INTEGRITY IN SNR-300

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SUMMARY

The licensing of the SNR-300 reactor tank demands a vessel integrity such as to survive an HCDA. This will be demonstrated numerically using the two-dimensional finite difference computer program ARES.

The calculation of the system's structural response to a hypothetical core disruptive accident is achieved by solving the partial differential equations for hydrodynamic flow and elastic-plastic deformation, given pertinent initial and boundary conditions in Lagrangian coordinates with cylindrical symmetry. Special features needed for engineering applications include the treatment of hydrodynamic flow through perforated structures, the description of the behaviour of the top plug and associated clamping system, a one-dimensional model of the pipes to the intermediate heat exchanger system and a fuel-coolant-interaction model for the damaged core.

Other features such as slide lines, hydrodynamic flow through grid lines, a two-step integration method, artificial viscosities and rezoning options were introduced into the code for numerical reasons.

The code has been verified by analytical test cases like one-dimensional shock-tube problems for the hydrodynamics and vibrating plate problems for elastic structures. Further verification was attained from comparison with solutions gained by similar computer programs but mainly from the evaluation of explosion tests at various scales and with varying complexity. For the mechanical HCDA analysis of the primary containment for SNR-300 a variety of parametric cases has to be considered depending on e.g. the form of the pressure-volume-curve of the disrupted core zone, the material models of the structure due to thermal and irradiation embrittlement and the perforation ratio of the dip plate designed to avoid the fluid hammer effect on the top plug. From the different resulting loading and deformation characteristics the most severe cases with respect to the radial and axial response of the structures are analysed.

Detailed loading and deformation patterns are presented. The calculated data include pressure histories in the hydrodynamic regions as well as stress and strain profiles and histories in the structures of the primary vessel, top hold-down bolts and various vessel internals like shield tank, perforated dip and grid plates, core support structure and inlet plenum vessel.

From these data it can be concluded that the integrity of the primary containment in case of HCDA is ensured in SNR–300.