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EXPLICIT FINITE ELEMENT ANALYSES OF DROP TESTS WITH THIN-WALLED STEEL SHEET CONTAINERS FOR THE KONRAD REPOSITORY

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ABSTRACT

Alternatively to experimental drop tests, the mechanical safety analyses of containers for final disposal of radioactive waste with negligible heat generation in the German Konrad repository may be carried out by numerical simulations within the safety assessment procedure. In the past, safety assessments for thin-walled steel sheet containers have been done exclusively by prototype tests and unfavorable drop scenarios were determined by engineering judgment. So far, reliable numerical simulations do not exist. Therefore, a research project was started to develop numerical simulation approaches for drop test analyses and to determine existing safety margins. Comparisons of experimental and numerical results confirm that the Finite Element (FE) model represents the general mechanical behavior of the steel sheet container sufficiently. Simulations have been used to determine an unfavorable drop scenario resulting in large deformation and damage. This paper presents the investigations carried out as well as the further development of the FE model in terms of damage mechanics.

NOMENCLATURE

A	Normal distribution
A_5	Elongation at fracture
D	Dimensionless material damage parameter
E	Young's Modulus
R_m	Tensile strength
S_N	Standard derivation
f^*	Effective void volume fraction
f	Void volume fraction
f_0	Initial void volume fraction
f_c	Critical void volume fraction
f_F	Void volume fraction at failure
$\dot{f}_G$	Growth of existing voids
$\dot{f}_N$	Nucleation of new voids
h	Drop height
q_1, q_2	Gurson model parameter
t	Sheet thickness
v_0	Initial velocity
α, β	Container orientation drop angles
ε_N	Mean strain for void nucleation
$\dot{\varepsilon}^p$	Plastic strain rate
$\dot{\varepsilon}^p_{kk}$	Volumetric part of the plastic strain rate
ν	Poisson's ratio
σ_e	Equivalent von Mises stress
σ_Y	Yield stress
σ_H	Mean hydrostatic stress
ρ	Density
Φ	Yield function

INTRODUCTION

The objective of this paper is to study structural failure mechanisms in thin-walled steel sheet containers subjected to dynamic loads in drop tests representing possible accident scenarios. The container type considered is planned for the use in the German Konrad repository for final disposal of radioactive waste with negligible heat generation. The research is aimed at the development of a reliable, verified Finite Element (FE) model of thin-walled, box-shaped containers for the purpose of investigating the mechanical as well as the failure behavior in unfavorable drop scenarios. This is achieved by means of experimental drop tests and numerical simulations.

Background

Radioactive waste of various kinds is generated at different facilities, especially at nuclear power plants, within the nuclear fuel cycle, during decommissioning of nuclear installations, in nuclear medicine as well as other industries. Radioactive waste forms differ widely in physical, chemical and radiological