

Experimental and calculation investigation on severe accidents in PWR reactors

A. Quaini, C. Guéneau, S. Gossé, D. Manara

► To cite this version:

A. Quaini, C. Guéneau, S. Gossé, D. Manara. Experimental and calculation investigation on severe accidents in PWR reactors. Materials Science and Technology 2016, Oct 2016, Salt Lake City, United States. cea-02438700

HAL Id: cea-02438700 https://cea.hal.science/cea-02438700

Submitted on 27 Feb 2020

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers. L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés. DE LA RECHERCHE A L'INDUSTRI



Experimental and calculation investigation on severe accidents in PWR reactors

Andrea Quaini¹, Christine Guéneau¹, Stéphane Gossé¹, Dario Manara²

¹ Den-Service de la Corrosion et du Comportement des Matériaux dans leur Environnement (SCCME), CEA, Université Paris-Saclay, F-91191, Gif-sur-Yvette, France ² European Commission, Joint Research Centre (JRC), Safety of Nuclear Fuel Unit

CONTEXT AND PURPOSE OF THE WORK

During a severe accident in a PWR reactor, the oxide nuclear fuel (UO₂ or (U,Pu)O₂) reacts at high temperature with the zirconium alloy clad the steel control rods cladding, the neutronic absorbers (Ag-Cd-In, $B_{4}C$) and the Inconel spacer grids leading to the formation of the so-called "Invessel corium" – a mixture of solid and liquid phases – in the lower-head of the reactor vessel. Depending on several parameters, such as the U/Zr ratio and the amount of dissolved steel, the corium forms a pool in the bottom of the vessel, constituted of two liquid phases, metallic and oxide. The formation of such a configuration of the corium pool is due to the existence of a miscibility gap in the liquid state. The fractions and compositions of these liquid phases have to be well known in order to model the thermal hydraulic properties of the pool. The aim of the present work is to experimentally investigate the thermodynamic properties of the U-Pu-Zr-Fe-O system representative for the in-vessel corium to improve the thermodynamic modelling using the Calphad method. It has been shown experimentally that the oxygen potential strongly influences the liquidus/solidus curves when a UO_2 -rich mixture is considered. By thermodynamic calculations it is possible to show that Pu preferentially segregates in oxide phases regardless of the temperature.



In parallel a novel experimental setup has been developed to study prototypic corium at very high temperatures (T>2500K). This setup called ATTILHA is based on the laser heating technique coupled with aerodynamic levitation. It is adapted to investigate metallic and oxide system as well as oxide-metallic system. Recent results have been obtained on the miscibility gap of the Fe-Zr-O system.



^[1] Quaini et al. JNM 467 (2015) 660-676 ^[2] Steinwarz & Sappok, Nucl. Technol. 125 (1999) 363-370

measurements \rightarrow in-situ evidence of the formation of the miscibility gap in the Fe-Zr-O system

MS&T16, October 23-27 2016, Salt Lake City, Utah USA