

# Parametric study of 15Cr / 15Ni austenitic steels swelling behavior under irradiation using cluster dynamics

A. Vaugoude, T. Jourdan, Mh. Mathon, D. Thiaudiere, A. Legris, Y. de Carlan

► **To cite this version:**

A. Vaugoude, T. Jourdan, Mh. Mathon, D. Thiaudiere, A. Legris, et al.. Parametric study of 15Cr / 15Ni austenitic steels swelling behavior under irradiation using cluster dynamics. ICAPP 2019 International Congress on Advances in Nuclear Power Plants, May 2019, Juan Les Pins, France. cea-02339464

**HAL Id: cea-02339464**

**<https://hal-cea.archives-ouvertes.fr/cea-02339464>**

Submitted on 27 Nov 2019

**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.

## Parametric study of 15Cr / 15Ni austenitic steels swelling behavior under irradiation using cluster dynamics

A. VAUGOUDE<sup>1</sup>, T. JOURDAN<sup>2</sup>, M-H MATHON<sup>3</sup>, D. THIAUDIERE<sup>4</sup>, A. LEGRIS<sup>5</sup>, Y. DE CARLAN<sup>1</sup>

<sup>1</sup> DEN-Service de Recherches Métallurgiques Appliquées (SRMA), CEA, Université Paris-Saclay, F-91191, Gif-sur-Yvette, France

<sup>2</sup> DEN-Service de Recherches de Métallurgie Physique (SRMP), CEA, Université Paris-Saclay, F-91191, Gif-sur-Yvette, France

<sup>3</sup> DRF – Laboratoire Léon Brillouin, CEA-CNRS, Université Paris-Saclay, F-91191, Gif-sur-Yvette, France

<sup>4</sup> Synchrotron SOLEIL, St Aubin, France

<sup>5</sup> Unité Matériaux et Transformations – UMR8207 (UMET), Centre National de la Recherche Scientifique : UMR8207 – Université Lille 1 Bâtiment C6 59655 Villeneuve d'Ascq, France

E-mail: adrien.vaugoude@cea.fr

As part of the research program on generation IV reactors, CEA is developing new grades of austenitic steels for the fuel cladding of Sodium Fast Reactors (SFR). Austenitic stainless steels show excellent properties in SFR's extreme operating conditions: corrosive environment, high operating temperature (400-700 ° C) and highly energetic neutron flux. However, the appearance of the swelling phenomenon under irradiation limits cladding lifespan. The most optimized French grade is AIM1, a 15Cr-15Ni austenitic stabilized steel, which sustain doses up to 100 displacements per atom (dpa).

The objective of this study is to evaluate the impact of metallurgical parameters and the role of chemical elements on the swelling under irradiation. The findings will contribute to develop AIM2, an optimized grade, successor of the AIM1, which should be usable up to 130dpa. Swelling is a threshold phenomenon that is a consequence of the formation and growth of cavities in the material. During the irradiation, collisions between highly energetic neutrons and cladding atoms induce an equal production of void and interstitial inside the matrix. Interstitials and voids can recombine mutually, be absorbed by different sinks in the microstructure or agglomerate with defects of the same nature. In the case of swelling under irradiation, some biased sinks such as dislocation, causes to an overconcentration of vacancies. This overconcentration, in addition to helium produced by transmutation, leads to the formation of cavities inside the matrix.

The swelling heavily depends on the material's microstructure such as grain size, dislocation density, precipitation nature or chemical composition of the solid solution. Unravelling swelling mechanisms is a challenge in order to improve the AIM2 design and have a better understanding of the swelling phenomenon.

The cluster dynamics is a medium-field modeling that can describe the evolution of point defects and clusters. This approach allows to study the impact of different punctual defects and sinks populations on the swelling under irradiation. A sensitivity study of swelling with respect to nature and characteristics of nano-precipitates is conducted using CRESCENDO code [1]. The simulations are compared with the evolution of model microstructures irradiated with heavy ion (Fe3 + 2MeV) on the CEA Saclay JANNuS platform up to 120dpa.