



# **Irradiation hardening of reactor pressure vessel steels: crystal plasticity law and polycrystal full-field simulations**

Loïc Chaixa, Mihail Garajeu, Martin I Idiart, Ghiath Monnet, Pierre-Guy  
Vincent

## **► To cite this version:**

Loïc Chaixa, Mihail Garajeu, Martin I Idiart, Ghiath Monnet, Pierre-Guy Vincent. Irradiation hardening of reactor pressure vessel steels: crystal plasticity law and polycrystal full-field simulations. MECOM2022 - XXXVIII Argentinian congress on computational mechanics, MECOM, Nov 2022, Bahía Blanca, Argentina. pp.1153. irsn-03948690

**HAL Id: irsn-03948690**

**<https://irsnn.hal.science/irsnn-03948690>**

Submitted on 20 Jan 2023

**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.

Copyright

## IRRADIATION HARDENING OF REACTOR PRESSURE VESSEL STEELS: CRYSTAL PLASTICITY LAW AND POLYCRYSTAL FULL-FIELD SIMULATIONS

Loïc Chaix<sup>a,d</sup>, Mihail Garajeu<sup>a</sup>, Martín I. Idiart<sup>b</sup>, Ghiath Monnet<sup>c</sup> and Pierre-Guy  
Vincent<sup>d</sup>

<sup>a</sup>*Laboratoire de Mécanique et d'Acoustique, 4 impasse Nikola Tesla, Marseille, France*

<sup>b</sup>*Centro Tecnológico Aeroespacial / Departamento de Aeronáutica, Facultad de Ingeniería,  
Universidad Nacional de La Plata, Avda. 1 esq. 47, La Plata B1900TAG, Argentina.*

<sup>c</sup>*EDF - R&D, MMC, Avenue des Renardières, Moret sur Loing, France*

<sup>d</sup>*Institut de Radioprotection et de Sûreté Nucléaire, B.P. 3, 13115 Saint-Paul-lez-Durance Cedex, France*

**Keywords:** irradiated RPV steel, crystal plasticity, polycrystal, Fast Fourier Transform based method

**Abstract.** The context of this work is relative to the aging of vessel steels in pressurized water reactors. Due to irradiation, microstructural changes occur in these reactor pressure vessel (RPV) steels. They are the key to understand and predict the modification of the viscoplastic responses of these steels (including the so-called "irradiation hardening") and their fracture properties with irradiation. Recently, a new physically based crystal plasticity law, derived from Monnet et al. (*J Nucl Mater*, 514:128–138 (2019)), has been proposed to describe the viscoplastic behavior of neutron irradiated RPV steels. The constitutive equations have been developed from molecular and dislocation dynamics results. To ensure the validity of this new crystal plasticity law, numerical simulations have been carried out on polycrystalline microstructures, for a range of temperatures and irradiation doses. These numerical simulations have been performed using the CraFT computer code, based on a Fast Fourier Transform method (FFT based method (Moulinec and Suquet, *Comp Meth Appl Mech Engng*, 157:69–94 (1998))). The representative volume element is a polycrystal composed up to 512 grains, whose orientations have been selected by following a Sobol sequence to mimic an isotropic polycrystal while optimizing the number of grains. The different results obtained were in good agreement with experimental data.