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THE EUROPEAN EFFORT TOWARDS THE DEVELOPMENT OF A DEMO STRUCTURAL MATERIAL: IRRADIATION BEHAVIOUR OF THE EUROPEAN REFERENCE RAFM STEEL EUROFER

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Ferritic-Martensitic steels, with Chromium contents ranging between 9% and 12%, were introduced into fusion material programmes about 30 years ago, when it became evident from research in fast reactor programmes that they possessed better swelling resistance and excellent thermal properties with respect to austenitic stainless steels. Reduced Activation Ferritic-Martensitic (RAFM) steels are presently considered as primary structural materials for a demonstration fusion plant (DEMO). Nowadays, the research concentrates on the development of RAFM steels, which significantly reduce the environmental impact after the service lifetime and the broadening of the operational window towards higher temperatures. The European Fusion Long Term Programme is carried out under the coordination of EFDA (European Fusion Development Agreement) Close Support Unit located in Garching, Germany. Within the area "Materials Development", first priority is given to timely supply a structural material for breeding blankets inserted in DEMO. As these have to be tested in ITER, this material has consequently to be fully qualified also to the needs of Test Blanket Modules (TBMs). The EU reference material is a 9Cr RAFM steel, called EUROFER, which exhibitis a tempered martensitic microstructure and allows operation up to 550 °C.

Historically, one of the main issues of RAFM steels was the irradiation at temperatures lower than about 400 °C. Neutrons harden and embrittle the material, affecting both mechanical properties and fracture behaviour. Of special concern is the effect of helium on embrittlement, which is manifested in Charpy tests by an increase in the ductile-to-brittle transition temperature (DBTT) and a decrease in the Upper Shelf Energy (USE). As a consequence, EFDA devoted considerable efforts and budget to the characterization of post-irradiation mechanical and microstructural properties of EUROFER. The task "*Irradiation Performance of EUROFER*" is one of the most important within the Long Term Programme and involves numerous European research institutes. The programme in the EU is progressing with irradiations of EUROFER to a wide range of radiation damage: from 0.3 to 1.0, 3 and 5, 10, 15, 30 up to 70-80 dpa. Lowest level irradiations support the analytical study of the build–up of radiation damage in the associated modeling programme. Medium damage levels are investigated to constitute a engineering database for TBM design and the high damage levels serve for DEMO application.

The investigation of irradiation performance limits of EUROFER includes the irradiation of various product forms at different temperatures, and various post-irradiation examinations (both mechanical tests and micro-structural evaluation).

This paper presents an overview of the progress made within the irradiation task, highlighting the most significant results achieved and outlining research activities envisaged for the near future.