Fracture toughness master curve analysis of the tempered martensitic steel Eurofer97

P. Mueller\textsuperscript{a}, P. Spatig\textsuperscript{a}, R. Bonadé\textsuperscript{a} and G. Odette\textsuperscript{b}

\textsuperscript{a}EPFL-CRPP, Centre de Recherches en Physique des Plasmas, Association Euratom-Confédération Suisse, CH 5332 Villigen PSI, Switzerland

\textsuperscript{b}Department of Mechanical Engineering UCSB, UCSB, Santa-Barbara, AK 93106-5080, United States of America

pablo.mueller@psi.ch

The reduced activation tempered martensitic steel Eurofer97 is the European reference reduced activation steel for fusion applications. In this study, the fracture toughness properties of this steel are investigated in the ductile-to-brittle fracture transition region. The ASTM E-1921 master curve (equation 1 with $\alpha = 0.019$) describes well the temperature dependence of the median toughness of a variety of nuclear reactor pressure vessel steels.

\begin{equation}
K_{Jc(median)} = 30 + 70 \exp[\alpha(T - T_0)]
\end{equation}

We previously showed that fracture toughness data obtained with 0.35T compact tension specimens are not satisfactorily described by the ASTM E1921 master curve in the lower transition region, corresponding to the temperature range [-150, -100 °C]. A better statistical description of the data was done, using a modified master curve shape with a coefficient $\alpha$ equal to 0.04 and a $T_0$ value of -97 °C.

In order to confirm the different shape of the fracture toughness curve of the Eurofer97, new fracture toughness tests were carried out at higher temperatures, up to -50 °C. These new data indicate that the $K_{Jc(median)}(T)$ curve in the transition is indeed steeper than the ASTM E1921 master curve. The validation of the modified master curve is discussed in terms of: i) the statistical predictions of scatter with temperature in comparison to the experimental data and ii) a self-consistent determination of $T_0$ by performing series of single temperature $T_0$-anaysis as well as multi-temperature $T_0$-analyzes. A very good agreement between the predictions and experimental observations is found. Finally, the underlying possible physical reasons responsible for this specific fracture behavior of the Eurofer97 steel in the transition are briefly discussed in relation to its microstructure.