LIMIT ANALYSIS OF W7-X CRITICAL MAGNET SYSTEM COMPONENTS WITH CONSIDERATION OF MATERIAL SERRATION EFFECT

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The superconducting coils of W7-X are mounted on the central support ring (CSR) via two central support elements (CSE's) per coil [1]. The CSE's are bolted to extension blocks that are welded onto the coil cases. The welds between these blocks and the coil cases are highly loaded due to the electro-magnetic forces [2]. Both the coil cases and extension blocks are made of austenitic stainless steel designated EN 1.3960 (cast). As many plastic materials this steel displays serrated yielding during specimen testing at 4 K under displacement-controlled loading (Fig.1). The sudden drops of the specimen stress/force are caused by abrupt temperature rise when the material yields over significant regions because of plastic work dissipation.

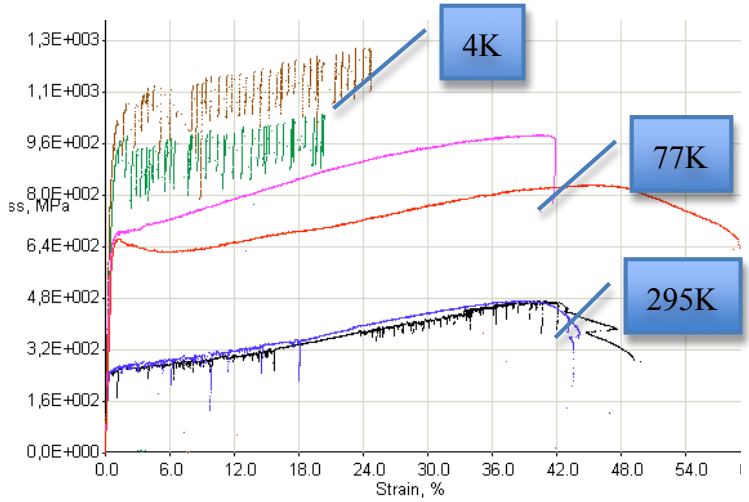

Figure 1: Examples of measured stress strain relation of stainless steel 1.3960 at 295 K, 77 K and 4 K in a deformation controlled tensile test

The objective was to determine the static load bearing capacity of critical CSE coil extension welds taking into account, in a conservative way, the serration effect. The FE models that have been developed to address this task enabled limit load analyses for different weld efficiency factors, using two different approaches for serration effect modelling. The results were compared with two extreme cases neglecting the serration effect, i.e. 4 K and RT material properties, respectively. The limit loads were estimated by predefined criteria including maximum plastic strain, the relative stiffness of the connection, and the amount of plastified material.

[1] V. Bykov, et al., Structural analysis of W7-X: Overview, Fusion Engineering and Design 84 (2009) 215–219
[2] Ł. Ciupiński, et al., Evaluation of the structural mechanical behavior of W7-X central support connections by meansof semi-automated FE analysis, Fusion Engineering and Design 84 (2009) 613-617