# LIMIT ANALYSIS OF NARROW SUPPORT ELEMENTS IN W7-X CONSIDERING THE SERRATION EFFECT OF THE STRESS-STRAIN RELATION AT 4K

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The magnet system of the Wendelstein 7-X (W7-X) nuclear fusion stellarator includes challenging components, called Narrow Support Elements (NSEs), placed between the Non Planar Coils (NPCs) and aimed at preventing major deformation of the coils themselves.
NSEs are small contact elements, with special coating to reduce friction, that have to withstand high compressive as well as shear loadings.
The objective of this activity has been to determine the structural stability of the NSEs under electromagnetic loading, taking into account in a conservative way the relevant material properties at cryogenic temperatures.

To this purpose, an appropriate detailed FE model of one NSE with its components (pad, pad frame and counter pad) and of a portion of the coils has been developed and test runs with prescribed loads and boundary conditions have been performed.
The steel as well as the Al-bronze components have been defined using the isotropic elastic-plastic material model with hardening/softening in order to include the serration effect at 4K: this phenomenon occurs in many stainless austenitic steels at cryogenic temperatures and it can cause, among other consequences, a decay of the mechanical properties.
This feature together with the contact interactions among the parts of the model and the geometric discontinuities of the NPCs has made the model strongly non linear.

The analyses have been performed with Abaqus Code and include consecutive steps concerning the physical processes of shrink fitting of the NSEs in the coils, of cooling down to 4K and of gradual increasing of displacements induced by the electromagnetic forces until failure. Failure of the structure is defined by either the percentage of local plastic strain or the percentage of average plastic strain or the change of the slope of the load-displacement curve.
A static procedure has been followed to simulate the process, but in order to overcome the numerical difficulties encountered in the implicit solution, the static response has been simulated using an explicit quasi-static solution procedure.

Keywords: W7-X, magnet-system, NSE, structural analysis, serrated yielding