MANUFACTURING DEVELOPMENT TO MEET THE MECHANICAL REQUIREMENTS OF THE ITER CENTRAL SOLENOID COILS

P. Libeyre[1], D. Bessette[1], A. Devred[1], C. Jong[1], N. Mitchell[1], S. Sgobba[2]

[1] *ITER Organization, Route de Vinon, CS 90 046, 13067 Saint-Paul-Lez-Durance Cedex - France*

[2] *CERN, CH-1211 Genève - Switzerland*

Corresponding author: paul.libeyre@iter.org

The ITER Central Solenoid (CS) includes six identical coils called modules, using a cable-in-conduit conductor, stacked upon each other and surrounded by a vertical precompression structure. When energized, these coils experience large electromagnetic forces. If the net resulting loads are transferred to the TF coils through a support structure, the internal loads have to be resisted by the coils themselves. Whereas the radial forces transfer into a tensile hoop load in the toroidal direction, the vertical forces apply a vertical compression to the coils. These loads, combining longitudinal tension with transverse compression are resisted by the conductor jacket itself, which is the main structural element of the CS coils. As plasma operation is pulsed, the design is driven by fatigue behaviour (60 000 cycles) of the CS conductor jacket.

The availability of a suitable conductor jacket material is thus a key point to achieve safe operation of the CS. This led to the early procurement of a small production of CS conductor tubes to address as well the setting up of industrial production as the mechanical characterization of the produced tubes. Two materials have been considered: a special high manganese austenitic stainless steel, developed in Japan and called JK2LB, and a modified 316LN stainless steel with very low carbon content to prevent sensitization.

The paper presents first the mechanical requirements on the CS conductor jacket derived from the mechanical analyses performed on the CS stack assembly, showing in particular which are the most critical points to meet the planned fatigue life with adequate margins. This is put in relation with the ITER design criteria and how they are handled in this particular case.

The different steps of the manufacturing sequence are then reviewed from the viewpoint of their impact on the jacket stress – strain state, showing the specificity of this manufacture. One particular aspect is the heat treatment of the wound conductor to form the Nb_3Sn, to be carried out at 600°C for a duration of around 200 h, the impact of which on the mechanical performances has to be verified.

The paper includes then a review of how the mechanical requirements have been translated into technical specifications and which are the parameters to be controlled to meet the mechanical requirements.

The characterization carried out on the prototype tube production is then presented, including destructive tests and non-destructive examination at different steps of the manufacture.
Finally, a critical assessment of the achieved parameters and their impact on the final performance in terms of mechanical behaviour is performed.