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# A SOLUTION FOR TRANSVERSE LOAD DEGRADATION IN ITER Nb3Sn CICCs; LONGER CABLE PITCHES AND RELATED ASPECTS FOR SHORT SAMPLE CONDUCTOR QUALIFICATION

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## ABSTRACT

We present the recent results of our novel model for transverse electro-magnetic load optimization (TEMLOP) especially developed for the ITER type of cable-in-conduit conductors (CICCs). The $Nb_3Sn$ CICCs for the International Thermonuclear Experimental Reactor (ITER) showed a substantial degradation in their performance correlated with increasing electromagnetic load, causing significant transverse strand contact and bending strain in the $Nb_3Sn$ layers, locally resulting in filament cracking and permanent degradation.

The most essential feature of the a priori TEMLOP predictions presented in May 2006 is that the severe degradation in CICCs can be improved outstandingly and straightforward by increasing the pitch length in subsequent cabling stages [1]. These corrective measures give more support to the strands, sufficiently reduce the bending and contact strain, and therefore avoid filament damage at strand crossover points in the cables. It was the first time that an increase of the cable twist pitches has been proposed and no experimental evidence was available at that time.

A full-size European prototype TF conductor sample (TFPRO-2), manufactured in autumn 2006, was adapted according this new insight and tested April 2007 in SULTAN for experimental validation of the predictions. The results were outstanding, for the first time an $Nb_3Sn$ CICC conductor achieved the performance that can be expected based on the single strand properties, with high n-value and no noticeable degradation. As the data reduction method and instrumentation was under discussion, a retest of the TFPRO-2 was carried out with extensive instrumentation in November 2007. The retest has experimentally confirmed now that the proposed changes recover the ITER TF conductor operation margin completely up to the expected strand performance and no special measures are required anymore to compensate for the performance loss, experienced for so many years. The ITER TF conductor specification is adapted and significant savings can be put through in the strand production [2].

As an input, besides cable properties, the model directly uses measured data from single strands under uni-axial stress and strain, periodic bending and transverse contact loads [3], [4]. A brief summary of the present status of strand results obtained with the

TARSIS setup is presented as well.

The qualification of the ITER conductors is carried out by short sample testing (3.5 m length) in the SULTAN test facility with a 0.45 m length of the high field region. The problems connected to short sample testing e.g. non uniform contact resistance distribution at the extremities, distribution in the strand transverse load degradation, variation of the cabling pattern and a distribution in the strand critical currents can affect the test data reduction in view of the acceptance criterion, being the critical current sharing temperature [5]. Latest modelling results are presented that quantify the phenomena related to this short sample qualification testing. The models results not only allowed to improve the ITER conductor design significantly but may also provide a better understanding of the phenomena connected to short sample testing, illustrating the conservative nature of short sample qualification testing and providing a credible prediction of the TF coil performance.

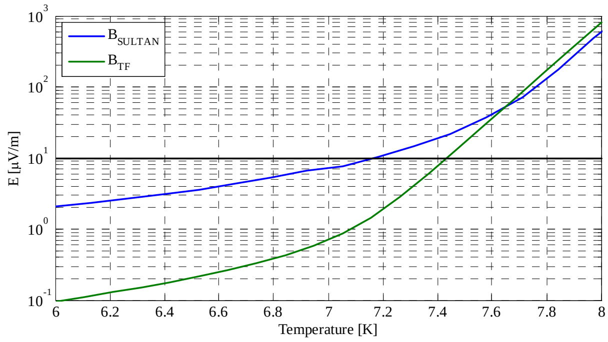


*Figure 1. A preliminary result of the computed electric field versus the temperature for a long pitches cabling pattern subjected to the SULTAN short sample and the TF coil conditions.*

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