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Post-Mortem Analysis of ITER CS Helium Inlets Fatigue Tested at Cryogenic Temperature

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In the ITER Magnet System, ten thousand tonnes of superconducting cable – in – conduit – conductor (CICC) are cooled down by a forced flow of supercritical helium, which is supplied from helium inlets. For the ITER Central Solenoid (CS), consisting of six independent pancake wound modules, the He inlets consist of three overlapping holes covered by an oblong shaped boss, welded to the CS jacket through full penetration, multi-pass Tungsten Inert Gas (TIG) welding. There are 120 CS He inlets and because they are located in a region of high cyclic tensile stresses, i.e. first turn at the inner diameter of the pancake, the CS inlets are one of the most critical structural components.

Qualification of the design is done by analysis and a comprehensive design optimization has been performed by finite element (FE) analyses. In order to guarantee the required fatigue life at cryogenic temperature of these component, a post – welding process consisting in ultrasonic shot – peening is required.

Based on a qualified weld procedure, six mock – ups including each two He – inlets on the opposite surfaces have been produced to run a mechanical fatigue testing program at cryogenic temperature with sufficient statistical significance to validate the findings of the FE simulations. Five were peened. One not peened.

The paper describes the results of a comprehensive post – mortem failure analysis which includes non – destructive (penetrant testing, leak testing, computed tomography) as well as destructive examinations (microoptical and hardness tests, scanning electron microscopy). It also includes a full assessment of the welds according to the most stringent acceptance levels of the standards in force.

The views and opinions expressed herein do not necessarily reflect those of the ITER Organization.

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