Proposed Rules for Ceramic Materials on Fusion Reactor Containment Boundaries

Rob Bamber¹, Roger Morrell², Chris Waldon¹, Mark Shannon¹

¹: Culham Centre for Fusion Energy, Culham Science Centre, Nr Abingdon, United Kingdom
²: National Physical Laboratory, Hampton Rd, Teddington, United Kingdom

During the design of a power transmitting window for the ITER ICRH system, the design team encountered problems regarding the design and manufacture rules and standards for ceramics. The design criteria in the SDC-IC * is not relevant for brittle materials such as ceramics due to its inherent assumptions regarding ductility and stress redistribution.

It is understood that this problem will persist into DEMO and beyond as the current safety philosophy is to define the torus vacuum boundary as the primary radioactive containment, placing significant emphasis on the design and manufacture of the components which form this boundary. Therefore the central engineering department at CCFE, in collaboration with NPL and AMEC decided to attempt to consolidate design criteria and manufacturing rules to demonstrate structural integrity into a single document * with the goal of easing regulatory approval, applicable to ceramic materials utilised on the boundaries of fusion devices. This paper describes the rules for the design by analysis part of this work and details their justification.

The failure mode of static fatigue which is unique to ceramics, whereby subcritical cracks grow with tensile stress and time, is introduced and a methodology presented for demonstrating strength in the end of life condition.

The difficulty of reconciling the statistical nature of failure in ceramics with the deterministic nature in codes is addressed and it is suggested that the only way to achieve this is by a proof testing approach. The inherent weakness of the proof testing methodology, quantifying the strength loss during the qualification test is discussed.

Further work is required to determine the validity of the rules experimentally.