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Repair processes of W7-X target modules

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The highly loaded surface of the actively water-cooled divertor of Wendelstein 7-X (W7-X) is made of 100 individual target modules. In each target module, a set of target elements is water-cooled in parallel and fed by manifolds. A target element is made of a CuCrZr copper alloy heat sink, armored with CFC NB31 tiles. Due to the width of the target elements, CFC tiles had to be successively electron beam welded onto the heat sink from two sides.

He leak testing under pressure in a vacuum oven was systematically performed for each target element and module. The type 5S target element had a higher percentage of rejection rate during the production, and one series element did not pass the leak test after high heat flux testing. The leakage was the result of the combination of a porosity concentration due to the CFC-CuCrZr - weld in the centre part of the element and the reduced CuCrZr thickness due to machined slots at this location. The selected solution was sealing of the slit between two tiles by electron beam welding.

The target elements were then connected by orbital welding to the piping system. One of the first produced batch of 30 target modules did not pass the integral He leak testing. Two leaks were detected in the weld seam between two target element connectors and manifold pipes. Their positions did not allow a reliable process for re-welding from outside due to the impossibility to install any jigs. The selected approach was drilling of apertures through the neighbouring manifolds to allow direct access to the leaking seams from inside. The openings allowed installation of an inside orbital welding head. This solution was validated in an intensive prototyping phase. Finally, the repaired target modules passed the He leak test in oven.

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