robotized ultrasonic testing of ITER geometrically complicated high-heat-flux components [[1]](#footnote-1)\*)

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To carry out the ultrasonic testing of the ITER high-heat-flux components, it is necessary to solve a number of both methodical problems, as the data on testing of the like products and materials are lacking, and practical problems caused by a complex acoustic behavior of materials and by complicated geometry of products.

In the ITER high-heat flux components a number of joints responsible for resistance of the plasma -facing armour and the reliability of the heat-sink system should be subjected to the ultrasonic testing, these are:

* joint of the steel base and bronze cover of the hypervapatron of the First Wall Panel (FWP) made by diffusion welding;
* joint of the steel base and bronze cover of the hypervapatron of the divertor made by explosion welding;
* brazed joint of the FWP beryllium armour to the hypervapatron cover;
* casting of a thin copper layer on the tungsten armour of the divertor;
* brazed joint of the copper-tungsten armour of the divertor to hypervapatron bronze.

When developing the methods for ultrasonic testing of the high-heat-flux components the approach was chosen which minimizes the probability of a human factor. To solve the UT problems a six-axis industrial robot is used as a manipulator.

This paper presents the results of application of robotized UT facilities, as well the practical results of investigation concerning the limits of detectability of discontinuities of the Be/bronze joint and diffusion Be/steel welded joint during testing through the beryllium (Be) cladding. The paper demonstrates that the Be/bronze joint can be confidently tested with sensitivity ØFBH = 2 mm. For the bronze/steel joint, the defect with ØFBH = 2 mm in the zones under the armour and ØFBH = 3 mm in the zones between armour tiles can be confidently detected during testing through the armour after brazing and heat treatment. After the vacuum testing, the armour becomes uncontrollable for UT because of attenuation on the beryllium surface. But an additional heat treatment makes beryllium again penetrable for sound. The most effective method turned out to be testing by immersion sensors with a frequency from 5 to 7.5 MHz and a piezoelectric element ½ inch in diameter.

To conclude, the use of the robotized complex for the ultrasonic testing fulfils the ITER requirement for the production quality both during manufacturing of the prototype and during mass production. After brazing of beryllium, the UT can be carried out with the required sensitivity, but has a number of limitations resulting from sound losses in the armour material and between tiles.

1. \*) [abstracts of this report in Russian](http://www.fpl.gpi.ru/Zvenigorod/L/E/ru/IS-Korolev.docx) [↑](#footnote-ref-1)