Irradiation Test Progress for the ITER Maintenance Robot

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1. Introduction

The inner lining ("blanket") of the vacuum vessel (VV) for ITER will be activated by 14 MeV neutrons generated by fusion reactions. Therefore maintenance of the blanket modules in the VV must be carried out under high gamma ray radiation conditions (~0.5 kGy/h) and in the presence of contaminated dust such as beryllium, carbon and steel. Thus all the activities inside the VV must be performed remotely.

Figure 1 shows the robot for maintenance of the blanket modules. The robot has about 20 degrees of freedom and is driven by an electrical AC servo motor with sensors to measure its position [1]. The robot

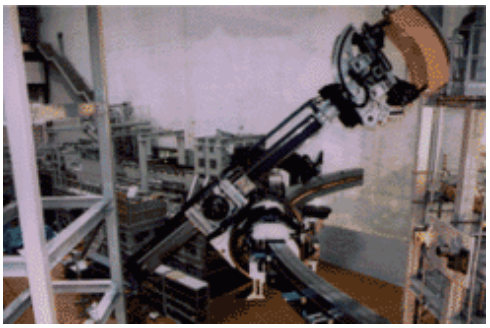

Figure 1. The ITER maintenance robot

components such as motors, sensors, lubricant, and cables have to be radiation hard components with a minimum demonstrated radiation lifetime of 5 MGy (total dose which corresponds to two consecutive years of operation under 250 Gy/hr). This target value of 5 MGy was determined so as to minimize the replacement of parts during the two year maintenance period from the view point of availability and was confirmed by RAMI analysis [2].

This paper describes the progress of the gamma radiation tests of the components used in the ITER maintenance robot. The objectives of this test are to clarify the effects of radiation exposure on the major robot components and to develop the radiation hard robot based on those obtained results.

2. Test plan for components

The results and the current progress of the irradiation tolerance tests for the ITER maintenance robot are shown in Table 1. In the past tests [3], substantial investigation into the radiation tolerance of robot components was done. However, further testing is required when the following points are taken into account.

1) Lack of irradiation data of the components

There is no radiation tolerance data for the following items: Slip ring, single cable

Table 1 Radiation test components

Category	Component	Acceptable dose (MGy)
Electrical	AC servo motor (improved)	Ongoing
	Resolver (improved)	Ongoing
	Single cable (non-halogen)	Ongoing
	Multi-core cable (non-halogen)	Ongoing
	Slip ring	No data
	Electric connector	100
	Proximity sensor for limit switch	> 26
	6-axes force sensor	No data
Mechanical	Lubricant (Grease)	10
	O ring	20 (catalogue base)
Optical	Adhesive for lens	3
	Fiber for laser welding	No data
	Camera	2 (catalogue base)
	Image fiber	3.1
	LED	No data

(non-halogen), multi-core cable (halogen), force sensors, fibers for laser welding and LEDs for lighting.

2) Lack of irradiation data for the integration testing
The integrated RV reduction gears and O ring for the oil seal to confirm the detection of an oil leak under radiation. Individual parts (grease and O ring) meet the conditions of irradiation tolerance, but there is no data in the case that these parts are integrated.

3) Improved components
In [3], new AC servo motors were developed and showed high radiation tolerance. However this turned out to be too expensive. We are modifying commercial AC servo motors to reduce the manufacturing cost. Preliminary radiation tests of the commercial AC servo motors have been done at the Takasaki Advanced Radiation Research Institute. The total dose was 8 MGy and the dose rate was 500 Gy/hr. Then it was found that the motors fail because of failures in the insulation. Figure 2 shows the brake cable after being irradiated. The outer cable jacket made of Polyolefin cracked and the cable insulation made of ETFE (yellow) peeled partially and the bare conductor cable was exposed. Thus the cable material was replaced from ETFE to polyimide for better radiation tolerance. The radiation tests are ongoing.

Figure 2. The brake cable after being irradiated

Testing of the components related to the driving mechanism will be given priority since a failure of the driving mechanism can lead to severe trouble. All the testing of the listed components will be done by 2014.

References

[1] K. Shibanuma, et al.: Blanket Remote Handling Systems, Fusion Eng. Des., 55, 249-257 (2001)
[2] Application of the System Analysis on the ITER remote Maintenance System, The 31st Annual Conference of the Robotics Society of Japan (in Japanese)
[3]K. Obara et al, Irradiation Tests of Critical Components for Remote Handling System in Gamma Radiation Environment, JAERI-Tech96-011,