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Decontamination Assessment for ITER Blanket Remote Handling System
ITERブランケット遠隔保守システムの除染評価

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In ITER, after plasma operations, the Blanket Remote Handling System (BRHS) will be installed in the vacuum vessel (VV) and it will exchange the blanket modules (BMs). The BRHS itself will undergo hands-on maintenance in the designated maintenance area after exchanging the BMs. Since the BRHS will be contaminated from radioactive dust in the VV, the workers will be exposed to radiation. In this study, potential contaminated areas of the BRHS and their respective dose rates are estimated using the MCNP5 code to assess exposure to maintenance workers. Methods to further reduce these dose rates are also proposed.

1. Introduction

The blanket module (BM) maintenance requires the handling of heavy modules weight up to 4.5 tons with high positioning accuracy of ±0.5 mm in close to the final locating of the vacuum vessel. To meet these requirements, the Blanket Remote Handling System (BRHS) will be installed in the vacuum vessel (VV) and it will replace / exchange the BMs (Fig. 1). The parts that compose the BRHS will be stored in the cask (Fig. 2) when the BRHS is transferred to the designated maintenance area. The detail of design is described in Ref.1 [1]. The BRHS will undergo hands-on maintenance in the designated maintenance area after exchanging the BMs. Since the BRHS will be contaminated from radioactive dust in the VV, the workers will be exposed to radioactive dust. In this study, the areas that cannot be decontaminated by cleaning tools (vacuuming and brushing) are clarified and their respective dose rates are calculated using simplified models and MCNP5 code. Moreover, preventive methods to limit exposure are proposed.

2. Assumptions for assessment

2.1 *Dose limits*

Dose limits must be as low as reasonably achievable (ALARA objective), in all cases dose limits must be < 10 mSv/ year, and the dose rate from the BRHS must be kept lower than 100 μSv/h in yellow zone of the hot cell according to the Preliminary Safety Report for ITER [2,3]. Moreover, the target of acceptable limit for hands-on work was estimated to be 5 μSv/h [4].

2.2 *Dust*

Dust will be produced inside the VV as a result of the interaction of plasma with the surfaces of plasma-facing components. Since beryllium dust will only contribute a small percentage, the W dust source term is used for the worst case scenario since it will contribute the most to the dose rates. W-181 and Ta-182 were used in this assessment.

The dust density on surfaces [g/m^2] was calculated to be 0.097 g/m^2. It was used to analyze the dose rates.

2.3 *Scenario until maintenance*

All the work scenarios from the end of plasma operations until BRHS maintenance have been estimated in reference document [5]. The minimal time to complete the blanket exchange, 40 days, was used in this assessment.

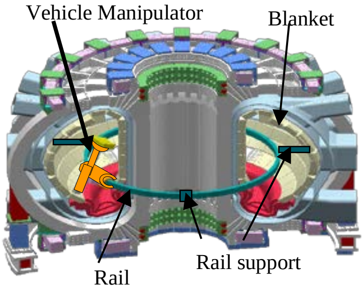

Fig. 1 Conceptual diagram of BRHS

3. Results

3.1 *First calculations*

Before the calculation, areas that are difficult to decontaminate via remote decontamination tools were clarified. The linear motion guide and rollers were assumed to be potential sites where dust would be trapped. A total of 13 areas of the Vehicle manipulator (VM) were estimated to be difficult to decontaminate. These areas were assumed to be contaminated by 0.097 g/m^2 of dust. On the other hand, the dust densities of areas that decontamination tools can access were determined to be 0 g/m^2. This value is consistent with the value in reference [6]. Then the dose rates from each source (the contaminated areas) were calculated at 20 assessment points, set around the equipment. Table I shows the effective dose rates from the VM. The effective dose rates of Ta-182 and W-181 and their sum total were calculated. Point 14 had a high dose rate most likely due to a source located inside the VM.

3.2 *Further reduction of dose rate*

According to the ALARA objective, the dose rate must be reduced further. Therefore, we evaluated how much the dose rate would decrease if 5 mm and 10 mm lead blocks are used as shielding. Fig. 2 shows the analysis model for this lead block shielding. The source was inside VM and it is assumed shielding will be placed between the VM and assessment point 14. The dose rate was recalculated using condition. As a result, the dose rates decreased to 2.7μSv/h for the 5 mm block, and 2.4μSv/h for the 10 mm block. Using this lead shielding, independent of the distance from the radioactive source, it is possible to decrease the dose rate by a third.

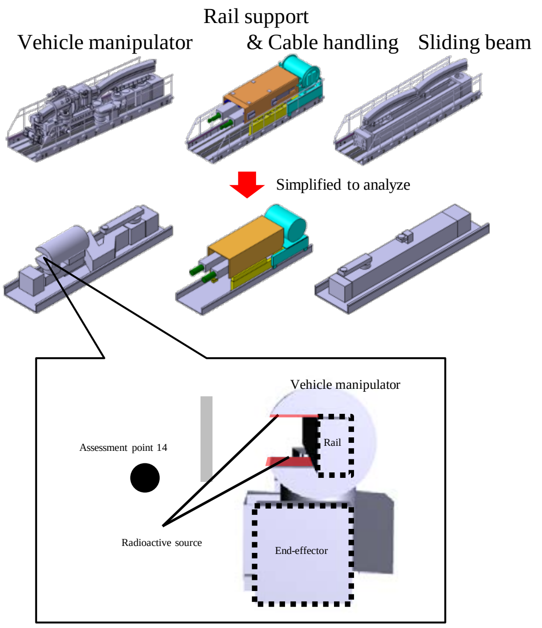

Fig. 2 Simplified analysis models and Analysis model for lead block shielding

4. Conclusion

In accordance with the ITER requirements, the dose rates from the vehicle manipulator, rail support equipment, cable handling equipment, and sliding beam were calculated using the MCNP5 code. Compared to 5μSv/h, the target of acceptable limit for hands-on work, the calculated dose rates were below the limit at almost all assessment points. There is a high dose rate point front of VM; however, it was possible to decrease the dose rates from Ta-182 and W-181 to half and almost zero, respectively, by using 5 mm and 10 mm lead blocks as shielding. During actual maintenance, either stacks of brick-shaped lead blocks or a lead apron will be used for shielding. In the case a lead apron is used, it will be able to prevent gamma rays from varying directions.

From these results, it was indicated that the linear motion guide is a cause of BRHS dust contamination. Therefore, the scraper, attached to the linear motion guide, is effective to avoid dust getting inside. In the future work, the decontamination performance of a scraper will be tested, and the feasible specifications will be reflected in the design.

Table I. Effective dose rates from vehicle manipulator

Assessment point	Total Effective dose rate [μSv/h]	Assessment point	Total Effective dose rate [μSv/h]
1	0.11	11	1.10
2	0.19	12	1.87
3	0.30	13	5.57
4	0.56	14	8.93
5	1.36	15	3.36
6	0.91	16	1.38
7	0.43	17	0.73
8	0.42	18	0.43
9	0.67	19	0.39
10	1.37	20	0.08

References

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