Nuclear radiation shielding and monitoring on the EAST device

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The nuclear radiation have come an important issue after the NBI heating system successful operation on EAST device. Massive DD neutrons produce from beam-thermal reaction are need effective measurement and shielding to safeguard for human and environment. Thirteen sites of dose monitoring arrangement on the sensitive district to online acquisition the neutron and gamma dose rate, and provide light and sound alarm during the dose rate exceed configured threshold. The EAST device shielding by 1.5 meters of concrete wall and the vacuum chamber wall interbed injection water to prevent the fusion neutron leaking into the environment. The monitoring data show that the neutron and gamma ray dose rates are around the natural background level.

Ⅰ. Introduction

Fusion energy is the best way to solve the energy crisis in the future. However, strong nuclear radiation such as neutron and gamma ray, which always accompanied with the fusion reaction. The ionizing radiation might cause huge damage to the human and the environment. Take active defense measure for radiation is very importance on fusion experiment research. The EAST is the first independent design and construction whole superconducting tokamak of china, it provide a good flat-form to explore the physical and engineering problems of fusion energy. The device locates in Hefei's western suburbs, in a peninsula of Dongpu reservoir, distance the downtown about 15 km. That project parameters is displayed on table 1, and the auxiliary heating systems occupy the ports are shown on Figure 1.

Table 1. Project parameters of EAST device

Toroidal magnetic (B_t)		3.5T
Plasma current (I_p)		≥1MA
Large radius (R)		1.7m
Small radius (a)		0.4m
Aspect ratio (R/a)		4.25
Cross sectional shape		D
Pulse length		1000 s
Heating and driving mode	NBI	8 MW
	ICRH	3 MW
	ECRH	0.5MW
	LHCD	3.5MW

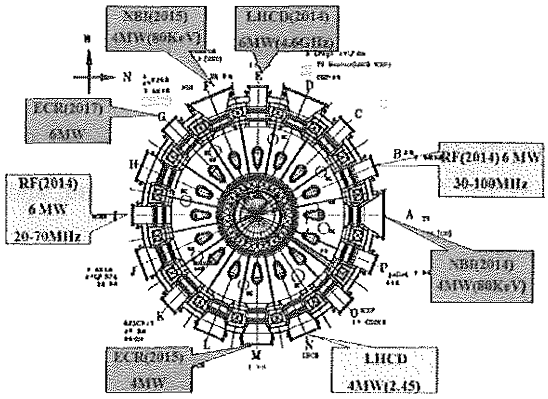

Figure 1. Heating system arrangement on EAST

At present, EAST fusion device mainly carries on deuterium plasma experiment, the main nuclear reaction process are as follows:

$$D+D \rightarrow T+p(3.02Mev) \qquad D+D \rightarrow {}^{3}He+n(2.45Mev)$$

DD fusion neutrons (2.45MeV) emission occupy dominate, and a less of DT neutron (14.1MeV) from deuterium reaction with produce tritium. During high power of auxiliary heating injection, the neutron yield approach to 1.0×10^{15}n/s. Besides, secondary nuclear radiation such as gamma rays and X rays

generated by bremsstrahlung and plasma breakdown.

II. Radiation shielding

The neutron and gamma rays will cause huge damage to human and environment. For the protection of personal safety and environment, radiation released into the environment should be as low as possible, and below the safety limits prescribed by the government. Radiation shielding measures is introduced, shown in figure 2. First, the double vacuum chamber wall, with 5 cm boron water, which can reduce the neutron influence of magnet and peripheral devices. Second, the pipeline of experimental hall was designed with labyrinth, to avoid direct leakage of radiation from the experimental hall. Last, the experiment hall, made by steel reinforced concrete, the size of the experiment hall is 33m×28m×23m, the thickness of the concrete is up to 1.5m, the experimental hall is the most important and effective way to prevent the nuclear radiation from escaping into the environment, which may cause huge damage to the human and the environment.

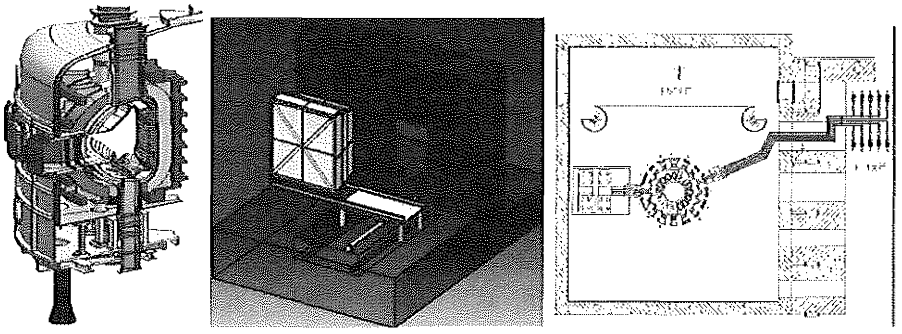

Figure 2. The radiation shielding measures on EAST device

III. Radiation monitoring and environmental evaluation

In order to obtain the radiation level around the EAST device, and evaluate the effect of EAST radiation shielding system. Thirteen fixed monitoring sites and one moving site were selected around the EAST, each site contains a neutron detector and a gamma ray detector (see Fig. 3).

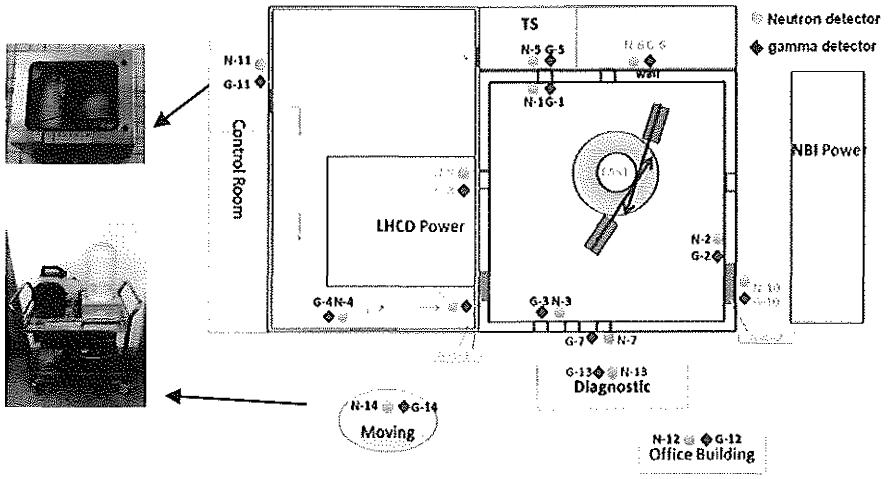

Figure 3. Distribution of the EAST radiation monitoring site

Moreover, a wide range of nuclear radiation investigation is executive, that items and position are shown in figure 4. Those survery include sound, electromagnetic and ionizing radiation. The ionizing radiation contain air absorbed dose rate, surface contamination, neutron cumulative dose and dose rate

monitoring. Soil and aerosol samples have been collection. This work is collaboration with the environmental protection department of Anhui province.

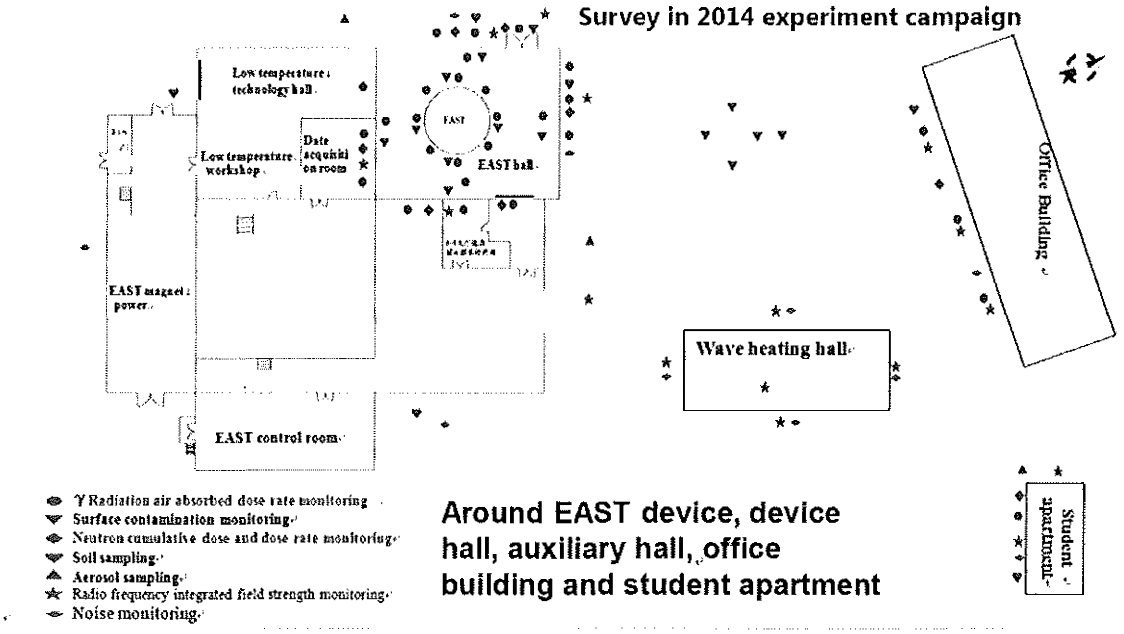

Figure 4. Radiation survey in 2014 experiment campaign

In order to intuitive evaluate the environment influence of the EAST experiment, the average radiation dose rate and the accumulated dose was given, as is shown in table 1, it respectively gives the comparison of radiation dose rate between pr-experiment and during the experiment. During the experiment the accumulated dose of G7、G10 is lower than pr-experiment, mainly affected by the different radiation background in different time. The neutron accumulated dose of N7、N10 during the experiment was both higher than before, but the difference is small. Overall, during the experiment, the dose rate is basically at the background level, the EAST shielding system provides good shielding for the neutron and gamma ray, EAST experiments will not cause additional radiation doses to the surrounding environment.

Table 1. Comparison of dose rate and accumulated dose before and during the experiment

Detector	Average dose rate before experiment/uGy·h^{-1}	Average dose rate during experiment/ uGy·h^{-1}	Accumulated dose before experiment /uGy	Accumulated dose during experiment/ uGy	Deviation of accumulated dose
G7	0.1489	0.1479	25.26	24.8473	-1.63%
N7	0.002305	0.002331	0.3910	0.3916	0.15%
G10	0.1120	0.1116	19.06	18.9930	-0.35%
N10	0.002218	0.002361	0.3763	0.3964	5.34%

IV. Summary

A large number of radiation dose rate data during the operation and the wide range of radiation survey data shows that the radiation shielding measures is effective, the radiation dose level of the surrounding environment is normal.

Acknowledgements

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