§1. Activation Analysis of Ar-41 for Deuterium Discharges in LHD

Nishimura, K.

Identification of radionuclides that resulted from deuterium discharges and evaluation of dose rate level are important to keep the safety working condition for workers. For this purpose, evaluation of dose rate level for the air was calculated taking account a planning deuterium experiments schedule.

Energies of neutron sources are 2.45 MeV (D-D reaction) and 14 MeV (D-T reaction). The neutron fluence was calculated using two-dimensional transport code DOT-3.5 by means of the FUSION-40 nuclear data set. Generations of radionuclides caused by 2.45 MeV (D-D reaction) and 14 MeV (D-T reaction) neutrons were calculated using CINAC code. Numbers and energies of neutron sources for standard calculation model are shown in Table 1.

Table 1. Parameters of neutron.

Energy (MeV)	Number (1/shot)
2.45	$2.4\text{x}10^{17}$
14.0	$4.3\text{x}10^{15}$

The most of 2.45MeV neutrons (D-D neutron) are generated by D plasma and D^0 beam reaction, which is called Two-Component-Torus (TCT) effect. The 14.0 MeV neutrons (D-T neutron) are generated by the reaction of deuterium with tritium (1.01 MeV) through D-D reaction. The number of D-D thermonuclear reaction is 1 – 3 % of that of TCT effect. The initial neutron fluence data was calculated using neutron source data in Table 1. Generations of radionuclides were calculated using CINAC[1)] code using the neutron fluence data calculated by DOT-3.5[2)].

Some operational modes are being planted. Typical operation modes are shown in Table 2. In this estimation, the highest neutron production rate mode was used. Used shot schedule is as follows; one shot with 3 seconds pulse in each 15 minutes, 30 shots in a day, 4 days in a week, 3 weeks experiment with deuterium gas and 3 weeks intermission, and 9 weeks deuterium experiments in a year.

Table 2. Planning operation mode.

Operation mode	Number of neutron (1 shot)	Plasma duration (sec)
The highest neutron production rate	$5.7\text{x}10^{16}$	3
Moderate heating by NBI	$9.8\text{x}10^{15}$	3
Long pulse by ICRF	$1.0\text{x}10^{17}$	3600

Main radioactive reactions of air were as follows,

^{14}N (n, 2n) ^{13}N,
^{16}O (n, p) ^{16}N,
^{40}Ar (n, γ) ^{41}Ar.

Half-life of ^{13}N, ^{16}N and ^{41}Ar are 10.1 min., 7.1 sec. and 1.82 hour, respectively. Since ^{41}Ar has relatively long half-life in comparison with shot interval of 15 minutes, time evolutions of ^{41}Ar concentration in the experimental hall and in the exhaust air are calculated. Air in the experimental hall is vented to the basements to keep low air-pressure in this hall at the rate of $500m^3/h$. This air diffuses in the basement (24000 m^3) and is vented to the exhaust stack at the rate of $500m^3/h$. Total air of 12550 m^3, which is total vented air from this building, is exhausted from the vent on the rooftop. Time evolutions of ^{41}Ar concentrations in the experimental hall and exhaust are shown in Fig. 1 for 1 week. The concentration in the experimental hall increases shot by shot and reaches to 9.2 $\text{x}10^{-2}$ Bq/cc at the last shot in a day. After that it decreases during interval and reaches to 1.4 $\text{x}10^{-4}$ Bq/cc. Through the experiments, concentration of ^{41}Ar is smaller than the legal worker's limit (0.1 Bq/cc). Similarly the concentration in the exhaust air does not exceed the legal environmental limit (5 $\text{x}10^{-4}$ Bq/cc).

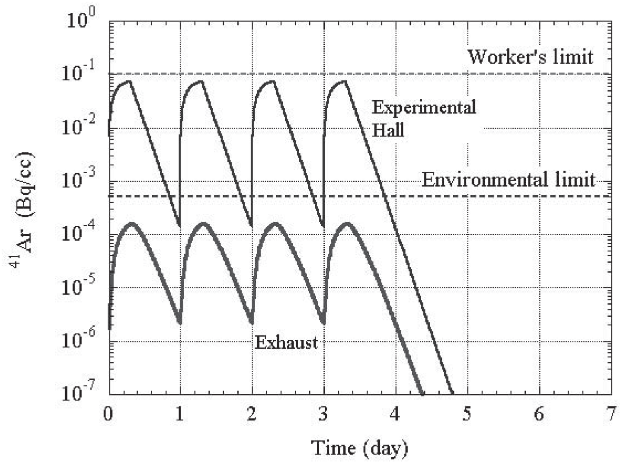

Fig. 1. Time evolution of ^{41}Ar concentration during experimental week.

1) J. Fukumoto, Nucl. Sci. Technol. **23**, 97 (1986).
2) W.A. Rhoades, F.R. Mynatt, Tech. Memo. ORNL/TM-4280, Oak Ridge National Laboratory, Oak Ridge, TN, 1973.