Neutron and γ-Ray Dosimetry by Means of Solid State Track Detector (CR-39) and TLD

V. 1 Neutron and γ-Ray Dosimetry by Means of Solid State Track Detector (CR-39) and TLD

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Introduction

In general, doses of radiations leaked from cyclotron facilities to the environment is low, but as the leakage might continue for a long period, we must pay attention to it.

Here we describe (1) dose levels of escaped γ-rays and thermal neutrons at 25 monitoring points in the Cyclotron and Radioisotope Center and (2) methods of measuring fast neutrons by means of CR-39.

CR-39 is one of the thermosetplastics. It has a unique sensitivity and high resolution in the recording of nuclear tracks, and alpha and proton particles can be easily measured by use of it, but neutrons are not measured with high sensitivity owing to the background defect counts of itself. We discuss the method of discrimination between the neutron counts and defect counts.

1) Measurement of γ-rays and thermal neutrons by use of TLD

Experimental

A pair of TLD elements was used. One element named UD-137N is sensitive to γ-rays and the other named UD-136N is sensitive to both γ-rays and thermal neutrons. We set the pairs of TLD elements on 25 monitoring points. Three months later we collected and measured the luminescence intensities of them with a TLD reader (NATIONAL UD-502B)

Results and discussion

The monitoring points are shown in Fig. 1 and radiation doses at the points are given in Table 1. The following conclusions were drawn from the results.

(1) γ-rays and thermal neutrons did not escape through the shielding door (7, 10, 11 and 12 points). It means that the radiation protection with shielding doors is very effective.

(2) In the underground passages γ-rays and thermal neutrons were detected over those of natural background (1-5 and 23 points).

Doses at point 2 were the largest and they were due to the scattered radiations from the electromagnet room. The doses at point 1 were ascribed to scattered radiations from the cyclotron vault, and doses at point 22 were explained by radiations emitted from an electromagnet which is set in the electromagnet room. In the period of cyclotron operation, the magnet was highly activated by the cyclotron beam and it radiated high energy γ-rays and fast neutrons. These radiations escaped through the floor concrete of 1 m thick down to the point 22 (We recommended that workers should not stop and stay in the underground passage).

(3) Although at present we have no data on the leakage of fast neutrons, we guess fast neutron doses in the passage are rather high during the operation of the cyclotron.

(4) It seemed that thermal neutrons observed at point 14 and 16 came through the exhaust air ducts from the cyclotron vault and from the TR-1 respectively.

2) Methods of measuring fast neutrons by means of CR-39

Experimental

A piece of CR-39 which was prepared by cutting a large plate (1.0 mm thick) of CR-39 into the size of 20×20 mm was sandwiched between two polyethylene sheets. The latters were used as radiators . Such detectors were irradiated with an Am-Be neutron source. After irradiation the polyethylene sheets were removed from CR-39 and dust particles on the surface of the CR-39 were washed away in distilled water and the CR-39 were treated with methyl alcohol for a fixed time (pretreatment). Etching was performed in an aqueous solution of KOH. After etching the detectors were washed with distilled water and dried. Then etch pit densities and size distribution of the etch pit diameter were measured with an automatic measuring system (a Particle Analyzer LUZEX 450, a Desk top computer HP-85, and an optical microscope).

Results and discussion

We investigated effect of the pretreatment on etch pit densities and the distribution of the etch pit diameter. Fig. 2 shows the etch pit densities of irradiated samples (gross and net counts) and of nonirradiated samples (background counts) as a function of pretreatment time. Treatment of the CR-39 with methyl alcohol for a given time may be effective in the sense of reducing the background etch-pits, but not reducing the net counts of the irradiated samples. Fig. 3 shows the variation of the distribution of the etch pit diameter with the methyl alcohol treatment. It may be pointed out from the figure that the etch pit counts at each diameter have a tendency to decrease as the treatment time increases. Especially this is clear between 1 to 3 μm of etch-pit diameter.

The decrease of the etch pit counts shown in Fig. 2 corresponds to the decrease of the etch pit counts between 1 and 3 μm diameter shown in Fig. 3. The results of Figs. 2 and 3 suggest that the treatment with methyl alcohol can increase the sensitivity and accuracy of neutron measurement by reducing the background etch pits.

Table 1. Escaped radiation doses at Cyclotron and Radioisotope Center

(dose: mrem/month)

Number of monitoring points	'83, Jan.-Mar. γ-ray	neutron	Apr.-Jun. γ-ray	neutron	Jul.-Sep. γ-ray	neutron	Oct.-Dec. γ-ray	neutron
1	21.4	316.0	20.9	8.9	24.9	10.5	30.4	11.9
2	256.3	316.0	223.7	283.0	271.4	332.8	413.7	471.3
3	12.4	2.1	10.2	3.7	12.1	5.0	13.5	3.3
4	9.5	0.9	8.6	0.7	9.9	0.9	12.3	0.9
5	14.4	0.6	11.5	0.6	16.1	1.1	14.4	0.7
6	7.8	0.1	8.6	0.0	8.1	0.1	11.4	0.1
7	9.6	0.0	—	—	9.9	0.1	11.4	0.1
8	124.0	0.0	7.5	0.2	62.5	0.1	14.1	0.0
9	9.6	0.1	9.5	0.0	10.8	0.0	13.7	0.0
10	6.1	0.0	5.9	0.0	6.8	0.0	10.7	0.0
11	6.5	0.1	6.5	0.0	7.2	0.1	10.3	0.0
12	6.4	0.1	5.9	0.0	5.6	0.4	9.8	0.0
13	6.6	0.1	7.4	0.1	7.7	0.0	10.7	0.0
14[a)]	11.2	1.2	10.1	1.1	11.9	1.3	16.9	1.6
15[b)]	7.5	0.0	7.0	0.1	7.9	0.1	12.4	0.1
16[c)]	13.3	1.2	12.0	0.9	11.7	1.1	18.0	1.1
17[d)]	7.3	0.0	6.5	0.0	7.9	0.0	11.0	0.1
18[e)]	7.1	0.0	5.7	0.0	8.3	0.0	11.5	0.1
19[f)]	9.4	0.1	8.8	0.1	10.5	0.1	13.2	0.0
20[g)]	10.0	0.1	12.8	0.1	12.0	0.2	15.6	0.1
21	—	—	44.5	0.1	25.0	0.0	20.3	0.1
22	—	—	18.0	4.6	21.1	5.6	25.8	6.7
23	—	—	8.4	0.0	9.5	0.2	11.8	0.0
24	—	—	8.0	0.0	15.2	0.1	10.8	0.1
25	—	—	9.2	0.1	10.0	0.1	13.1	0.1

a) Near the exhaust air ducts on the roof of the cyclotron vault
b) On the roof of the cyclotron vault
c) Near the exhaust air ducts on the roof of the TR-1
d) On the roof of the TR-5
e) On the roof of the RI building
f),g) In the cold laboratory of the RI building (control)

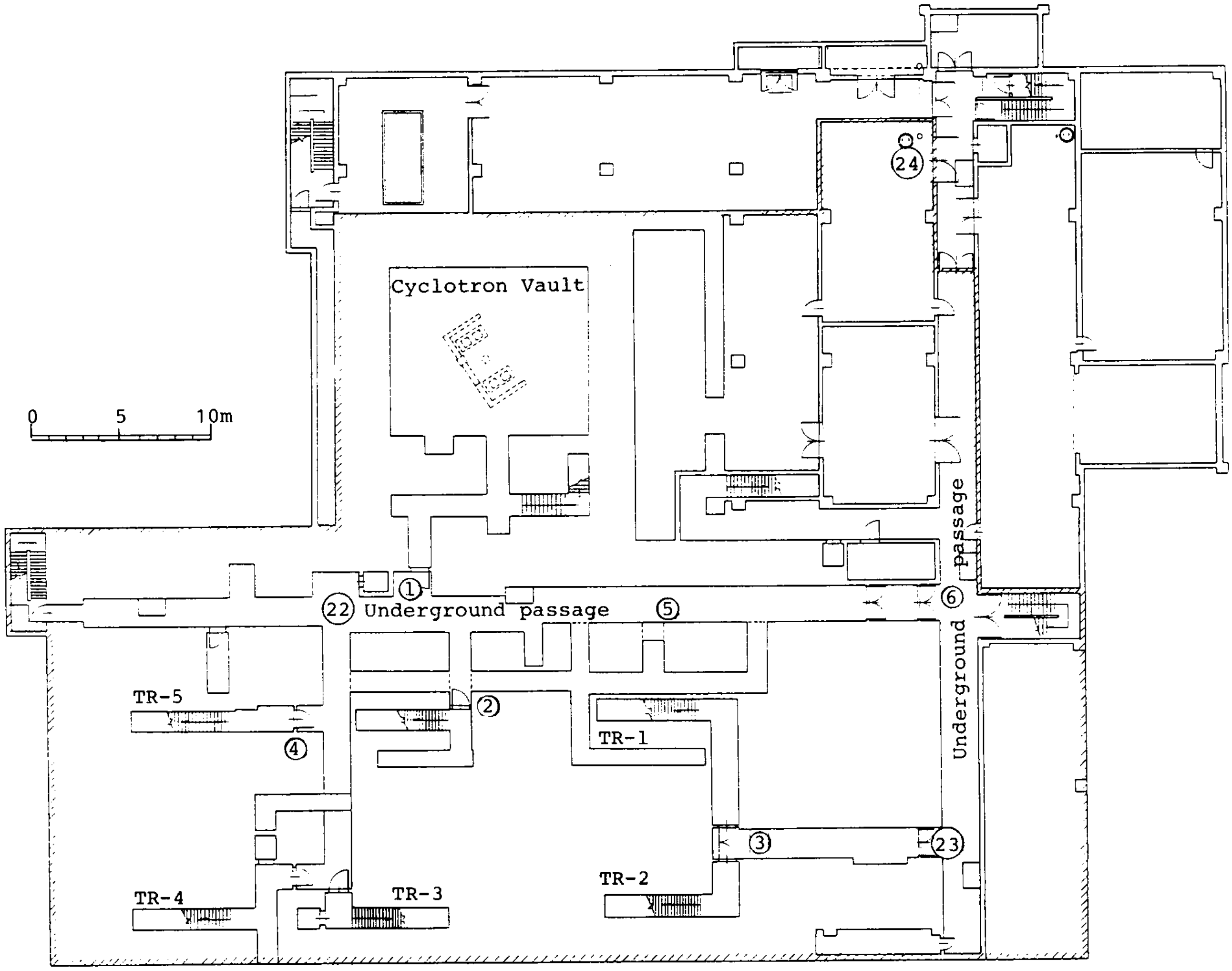

Fig. 1. a) The basement floor of cyclotron building

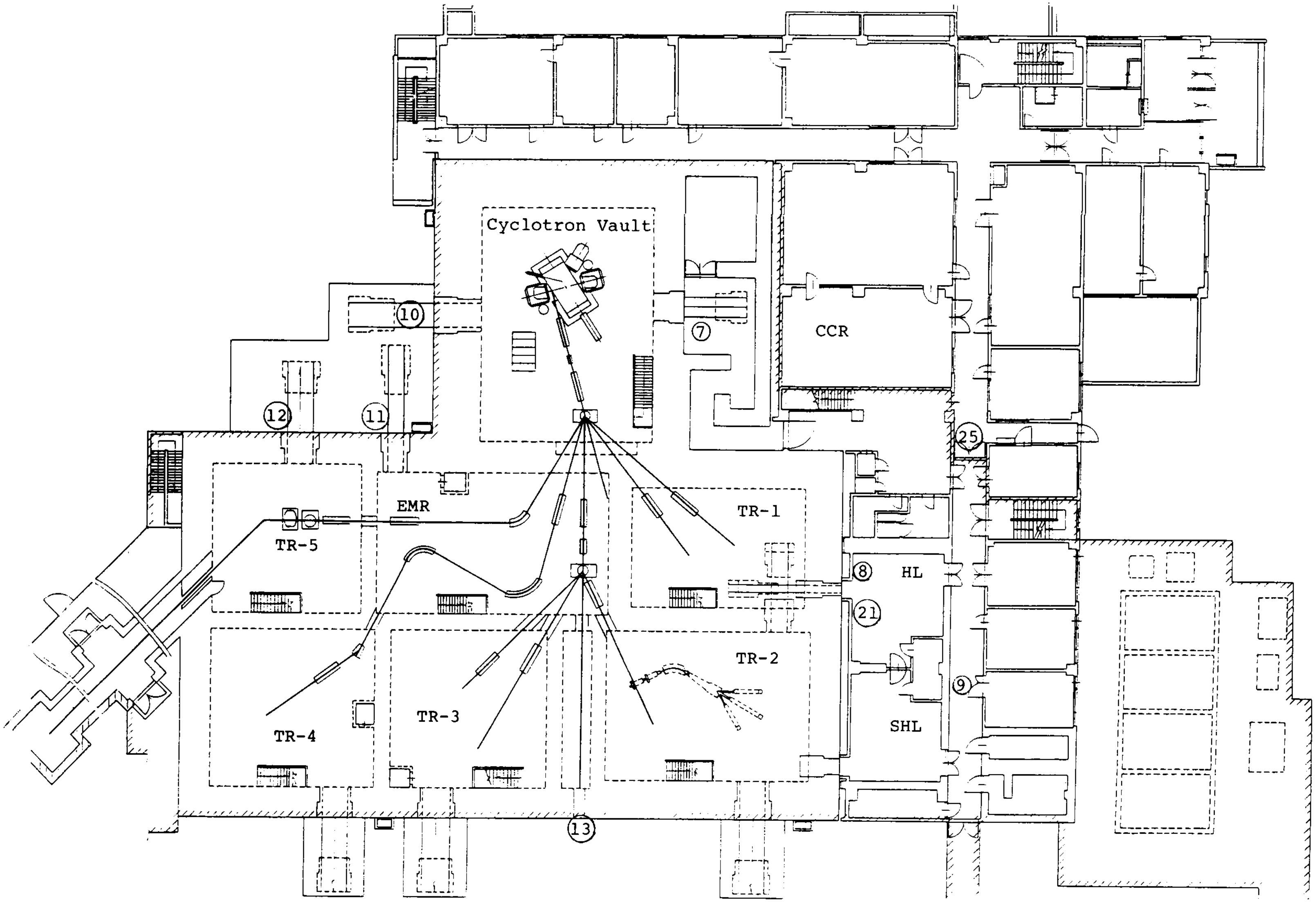

Fig. 1. b) The first floor of cyclotron building

TR-1: Target Room-1 HR: Hot Laboratory

EMR: Electromagnet Room SHR: Semi Hot Laboratory

CCR: Cyclotron Control Room

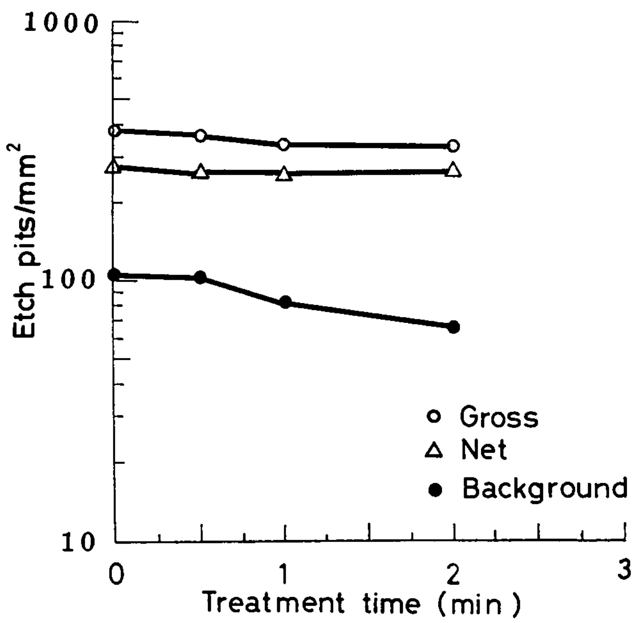

Fig. 2. Effect of treatment time with methanol on etch pit

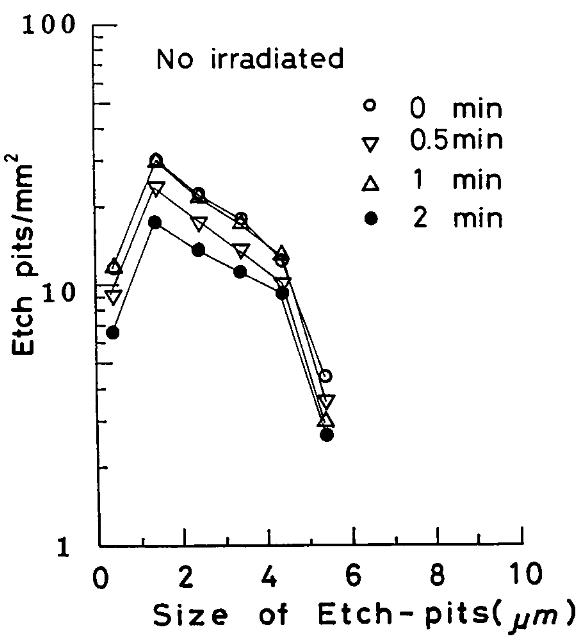

Fig. 3. Effect of treatment time with methanol on etch-pit diameter distribution