TWENTY YEARS OF TRITIUM INTERNAL MONITORING IN JAPAN ATOMIC ENERGY RESEARCH INSTITUTE

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INTRODUCTION

The Japan Atomic Energy Research Institute(JAERI) was established in 1956, and research activities at the Tokai Research Establishment were started in 1958. Among many facilities at Tokai Research Establishment, the following facilities are concerned with tritium exposures:

a. Tritium production laboratory; recently, for the fusion research and development program, production of tritium on 100 Ci level are carried out. During the purification process, tritium was handled as a gas. At the present time, annual production of tritium is several hundred curies.
b. Heavy water reactors, JRR-2 and JRR-3; At Tokai Research Establishment, there are two heavy water research reactors, that is, JRR-2 and JRR-3. The concentration of tritium in the reactor water increases every year. Presently, the concentration is about 1 mCi/ml for the both reactors. During the past 20-23 years of reactor operation, leakage of the heavy water occurred occasionally. The largest leakage rate was about 3.5 l/week for JRR-2.
c. Van de Graaf accelerator; tritium is frequently used as a target. In most cases, the amounts of tritium handled are on the curie level. Leakage of the tritium sometimes occurs in the target room.
d. Other facilities; low level contamination with tritium is also observed occassionally in the waste treatment plant.

In JAERI, the chemical form of tritium handled is tritiated water or tritium gas. We have no experiences of internal contamination other than by DTO and HTO. At Tokai Research Establishment, the number of radiation workers is about 1,800(in 1983), of which about 220(in 1983) are workers handling tritium or working under a tritium atmosphere.

MONITORING OF TRITIUM AT WORKPLACES AND FOR INDIVIDUALS

Monitoring of The Workplace

Several techniques are used to monitor tritium concentrations. An air flow type ionization chamber monitor is used for continuous measurement of total tritium (tritium gas and tritiated water) in air at the workplace. In addition to this continuous monitoring method, cold trap method and adsorption method are also used. When contamination is suspected, surface monitoring or exhaled air monitoring for the workers is of course carried out.

Protection of The Worker from Internal Contamination

An air supplied suit with a full-face mask is used at high level air contaminations. For the workers, when internal contamination is suspected, tritium concentration of the exhaled air is then measured for preliminary individual monitoring. If an internal contamination of more than 10 mrem is estimated by the exhaled air measurement, then the worker is sent to Bioassay Division, where the internal contamination is monitored in detail.

INDIVIDUAL MONITORING OF INTERNAL CONTAMINATION

The Bioassay Division carried out individual monitoring, on a routine and special monitoring basis.

Routine Monitoring

The purpose of routine monitoring is to check for the presence of significant internal contamination. At present, for tritium, 10 mrem (50 years committed dose) is adopted as the significant exposure level for internal contamination.

The number of workers who have a risk of tritium contamination is about 220, however, except for the test production group, the level of tritium handled is very low, and furthermore, the workplace monitoring is carried out very strictly. For these reasons, individual monitoring is not carried out on a routine basis for all workers who have a risk of tritium contamination. At present, about 60 workers are selected as subjects of routine monitoring. This routine monitoring is carried out every three months.

Special Monitoring

The purpose of special monitoring is to estimate the body burden, and a committed dose if necessary. This special monitoring is carried out for the following workers,

a. workers found by routine monitoring to have a significant contamination,
b. workers who have had an accidental intake of tritium,
c. workers who are suspected of having a tritium contamination.

Method of Bioassay for Tritium

In general, urine is taken as a sample. Water contained in exhaled air and saliva is often used as the sample. For urinalysis, 0.2 ml of urine is mixed with 15 ml of scintillator solution(PPO-POPOP/toluene-ethanol). After several hours, the tritium activity is measured with a low background liquid scintillation counter for 10 to 30 minutes. For the exhaled air, sample water is collected by condensing exhaled air directed through small test tube cooled by an ice bath. In the case of 10 minutes counting, the detection limit is about 10 pCi/0.2 ml for urine or other water samples.

DOSE CALCULATION

Based on the recommendation of ICRP, the committed dose equivalent is calculated by the following formula,

$$D = 51.2 \cdot (\mathcal{E}/m) \cdot q_0 \cdot \int_0^{50y} R(t)\, dt \qquad \text{----------(1)}$$

where D: committed dose equivalent(rem/50 years),
$\mathcal{E}$: effective energy of tritium(0.006 MeV),
m: mass of the critical organ(body water, 43 Kg),
q_0: amount of intake(μCi)
R(t): a retention function($e^{-0.693t/T}$), and
T: effective half-life(day).

Based on the assumption that the tritiated water is distributed uniformly in the body water, the amount of intake, q_0, is calculated as

$$q_0 = U_0 \cdot m \qquad \text{----------(2)}$$

where U_0: initial concentration of tritium in the body water such as urine.
Combining equations (1) and (2),

$$D = 51.2 \cdot (\mathcal{E}/m) \cdot U_0 \cdot m \cdot (T/0.693) = 0.44\, U_0 \cdot T \qquad \text{----------(3)}$$

In equation (3), T is usually determined by follow-up analysis of the body water. If the follow-up is not possible, the ICRP recommended value of 10 days is used.

EXPERIENCE OF TRITIUM MONITORING FOR INTERNAL CONTAMINATION AT JAERI

Results of Routine Monitoring

At JAERI, routine monitoring of tritium by urine analysis started in 1970. The results of the monitoring are shown in Table 1.

Table 1 The results of routine monitoring at JAERI

Year	Number Monitored	Number found Contaminated*1
1970	38	0
71	55	4*2
72	52	0
73	61	0
74	105	1*3
75	98	1*2
76	175	0
77	206	0
78	211	0
79	182	0
80	207	0
81	228	1*4
82	254	0
1970-82	1872	7

*1: Significant exposure level is 10 mrem(committed dose)
*2: Van de Graaf accelerator
*3: JRR-2
*4: JRR-3

During the past 13 years, about 1900 measurements were carried out. As a results, only 7 subjects were found out to have significant contamination. All these subjects were sent to special monitoring.

Results of Special Monitoring

Special monitoring at JAERI for tritium started in 1963. The results of the special monitoring are shown in Table 2.

In the past 20 years, a total of 358 measurements were carried out. As a result, we found about 70% of the subjects to have tritium contamination. However, the evaluated committed doses are very small for most of the subjects, and a committed dose of over 250 mrem was observed only in one subject(380 mrem).

Biological Half-life of Tritium

In the past 20 years, 255 subjects were found to have tritium (tritiated water) contamination. The half-life of tritium retention was observed for 50 subjects by follow-up measurement. Careful investigation of their working conditions were performed, and 41 subjects were selected as having no repeated contamination of tritium. The observed half-lives for 41 subjects are shown in Fig.1.

As shown in Fig.1, the observed half-lives are in the range of 5 to 17 days, an average value is about 10 days. These findings are in good agreement with those reported by ICRP(4 to 18 days, a typical value is 10 days).

Because the observed cases are so few, both the seasonal and age variations of the biological half-life are not obtained from the data.

Table 2 The results of special monitoring at JAERI

Year	Number of Cases	Number of Subjects	No Contamination	Estimated Committed Dose (mrem)			
				< 10	10-250	250-1000	>1000
1963	1	1	0	0	1	0	0
64	4	6	6	0	0	0	0
65	4	80	22	49	9	0	0
66	8	18	2	16	0	0	0
67	9	55	30	20	5	0	0
68	6	22	0	9	13	0	0
69	7	26	4	15	7	0	0
70	8	33	6	12	14	1	0
71	6	23	5	6	12	0	0
72	3	8	6	2	0	0	0
73	1	3	0	3	0	0	0
74	4	13	5	7	1	0	0
75	3	4	0	2	2	0	0
76	1	3	0	1	2	0	0
77	2	5	0	1	4	0	0
78	2	9	5	4	0	0	0
79	5	35	8	26	1	0	0
80	4	4	3	0	1	0	0
81	3	8	1	3	4	0	0
82	1	2	0	1	1	0	0
Total	82	358	103(29%)	177(49%)	77(22%)	1	0

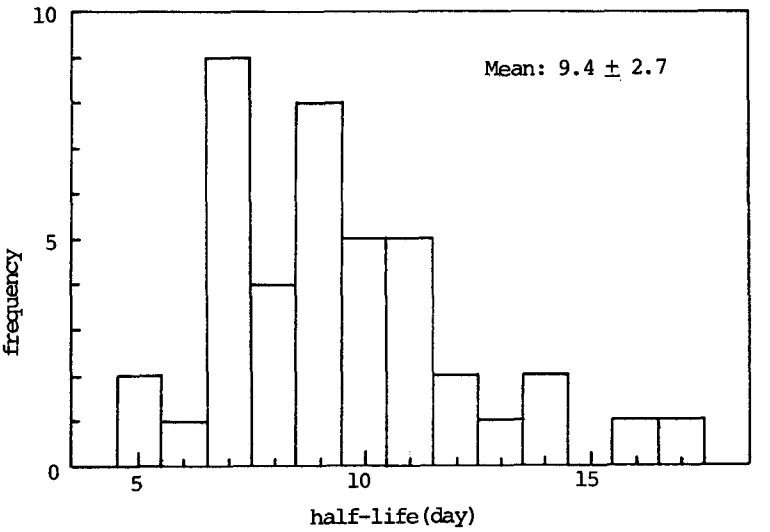

Fig.1 Biological half-lives of tritiated water observed for Japanese adults