RADIATION SAFETY PROGRAMS AT NIRS CYCLOTRON FACILITY

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I. Introduction

The NIRS(National Institute of Radiological Sciences) cyclotron has been pricipally used for a clinical trial of fast neutron radiotherapy and for production of short lived radionuclides. For the use of cyclotron in safety, health physicists should arrange information concerning on the protection of man and his environment from unwarranted radiation exposure. Health physicists should be also familiar with the following matters in order of efficiently meet his reponsibilities and to provide the services required of him; (1)Familiarity with the immediate program of accelerator operation: (2)Periodic surveys of all radiation produced: (3) Studies of induced radioactivity: (4) Evaluation of shielding: (5) Proper use, calibration, and interpretation of radiation monitors including personnel monitors: (6)Radiation safety training: (7) Knowledge of rules and regulations concerning on personnel and environmental exposure: and (8)Public relations.

A manual of radiation safety programs in the cyclotron facility were prepared by the working group of radiation safety which consists of health physicicts and staff of radiation safety division. The clinical trial of fast neutron radiotherapy, production of radionuclides and basic studies of radiological physics and radiobiology have been organized according to the manual of radiation safety programs.

II. Cyclotron Facilities

The cyclotron building is close to the building of hospital. In the cyclotron building, there are four irradiation rooms centering the cyclotron vault: namely (1)general experimental room where the crinical trial of proton radiotherapy will be started in near future; (2) radionuclide production room; (3) biological irradiation room and (4) fast neutron radiotherapy room. A nuclear medical investigation room is situated on the second floor. The fast neutron radiotherapy area is centerized in the basement of cyclotron building jointed to the hospital through an underpass and the nuclear medical investigation room is connected with the second floor of hospital building. Therefore, the cyclotron building has three entrances,so that the check of entrants into the building is not quite easy. The entrance and exit at the basement and the second floor is controlled with a "Vip Gate System". This system can automatically record when and who passed through the gate by inserting a proper card in the machine. This system may make it possible to check the the entrance and exit.

The shielding design of cyclotron building was carried out using an attenuation data of ordinary concrete against D-T neutrons[1]. A maximum thickness of concrete wall for the cyclotron vault room was 350 cm and the ceiling thickness was 200 cm. The cyclotron vault room joints with the operation room through the maze as shown in Fig.1A on the basement. Dose equivalent distribution in the maze measured with a 'rem counter' and an ionization chamber is given in the Fig.1A. A maximum wall thickness of irradiation room except for the general experiment room was 300 cm and the thickness of concrete wall adjoining other irradiation room was usually 200 cm. The doors of entrances into the irradiation room consist of 200 cm thick steel container filled with water, so that time is consumed for opening and shutting the door. For this reason, a maze was constructed in the radiotherapy room and the entrance door was reduced to a 20 cm thick concrete. This can carry on the fast neutron radiotherapy smoothly. The dose equivalent distribution in the maze is shown in Fig. 1B.

In the biological irradiation room, neutrons and gamma-rays were detected on the line prolonged the beam transport when deuteron beams stopped on beam shutters placed before and behind the switching magnet. These radiations were released from the beam stoppers bombarded with deuteron beams. A neutron shutter installed inside the concrete wall between the cyclotron vault and the biological irradiation room reduced dose equivalent from the leakage radiations as shown in Table 1. Table 1 gives dose equivalents measured at a point in front of beam transport for the biological irradiation when the beam stoppers and/or the neutron shutter were closed. The neutron shutter made it possible for users to arrange their experimental materials in the biological irradiation room even when the cyclotron is operated for production of radionuclides and proton therapy.

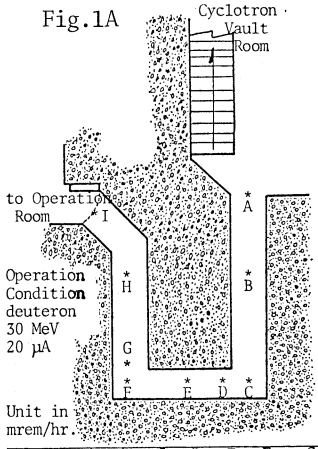
III. Monitoring System

An area monitor system, which consists of a cylindrical ionization chamber(18cm diam. 27cm long), is installed in the cyclotron vault room and each irradiation room. These are available to indicate the presence of radiation in high radiation area. And a suitable survey meter is used to monitor unsuspected radiation upon entry to a shut-down cyclotron or high radiation area. It shall be the duty of persons working in the cyclotron facilities to take with the survey meter into high radiation area after beam shut-down. Radiation level is dependent on substance and nature of a given work. As an example, decays of dose rate from induced radioactivity in the radiation areas are shown in Fig.2. The radioactivity induced in air is checked with a gas monitoring system placed at the exhaust port of stack. However, cooling air used for radionuclide production and a part of air in the cyclotron vault room are temporarily stocked in two special tanks(each 100 cubic meters x 5 atm.) and are released from the stack after about 3 hr.

The environmental monitoring systems are used to check leakage radiations from the cyclotron facilities. Four monitors are situated around the cyclotron building. The detector consists of BF_3 proportional counter with 10 cm paraffin moderator for neutrons and 1 inch diam. NaI(Tl) scintillation counter for gamma-rays, respectively.

All the monitoring systems are calibrated with the radioisotope sources or a substandard chamber twice a year.

Fig.1A



Point	A	B	C	D	E	F	G	H	I
Neutron	680	80	20	5	2	0.6	0.2	0.1	0.0
Gamma	60	34	10	3	1	0.4	0.1	0.0	0.0

Fig.1B

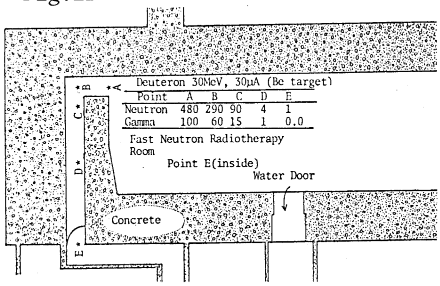


Fig.2.

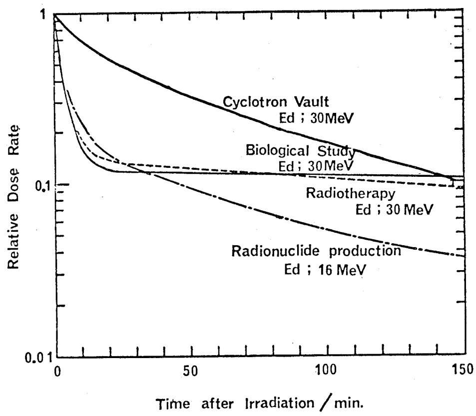


Table 1.

Irradiation Condition	Beam Stopper I	Beam Stopper II	Neutron Shutter	Neutrons mrem/hr.	Gamma-rays mrem/hr.
Deuteron 30 MeV 30 μA	close	close	open	390	140
	close	close	close	0.02	0.0
	open	close	open	3400	1400
	open	close	close	0.1	0.0

References [1] J.J.Broerse and F.J.van Werven;Health Physics,12,89- (1966)