Radiation Shielding Design for the SPring-8

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1. Introduction

Based on ALARA principle, we employed for shielding calculations the dose limit at the boundary of controlled area to be 2μSv/h and to the general public at the nearest access to be 50μSv. The shielding calculation was carried out with well verified formulas using conservative calculational conditions.

2. Shielding for the Electron Beam Tunnel

In bulk shielding calculations the radiation sources we assumed are high energy neutrons, Bremsstrahlung and muons generated through electro-magnetic cascade process. In forward bulk shielding calculations, ESRF's formula[1] was employed for Bremsstrahlung and neutrons, and Swanson's formula[2] for muons. In the transverse direction, Jenkins' formulas[3] for Bremsstrahlung and neutrons were used.

The shielding for the SPring-8, mainly made of ordinary concrete (ρ=2.2 g/cm^3), has a structure of tunnels covering the beam ducts running through the linac, the synchrotron and the storage ring. It includes, however, some exceptions at the e^-/e^+ convertor, the beam dump of the linac and the beam end port of the storage ring, where auxiliary shields made of heavy concrete, steel and/or lead are added. In Fig.1 is given a shielding specification of the linac. The thicknesses of the shielding wall of the synchrotron and the storage ring is given in Table 1.

3. Shielding for the Beamline

We have already made preliminary shielding calculations for several typical beamlines. We developed a new beamline shielding design code STAC-8[4]. The shielding calculation includes the calculations for the beam end port, the beam shutter, the photon stoppers and the side walls of the optics and the experimental hutches. In the calculation the following 4 radiation sources were considered.

1) Synchrtron radiations frombending magnets and insertion devices,
2) Gas Bremsstrahlung generated at straight sections of the beam tunnel,
3) Neutrons and photons due to electron beam loss and
4) Muons

The required shield thickness for the beam end port obtained are:

1) Injection region :
   Lead (15cm) + Ordinary Concrete (60cm)
2) Non-injection region :
   Lead(10cm) + Ordinary Concrete (55cm)

4. Dose Estimation to General Public

One of the main purpose of the shielding design is to protect general public from harmful radiations. For the purpose we carried out a shielding calculation (so called a skyshine calculation) to estimate the annual dose at any points on the site boundary of the SPring-8.

Stevenson-Thomas formula[5] was employed for the skyshine calculation with the assumption that the total dose is contributed only by neutrons with the conservatively assumed 1/E energy spectrum. The calculation was made for an annual operation time of 5,500 hours. The annual dose at the site boundary about 100m apart from the nearest storage ring was estimated to be 23μSv, consisting of the skyshine component of 10μSv and the direct one of 13μSv. The result shows the evaluated dose value is well below the dose limit of 50μSv.

References

[1] E.Braeuer :"Radiation Shielding for the 6 GeV ESRF", ESRF/SHIELD/88-04 (1988).

[2] W.P.Swanson :"Radiological Safety Aspects of the Operation of Electron Linear Accelerators", Technical Report Series No.188, IAEA (1979).

[3] T.M.Jenkins : Nucl. Instr. Meth. 159, 265(1979).

[4] Y.Asano and N.Sasamoto : Radiat. Phys. Chem. Vol.44, No.1/2, 133 (1994).

[5] G.R.Stevenson and R.H.Thomas, Health Physics

Table 1. Shielding wall thickness of the synchrotron and the storage ring.

	Synchro.	Synchro.	Synchro.	Strg. Ring	Strg. Ring
	Injection	Extraction	Other Reg.	Injection	Non-injct.
Outer Wall	240 cm	240 cm	110 cm	170 cm	100 cm
Inner Wall	*	*	*	140 cm	100 cm
Ceiling	230 cm	230 cm	100 cm	150 cm	100 cm

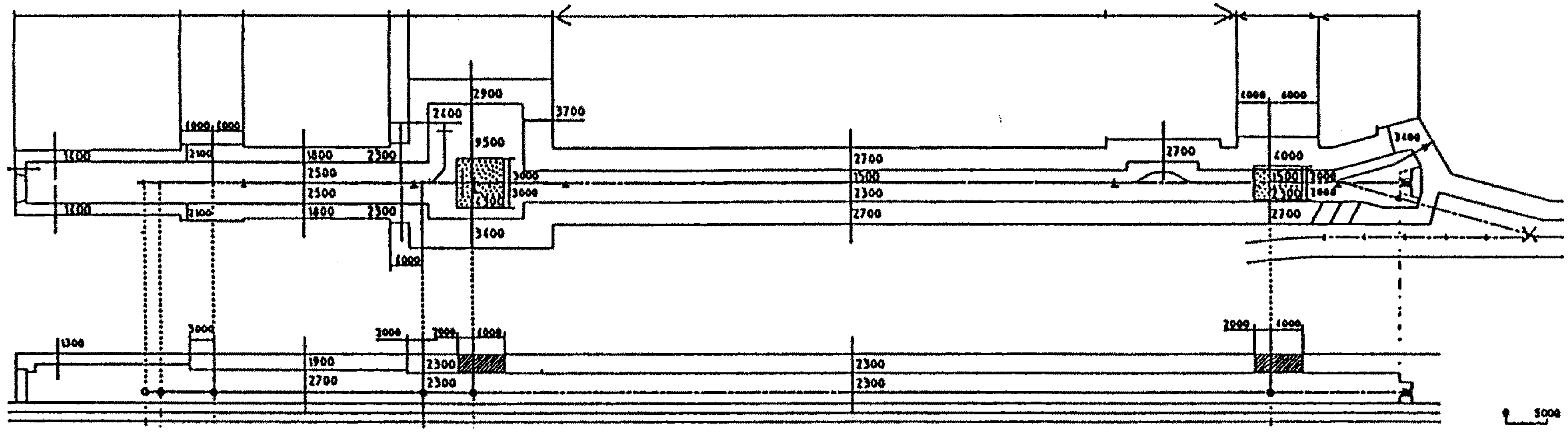

Fig. 1. Shielding specification for the linac