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Site Area Zoning for the Radiation Shielding Design in the Conventional Facilities of PEFP

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1. Introduction

Improvements of the science technology that can get through development of the proton accelerator is getting expectation over several fields.

The conventional facilities[1] involved with the Proton Engineering Frontier Project (PEFP) include building structures, electric power and communication systems, HVAC systems, mechanical and piping systems, wastewater treatment systems, equipment control systems, radiation monitoring systems, and a maintenance facility. On the operation of the accelerator which generates high energy and current, radiation damage occurs by leakage of primary proton beam and by secondary particles and activation.

The purpose of this paper is to set relevant cover design standard and shielding requirement for external expose rate reduction in the conventional facilities of PEFP.

By establishing proper shielding and arranging strategy, we can expect that radiation damage is reduced outside as well as inside of the accelerator research center.

2. The Radiation Shielding Design Criteria

2.1 General Design Requirements

The radiation shielding of the proton accelerator conventional facilities should be capable of minimizing radiation levels, keeping occupational doses and doses to the members of the public as low as reasonably achievable(ALARA), and preventing loss or degradation of equipment performance caused by radiation environment during normal operation conditions or not.

For the radiation shielding design, we divided the proton accelerator research center by several zones based on the design values listed in Table 1. As shown in Table 1, the zones are divided by three classifications according to the workers' access availability and frequency. The design values have been specified as a half value of the law in order to ensure the safety margin.

Table 1 Radiation Zone Classification

Zone Designation	Design Value (uSv/hr)
General Public Area	DL≤ 0.25
Radiation Worker Area	0.25<DL≤ 12.5
High Level Radiation Area	DL>12.5

The areas in building that worker's entrance is frequent are not admitted to exceed amount of 1 mSv per week. In the general public area outside the radiation worker area, it is not admitted to exceed the amount of 1 mSv per year.[2] Radiation dose rate limitations described above are regulated on the nuclear energy law. An ordinary concrete shield thickness should be based on a density of 140 lb/ft^3 when radiation shielding calculation is performed. For other concrete with density differing from it, shield thickness of this concrete should be determined to ensure that the attenuation properties are the same as those of ordinary concrete shield required in the area of concern. When multiple sources affect the protected area, shield thickness should be adequately determined to ensure that the radiation level from all significant radiation sources in that area will not exceed the designated dose limit.

2.2. Facility shielding design requirements

1) Accelerator & Beam Application Building

As shown in Fig. 1, the Accelerator & Beam Application Building is a reinforced concrete and steel-frame structure, and accommodates the related facilities, injecting beam(20 MeV and 100 MeV) from the accelerator located in the Accelerator tunnel below the 8.5 meters ground. The incidental facilities of the proton accelerator are divided into Accelerator & Beam Application Building, Ion Beam Application Building and Utility Building.

As shown in Figures 1 and 2, the Accelerator & Beam Application Building consists of the accelerator tunnel, klystron gallery area, accelerator assembly area, accelerator control area, beam experiment hall and beam application research area.

The accelerator tunnel is a space for installing LINAC structures such as accelerator, RFQ, DTL, etc. Therefore, the accelerator tunnel is a high level radiation area on operating. Proper radiation shielding must be designed according to the design value of each area such as Radiation Worker Area or General Public Area, etc. For the proper radiation shielding design, a classification of each area of the proton accelerator conventional facilities is needed. In table 2, we described the classification of each area.

Beam experiment hall contacts justly with accelerator tunnel that generate main cause of radiation. klystron gallery is arranged on upper part ground class.

When operating the accelerator, the inner part of the accelerator tunnel is changed into a high level radiation area. Therefore, exit and entrance is prohibited during that time. At that time, radioactivity gas of inside is diluted by decay and HVAC system after shut down as well as during the operating.

Table 2 The Radiation controlled Area Classification

Area	Classification
Accelerator Tunnel	High Level Radiation Area
Klystron Gallery	Radiation Worker Area
Beam Experiment Hall	Radiation Worker Area
Ion Beam Application BLDG	High Level Radiation Area
Enclosed Room	Radiation Worker Area
Access	Radiation Worker Area
Office & Outside a Building	General Public Area

Accelerator tunnel which consists of concrete wall should be designed to satisfy the design value of the general public area outside of the tunnel.

All passageways connected with Accelerator tunnel are designed to satisfy the design value of Radiation Worker Area.

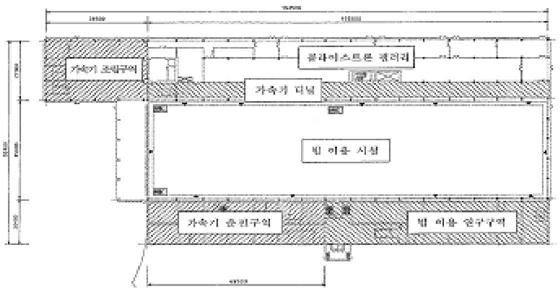

Fig. 1 Accelerator & Beam Application Building

The shielding design of the upper part of accelerator tunnel is different from that of side part in consideration expansion of the power of proton accelerator by 1 GeV hereafter.

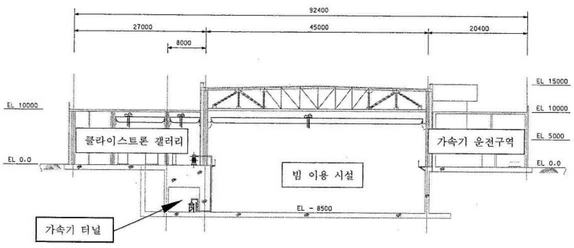

Fig. 2 Accelerator & Beam Application Building

Because present beam experiment hall is divided into different parts that are a low(20 MeV) and a middle energy(100 MeV) beam facility, energy of source term concerned is 100 MeV when decide the thickness of shielding wall that is contacted with accelerator tunnel.

Hereafter, a radiation estimation will be performed and if a shielding would be needed to add, we should do, when the power of accelerator expanded by 1 GeV.

2) Ion Beam Application Building

In Ion Beam Application Building, experimental facilities are placed and operated. Adequate radiation shielding for experimental facilities should be provided to assure the safety of the facility operator and also to prevent leakage of radiation.

External expose dose rate is designed by below ‘12.5 uSv/h’ around the tandem and implanter. It is designed as General Public Area (0.25 uSv/h) outside the building.

In Ion Beam Application Building, through the source term estimation by the charged particles shielding design, because the radiation risks are caused by a secondary charged particles rather than ion beam itself.

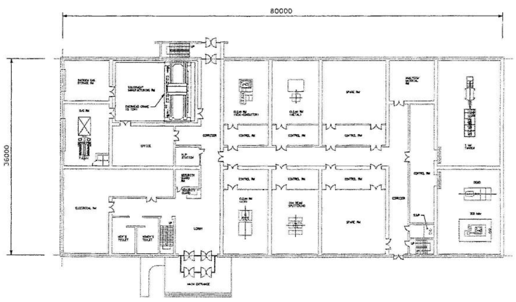
Fig. 3 Ion Beam Application Building (0m)

3. Conclusion

In this paper, we defined the classification of zone for the radiation protection. The zoning is divided into three parts by reliable domestic regulation with considering safety margin. There must not be any damage in nuclear facilities by the first and second radiation of the proton accelerator, and by the activation during operation or not. A lot of previous studies for the shielding design were considered in shielding design of the proton accelerator. A radiation protection system of the facilities and shielding design shall be made according to domestic conditions and 'ALARA' protection principle.

Acknowledgement

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[2] Article 2 (5) in Enforcement Decree of the Act, Korea