Radiation Analysis to Ensure Radiation Safety for the Proton Accelerator Research Center of PEFP

Jun Yeon Kim, Jang-Hyung Cho, Yi-Sub Min, Kyeong-Jun Mun
Proton Engineering Frontier Project, Korea Atomic Energy Research Institute,
Daedeok-Daero 1045, Dukjin-Dong Yuseong-Ku, Daejeon, 305-353, Korea
[*]Corresponding author:jykim2@kaeri.re.kr

1. Introduction

Proton Engineering Frontier Project (PEFP) has been developing a 100 MeV proton linear accelerator. Also, PEFP has been designing the Proton Accelerator Research Center in Gyeong ju.

In Accelerator Tunnel & Beam Experiment Hall in Proton Accelerator Research Center, 5 target rooms for the 20 & 100 MeV beamline facilities exist in the Beam Experiment Hall, respectively. For the 100MeV target rooms during 100MeV proton beam extraction, a number of high energy neutrons, ranging up to 100MeV, are produced.

To ensure radiation safety, we analyzed radioactivity in air for each high radiation area, such as accelerator tunnel, beam line enclosure and each target room. We also designed radiation shielding scheme of PEFP.

2. Radioactivity Analysis of PEFP

In Accelerator Tunnel & Beam Experiment Hall of PEFP, Ar-41 is produced by spallation. For accelerator tunnel, Ar-41 production is evaluated by considering neutron source of 100MeV accelerator facilities and beam dump. To evaluate neutron source of beam dump, we assumed 1kW neutron source without radiation shield.

Table 1 describes Ar-41 concentration in accelerator tunnel. Table 2 describes concentrations of each radioactivities in beam line enclosure and each target room.

Table 1 Ar-41 Concentration in Accelerator Tunnel

Accelerator Facilities	Volume [cm^3]	Neutron Source Strength [neutrons/sec]	Ar-41 Concentration [Bq/cc]
To DTL107	2.5778E+09	4.2147E+11	7.18E-03
Beam Dump	2.5778E+09	1.1410E+13	4.58E-02

Table 2. Concentrations of each radioactivities in beam line enclosure and each target room [Bq/cc]

	H-3	Be-7	C-14	N-13	O-15	Ar-41
TR 21	2.91e-2	-	6.56e-3	6.49e-3	-	4.97e-1
TR 22	1.98e-3	-	4.57r-4	4.89e-4	-	3.47e-2
TR 23	2.92e-2	-	6.66e-3	7.20e-3	-	5.05e-1
TR 24	1.59e-3	-	9.38e-4	1.45e-3	-	7.16e-2
TR 25	5.81e-3	-	2.56e-3	9.83e-3	-	1.94e-1
TR 101	3.35e-5	-	6.72e-6	5.06e-4	9.01e-6	5.17e-4
TR 102	7.39e-4	1.72e-3	1.34e-4	3.57e-2	1.19e-2	1.05e-2
TR 103	2.48e-3	5.86e-3	5.00e-4	9.76e-2	3.68e-2	3.94e-2
TR 104	6.97e-4	2.30e-3	8.83e-5	3.36e-2	1.11e-2	6.85e-3
TR 105	4.86e-7	-	3.30e-8	7.69e-6	1.51e-7	2.42e-6
BL-20 MeV	4.12e-5	-	1.19e-5	1.03e-5	-	6.91e-4
BL-100 MeV	8.67e-3	6.71e-4	8.53e-5	3.39e-2	1.27e-3	4.88e-3

3. Radiation Shielding Design for the Target Room

In Accelerator Tunnel & Beam Experiment Hall of PEFP, 5 target rooms for 20 MeV and 100 MeV exist to utilize proton beam. Layout of the 20MeV and 100MeV target room is illustrated in Fig. 1.

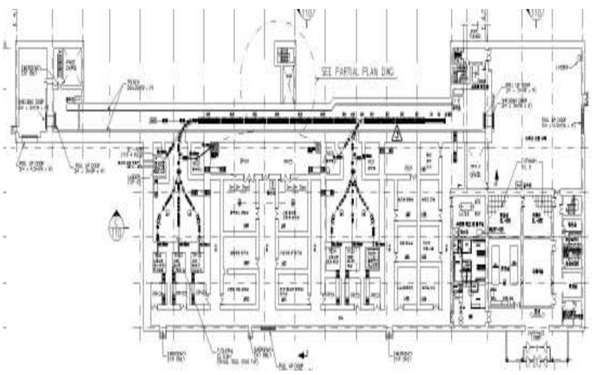

Fig. 1 Layout of the 20 and 100MeV Target Room of PEFP

For the 20 MeV target rooms under normal operating conditions, because dose limit is satisfied with concrete wall thickness determined by structural design analysis, radiation shielding design of 20MeV target rooms is unnecessary. For the 100 MeV beam utilization, PEFP designed the 5 target rooms (TR101, TR102, TR103, TR104 and TR105) for the 100MeV beamlines in the Beam Experiment Hall. Fig. 2 describes 100MeV target rooms in the beam experiment hall of PEFP.

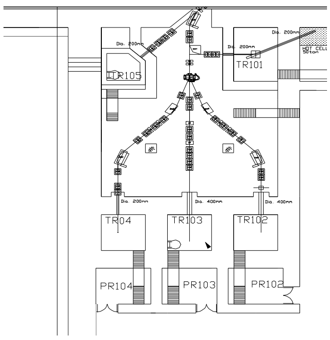

Fig. 2 100 MeV Target Rooms in Beam Experiment Hall

For the optimal shielding design of the 100MeV target rooms of PEFP, permanent and removal local shield structure was adopted. Iron and concrete were employed as a permanent shield structure. Lead and high density polyethylene (HDPE) were employed as a local shield structure. Shield wall thickness by permanent shield structure for the 100MeV target rooms are described in Table 1.

Table 1 Permanent Shield Wall Thickness and Radiation Level for 100MeV Target Rooms

Target Room	Shield Wall Component	Radiation Level [uSv/hr]	Beam Direction
TR101	Concrete-Iron-Concrete Max Thick. : 270cm	≤12.5 (Front Wall Outside) ≤ 0.25 (others)	Horizontal Beam
TR102	Concrete-iron-concrete Max Thick. : 270cm	≤ 0.25 (roof outside) ≤ 12.5 (others)	Horizontal Beam
TR103	Concrete-iron-concrete Max Thick. : 270cm	≤ 0.25 (roof outside) ≤ 12.5 (others)	Horizontal Beam
TR104	Concrete-iron-concrete Max Thick. : 300cm	≤ 0.25 (roof and Left Side Wall outside) ≤ 12.5 (others)	Horizontal Beam
TR105	Concrete-iron-concrete Max Thick. : 300cm	≤ 0.25	Vertical Beam

At the end of the beamline, rear wall of each target room is located. When a target room is not in operation, radiation from other beamlines or target rooms should be shielded to keep its radiation doses below 12.5uSv/hr (radiation worker area). Also, when beamlines are not in use, they are filled with water to protect radioactivation.

5. Conclusions

In this paper, we evaluated amount of radioactivites in accelerator tunnel, beam line enclosure and each target room.

We proposed shielding scheme to keep its radiation doses below 12.5uSv/hr (radiation worker area). To prevent the migration of the airborne radioactivity to accessible area,

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REFERENCES

[1] “Radiation Protection for Particle Accelerator Facilities,” NCRP Report No. 144, published by National Council on Radiation Protection and Measurements, 2003.