Preliminary Test Results of Radiation Shielded Transport Container for Sr-82

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1. Introduction

For the RI (Radioisotope) production using high energy proton accelerator, the separation & purification processes has to be followed after long-time proton beam irradiation to the target. After proton beam irradiation, the target is very highly activated. Then this radio-activated target has to be moved to the hot-cell for the chemical processes. We have been developing Sr-82 production using RbCl target and 100-MeV proton accelerator. If we have to conduct the chemical processes outside of the KOMAC (Korea Multi-purpose Accelerator Complex), the radiation shielded transport container have to be prepared and it has to satisfy all requirements of the government regulations [1] for the radiation safety. The activity of the target was calculated using MCNPX code simulation. The activity of the target reach to 1.15E+7 Bq and 3.44E+9 Bq in the case of 1 μA proton beam irradiation during 20 minutes and 100 μA during 10 hours with 16 days cooling time. The Sr-82 activities are 17.3 μCi and 50.19 mCi each. For the safe transport to somewhere outside of the KOMAC, we considered L-type and A-type containers. The wall thickness of the container was decided to be 10 cm and inner space for the target was decide to be 9.8-cm in diameter and 10.5-cm of height. For the L-type container, the required thickness is 7 cm. In this paper, the preliminary, i.e. not certified yet, test results for the L-type container are presented.

2. Methods and Results

2.1 MCNPX Code Simulation

The target activation occurred by the proton beam bombardment to RbCl target was calculated using MCNPX code simulation. The geometry of the target for the calculation is shown in the Fig. 1. The target assembly is composed of inner cover, outer cover and target itself.

The parameters for the MCNPX calculation are summarized as follows;

- Incident Beam Energy : 70 MeV
- Beam Current : ~ 0. 1 mA
- Irradiation Time: 20 min. ~ 10 hrs
- Cooling Time : ~ 32 days
- Traget Thickness : 0.7 cm
- Target Material : RbCl
- Target Radius : 1.5 cm
- Case Material : STS

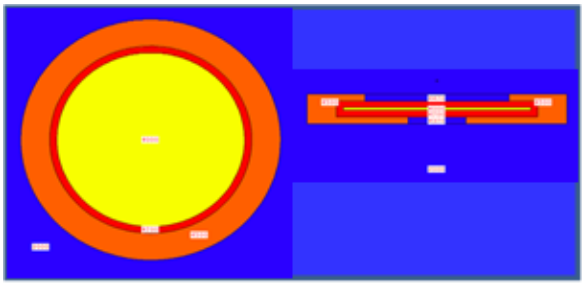

Fig. 1. RbCl target geometry for the MCNP code simulation.

For the Sr-82 production, the target has to be cooled longer than 16 days to avoid radioactive impurity problem, induced by Sr-85, Rb-83, Rb-84, and Sr-83. For that reason, all radiation activities are calculated based on the time 16 days after proton beam bombardment. The activity of the target is 2.43E+10 Bq with 100-μA and 10-hours irradiation, and there's no alpha radiation remained. According to the regulation of the transport for the radioactive material without alpha nuclides, the upper limit of the transportable activities for L-type and A-type are 2E+7 Bq and 2E+10 Bq. In addition, target case also is activated to 9.98E+9 Bq. So, the total value of the target assembly is 3.43E+10 Bq and exceeds the limit of both L-type and A-type. If we reduce the beam current and irradiation time to 1 uA and 20 min, the total activity reduced to 1.13E+7 Bq which does not exceed the value of L-type. In this case, the radioactivity of the Sr-82 is 17.3 μCi.

The big difference between an L-type and an A-type container is the need of the certification. This time we tested every conditions required by the regulations but the results are not certified.

2.2 Design of the Radiation Shielded Transport Container

The container wall thickness is decided to be 10 cm which has some margin for the calculated value, 7 cm to satisfy the condition that the dose rate has to be less than 2 mSv/hr at the surface of the container. For the space for the target assembly and shock absorber is 9.8-cm in diameter and 10.5-cm of height as shown in Fig. 2. The total weight is 256 kg. The diameter and the height are 310 mm and 440 mm.

2.3 Safety Test of the Container

To assure the safety and no leakage of the radioactive material during transport, the regulation recommends to

do some tests under severe conditions even though for the L-type container. We tested the radiation safety of the container according to the conditions which recommended by the regulations, such as a load test, a pressure test, a sprinkling test, a drop test, a built-up test, and a puncture withstand test. After finishing all test procedures, we conducted gamma survey test to check the change of the shielding capacity.

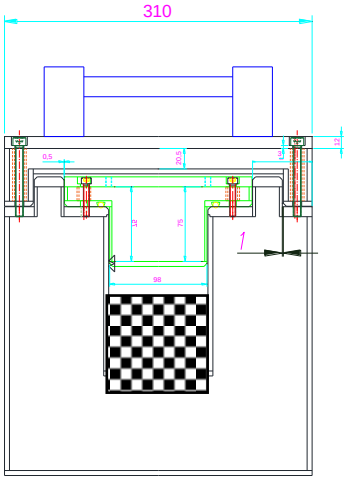

Fig. 2. Design of the container for RbCl target transport.

For the load test, we loaded 768 kg, 3 times heavier weight to the container's. As a result, there's no problem during 10 minutes. Then for the pressure test, we pressurized the inner space of the container to the 0.62 MPa, As a result, there's no big pressure drop during 10 minutes. For the sprinkling test, we put the container under the rainfall > 5 cm/hr during 70 minutes. As a result, there's no water leak to the space for the target assembly. The drop test result shows that there's also no problem. The container dropped from 1.2 m height had no deformation which can occur degradation of the shielding capacity or structure change. A 2,061-kg load was placed on the top cover of the container during 24 hours for the built-up test. There's no structure change. For the puncture withstand test, a STS rod with 3.2-cm diameter, 6-kg weight, and hemi-spherical cross-section was used. The rod was dropped from 1 m height to the top cover and side weak point of the container. The rod also did not make a big mark or structure change of the container. The whole procedure was successfully conducted and the test results satisfied the recommended requirements.

2.4 Shielding Performance Test

After safety test, we conducted the shielding performance test, i.e. gamma survey test. The tests were conducted for the top cover, inner cap, and body. The measured values were not exceeded the calculated reference dose rates when we are using 0.797 TBq Ir-192.

3. Conclusions

A radiation shielded transport container was designed and manufactured for Sr-82 production. To use it as a L-type container, we tested it according to the regulation of radioactive material transport. According to the test results, the container can be used for L-type container with limited radioactive material contents. If we get a certification from the certified institute, it maybe will be possible to be used as an A-type one. By using this container we can transport RbCl target assembly surrounded by STS case including 17.3-μ Ci Sr-82 produced by 70-MeV and 1-μ A proton beam bombardment during 20 min. at the 16 days after EOB. It can be used for the development of the separation and purification process for Sr-82 production and other radioisotopes in future.

ACKNOWLEDGEMENT

This work was conducted as a part of the R&D project (NRF-2017M2A2A6A05016601) and partially supported by the operation fund of KOMAC (Korea Multi-purpose Accelerator Complex) of the MSIT (Ministry of Science and ICT).

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[1] WAste Comprehensive Information Database (http://wacid.kins.re.kr/ETC/tr03.aspx)