SHIELDING DESIGN OF THE UCN TARGET TRANSPORT FLASK

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This report describes the conditions necessary for the detailed design of the UCN target transport flask. The design of the shielding layout for target transport flask has been calculated using the MICROSHIELD program.

INTRODUCTION

After use, the target assembly of the Ultracold Neutron Source (UCN) has to be transported into the ATEC area of PSI West for disposal. It will be highly activated due to direct exposure to the primary 590 MeV proton beam and the secondary particles produced in spallation reactions To transport the assembly from the UCN area to the hot cell of the ATEC a shielded transport flask has to be designed.

To gain access to the target assembly, the steel shielding blocks mounted behind it have to be taken out after a cooling time of about 30 days. Thereafter, the transport flask will be positioned on a trolley and pushed into the opening towards the end of the target assembly. The heavy water, which serves as a coolant in the target assembly, will be pumped out, cooling pipes and power supplies will be disconnected, then the target will be pulled into the transport flask.

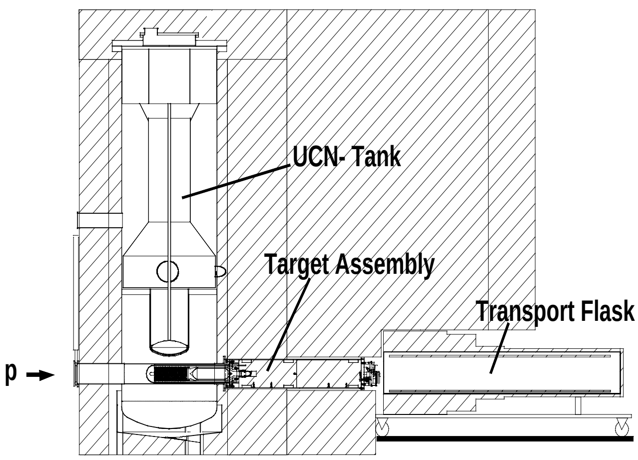

Fig. 1: Schematic drawing of target assembly and transport flask.

As stated above, the target assembly will be highly activated. To be able to transport it to the hot cell of the ATEC area, the flask has to provide shielding so that the maximum dose rate is 2 mSv/h on the outer surface and 0.1 mSv/h at a distance of one meter [1].

SHIELDING DESIGN

For the shielding layout of the transport flask the programme MICROSHIELD [2] has been used. This code converts isotopic compositions into corresponding decay gamma spectra and then calculates the resulting external dose rate including the attenuation due to shielding between source and "measuring point". This is done using built-in attenuation coefficients and build-up factors. MICROSHIELD allows calculations of systems with one source and one shielding thickness. However, the target assembly is composed of different materials and the irradiation conditions vary with position. This leads to significant variation of the nuclide inventory. Thus, the target was split into eight regions as depicted in Fig. 2.

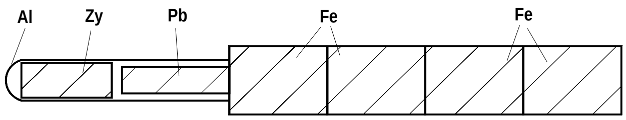

Fig. 2: Composition of the target assembly**.**

For each of the components specified in Fig. 2 the isotopic composition was calculated using a combination of the Monte-Carlo transport code MCNPX and the European Activation System (EASY) [3]. An average proton current of 20 µA was assumed to hit the target for one year, followed by a cooling period of 30 days [4]. These calculated nuclide inventories then served as an input for the calculation of the shielding of the transport flask.

The shielding design for the transport flask must fulfil two main criteria: (1) the dose rate criteria mentioned above and (2) the weight of the transport flask, including the target assembly, has to be below 20 tons, the maximum capacity of the crane in the UCN area.

In order to reduce the weight of the transport flask the thicknesses of the transport flask will be varied over the length of the target assembly – see Fig. 3.

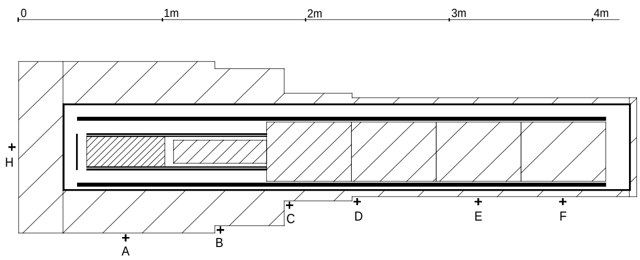

Fig. 3: Schematic cross section of the shield of the transport flask. The labeled points (+) indicate the measuring points to determine the dose rates on the outer surface of the transport flask.

It should be noted that the target assembly is not mounted symmetrically because the mechanics to pull the target assembly are included above it (Fig. 3).

The shielding material was chosen to be Steel. A thickness of 30 cm will be needed in the region of the Zircaloy rods because this is where the activities are highest. After a length of 135 cm the shielding thickness can be decreased by 5 cm giving a dose rate at the surface of 0.47 mSv/h. At the measuring point C the shielding thickness is reduced to 8 cm. At this measuring point one observes the highest dose rate at the surface of the container of 0.68 mSv/h. The last section has a thickness of 5 cm and a maximal dose rate of 0.43 mSv/h. Table 1 lists the calculated surface dose rates at all measurement points.

Measuring Point	Dose Rate [mSv/h]
A	0.40
B	0.47
C	0.68
D	0.43
E	0.002
F	6e-5
H	0.4

Table 1: Dose rates [mSv/h] at the outer surface of the transport flask calculated at different points – see Fig 3.

The dose rates at a distance of one meter from the surface of the transport flask are given in Table 2. All of them are within the limits given by the maximum permissible dose rate of 0.1 mSv/h.

Since only one shielding thickness and source may be calculated with MICROSHIELD at the time, the dose rates are calculated from the results of separate calculations using each of the eight sources together with a conservative assumption about the shield thickness depending on source and measurement position.

Measuring point	Dose Rate [mSv/h]
A’	0.08
B’	0.05
C’	0.07
D’	0.1
E’	0.03
F’	0.03
H’	0.08

Table 2: Dose rates [mSv/h] in a distance of one meter from the outer surface of the transport flask calculated at different points.

The weight of the shielding design shown in Fig. 3 amounts to 16.2 tons. The target assembly weighs 2.5 tons so there remains a weight of 1.3 tons before the lifting capacity of the crane is reached; this is sufficient for the mechanics, the contamination pipe, the pipe guide rails, the lifting gear drive with electric motor and control system.

CONCLUSION

The shield of the transport flask for the UCN target assembly has been designed using the MICROSHIELD programme. Special attention was paid to the weight requirement due to the crane capacity in the UCN area, as well as to the dose rate limits for the transport within PSI. The layout presented in this report meets all these requirements with a weight of approximately 16.2 tons and a maximum dose rate of 0.68 mSv/h at the surface and 0.1 mSv/h in one meter distance.

The detailed design of the transport flask will be based on these results.

REFERENCES

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