1. Introduction

- During the 2010 outage of the Leibstadt NPP, a diver performed maintenance work in the fuel transfer pool. After completing his work, he recovered a highly activated object.
- The diver’s ring dosimeter measured $H_p(0.07)$ of 1.1 Sv to the right hand while whole body dosimeters indicated $H_p(10)$ values between 19 and 40 mSv.

Underwater picture of the object that was identified as a lost piece of a dry tube of 30 cm length that had been unnoticed in 2006 outage.

2. Objectives

- This study aimed at assessing both diver’s skin dose to the hand and effective dose by performing dose reconstructions based on analytical calculations and Monte Carlo (MC) simulations associated with numerical phantoms.

3. Materials and methods

1. Activity estimation

- The activity was estimated by comparing dose rate measurements at several distances of the object under water with dose rates per unit activity of $^{60}$Co calculated in water using MicroShield and MCNPX 2.5.0.

- The activity was also obtained through activation calculation using the ICRP reference voxel phantom.

- The average activity of the object was 1.8 TBq (range, 0.9-2.8 TBq).

2. Personal dose estimation

- The skin dose to the hand in contact with the object was calculated for a likely handling time of 45 s, the contact skin dose was 7.5 Sv (range, 5.3-10.4 Sv).
- If the object was not in contact but located at 2 cm from the ring dosimeter, the calculated dose is between 1.0 and 3.3 Sv. Those values are compatible with the measured $H_p(0.07)$ of 1.1 Sv.

- The effective dose was estimated to 28 mSv combining dosimeters from routine monitoring and 14 mSv using MC simulations associated with the ICRP voxel phantom.

Conclusions

- We retained a MC-calculated skin dose of 7.5 Sv for the hand, which corresponds to the most probable maximum dose.
- For the effective dose, the value of 28 mSv derived from individual routine monitoring was registered because the uncertainties related to the positions of the object during the diver’s move make hard to obtain a better estimate using MC calculations.
- MC-based dose reconstructions provide valuable information when phantoms measurements are not feasible due to radiation safety limitations.