Radiation Safety and Security Measures for Radium Collection and Conditioning Operation

Milan Orlić, Snežana Pavlović, Maja Gajić-Kvaščev
Vinca Institute of Nuclear Sciences, Belgrade, Serbia
morlic@vin.bg.ac.yu, spsnow@vin.bg.ac.yu, gajicm@vin.bg.ac.yu

ABSTRACT

It is assessed that there are some 10 g of unused $^{226}$Ra sources on several locations in Serbia [1,6,7]. The majority of those sources are in Vinca Institute, in several different storage locations. Another place, with a significant amount of radium, was Institute for the Oncology and Radiology of Serbia (IOR) in Belgrade. Having in mind the amount and condition of those sources as well as the location of the IOR, the whole operation of collection, repackaging, transportation and conditioning of the sources needed to be carefully preplanned and conducted with all radiation safety and security measures needed being implemented and in place. Repackaging and conditioning of the sources have been done under IAEA project by the Hungarian „Izotop“ firm, and radiation safety and security measures have been obligation of national counterpart, Vinca Institute, with full supervision and support of all relevant national state agencies.

The overall radiation safety assessment of the operation and safety and security measures taken during those activities are presented in this paper.

1 INTRODUCTION

The project of removal of $^{226}$Ra sources from IOR and their transport, conditioning and storage in Vinca Institute [1] has been realized according to the approval of the Ministry of Science of the Republic of Serbia and in accordance with national legislation, and IAEA standards of radiation safety and nuclear security presented in The Report on Radiation Safety for the Operation of Removal, Transport, Conditioning and Storage of Radium [2] and with financial, technical and expert support of IAEA. Besides that, the government of the Republic of Serbia has not just funded the realization of the project, but, through direct involvement of Nuclear Regulatory Commission has significantly increased efficiency and safety of the project. The Hungarian “Izotop” firm has been contracted by IAEA after the bidding procedure, and they accomplished removal and repackaging of the radium and other sources from the “bunker” (fig. 1) from IOR, transported them in a special convoy to Institute “Vinca” into storage H0 [5]. The “Vinca” Institute has collected disused radium sources from two more locations: The Institute for Occupational Health of Belgrade and NIS Novi Sad and transported them to Vinca.

Conditioning of radium and other sources for which it was possible have been realized in the Radioisotope Laboratory of the Vinca Institute. Conditioned waste and remaining unconditioned sources have been stored again in H0, where they will be kept up to operational phase of newly constructed radioactive waste storage H3. Depending on the waste acceptance
criteria for specific facility [14], the waste will be then transferred and stored into either hangar H3 or secure storage SS.

Figure 1. Interior view on radium bunker inside IOR

The Vinca Institute has provided all other necessary logistics for project realization such as safety documents, licensing documents and radiation safety and security measures during the project, which are presented in this paper.

2 RADIATION SAFETY MEASURES

All phases of activities have been conducted with applied technical safety measures such as defence in depth and good engineering practice [4,8,9,10,11,15,16]. Activities with old disused sources, some of which being approved as dehermetic, have been conducted with application of multiple barriers preventing spread of contamination. Members of “Izotop” had extensive experience on similar operation, thus everything has been realized according to well trained operational procedures. Operation has been carefully prepared, and before the beginning of operation, the whole team and each member of both teams have been informed about details and their roles and responsibilities.

2.1 Radiation Accident/Incident Response Plan

Radiation emergency response plans have been prepared for both possible circumstances: in the city, during collection and transportation and in the Vinca Institute, during repackaging [13].

Figure 2. Response after emergency
Depending on location and scale of eventual emergency outside the Vinca Institute, involvement and intervention of all responsible state agencies have been foreseen in the response plan prepared by the Ministry of Environmental Protection. Response on emergencies in the Vinca Institute, not threatening locations outside Institute boundaries, has been prepared according to approved Plan for emergency response in the case of accident in the Institute.

Minor incident due to turn over of transport container and spill of radium needles has been immediately taken care of by the Hungarian team and the surface of floor has been decontaminated and surveyed by the Vinca’s team (fig. 2).

The whole project has been finalized without any accident.

2.2 Radiation Protection

Controlled radiation areas have been established in all places where it was needed to prevent spreading of contamination and a possibility of public exposure, and assure that occupational exposure will be less than operational limits.

For the activities of collection of sources from IOR, the controlled area was the room with a bunker and adjacent hall, where a special tent has been installed (fig. 3).

![Figure 3. Containment in IOR](image)

In the Vinca Institute, the controlled zone has been established in one of the laboratories in the controlled zone of the Radioisotope Laboratory (fig. 4), and confinement has been reassured with the installation of an additional filtration unit with HEPA filters (fig. 5).

According to [12,18] and based on operational experiences in previous radium conditioning operations and exposure data, the following authorized operational dose limits have been established for the project:

- Effective dose at 5 mSv for the whole operation;
- Effective dose at 0.5 mSv daily;
- Extremity and skin dose equivalent at 20 mSv, for the whole operation.

Table 1. The results of external exposure monitoring [3]

<table>
<thead>
<tr>
<th>Ref. no</th>
<th>Effective dose (mSv)</th>
<th>Dose equivalent (mSv)</th>
<th>The highest recorded dose rate (mSv/h)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.650</td>
<td>4.28</td>
<td>3.13</td>
</tr>
<tr>
<td>2</td>
<td>0.462</td>
<td>4.18</td>
<td>3.13</td>
</tr>
<tr>
<td>3</td>
<td>0.229</td>
<td>/</td>
<td>1.25</td>
</tr>
<tr>
<td>4</td>
<td>0.641</td>
<td>/</td>
<td>4.21</td>
</tr>
</tbody>
</table>
Compliance with those limitations has been controlled with TL and EP dosimeters, for the whole body as well as for extremities. Besides those limitations all other safety measures have been applied such as time, distance and shielding.

The results of the external exposure monitoring of operators that have collected and conditioned radium needles are presented in Table 1. A graphical presentation of the dynamic changes of exposure level for one of the operators, measured by EPD is given in fig. 6.

According to the results of the measurements of effective doses and dose equivalents for all radiation workers in radium condition operation it may be concluded that none of them has been exposed above established operational limits during operation.

Before, during and after the operations of repackaging and conditioning of radium sources airborne contamination monitoring has been organized as well as working area contamination control by smear tests. According to the results [3] it can be concluded that the working area and the environment remained cleaned after the project. During the operation there were no detected emissions in the environment.

During the conditioning operation, the position of the air sampler has been determined according to the actual meteorological data and to the dispersion model, on a daily basis. [3]

Although the presence of a neutron field has been expected according to the results of the working area monitoring (around 30 µSv/h from neutrons) it was surprising that during
the conditioning operation, no individual neutron source has been identified, but it was proved that radium, itself, depending of the amount at one place, emits a measurable neutron field.

During the whole operation, for eventual incidents or human decontamination, an emergency medical team from Vinca Institute was prepared, and for case of major accidents team of Medical Military Academy in Belgrade was prepared, according to the national response plan.

![Image of graph](image)

**Fig 6. External exposure (dose and dose rate) during conditioning operation for one of the operators (measured by EPD)**

All members of the teams have been qualified and trained for their jobs. Before the beginning of the operation, the details of the project have been briefed with the whole teams. Emergency response teams have been prepared and trained with specific course with tailored programme.

3 **RADIATION SECURITY MEASURES**

Security measures applied for this project have several parts according to the timing of the project. The security unit of IOR provided security measures during the repackaging operation in IOR and the preparation of the special convoy. Special units of the Ministry of Interior, according to the national plan, provided security measures, all the way up to receiving radioactive material in the Vinca Institute.

Storage H0 has been put under constant visual access control from CAS of the Vinca Institute, as presented on figure 7. All other security features of H0 have been improved as well, such as double keys and access procedures.

During the conditioning operation in the Vinca Institute and the radium temporary storage in H0, the activities of the security services of Vinca have been intensified, according to internal procedures, and the security features of the Radioisotope Laboratory have been improved as well.
4 CONCLUSION

The project of removal of radium and other disused sources from The Institute of Oncology and Radiology of Serbia, their transport, conditioning and storage in the Vinca Institute has been completed according to the requirements of the project [1], safety report and licenses [2] and technical plan of the Izotop firm [5].

The most important result of the project is the fact that more than 2 g of radium have been removed from the center of Belgrade to Vinca, solving security and safety concern of IOR and all relevant state bodies. The sources have been conditioned in compliance with the safety standards and practices of IAEA.

The second important result was that the project served as well as training and exercise for all relevant lines and services needed for future big operation of the transport of SNF.

A very important result is also the opportunity for the Vinca staff to see and a experience standard source conditioning operation.

Analyzing all parameters of radiation safety and relevant facts such as:

1. working areas of IOR and Vinca Institute have been decontaminated,
2. there were no emissions in the environment during operation,
3. it has not been detected contamination of the environment,
4. personal exposure levels have been below operational limits,
5. RW have been stored, recorded and secured,
6. the project has been realized without any incident,

it may be concluded that complete operation of removal, repackaging, transport, conditioning and storage of disused radium sources have been completed in accordance with the plan, project and license conditions with all safety and security measures provided.

ACKNOWLEDGMENTS

The authors gratefully acknowledges the work done by all involving organisation in that project: “Izotop” (Hungary), Ministry of Science of Serbia, Ministry of Environmental Protection of Serbia, Ministry of Health of Republic of Serbia, Ministry of Interior of Republic of Serbia, Nuclear Regulatory Commission of Serbia, The government of City of Belgrade, Institute of Oncology and Radiology of Serbia and all members of Vinca team.
REFERENCES

[1] Institute Vinca, Project for the removal, conditioning, transportation, and storage of radium sources from Institute of Oncology and Radiology of Serbia, 2008


[12] Internal act on radiation protection in Vinca Institute , Vinca 2006


[17] Law on radiation protection Off.bul. FRY 46/96