INTRODUCING X-RAY BLOOD IRRADIATORS IN JORDAN UNDER THE GLOBAL CESIUM SECURITY INITIATIVE (GCSI)

Abstract

In Jordan, there are seventeen facilities dealing with Category 1 and 2 radioactive sources. The Cesium Irradiator Replacement Project with the US Office of Radiological Security (ORS) under the Global Cesium Security Initiative aims to reduce high-risk radioactive sources within Category 1 by removing radioactive Cesium sources and replacing them with alternative technology.

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INTRODUCTION

In Jordan, there are seven facilities that deal with Category 1 radioactive sources, four of which utilize Cs-137 blood irradiators, with an average activity of 1200 Ci for each one (see Figure 1). Also, there are around ten facilities dealing with Category 2 radioactive sources for the purposes of industrial radiography and brachytherapy.

The Cesium Irradiator Replacement Project with the US Office of Radiological Security (ORS) under the Global Cesium Security Initiative (GCSI) aims to reduce high-risk radioactive sources within Category 1 by removing radioactive cesium sources and replacing them with alternative technology. After the end of this project, it is expected that there will be no radioactive cesium sources in use in Jordan within Category 1.

BACKGROUND

The Energy and Minerals Regulatory Commission (EMRC, www.emrc.gov.jo) is a Jordanian governmental body with financial and administrative independence, which carries out regulatory functions related to nuclear and radiation safety and security.

Figure 1: Old blood irradiator with a Cs-137 source (activity – 1200 Ci)

According to the law, the EMRC is responsible for coordinating relations between Jordanian entities concerned with radiation protection, nuclear safety, and security on one hand and relevant international, regional, and Arab organizations and agencies on the other. In coordination and cooperation with relevant authorities, the EMRC aims to achieve the following:

- ✓ Regulate and control the use of nuclear energy and ionizing radiation.
- ✓ Protect the environment, human health and property from the hazards of contamination and exposure to ionizing radiation in accordance with the provisions of this law.
- ✓ Ensure the fulfilment of requirements of public safety, radiation protection, and nuclear safety and security.

In Jordan, there are four facilities that handle blood irradiators using Cs-137. The regulatory control over these facilities is part of the overall Jordanian national regulatory control system for the lifecycles of the radioactive sources. This practice is considered to fall within Category 1 practices, which necessitate effective control due to the associated high risks. Facilities using such sources are mandated to install effective physical security systems and have financial and administrative arrangements to repatriate these sources to their origin once they become disused.

The EMRC received assistance in different areas of its regulatory functions through cooperation with the US Office of Radiological Security (ORS) to ensure the security of high activity radioactive sources, including the implementation and upgrading of security measures for facilities dealing with Category 1 and 2 sources. US DOE helps to establish security measures for the facilities mentioned above through a Jordanian national contractor based on international recommendations. US DOE also provided free maintenance for three years after finishing the implementation of the security measures. According to the contract, the responsibility for the sustainable maintenance of security measures rests on the licensees after closing the project.

After ORS presented the experiences of other countries that have switched to alternative technology, the EMRC made a comparison between technology that depended on the use of radioactive sources and alternative technology from a radiation safety and security standpoint. The EMRC came to the following conclusions:

- ✓ Employing alternatives means a shift from dealing with Category 1 radioactive sources to a less dangerous category (up to Category 5).
- ✓ Such an approach reduces the risk associated with the practice.
- ✓ Regulatory requirements and functions are less complex for alternative technology (licensing requirements, review and assessment processes, periodic inspections), while certain requirements, such as security plans for sources and a radioactive waste disposal plan, are absent.

Thus, the EMRC initiated a Cesium Irradiator Replacement Project with the US ORS under the GCSI. This project includes removing cesium irradiators and replacing them with x-ray irradiators as an alternative technology. This replacement will reduce the possibility of radiological consequences associated with the potential misuse of high activity sources.

PROJECT DESCRIPTION

The project – which began in 2018 and is slated to end in 2023 – includes several stages.

1. Preparatory Stage

This stage took three months and included introducing the project and the advantages of alternative technology by presenting the characteristics of radiation devices and the experiences of other countries in this field.

Name	Abbreviation	Role
US Office of Radiological Security	ORS	Main partner for implementing the project and allocating financial resources
Energy and Minerals Regulatory Commission	EMRC	Coordinator among the project stakeholders and facilities, and controller of the project milestones
Middle East Scientific Institute for Security	MESIS	Organizer of project activities and responsible for follow-up
Jordan Food and Drug Administration	JFDA	Approver of the x-ray irradiators for use
Jordan Atomic Energy Commission	JAEC	Manager of the central storage facility (sources' removal and storage)

Table 1. The main stakeholders

Jordan conducted a national workshop intended to provide the participants with an overview of the replacement project and its main phases. Among the participants were the four facilities with cesium irradiators, the Ministry of Health, the JFDA, the EMRC, and representatives from the ORS. The workshop took place at the Middle East Scientific Institute for Security (MESIS) on 15-16 July 2018. It included discussions on the challenges of maintaining physical security systems due to the substantial amount of funds required for sustainability/maintenance, as well as a study on comparing irradiators with alternative technologies (cesium irradiators versus x-ray irradiators). This comparison covered the purchase price, site preparation, licensing costs, security requirements, transportation, disposal of the radioactive material, lifecycle, preventive maintenance, yearly spending related to the system, regulatory inspection, and irradiation time per unit dose. In addition, the discussions focused on the technical issues for using the x-ray irradiators and the dose delivered to blood samples.

2. Contracting Stage (four months)

The EMRC initiated official correspondence with the four facilities. Three of them responded showing their intent to benefit from this project, and one facility is be considered in the next cycle. Furthermore, a joint team from the EMRC and ORS conducted site visits to meet upper management at the facilities for further discussions about the advantages of the alternative technology. Based on that, the facilities agreed to replace Cs-137 sources with alternative technology and sent official letters expressing their agreement. The letters included the following main parts:

- ✓ Responsibilities of the ORS:
    - The ORS will support the procurement of acceptable alternative technology according to the agreed technical specifications.
    - The alternative technology must meet or exceed the current technological capacity of the existing device and will seek to minimize operational impacts.
    - The ORS will assist the facilities during the transition period as specified in the contract.
- ✓ Responsibilities of the facilities:
    - Plan to operate the ORS-funded alternative technology equipment appropriately and incorporate operational and maintenance procedures into their regular routine.
    - Provide new staff with training on how to operate and test the equipment.
    - Recognize that they are responsible for the security of the material at their sites and that at the end of the validation period, as specified in the contract, they intend to allow the removal of their existing cesium-137 gamma irradiator unit.
    - Have no future plans to obtain a cesium-137 blood or research irradiator.
    - Assume full responsibility for the operation, testing, and maintenance of the x-ray irradiators at the end of the ORS-funded maintenance and warranty period as specified in the contract.
    - Contact ORS in case they need additional support as appropriate concerning the project's scope of work for the removal of the existing cesium-137 gamma irradiator unit and replacement with an alternative technology.

3. Choice of the alternative technology

In cooperation with ORS, the EMRC sent technical specifications from different vendors of the relevant alternative technology to the end-users targeted in the project, so that they, in turn, develop the technical specifications appropriate to the nature of their work. Three facilities provided the requested technical specifications for the x-ray irradiators to CRDF Global, an organization that is responsible for procurement of x-ray irradiators. These facilities received three x-ray blood irradiators and one research irradiator between one month (in one facility) and six months (in others) after they sent the agreement to the EMRC. Transition periods for blood irradiators are one year and two years for research irradiators.

4. Acquiring funds for the equipment purchase

Figure 2: Dose assessment of the transport package

The cost of the project to replace four irradiators with alternative technology was estimated to be around 1,300,000 US dollars. This included the value of the devices using alternative technology, one-year free maintenance contracts for each site, and training on operating alternative devices, as well as the cost of removing and storing the radioactive sources. US ORS covered the entire financial side of the project.

The government granted the hospitals exemptions from customs and sales taxes related to the import of these devices. The facilities then covered the licensing fees paid to the regulatory body, the EMRC.

5. Room selection and upgrades of the new device

The facilities selected new rooms to install alternative technology suitable for the devices through site visits and technical recommendations by experts. As per the initial site assessment conducted ahead of installation, the facilities had to ensure that the following requirements were met:

- ✓ Availability of and connection to an Uninterruptible Power Supply (UPS) device
- ✓ Appropriate ventilation system
- ✓ Adequate and compatible power supply source

6. Obtaining regulatory approvals

Two licenses were required in order to gain the necessary regulatory approval. The subcontractor was responsible for obtaining the import license ahead of delivery and installation, whereas the facility was responsible for the operation license which was issued

by the EMRC. The operation license must be renewed every two years. The following requirements must be met to renew a license for a general x-ray device:

- ✓ Maintain a radiation protection programme for the facility.
- ✓ Keep maintenance records for the device.
- ✓ Be under supervision of the radiation protection officer of the facility.

The EMRC indicated that the requirements for the new device make the facility exempt from having a security system, security plan, and emergency plan. Instead, the requirements entail that the facility should have relevant emergency procedures in place.

7. Source removal

The EMRC contacted the Jordan Atomic Energy Commission (JAEC) to store the removed sources in the Central Storage Facility (CSF), which is managed by the JAEC until a possible solution is found to repatriate the sources to their countries of origin or for final disposal. The JAEC agreed to assist in implementing this project and took responsibility for source removal and transportation.

Currently, one university hospital has finished the transition period: their cesium irradiator was removed and is now being stored at the CSF. The next step for the project is removal of the two sources from two remaining sites.

MAIN CHALLENGES AND SOLUTIONS

The main challenges identified during the project can be summarized as:

- ✓ The lack of experience and knowledge of the facility personnel in working on the x-ray irradiators.
- ✓ The funds needed for preventive maintenance and sustainability.
- ✓ The difficulty in determining the exact transition period required for each facility.
- ✓ Understanding the needed/expected technical specifications of the x-ray irradiators.
- ✓ Administrative issues with higher facility management.

Figure 3: Cesium source removal

There were several meetings regarding the concerned facilities. The ORS and MESIS participated in order to facilitate the understanding of technical specifications and the cost of the project. The facilities were also provided with examples showcasing international experience in using x-ray irradiators. The ORS provided the facilities with brochures and videos on modern types of x-ray irradiators and their specifications, which assisted the facilities in defining their needs.

The EMRC conducted a meeting with the management of the facilities to discuss relevant issues under the project and to ensure that they understand the main elements. The facilities approved the acceptance of the project based on the following terms:

- ✓ They will not bear any cost related to the source removal.
- ✓ They will get new-free x-ray irradiators with technical capacities equivalent to or exceeding the use of cesium irradiators.
- ✓ There is no need to install a physical security system for x-ray irradiators.
- ✓ The old security system would be removed, eliminating the costs associated with sustaining it.

CONCLUSIONS AND MAIN LESSONS LEARNED

The EMRC has been in contact with the facilities working on x-ray irradiators to get their responses and feedback on the use of alternative technology. So far, no problems have been reported to the EMRC or identified.

The hospital where the cesium irradiator was removed prepared a Site Evaluation Report with positive feedback. During the trial period, the hospital conducted an operational and quality assessment for the new x-ray device, including radiation dose measurement and accuracy tests. The facility came to the following conclusion about the device in comparison with the cesium-based device:

- ✓ As the cesium-based device was installed and operated at a location distant from the Blood Bank, where other relevant procedures take place, the installation of the new x-ray device at the Blood Bank saved time and effort of staff to conduct operations.
- ✓ The new device reduced the time needed for blood irradiation from 15 to four minutes, which enhanced the overall patient care service at the facility.
- ✓ The results of the radiation dose measurement tests for the new x-ray device were satisfactory.
- ✓ The efficiency and performance of the new x-ray device were higher. The device met the facility's operational and technical requirements for blood irradiation.
- ✓ The facility found the new x-ray device to be manageable and user-friendly.
- ✓ There were no issues or problems reported during the process of installing the device.

For the project completion, future activities include following up with the three facilities currently using x-ray and one facility still in the discussion process. All the three facilities reached the transition phase without reporting significant problems to the vendor or the EMRC. It is expected that the project will end in mid-2023.

Recommendations for stakeholders involved in a similar project include the following:

- ✓ There is a need for effective coordination among institutions at the national and international levels.
- ✓ It is necessary to provide appropriate information and training for users of radioactive sources and encourage them to search for suitable alternative technologies that pose the least possible risk. This should be considered within the promotion of safety and security culture.

- ✓ Risk assessment considerations should be taken into account when deciding whether to purchase/use ionizing radiation units or to implement alternative technology.