# Management of Disused Radioactive

# Sources from the Irradiation Facility

# Product I in Cuba

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**Abstract**

The industrial irradiation facility, type Product I from the former Soviet Union, was put into operation in Cuba in 1987, in the Research Institute for Food Industry. It was used for irradiation of foodstuffs and other types of products. The facility stopped operating in the nineties. In order to recover the irradiation capacities, it was necessary to recharge the irradiator with new Co-60 sources. The 52 disused radioactive sources (DSRS) had to be previously removed from this installation. Adequate container was not available to put the DSRS and transport to the National Radioactive Waste Storage Facility. So the DSRS were transferred and temporary stored in the reserve pit, located in the same room. Adequate technical and safety conditions were developed in the facility and the authorization from the Regulatory Body was granted for this operation. Later on, a container for safe transport and storage of the 52 Cobalt-60 DSRS was received with the support of the IAEA. Operational and safety procedures, radiation protection program and safety analysis were developed for transferring the DSRS from the reserve pit to the container, preparation of the package and transport to the Waste Storage Facility. The required documents were presented to the Regulatory Body and the authorization was granted. The transportation should be carried out under special arrangement. The technological and safety conditions developed for handling the DSRS are described in the paper.

## INTRODUCTION

The Food Irradiation Plant (PIA), type Product I from the former Soviet Union, was put into operation in Cuba in 1987, in the Research Institute for Food Industry (IIIA). It was designated mainly for irradiation of foodstuffs for preservation, later it was also used to irradiate medical and pharmaceutical products for sterilization. According to the IAEA classification, this is a category II irradiator, panoramic irradiator with dry storage of the radioactive sources. The facility was charged with 52 Co-60 radioactive sources, with an initial total activity of 2.50E+15 Bq (67.6 kCi), reference date May 1986. The facility stopped operating in the nineties.

There exists the intention to recover the irradiation capacities at PIA and for that it was required to install new radioactive sources. Consequently, it was necessary to unload the 52 DSRS from the irradiator and temporarily transfer to a reserve pit located in the same facility, as an adequate container was not available at that time for the transport and safe storage of the sources.

Last year, a container for the 52 DSRS was received through a Technical Cooperation Project with the IAEA. The sources will be removed from the reserve pit and transferred to this container, for the safe transport and storage at the Radioactive Waste Storage Facility.

The transfer of DSRS from the irradiator to the reserve pit, as well as their removal from the reserve pit and transfer to the storage container, required adequate planning and preparatory works to ensure safety, this includes:

* Design and construct auxiliary devices to facilitate the operations and to optimize the radiation doses;
* Train the operators in the use of the containers, auxiliary devices and special tools to handle the sources;
* Develop operational and safety procedures for operations, radiation protection program, the safety analysis and emergency plan;
* Present these documents to the Regulatory Body to apply for authorization.

These activities are described in the paper.

## Transfer of the disused sealed radioactive sources from the irradiator to the reserve pit

### Preparation for the operations

The reserve pit, by design, is the same as the irradiator and its function was to temporary store the radioactive sources during maintenance operations in the irradiator. The reserve pit was reviewed and maintenance works were carried out in order to prepare it to receive the sources (figure 1).

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| *FIG. 1. Review of the reserve pit before transferring the DSRS* |

A transfer container to move the DSRS from the irradiator to the reserve pit was available in the facility, but it had to be reviewed and repaired as some parts were damaged (figure 2).

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| *FIG. 2. Reviewing the transfer container and preparing for the operations* |

Some auxiliary devices to operate the container were designed and produced, in order to facilitate the operations and to optimize the operator doses. A key point of the operations is the alignment of the channels of the container with the channels of the pits (of the irradiator to remove the DSRS and of the reserve pit to place the DSRS). The device showed in figure 3 was used to facilitate this operation. After the container is placed over the channels of the pit, the alignment is verified using a special rod.

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| *FIG. 3. Device constructed for alignment of the channels of the container with the channels of the pits* |

Cold runs were carried out in the reserve pit, using the container, auxiliary devices, tools and dummy sources. The objective was to verify the correct functioning of the container, tools and devices, as well as to measure the time for each operation in order to estimate the operator doses.

Operational and safety procedures were developed including the description of the container functioning, the cold runs, the real operations for transferring the sources from the irradiator to the reserve pit, the radiological controls during and at the end of the operations and for the record of the information.

### Authorization from the Regulatory Body

The operational and safety procedures, the radiation protection program, the safety analysis, as well as the emergency plan were prepared and presented to the Regulatory Body to support the license application.

The risk matrix methodology was used for the safety analysis [1, 2]. The possible initiating events of accidental sequences and their radiological consequences were identified, as well as the safety barriers to prevent accidents or to mitigate their consequences. The estimation of expected doses during normal operations and in radiological emergency situations was also included in the safety analysis [3].

These documents were evaluated by the Regulatory Body and the license was granted.

### Brief description of operations

The DSRS were transferred from the irradiator to the reserve pit in 2015, with the assistance of an IAEA expert. The initial distribution of the radioactive sources in the irradiator’s channels is presented in the figure 4. Transfer operations were planned in stages (7 cycles). All the sources contained in a selected channel of the irradiator were loaded into the container and transferred to a predefined channel of the reserve pit. The dummies were removed from the irradiator, but they were not transferred to the reserve pit. The final distribution of DSRS was adequately recorded (figure 5).

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| *FIG. 4. Initial distribution of sources (red) and dummies (grey) in the irradiator’s channels* | *FIG. 5. Distribution of DSRS in the channels of the reserve pit* |

The crane available in the facility was used to move the transfer container. The device showed in figure 3 was used for the alignment of the channels of the container with the channels of the pits. The figure 6 shows some pictures taken during the operations.

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| *FIG. 6. Pictures taken during the operations: moving the transfer container, removing the DSRS from the irradiator´s channel, unloading the DSRS in the reserve pit* |

Radiological controls were carried out (figure 7), including:

* Dose rate measurements at the base of the container:
	+ - * to check the passage of the radioactive source, from the irradiator´s channel to the transfer container and from the container to the channel of the reserve pit,
			* to verify the removal of a dummy source from the irradiator’s channel;
* Dose rate measurements on the top of the transfer container to control the movement of the tool with the radioactive source;
* Dose rate measurements around the container when loaded with the sources;
* Dose rate measurements at the surface of the floor and at 1m from the reserve pit, at the end of the operations;
* Contamination controls through direct measurements of the dummies and plugs removed from the irradiator´s channels;
* Contamination controls by taken wipe samples on the tool after handling the radioactive sources;
* Contamination controls by taken wipe samples on the top of the channels of both pits.

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| *FIG. 7. Radiological controls during the operations: dose rate measurements above the reserve pit and around the container with the DSRS, contamination controls of dummies and plugs.*  |

The results of radiological controls were also recorded. No radioactive contamination was detected, so it was inferred that the sources remain sealed. The irradiator´s channels and the transfer container were check at the end of operations to verify that no radioactive source was left inside.

No radiological incidents occurred during real operations. The results of individual radiological monitoring during real operations demonstrated that the doses received by the operators were below 0.1 mSv (the predicted values were not exceeded).

The removal of the DSRS from the irradiator allowed the revision and maintenance of the auxiliary systems in the facility, including the irradiator rack and its hoist mechanism. The facility was then recharged with new Co-60 radioactive sources.

## removal of the DSRS from the reserve pit and transfer to the Waste storage facility

A container (CUB-40) for the 52 DSRS was received through a Technical Cooperation Project with the IAEA. The container provides adequate shielding for the 52 sources with total activity of 4.0E+13 Bq (1.08 kCi).

### Preparation for the operations

Adequate planning and preparatory works were necessary to ensure safety of the operations. The design of the container allows the direct loading of the sources from the channels of the reserve pit, using a special tool. Cold runs were carried out, using the container CUB-40, dummy-sources, the tool for handling the sources/dummies and the auxiliary devices (for the alignment of the container with the channels of the reserve pit, figure 3, and metallic rods for the operation of the container).

The cold runs allowed the training of the operators in handling and operation of the container, tools and auxiliary devices. Training was very important for the operators, as it is the first operation involving the handling of high activity sources, without the support of external experts.

After that it was possible to develop the operational and safety procedures, including:

* Description of the container CUB-40 and auxiliary devices,
* Procedures for the cold run using the container CUB-40 and auxiliary devices,
* Procedures for the removal of DSRS from the reserve pit,
* Procedures for the radiological controls during the source removal operations.

### Authorization from the Regulatory Body

The authorization from the National Regulatory Body was required for the removal of DSRS from the reserve pit and transfer to the container CUB-40. As for the previous operations for the transfer of DSRS from the irradiator to the reserve pit, the operational and safety procedures, the radiation protection program, the safety analysis, as well as the emergency plan were prepared and presented to the Regulatory Body to support the license application.

The container CUB-40 is not a Type B, as required for the transport of the Co-60 sources, because of their activity. So the transportation should be carried out under special arrangement.

The safety analysis carried out to support the license application for source removal operations included the dose estimation due to external radiation during normal operation and potential doses for foreseeable incidents.

The expected doses for occupational exposed workers during normal operations were estimated according to the working procedures, taking into account the foreseeable workload and using conservative scenarios. As a result, it was obtained that the total effective dose will not exceed 1.1 mSv and the equivalent dose to the extremities will not exceed 0.35 mSv.

Potential doses were also estimated for foreseeable accidental situations that may occur during: removal of the DSRS from the channels of the reserve pit and transfer to the container CUB-40, preparation of the package for transportation and the transport the sources to the Waste Storage Facility. A series of events were postulated, related with the failure of equipment, leakage of radioactive sources and human errors. The safety barriers to prevent or mitigate accidental situations were identified and radiological consequences were evaluated. The methodology of risk matrixes was used to evaluate the postulated initiating events [1, 2]. According to this method, the risks were classified by levels. The results obtained were used for decision making regarding the operational safety.

The results of the safety analysis were used as reference to develop the emergency response plan, where all initiating events of accidental sequences previously identified were included.

All the required documents were presented to and evaluated by the Regulatory Body. The authorizations were granted to the Centre for Radiation Protection and Hygiene (CPHR), in form of two permissions:

* Special permission for the removal of DSRS from the reserve pit of the Food Irradiation Plant,
* Special arrangement for the transport of DSRS from the Food Irradiation Plant to the Waste Storage Facility.

The source removal operations and the transport of the package to the Waste Storage Facility will be implemented by the end of this year.

## Conclusions

* As an adequate transport and storage container was not available for the 52 DSRS of the Food Irradiation Plant, the sources were temporary transferred to the reserve pit, to allow the revision and maintenance of the auxiliary systems in the facility, including the irradiator rack and its hoist mechanism. The facility was then recharged with new Co-60 radioactive sources.
* Storage of the DSRS in the reserve pit should be a temporary measure, the DSRS should be transferred to the Waste Storage Facility, this operation will be implemented by the end of this year.
* Safety analyses carried out for transferring the DSRS from irradiator to the reserve pit, for the removal of sources from the reserve pit and transfer to the container CUB-40, and for the transport to the Waste Storage Facility demonstrate the safety for the Occupational Exposed Workers and the public. The authorizations from the National Regulatory Body were granted to the CPHR.

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