Experience and Lessons Learned from Conditioning of Spent Sealed Sources in Singapore – 13107

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ABSTRACT

In 2010, IAEA requested KAERI (Korea Atomic Energy Research Institute) to support Singapore for conditioning spent sealed sources. Those that had been used for a lightning conductor, check source, or smoke detector, various sealed sources had been collected and stored by the NEA (National Environment Agency) in Singapore. Based on experiences for the conditioning of Ra-226 sources in some Asian countries since 2000, KAERI sent an expert team to Singapore for the safe management of spent sealed sources in 2011. As a result of the conditioning, about 575.21 mCi of Am-241, Ra-226, Co-60, and Sr-90 were safely conditioned in 3 concrete lining drums with the cooperation of the KAERI expert team, the IAEA supervisor, the NEA staff and local laborers in Singapore. Some lessons were learned during the operation : (1) preparations by a local authority are very helpful for an efficient operation, (2) a preliminary inspection by an expert team is helpful for the operation, (3) brief reports before and after daily operation are useful for communication, and (4) a training opportunity is required for the sustainability of the expert team.

INTRODUCTION

Sealed radioactive sources are extensively used in agriculture, industry, medicine, and various research fields in both developed and developing countries. The number of sealed radioactive sources worldwide is estimated to be in the millions. If a source is no longer needed or becomes unfit for its intended application, it is considered spent. A sealed radioactive source may still be highly radioactive and potentially dangerous to human health and the environment.

The IAEA has a program on spent sealed radioactive sources, which was established in 1991. The purpose of the program is to assist member states in their effort to avoid situations that might result in an unnecessary exposure or accident [1].

In 2010, the IAEA requested KAERI to support Singapore for the conditioning of spent sealed sources. Those that had been used for a lightning conductor, check source or smoke detector, various sealed sources were collected and temporarily stored by the NEA (National Environment Agency) in Singapore. Thus based on experiences for the conditioning of Ra-226 sources in some Asian countries since 2000, KAERI sent an expert team to Singapore for the safe management of spent sealed sources. As a result of the conditioning operation, about 575.21 mCi of the sealed sources were safely conditioned in 3 cement packages.

PREPARATION

Before the conditioning operation, a source segregation plan, conditioning procedure, working area, and materials were prepared.

Source Segregation Plan

The segregation plan was developed based on the radionuclides, type, and radioactivity of the target sources. Table I describes the initial information on the sources given by the NEA, which was in charge of the management of the sources. In addition to those, twelve Ra-226 sources were added for the conditioning during operation.

For conditioning, the sources should be segregated into stainless steel capsules and welded. After that, the capsules were packed in lead shields for the final conditioning in cement lining drums. Thus, the segregation plan was set up as grouping the sources for each capsule and assigning the capsules for each lead shield. As there were thousands of sources with various shapes, 2 types of lead shield were considered. The type I shield had 1 large hole (with an inner diameter of 60 mm) at the center and 5 small holes (with the inner diameter of 50 mm) around the large one. On the other hand, the Type II shield had 1 large hole (with an inner diameter of 50 mm) at the center and 6 small holes (with inner diameter of 40 mm) around the large one.

As each source has no identification, the major segregation plan was 1) grouping sources according to radionuclides, 2) putting considerable amount of sources into one capsule without counting, and 3) high activity sources at the center hole.

Table I : Information on Sources for Conditioning

Source	Type	Shape	Qty.	Activity (mCi)
Am-241	lightning conductor, check source, smoke detector	steel plate, round ceramic piece, button	553	377.58
Ra-226	lightning conductor, check source	steel plate, button	2,583	193.53
Co-60	check source	button	34	0.17
Sr-90	check source	button	32	0.16
Total			3,202	571.43

Equipment and Material

For the source packaging, stainless steel capsules for sources, lead shields for containing the capsules and concrete lining drums for containing the lead shields were required. On each lead shield and concrete lining drum, a name plate was attached for identification. In addition to that, steel bars, steel plates and concrete material for the preparation of concrete drums, tongs for handling the capsules, tweezers, funnels, mirrors, trays and etc. for source handling during source segregation and transfer were required.

The objectives for welding were the capsules, lead shields, and steel plates of the drums. For welding, the TIG welding equipment, Argon gas, masks, and respirator were basically required. Additionally, a turn table and lead shielded pot were used for easy and safe operation. Also, for checking the integrity of the welding, the leakage of the capsule was tested and some equipment such as a compressor, desiccators, ethylene glycol, and etc. were used.

For radiation monitoring of the working area, a dose rate monitor and surface contamination monitor were used. Also, for the radiation protection of the workers, a TLD, pocket dosimeter, radiation mark, lead glass, lead bricks, area isolation tape, gas face masks with a filter for radon, overalls and etc. were required. In addition, materials for decontamination were also prepared at the conditioning area.

Additionally, for a safe and easy conditioning operation, a light source (portable), absorbent paper, concrete mixer, concrete vibrator, concrete mould frame, concrete drill bit and etc. were used.

CONDITIONING OPERATION [2]

The conditioning of the spent sealed source was carried out in a designated area with a working table and an air exhaust unit.

Working Area

Figure 1 describes the working area prepared for the conditioning. The area consisted of a conditioning area, a radwaste storage room, a cementing room, a cement mixing area, and a preparation room.

The preparation room was used as a changing room and meeting room before and after daily process for efficient communication between the participants and safe operation. The cement for drum lining was made at the cement mixing area. The cement lining room was used for making and curing the cement lining drums. The radioactive sources were stored at the radwaste storage room before operation. Also, the radwaste storage room was used for storage of the finalized drums.

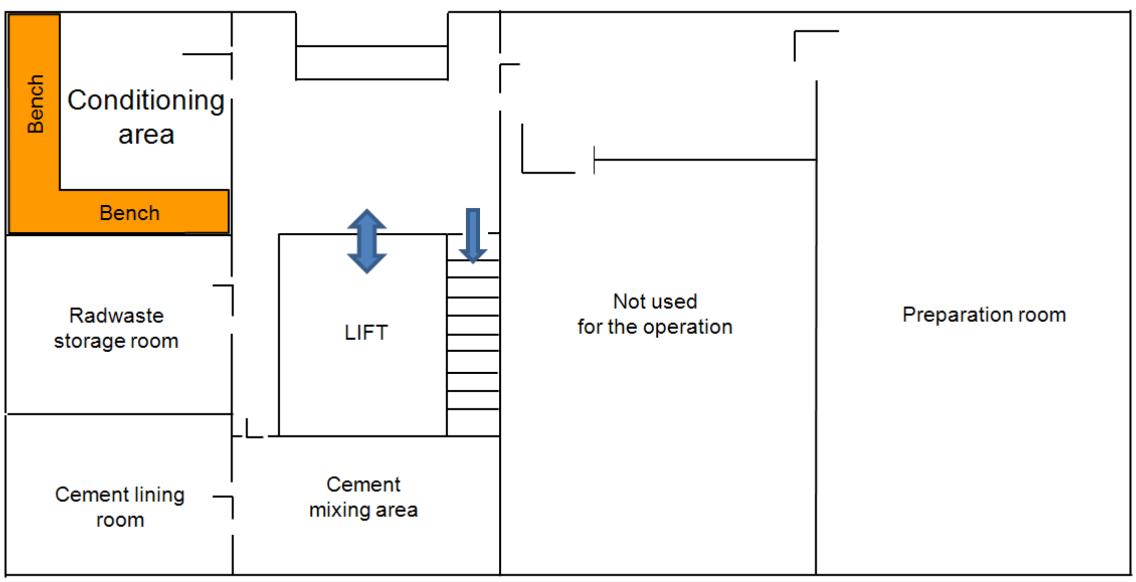


Fig. 1. Layout of the Working Area

Conditioning Area

As shown in Figure 2, for efficient and safe conditioning operation, the conditioning area was divided into the transfer zone, receiving zone, welding zone, leak testing zone, and material preparation zone. Before the operation, the whole area was covered with plastic sheets to limit contaction with radioactive dust. Also, the radiation level of the area was checked and compared between before and after the operation for detecting the contamination caused by the operation.

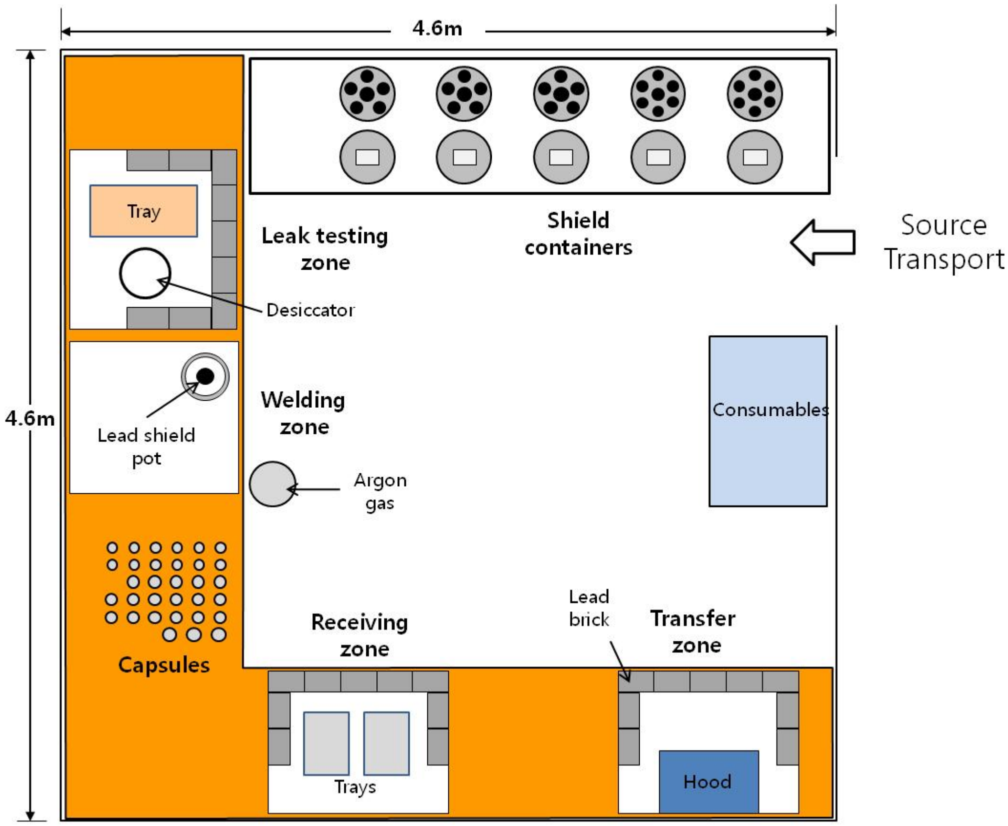


Fig. 2. Layout of the Conditioning Area

Procedure of Conditioning Operation [3]

For the operation, lead containers with sealed sources were tansported from the radwaste storage room to the conditioning area one by one using a trolley. At the entrance of the conitioning area, only the sources were carried into the area and the lead containers were sent back to the radwaste storage room.

In the contitioning area, sources were transported using a stainless steel tray to the receiving zone. At the receiving zone, sources were segregated and some amount of sources containable in a capsule were sent to the transfer zone. Once the source packaging was completed, the capsule was covered with its lid and sent to the welding zone.

When transported to the welding zone, the capsule was inserted into a welding pot, and the lid was hit lightly with a hammer until it became flush with the capsule body edge. TIG welding was then used for sealing the capsule. After welding, the capsule was cooled for a few minutes and transferred to the leak testing zone

At the leak testing zone, the capsule was fully soaked in a vacuum chamber with 2 liter glycol and the chamber pressure was reduced to 0.25 kPa for inspecting the welding integrity by observing air bubble generation from the capsule. If no bubble was observed during 1 minute, the capsule was picked out, cleaned, and dried. If the capsule did not pass the leak test, additional welding was applied and tested again.

After checking the welding integrity, the capsule was inserted into a hole at a lead shield container. When all holes of the shield container were filled with capsules as planned, it was covered, welded, and packaged into a concrete lining drum.

Finally, the concrete lining drum with 2 shield containers were combined with a steel plate and stored at the radwaste storage room. Figure 3 shows a lead shield with capsules and a concrete lining drum with a welded steel plate.

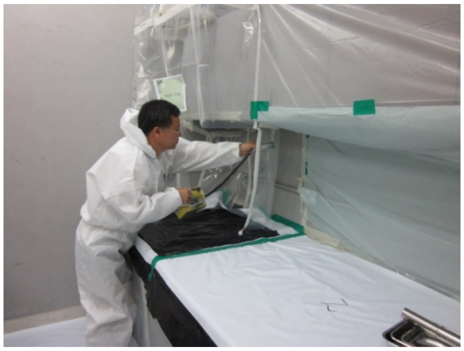
Fig. 3. Lead Shield and Concrete Lining Drum

POST-CONDITIONING OPERATION

During the source conditioning, some part of the conditioning area might be contaminated owing to the release of radioactive dust. Also, secondary waste was generated during the conditioning operation. Thus, after the conditioning, a contamination check and secondary waste treatment were performed.

Contamination Check

After the operation was completed, the working area was checked for radioactive contamination before removing the plastic sheet. Though no contamination was detected, double check was performed after removing all plastic sheets, and no contamination was again found. This process is described in Figure 4.



[Contamination check after operation]

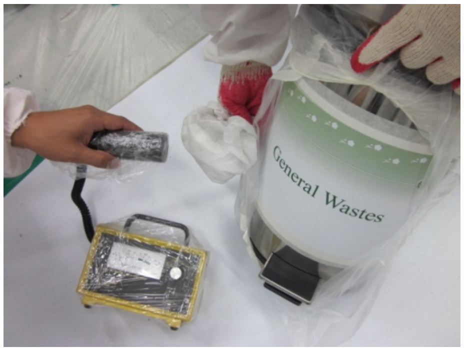
[Double check for contamination]

Figure 4. Contamination Check for the Working Area

Secondary Waste Treatment

During and after the conditioning operation, disposable gloves, masks, tissues, plastic sheets and etc. were generated as general and radioactive waste. For release control and a minimized generation of secondary radioactive waste, all wastes were checked for radioactive contamination and collected separately as general waste or radioactive waste.

When the conditioning operation was completed, before disposal, the collected general wastes were checked again for contamination. Secondary waste that had been collected in a plastic box was packaged into an upper part of one of the cement lining drums. Figure 5 shows the contamination checking process for general waste and secondary waste packaged into a lining drum.



[Contamination check for general waste]

[Packaging secondary waste into a lining drum]

Figure 5. Collection and Packaging Secondary Waste

LESSONS LEARNED

The conditioning operation of the spent sealed sources in Singapore was successful. However, as there were no IDs on the sources and many sources were conditioned with limited resources, the accurate quantity or activity of the sources for each capsule or lead shield was not checked and could only be estimated based on the segregation plan.

The lessons learned at the conditioning operation are as follows.

- Preparation by a local authority was very helpful for efficient operation: Before the arrival of the KAERI team, the zoning of the conditioning area was prepared and the floor and table were already covered with plastic sheets by the local authority. Also, lead bricks were already installed in some area. Owing to this, the operation period could be shortened during the preparation phase.

- A preliminary inspection by the expert team was helpful for the operation: Though preparation by local authority was very helpful, some modifications were required for the preparation, such as additional covering plastic sheets on the side walls, reinforcing plastic sheets using hard plastic sheets. In addition, the understanding of the storage status of radioactive sources can be helpful for an efficient planning for segregation and saving money.

- Brief reports before and after daily operation were useful for communication: As mentioned before, thousands of sources were conditioned within a limited period and tens of sources were sealed in a capsule without counting. Thus, for an estimation of the radioactivity of each capsule, a daily conditioning plan was reported briefly before operation. Also, after the operation, the conditioning results were reported. Through these reports, all participants were well informed of the progress of the operation.

- Training is required for the sustainability of the expert team: Expertise for the operation should be transmitted, but in the current situation, as there are only few chances for the operation, it is hard to train a younger person. Thus, the training opportunity or more frequent operation is required.

CONCLUSIONS

As a result of the conditioning operation in Singapore, about 575.21 mCi (e.g. 380.99 mCi of Am-241, 193.89 mCi of Ra-226, 0.17 mCi of Co-60 and 0.16 mCi of Sr-90) of the sealed sources were safely conditioned in 32 stainless steel capsules. Also, the capsules were placed into 5 lead shields. Finally, 3 concrete lining drums were used for packaging 5 lead shields and a secondary waste package (one drum contained 1 packaged secondary waste at the upper part).

After the operation, each zone was decontaminated and the radiation level of the whole operation area was checked and no contamination from the operation was detected. Also, a dosimeter reading shows that there was no over dose to the workers.

REFERENCE

1. IAEA, Handling, Conditioning and Storage of Spent Sealed Radioactive Sources, IAEA-TECDOC-1145, 2000

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3. IAEA, Conditioning and Interim Storage of Spent Radium Sources, IAEA-TECDOC-886, 1996