Conditioning and Repackaging of Spent Radioactive Cs-137 & Co-60 Sealed Sources in Egypt – 13490

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ABSTRACT

Radioactive Sealed sources (RSSs) are widely use all over the world in medicine, agriculture, industry, research, etc. The accidental misuse and exposure to RSSs has caused significant environmental contamination, serious injuries and many deaths. The high specific activity of the materials in many RSSs means that the spread of as little as microgram quantities can generate significant risk to human health and inhibit the use of buildings and land. Conditioning of such sources is a must to protect humans and environment from the hazard of ionizing radiation and contamination. Conditioning is also increase the security of these sources by decreasing the probability of stolen and/or use in terrorist attacks. According to the law No.7/2010, Egyptian atomic energy authority represented in the hot laboratories & waste management center (centralized waste facility, HLWMC) has the responsibility of collecting, conditioning, storing and management of all types of radioactive waste from all Egyptian territory including spent radioactive sealed sources (SRSSs). This paper explains the conditioning procedures for two of the most common SRSSs, Cs^{137}& Co^{60} sources which make up more than 90% of the total spent radioactive sealed sources stored in our centralized waste facility as one of the major activities of hot laboratories and waste management center. Conditioning has to meet three main objectives, be acceptable for storage, enable their safe transport, and comply with disposal requirements.

INTRODUCTION

Radioactive sealed sources in Egypt are used in industry (well logging, thickness meters, level gauges etc.). Radioactive sources are also used in hospital centers, nuclear medicine laboratories and oncology institutes. The main radioisotopes in stored in HLWMC are: Tc-99, Cs^{137}, Co^{60}, Ir-192,Am-Be, Kr-85,Sr-90, Am^{241}; etc, which make up more than 90 % of all the volume of solid radioactive wastes generated in Egypt. Among these sources spent radioactive Cs^{137}& Co^{60} sources are make up more than 80% of the total spent radioactive sealed sources stored in the centralized waste facility at Inshas site.

The interim storage period can take many years. Interim storage provides for an observation period of some years before disposal of the drums in the repository. During that time, drums are periodically controlled for deformation, corrosion, etc. since necessary precautions must be taken before disposal. Interim storage can take advantage of the activity decay with time to facilitate the safe transport to the repository. Conditioning of spent radioactive sealed sources is important to facilitate the transportation process and to protect the workers from the exposure risk of such sources [1].

RECEIVING THE SPENT RADIOACTIVE SEALED SOURCES

Radioactive sealed sources should be declared as spent sources by the user who should confirm the centralized waste facility by a official letter includes all the source data (type of radionuclide, surface dose rate, initial activity, production date, serial number etc.). The recovery team prepares a mission for the user to verify this data and to decide if the source situation is suitable for transportation or it needs special arrangements for transportation.
After the source container or equipment is received the surface dose rate is measured and a registry form for this source is opened [Table I]. The registry form includes all data of the spent radioactive sealed source like: User name and address date of receiving, type of radionuclide, surface dose rate, initial activity, production date; etc. If the source data is unknown, verification of data carried out to characterize the received source.

TABLE.I: REGISTRATION FORM FOR THE RECEIVED SPENT RADIOACTIVE SEALED SOURCES

No.	Date	Owner	Radioisotope	No. of sources	Initial Activity	Manufac-ture Date	Serial No.	Storage Code
1.	26/9/2010	Elmansory company	Cs-137	1	1.5 Ci	1990	2355	A1
2.	10/10/2010	Egypt for packing materials	Co-60	1	122 mCi	1996	BX3666	A2
3.	16/12/2010	Children censer hospital	Ge/Ga-60	3	2.14,1.26,1.26 mCi	N/A	N/A	B1

MATERIAL AND METHODS

The sustainable option to reduce the safety and security risks for accidents with spent radiation sources is the disposal, but in case of no disposal facility available, the conditioning or immobilization of these sources in a matrix like concrete is preferred. The method has the advantage of using unsophisticated technology and material and equipment which are easily available. The selected sources are firstly dismantled to a prefabricated cask which is designed to host the activity of the dismantled sources to a permissible limits (1Ci for Co^{60} and 5 Cs^{137}sources) [2,3]. The final product package (200 L drum) is stable for a long time under interim storage conditions. Using an additional shielding from concrete inside the drum if needed to comply with the transport regulations for radioactive materials and reduces the surface dose rate and contamination in case of security failure. By proper conditioning of a spent sealed source in concrete, the source is transformed into a form which cannot cause any large exposure even if the waste package is handled without special precautions [4, 5].In Egypt, in accordance with IAEA

guidance; conditioning of spent radiation sources in Type A packages was used. The conditioning option is based on the immobilization of the source within a Type A package. The source/sources in its cask and is placed in the center of a 200 L drum lined with cement mortar. This conditioning procedure is suitable for any type of source, assuming its size fits to be accommodated in the center of a 200 L drum. Conditioning in this way prevents unauthorized removal of the source because of the weight, bulk and robust nature of the package. It also provides a barrier against loss of containment of radioactive material. The adoption of this method will depend upon a number of factors including: the number of spent sealed sources, the half life and activity of the sources, the toxicity of the radionuclides in the sources, and the final disposal scheme for the sources.

DEFINE THE PROBLEM AND SCENARIO

According to the legacy spent radioactive sealed sources , storage facilities at our centralized waste facility were accumulated with a large number of boxes and packages that contain unconditioned spent radioactive sealed sources meanly Co^{60} & Cs^{-137} sources with no real inventory from all Egyptian territory. Strong needs to condition these sources to achieve volume reduction of radioactive solid waste and reduce the safety and security risks for accidents with spent radiation sources were a priority. Figure [1], Show one of the storage facilities accumulated with the SRSSs.
The scenario of the work was planned so that the recovery team prepares a suitable working area to start and complete this mission and the radiation protection procedures will be applied to all the workers in the mission. All the expected hazards were studied carefully and several plans were suggested in order to overcome these hazards. For example, the exposure dose for each individual was limited to 80 μSv per day as a maximum effective dose. In addition, protective clothes and remote handling tools were used to limit the possible contamination as well as direct contact between workers and spent radioactive sealed sources. Waste conditioning has to meet three main objectives. The resulting waste packages must: be acceptable for storage, enable their safe transport, Comply with potential disposal requirements.

DOCUMENTATION

In order to register the obtained data and insure the radiation protection procedures, we prepared registration forms. Three forms were designed: the first was design to register the activity of the inspected radioactive sealed sources as well as source identification and characterization data if applicable after receiving the source from the owner [Table I]; the second form was designed to register the personal dosimeter readings for each worker [Table II]; the third form [Table III] is a registration form for each cask containing the dismantled SRSSs and all available data of conditioned SRSSs. The number and code of the drum, kind of spent radioactive source and some data of the conditioned sources are registered in the inventory of the SRSS program on a Personal Computer.

TABLE II: PERSONNEL DOSIMETER READINGS (TLDS

Name	Period-1	Period-2	Period-3	Period-4	Period-5	Accumulated Dose (μSv)*
	Dose (μSv)*	Dose (μSv)*	Dose (μSv)*	Dose (μSv)*	Dose (μSv)*	
Worker 1	188	150	120	190	300	948
Worker 2	190	155	110	175	250	880
Worker 3	185	160	130	160	270	905

TABLE III: DATA OF CONDITIONING LEAD CASKS CONDITIONING SHIELD FORM

Shield No.: Cask#01_Co-60
Label on Shield: Cask#01_Co-60
Radionuclide: Co-60

Item	Serial No.	Production Date	Initial Activity (mCi)	Current Date	Current Activity (mCi)	Manufacturer	Owner
1	N/A	1985	100	10-1-2007	5.929	Radioeir Isotopen Service, Germany	N/A
2	69/85	1985	20	10-1-2007	1.309	Radioeir Isotopen Service, Germany	National Cement C
3	67/85	1985	20	10-1-2007	1.309	Radioeir Isotopen Service, Germany	National Cement C
4	N/A	1985	2	10-1-2007	0.123	N/A	N/A
5	N/A	N/A	N/A	17-1-2007	0.962	N/A	N/A
6	N/A	N/A	N/A	17-1-2007	6.31	N/A	N/A
7	N/A	N/A	N/A	17-1-2007	6.006	N/A	N/A
8	N/A	N/A	N/A	17-1-2007	6.391	N/A	N/A
9	N/A	N/A	N/A	17-1-2007	0.308	N/A	N/A
10	N/A	N/A	N/A	17-1-2007	6.7	N/A	N/A
11	N/A	N/A	N/A	17-1-2007	6.552	N/A	N/A
12	N/A	N/A	N/A	17-1-2007	0.115	N/A	N/A
13							

WORKING AREA SET-UP

Suitable place inside the centralized waste facility was chosen as a working area for the dismantling process with low radiation background. The working area was equipped with good lighting system, girder crane, electricity suppliers and ventilation system. As a solution the team started to empty the one of the storage facilities from its contents and distribute it to the others. Figure [2], shows a side of the working area inside the emptied storage facility. The team then set-up a working area provided with adequate shields as shown in Figure [3]. The working area was designed so that workers inside the hangar will not be exposed to high doses.

Figure 1: WORKING AREA STORAGE FACILITY BEFORE EMPTYING ITS CONTENTS

Figure 2: WORKING AREA STORAGE FACILITY AFTER EMPTYING ITS CONTENTS

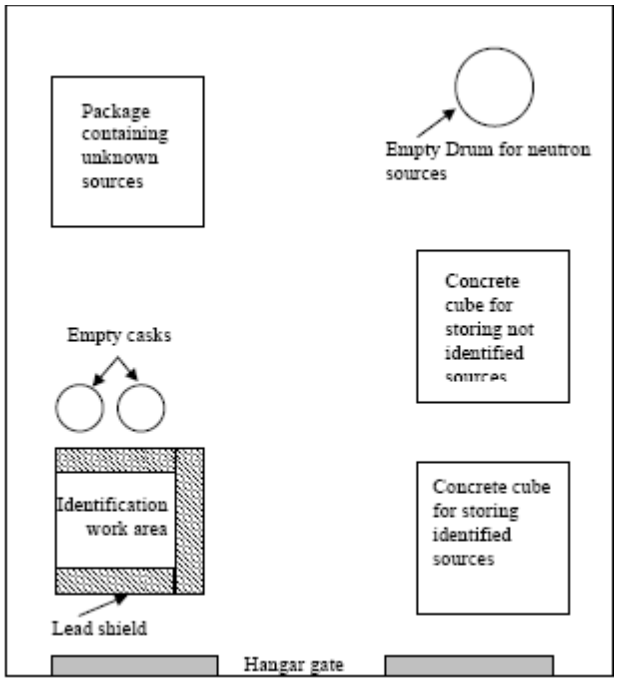

Figure 3: SCHEMATIC DIAGRAM OF THE WORKING AREA

ACTIVITY MEASURING

Because the total activity of the conditioning cask contents must not exceed 1 Ci for Co^{60} and 5Ci for Cs^{137} sources, as illustrated in the conditioning procedures [2,3], it was of main concern to determine the current activity of each spent source before putting it in the conditioning cask. Unfortunately, most of the spent sources activities were of unknown and missing the production date. To determine the current activity of the spent sources by measuring their dose rate at constant distance. Knowing the radionuclide, measuring distance and dose rate, the current activity of each spent source can be determined using the following equation:

$$D = \frac{A\Gamma}{d^2}$$

Where;
D = dose rate (mSv/hr)
A = current activity (GBq)
d = distance between source and detector Γ= gamma factor for radionuclide

As shown in Figure [4], a working area was set by the team to measure the current activity of each spent source. A telescopic probe type THERMO FH-1 0T attached to a survey meter type THERMO FH40G-L was fixed at distance of 1 m from the source. Lead shield walls were erected as shown in Figure 1 to provide adequate shielding in three directions. The telescopic probe was extended to distance not less than 4 m in order to minimize the exposure. Spent sources were then put in the specified place one by one and the dose rate of each source was measured. A computer model then was developed for calculating the current activity of each source using the mentioned equation. Each measured source is then placed in the conditioning cask and the total activity of the sources in each cask was calculated.
To evaluate the method of measuring, some sources of known radionuclide, production date and initial activity were measured by this method. The current activities of these sources were calculated according to the decay law as well. The results of the calculated and measured activities are illustrated in Table IV. As one can conclude from Table I, the error values are of acceptable range.

CONCLUSION

In Egypt methods used by the centralized waste facility up to now, to condition low-level radioactive wastes and spent radiation sources, are performed in compliance with the experience of other countries, IAEA recommendations and world -wide literature. Using this conditioning procedure, more than 600 Co60 & Cs137 sources had been dismantled and conditioned in 200 L drums which make a significant volume reduction of the solid radioactive waste in Egypt.

The number and code of the drums, kind of spent radioactive sources and some data of the conditioned sources are registered in the inventory of the SRSS program at our centralized waste facility.

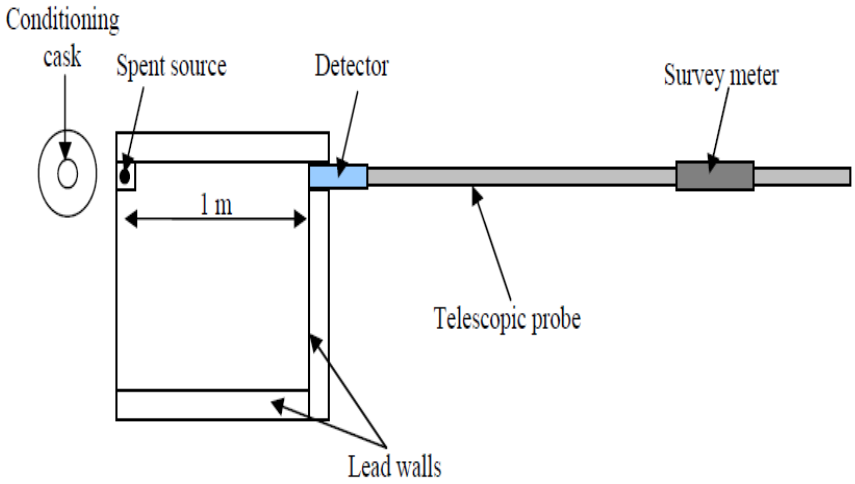

Figure 4: ***SETUP FOR ESTIMATING THE CURRENT ACTIVITY OF SPENT RADIOACTIVE SEALED SOURCES***

TABLE IV: ERROR ESTIMATION OF THE METHOD USED FOR MEASURING CURRENT ACTIVITIES OF RADIOACTIVE SEALED SOURCES (CALCULATIONS ARE BASED ON DECAY LAW, THE CURRENT DATE IS 2007 AND HALF LIFE = 5.3 YEARS)

Source No.	Radionuclide	Production Date	Initial Activity (mCi)	Current Activity "Calculated" (mCi)*	Current Activity "Measured" (mCi)	Error (%)
1	Co-60	1985	100	5.629	5.929	5.3
2	Co-60	1985	20	1.258	1.309	4.1
3	Co-60	1985	20	1.258	1.289	2.5

SPENT CO^{60} & CS^{137} SOURCES BEFORE THEIR DISMANTLING

WORK AREA SETUP

PREFABRICATED CASKS CONTAIN THE DISMANTLED CO^{60} OR CS^{137} SOURCES

200 L DRUM READY FOR THE PREFABRICATED CASK CONTAIN THE DISMANTLED CO^{60} OR CS^{137} SOURCES

200 L DRUM CONTAINS THE PREFABRICATED CASK CONTAINS THE DISMANTLED CO^{60} OR CS^{137} SOURCES

CONDITIONED DRUMS READY FOR INTERIM STORAGE

REFERENCES

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