

## **Management of Disused Radioactive Sealed Sources in Egypt – 13512**

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### **ABSTRACT**

The future safe development of nuclear energy and progressive increasing use of sealed sources in medicine, research, industry and other fields in Egypt depends on the safe and secure management of disused radioactive sealed sources. In the past years have determined the necessity to formulate and apply the integrated management program for radioactive sealed sources to assure harmless and ecological rational management of disused sealed sources in Egypt. The waste management system in Egypt comprises operational and regulatory capabilities. Both of these activities are performed under legislations. The Hot Laboratories and Waste Management Center HLWMC, is considered as a centralized radioactive waste management facility in Egypt by law 7/2010.

### **Policy Statement**

Sealed sources are commonly used in Egypt, from irradiation sources or therapy sources of very high activities (up to TBq or higher), to check sources or calibration sources of very low activity (down to kBq or lower). The policy of the Egyptian Atomic Energy Authority, EAEA on the disposal of these disused sources is to as far as possible return them to the original suppliers. This policy is in fact laid down as one of the conditions of the license to all users of sealed sources in Egypt. It is in conformance with international practice (e.g. The Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management, 2001, Article 28), and with the Code of Good Practice drafted by the International Source Suppliers and Producers Association (ISSPA, website: <http://www.isspa-intl.com>) [1]. As for certain legacy sources, either by themselves or contained or embedded in some equipment or gauges, if the licensee can provide evidence that the original source and equipment suppliers are no longer in business, and that the licensee's efforts to send those sources to waste management facilities in the country of origin have failed, then the EAEA, might consider approving of the transfer of these disused sources to the local Radioactive Waste Storage Facility. Again, the transport or conveyance of these disused sources has to meet the **IAEA Transport Regulations [2,3]**.

### **INTRODUCTION**

Radiation sources are used throughout the world for a wide variety of beneficial purposes, in industry, medicine, research and education. The risks posed by these sources vary widely, depending on the amount of activities, the characteristics and chemical form of radionuclide, etc. If sealed sources are not damaged or leaking, sealed sources present a risk from only external radiation exposure. However, damaged or leaking sealed sources as well as unsealed radioactive materials may lead to contamination of the environment and internal exposure. The Goiania

accident in 1987 could be listed as one of the biggest accident. After the Goiania accident, such kind of accidents occurred incessantly, Tammiku, San Savador, Nesvizh, Yanango, Hanoi, Soreq, Sarov, Samut Prakarn, etc. These accidents caused 266 individual exposed, 39 fatalities and serious economic consequences. Recently, the International Atomic Energy Agency (IAEA) has been a growing awareness of these kinds of problems associated with radiation sources and has begun several activities. The activity of the source depends upon the duty required and varies from less than 1 microcurie to powerful sources containing thousands of curies. The higher activity sources are usually double encapsulated in a corrosion resistance metal such as stainless steel. The main categories of sources and their fields of application are,

Type of source	Applications
Gamma sources	Industry, radiotherapy, clinical therapy, and sterilization
Beta sources	Industry (thickness gauge), clinical therapy, educational and training
Alpha sources	Heat sources, analytical practices and educational and training
Neutron sources	Industry, calibration techniques, analytical practices and educational and training

### *Applications*

Before 1940 the only sealed radiation source, which were widely distributed, were the radium sources used in hospitals. After 1940, when it became possible to make new types of sources, with different characteristics, using particle accelerator and nuclear reactor, a large number of applications were developed in medicine, research and industry.

### *Medical applications*

Hospitals are still among the largest users of sealed radiation sources. They are mostly used for teletherapy and brachtherapy. The radionuclide used in teletherapy is  $^{60}\text{Co}$ , but some  $^{137}\text{Cs}$  sources are also in service. Because of the large activity of these sources, 0.1-0.5 pBq, they are always used in heavily shielded radiation heads, which weigh of the order of one ton. Today most of the old radium sources ( $^{226}\text{Ra}$ ) previously used for brachtherapy have been replaced by sources containing  $^{60}\text{Co}$ ,  $^{137}\text{Cs}$ , and  $^{192}\text{Ir}$  or other radionuclides.

### *Research applications*

Almost any radionuclide may be required for research, especially for calibration, detectors, and analytical balance and also for soil moisture and density gauge ( $^{241}\text{Am/Be}$  and  $^{137}\text{Cs}$ ).

### *Industrial applications*

The industrial sources giving most cause for concern are those used for industrial radiography.  $^{192}\text{Ir}$  is the most common radionuclide in this context, but  $^{60}\text{Co}$  and  $^{137}\text{Cs}$  are also used. Large neutron and gamma sources are used for well logging in the oil and mining industries.

<i>Radionuclides</i>	<i>Radiation</i>	<i>T<sub>0.5</sub></i>	<i>Applications</i>
<sup>60</sup> Co	$\beta, \gamma$	5.3 y	Level gauge, industrial radiography, sterilization, irradiator, clinical teletherapy and calibration of gamma camera
<sup>137</sup> Cs	$\beta, \gamma$	30.2 y	Level gauge, industrial radiography, sterilization, irradiator, clinical teletherapy
<sup>192</sup> Ir	$\beta, \gamma$	73.8 d	Industrial radiography, clinical teletherapy
<sup>241</sup> Am	$\alpha, \gamma$	432.2 y	Density gauge, bone densitometer
<sup>241</sup> Am/Be		432.2 y	Moisture detector, well logging
<sup>90</sup> Sr	$\beta$	28.6 y	Thickness gauge, density gauge, eye applicator.

### Options in the Management of Disused Sealed Sources in Egypt

Sealed sources became surplus when the activity of the sources have decayed to the extent that they are no longer suitable for their original purpose, the program using the source is completely or discontinued, the source develops a leak or the source apparatus becomes outdated or difficult to operate. While a source may not be suitable for its original purpose, it still may be highly radioactive and should be treated as hazardous material [4,5,6].

Users may have the following management options to consider:

- The transfer the source to another user for application elsewhere at the current activity level is not applicable in Egypt and there is no valid mechanism for this option.
- Return the disused sealed sources to the original supplier are most viable option.
- Decay storage of the sources containing radionuclides with short half-lives.
- Collection, and storage of the sources in interim storage facility until dismantling the sources and conditioning them using 200 L drum and/or prefabricated 1 m<sup>3</sup> concrete cubes, inside the conditioning facility in HLWMC.
- Conditioned sources and unconditioned highly active sealed sources stored in the long term storage facility until a repository is available.
- Egypt adopting a borehole disposal concept to permanently isolate the unused sealed sources from biosphere. Both concepts of South Africa (Borehole for Sealed Sources, BOSS) and USA (Greater Confinement Disposal, GCD) are under studies to adopt one of them to be implemented.

The option selected for a particular sealed source will depend on the variety of relevant factors including activity, radioisotopes content, terms of the purchasing contract and physical condition of the source.

#### *Decay storage of short half-life disused sources*

A decay period of about 10 half-lives is often enough to allow decay of the activity to levels acceptable for disposal as non-radioactive waste. However, disposal of decayed disused sealed sources to municipal waste areas or other non-radioactive waste fill/burial sites should not be made until it is confirmed that the residual activity to be released to the environment meets the standards/guidelines established by national competent Authority. Disused sealed sources containing the following radionuclides may be considered for decay storage:

Nuclide	Half-life (days)
$^{32}\text{P}$	14.3
$^{192}\text{Ir}$	74
$^{210}\text{Po}$	138

Administrative controls and surveillance should be maintained over the disused sealed source during the decay storage period. Periodical examination and testing of the sealed source are advisable to ensure that there is no leakage of radioactivity from the source. In the event of a loss of containment, the source should be removed and conditioned.

The area for decay storage is existed within the facility. It is located to avoid the source leakage into ground or rainwater and area with a history or prospect flooding. Special shelving may be convenient for small packages. The floor in the storage area is constructed using concrete with epoxy paint for easy decontamination. Access to the storage area is restricted to qualified staffs that have a need to enter. Security measures are instituted to reduce the risk of entry by unauthorized persons.

#### *Interim Storage of Disused Sealed Sources*

The interim storage of conditioned disused sources is likely suitable in most developing countries. The variety of conditioned spent sealed sources storage concepts are used in Egyptian Radioactive waste management programs depending on a number of factors including [7,8,9]:

- ✓ Nature of radionuclides conditioned
- ✓ Package size and shape
- ✓ Package handling requirements
- ✓ Volume of waste for storage
- ✓ Period of storage
- ✓ Need for future store expansion
- ✓ Local site factors (i.e. weather, land conditions)
- ✓ National factors

Storage may be defined as the placing of the source in a system with the intention of retrieving it at a future for a further purpose (may be disposal or reuse). Design can be divided into two categories; area storage or engineered storage. Area storage involves the standing the waste package on the ground, in the open or with simple covering. Area storage is not generally suitable for the lengthy storage period required for developing countries like Egypt. Many engineered storage designs are based on spent fuel and disused radioactive sealed sources with the need of handling large volume of drums and waste packages with high surface dose rates. In storage, containment, radiation protection of operators and security must be ensured. All storage systems with good access require a secure site and connected with appropriate security measures, e.g:

- Surveillance
- Physical barriers to intrusion
- High security locks
- Alarm systems
- Guarding by trained personnel

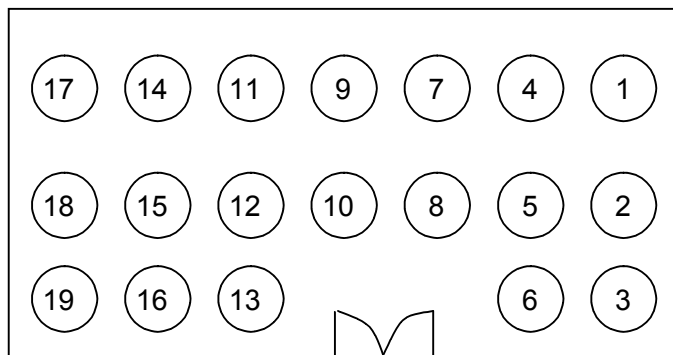
In the storage systems considered here, the sources are assumed to be packaged in a lead casket, which has appropriate shielding properties with the casket placed in a lidded thin gauge steel container. All containers consigned to interim storage should be marked with the suitable mark and label [10,11].

### Storage in a Concrete Bunker

A reinforcement concrete bunker is used for the storage of small and medium packages due to the size of the bunker. A comparatively bunker with a capacity of a few cubic meters and designed with a heavy lid weighing a few tones could serve as a cheap but also secure system for the storage of small and medium packages. A large bunker with a heavy lid could house small and medium and would be useful where there are larger number of sources for storage. If required this bunker could easily converted to long term storage requiring minimum surveillance by sealing the entries with reinforcement concrete. The storage facilities in Egyptian Atomic Energy Authority contain two sets of 19 concrete pits each set and the decision has taken for those pits to host Highly Active Radioactive Sealed Sources SHARS including neutron sources especially Am/Be sources. Currently the concrete bunkers contain all inventory of neutron sources and some unconditioned radium needles inside its original shields recently recovered from old clinics near Cairo [12].



Concrete bunkers for medium and long term storage



### **Conditioning Of Disused Radioactive Sealed Sources**

Although the immediate objective of conditioning is to facilitate interim storage for the waste package, it is important that it should also facilitate transport, when that is eventually required e.g. to consign the package to a disposal facility. It is also important that the conditioning process will produce a package likely to be suitable and acceptable for handling, transporting and disposal. For this reasons the conditioning processes involve [ ]:

- The production of a package type which is recognized in and conforms to IAEA transport regulations
- The use of an immobilization matrix for example cement which is already widely accepted in many countries like UK, France, Germany, etc for interim storage and in disposal repositories.

The methods of conditioning described in this summary therefore are based on Type A and Type B packages as defined in IAEA transport regulations [2].

#### *Packages*

Package means for radioactive materials, the packaging together with radioactive content as presented for transport. The three basic packages are:

- Strong tight containers, whose characteristic are not specified by regulation
- Type A containers
- Type B containers

Both Type A and B have very specific requirements in the regulations.

#### *Type A*

A packaging that together with its radioactive contents limited to A1 or A2 and is designed to retain the integrity of containment and shielding under normal conditions of transport.

#### *Type B*

A packaging that together with its radioactive contents designed to retain the integrity of the containment and shielding under the normal conditions of transport and hypothetical accident.

The system created to ensure safe transport of radioactive materials is based on the assignment of a number to each radionuclide, depending upon its form (i.e., its relative hazard if released from the package during transport). The number, or "A" value, represents the limit, in curies, permitted to be transported in a Type A package. There are two distinct categories established for this system.

Special form (A1) radionuclides are usually encapsulated sources, which would only pose an external radiation hazard, not a contamination hazard, if the package was ruptured.

Normal form (A2) radionuclides are usually not securely encapsulated and could yield significant contamination if the package was ruptured. These materials could pose an internal hazard to people at the scene of an accident. Normal form materials are typically liquids and powders.

Since the "A" values provide the limit for the amount in a package, A2 values cannot be greater than A1 values, since A2 values represent material in normal form, which makes it more "hazardous." However, for some nuclides, the hazard may be the same in either form so that A1 can be equal to A2. In any case, neither A1 nor A2 can be greater than 1000 curies [13,14].

### Samples "A" Values (TBq)

<i>Materials</i>	<i>Special Form (A1 Values) IAEA TBq</i>	<i>Special Form (A1 Values) NRC TBq</i>	<i>Normal Form (A2 Values) IAEA TBq</i>	<i>Normal Form (A2 Values) NRC TBq</i>
	<i>Am-241</i>	<i>10</i>	<i>2.0</i>	<i>0.001</i>
<i>Co-60</i>	<i>0.4</i>	<i>0.4</i>	<i>0.4</i>	<i>0.4</i>
<i>Cs-137</i>	<i>2.0</i>	<i>2.0</i>	<i>0.6</i>	<i>0.5</i>
<i>I-125</i>	<i>20</i>	<i>20</i>	<i>3.0</i>	<i>2.0</i>
<i>Ir-192</i>	<i>1.0</i>	<i>1.0</i>	<i>0.6</i>	<i>0.5</i>
<i>Ra-226</i>	<i>0.2</i>	<i>0.3</i>	<i>0.003</i>	<i>0.02</i>
<i>Sr-90</i>	<i>0.3</i>	<i>0.2</i>	<i>0.3</i>	<i>0.1</i>

### Near Surface Disposal

Near surface disposal for those wastes that contain only low or medium levels of activity consisting mainly of short-lived radionuclides even disused radioactive sealed sources with no alpha is adopted by Egyptian Atomic energy Authority. These wastes commonly describes as low- and intermediate level radioactive wastes (LILW), the final step of the national radioactive waste management system is disposal in a near surface disposal facility in Inshas site. Its safety is ensured by combination of engineered and natural barriers that keep the disposal vaults dry and prevent radioactive releases into the environment. The repository was built in geological formation with low permeability and high sorption capacity, and the disposal vaults were surrounded by an additional artificial construction clay layer. The temporary and final covers are designed to avoid water penetration into the disposal vaults and the drainage system is also existed to remove the residual liquids. The repository is designed for disposal of solid and solidified LILW into inspected reinforced concrete containers that represent an additional engineering barrier. Selection of the repository site was carried out between 1999 and 2007. Out of 10 sites selected on preliminary basis, 3 were chosen for further investigation and based on agreed selection criteria, the Inshas site was chosen as the most suitable report construction. Permission for construction and temporary operation for low surface dose rate package was granted by National Center for Nuclear and Radiological Control, according to this permission about 100 containers were disposed of. The capacity of this near surface disposal facility for LILW is sufficient for all operational wastes, but not for all decommissioning waste and it is expected that the capacity of the Inshas repository will be increased in due course to accept also decommissioning waste. For the time being conditioned radioactive waste that is not acceptable for disposal in the near surface repository will be stored at Inshas storage facility where it arises. Further arrangements for its storage are planned by radioactive waste operator. The arrangements

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for buffer storage of short-lived waste whose activity will eventually decay to levels those are acceptable for near-surface disposal, or for release from radiological control.



The repository for LILW at Inshas Site



## Conclusions

The management problems of disused radioactive sealed sources imposes to respect the national and international agreed regulations regarding their transportation, conditioning, storage and disposal, taking into account both for maintaining the humans health and environment exposure under the specified limits, during the transport, conditioning and specific additional operations and also for reducing the impact on the environment. To mitigate any consequences from mismanagement of radiation sources needs such decontamination, evacuation, medical treatment public information etc need a lot of resources and developing countries like Egypt has no extra budget to do so, but the proper management and safely and security measures are very good tools to keep sources out of wrong hands and decrease the probabilities of accidents in Egypt.

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