Safety and security management of disused sealed radioactive sources in Thailand

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Abstract. When sealed radioactive sources are no longer in use, they should be returned back to the country of origin. However, most of them could not be returned to the origin; therefore, disused sealed radioactive sources (DSRS) have to be managed locally to ensure the safety and the security for long term storage before final disposal. The Radioactive Waste Management Center, Thailand Institute of Nuclear Technology, is authorized to operate the treatment, conditioning and storage of DSRS in Thailand. This paper will describe the operational procedures on characterization technique, identification of unknown sources, volume reduction technique, re-packaging, registration and record keeping of DSRS. The successful results included that the record keeping of DSRS has been developed, and the national inventory of stored DSRS has been made up to date. The results confirmed that the quality control at the DSRS storage facility at Thailand Institute of Nuclear Technology was established and well implemented to ensure safe and secure management.

1. Introduction

A sealed radioactive source is a container of encapsulated radioactive material, which usually has the appearance of a small, harmless piece of metal. The capsule or material of a sealed source is strong enough to maintain leak tightness under the conditions of use for which the source was designed, and also under foreseeable mishaps. In more technical terms, it is radioactive material that is permanently sealed in a capsule or closely bound in a solid form. The source is designed to contain the radioactive material under normal operating conditions and usually has high concentration of radioactive material in a small volume. The earliest uses of radioactive sources typically involved radium-226 particularly in medical applications in Thailand since 1950 [1].

Up to now sealed radioactive sources are used in various applications in medicine, agriculture, industry, transportation, construction, geology, mining, research, etc. In most of these areas the use of sealed radioactive sources either cannot be replaced by other methods or provides results that are unmatched by other methods. The first sealed radioactive sources were used for medical purposes from
the beginning of the twentieth century. Until the 1940s sources were only using naturally occurring isotopes (radium and polonium). Today sealed radioactive sources are made of numerous artificial radioisotopes. The gamma rays emitted by the source were used to treat cancer. The radioactive source material, over 1,000 curies of cobalt-60, was contained in a doubly-encapsulated stainless-steel cylinder approximately one inch in diameter. The rest of the capsule (approximately two inches in diameter) consisted of a tungsten alloy housing threaded to fit into the teletherapy unit. The top of the housing contained an opening through which the stainless-steel source container could be seen [2].

When sealed radioactive sources are no longer in use, and there is no intention of using them again, they are usually called “disused sealed radioactive source” or “DSRS”. Worldwide, the number of sources that are considered disused is very large [2] and warrants dedicated efforts for their management in a safe and secure manner. If lost or not properly controlled, disused sealed sources can be a threat to human health and the environment. Exposure to large doses of radiation from an unshielded high activity source can be lethal or cause severe radiation injury. If the source capsule is damaged the radioactive material can be released and dispersed, resulting in contamination to the environment, social and economic impacts.

2. Why we need the safety and security management on DSRS

The serious radiological accident in Thailand occurred in Samut Prakan province in 2000, when cobalt-60 head of a disused teletherapy unit was partially dismantled, and taken from that storage to be sold as scrap metals [3]. Three victims died and 10 people received high doses from the radioactive source. It was an expensive lesson to be learned in Thailand [1]. Therefore, we do really need the safety and security management of DSRS. The picture of the Samut Prakan radiological accident is shown in figure 1.

![Figure 1. Photographs from the Samut Prakan Radiological Accident in 2000 [2] (Permission to publish was granted by IAEA).](image)

The safety and security concerning sealed radioactive sources became a highlighted topic after the attack on the United States on 11 September 2001. The US itself, including the International Atomic Energy Agency (IAEA) and other countries put an increased awareness of the need for safety and security measures to protect radioactive sources against terrorism [4]. The planning of security measures of radioactive source must take greater account of the potential for deliberate acts to attack or use radioactive sources to expose people and cause contamination. These include fatal and injurious radiation exposure, contamination of the environment, the serious economic and psychosocial costs; the total effect of which is mass disruption. As a consequence, the management of DSRS is highly justified, and the need for special security measures to protect against terrorism should then become part of the safety assessment.
3. Management of DSRS

In Thailand, when a radioactive source is no longer in use, it should be returned back to the country of origin [5]. However, most of DSRS could not be returned to the origin; therefore, it became the responsibility of the Radioactive Waste Management Center (RWMC), Thailand Institute of Nuclear Technology (TINT), to manage these DSRS under the regulatory control of the Office Atoms for Peace (OAP), the Thai nuclear and radiation regulatory body. The procedures of DSRS management in Thailand are as follows:

- History of source / record keeping
- Identification
- Characterization
- Volume reduction (if possible)
- Conditioning / re-packaging
- Interim storage and final disposal (in the future)
- Inventory of DSRS / registration of DSRS

4. Procedures

The reorganization operation of DSRS has been conducted at TINT radioactive waste storage facility no.1 located in Bangkok, Thailand. The operation included revision and development of proper techniques on identification, characterization, and record-keeping. An inventory of DSRS has also been developed.

The technical procedures were as follows:
1) The operating area was prepared by using plastic sheets to cover the designated area;
2) Each DSRS was checked for radioactive contaminations before it was moved to the operating area as shown in figure 2;
3) Each individual source was taken to the operating area and checked for dose rate (figure 3);
4) The identification label was checked, and its photo was taken (figure 3);

Figure 2. Checking for contamination and dose-rate of DSRS.

Figure 3. Identification of DSRS.
5) The sources were placed in an empty room prepared for DSRS storage, organized by the type of radioactive sources and radionuclides (segregation) as in figure 4;

![Figure 4. Segregation and grouping by type of radioactive sources and radionuclides.](image)

6) Volume reduction of DSRS was achieved by removing DSRS from their large containments and re-packing them in 200 liter drums as shown in figures 5 and 6;

![Figure 5. Volume reduction by removing DSRS from their containment and re-packing them.](image)

![Figure 6. Re-packing of DSRS in 200-liter drums.](image)

7) DSRS were inventoried;
8) The storage conditions were improved by cleaning the floor and the cellar;
9) The sources were arranged in baskets and put on shelves, grouped by radionuclides and type of radiation emitted;
10) A record was kept for each operation and DSRS. For record keeping, the following information was recorded:

- Former owner who possessed the source and associated device, including the contact information,
- Unique identification of the source (manufacture, model number, serial number, and date of manufacture),
- Unique identification of the associated device (manufacture, model number, serial number, and date of manufacture),
- Radionuclide, the sources activity and the date on which the activity was measured,
- Category of the source,
- Form of the radioactive material (physical and chemical) including its special form status,
- Record of where the source was received from or transferred to,
- Date on which the source and associated device was entered into the register,
- Planned disposition of the sources such as the planned date of its transfer to a waste storage or a disposal facility.

![Figure 7. Before and after the reorganization of DSRS at TINT storage facility no.1.](image)

5. Results and Discussion

The total number of DSRS which were characterized and re-organized at TINT storage facility no.1 was 418 pieces. These DSRS included Am-241, Am-241/Be, Co-60, Cs-137, Kr-85, Sr-90, Ni-63, Pm-147 and Ra-226. Most of DSRS were removed from the old containers and then re-allocated to new pallets and new metal boxes. The number of pallets for re-allocated DSRS was 53; they were stacked into 3 shelves. Four unknown sources were identified to the known sources by identifier tool and the international source information catalogue [6]. Also, old records in TINT waste storage facilities must be checked and updated regularly. Sometimes workers who have been employed for a long time and are near retirement age will need to provide ascertained information about unknown sources. It is especially important to tap into this information resource before such individuals disappear. From this mission, the Radioactive Waste Management Center has to revise the working instruction (WI) of DSRS storage and to add the characterization procedure into the WI of DSRS storage.

The new registration of all DSRS in storage facility no.1 was included in the process as recommended by the OAP. From this mission, the security and safety process of DSRS at storage facility no. 1 has been put in place and well controlled by the operator (TINT) and the regulator (OAP). The access control, key cards, fire extinguisher, and the emergency preparedness and response plan at the storage facility of DSRS were revised and implemented during this mission by the advice and supports of TINT Safety Unit.

The outputs achieved as the results of activities implemented were as follows:

- The record keeping of 418 sources was developed and updated;
- The reorganization of DSRS was well done within the storage facilities as shown in figure 7
Unknown DSRS was re-categorized as known DSRS based on characterization results.
The national inventory of stored DSRS was made up-to-date.
Proper operational procedures and quality control at DSRS storage facility was established and implemented, such as characterization procedures, the emergency preparedness and response plan at the storage facility.

6. Conclusion
In general, the users and owners of radioactive sources would have some information about their sources, and may also have documents or records of sources that they possessed or used in the past. In fact, some sources may have been transferred to others without regulatory control. This sometimes happens; therefore, the Radioactive Waste Management Center, TINT, has to characterize and identify the stored DSRS to get the correct information for record keeping. The re-organization of DSRS was very useful and really needed. The characterization and categorization of disused radioactive sources, and identification of each DSRS with a label to complete the records are very important steps to organize the DSRS according to the radionuclide and the type of sources. The outcome of this work was the updated inventory of DSRS control. Additional advantage of this work was the volume reduction of DSRS at the TINT storage facilities.

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References
[1] Ya-anant N, Tiyapun K and Saiyut K 2011 Radiation Protection Dosimetry 146 111–4
[2] International Atomic Energy Agency (IAEA) (n.d.) What is a Sealed Radioactive Source Retrieved March 13, 2015, from http://www.iaea.org/OurWork/ST/NE/NEFW/Technical-Areas/WTS/sealedsources-sealedsources.html
[3] International Atomic Energy Agency 2002 The Radiological Accident in Samut Prakan, (Vienna: IAEA)
[4] United States General Accounting Office 2003 GAO-03-804: Nuclear Security Federal and State Action Needed to Improve Security of Sealed Radioactive Sources (Washington D.C.: GAO) pp 5-6
[5] Ministry of Science and Technology 2003 Regulation on Procedure on Radioactive Waste Management B.E.2546 Bangkok, Thailand
[6] International Atomic Energy Agency (n.d.) International Catalogue of Sealed Radioactive Sources and Devices (ICSRS) Retrieved March 13, 2015, from http://www.iaea.org/OurWork/ST/NE/NEFW/Technical-Areas/WTS/information-SOURCE.html