Categorization of In-use Radioactive Sealed Sources in Egypt

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ABSTRACT

Radioactive sealed sources have widespread applications in industry, medicine, research and education. While most sources are of relatively low activity, there are many of medium or very high activity. The mismanagement of high activity sources is responsible for most of the radiological accidents that result in loss of life or disabling injuries. Because of the variety of applications and activities of radioactive sources, a categorization system is necessary so that the controls that are applied to the sources are adequate with its radiological risk. The aim of this work is to use the international Atomic Energy Agency (IAEA) categorization system to provide a simple, logical system for grading radioactive sealed sources in Egypt. The categorizations of radioactive sealed sources are based on their potential to cause harm to human health. This study revealed that total of 1916 sources have been used in Egypt in the different applications with a total activity of 89400 Ci according to available data in October 2005.

INTRODUCTION

There are a significant numbers of radioactive materials that are stored and used in the public sector - where controls are less than ideal. The radioactive materials in “public” locations are typically contained in small, stainless steel capsules known as radioactive sealed sources (RSSs). These capsules seal in the radioactive materials, but not the radiation, because it is the radiation that is needed for the variety of applications at hospitals, medical clinics, manufacturing plants, universities, construction sites, and other facilities in the public sector. Radiation sources are readily available, and there are hundreds of thousands of RSSs worldwide. The radioactive sealed sources have different range of activities from few milli curies to several thousands of curies. The hazard of RSSs is dependant on the type of radiation (alpha, beta, gamma and neutron radiation) and the activity (quantity of radioactive material).

The accidental misuse and exposure to RSSs have caused significant environmental contamination, serious injuries and many deaths. In Brazil in 1987 **(1)**, a sealed RS containing cesium-137 was stolen from a closed medical clinic and deliberately cut open. Children were allowed to play with the glowing material inside. Four people died within days, several hundred suffered health effects, and public hysteria ensued. Contaminated soil and many buildings had to be cleaned-up, generating thousands of cubic meters of radioactive wastes. (IAEA, 1991 and Cameron, 2001)

In Morocco in 1984 a 1.1 TBq ^{192}Ir source became disconnected from its cable drive. It was not noticed due to lack of appropriate monitoring and fell out of the guide tube. It looked like an interesting item and was picked up by a member of the public who took it home. It was out of control from March to June and as a result eight people died.

In the spring of 2000 there was a very similar incident in Met Halfa, Egypt. A farmer picked up a 3 TBq ^{192}Ir source, thinking it is a valuable item and took it home. In May 2000 the farmer and his 9-year-old son went to their local doctor complaining of skin burns. The doctor prescribed medication for a viral or bacterial infection. Both the farmer and his youngest son died in June 2000. The blood test for other family members showed severe depression of the white blood cell count and radiation exposure was suspected. The source was located and recovered. Other family members were hospitalized. Four men were charged with gross negligence, manslaughter, and unintentional injury because they had failed to notify authorities that the source, used to inspect natural gas pipeline welds, was not recovered after the job.

As a result of these accidents and the hazardous effect of misuse of RSSs, it was clear that a simple logical system for ranking radioactive sources based on their potential to cause harm to human health and for grouping the practices in which these sources be used. The IAEA developed a system called "Categorization of Radioactive Sources" **(2)**, which was revised in the summer of 2003. The IAEA categorization system could be applied to many situations such as, regulatory measures (notification, registration, licensing and inspection), security measures, national registry of sources, import/export control, labeling of high activity sources, emergency preparedness and response, prioritization for regaining control over orphan sources, and communication with the public.

RESULTS

Table I. shows the IAEA categorization system for routine RSSs. According to this table any RSS would be ranked according to two parameters. The first parameter is the activity (A) in TBq of the source and the second one is the radionuclide-specific activity level (D), which called the D-value and defined as the radioactivity above which a radioactive source is consider to be a dangerous source. According to the value of A/D, RSSs are classified into five categories.

According to the IAEA categorization system, radioactive sealed sources are ranked into five categories: A) **category (1)**, which is the most dangerous category and could cause permanent injury in a few minutes or death in a few minutes to an hour if not safely managed. This category includes, blood irradiators, industrial irradiators, radioisotope thermoelectric generators (RTGs), and teletherapy, including fixed, multi-beam teletherapy (gamma knife). B) **Category (2),** is considered personally very dangerous and could cause permanent injury in minutes to hours or death in hours to days if not safely managed. This category includes industrial gamma radiography and brachytherapy. C) **Category (3)**, includes sources that could cause permanent injury in hours or death in days to weeks if not safely managed. This category includes, well logging gauges and fixed industrial gauges. D) **Category (4)**, includes sources that are very unlikely to harm anyone if the source was not safely managed. This category includes, portable moisture/density gauges, thickness/fill-level gauges, and low dose brachytherapy. E) **Category**

(5), includes sources that could not cause permanent injuries to any one. This category includes, low dose brachytherapy eye plaques and permanent implant sources, x-ray fluorescence devices, electron capture devices and positron emission tomography checking.

In Egypt, radioactive sealed sources are use in different fields like, Gauging, Logging, Radiography, Medical, and Research. Table **(II)** shows the types and numbers of the different radioisotopes used in various applications in the country of Egypt.

Table I. Summary for the IAEA Categorization System

Category	**Categorization of Common Practice**	**Activity ratio (A/D)**
1	Radioisotope thermoelectric generators (RTGs) Irradiators Teletherapy Fixed, multi-beam teletherapy (gamma knife)	**A/D ≥ 1000**
2	Industrial gamma radiography High/medium dose rate brachytherapy	**1000 >A/D ≥ 10**
3	Fixed industrial gauges - level gauges - dredger gauges - conveyor gauges containing high activity sources - spinning pipe gauges Well logging gauges	**10 >A/D≥ 1**
4	Low dose rate brachytherapy (except eye plaques and permanent implant sources) Thickness, fill-level gauges Portable gauges (e.g. moisture/density gauges) Bone densitometer Static eliminators	**1>A/D≥ 0.01**
5	Low dose rate brachytherapy eye plaques and permanent implant sources X-ray fluorescence devices Electron capture devices Mossbauer spectrometry Positron emission tomography (PET) checking	**0.01>A/D≥ Exempt/D**

Table II. Types and Numbers of the Different Radioisotopes Which are in Use in Egypt

Type of Radioisotope	**Number**
Am-241	20
Am-241/Be	103
Ba-133	4
Bi-207	1
Cd-109	1
Cf-252	10
Cm-244	2
Co-57	7
Co-60	210

Cs-137	1190
Eu-154	1
Eu152	1
Fe-55	2
I-125	1
H-3	4
Ir-192	134
Kr-85	21
Mn-54	1
Na-22	3
Pb-210	1
Pm-147	2
Po-210	11
Ra-226	30
Ru-106	8
Sn-113	1
Sr-90	129
Th-232	13
Tl-204	4
Zn-65	1

The IAEA categorization system should be used by the regulatory body to provide a consistent basis for implementing requirements including the following (3):

- Regulatory measures: To assist in ensuring that the protection measures (including allocation of resources) are commensurate with the degree of risk associated with the source.
- Security measures: To assist in the choice of the security level that should be taken for each category.
- Labeling of high activity sources: To help in labeling high activity sources with an appropriate label in addition to the radiation trefoil.
- Emergency preparedness and response: To ensure that the emergency plans and response to accidents are commensurate with the hazards posed by the source.
- Import and export control: To optimize the import and export of sources according to the national obligations.
- National register of sources: To determine what level of detail should be used in the national register of sources.
- Control over orphan sources: To determine how efforts should be focused to regain control over orphan sources.

The categorization system developed by the IAEA was used to rank the in-use radioactive sealed sources in the country of Egypt as shown in Table **(III)** and represented by Fig **(1)**.

Table III. Categorization of RSSs that are in Use in Egypt According to IAEA- TECDOC- 1344

Category	Number of sources
1	42
2	157
3	1551
4	132
5	34

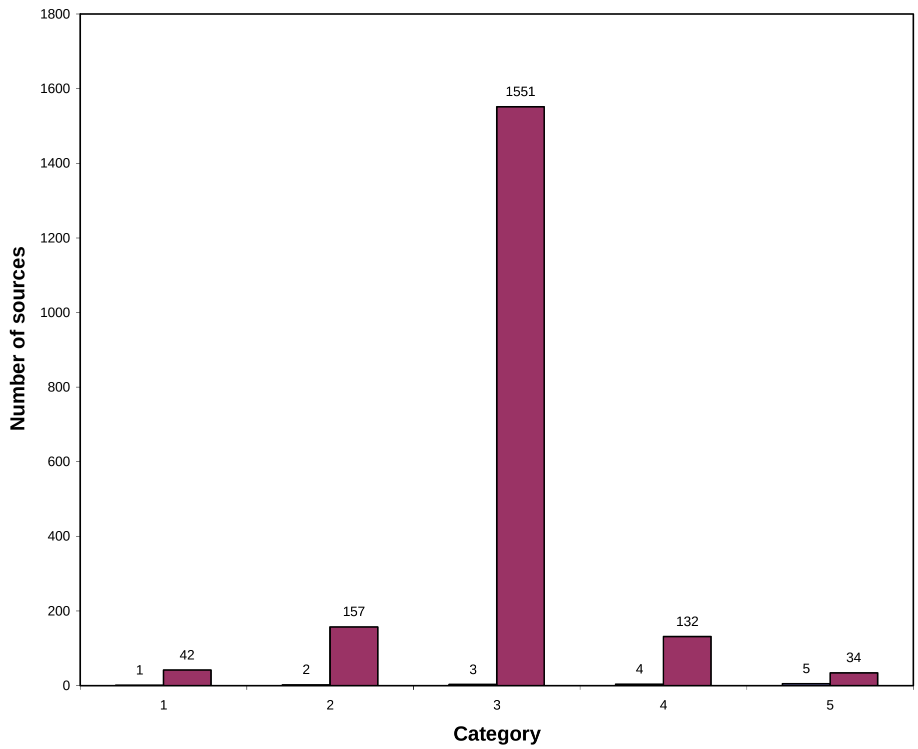

Fig. 1. Categorization of in-use RSSs in Egypt

CONCLUSION

Radioactive sealed sources have widespread applications over the world in industry, medicine, research and education. While most sources are of relatively low activity, there are many of medium or very high activity. According to the hazard from the exposure to such sources, it was very important to develop a simple logical system for ranking radioactive sources based on their potential to cause harm to human health and for grouping the practices in which these sources are used. According to the IAEA, five categories were ranked. Appling this categorization system on the radioactive sealed sources in Egypt we found that, Egypt has 42 sources of category (1), 157 sources of category (2), 1551 sources of category (3), 132 sources of category (4), and 34 sources of category (5). This categorization system is very important for helping the regulatory bodies to take into account the regulatory measures, security measures, national register of sources, import and export control over sources, labeling of high activity sources, control over orphan sources and emergency preparedness and response.

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