SPENT SEALED RADIUM SOURCES CONDITIONING IN LATIN AMERICA

Rogério Pimenta Mourão
Centro de Desenvolvimento da Tecnologia Nuclear, CNEN
Caixa Postal 941
30123-970, Belo Horizonte, MG, Brazil

ABSTRACT

The management of spent sealed sources is considered by the IAEA one of the greatest challenges faced by nuclear authorities today, especially in developing countries. One of the Agency's initiatives to tackle this problem is the "Spent Radium Sources Conditioning Project", a worldwide project relying on the regional co-operation between countries. A CDTN team was chosen as the expert team to carry out the operations in Latin America; since Dec/96 radium sources have been safely conditioned in Uruguay, Nicaragua, Guatemala, Ecuador and Paraguay. A Quality Assurance Program was established, encompassing the qualification of the capsule welding process, written operational procedures referring to all major steps of the operation, calibration of monitors and information retrievability. A 200L carbon steel drum-based packaging concept was used to condition the sources, its cavity being designed to receive the lead shield device containing stainless steel capsules with the radium sources. As a result of these operations, a total amount of 2,897 mg (approx. 107 GBq) of needles, tubes, medical applicators, standard sources for calibration, lightning rods, secondary wastes (generated during the operations) and contaminated objects were stored in proper conditions and are now under control of the nuclear authorities of the visited countries.

Key Words: packagings, sealed sources, testing, transport, waste management.

INTRODUCTION

The appropriate management of spent sealed radioactive sources is one of the challenging tasks faced by nuclear authorities today, especially in developing countries. Concerned with the figures of the accidents involving these sources, their political and psychological impact and the expenditure of millions of dollars in remediation actions (1), the International Atomic Energy Agency decided at the beginning of this decade to include a special project in its plan to review and access the magnitude and nature of the problems associated with old sources in Member States. This initiative spawned the "Spent Radium Sources Conditioning Project", a hands-on worldwide project, relying on the regional co-operation between countries, to collect and safely condition radium sources in countries lacking adequate infra-structure and organization to deal with these specific sources.

A CNEN/CDTN team has been chosen as the expert team to carry out the operations in Latin America. Since Dec/96 radium sources have been safely conditioned in Uruguay, Nicaragua, Guatemala, Ecuador and Paraguay. As a result of these operations, a total amount of 2,897 mg (approx. 107 GBq) of needles, tubes, medical applicators, standard sources for calibration, lightning rods, secondary wastes (generated during the operations) and contaminated objects were stored in proper conditions and are now under control of the nuclear authorities of the visited countries.

This paper describes the most relevant aspects of the operations carried out in these countries, including the applied Quality Assurance Program, description of the packagings used, personnel involved, the radioprotection planning and operational details.

QUALITY ASSURANCE PROGRAM

In order to accomplish the work with due reliability, a comprehensive QA Program was established and followed. This Program included the following items:

- Written Operational Procedures. These procedures refer to all major steps of the operation, as well as radioprotection aspects. The aspects covered are: preparation of the packaging, sources conditioning, capsule welding, leakage test and radioprotection planning.
- Qualification of the capsule welding process. The closure of the stainless steel capsule — the primary containment system — is a crucial step in the source conditioning process. Therefore special attention is given to its preparation and performance, which includes the specification of equipment, operation parameters (argon flow, welding current, welding time, cooling, etc), personnel qualification and leak testing.
- Calibration of monitors. All dose rate and surface contamination monitors used during the conditioning operation are calibrated and checked before use. This is of great importance not only in terms of personnel safety and reliability of the site contamination verification but also to guarantee that the conditioned inventory has been accurately evaluated, given that the radium activity is indirectly measured by the corresponding dose rate at 1m distance.
- Information retrieval. Information concerning the conditioned source inventory must be available during the whole interim storage period. For this, the capsules, shielding devices and drums have to be permanently marked (for instance, by engraving) according to a sequential pattern and all relevant data — activity (total, per package and per capsule), capsule position inside the shielding device, packaging dose rate (superficial and at 1m distance), conditioning date — collected and organized in tables. Copies of these records are given to the local nuclear authority, to the IAEA officer present at the operation site and to the conditioning team leader.

INVENTORY DESCRIPTION

The radium sources conditioned during these operations so far consisted mainly of sources used for medical applications: needles, tubes and applicators. The needles consist of radium salt encapsulated in platinum or platinum-iridium alloy (0.5mm wall) in five sizes: 1, 2, 3, 5 and 10 mg of radioactive content. Their diameter is 1.7mm, with different active lengths, according to their size. The tubes are encased in 1mm wall thickness platinum (or platinum-iridium) capsules with typical activities of 5, 15 and 25 mg. The applicators (nasopharyngeal or vaginal) vary widely in size and activity, having in average 45 mg of radioactive content.

The few non-medical sources encapsulated during the operations were lightning rods and calibration sources, the latter being very small in activity (in the range of μg).

PACKAGING DESCRIPTION

The packaging concept used reflects one of the project's basic assumptions: the sources should remain retrievable after conditioning. The rationale behind this is that, since these sources pose a potential hazard to the human health in the present, they shall be immediately conditioned in a safe way; however, as they have a long half-life (1,602 y), they must eventually be disposed of in deep geological formations. As this final solution is still not available in developing countries and it is expected that for the next 50 years no commercial disposal facility will be in operation in these countries, the sources must not be immobilized in matrix, once no acceptance criteria for the future disposal facilities is known so far.

Owing to this, a 200L carbon steel drum-based packaging was chosen (Figure 1). Its main components are:

- metallic drum with internal concrete lining;
- lead shields;
- stainless steel capsules.

The drum has an internal painting of white epoxy and an external coating of yellow enamel. It is provided with an internal hollow concrete lining, with the double role of providing radiation shielding and mechanical strength. Its cavity is designed to receive up to two cylindrical lead shield device containing stainless steel capsules with the radium sources. To avoid unintentional or unauthorized removal of the lead shield, two steel bars are cross-welded upon the cavity. These bars had been hardened in furnace and annealed to release residual stresses. This, allied to their high carbon content, prevents their destruction through unauthorized sawing.

Figure 1. Steel Drum-based Packaging (Without Lid)

The stainless steel capsules in which the sources are directly loaded are presented in two sizes: standard (¾ inches in diameter and 110mm in height) and large (2 inches x 130mm), the latter being intended for odd-sized sources and for standard capsule re-encapsulation, in case of failure of the latter in the leak test.

Five consecutive barriers — the stainless steel capsule, the lead shield, the stainless steel one-way mold, the concrete layer and the metallic drum — guarantee an adequate mechanical and radiological protection for the conditioned inventory during the period the intermediate storage is supposed to last (several decades). The package total weight amounts to 550 kg.

This package is classified as Type A package for special form material according to the IAEA standards (2). This means that the radiation level ant any point of the external surface shall not exceed 2 mSv/h and, for exclusive ^{226}Ra content, the activity limit per package is 200 GBq (approx. 5,400 mg).

Besides this standard package, a special purpose package was produced in one case: a square steel box used to condition contaminated objects and the secondary wastes produced during the operation in Guatemala (Figure 2). As the whole inventory of this country, together with a heavy safe containing some sources, had been stored for years in a pit in the premises of a local hospital which throughout that period was flooded by rain water, two shields, the wood box surrounding one of the shields and the safe were heavily contaminated. These objects were immobilized in a cement matrix with bentonite, used to improve the concrete radium adsorption capacity.

Figure 2. Packaging for Contaminated Objects and Secondary Wastes

PERSONNEL

The conditioning team is made up of three people. The team leader is a senior nuclear engineer with a background in radioactive waste management and packaging design and testing. He is also responsible for the leak testing. The radiation protection supervisor is also a senior nuclear engineer with an extensive experience in dosimetry control, specially in medical applications. His duties are restricted area characterization, personnel access control, on-line personal and area monitoring, contamination surveillance, decontamination operation (if necessary), radiation protection equipment supply and maintenance, original and conditioned inventory record keeping. The TIG welder is a skilled mechanical technician with a large experience in stainless steel welding. His duties include capsule sealing by welding and in situ manufacture of the required small items.

The local personnel is responsible for logistic, administrative and radioprotection support. This includes site preparation, forklift hire, drum lining manufacture, source transfer from the storage room to the conditioning laboratory, external radiological surveillance and provision of last-minute items.

A WTS/IAEA technical officer supervises the operation and approves the operation procedures.

SITE REQUIREMENTS

For a site to be considered adequate for the operation the following criteria have to be met: low radiation background, good ventilation, good floor quality (for an easy decontamination), compatible dimensions, water and electricity supply, restricted personnel access, protection from weather, access to a forklift truck, availability of a site in the neighborhood for drum concrete lining manufacture. The team radioprotection expert is always sent to the country in a pre-mission to discuss with the local counterpart the site conditions and suggest the necessary improvements. He also checks the inventory for activity, integrity (leaking sources), source types and dimensions and checks unknown sources to determine the radionuclide type.

A typical site layout is presented in Figure 3. Although specific arrangements can vary according to the local conditions, the minimum necessary configuration is depicted in that figure.

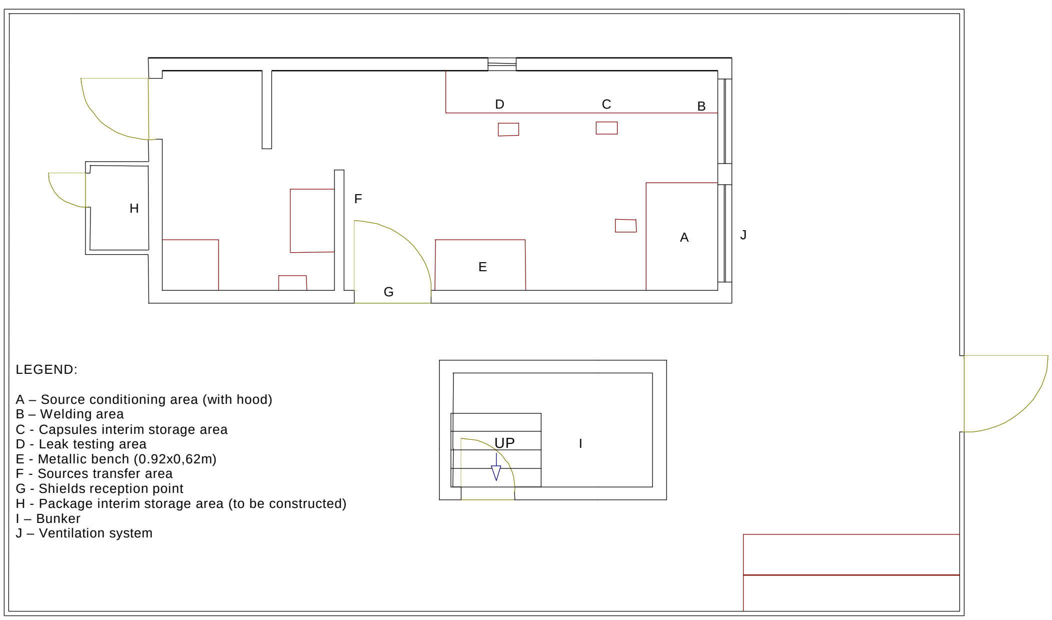

Figure 3. Conditioning Room Layout

CONDITIONING OPERATION DESCRIPTION

Prior to the source manipulation the controlled area has to be characterized and isolated, the lead brick walls built, the equipment set up and the drum concrete lining prepared.

The conditioning operation starts by transferring the sources from the original storage site to the conditioning room checkpoint, where the shield surface dose rate is measured and recorded. The shields are then put in a transfer area, the sources placed in a transfer shielding device, which is moved to the conditioning area. The sources are then transferred to the stainless steel capsules, the activity of the capsule being estimated by the dose rate at 1m distance. For ^{226}Ra, a dose rate of 0.01mSv/h corresponds to 1mg of the isotope. The capsule contents limit is established as 50mg.

Once loaded and the lid placed in position, the capsule is transferred to the welding area, the lid welded and, after a cooling period, the leak test takes place. Once approved, the capsule is finally transferred to an appropriate shielding device hole. Failed capsules are re-encapsulated in a large capsule.

In the operation carried out in Paraguay, owing to unusual way the inventory was stored – in few but heavy and clumsy shields –, a source transfer between shields preceded the real sources conditioning. A mobile frame equipped with a rotating cage was constructed to handle the heavy shields (Figure 4).

Figure 4. Mobile frame holding a heavy shield

Except for some minor modifications introduced to adapt to local conditions, the bulk of the operations follows the recommendations of the IAEA for this type of conditioning (3). The leak test adopted in these operations follows the vacuum bubble test procedures specified by the International Organization for Standardization (4).

As post-operation tasks, the site and all items used during the operations are monitored.

IMPACT OF THE PROJECT

The output of the operations carried out in five Latin-American countries so far is the conditioning of 2,897 mg (approx. 107 GBq) of radium sources, secondary wastes generated during the operations and contaminated objects. These sources, inappropriately stored before the operations and thus prone to be stolen or manipulated by unauthorized persons, are now under control of the local nuclear authorities. Inventory records were produced, including data on individual capsule and packaging activities, packaging identification, surface and 1m distance dose rate and measuring date records. Copies of these records were given to the local nuclear authorities, to the sponsoring agency (IAEA) and to the conditioning team organization (CNEN/CDTN).

The most relevant data about the conditioned inventory are presented in Table I. A total of nine packages was produced: eight standard drum-based packages and one steel box for contaminated objects and secondary wastes.

The success of this pioneer project, now being spread out to other regions of the world, shows the feasibility of using inter-regional cooperation in the solution of the problem posed by the spent sealed sources in developing countries. These sources are often conditioned under unsafe conditions and represent a potential harm to the population and the environment.

It also represented an opportunity for CDTN to put in practice the experience gathered in the areas of waste management, radiological protection and manufacturing processes for the nuclear industry.

As regards radioprotection aspects, all guidelines established in the corresponding Operational Procedure were entirely followed. This included area characterization and restricted personnel access, frequent site monitoring and permanent use of radioprotection items. As a result, the accumulated dose exposure of all operations for all members of the Brazilian team was negligible compared with the maximum limits for nuclear workers. Besides, no radionuclide incorporation occurred, as shown in the whole body counting carried out after each mission. The local personnel and the IAEA technician present at the operation site were also dose controlled by the CDTN Radioprotection Service and showed even lower radioactive exposure.

Site contamination occurred only in Uruguay owing to leaking sources and source dismantling, specially lightning rods. Being a pioneer mission, the conditioning team was not aware of the potential problems posed by the manipulation of this kind of sources. Thus, in Uruguay, the bench on which the lightning rods were dismantled became contaminated. Also some of the lead bricks used to erect protective shielding walls got slightly contaminated, as well as some spots on the plastic sheets that covered the laboratory floor. A decontamination operation was carried out later on with complete success. The lessons thus learned lead to procedures improvements and no other site contamination has since occurred.

Host country	**Number of packages produced**	**Total conditioned activity (GBq)**	**Conditioned inventory description**	**Operation date**
Uruguay	05	58.7	Needles, tubes, medical applicators, lightning rods and secondary wastes from site decontamination	Dec 1996
Nicaragua	01	9.7	Needles, tubes, medical applicators and calibration sources	Oct 1997
Guatemala	02	20.3	Needles, tubes, medical applicators, calibration sources, secondary wastes and contaminated shields	Dec 1997
Ecuador	01	8.6	Needles, tubes and calibration sources	Mar 1998
Paraguay	01	9.9	Needles and tubes	Oct 1998

TABLE 1. Conditioned Inventory

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