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RETRIEVAL AND CONDITIONING OF RADIUM SOURCES-CONTAINING PACKAGE IN PANAMA

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ABSTRACT

A team of CNEN experts successfully conducted an operation in Panama to recover and condition disused radioactive sources stored in an unsafe condition. The sources, containing the Ra-226 isotope, were used in the past to treat tumors using the technique known as brachytherapy and were immobilized in a complex package buried in an old hospital wing destined for demolition. The compartment where the package stayed for decades, built under the floor of a hospital laboratory, was contaminated with radon and daughters, including Pb-210, responsible for the contamination found. The operation consisted of extracting the package from this compartment, placing it in a cylindrical metal overpack, transporting it to the temporary storage site and carry out site decontamination. Besides the package with the sources, three 200L drums containing contaminated debris from the demolition of walls and floor were generated. No relevant event of radiological protection, such as occupational dose above the established limits, contamination of personnel or place, etc, was observed. The package produced, together with those containing the contaminated debris, was transferred to the facilities of the National Oncology Institute.

1. INTRODUCTION

The National Oncology Institute of Panama (ION) has requested technical assistance from Brazil's National Nuclear Energy Commission (CNEN) for the recovery and reconditioning of disused radioactive sources. These sources were immobilized in a package buried in a disused hospital facility, the former Physics Laboratory of the Santo Tomás Hospital (HST) in Panama City.

The assistance was provided through a field operation carried out from April 8 to 12, 2019, when the packaging with the sources was unearthed, conditioned in an overpack and transported to a temporary storage room at ION's premises. Due to the seepage of radon gas into the environment, the surfaces of the underground chamber where the package remained for decades were contaminated. The chamber´s wall internal cover had to be removed and the debris packaged in metal drums. Air samples taken during the operation revealed the presence of airborne radon in relatively high concentrations.

A radiometry survey carried out at the end of the operation indicated that the local dose rates were within the acceptable free area, but further analysis is advised to assess the soil contamination levels by the radon radioactive daughters with longer half-life (e.g. Pb-210).

The CNEN team consisted of four experts: a coordinator, a radioactive waste management specialist and two radiation protection officers. The local human resources support was provided by two radiation protection officers from ION and HST and by laborers from a local contractor.

2. QUALITY ASSURANCE PROGRAM

The safety-critical operations were carried out in accordance with the CDTN Quality Assurance Program. Thus, the team was formed by trained specialists with extensive experience in their respective areas of expertise. The measuring equipment used for the various functions - area monitoring, surface contamination, individual protection - were calibrated and in an appropriate state of use.

The area access control, the guidance for conduct of work and control of personnel in the operational area, the management of the radioactive waste generated and the transport documentation of the packages were done in accordance with the procedures of the CDTN´ s Radiological Protection Program. Also operational records were generated containing information on the operation carried out, the conditioned inventory, the packages generated, besides the radiological protection records. All packages were marked with sequential numbering (PAN-01 to PAN-04) and bore the international radiation symbol.

3. RADIATION PROTECTION ASPECTS

3.1. Personnel Control

For the extraction of the package from its place of burial, a whole set of personal protective equipment (PPE) was provided for the entire team. The dosimetry monitors used were TLD and OSLD type chest dosimeters for whole body dose and, given the nature of the operation, finger dosimeters to record the dose in the hands. For a real time evaluation of the workers' exposure conditions, electronic personal dosimeters were used, with acoustic alarm set at 10 µSv/h dose rate or 10 µSv accumulated dose. For area dosimetry external dose and surface contamination monitors were used. Also employed were a radioisotope identifier, a continuous air sampler, and passive environmental radon monitors.

Prior to the commencement of the tasks, the contractor's staff received instructions on the risks associated with working with radiation and the precautions necessary to prevent or minimize exposure or contamination with radioactive material. The main aspects addressed were not drinking or eating or smoking within the controlled area; using the personal protective equipment provided; staying away from the radiation source whenever possible; and washing hands and face when leaving the controlled area for hydration, meals or at the end of the day.

As contamination was expected to be present in the package material and surroundings, applicable personal protective items were provided, such as coveralls with hood, gloves, goggles, waterproof shoe covers, and facial air-purifying respirator.

3.2. Area Control

As a measure to manage possible contamination and to keep exposures as low as reasonably achievable, work areas and access control were established (Figure 1). A more strictly controlled area was designed encompassing the room where the package was buried and the open area behind this room. Access to this site was only to carry out defined tasks, with mandatory use of PPE and appropriate dosimetry. A less strict supervised area was established covering all rooms, aisles and open areas adjacent to the controlled area up to the control point. The adequate personal preparation before access to the controlled area and the monitoring of personnel leaving for the free area were performed at the entrance to the supervised area. Only the personnel involved in the work and the staff of the regulatory agency had access to the site.

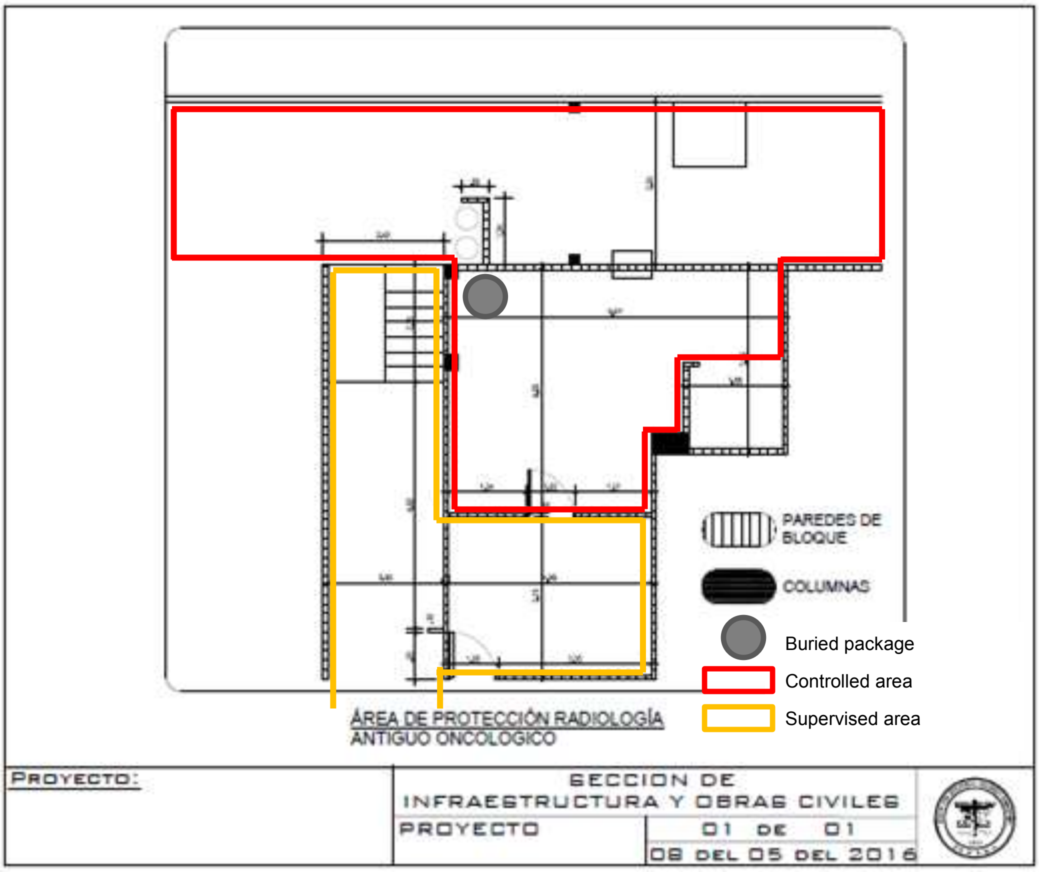


Figure 1: Work areas and access control [1]

3.3. External dose and contamination control

The individual dose limit for the operation was set at 300 μSv. The following measures were adopted for the control of the external exposure and contamination:

- Use of the necessary PPE;

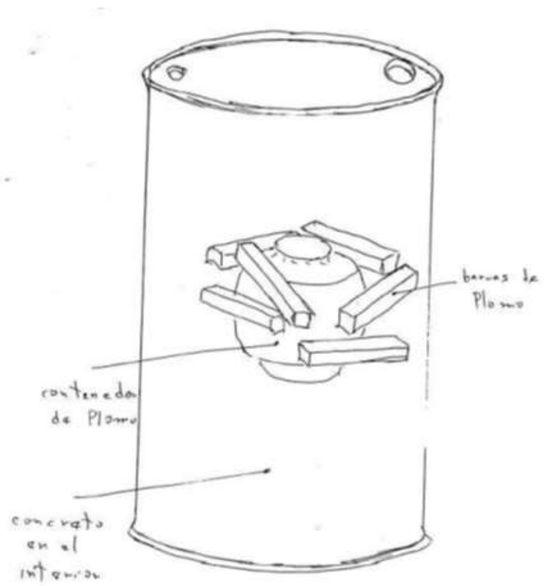
- Approximation to the source only when strictly necessary;
- Frequent external dose monitoring and smear testing to check fixed and non-fixed contamination;
- Use of external radiation and surface contamination monitoring equipment;
- Use of electronic dosimeters with alarms set in accumulated dose and dose rate modes in order to provide real-time monitoring.

4. INVENTORY DESCRIPTION

The package to be treated consisted of an external 200-liter metallic drum, a centralized lead shielding device, twelve lead bars surrounding this device to improve the package´s shielding capacity and a block of high-density concrete filling the void space (Figure 2, left side). The radium sources were immobilized inside the shielding device by molten lead poured into the device´s cavity. A pipe coming from inside the concrete block stood out by the upper surface of the block. The drum cover was missing.

The package thus constituted was buried under the floor in one corner of the Physics Laboratory of the Santo Tomás Hospital (Figure 2, right side), and the burial site was marked by a different type of ceramic applied to the floor. The package construction and burial occurred in the 1970s.

Regarding the inventory, the available information was that these were Ra-226 tubes and blades, some of which presented leakage, imported in the 1960s.



Main components[1] [2]

Package in burial site, after floor and wall removal

Figure 2: Package with radium sources

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[1] The following parts are identified in Figure 2, left side: shield container (*contenedor de plomo*); lead bars (*barras de plomo*); concrete inside (*concreto en el interior*).

5. OPERATION DESCRIPTION

The operation consisted of preparatory work, the operation execution and a post-operation stage. In the preparatory phase, the controlled area was delimited, the control point established, an initial radiometry and contamination survey carried out, air samplers were installed, the radionuclides present in the area were identified, and the surfaces prone to contamination were covered with tarpauling.

The pre-operational radiation values found indicated a radiation field above the background radiation, with a maximum value of 10 μSv/h. As for surface contamination, no removable contamination was detected at that time. The identification of the radionuclide present was made using a spectroscopy radiation detector, and Ra-226 was positively identified as the only one existing.

Sampling of ambient air was performed using a continuous air sampler and radon samplers (Figure 3). The first was installed in the operating room at a height of approximately 1.20 m, and its filter was read and changed every day, while the radon samplers were installed at floor level, also changed in a daily basis.

Continuous air sampler

Radon samplers

Figure 3: Air samplers

The operation started with the removal of the side wall and the floor around the burial place. A pneumatic hammer, sledgehammers and chisels were used for this purpose. The control of the ambient radiation level was frequently done during this stage and the debris generated by the dismantling was collected in thick plastic bags. In order to minimize the presence of radon gas, a portable industrial fan was used to renew the air in the workplace.

The visual inspection of the package after its exposure revealed that the metal drum and the concrete block were in good state, without corrosion or noticeable signs of deterioration. A metallic tube emerging from the inside of the block, probably for radon venting, was detected in the inspection. The maximum surface dose rate measured on the surfaces accessible before the removal of the package from its original position was 143 μSv/h.

A decision was made not to destroy the concrete matrix and recover the shielding device but, alternatively, to condition the original package in a metallic overpack. This decision was based on the information that the sources had been immobilized in solidified liquid lead, and on the absence of damage to the package. Also the high dose rate expected if the concrete matrix were to be broken in order to recover the lead shielding with the sources was taken into account, as well as the presence of surface contamination in the concrete by the radon by-products with longer half-life (e.g. Pb-210, $T_{1/2}$ = 22.2 years),

The next steps were the manufacture of the overpack and the setup of a structure to hoist the package to the Laboratory floor level. The metal structure for hoisting the final package was mounted on the floor of the room and fixed to the floor and to the side wall (Figure 4).

The cylindrical overpack was manufactured in carbon steel, provided with eye plates and wheels for handling and had the following measures: thickness 6.35 mm, diameter 64 cm, height 90 cm (Figure 5).

Hoisting frame

Lifting the final package

Figure 4: Package handling

Figure 5: Final package after painting and marking

Once the package was removed from its original position, the surfaces of the chamber where it was buried were monitored. Significant levels of contamination on the chamber walls were recorded, prompting the removal of the chamber wall cover. This operation removed all contaminated material, showing that radon penetrated only a few centimeters into the wall before decaying to its solid byproducts.

The removal of walls and floors generated approximately 0.6 m^3 of debris. In view of this relatively small volume, it was decided not to segregate this material, which was all directly conditioned in three commercial metal drums.

The final package and the drums with debris were transported to ION, where they were stored in a temporary deposit. A new warehouse will be built at ION premises to receive all four packages.

Once the operational phase was completed, a radiological evaluation of the site was carried out. Floors, walls, tarpaulins used to cover the floor, equipment and PPE were monitored. No residual contamination was detected, except from the bottom of the burial chamber, where the infiltration of radioactive material was verified, caused by the seeping of the radon gas through the cracks of the chamber, causing the deposition of their decay daughters along the way. The local counterpart was advised to carry out additional analyses in order to inform the actions to be taken in that place.

6. OPERATIONAL REGISTRY

Different records were generated as a result of the operation containing information on the scope of the work performed, the conditioned inventory and the package produced, as well as radiological safety records.

It is worthy to mention that the individual dose limit established for the operation - 300 μSv - was not exceeded. The highest individual dose recorded was 65 μSv, received by the leader of the contracted team, who stayed most time close to the sources, including the performance of time consuming tasks, such as the welding of the overpack. No personal contamination was observed during the operation.

As for air and surface contamination, all samples of wall and floor disassembly debris were found contaminated. The smear tests on the chamber floor and walls and the air sampler filters all showed contamination. On the other hand, no samples of floors of other areas and the soil of the external area showed contamination.

The concentration of radon in the air at the site of operation varied between 635 and 5,130 Bq/m^3. These values are higher than the limits suggested by the World Health Organization for indoor environments – between 100 and 300 Bq/m^3 [3].

7. CONCLUSIONS

Brazil's National Nuclear Energy Commission responded to a request from the National Oncology Institute of Panama to recover and recondition a package containing radioactive sources for medical use buried in a disused hospital facility in Panama City.

In order to fulfil this task on site operation was carried out that resulted in the removal of the package from its burial site, its conditioning in a robust overpack and its transportation to an temporary storage facility at ION premises, awaiting the construction of a suitable building for its long-term storage. A volume of approximately 0.6 m^3 of contaminated rubble was generated as a result of the removal of walls and floors around the burial place. A radiometry survey carried out at the end of the operation showed that the level of external radiation was in accordance with the classification of the area as free area and that most of the contamination found was removed. The doses received by the members of the operation teams did not exceed the limit established for the operation – 300 μSv for the whole body.

A phenomenon observed in the operation is that radium medicinal sources, whose use was discontinued worldwide, may lead to storage site contamination due to the presence of radon gas (Rn-222). In the present case, the walls and floors in the immediate vicinity of the buried package were contaminated. On the other hand, it was found that the decaying of Rn-222 is a factor that limits the dissemination of contamination. This could be seen when no contamination was detected in the chamber walls after the removal of its cover layer.

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