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ACTIVITY DETERMINATION OF A ^{137}Cs RADIOACTIVE SOURCE OBTAINED FROM AN OIL-WELLING STUDY IN ALBANIA

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Abstract. *Institute of Applied Nuclear Physics (IANP) is responsible for the safe and secure management of radioactive waste and DSRS at the National level. IANP collaborates with different institutions and private companies for the safe storage and transport of radioactive materials. This study describes the procedure followed to evaluate the total activity of two radioactive sources of unknown activity. During 2018, IANP received in the National Radioactive Waste Storage Facility 5 DSRS from geophysical service center in Fier, Albania due to the closure of their temporary storage facility. Based on the data of radioactive sources from their certificates that IANP possesses, and the measurements carried out on site of these sources, it turned out that the sources were two ^{241}Am-Be of 5 Ci initial activity each and one ^{137}Cs of initial activity 300mCi in separate containers each and two ^{137}Cs of initial activity 52mCi and 51mCi each, into one container. the two ^{137}Cs sources of activity 52mCi and 51mCi each (reference date July 1978), were supposed to be together in one container, and we needed to verify that they were both into one capsule. We estimated the activity of the source using the geometry of a point source. By making a comparison with the actual activity calculated on the basis of the certificate of these sources it resulted that the activity calculated on the basis of the measurements performed was 1.418 GBq, which was approximate to that calculated on the basis of the certificate 1.528 GBq in March 2018 and, finally, we confirmed that the last two ^{137}Cs sources were in the same capsule. Then all sources were transferred to the National Radioactive Waste Storage Facility in Tirana.*

Keywords: *radiation protection, ionizing radiation, storage facility, DSRS*

1. Introduction

Since 1999 a new radioactive waste storage facility (RWSF) is constructed within the territory of IANP for processing and temporary storage of radioactive wastes and disused sealed radioactive sources (DSRS) in accordance with National / International waste acceptance criteria (WAC) [2], [3]. The basic law for radiation protection in the Republic of Albania is Law no. 8025, dated 11.01.1995 "On protection against ionizing radiation" amended No. 9973, July 28th 2008 and No. 26/2013, March 2013, [1] which establishes basic safety standards to protect the health of workers and the general public environment against the dangers arising from the ionizing radiation. The safety assessment of this facility is performed considering its impact on workers, the public, and the environment [1], [4], [6]. The site receiving LLW/ILW of non-nuclear power plant origin (health care, industry, agriculture, education, research) has been operating since 1971 with a capacity of 60 m^3, reinforced by concrete/bricks vaults accommodating solid spent sources into drums.

All the disused sealed radioactive sources (DSRS) and radioactive waste should be characterized before being accepted in the radioactive waste storage facility. Priority should be given to the volume reduction of radioactive waste, which needs long-term management. To facilitate this process, Radiation Protection Commission applies and implements the Code of Conduct on the safety and security of all radioactive sources imported into the country and its additional guides. In pursuant to this, it will require importers of radioactive sources to ensure their return to the manufacturer or to a warehouse abroad. Disused sealed radioactive sources which are not processed by IANP should be exported abroad.

For the DSRS should be provided for their return to the manufacturer after the end of working hours (consumption). In cases where the return is not provided or is not feasible, and in other cases of unknown origin, the treatment of this radioactive waste or DSRS will be performed by IANP. Acceptance of these DSRS will be made on the basis of a draft agreement between IANP and interested companies. IANP remains the main center of collection and treatment of unusable radioactive sources, disused sealed radioactive sources, or radioactive waste in the country.

The Albanian oil production company due to the reason of non-renewal of the License for the storage of radioactive sources had to transfer all the radioactive sources to the National Radioactive Waste Storage Facility at IANP. Oil and gas industry utilize many radiation sources in various applied radiation-based technologies. Those technologies provide significant benefit to the daily operations of the industry. Gamma emitter sources of Caesium-137 (137 Cs), and neutron source Americium-241/Berylium (241 Am-Be) are used in well logging [11]. Gamma and neutron radiation

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sources are used in well logging to assist in determining whether a drilled well has certain rocks or minerals, oil, gas, or other substances of consumer value. Well logging generally uses sealed sources containing radioactive materials that emit gamma rays or neutrons. The depth of penetration of these radiations is an indication of the type of material [12].

Institute of Applied Nuclear Physics (IANP) according to the request of this company for the temporary storage of DSRS that this company had in their storage, after proper characterization carried out the transportation of all the DSRS described below, from their Storage to the Radioactive Waste Storage Facility at IANP, Tirana.

2. MATERIALS AND METHODS

2.1. Method Used for DSRS Characterization

In order to make the proper characterization of the DSRS first we need to check the radiation levels around the radioactive source. We do not approach the source if radiation levels are too high and use appropriate equipment for measurements and follow the instructions for radiation protection measures to be taken. If any problem occurs during the manipulation with the radioactive source of ^{137}Cs will be followed the instructions for radiation protection described in the Procedure Nr.11 "Procedure for Radiation Protection" [10].

Register the dose rates measured at the surface and 1 meter from the radioactive source. First, we have to check the DSRS for radioactive contamination and wipe the external surface of the source/unit with a swab or another absorbent material. For gamma-emitting sources, we need to use a long-handled tong to hold the swab. For alpha-emitting radionuclides, held the sample in your gloved hand. Measure the swab using a sensitive Geiger-Muller survey meter with a pancake probe in a low background area to determine if the source is leaking. When compared to the background reading, values greater than the background plus 3 times the standard deviation indicate removable contamination.

Figure 1. Example of labels on the radioactive sources or devices

We need to look for any label on the surface of the device with information about the source and the unit. Register any information regarding the device, such as Type of unit (e.g. brachytherapy source, soil moisture-density gauge, level gauge, lightning rod, transport container, etc.), Model and serial number of the device, Unit dimensions, and estimated weight.

Register any information about the radioactive sources:

- Source serial number
- Source nuclide
- Source activity
- Reference date for the activity

If activity and manufacture date are on the source label, we would calculate the activity at the present date using the radioactive decay equation.

$$A_t = A_0 e^{-\frac{Ln2}{T_{1/2}} t} \qquad (1)$$

$$A_t = A_o e^{-\lambda t} \qquad (2)$$

where:

t = time (from the date of manufacturing to present date), A_t = activity at time t

A_0 = initial activity, λ = decay constant, $T_{1/2}$ = half life of the radionuclide

In this case, no identification label was available on the device, so we needed to characterize the source using appropriate instruments [5], [7]. We identified the radionuclide using a portable spectrometer (this is applied for sources containing gamma-emitting radionuclides).

Figure 2. Measurement of dose rate at 1 m distance.

The shielding attenuates the dose rate measurements, so, in this case, the radiation levels were not high, and we opened the cover and took the source out of the shielding.

We estimated the activity of the source using the geometry of a point source. We measured the dose rate (DR) at a 1 m distance (r) from the source and used the following expression to estimate the activity.

$$DR = \Gamma \times A / r^2 \qquad (3)$$

where:

DR – dose rate at a distance "r" from the source, expressed in mSv/h.

Γ - Ambient dose equivalent rate, H*(10), produced at 1 meter by the radioactive source, expressed in mSv.m²/h.GBq. These values are given in Table 1 for the radionuclides more commonly used in sealed sources.

A – Activity of the source, in GBq.

Table 1. Characteristics of Specific Isotopes

	Half-Life $T_{1/2}$	Specific Activity (TBq/g)	Ambient dose equivalent rate, H*(10), at 1 meter, mSv.m²/h.GBq
Cs-137	30.2 y	3.22E+00	0.092

3. Results and Discussion

Based on the data of radioactive sources from their certificates that IANP possessed, and the measurements carried out on site of these sources, it turned out that the sources were 2 ^{241}Am-Be of 5 Ci Activity each, 1 ^{137}Cs of initial activity 300mCi, two ^{137}Cs of activity each one 52mCi and 51 mCi, and 1 ^{137}Cs with unknown activity.

The two ^{137}Cs of activity each one 52mCi and 51mCi were supposed to be together in one container, so we needed to make the characterization of these two sources according to the method described above for the DSRS characterization.

After checking the DSRS for radioactive contamination, there was no contamination of the source container. The measurement values varied from 0.0017-0.0019 Bq/cm^2 for alpha emitters and 0.011-0.013 Bq/cm^2 for beta and gamma emitters. These values were very close to the measured values of the storage floor area where these sources were stored which varied from 0.0015-0.0026 Bq/cm^2 for alpha emitters and 0.00156-0.0172 Bq/cm^2 for beta and gamma emitters.

So, the contamination level was in compliance with IAEA instructions on packages contamination level (The *non-fixed contamination* on the external surfaces of any *package* shall be kept as low as practicable and, under routine conditions of transport, shall not exceed the following limits:

(a) 4 Bq/cm2 for beta and gamma emitters and *low toxicity alpha emitters*;

(b) 0.4 Bq/cm2 for all other alpha emitters. These limits are applicable when averaged over any area of 300 cm2 of any part of the surface.) [9]

We used the Identifinder-2 Flir apparatus for the dose rate measurement, and the measured values for ^{137}Cs source with its shielding at surface and 1 m are described in Table 2.

Table 2. Dose rate measurements of ^{137}Cs Source

Radionuclide	Initial Activity	Reference date/ Actual date	Actual Activity	Dose rate on surface (μSv/h)	Dose rate at 1 m (μSv/h)
^{137}Cs	52 mCi	July 1978/February 2018	20.86 mCi/0.7718 GBq	209.2	8.4
^{137}Cs	51 mCi	July 1978/February 2018	20.46 mCi/0.757 GBq		

Seeing that we didn't have information on the type and dimensions of ^{137}Cs source shielding we took the source capsule out of the shielding and measured the dose rate at a 1 m distance from the bare capsule of these sources. The measured value resulted 130.5 μSv/h.

Using the formula below we calculated the Activity of these sources. The ambient dose equivalent rate for the Cs-137 source is 0.092 mSv.m^2/h.GBq.

According to Equation 4 described above, the result was:

$$A = 1.418 \text{ GBq} \quad (4)$$

The activity of both Cs-137 sources resulted in 1.418 GBq from the calculations above. After confirming the presence of two Cs-137 sources all radioactive sources were transferred to metal buckets, with the respective labeling. Then all sources were transferred to the radioactive waste storage facility in Tirana, for temporary storage [8].

The radiation protection tools that we used during this operation are described below and are part of the instructions for radiation protection described in the Procedure Nr.11 "Procedure and Programme for Radiation Protection" [10].

<u>Radiation safety equipment:</u>

- Dose rate monitor (with valid verification)
- Contamination monitor (with valid calibration)

<u>PPE and dosimetry</u>

- TLD (filmbadge)
- Electronic Personal Dosimeter (alarm)
- Safety shoes
- Neutron film badge
- PVC gloves
- Leather gloves to handle source containers
- Overshoes
- Overall

4. Conclusion

By making a comparison with the actual activity calculated on the basis of the radioactive source certificate it resulted that the activity calculated on the basis of the measurements performed 1.418 GBq was approximate to that calculated on the basis of the certificate 1.528 GBq and, finally, we concluded that the two ^{137}Cs of activity each one 52mCi and 51mCi were together in the same capsule in one container. Both sources are temporarily stored at Tirana, Albania's radioactive waste storage facility. IANP performs processing of orphan sources in the country. Radiation detection portals that are installed at customs points are monitored by competent authorities at different border custom points The competent authorities shall maintain and, where necessary improve existing detection system at customs regarding the safety of the public and employees. As a first responder in case of detection of an event, IANP will be responsible for managing of sources further findings which will be transported to the radioactive waste storage facility in accordance with the emergency plan. This facility consists of two main parts, namely the operational area and the interim storage facility. The interim storage facility for conditioned radioactive waste and DSRS is foreseen to be fulfilled by 2030. Management and treatment of radioactive waste and DSRS is not a static process. Review of programs that deal with the problems of radioactive waste storage facilities is a permanent task of the staff working in this field. Rhythms of activities with radioactive sources in the near future in our country will be added. Based on this rhythm the filling and closing of the works in the premises of temporary storage in IANP are planned for the year 2030. As result will be undertaken a study on the location and construction of a permanent storage of radioactive waste in our country. This study should be undertaken taking into account the guidelines and recommendations of the IAEA for the design and construction of such buildings or special places for storage of the radioactive waste with low and intermediate activity near the soil surface.

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