WIPE TESTING OF SEALED RADIATION SOURCES USING A RADIATION PROTECTION ASSISTANT ROBOT

by

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Sealed radiation sources are commonly used in different research institutes, industries, and hospitals. The sources of various strengths are manufactured in different sizes and shapes. It is a regulatory requirement that these sources must be monitored frequently for their integrity and to avoid any radiological contamination hazard. Mainly, a wipe test is recommended for the contamination detection due to the leakage of sealed radiation sources. A radiation protection assistant robot has been fabricated to execute different tasks in a hazardous radiation environment. In this study, the robot was used to conduct the wipe test of five sealed radiation sources. The sealed radiation sources were tested safely and securely without giving any radiation dose to the radiation worker. The radiation doses received by the robot gripper and waist during the wipe test were 3.4 Gy and 208.9 mGy, respectively.

Key words: wipe test, radiation, robot

INTRODUCTION

Nowadays, the demand of sealed radiation sources (SRS) has increased due to their extensive application in high quality mass productions industry and other fields of bio and medical sciences. In industry, the main application of SRS is the non-destructive and fast quality control and material inspection. In nuclear medical centers and hospitals, SRS are used for disinfection and sterilization of surgical and medical instruments, radio-imaging, and radiotherapy. The SRS are also intensively used for radiation sterilization of a variety of food stock items. Due to the variety of uses, SRS are available in different makes, types and activities. Because all types of SRS are radioactive materials, frequent and strive monitoring for leakage/contamination is necessary during their use. The International Organization for Standardization (ISO) has classified standard procedures [1, 2] for checking the leakage and/or presence of loose radioactive contamination.

The standard leak test frequency ranges from six months to several years depending on the type and frequency of use. The SRS used for industrial radiography and other quality control and food stock sterilization processes are of higher radiation strength; their leak test is recommended after six months [3]. Some SRS are used for small level sterilization in hospital and their leak test is recommended annually. The low strength SRS are used in level monitoring, moisture, soil, and alignment gauges. For such SRS, the leak test is recommended after every 2 years. An integrity or leak test is not carried out for sealed source containing a radionuclide with a half-life of less than 30 days, liquid or gaseous radionuclide(s) or radionuclide with beta activity less than 185 MBq and/or gamma emitting material or not more than 185 kBq of alpha emitting material [3]. Sealed gaseous radionuclides are exempted from integrity testing because of the rapid escape of gases. The gaseous and liquid sealed radioactive sources are treated as radioactive materials [4]. The SRS used in smoke detectors and electron capture detectors, and unsealed sources are not subjected to the leak test. Similarly, electroplated sources are not tested with the wipe test procedure. Furthermore, an indication of leakage is also obtained by checking the storage container for radioactivity [5].

The wipe test is only suggested for long half-life gamma emitter radionuclide SRS. The wipe test equip-

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ment should be capable of detecting as low as 185 Bq of radioactive material on the test sample. Only the record keeping is recommended when the wipe test indicates less than 200 Bq on SRS surface or 20 Bq on an equivalent surface of a container [6]. When the wipe test reveals the presence of leakage, the SRS is instantly withdrawn from the services and stored in a separate shielding container in a secure interim storage. This is necessary to prevent the spread of radiological contamination. Moreover, due to radioactivity the SRS handling represents a risk; hence specially designed hot cell, master-slave manipulators, special tools and equipments are required for the SRS wipe tests.

In this study a specially designed and locally fabricated radiation protection assistant robot (RPAR) has been utilized for the wipe testing. A total of five cylindrical SRS were subjected to the wipe test. The radiation doses taken by RPAR were also measured as if it is a radiation worker conducting the test. By using a robotic arm, there is no need to follow the leak test procedures given by [7]. The wipe tests were carried out by using isopropyl alcohol and double-distilled de-ionized water.

MATERIAL AND METHODS

The RPAR has a 4-degree-of-freedom (DOF) articulated robotic arm (fig. 1). The RPAR has been designed and constructed to assist radiation workers in hazardous radiation environments [8]. It can be controlled manually through a remote consol or automatically through a task programme. The RPAR was used without any mechanical alteration or amendment in the present study. The RPAR picked and placed SRS directly from the shielding with the help of the remote consol. The remaining procedure of the wipe test, *i. e.* pressing and rolling over a wet cotton swab was carried out automatically with the help of a press and roll task programme. This programme is sufficient to wipe off thoroughly the external surface of SRS. When the programmed wipe test routine ended, the SRS was stored back in the shielding with the remote console. The whole operation was carried out in a hot cell with the help of an onboard RPAR's web cam (fig. 2), and a camera fitted inside the experimental room (fig. 3).

Figure 1. Radiation protection assistant robot (RPAR)

The swab holder mechanism consists of two perspex sheets with a polystyrene sheet, 3 mm thick, in between. The base tray has dimensions 110 × 60 × 5 mm. The swab holder sheet (80 × 60 × 16 mm) has a 1.5 millimeter deep cavity at the top to hold a double folded wet cotton swab (20 × 20 mm). The polystyrene sheet provides the necessary flexibility to the swab holder sheet during testing. A list of the SRS used for the wipe testing is given in tab. 1.

Wipe test with isopropyl alcohol. Five cotton swabs were prepared, one for each SRS. For each wipe test experiment the swab was moistened with analytical grade isopropyl alcohol (E. Merck, Germany), as the isopropyl alcohol moisten swab was found 100 times

Figure 2. View from onboard RPAR's web cam

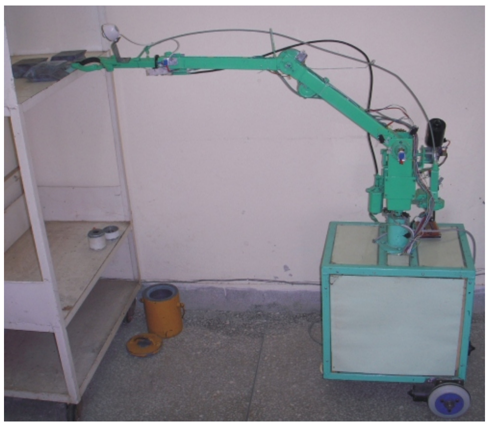

Figure 3. View from the camera fitted inside the experimental room

Table 1. Lists of sealed radiation sources

S. No	SRS	Physical form	Activity [MBq]
1	^{60}Co	Cylindrical	87.4
2	^{137}Cs	Cylindrical	4080
3	^{137}Cs	Cylindrical	3140
4	^{226}Ra	Cylindrical	1760
5	^{226}Ra	Cylindrical	1660

more efficient to wipe off the loose radioactive contamination compared to a dry swab [9]. The wet cotton swab was placed in the cavity of the perspex tray. With the help of the remote console of the RPAR a SRS was picked out of the shielding and was brought to a predefined position over the tray cavity. After adjusting a proper position of the RPAR gripper with the grabbed SRS, the press and roll task programme was started. This programme wiped the SRS five times over the wet cotton swab and rotated through 185 deg at the same time. Each stroke consisted of two half strokes. In first half, the wiping started from one side of the swab and continued towards the end with the rubbing action. Then the subjected SRS was flipped over and the second half was wiped in a similar way. The press and roll of SRS over the cotton swab is illustrated in fig. 4. After the completion of the task programme for ten strokes, the wet cotton wipe was allowed to dry in the open air. The dried smear was inserted and sealed in a small polystyrene sample counting vial with the help of the forceps.

Wipe test with double distilled de-ionized water. The wipe test procedure was repeated with double distilled de-ionized water in a way similar to that of the wipe test experiment with isopropyl alcohol. The wipes were allowed to evaporate till completely dry and then inserted in a small polystyrene counting vial.

MEASUREMENT OF RADIOACTIVITY

The measurement of leakage (radioactivity) was performed with a HPGe detector (Canberra Model AL-30) connected to a PC-based intertechnique multichannel analyzer (MCA). Intergamma, version 5.03 was used for data acquisition. The system has the resolution of 1.9 keV at 1332.5 keV peak of ^{60}Co and peak to Compton ratio of 40:1. The data files, containing γ-spectra were then used by our indigenously developed computer programme for activity calculations. In the calculation step background subtraction was applied for each swab.

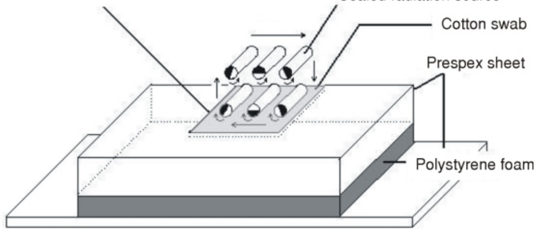

Figure 4. Press and roll of SRS over the cotton swab

RADIATION EXPOSURE RECEIVED BY RPAR

Each scrubbing stroke completed in 3 seconds. The RPAR conducted a single wipe test in about four minutes. To measure the radiation dose received by the RPAR, four thermoluminous dosimeters were used. Two dosimeters were mounted on the gripper and two were mounted on the waist segment.

RESULTS AND DISCUSSION

Each swab was subjected to gamma spectrometry for one hour. The spectrum shows only the background peaks. All the gamma spectra contained radionuclides originating from^{238} U and ^{232}Th series, and from ^{40}K. No radionuclide from any SRS was observed. The results indicate that all the wipe-tested SRS have no surface contamination and that the sources are leak tight and intact.

For all the SRS, the gripper and waist of RPAR received a total dose of 3.4 Gy and 208.9 mGy, respectively. The wipe testing was carried out in a hot cell. During this test, the operator remotely controlled the RPAR; therefore, he did not receive any radiation dose. The performance of the RPAR has been found satisfactory in high radiation environment.

CONCLUSION

A robot having four degree of freedom articulated robotic arm can perform the wipe test on sealed radiation sources. The wipe testing is more convenient with a robot as compared to a master-slave manipulator inside a hot cell. The master-slave manipulator has limited range and accessibility as compared to a mobile manipulator. The technique will protect the radiation workers from getting avertable ionizing radiation dose.

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ТЕСТИРАЊЕ БРИСОМ ЗАПЕЧАЋЕНИХ РАДИОАКТИВНИХ ИЗВОРА КОРИШЋЕЊЕМ ПОМОЋНОГ РОБОТА

Запечаћени радиоактивни извори обично се користе у различитим истраживачким институтима, индустрији и болницама. Извори различитих јачина производе се у разноврсним облицима и величини. Прописима се налаже честа контрола извора у погледу њихове целовитости, а ради избегавања ма каквог ризика од радиолошког загађења. За детекцију загађења запечаћених радиоактивних извора углавном се препоручује тестирање брисом. За обављање различитих задатака у ризичном радијационом окружењу произведен је помоћни робот. У приказаном испитивању, робот је коришћен да обави тестирање брисом пет запечаћених радиоактивних извора. Извори су тестирани поуздано и сигурно, без икакве примљене дозе зрачења од стране радника. Дозе зрачења регистроване током теста брисом на хватаљци и појасу робота биле су 3.4 Gy и 208.9 mGy, респективно.

Кључне речи: тестирање брисом, зрачење, робот