Dismantling of Radium-226 Coal Level Gauges: Encountered Problems and How to Solve

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ABSTRACT

This paper describes the techniques for dismantling of disused-sealed Radium-226 (Ra-226) coal level gauges which the source specifications and documents were not available, including problems occurred during dismantling stage and the decision making in solving all those obstacles. The 2 mCi (20 pieces), 6 mCi (20 pieces) and 6.6 mCi (30 pieces) of Ra-226 hemispherically-shaped with lead-filled coal level gauges were used in industrial applications for electric power generation. All sources needed to be dismantled for further conditioning as requested by the International Atomic Energy Agency (IAEA). One of the 2 mCi Ra-226 source was dismantled under the supervision of IAEA expert. Before conditioning period, each of the 6 mCi and 6.6 mCi sources were dismantled and inspected. It was found that coal level gauges had two different source types: the sealed cylindrical source (diameter 2 cm x 2 cm length) locked with spring in lead housing for 2 mCi and 6.6 mCi; while the 6 mCi was an embedded capsule inside source holder stud assembly in lead-filled housing. Dismantling Ra-226 coal level gauges comprised of 6 operational steps: confirmation of the surface dose rate on each source activity, calculation of working time within the effective occupational dose limit, cutting the weld of lead container by electrical blade, confirmation of the Ra-226 embedded capsule size using radiation scanning technique and gamma radiography, automatic sawing of the source holder stud assembly, and transferring the source to store in lead safe box.

The embedded length of 6 mCi Ra-226 capsule in its diameter 2 cm x 14.7 cm length stud assembly was identified, the results from scanning technique and radiographic film revealed the embedded source length of about 2 cm, therefore all the 6 mCi sources were safely cut at 3 cm using the automatic saw. Another occurring problem was one of the 6.6 mCi spring type source stuck inside its housing because the spring was deformed and there was previously a leakage on inner source housing. Thus, during manufacturing the filled-lead for shielding passed through this small hole and fixed the deformed spring together with the source. The circular surface of inner hole was measured and slowly drilled at a diameter 2.2 cm behind shielding, till the spring and the fixed lead sheet were cut, therefore the source could be finally hammered out. The surface dose rate of coal level gauges before weld cutting was 10 - 15 mR/hr and the highest dose rate at the position of the weld cutter was 2.5 mR/hr. The total time for each weld cutting and automatic sawing was 2 - 3 minutes and 1 minute, respectively. The source was individually and safely transferred to store in lead safe box using a 1-meter length tong and a light container with 1 meter length handle. The total time for Ra-226 (70 pieces) dismantling, including the encountered problems and their troubles shooting took 4 days operation in which the total dose obtained by 18 operators were ranged from 1 - 38 μSv. The dismantling team safely completed the activities within the effective dose limit for occupational exposure of 20 mSv/year (80 μSv/day).

KEYWORDS

Coal Level Gauge, Dismantling, Gamma Radiography, Ra-226, Scanning Technique

INTRODUCTION

The sealed Ra-226 sources were widely used in Thailand since 1953 for several aspects, not only in medical but also in industry, research and education. For industrial applications, the sources were used as coal level gauges, lightning preventions and standard calibrators. As IAEA requested member states to stop the utilization of Ra-226 because of the long-term effect of radon gas to human and environment in case of Ra-226 containers were cracked or leaked. The unfavorable radiological characteristics of Ra-226 required special conditioning techniques that resulted in a safe containment from both radiological and physical security points of view in order to guarantee the protection of man and environment. Therefore, OAP by Radioactive Waste Management Program (RWMP) as the centralized radioactive waste processing facility in the country collected all the Ra-226 sources for further management as proposed in the IAEA - Work plan for Managing Radioactive Waste in Thailand: INT/4/131. The 70 pieces of Ra-226 coal level gauges were also gathered and needed to be dismantled prior to conditioning. Lacking of source specifications, then the related details and information on similar type of sources were investigated, but the information in hands was still insufficient. Thus, one of 2 mCi was dismantled under the IAEA expert suggestion and the rest of sources were under the RWMP responsibilities. Some problems had occurred and the OAP dismantling team had to solve them in order to meet the final requirements.

MATERIALS AND METHOD

As data of these Ra-226 hemispherically-shaped with lead filled coal level gauges were not available, more related information of coal level gauges [1] were obtained via internet. Under the supervision of IAEA expert (Ms. Sophia Teh Whei Miaw), one of the 2 mCi Ra-226 was taken out from OAP temporary storage on 26 November 2003 for visual inspection, surface dose rate measurement, calculation of working time with the source while the effective occupational dose limit of 20 mSv/year (80 μSv/day) [2] was applied, weld cutting using electrical blade as shown in Fig. 1 with time recorded. The 2 mCi source type was observed and the actual dimension of this radium source was measured.

Fig. 1. Weld cutting using electrical blade

Before dismantling all sources, each of 6 mCi and 6.6 mCi Ra-226 source were taken out from OAP temporary waste storage to check the source type. The surface dose rate of each source was measured and the occupational working time for weld cutting was calculated. The weld of lead containers were cut and the sources were dismantled. The different types of these 2 sources were found: embedded capsule in source holder stud assembly for 6 mCi and cylindrical type fixed with iron spring for 6.6 mCi as shown Fig. 2. Then, there was a problem on how to check the size of embedded capsule in its assembly.

Fig. 2. Ra-226 cylindrical type fixed with iron spring

Confirmation on the size of 6 mCi Ra-226 embedded capsule was performed using radiation scanning technique and reconfirmed by gamma-radiography. For scanning technique, the source assembly was slowly moved from its first end through the small hole behind 10 cm thick lead shielding. The dose rate decreasing point was evaluated and the active source length was measured. For gamma-radiography, the Ra-226 source assembly was placed on the radiographic-film at a distance of 24 inches from the 10 curies Ir-192 source to film for 14 minutes exposure time. The film was then developed and the size of embedded capsule was evaluated as shown in Fig. 3.

Fig. 3. Confirmation of Ra-226 embedded capsule size using gamma radiography

The total 6 mCi embedded capsules in stud assemblies were accordingly cut at 3 cm by automatic sawing behind 12 inches thick heavy concrete shielding. All the rest of Ra-226 sources were finally dismantled and the source was individually and safely transferred to store in lead safe box using a 1 meter length tong and a light container with 1 meter length handle for further conditioning. For radiation safety during temporary storage, the surface dose rate on 5 sides of 2 lead safe boxes were confirmed.

Another problem occurred was one of 6.6 mCi Ra-226 spring type got stuck inside its housing and could not be taken out. Because the spring was deformed and fixed by filled-lead during manufacturing. It could be assumed that there was a leakage on the inner housing and the filled-lead for shielding passed through this small hole. The lead then fixed the deformed spring and the source together with its housing. Thus, the circular surface of inner hole was measured and slowly drilled at a diameter 2.2 cm behind 12 inches thick heavy concrete shielding till the spring and the fixed lead sheet around spring and source were cut. For radiation safety in observation of the stuck source condition inside its housing, the mirror was used. The reflected image of the stuck source after drilling was shown in Fig. 4.

Fig. 4. Reflection of the stuck 6.6 mCi Ra-226 after drilling

RESULTS AND CONCLUSIONS

From the first inspection under the IAEA expert supervision, the type of 2 mCi Ra-226 hemispherically-shaped coal level gauge was a sealed cylindrical source of a diameter 2 cm x 2 cm length, locked with iron spring in lead filled housing. The contact dose rate was ranged from 5 - 10 mR/hr which the weld cutter was able to work directly at the source surface for 6 minutes. However, the weld cutter was working at a distance of 20 – 30 cm from the source, except his hands. Therefore, the obtained dose was relatively low. During this 2 mCi Ra-226 dismantling, the weld cutter received total dose less than 1 μSv for 1 minute cutting.

For the 6 mCi Ra-226 source was the embedded type in total 14.7 cm length stud assembly with a diameter of 2 cm, the results from scanning technique and radiographic film showed the source length of about 2 cm, therefore, all the 6 mCi sources were safely cut at 3 cm using automatic saw.

The 6.6 mCi Ra-226 source was cylindrical type of a diameter 2 cm x 2 cm length fixed with iron spring. For taking out the stuck source, after the deformed spring including the lead sheet around spring and source were finally cut, then the source could be slowly hammered out.

Overall dismantling, the surface dose rate of coal level gauges before weld cutting varied from 10 - 15 mR/hr and the highest dose rate at the position of the weld cutter was 2.5 mR/hr. Total time for each weld cutting was between 2 - 3 minutes which depending on the sharpness of cutting blade and how rusty of the fixed screw. The time consumed for automatic sawing was 1 minute. The sources were stored in the 2 lead safe boxes with the highest surface dose rate at 4 mR/hr. The total time for 70 pieces of Ra-226 dismantling including the time for problems solving took 4 days operation, in which the total dose obtained by 18 operators were ranged from 1 - 38 μSv as shown in Table I. The dismantling team safely completed the coal level gauges dismantling activities within the effective dose limit for occupational exposure of 20 mSv/year (80 μSv/day).

Table I. Total Dose Received by 18 Operators

Total Dose Received (μSv)	**Number of Operator**
1 - 5	9
5 - 10	3
10 - 15	3
15 - 20	-
20 - 25	-
25 - 30	2
30 - 35	-
35 - 40	1

DISMANTLING TEAM

The dismantling team comprised of 18 operators from different sectors in OAP as listed in Table II. Each operator had his own assignments and could complete his responsibilities in this operation successfully

Table II. The Coal Level Gauges Dismantling Team

Radioactive Waste Management Program: 1. Mrs. Monta PUNNACHAIYA 2. Mr. Panya NUANJAN 3. Mr. Leua SUKSAWAD 4. Mr. Narong PATONG	**Research Reactor and Nuclear Technology Operation Program:** 1. Mr. Kosol MOOMBANSAO 2. Mr. Tissanu SAWANGSRI 3. Mr. Monchai KAMSALEE 4. Mr. Supol DANKASAI 5. Mr. Narong THAMASAT 6. Mr. Manus MATRA 7. Mr. Chattasak KAEWTHANAWIT 8. Mr. Jen INNUMPHAN 9. Mr. Somsak KATEMANEE
Radiation and Nuclear Protection Program: 1. Mr. Paphot PRUANTONSAI 2. Mr. Kusol SRICHOM	
Rare Earth Research and Development Center: 1. Mr. Chaliew KLINKAMOL 2. Mr. Pruan MANEERAT	

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