

Conditioning of the 4 Curies Radium-226 Sealed Radiation Source in Thailand

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ABSTRACT

This paper describes the conditioning of the 4 curies Radium-226 (Ra-226) sealed radiation source using as a teletherapy unit for cancer treatment in Thailand. The conditioning was under the International Atomic Energy Agency (IAEA) supervision and budgetary supports, comprised of 6 operational steps: the surface dose rate and actual dimension of radium unit measurements, the appropriate lead shielding design with IAEA approval, confirmation of radioactive contamination before conditioning (smear test and radon gas leakage test), transfer of radium source unit into the designed shielding, confirmation of radioactive contamination and dose rate measurement after conditioning, and transportation of Ra-226 conditioning waste package to OAP interim waste storage.

The Ra-226 unit was taken out of OAP temporary waste storage for the surface dose rate and the actual dimension measurements behind the 12 inches thick heavy concrete shielding. The maximum measured surface dose rate was 70 R/hr. The special lead container was designed according to its surface dose rate along the source unit which the maximum permissible dose limit for surface dose rate of waste package after conditioning at 2 mSv/hr was applied. The IAEA approved container had total weight of 2.4 ton. After the confirmation of radioactive contamination, Ra-226 source unit was transferred and loaded in the designed lead shielding within 2 minutes. The results of smear test before and after conditioning including radon gas leakage test revealed that there was no radioactive contamination. After conditioning, the surface dose rate measured on the top, bottom were 15, 10 mR/hr and varied from 6 – 50 mR/hr around lead container. The Ra-226 conditioning waste package was safely transported to store in OAP interim waste storage. Total working time including the time consumed for radon gas leakage test was 3.5 hours. The total radiation dose received by 16 operators, were ranged from 1 – 69.84 μ Sv and the operational team completed the conditioning safely within the effective dose limit for occupational exposure of 50 mSv/year (200 μ Sv/day).

KEYWORDS

Conditioning, Ra-226, Radium Bomb, Radium Conditioning, Radium Teletherapy Unit

INTRODUCTION

Radium-226, an alpha emitter with a half life of 1600 years was the primary sealed radiation source used in Thailand for more than 50 years in medical applications as brachytherapy, applicators for external betatherapy and teletherapy. The 4 curies Ra-226 source was used as a radium teletherapy unit for cancer treatment at Pramongkutklao Hospital, Bangkok since 1953. At that time it was so called Radium Bomb

[1,2]. The hospital stopped its operation because the source was not in its proper position and the sealed Co-60 source became more acceptable to be used instead of Ra-226, including the Co-60 source was safer and easier to handle than those containing radium. The whole radium unit was sent to OAP as radioactive waste on 10 August 1986. The unfavorable radiological characteristics of Ra-226 required special conditioning techniques which resulted in a safe containment from both radiological and physical security points of view. The strategy for safe management of disused radium source was the optimization of conditioning technique which the possibility to retrieve and recondition radium source should be maintained. OAP by Radioactive Waste Management Program (RWMP) conditioned the Ra-226 source after the IAEA approval of proposed procedures and shield design. This radium conditioning was under IAEA - Work plan for Managing Radioactive Waste in Thailand : INT/4/131.

MATERIALS AND METHODS

The 4 curies Ra-226 source was taken out of OAP temporary storage on 13 December 2003 for measuring the actual dimension of Ra-226 source unit in Fig. 1, and the surface dose rate measurement behind 12 inches thick heavy concrete shielding while the working time in hot area was previously calculated using the effective dose limit for occupational exposure of 50 mSv/year (200 μ Sv/day) [3]. The dose received by operators was controlled. The maximum measured surface dose rate of the source unit was 70 R/hr with the total weight of 110 kilograms.

Special lead container was designed according to its surface dose rate along the source unit which the maximum permissible dose limit for surface dose rate of waste package after conditioning at 2 mSv/hr was applied [4]. The designed lead shielding under the IAEA approval was shown in Fig. 2.



Fig. 1. Ra-226 (4 Ci) teletherapy unit

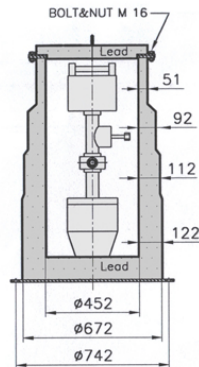


Fig. 2. The designed lead shielding

The operation of conditioning process started on 2 April 2005 by setting of designed lead shielding for radium source loading : turned the bolster on by lifting equipment (workload > 10 tons) which assembled with lifting anchorages and lifted the shielding by 2.5 tons forklift. Assembled the bolt & washer (M16*1.5*40/4 sets) to the located nuts of bolster using wrench No. 24 and disassembled the lifting equipment. Transported the shielding by 2.5 tons forklift to OAP temporary waste storage. Disassembled the lid-bolts using wrench No.19, opened the lid by assembling of lifting equipment with cap handles, lifted by forklift and placed it near shielding (undisassembled the lifting equipment from cap handles for fast assembling of the lid).

Radon gas leakage was verified by setting the measuring equipment closed to the temporary waste storage. The equipment used was the RAD7 radon detector. The grab sampling mode was used. First, the background values were measured. Then the radon leakage measurement at the vessel was performed. The air was pumped into the RAD7 for 5 minutes flushing the measurement chamber and then stopped. The RAD7 waited for five minutes and counted for four 5-minute cycles. At the end RAD7 printed out the summary including the average radon concentration. The radon gas leakage measurements were performed before and after Ra-226 source loading.

Before taking out the source unit, Ra-226 contamination on the source handle and surfaces around storage area were verified by indirect measurement (smear test). The direct measurement was performed using the portable tele-GM counter FH40G by previously checked the local background, then put the detector probe as close as possible to the source handle but avoided direct contact to prevent contamination on the probe and recorded of the surface dose rate in mR/hr. Estimated the working time for smear test within the safety limit. Measured the local background of the area without radiation fields and used the damped (with ethanol) smear paper to smear on the required surfaces. Placed the smear paper in plastic bag and measured contamination level in Bq/cm² at the area without radiation fields using the surface contamination monitor LB122. The RWMP maximum allowable surface contamination limit at 4.0 Bq/cm² was applied [5].

After no radioactive contamination was found, the source was taken out of the temporary waste storage. Assembled the cantilever beam (2.2 m, workload 500 kg.) to the 1.5 ton forklift and attached the lifting equipment (workload 500 kg.) at the end of the cantilever beam. Removed the lead bricks from temporary shielding using 2 levers (1.0 m & 1.5 m). The 5 operators alternately attached the lifting equipment to the source handle with time control. The source unit was lifted from waste storage by 1.5 ton forklift while the operational team used the hook with 3 m length wood handle to assist. Working time was controlled and Ra-226 source unit was then loaded into the designed shielding as shown in Fig. 3 within 2 minutes. Disassembled the lifting equipment from source handle and closed the lid by lifting equipment. Fixed the bolt sets on the lid and diagonal tightened them with the wrench No.19 (for uniform - distribution tightening force).

After loading Ra-226 source unit into the designed shielding, radon gas leakage test and radioactive contamination by indirect measurement on both sides (A and B) including at the top and bottom of shielding were performed. The dose rate on surface and at 1 m distance was also recorded. The results from smear test and radon gas leakage revealed of no radioactive contamination. The Ra-226 conditioning waste package was then safely transported by 2.5 ton forklift to store in OAP interim waste storage. The 4 curies Ra-226 operational team was shown in Fig. 4.



Fig. 3. Ra-226 loading in lead shield



Fig. 4. Ra-226 (4 Ci) operational team

RESULTS AND CONCLUSIONS

After the designed shielding and the operational steps had been approved by IAEA, the lead shielding was then manufactured at the total weight of 2.4 tons and transported to RWMP – OAP. Before taking out the source from temporary waste storage, the radioactive contamination on the source handle and surfaces of storage area by smear test resulted of no contamination at 0 Bq/cm^2 . The radon gas as background level determined in the morning at 2 different positions on the designed shielding were 32.5 and 40.5 Bq/m^3 at monitoring time different of 0.5 hr , while the average outdoor radon concentration measured in Bangkok was 40 Bq/m^3 [6]. The surface dose rate on the source handle was $80 - 100 \text{ mR/hr}$, therefore each operator needed to work with the source handle within 1.5 minutes.

After loading of Ra-226 source unit into the designed shielding, the dose rate on surface and 1 meter were measured. Radon gas leakage and smear test were re-checked. The radon gas level measured in the afternoon at gas monitoring point of shielding was slightly above background, while the contamination level found was 0 Bq/cm^2 . The results revealed of no radioactive contamination. The measured dose rate on container side A and side B were shown in Table I. The Ra-226 conditioning waste package was safely transported to store in OAP interim waste storage. The total dose received within total working time 3.5 hours by 16 operators, ranged from $1 - 69.84 \text{ } \mu\text{Sv}$ as shown in Table II, where the forklift driver obtained the highest dose. The Ra-226 conditioning team completed the operation safely within the effective dose limit for occupational exposure of 50 mSv/year ($200 \text{ } \mu\text{Sv/day}$).

Table I. The Measured Surface Dose Rate on Ra-226 Waste Package after Conditioning

Position on Shielding	Dose Rate on Side A (mR/hr)		Dose Rate on Side B (mR/hr)	
	Surface	1 meter	Surface	1 meter
Top	6	1.0	15	1.8
1	6	1.2	8	1.4
2	10	1.5	10	1.5
3	30	2.8	30	3.0
4	30	3.0	50	4.5
Bottom	6	1.0	10	1.6

Table II. Total Dose Received by 16 Operators

Total Dose Received (μ Sv)	Number of Operator
1 – 5	6
5 – 10	3
10 - 20	2
20 - 30	-
30 - 40	3
40 - 50	-
50 - 60	1
60 - 70	1

CONDITIONING TEAM

The conditioning team comprised of 16 operators from different sectors in OAP and a personnel from shielding manufacture company as listed in Table III. Each operator clearly understood his assignments and could successfully and safely complete his responsibilities both in physical and radiological aspects.

Table III. The 4 Curies Ra-226 Conditioning Team

Radioactive Waste Management Program: <ol style="list-style-type: none"> 1. Mr. Sutat THIANGTRONGJIT 2. Mrs. Monta PUNNACHAIYA 3. Mrs. Nanthavan YA-ANANT 4. Mrs. Archara PHATTANASUB 5. Mr. Panya NUANJAN 6. Mr. Leua SUKSAWAD 7. Mr. Kate AMPORNPOG 	Research Reactor and Nuclear Technology Operation Program: <ol style="list-style-type: none"> 1. Mr. Tissanu SAWANGSRI 2. Mr. Monchai KAMSALEE 3. Mr. Supol DANKASAI 4. Mr. Sanee TAWEESUK Radiation and Nuclear Safety Program: Mr. Paphot PRUANTONSAI
Rare Earth Research and Development Center: Mr. Chaliew KLINKAMOL	Office of Secretary: Mr. Prapas PADSEE
Bureau of Technical Support for Safety Regulation: <ol style="list-style-type: none"> 1. Mr. Paitoon WANABONGSE 2. Mr. Sakon RATTANABUSSAYAPORN 	Shielding Manufacture Company: Mr. Pew TAWEESUK

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