3.8 Radioactive Waste Management (RWM) Status in Thailand

Thailand set up the "Office of Atomic Energy for Peace" (OAEP) in 1961, following the enactment of the Atomic Energy for Peace Act (B.E.2504). Later, the first Thai research reactor went to criticality on 27 October 1962. Thus the first step was taken in research and development and towards as a better standard of living.

In October 2003, "Office of Atomic Energy for Peace" (OAEP) was changed its name to "Office of Atoms for Peace" (OAP) because of the re-structurization of OAEP and also the re-structurization of Ministry of Science and Technology (MOST).

Currently, there are about 800 licensed radioactive users. These licensees are a heterogeneous mixture of individual and governmental institutions which possess the radionuclides of activity ranging from a few kilo becquerel up to some giga becquerel. The type of nuclear facilities and radionuclides utilizing facilities in Thailand is vary on the development of the nuclear techniques in the country. Apart from net benefits of nuclear utilizations, such development is inevitably accompanied by the increasing production of radioactive wastes in quantities and forms.

Up to now, the radioactive waste in Thailand is compose of low level and low-intermediate level wastes from the application of radioisotopes in medicine, industry, agriculture, universities, research institutes and other uses. The main waste from the OAP itself comes from the operation of the 2 MW TRIGA Mark III Research Reactor, radiochemistry laboratories, and the production of radioisotopes, such as I-131, Tc-99m, P-32 etc.

Since, the OAP has been responsible for radioactive waste management in Thailand. This mission was assigned to the Radioactive Waste Management Program (RWMP), where is the centralized radioactive waste management facility in the country. The radioactive wastes from all activities described above are sent to the RWMP. The responsibilities cover on collection, segregation, treatment, conditioning, storage and disposal. The waste management facility is composed of the solid waste treatment facilities; incinerator, compactor, and the liquid waste treatment facilities; accelerator for chemical precipitation plant and storage facilities.

3.8.1 RWM Policy

In 1961, the first Thai legal instrument concerning nuclear energy, the Atomic Energy for Peace Act, B.E. 2504, was enacted and became effective on April 26, 1961. Both the Atomic Energy Commission (AEC) as a policy making organ, and the Office of Atomic

Energy for Peace (OAEP) as its executive organ, have been established by virtue of this Act.

In 2003, the Ministerial Regulation on Rules and Procedures of Radioactive Waste Management, B.E.2546 was established and implemented; the main content is the guideline for waste generators to follow the rules and procedures. Since Thailand does not have any specific regulation on disposal and radioactive waste management operations. All users of radioactive materials are required to be responsible for the wastes they produced. The OAP has the responsibility to provide services in the radioactive waste management, including the authorization, controls and inspections. Other responsibilities are the calibration of radiation protection instruments, the operation of environmental surveillance program, and the information exchange.

The fundamental principle RWM policy is as follows:

- Radioactive Waste needs to be safely managed in accordance with internationally agreed principles;
- Reuse/recycle and minimization of radioactive waste should be taken to reduce the amount of waste generated;
- Radioactive Waste needs to be classified by method of treatment, conditioning and disposal;
- Appropriate Research and Development to support the operational and regulatory is needed.
- Spent Sealed Radiation Source should be returned to the supplier/ manufacture.
- Safety and Security of spent radiation source need the responsibilities of all parties, e.g. owner/licensee, regulatory body and the National Centralized Radioactive Waste Management Operating Organization.

3.8.2 RWM Practice

3.8.2.1 Regulatory Framework

Regulatory function of Thailand is conducted by the Office of Atoms for Peace, Ministry of Science Technology. And the OAP works as secretariat of the Thai Atomic Energy Commission (Thai AEC). The OAP has regulated for licenses of the production, possession, and utilization of radioactive materials including X-ray machines recently. At present, there are about 800 licenses for radiation source possession, see Table 3.8-1 and Table 3.8-2.

Regulation on Radioactive Waste Management.

In 2003, the RWM regulation and guidance was first implemented under the Atomic Energy for Peace Act B.E.2504 (1961), so called the Ministerial Regulation on Rules and Procedures of Radioactive Waste Management, B.E.2546 (2003).

In the same year, the Ministerial Regulation on Conditions and Method for License Application and Issuing B.E.2546 (2003) was also implemented. The main content of both ministerial regulations are for users of radioactive materials to follow the rules and procedures for the possession and management of radiation sources.

Until now, there is no specific regulation on licenses of radioactive waste disposal site and radioactive waste management operation facilities.

3.8.2.2 Organization and Responsibilities

Soon, the OAP will be split to 2 organizations, the new organization; "Thailand Institute of Nuclear Technology (TINT)." will be established. The organization chart of the TINT and future OAP are shown in Fig.3.8-1.and Fig.3.8-2 respectively.

The TINT will have the responsibilities on the followings:

- Promotion of Nuclear Technology and Utilization
- R&D in Nuclear Science and Technology including R&D in Radioactive Waste Management
- Operation and Services (including Waste Management Operations and Services)
- Public Awareness in Nuclear

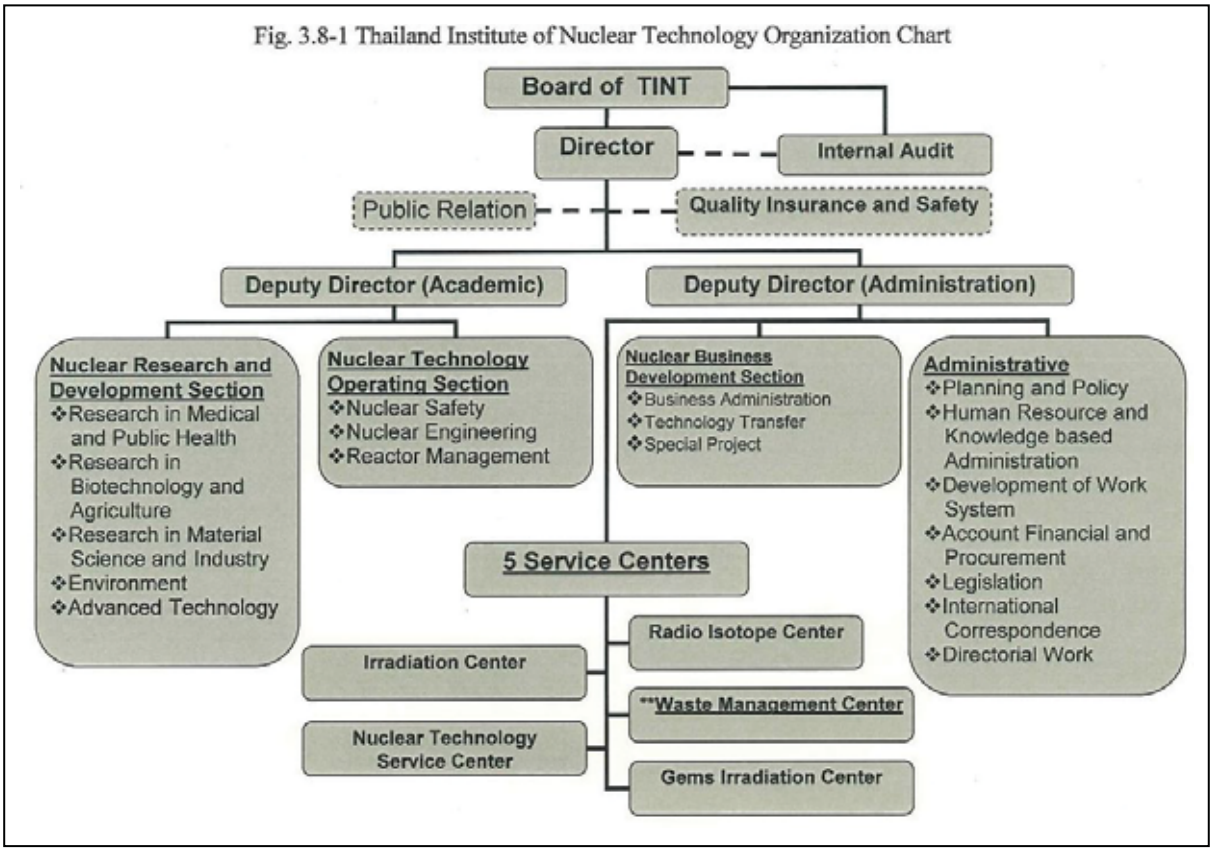

Fig. 3.8-1 Organization Chart of Thailand Institute of Nuclear Technology

The OAP will have the responsibilities on the followings:

- Policy and Strategic plan formulation on all nuclear matters
- Nuclear and Radiation Safety Control
- Licensing
- Intermediary Co-ordination Role in Nuclear

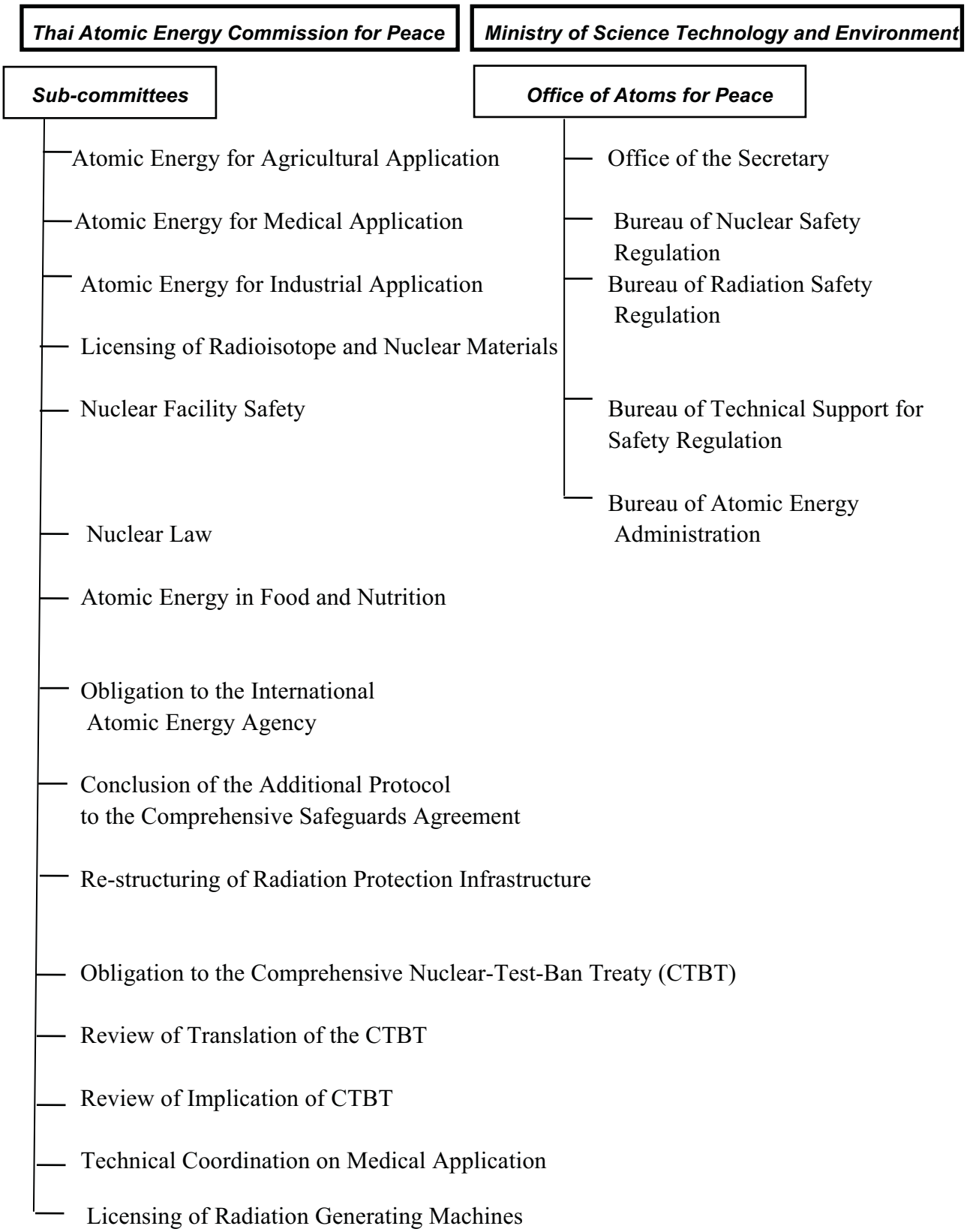

Fig. 3.8-2 Governmental Organization Regarding Atomic Energy in Thailand

Table 3.8-1 Number of Licensee in Radiation Utilizations in Thailand (As the fiscal year 2005)

Radiation-Application	*Number of Licensee*
Medicine	85
Industry	352
Research & Education	225
Others (smoke detector, lightning preventor)	134
Total	**796**

Table 3.8-2 Type of nuclear and radionuclides utilizing facilities in Thailand (As the fiscal year 2005)

Facilities	Number of Installation/ Unit
Research Reactor	1 installation
Isotopes Production	1 installation
Synchrotron	1 installation
Research Gamma Irradiator	5 installation
Industrial Gamma Irradiator	5 installation
Medical Teletherapy	44 units, 25 facilities
Medical Remote after-loader and Brachytherapy	56 units
Industrial Radiography	23 installation
Education and R&D Laboratories using radionuclides	~230 facilities
Cyclotron	1 installation
Monazite Extraction Plant	1 installation
Radioactive Waste Processing and Storage	1 installation

3.8.3 Criteria used to define and categorize radioactive waste

In general, the radioactive waste produced in Thailand can be categorized as **low level wastes** and **spent sealed radiation sources**. The activities of low level wastes are in the range of 3.7-37 Bq/L for liquid and about background level to 20 micro-sievert per hour for solid waste. The activities of the spent sealed radiation sources can be considered as a high activity waste ranging from few kilo-becquerel up to some ten gega-becquerel per piece.

Regarding to the Ministerial Regulation (B.E.2546), the criteria and classification of radioactive waste as follows:

Class	Description
(1) Very low level waste	Radioactive waste containing activity concentrations and/ or total activities less than clearance level.
(2) Low level / short lived waste	Radioactive waste containing short lived radionuclides with half lives less than 100 days that will decay to clearance levels within three years.
(3) Low and Intermediate level / short lived waste	Radioactive waste containing beta/gamma emitting radionuclides with half-life 100 days to less than 30 years which will not decay to clearance level within 3 years and/or alpha emitting radionuclides with an activity less than 400 Bq/g and a total activity less than 4000 Bq in each waste package.
(4) Low and intermediate level/ long lived waste	Radioactive waste containing radionuclides with concentrations above those for (3) and which does not generate heat at above 2 kW/m^3 of waste.
(5) High level waste	Radioactive waste containing radionuclides with concentrations above those for (4) which generates heat at above 2 kW/m^3 of waste.

Characteristic of Radioactive Waste in Thailand

Since the main radioisotope users are those in the medical sector, thus, most of the wastes originated from the hospitals in Bangkok. The waste from this quarter can be estimated at 55 percent of the total volume of waste production annually. All the waste

emanated is accumulated at the place of the waste producer, and later on, transported by means of the specific truck to the OAP.

. The volume of treated waste has been gradually increased, the general needs for more interim storage become apparent. Therefore, a new storage at New Nuclear Research Center for the center of waste management has been set up. The near surface disposal method is also studied because of its simple, inexpensive and adequate safe and very well-known process.

The liquid wastes are predominantly aqueous solutions with low content of salts, and small amount of organic liquids. The volume of liquid waste is around 100 - 200 cubic-meter per year.

The raw solid wastes constituted refuse or debris, scrap metal contaminated with radionuclides as well as biological waste are about 45-50 cubic -meter per year.
There are also a high volume of the spent radiation sources, such as: Co-60, Kr-85, Sr-90, Cs-137 and Ra-226, has been accumulated at OAP. The distribution of type of the Institution by Waste stream is shown in Table 3.8-3, and the Principal Type of Radioactive Waste Generated in Thailand is shown in Table 3.8-4.

Table 3.8-3 Distribution of Type of the Institution by Waste stream

Waste stream	Percentage	Major Radionuclide	Chemical Composition
Medical	55	Ga-67,Cr-51,Tc-99m, Co-60, I-125, I-131, Tl-201, H-3,C-14, P-32, S-35,Ra-226, Sr-90	HCl,Po_4^{-3},NO_3^-, NaCl, NaOH, serum blood, scintillant, urine (and Sealed sources)
Education & Research	15	P-32,S-35,Cr-51,Ca-45, Tc-99m,I-131,Co-60,Sr-90 Cs-137,Am-241, Be-10	Po_4^{-3},Ca^{+2},Cl^-, No_3^{-2},HNO_3,H_2SO_4, $HClO_4$ (And Sealed sources)
Industrial	30	Fe-55,Kr-85,Sr-90, Cd-109,Cs-137,Co-60, Ir-192,Am-241,H-3	Most of them are Sealed sources

Table 3.8-4 Principal Type of Radioactive Waste Generated in Thailand

Waste Forms	Waste Compositions
Liquid: Aqueous	- Laboratories, hot cells (Isotope production), Fuel storage pool(research reactor), Decontamination campaign, Sump, Rinsing water, Mining and milling laboratory and pilot plant scale
Organic	- Extraction experiments with uranium and thorium mineral Lubricant oil, etc. Scintillation liquids, Extraction solvent (TBP/kerosene, etc.)
Solids: compactable/combustible	Tissues, swabs, paper, cardboard, rubber, plastic (Poly-vinylchloride; PVC, Polyethylene;PE), gloves, filters, protective cloths, glassware, carcasses
non-compactable/ non-combustible	Ion exchange resins(from research reactor), Metallic and scrap metal contaminated with radionuclides, Brick
Spent Sealed Sources	Teletherapy Units from hospitals; Co-60,Ra-226 (external-applicator), Eye Application: Sr-90 Brachytherapy ; Ra-226, Cs-137, Co-60, Sr-90, etc. Gauging; Co-60, Cs-137, Ra/Be, Sr-90, Kr-85 and etc. Smoking Detector; Lightning Preventer,Am-241 and Ra-226

3.8.4 RWM Facilities

At present, there are waste processing facilities and waste storage facilities in the OAP, located at Vibhavadi -Rangsit Road, Chatuchak, Bangkok.

Radioactive Wastes Processing and Storage Facilities

The chemical co-precipitation process has been employed for liquid aqueous wastes. The liquid waste treatment facilities are shown in Fig. 3.8-3 and Fig. 3.8-4

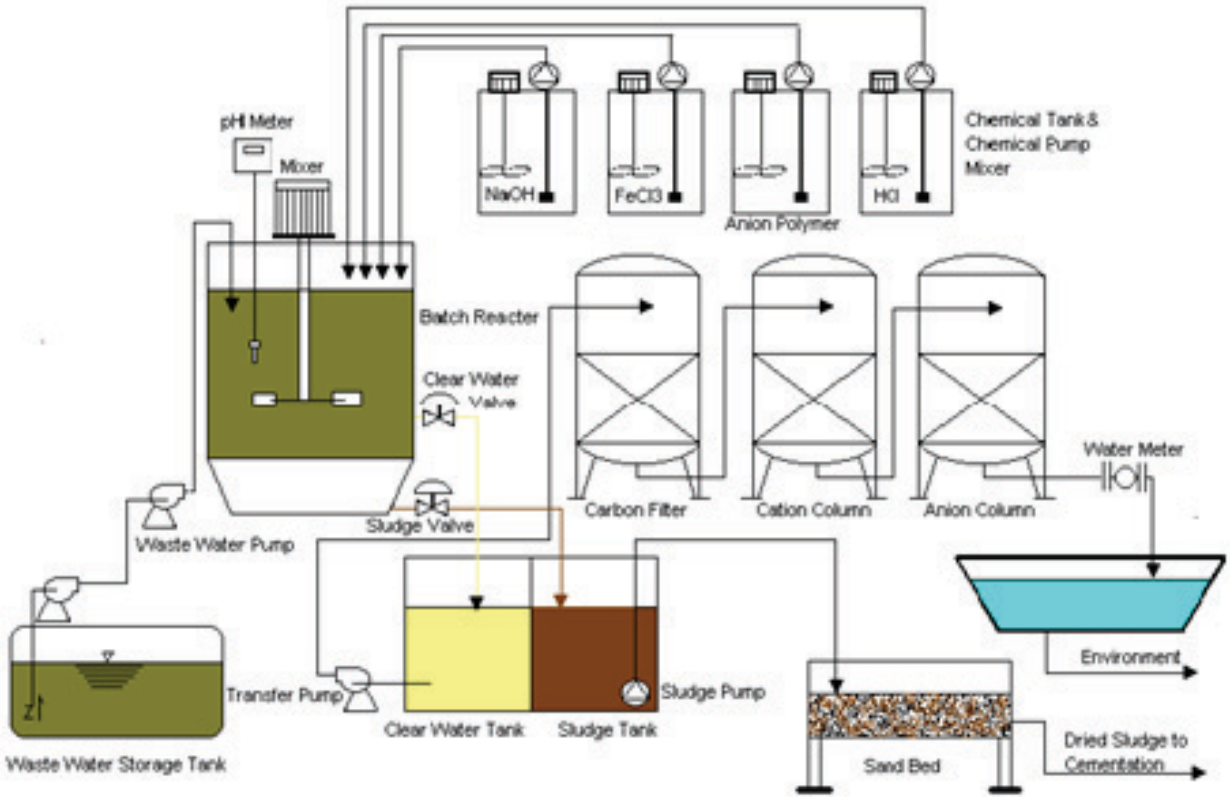

Fig. 3.8-3 Radioactive Liquid Waste Treatment Process

Fig. 3.8-4 Liquid Waste Treatment Facilities

For the solid waste, after segregation, the burnable waste was incinerated in a small incinerator, and non-burnable waste was packed in a compactor for volume reduction. At present, the ashes and compaction products and other raw wastes have been totally kept in around 500 drums (200 liter). The solid waste treatment facilities, is shown in Fig. 3.8-5.

Compactor

Incinerator

Fig. 3.8-5 Radioactive Solid Waste Treatment Facilities

The treated wastes such as the sludge residues, ashes, compaction products and the spent ion –exchange resin, are transferred to the conditioning process, using cement as an immobilization means. The treated waste, are stored in the storage facilities, as shown in Fig. 3.8-6.

Fig. 3.8-6 Waste Storage Facility for RI waste at OAP

More details of Radioactive Waste Management Facilities in Thailand, is shown in Table 3.8-5.

Table 3.8-5 Radioactive Waste Management Facilities in Thailand

Facilities	Items	Capacity	Type of Waste
Solid Waste Treatment	- Incinerator equipped with off gas cleaning system	15 kg/hr	Burnable waste
	- Compactor	40 ton	Compactable waste
Liquid Waste Treatment	- Accelerator for chemical precipitation plant	5 m^3	Aqueous waste low salt content
	- Stainless steel container	5 m^3 x 2	Organic liquid waste
Interim Storage	- Storage facility no.1	65 m^2 x 4.5 m	Disused sealed sources
	- Storage facility no.2	80 m^2 x 4.5 m	LLW (RI waste)
	- Storage facility no.3 (will be operated soon)	300 m^2 x 5 m	LLW (RI waste)

Disused Source Management

Some spent sealed radiation sources have been conditioned. And some are allowed to decay in a shielding after collection. They can be divided into 2 levels of activities, for the high activity is kept in the designed lead-shielding and low activity is in their own shielding. Both are stored at the OAP temporary storage facilities. Some spent sealed sources are reused in other industrial and educational. In addition, the high activity of disused sealed radiation sources i.e. the 400 Ci Co-60 from the radiological accident in year 2000 was conditioned and kept in the new lead container. Recently the 4 Ci Ra-226 (external source, tele-theraphy unit) was conditioned in a lead container in 2005. The other spent Ra-226 sources from hospitals and industries were completed conditioned in 16 drums (200 L) and kept in the storage facilities in the OAP.

There is a policy that the sealed radiation source users must sign contract with the supplier to return the spent sealed source to the supplier/producer if the activity of source after 10 years is equal or more than 100 MBq or after the expired date of using or not later than 15 years after the date of purchase. In case of non-returnable or orphan sources, the OAP has to accept those disused sealed-sources for further management.

3.8.5 Inventory of Radioactive Wastes

3.8.5.1 RW in Interim Storage

Radioisotope wastes (RI waste) in Thailand are mainly generated from radioisotope applications in the field of medical diagnosis and therapy, education and research. The spent sealed radiation sources are mainly generated from industries.

The arising wastes can be classified into low level-short lived waste and spent sealed radiation sources. Inventory to Radioactive Waste and waste accumulation in Thailand is shown in Table 3.8-6, and the inventory of disused sources is shown in Table 3.8-7.

Table 3.8-6 Cumulative Quantity of Radioactive Waste stored at OAP

Categories	Radionuclides	Volume(m^3/y)	Total accumulation
Low Level Waste Solid Waste	^{125}I , ^{131}I, ^{99}Tc ^{3}H, ^{14}C, ^{35}S, ^{32}P	45-50	500 (200 L drum) (treated and raw wastes)
Liquid waste Organic waste	^{137}Cs, ^{125}I , ^{131}I, ^{99}Tc	100-200 less than 0.2	none 5 m^3
Ion Exchange Resin (from Research Reactor and Waste Treatment Plant)	^{3}H, ^{14}C and Activation Products Corrosion Products Fission Products	0.3	2 m^3
Spent SRS from Medicine, Research Education and Industry (Including orphan sources)	^{60}Co, ^{85}Kr, ^{90}Sr ^{109}Cd, ^{137}Cs ^{210}Po, ^{226}Ra ^{241}Am ,^{241}Am /Be	~ 6Ci	16 Drums (200 L) (Conditioned ^{226}Ra) 2 Lead-containers (Conditioned 400 Ci ^{60}Co and 4 Ci ^{226}Ra) and 1452 pieces (unconditioned sources)

Table 3.8-7 Inventory of Spent Sealed Source Collected at RWMP (as Jun 2006)

Isotope	Half Life	Pieces	Total Activity (GBq)	Note
Am-241	432.7 y	364	222.5602	Not yet conditioned
Am-241,Be	432.7 y	23	399.0472	Not yet conditioned
Au-195	186.1 d	1	0.037	Not yet conditioned
Ba-133	10.66 y	2	0.0097	Not yet conditioned
Cd-109	462.0 d	30	4.9855	Not yet conditioned
Cf-225	2.645 y	1	2.012	Not yet conditioned
Cm-244	18.1 y	1	0.37	Not yet conditioned
Co-57	271.8 d	23	15.976	Not yet conditioned
Co-60	5.271 y	229	402,134.10	Not yet conditioned
Co-60*	**5.271 y**	**1***	**400 Ci***	**Conditioned* (2002)**
Cs-137	30.17 y	351	5,436.55	Not yet conditioned
Cs-137,Ba	30.17 y	10	0.0033	Not yet conditioned
Depleted Uranium	4.47 x 10^9 y	61	784.50 kg	Reused
Fe-55	2.73 y	25	27.864	Not yet conditioned
Gd-153	241.6 d	3	33.3333	Not yet conditioned
Hg-203	46.76 d	2	0.008	Delay and decay
Ir-192	73.83 d	10	37.0001	Delay and decay
Kr-85	10.73 y	60	851.4621	Not yet conditioned
Mn-54	312.20 d	2	<0.0001	Not yet conditioned
Na-22	2.6 y	2	<0.0001	Not yet conditioned
Neutron Source	432.7 y	1		Not yet conditioned
Ni-63	92 y	33	13.3874	Not yet conditioned
Pm-147	2.6234 y	30	340.313	Not yet conditioned
Po-210	138.38 d	34	4.4995	Not yet conditioned
Tl-204	3.77 y	28	0.1446	Not yet conditioned
Ra-226*	**1.60 x 10^3 y**	**948**	**4823.6 mg***	**Conditioned Total 10 drums (2000)**
Ra-226*	**1.60 x 10^3 y**	**477**	**1923.75 mg***	**Conditioned Total 6 drums (2004)**
Ra-226*	**1.60 x 10^3 y**	**1***	**4 Ci**	**Conditioned* (2005)**
Ra-226	1.60 x 10^3 y	10	0.1312	Not yet conditioned
Ra-226,Be	1.60 x 10^3 y	5	0.8145	Not yet conditioned
Sr-90	29.1 y	101	133.348	Not yet conditioned
Std. Calibration. Source	Total 10 Isotope	10	0.6152	Not yet conditioned
	Total	**1452**	**~409,000**	**Not yet conditioned**

3.8.5.1 RW in Disposal

Currently, there is no disposal facility/ repository in Thailand. Considerations may make for the future waste management programs.

3.8.6 Nuclear Facilities in the Process of being Decommissioned and the Status of Decommissioning Activities at those Facilities

Due to the delay of the construction of the new nuclear research reactor in Ongkharak District in Nakorn Nayok Province, the Decommissioning Project of the existing Thai research reactor has been also delayed. The Decommissioning Plan of the Thai research reactor may be revised again in the near future.