9. Report on Recent Status of TENORM in Thailand

9.1 Introduction

NORM is the acronym for "Naturally Occurring Radioactive Materials "as defined by IAEA safety division[1)]means " material containing no significant of radionuclides other than naturally occurring radionuclides". IAEA definition on NORM also included the materials of which the activity concentration of the naturally occurring radionuclides have been changed by man-made processes which sometimes called technologically enhanced NORM or TENORM. The term NORM then sometimes is used in contrast with TENORM i.e. to refer only materials in which the activity concentrations have not been technologically enhanced.

Naturally occurring radionuclides means radionuclides that occur naturally significant on earth. These include the primordial radionuclides i.e. ^{235}U, ^{238}U, ^{232}Th, and ^{40}K. ^{3}H and ^{14}C are also naturally occurring radionuclides because they can be produced by natural activation process by cosmic ray.

Historically in most countries, the rules and regulations governing the handling and storage of radioactive materials were intended to apply to the products of nuclear reactors. In these devices, extremely high levels of radioactivity are found as the by-product of nuclear fission. National governments have been hesitated to get involved in the regulation of those materials, which contain radioactivity encountered within the natural environment. On the other hand, the exposure of human beings to ionizing radiation from all sources is of great concern to those authorities dealing with public health and workers.

As quoted in the 11th International Congress of the International Radiation Protection Association in Madrid, Spain during May 23-28, 2004 [2)]; pressed by a WHO Expert committee by the end of the years fifties concerned about genetic effects that might be produced in humans due to the use of ionizing radiation in medicine, science and technology. It was expected that the study of human populations exposed to relatively large amount of background radiation i.e. of the order of 10 mSv/y would bring untapped information on radiation induced mutation and their fate. The obvious population to be studied were those living in high altitude areas, for example; Cerro Pasco, Peru (4.3 km,10^{o}S lat.); Lhasa, Tibet (3.7 km,10^{o}N lat.); La Paz, Bolivia(3.6 km,16^{o}S Lat.); Quito, Ecuador(2.9 km,0^{o}Lat.); and Bogota, Columbia (2.6 km, 4^{o}N lat.)

TENORM is now receiving more attention because of its potential to cause elevated exposure to radiation. Thailand by Radioactive Waste Management Program (WMP) of the Office of Atoms for Peace (OAP) concerns NORM and TENORM in order to increase the awareness of the public in Thailand to TENORM materials and to provide guidance or regulations to help the industries that generate this materials to manage and dispose of their TENORM waste in economically and efficient ways to protect people and environment.

This report summarizes Thailand inventory of the TENORM, current regulations and the country specific problems to be solved.

9.2 TENORM Inventory in Thailand

The locations and extents of the TENORM in Thailand have never been studied. This should be one of national problems on controlling of TENORM. Since TENORM are produced by many industries in various amounts in a wide variety of products, Table 1 shows list of industries in Thailand that probable to generate the TENORM, its capacity and estimated waste. Waste produced was estimated based on information from various reports and data.

9.3 Regulation on TENORM

Thailand has no regulation directly control of NORM and TENORM. Thai Ministerial Regulation No.5 B.E. 2516 (A.D. 1973) laid down basic safety standards for the protection of workers and general public against the dangers arising from ionizing radiation which intended to apply to the products of nuclear reactors or artificial sources. However, the regulation was also applied to natural occurring radioactive sources if the natural occurring radionuclide materials would be processed in view of their radioactive properties. As such, according to article 2 of the ministerial regulation; any materials that contained uranium oxide (U_3O_8) or thorium oxide (ThO_2)/ or uranium oxide and thorium oxide at concentrated level more than 15% of the original ore element will be accounted as radioactive source materials. Therefore, to deal with these materials, a practical guidance based on BSS No.115 [3)] must be applied.

In 2003, the Ministry of Science and Technology has issued two ministerial regulations concerning radiation safety: Thai Ministerial Regulation on Conditions and Methods for License Application and Issuing B.E.2546 [9)] (A.D.2003) and Thai Ministerial Regulation on Rules and Procedures of Radioactive Waste Management B.E.2546 [10)] (A.D. 2003). These two regulations also were originally intended to apply to the products of nuclear reactors or artificial radioactive sources. The basis/concept of criteria/standard of the ministerial regulations are as follows:

1) Recommended Dose Limit

The basis concept of the ministerial regulation [9)] is the total integrated radiation dose to individuals from all sources must be minimized. The latest recommended dose limits given in the ministerial regulation is summarized as follows:

Table 1 Industries Lead to Enhanced Occupational and Public Exposure to TENORM. [4,5]

Industrial Sector	Capacity	Estimated Waste Volume	Activity Concentrations (Bq/g)	Basis for Estimation of Waste Volume
Oil and gas exploration and production	61,994 bbl/d for crude petroleum; 47,188 bbl/d for condensate; and 681,750 bbl/d for refinery of crude petroleum	3.4×10^{3} t/y	13.3 and 2.07 ^{226}Rn for scales and sludge, respectively.	Extrapolated from USA data [6]
Tantalum & Niobium extraction	250,000 t/y	9,612 t/y	Not known	Report of H.C. Starck (Thailand) Co.,Ltd.[7]
Tin production	3,000 t/y for production; 30,000 t/y for smelter	Not known	1.59-^{238}U and 0.7-^{232}Th [6]	
Rare earth	300 t/y	16 t/y	Not known	Report of Rare Earth Research& Development Center (OAP) [8]
Cement production	55×10^{6} t/y	Not known	Not known	
Steel refinery	6×10^{6} t/y	Not known	Not known	
Water treatment	Not known	Not known	Not known	

Table 1 (cont): Industries Lead to Enhanced Occupational and Public Exposure to TENORM.[4,5]

Industrial Sector	Capacity	Estimated Waste Volume	Activity Concentrations (Bq/g)	Basis for Estimation of Waste Volume
Coal	19.9×10^6 t/y for production; 15.7×10^6 t/y for coal fire power plant	1.49×10^6 t/y	0.14-^{226}Ra	From USA data [6] : electricity boilers generate ash about 10% of the original coal of which 95% is retained; Electricity Generating Authority of Thailand consumed 15.7×10^6 t/y
Chemical fertilizer	10,000 t/y phosphate rock; 3.65×10^6 t/y production	Not known	0.41-1.3 ^{226}Ra in phosphogypsum ; 0.74-1.85 U & Th, 0.15-1.5 ^{226}Ra in phosphate slag	USA data [6]
Residues from past activities	Not known	Not known	Not known	

Table 2 Recommended Dose Limits Given in the Ministerial Regulation [9)]

	Occupational	Public
Effective dose	20 mSv/y ,averaged over defined periods of 5 years	1 mSv/y

2) Disposal and Transport

As specified in the regulation [9)]; material contained NORM above the following level is designed as NORM-contaminated and must be restricted on disposal and transport.

Table 3 Limits for Safe Transport of Radioactive Material

Nuclides	Diffuse NORM (Bq/g)	Discrete NORM (Bq.item/s)
^{226}Ra and progeny	10	10,000
^{222}Rn and progeny	10	10,000,000
^{210}Pb and progeny	10	10,000
^{228}Ra and progeny	10	100,000
Natural uranium	1	1,000
Natural thorium	1	1,000

Note: - Diffuse NORM means NORM contaminated material which is low in radioactive concentration, uniformly dispersed and relatively large in volume.
- Discrete NORM means NORM contaminated material which has much higher levels of radioactive concentration than the surrounding environment which can be non-uniformly distributed as in the case of scrap pipe, for example.

3) Disposal

Disposed of NORM contaminated material either by land spread or discharge to bodies of water must follow the regulation of management of radioactive waste [10)]

Table 4 The Exempt Limit for Disposal of Radioactive Waste

Nuclides	Aqueous(Bq/L)	Solid (Bq/kg)	Air (Bq/m^3)
^{226}Ra	2	10,000	0.04
^{232}Th	4	1,000	0.003

Note: - Activity discharged not more than 1,000,000 Bq/y
- Amount discharged not more than 3,000 kg/y
- Activity discharged not more than 100,000 and 10,000 Bq/y for ^{226}Ra and ^{232}Th, respectively.

9.4 Case Study Related to TENORM

During August 23-27, 2004, a task group from Japan visited Thailand. The group included Prof. Toshiso Kosako (Japan Project Leader, Tokyo University), the group leader, and Japanese experts. Discussion/Survey meeting was held with a number of technical experts and relevant personnel in Thailand including representatives from the Office of Atoms for Peace (OAP), Chulalongkorn University, National Fertilizer Public Company (NFPC) , H.C. Starck (Thailand) Co.Ltd., Petroleum Authority of Thailand(PTT), PTT Exploration and Production Public Co.,Ltd., Unocal Thailand Ltd. and the Mineral Resources Department followed up with a visit to the mineral dressing plant at G.M.T. Co.,Ltd, Phangna province, the titanium separation plant ,H.C. Starck (Thailand) Co.,Ltd. and the phosphate fertilizer production plant, the National fertilizer public company at Map Ta Phut Industrial Park in Rayong province.

1) Technical Visit to the H.C. Starck (Thailand) Co., Ltd.

On August 26, 2004 the task group with Thai participants visited to the H.C. Starck (Thailand) Co. Ltd. The company is the one of the biggest producer in Thailand of high purity tantalum metal powder as well as tantalum and niobium compound. The site visit provided an insight into operational control issues relating to NORM. The standard guideline of the “Responsible Care Program” belongs to the German association of the Chemical Industry has been practicing in the company The company has also received the certificates of OHSAS 18001-1999 (Occupational Health and Safety Management System), ISO 14001:1996 (Environmental Management System) and the Occupational Heath and Safety Management System Certification; RWTUV (Thailand) Ltd. Solid waste produced in 2002 and 2003 was around 7908 and 9617 tons, respectively. From 1992 to 2003, waste was disposed at HCST landfill. After 2003 waste was disposed outside at authorized landfill. The radiation protection program consists of monitoring of raw materials storage and radon grab sampling station. Labeling, Survey and TLD measurements are required.

2) Technical Visit to the National Fertilizer (Public) Company

In the afternoon of August 26, 2004 the group visited the National Fertilizer Public Company which also situates in the industrial park. The group was informed of the management problem of large amount of the by-product phosphor-gypsum or “stacks”. The stacks have been compiled since the operation of the company eight years ago. Any decision on managing of these “stacks” could not be made due to the unclear policy on NORM and TENORM of Thai government authority. The company has no inventory of the stacks. The radioactivity of raw materials and the stacks is shown in Table 5.

Table 5 Radioactivity in Phosphate Rocks, Phosphor-gypsum and Natural Gypsum at NFPC [11)]

Type of samples	Sources	Radioactivity concentration (Bq/g)			
		^{232}Th	^{238}U	^{226}Ra	^{40}K
Phosphate rock	South Africa	10	1360	685	50
Phosphate rock	Jordan	7	875	580	<15
Phosphate rock	Woof Thai Co.-Thailand	110	<180	65	1035
Phosphorgypsum	NFPC-Thailand	8	<140	310	<10
Natural Gypsum	Thailand	<1.7	<88	4	<5

9.5 Specific Problems to be Addressed

The major problems for controlling TENORM in Thailand are the followings:

1) Understanding of the Sources of TENORM

In the country, there is still no fully understanding of TENORM and all its potential risks to humans and the environment. The study of TENORM-producing industry in the country should be done to learn which aspects of the problem, what is in the waste form and how much risk they pose. There should be an individual report of each industry since some problems are unique to a given industry but some are common across all industries. Each report may contains the main information i.e. generation of TENORM by industry; content of the TENORM; ways that people could exposed to the TENORM from the industry; and how the industry handles or disposes of TENORM waste.

2) Existing TENORM Sites

As mentioned before, the location and extent of existing TENORM sites have never been characterized. This caused a nation-ambiguous idea of the problem- where the wastes are; what is in them; and the risks they present. The study of existing TENORM sites in the country will provide information needed to select methods for estimating risks and the most economical ways to dispose of the TENORM.

3) Lack of Guidance

Guidance for safely and economically controlling exposure to TENORM waste should be provided. Guidance should contain a listing of various types of minerals and sites, which might have associated TENORM radioactivity. It should also provide the advice for health and safety protection, as well as advice on how to conduct radiation site surveys, field sampling, clean up and monitoring.

4) Information Distribution and Cooperation

Since in the country there is still lack of understanding about TENORM, information should be developed and distributed through educational institutes, state agencies, environmental groups, and industrial sectors that are confronting the problem of TENORM. Cooperation or network among group associated with this problem should be set up. These activities will help the public more understandable and to deal with this problem more efficiently.

5) Lack of Suitable and Correct Method on Sampling and Measurement of TENORM

Now Thailand has some knowledge to analyzed TENORM i.e. ^{222}Rn, ^{226}Ra, ^{228}Ra, ^{232}Th and ^{238}U and ^{235}U but only in the laboratory. The experiences on sampling and field measurement are still lacked. All capability in these fields should be dbnveloped in the country especially at OAP, which have sufficient input such as nuclear scientists and nuclear instruments.

9.6 Conclusions

In conclusion, controlling of exposure from NORM and TENORM is a new issue for Thailand. Before issuing any regulation or guideline to regulate and/or advice any practice to NORM and TENORM, this problem should be studied and made understandable to the public. These could be done through the following approaches: understanding of the sources of TENORM; locate and characterize the existing TENORM sites; formulate the guidance on any practice on NORM and TENORM for health and safety protection; and develop and distribute information and formulate cooperation and/or network among group of relevant problem.

Currently, Thailand does not have any regulation for controlling radiation exposure specifically from NORM and TENORM. However, this topic has now received attention from international and national organizations which work concerning the safety of radiation i.e. International Atomic Energy Agency (IAEA), the International Commission on Radiological Protection (ICRP), and the Environmental Protection Agency of USA (US. EPA). From this trend of the world, Thailand is now studying this problem for the most suitable practice on controlling of NORM and TENORM for the health and safety of its human beings and the environment.

References

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