

8. NORM/TENORM Management in China

8.1 Introduction

In China, NORM mine refers to non-uranium mines containing relatively high concentrations of natural radionuclides (e.g. rare earth mines and phosphate mines, etc.). Radioactivity will probably be concentrated and enriched in products, by-products or wastes in the process of processing, smelting and utilizing of NORM mines.

NORM/TENORM ubiquitous existing in rare earth, phosphate and non-ferrous metal industries has been paid attention for long term in China. Some regulatory requirements have been established and enacted.

8.2 TENORM Inventory

China still has not comprehensive nation-wide investigation data on TENORM inventory and only segmental data is available. Table 1 lists some of data collected.

Table 1 Data on Radioactivity Concentration in Industries Related to NORM/TENORM

Industry			Activity Concentration (Bq/kg)		
	Region	Type of samples	²³⁸ U	²³² Th	²²⁶ Ra
Rare earth	Inner Mongolia	Raw mine	19.3	2600	*
		Concentrates	*	9800	20.1
		Tailing	22.3	1012	23.4
	Sichuan	Raw mine	450	1335	279
		Concentrates	766	3962	540
Phosphate		Mine	15-3032	*	13-3012
		Fertilizer	22-1660	*	4-1097
Coal	Country	Raw coal	72.5	51.3	72.5
	Anhui	Stone coal	930	9	820
	Hubei	Stone	1560	35	1670
	Anhui	Slag	460	12	680
	Hubei	Sslag	2690	60	3130
Building material		Brick	*	65	55
		Concrete	*	30	50

Note: * data not available

8.3 Regulation on TENORM

8.3.1 Regulatory Authorities

State Environment Protection Administration (SEPA) and Provincial Environment Protection Agency take responsibility of supervising and managing radioactivity contamination resulting from NORM/TENORM.

SEPA's functions and duties on NORM/TENORM are: (1) developing policies, regulations, standards and technical guides; (2) providing guides to local environmental protection agency; and (3) handing accidents of cross-province radioactivity contamination.

Provincial Environment Protection Administration's functions and duties are: (1) supervising and surveillance NORM/TENORM activities; (2) reviewing and approving environment impact statement report; and (3) environmental radiation monitoring in provincial range.

Local environment protection agency takes part in supervising and management activities.

8.3.2 Legislative Requirements

Currently, China still has not specific regulation directly control of NORM/TENORM but NORM/TENORM management has been involved in other legislative documents.

Legislation system in nuclear safety and radiation safety composed of 5 hierarchy, i.e. law, regulation, department rule, standard and technical guideline.

a) Law

“Law on the Prevention and Control of Radioactive Contamination” went into force on 2003-10-01 is the first law on radioactive waste management. This law set up specific chapter for NORM/TENORM, i.e. Chapter V: Prevention and control of radioactive contamination during the operation of uranium, thorium mines and mines accompanying natural occurring radioactivity material (NORM).

The law states:

- units exploiting and utilizing mines with NORM shall, before applying for a mining license, draw up an environmental impact report and report to the competent environmental protection administration department of the people's government at provincial level and higher for examination and approval;
- radioactive contamination prevention and control facilities integrated with structural units at uranium, thorium and NORM mines shall be designed, constructed and put into operation at the same time as the main part of the project;
- radioactive contamination prevention and control facilities shall be checked and accepted at the same time as the main part of the project; only after checking and accepting that the standards have been met the main part of the project be put into production or operation; and

- tailing repositories shall be constructed for the storage and disposal of tailings produced during the operation of uranium, thorium and NORM mines; tailing repositories shall conform to radioactive contamination prevention and control requirements.

b) Department Rule

SEPA has promulgated several department rules involving NORM/TENORM. The important rules are listed as the followings:

- Radiation Environment Management Rule (1990); and
- Regulatory Requirements on Nuclear Application Waste (1987).

These department rules defined:

- environmental impact assessment document should be submitted to environmental protection authority for reviewing and approve before the project starts;
- the enterprises shall take effective measurements to ensure radiation safety and decrease the waste volume; and
- radioactive slag and tailings with specific activity above 2×10^4 Bq/kg should be storage in tailing heap or impoundment manner.

c) Standard and Technical Guideline

The “Regulation on Radioactive Waste Management (2000)” is the comprehensive standard on radioactive waste. The specific chapter on NORM/TENORM is set up in the standard.

The standard stipulates basic requirements on NORM/TENORM waste management, which can be summarized as the followings:

- waste generators are responsible for taking effective measurements to manage NORM/TENORM waste;
- necessary facilities for waste management shall be set up;
- discharging of gaseous and liquid effluents should not exceed the limitation approved by regulatory bodies;
- environmental impact assessment files should be submitted and approved before constructing disposal facilities of NORM/TENORM solid waste;
- for NORM/TENORM solid waste or residues already existed, remediation measurements should be taken;
- status of radioactivity in the environment should be assessed before closure and decommissioning of waste generating facilities; and
- reuse and recycle of NORM/TENORM waste shall be reviewed and approved by regulatory bodies.

Another important standard is the “ Limit of Radionuclides in Building Materials”. The standard first defines internal exposure index (I_{Ra}) and external exposure index (I_r) of building material, i.e.

$$I_{Ra}=C_{Ra}/200$$

$$I_r=C_{Ra}/370+C_{Th}/260+C_K/4200$$

Where, C_{Ra} , C_{Th} , C_K is specific activity of Ra,Th and K in building materials, respectively, unit in Bq/kg.

Then Table 2 can be adopted to judge use and limit of building material

Table 2 Limit of Radionuclide in Building Materials

Classes	I_{Ra}	I_r	Use
A	≤ 1.0	≤ 1.3	Used anywhere
B	≤ 1.3	≤ 1.9	Not used in bedroom
C		≤ 2.8	Cover of the wall of building
		> 2.8	Cover of the wall Tombstone and garden stone

8.4 Case Study Related to TENORM

8.4.1 Radiation Level in a Thoriated Tungsten Electrode Manufacturing Factory

The process of manufacturing thoriated tungsten electrode caused occupational exposures and produced radioactive waste. Therefore, the polluted items in the manufacturing process were analyzed and γ absorbed dose rate, potential alpha energy of thoron progeny and surface contamination were monitored. The results showed: (1) γ absorbed dose rate in air was usually in the range of $10\text{-}30 \times 10^{-8}$ Gy/h but the value approached to 600×10^{-8} Gy/h in few places; (2) potential alpha energy of thoron progeny was in the magnitude order of hundred nJ/m³ but the value was one magnitude order higher than other workshops; (3) α, β surface contamination level of workshops was very low, most was below 0.04 Bq/cm² for α contamination and 0.4 Bq/cm² for β contamination; (4) specific activity of ²³²Th in liquid waste was in the range of $40 \sim 82$ Bq/l; and (5) volume of solid waste was 30 Kg/a or so, the specific activity accessed to 4800 Bq/kg.

The effective measurements have been taken for protection of workers and environment, including:

- arranging properly layout of workshops;
- workers in some workshops, which radiation level are higher, are required to put protective clothing and other protective equipments on;
- gaseous waste and liquid waste is treated properly before discharging into the

- environment;
- solid waste and slag are stored in specific storage facilities, slag is reused by professional corporations; and
- radiation level in environment is periodically surveyed.

8.4.2 NORM/TENORM Waste Management in Taiyuan Steel Corporation

The Taiyuan Steel Co. started their operations in 1934. Their initial production capacity was 16 thousands tons, the capacity has been increased and in 2003's the capacity is 4 million tons. Now this company is the biggest stainless steel manufacturing company in the world. They have three blast furnaces of 1650 m³, revolving furnaces of 80 tons, AOD furnaces of 60 tons, and other equipments for steel making.

Through the process of steel production, huge amounts of wastes were generated. Those generated wastes were only piled up without any segregation for more than 50 years since their starting time. As the results, the wastes heap became very high and steep, and the surrounding environments were getting worse due to dusts suspended by wind.

Therefore, the remediation work has been started in 1983. The accumulated wastes were segregated for recycling. To recycle the wastes, a cement production plant was constructed. Cement, bricks and other products were made from those wastes. The wastes not applicable for recycling were covered with soil and used for construction of a park wall. The height and length of the wall are 13 m and 2,500 m, respectively.

The recycling of wastes is continuously carried out at present time. There are six pits for the interim storage of the wastes. Wastes generated are stored in each pit depending on type of waste, and then are segregated. The recyclable materials are recycled and the residual wastes are land filled.

8.5 Problems to be Solved

China meets some problems in NORM/TENORM control. These problems result from two sides, one is regulatory side and another lies in technology side.

In regulatory side, the existing difficulties are the followings:

- quantitative criteria for NORM mine have still not be defined ;
- having not practicable criteria in exemption and clearance of TENORM waste and residues; and
- regulatory area is not clear in other works i.e. which industries should be regulated. At present, some industries such as rare earth, phosphate and non-ferrous smelting, have entered into regulatory authorities' sight. However, some industries, for example, petroleum and natural gas industries, which are concerned extensively in some countries, have not been regulated.

In technical side, specific technologies need to be developed due to low radioactivity concentration and large volume of NORM/TENORM waste and residues. The technologies on disposal, recycle and reuse of NORM/TENORM wastes and residues as well as safety assessment methodology should be considered as priority issues.

8.6 Conclusions

NORM/TENORM is ubiquitous existing and may lead exposure at some stage of the processes and in the use or reuse of products, residues and wastes. Radiation protection and environment contamination in the field should be concerned.

China has long history in exploiting, processing and using of NORM/TENORM materials and has also paid attention to control and use properly of these materials. Although radiation level in these industry fields has been investigated and primary regulatory principles have been established, some problems still exist such as having not practicable criteria on exemption and clearance of residues and wastes.

Considering the fact that NORM/TENORM is involved in a variety of industrial fields in China as well as its specific characteristics of large waste volume, low radioactivity concentration and long lived radionuclides contained in wastes. Regulatory polices should be considered carefully so that the contradiction between cost and benefit can be in balance.