Safety Aspects in Thorium Mining and Milling

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On account of limited uranium and vast thorium resources, India has adopted a three stage nuclear energy programme wherein initially the existing uranium reserves shall be explored and at later stages the thorium reserves shall be utilized for nuclear power production. Thorium occurs in in nature as mineral monazite, which along with other heavy minerals, is found abundantly in the beach sands along the coastal stretches of peninsular India. Recovery of thorium therefore involves mining of beach sands, mineral separation to obtain monazite and its chemical processing to obtain thorium values. The process for recovery of thorium involve both radiological as well as conventional hazards.

Radiological Hazards

The radiological concerns in a monazite mining and mineral separation can be attributed to the entire thorium decay series which contain six alpha emitters, four beta emitters and accompanying gamma rays. In view of the presence of trace quantity of uranium in monazite, the contribution from uranium decay series is negligible. In beach sand mining, monazite concentration remains the same as that was naturally occurring in the beach sands. Since there is no alteration in the monazite concentration, there is no additional external exposure during mining. As most of the mining is by open-pit methods or by wet dredging, the radiological problems, particularly inhalation hazards are also insignificant. Thorium and its long-lived daughter products in the working atmosphere as well as thoron and its short lived decay products are also not of much significance in a mineral separation plant owing to atmospheric dilution due to open working conditions. However, in order to avoid spillage and dust generation enclosures of equipment and conveyors, control on the feed rate and proper exhaust ventilation is enforced. Thorium series have high energy gamma emitters. Therefore external exposure will depend on the varying concentration of monazite in different stages of mineral separation. To minimize the external radiation exposures in mineral separation plants which occur from being in close proximity to stored material, adequate shielding of stored material is provided. In addition, some areas in separation plants are designated as controlled areas to control unwanted occupancy.

In chemical processing of monazite, the impact of thorium and its long-lived daughter products as well as thoron and its short lived decay products is significant only in the initial monazite grinding and dissolution stages. In order to minimise the exposure, such operations are carried out in enclosed equipment with primary ventilation. In addition, pronounced external exposure is observed during chemical processing due to presence of high energetic gamma rays. External exposure is controlled by providing shielding wherever needed and job rotation of workers to reduce the time of exposure. Surface contamination can contribute to airborne activity through re-suspension if it is not controlled by proper containment and regular housekeeping.

Conventional Hazards

The conventional hazards in monazite mining is specific to surface mining operations. Sinking of the dredge is once such hazard which can be minimised by maintaining a 250mm minimum free board of the deck. The dredge operation is carried out upto a maximum wind speed of 90km/hr so as to avoid destabilising of the dredge due to cyclone. In addition to this, railings, nylon nets and chains are provided through out the path from the shore to the

dredge, integrity tests of the pontoons is performed and life buoys and life jackets are made available to avoid drowning of persons.

In a chemical processing, large quantities of acids and other hazardous chemicals are used. Storage of chemicals in bulk quantities, storage of gas cylinders pose additional industrial hazard. These are stored as per the requirements specified in the Manufacture, Storage and Import of Hazardous Chemicals (amendment) Rules, 2000 and Gas Cylinder Rules, 2004. Significant quantity of dust may be liberated during grinding operations. Appropriate enclosure with local exhaust systems having dust collection and scrubbing facilities are provided in the dust prone milling activities. Wherever necessary use of personal protective equipment (PPE) is enforced. In addition to the above hazards, conventional mechanical, electrical and fire hazards also persist which are controlled by adhering to statutory provisions, providing proper guarding to rotating parts, using standard materials and having an elaborate fire prevention and mitigation measures.

Waste Management

Beach sand mining and mineral separation generates silica rich sand which is used for backfilling the mined out sites. As the silica rich sand is devoid of monazite content, the radiation levels at the backfilled sites are lower than the prevailing natural radiation background of the area. The tails water is reused in pumping and slurrying operation. As the entire process is carried out in open atmosphere, there is no gaseous emissions which need to be exhausted out.

Chemical processing of monazite on the other hand generates thoron and long lived Thorium activity which is passed through HEPA filters prior to discharge to the environment. The liquid effluents generated are acidic and alkaline in nature and are neutralized and treated to remove Ra-228 and other radionuclides. The treated effluent conforming to specified limits are discharged to the environment. Various types of solid wastes are generated during thorium milling having different chemical characteristics and varying in radioactivity content. The solid wastes are disposed off in engineered trenches with FRP lining.

Regulatory Control

In order to protect the workers, the public and the environment from the adverse affects of mining and processing of monazite, several legal instruments are in place. Regulatory authorities, which administer the provisions of different statues to safeguard the environment, stipulate various conditions that the beach sand mining and processing facilities have to necessarily follow. These pertain to protection of the coast and coastal ecology, adherence to safe operating procedures, periodic monitoring of the work place and workers, employment of best available technology for minimization of waste generation, treatment of gaseous emissions and liquid effluents, containment of solid wastes in engineered storage ponds/landfills, bore well monitoring and periodic environmental surveillance. In addition, regulatory authorities conduct periodic inspections to ensure compliance with the statutory norms and regulatory stipulations.

The radiological safety provisions in the thorium mining and milling as well as the industrial and fire safety aspects in thorium milling are enforced by the Atomic Energy Regulatory Board (AERB), which is the national regulatory body of India for nuclear and radiation safety. AERB's regulatory oversight span through all consenting stages namely, siting, construction,

commissioning, operation and decommissioning. AERB is supported in its work by elaborate committee structure and follows a multi-tier review system of safety committees to carry out review and assessment. The individual doses in thorium mining and milling facilities as well to those of public residing in vicinity of these facilities is well within the specified limits. Industrial and fire safety statistics in thorium mills are also better when compared to similar conventional industries.

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