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FUEL CYCLE PROJECTS

After successfully establishing pilot plants for various components of nuclear fuel cycle in 1950s at Trombay, DAE in 1960s started installing units with larger capacities to run on commercial lines to meet the demands of an emerging nuclear power programme in the country. It was important to install plants which will produce large quantities of nuclear fuel and heavy water. Thus the Uranium Corporation of India Limited (UCIL) was established in 1967 at Jaduguda, in the then Bihar state. Similarly, Indian Rare Earths Limited, established as a private limited company in 1950 became a full fledged Central Government undertaking under DAE in 1963. A Nuclear Fuel Complex was set up in 1968 at Hyderabad for production of finished fuel assemblies for various reactors of DAE. In 1969 Sarabhai constituted Heavy Water Group which later became Heavy Water Board with a mandate to produce heavy water in large scale to meet the demands of many PHWRs that were on the drawing boards of DAE.

Uranium Corporation of India Limited (UCIL) Projects

UCIL started its first mining operation at Jaduguda in 1967 and commissioned in 1968 its uranium mill with a capacity of 1000 tons per day to produce the yellow cake (magnesium di-uranate). Safety of these operations was reviewed by Health Physics Division, BARC/DAE-SRC in the earlier years and later by SARCOP from 1987 onwards. One of the major safety concerns in the early days was high radon concentration in the Jaduguda mine. A Committee was constituted by DAE-SRC in June 1985 to review the Jaduguda mine ventilation system, with a view to reducing the annual average per capita radiation dose to the mine workers arising from radon and its progeny. The Committee recommended various steps to improve the ventilation system of the mine. In September 1991, AERB constituted a committee to review the progress in the implementation of earlier

recommendations and to review the radon concentrations and related aspects in the mine. The Committee observed that the improvements made were only marginal and recommended installation of a large fan to augment the air flow and a split ventilation system in order to provide fresh air to each of the working level. The average radon levels are now within the derived air concentration limits.

Narwapahar and Turamdih Projects

In 1988, UCIL sought the clearance for Narwapahar and Turamdih mines located in the Singhbhum Belt of Jharkhand and the ore processing plant at Turamdih. In 1992, the DAE decided to discontinue the Turamdih mining project. At the time of closing of Turamdih mine, the 8° Access Decline had reached at the upper horizon at a depth of 70 m from the surface and the 11° incline to be used for hoising of ore by conveyor had progressed about 336 m.

Narwapahar mine with mining access through declines and fully mechanized operations was expected to yield 1350 tons per day. AERB constituted a Project Safety Review Committee (PSRC) chaired by S. Sen, the then Director, Chemical Engineering Group, BARC and an Advisory Committee for Project Safety Review (ACPSR) for the project chaired by S.D. Soman, the then Director, Health Safety and Environment Group, BARC. The proposal was subsequently reviewed by the Safety Committee for UCIL and AMD (UASC) chaired by V.S. Keni, former Head, Chemical Engineering Division, BARC. In order to treat the extra load coming from Narwapahar, the existing mill at Jaduguda had to be augmented to an annual capacity of about 2000 tons of ore.

UCIL also proposed to extend the tailings pond by 30 hectares. Some of the issues which were discussed at length during the review of this proposal by the UASC chaired by S.K. Ghosh, Head, Chemical Engineering Division, BARC included seismic safety of the tailings dam, control of public access to the tailings pond area, performance

efficiency of the Effluent Treatment Plant (ETP) and control of internal exposures of the miners. Authorization for mining of ore from Narwapahar and its processing was given in August 1995.

In 2001, DAE had directed UCIL to re-open the Turamdih mine to augment the production of uranium ore. The project proposal was reviewed in great detail by the Safety Committee and authorizations were issued to UCIL in stages from 2001 to 2005. The final authorization issued in August 2005 was for mining and ore transportation to Jaduguda mill upto a production rate of 550 tons per day. Authorization for construction of Turamdih ore processing plant was issued in October 2003. Safety analysis of the tailings ponds for Turamdih was reviewed in great details by the Safety Committee and based on its recommendations construction of a check dam was recommended following the concept of defence-in-depth. The authorization for construction of tailings dam was given in July 2006. The commissioning results of the ore processing plant is currently being reviewed by USC.

Banduhurang, Bagjata and Mohuldih Projects at Singhbhum Belt, Jharkhand

Banduhurang mine, unlike the other mines, is the first open cast uranium mine in the country with an yield of 2400 tons per day. UCIL Safety Committee (USC) discussed at length the issues like the dust suppression measures, mine water treatment, etc. As per the deliberations, mine water from Banduhurang after treatment would be stored in an industrial water pond and could be used by the ore processing plant at Turamdih. The water from industrial pond would be discharged only during monsoon in the Kharkai river. AERB issued the authorization for the mining operation in March 2005.

Bagjata Mine is estimated to yield 500 tons per day of uranium ore. The project was reviewed by USC and ACPSR for Fuel Cycle Facilities

(ACPSR-FCF) chaired by R.K. Garg, former CMD, IREL. Issues like the transportation of ore, treatment of mine water and waste rock dumping were deliberated. Authorization for development of Bagjata mine was issued in April 2005.

Mohuldih mine is expected to produce 500 tons per day of uranium ore. The project was reviewed by Design Safety Review Committee for Uranium Extraction Projects (DSRC-UEP) chaired by S. Majumdar, former Head, Radiometallurgy Division, BARC and by ACPSR-FCF with particular emphasis on transportation of ore, health physics monitoring, ventilation scheme, storage and disposal of sludge from desilted pond. The authorization for development of the mines was issued by AERB in October 2007.

Tummalapalle Project, Andhra Pradesh

Tummalapalle mine located in Cuddapah district of Andhra Pradesh has a production target of 3000 tons per day. After regulatory review, authorization for the project was given at various stages. Approval was given by AERB in January 2005 for exploratory mining of 2000 tons of ore and its transportation to Jaduguda Mill for pilot plant study. UCIL applied for regular authorization for mine development in July 2007. The project was reviewed by DSRC-UEP and ACPSR-FCF. Issues like waste rock treatment, health physics monitoring, transport of sludge from desilting pond were deliberated. The authorization for development of mine was issued in February 2008.

Since Tummalapalle ore contains carbonate, alkali leaching of the ore was proposed. UCIL proposed to set up a Technology Demonstration Pilot Plant (TDPP), Jaduguda for carrying out extraction studies. The proposal was approved in August 2005. Based on the outcome of the studies, UCIL decided to set up an ore processing plant at Tummalapalle itself. The siting of the

processing plant was reviewed by DSRC-UEP and ACPSR-FCF. Siting clearance for the ore processing plant at Tummalapalle was issued in February 2007 with the stipulation to submit soil analysis report and approval from state government for water supply.

Nuclear Fuel Complex (NFC) Projects

Following the decision by DAE to establish the Nuclear Fuel Complex at Hyderabad in 1968, a number of plants were commissioned in 1970s. These include Zirconium Oxide Plant (ZOP), Zirconium Sponge Plant (ZSP), Zirconium Fabrication Plant (ZFP), Uranium Oxide Plant (UOP), Uranium Fabrication Plant (UFP). Like other radioactive installations of DAE, safety aspects of these plants were reviewed earlier by HPD, BARC/DAE-SRC and later by AERB-SARCOP from 1987.

For augmenting the production capacity to meet the increasing requirements of PHWR fuel inventories, NFC proposed in late eighties construction of number of plants. Important among them were New Uranium Oxide Fuel Plant (NUOFP), New Zircaloy Fabrication Plant (NZFP) and New Uranium Fuel Assembly Plant (NUFAP). AERB constituted a Project Safety Review Committee (PSRC) chaired by K. Subramaniam, the then Director (Technical), IREL for safety review of these plants.

NUOFP located within the NFC premises had a design capacity to manufacture 335 tons per year of UO_2 pellets for PHWR plants. During the safety review, main issues addressed were i) appropriate mechanization of handling of uranium powder operation, ii) design provision for containment of powder and iii) adequacy of ventilation system. Authorization for siting was given in 1990, approval for design in 1991 and for commissioning trials in 1998.

NZFP was designed for manufacturing 59 tons per year of Zircaloy tubes and components for PHWRs. The main issue during the safety

review was implementation of an appropriate effluent treatment scheme for spent pickling solution. For this project authorization for siting was given in 1990, for construction in 1991 after the design review and for commissioning the plant in 1997.

NUFAP had a design capacity of 300 tons of PHWR fuel bundles. Based on the review by the PSRC of all the engineering and safety aspects of the plant, AERB issued the authorization for the operation of the plant in 1996.

NFC has established a Zirconium Complex at Pazhyakayal, near Tuticorin in Tamilnadu to provide 250 tons per year of reactor grade zirconium sponge. A site authorization issued earlier by AERB in 1990 was revalidated and issued in 2003 after review of the site evaluation report by the NFC Safety Committee chaired by R. P. Singh, Head, Atomic Fuels Division, BARC. Major recommendation of the Committee included adequate safety margin over the design basis flood level and drainage slope, arrangement for alternate escape route for site, space for future expansion and mechanization for material handling. After review by ACPSR-FCF, authorization for construction was issued in November 2005.

In 2007 NFC carried out revamping of Zirconium Oxide plant from dissolution to precipitation section to increase the plant capacity from 300 to 500 tons per year with better instrumentation and control. The NFCSC reviewed the proposal. NFC had also proposed to carry out the revamping of the existing Uranium Oxide plant in 2008 to improve automation without increasing plant production capacity. NFCSC reviewed the proposal. The major recommendations were to enhance the structural stability of UOP building, segregation of active and non active scrap materials of the plant, development of piping specifications for new pipelines, laying of power cables as per standard, provision for single point entry to the plant and automation and improvement in the ventilation of the plant. The progress status of the revamping of UOP is being periodically reviewed by NFCSC.

Indian Rare Earths Limited (IREL) Projects

Indian Rare Earth Limited had been in operation with plants located at Trombay, Chavara, Manavalakurichi, Udyogamandal and Chatrapur. The mineral separation plants at Chavara and Manavalakurichi started during 1920s as private enterprises. IREL took over their operations in 1960s. The monazite processing plant at Udyogamandal for separating rare earths and thorium dates back to 1952, followed by Thorium Plant at Trombay in 1955. Thorium nitrate and nuclear grade thorium oxide were the main products of Trombay Plant, while uranium and rare earth salts were the other products. The process underwent partial modification in 1971 when solvent extraction was introduced. The mineral separation plant and thorium plant at OSCOM (Orissa Sand Complex) plant at Chatrapur started in the year 1986. The safety aspects of these plants were reviewed earlier by HPD/DAE-SRC and later by SARCOP from 1987.

Decommissioning of REP, Udyogamandal and Thorium Plant, Trombay

In 1988, the operations at the Rare Earths Plant at Udyogamandal were stopped due to structural weakness from ageing and corrosion. The decommissioning work was carried out during 1990-1991. It was for the first time that a commercial chemical plant processing radioactive material was decommissioned in the country. The Thorium plant, Trombay ceased operation in 1997 as the civil structures got weakened, due to ageing. The plant was decommissioned during 2000-2001. The residual contamination levels, results of decommissioning trials, environmental impact assessment were reviewed by AERB. The major activities which involved detailed review were areas related to safety which were recovery of sludge from tanks, decommissioning of tanks and other equipment, removal of floor and wall contamination, disposal of wastes and contaminated scraps.

MOHUR and HERO projects, IREL Udyogamandal

The Advisory Committee for Safety Review chaired by S.D. Soman reviewed the design and operational safety of Modernization of Helium Uranium Recovery (MOHUR) project. Besides experts from the DAE units, the Committee included Director of Mine Safety, Bhubaneshwar region as a member. The project proposed to process monazite to recover tri-sodium phosphate, rare earths chloride and thorium hydroxide concentrate. Along with these products the plant would also produce nearly 1.75 tons of Ammonium Diuranate and 3200 cubic metre of helium annually. Initially, in 1989 AERB issued provisional authorization to operate excluding the high pressure helium system. Safety aspects of the Helium Recovery Plant were further reviewed by ACPSR and based on the review, AERB issued authorization for continued operation of Helium Plant of IREL, Udyogamandal in February 1996. The same Committee reviewed and approved another proposal from IREL to set up a Heavy Rare Earths Oxide (HERO) plant at Udyogamandal for recovering pure samarium, gadolinium, yttrium and europium concentrates from rare earth chlorides.

One of the major safety concerns which emerged during the processing of monazite was storage of thorium hydroxide in the silos 1, 2 and 3, located close to river Periyar. These silos were general purpose storage sheds and not engineered for storage of radioactive materials as were the other silos. Environmental impact in the public domain consequent to a postulated failure of the silos and the already observed deterioration in the structure of these silos had been a cause of concern. At the instance of AERB, strengthening measures with respect to structural integrity of the silos were taken up. In 1999 IREL had proposed to retrieve the thorium concentrates from the silos. Reprocessing and storage was envisaged by water jets, transfer of slurry to road tankers, spray drying, pelletization, calcinations and storage in drums in

underground vaults. The project was recommended by IRE Safety Committee chaired by K.C. Pillai, Former Head, HPD, BARC with various stipulations. However, the project was abandoned by IREL mainly due to difficulties in retrieval by water jetting and high cost of the project.

THRUST Project, IREL, Udyogamandal

In 2002, a fresh proposal was put up to IRE Safety Committee for retrieval and processing of the thorium concentrate from the silos to recover uranium and thorium values after phasing out monazite processing operation. This project for Thorium retrieval, Uranium Recovery and Storage (THRUST) was taken up in two stages namely THRUST Phase-I under which the thorium concentrates would be retrieved from silo 1, 2 and 3 and THRUST Phase-II for the remaining silos. Based on the review by IRE Safety Committee chaired by D.S. Shukla, the then Head, CTD, BARC, SARCOP issued authorization for construction of the project in December 2002. The interim clearances for operation of the project were issued in two stages, initially for retrieval and processing of 300 tons of thorium concentrate on trial basis and subsequently for retrieval and processing of additional 1000 tons of thorium concentrate. These clearances were issued after extensive reviews and implementation of a number of modifications in the plant systems including total revamping of ventilation system, as stipulated by AERB. The final clearance for THRUST Phase-I operation was issued in 2005. Detailed review of THRUST Phase–II was carried out by IRESC chaired by V.K. Kansal, the then Head, Chemical Technology Division, BARC and SARCOP with respect to issues pertaining to ventilation and long term storage of thorium oxalate. After ensuring satisfactory compliance with safety requirements, SARCOP agreed in 2007 to permit THRUST Phase-II operation.

New Thorium Plant, IREL, OSCOM, Chatrapur

With the experience gained from Thorium Plant, Trombay, IREL

had proposed to set up a New Thorium Plant at IREL, OSCOM for processing of thorium oxalate for production of thorium nitrate and thorium oxide. The proposal was reviewed by a Project Safety Review Committee (PSRC) chaired by S. Sen the then Director, Chemical Engineering Group, BARC. PSRC reviewed the project from the point of view of plant performance, radiological and industrial safety aspects, effluent characteristics. Authorization for the plant operation was issued in 1992.

Monazite Processing Project (MoPP), IREL, OSCOM, Chatrapur

IREL, OSCOM proposed setting up a monazite processing plant with a capacity of 10,000 tons per annum at IREL, OSCOM. The Site Evaluation Report was reviewed by IRE Safety Committee and the authorization was issued in 2006. The detailed review for the construction of the project was carried out by Design Safety Review Committee for Uranium Extraction Projects (DSRC-UEP) and subsequently by ACPSR-FCF. The project was subjected to extensive review with particular attention to structural safety in view of the high frequency of cyclone at the site, disposal of wastes, radiological and environmental safety, etc. Based on the review, authorization was granted in 2007 for construction of the plant.

Beach Sand Minerals (BSM) Processing Facilities

Consequent to the Policy announcement by DAE in 1998 on exploitation of Beach Sand Minerals (BSM), private entrepreneurs also started mining, mineral separation, processing and value addition of the beach sand minerals. These BSM facilities preferentially separate the titanium minerals (ilmenite, rutile, leucoxene), garnet, sillimanite, zircon. Monazite is being exclusively separated by IREL plants. The BSM processing facilities were licensed by DAE under the Atomic Energy (Working of the Mines, Minerals and Handling of Prescribed Substance) Rules, 1984 after obtaining a No Objection Certificate from AERB. AERB teams carried out inspection of these facilities.

In 2004 Chairman, AERB constituted a Committee under the chairmanship K.C. Pillai, former Head, HPD, BARC to examine the radiological issues involved in mining and milling of beach sand minerals. In view of generation and disposal of monazite enriched tailings, Committee recommended that all BSM processing facilities should be licensed under the Atomic Energy (Radiation Protection) Rules, 2004. Consequent to delisting of the titanium minerals and zircon from the list of prescribed substances in January 2007, the BSM facilities handling these minerals no longer required license from DAE. However, to exercise control on the disposal of monazite enriched tailings, the BSM processing facilities would require license under the Atomic Energy (Radiation Protection) Rules, 2004 from AERB. As a consequence of this requirement, the IRE Safety Committee has been reconstituted as Beach Sand Minerals Safety Committee (BSMSC) in 2008 with V.K. Kansal as the Chairman to take over the safety review of all BSM facilities including IREL plants.

Heavy Water Board (HWB) Projects

By the time AERB came into existence, Heavy Water plants at Kota, Baroda and Tuticorin were already operational. The plant at Thal was nearing completion and was commissioned in 1986. The safety review of these plants was carried out by DAE-SRC and later by AERB-SARCOP from 1987 onwards. One of the important safety issues related to HWP, Kota was the potential impact of an accidental release of hydrogen sulphide owing to its proximity to Rajasthan Power Stations. At the instance of AERB, an assessment of the impact was carried out. The subsequent projects of Heavy Water Board reviewed by AERB are described below.

Heavy Water Project- Manuguru

Based on the experience gained from operation of Heavy Water Plant, Kota, Heavy Water Board had proposed to set up another hydrogen sulphide based heavy water plant at Manuguru, Andhra

Pradesh. For this project an Advisory Committee for Project Safety Review (ACPSR) chaired by R.K. Garg, Former CMD, IREL and a Project Design Safety Committee (PDSC) chaired by H. K. Sadhukhan, the then Director, Chemical Engineering Group, BARC were constituted by AERB. The project was also subjected to an in-depth safety review by an expert sub-committee of AERB in areas such as design of systems important to safety, quality assurance during construction and start up tests. Based on the recommendations of PDSC and ACPSR, generation of 430 tons of hydrogen sulphide was approved. Authorization for operation for Exchange Unit-II at 12 kg/cm^2 and operation of Units 1&2 of the Captive Power Plant were issued in 1990. Later in 1991, authorization for operation of both the Exchange Units-I &II at the design pressure and to charge hydrogen sulphide into the Exchange Unit-I for the purpose of film formation was issued. Currently, the safety review of the plant is carried out by HWP Safety Committee chaired by C.S.R. Prasad, Chemical Technology Division, BARC and SARCOP.

Heavy Water Project- Hazira

After Thal, the Hazira plant in Gujarat was the fourth ammonia based heavy water plant. The synthesis gas for the project would be drawn from the ammonia plants of Krishak Bharati Cooperative (KRIBHCO). The Site Evaluation Report was reviewed by the PDSC and ACPSR for Heavy Water Projects. In December 1990, based on the recommendation of these Committees, AERB authorized for continuous operation of streams A and B in 1991 with synthesis gas/ ammonia and potassium amide as a catalyst.

In the year 1992, PDSC while reviewing the commissioning status observed that the cable tray forgings located inside towers of the ammonia based plants have not been subjected to pressure testing from outside. These cable forgings are used for the purpose of taking the cables from inside the tower, which is under pressure. This is done through the glass seals located at the bottom of the cable

forging. The towers have been designed as per ASME Section VIII Division II. However, in the code there is no mention about the test requirements for components designed for external pressure, which is the case with respect to the cable forgings.

The American Society of Mechanical Engineers (ASME), Bureau of Indian Standards (BIS) as well as other organizations which have expertise on design and fabrication of pressure vessels were contacted to seek their views on the above problem. Discussions were also held with experts in the field from BARC. One of the solutions considered was that the cable forging could be subjected to a hydraulic test with internal pressure of 1.25 times the external design pressure. However, due to the presence of the glass seals at the bottom of the cable forging, any internal pressure would cause a leakage from the glass seals since they are designed to seal only when there is pressure applied from outside the cable forging. Since the cable forging could not be hydraulically tested internally, it was finally decided that the cable tray forging should be subject to an external pressure equal to 1.25 times the design pressure. HWP-Hazira has carried out hydro testing of cable tray forging as per stipulations of AERB.

Heavy Water Plant-Baroda Revival Project (BRP)

The Heavy Water Plant, Baroda, which was commissioned in mid seventies, was being operated for production of heavy water by extraction of deuterium from ammonia synthesis gas on mono-thermal Ammonia-Hydrogen exchange process. The operations of HWP, Baroda was suspended since beginning of 1999 due to suspension of supply of required high pressure feed synthesis gas from M/s GSFC and thus the Baroda Revival Project (BRP) was initiated by HWB as a technology demonstration plant to sustain operation of HWP independent of fertilizer plant. BRP is based on the deuterium exchange process between water and ammonia, where deuterium from water gets transferred to ammonia vapour and the Ammonia-Hydrogen monothermal isotopic exchange process is used

for further enriching the deuterium laden ammonia. HWPSC and SARCOP reviewed the Design Basis Report, Safety Report, Hazard Operability (HAZOP) studies, Fire safety provisions, Quantitative Risk assessment (QRA), Waste Management, Technical Specifications for operation, document for authorisation of operating personnel and In-Service Inspection (ISI) manual for equipment and piping. On the recommendation of SARCOP, AERB granted the license for operation of HWP-Baroda in June 2006. IPSD had also carried out a Chemical Exposure Index study and consequence analysis of ammonia leakage with the help of the software 'PHAST professionals' for this project.

Diversified Projects of HWB

In the recent years, due to fall in demand of heavy water by the PHWR based NPPs, HWB ventured into the production of various solvents, boron enrichment, etc. R&D pilot plant for development of technology for production of Di-2 Ethyl Hexyl Phosphoric Acid (D2EHPA) at Talcher was reviewd by the erstwhile Safety Committee for Heavy Water Operating Plants (SCHWOP) which later got renamed as HWPSC. Issues of In-Service Inspection procedure for glass lined reactors, pressurization and containment of phosphorous trichloride were addressed. Based on the review of SCHWOP, operational clearance was granted by SARCOP in July 2001. Similarly the proposal for setting up of the TBP facility with a capacity of 60 MT per year was reviewed extensively by HWPSC and SARCOP with emphasis on risk assessment, waste management and Technical Specifications for the operation. Regular operational clearance was given by SARCOP in December 2003.

The project for setting up of the Boron Enrichment Exchange Distillation (BEXD) Facility at Talcher was initially reviewed by HWPSC and later by Design Safety Review Committee for Diversified Projects (DSRC-DP) chaired by S.M. Rao, former DCE, NFC. Issues of availability of HF and Ether monitors, results of HAZOP studies and revision of Technical Specifications were addressed.

Based on the recommendations of DSRC-DP and ACPSR-FCF AERB granted authorization for the operation clearance in July 2008.

Recent Developments

In 2006, AERB published a document on 'Consenting Process for Nuclear Fuel Cycle Facilities and Related Industrial Facilities other than Nuclear Power Plants and Research Reactors' (AERB/NF/SG/G-2). The document outlined the regulatory requirements at various consenting stages of siting, construction, commissioning and operation for the fuel cycle facilities. Regulatory inspections of the fuel cycle facilities are being carried out during various stages of consenting as per the requirements laid down in the AERB document 'Regulatory Inspection and Enforcement in Nuclear Fuel Cycle and Related Industrial Facilities other than Nuclear Power Plants and Research Reactors' (AERB/NF/SM/G-2). In the recent years, AERB had also published safety guidelines on 'Safety in Thorium Mining and Milling', 'Radiological Safety in Uranium Mining and Milling' and 'Management of Radioactive Waste from Mining and Milling of Uranium and Thorium'.

After the operational consent is given, the operational safety review of these facilities are carried out by the units safety committees such as UCIL safety Committee, BSM Safety Committee, NFC Safety Committee and HWP Safety Committee and subsequently by SARCOP.

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