Radiological safety Experience in Nuclear Fuel Cycle Operations at Bhabha Atomic Research Centre, Trombay, Mumbai, India

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INTRODUCTION

Activities at Bhabha Atomic Research Centre (BARC), Mumbai, cover nuclear fuel cycle operations based on natural uranium metal as the research reactor fuel. The facilities include the fuel production and fabrication plants, research reactors, a plant for fuel reprocessing and radioactive waste management programmes in each of these stage. Comprehensive radiation protection programmes for assessment and monitoring of radiological impact of these operations, both in occupational and public environment, are in place in BARC since the beginning. These programmes, based on the 1990 ICRP Recommendations as prescribed by National Regulatory body, the Atomic Energy Regulatory Board (AERB), are being successfully implemented by the Health, Safety and Environment Group, BARC. The operational health physics experience in some of these facilities is discussed in this paper.

CURRENT PROTECTION STANADARDS

Effective dose limits have been stipulated for occupational workers by Atomic Energy Regulatory Board (AERB) (1). The limits are based on the recommendations of 1990 Recommendations of the International Commission on Radiological Protection (ICRP) (2). The cumulative effective dose constraint for five-year block beginning from Jan. 1, 1999 to Dec. 31, 2003 is 100 mSv for individual radiation workers. The annual dose limit to individual workers is lower at 30 mSv instead of 50 mSv recommended by ICRP (2). Any individual exposure exceeding 20 mSv in a year is investigated by a committee to be constituted by Chairman, AERB. The cumulative life time occupational dose of a worker shall not exceed 1 Sv. Medical review shall be undertaken at cumulative exposures exceeding 0.5 Sv to the workers. Intake limits to the workers are as stipulated by the AERB, based on the ICRP-61 (3).

RADIATION HAZARDS CONTROL ACTIVITIES

Radiation Monitoring Programmes

Workplace Monitoring:

Surveillance of the radiation status in controlled areas is an important aspect of checking the adequacy of safety provisions in the facilities. The radioactive areas are routinely monitored using appropriate monitoring systems and equipment, either hand-held or installed. Fixed area gamma monitors (AGMs) and continuous air monitors (CAMs) are located in strategic locations for continuous radiation field and airborne activity measurements respectively. The display from these fixed location units are recorded in the control room in reactors and fuel reprocessing facilities. The radiation levels, in continuously occupied areas, are maintained lower than 10 μGy/h, as specified by the regulatory authority. Caution boards are kept in areas with higher radiation levels, and work in these areas are carried out under Special Work Permit (SWP) system, which is in force in all the facilities.

Personnel Monitoring Programme:

Individual monitoring for external radiation provides data for estimation of effective dose to the whole body and equivalent dose to the skin , extremities and lens of the eyes. In the course of such monitoring the type of quality of the radiation should be known for reducing the exposure by employing proper protective gears. Personnel working in active areas are provided with thermoluminescent dosimeters (TLDs) to record their cumulative external exposures during a service period, which is monthly or quarterly, depending on the radiation status in the facility. The TLD badges used are energy independent and have a flat energy response from 200 keV- 2 MeV as most of the nuclides encountered falls in this range. MDL (Minimum Detectable Level) of these badges is 0.05 mSv which is very much below the operating limit of 4 mSv in the monitoring period of the month. Additional dosimeters such as neutron badges, wrist badges and direct reading pocket dosimeters (DRDs) are also arranged depending upon the nature of the operations and type of radiation involved.

The knowledge of constituents in system activity and the improved practices have led to the reduction of collective dose of the various nuclear facilities in Trombay. Radiometric characterisation of the sources of exposure, spectrum of the radionuclides present, their mode and half-life help immensely in devising means of suitable exposure control. Other radiological properties like effective half-life in humans help to employ proper methods of measurement resulting internal contamination and exposure control. The radiation exposures are low, and maintained as low as reasonably achievable (ALARA). The average individual exposures are about 1/20th of the annual effective dose of 20 mSv. In spite of long duration of operation of many of these facilities, the average individual dose shows decreasing trend over the years. Introduction of well planned monitoring systems with high degree of reliability and study of work environment , have helped in early diagnosis of deficiencies in the system status thus helping to reduce the total collective dose during course of time.

Internal exposure of the workers is assessed both by bioassay and whole body counting techniques. Internal monitoring programme for direct assessment of organ burdens of alpha emitters, such as Pu and Am form an important part of personnel monitoring for workers in back-end of the nuclear fuel cycle (4). The phoswich detector system used for this purpose consists of a sandwich of NaI (Tl) (200 mm dia. X 3 mm thick) and CsI (Tl) (200 mm dia. X 50 mm thick) detectors mounted on a single photomultiplier with radiation entrance window of 1mm thick Be. For monitoring chest burden, the phosphor is positioned carefully over the chest. Am-241, with 60 keV gamma photon, is chosen for Pu lung counting since it is always associated with Pu, and the ratio of Pu and Am is known for a given fuel burn-up in reactor. Shadow shield counter is used to measure internal contamination from beta gamma emitters. Such measurements are done on a routine basis.

The Minimum Detectable Activities (MDA) for the nuclides characterizes a priori the measurement procedure and allows predictions of sensitivity attainable with specific combination of equipment, detection geometry and measurement time. The MDA values achieved in BARC labs compare well with international standards. In the last four decades of experience in nuclear fuel cycle activities at BARC, internal contamination due to fission/ activation products has been found to be < 1% of the total collective dose.

Wherever such measurements are not adequate or feasible, particularly in some reactor areas and uranium handling facilities, assessment of the internal dose to different categories of workers is made based on air monitoring data and occupancy factor in a given area. Such assigned dose is also included in the personnel dose records. The records of the personnel exposures are maintained.

RADIOACTIVE WASTE MANAGEMENT

The nuclear fuel cycle operations generate various types and categories of waste, i .e., high, medium and low level solid and liquid wastes. Low level liquid wastes from the fuel production/fabrication facilities and reactors are discharged into the sea in a controlled manner and the releases are well below the derived discharge levels stipulated by the regulatory body. In addition to these, gaseous fission product, ^{85}Kr from fuel reprocessing, and gaseous activation products, ^{3}H and ^{41}Ar, from the reactors are also discharged into the environment. The activity discharged from the BARC site into the environment over the years is found to be well with in the regulatory limits.

Waste Storage Facilities: Adequate interim storage is provided for the high and intermediate level liquid waste arising from the reprocessing facility. The acidic waste is concentrated and stored in stainless steel high integrity tanks in underground vaults. Indian experience with the waste storage tanks has been highly satisfactory. The storage vault internals and surroundings are regularly monitored to ensure the integrity of the containment. Periodic agitation of the contents prevents sedimentation. Ventilation is provided for the high level waste tanks to maintain temperatures below 40 C.

The waste storage facility has well designed containment with enough barriers (5):

- The SS tank shell
- SS lining for vault
- Reinforced concrete containment (RCC) vault
- Peripheral RCC envelope for vault

The last mentioned barrier is provided with sampling and pumping facility to detect any leakage / seepage from and into the vault. An array of bore holes with sampling provisions are available to monitor the contamination of sub soil water body as a result of highly improbable breach of all the four containment. Routine sampling from these bore holes are being carried out to ensure the integrity of the underground storage tanks and effluent pipe lines. Normal routine environment surveillance programme consisting of monitoring of environmental matrices like fish, salt, water etc., are not indicative of any undetected leakage of effluent to the public domain (6).

Intermediate level and high level solid wastes and alpha bearing wastes are stored / buried in specially designed disposal facilities, in controlled areas, depending on the type, quantity and specific activity of the waste.

ENVIRONMENTAL SURVEILLANCE

Environmental monitoring around the nuclear facilities is carried out on a regular basis to keep check on the adequacy of the safety provisions in the facilities as well as to check compliance with the regulatory limits. No enhancement in the environmental levels were observed which could be attributed to the nuclear fuel cycle operations at Trombay.

TRAINING

Based on the operating experience in various fuel cycle plants, the workers are trained in various aspects of radiation protection, in addition to training in their respective jobs. The training includes lectures on biological effects of radiation and on methods and procedures of radiation protection. A scheme termed Qualification Incentive Scheme (QIS) is in force all the reactors and reprocessing plants for the qualified workers. The scheme requires the workers to go through different stages of education and training, such as lectures, written test, checklist, walk-through and finally the personal interview with a committee consisting of experts, whcih include an expert in radiation protection. This scheme provides the necessary education and training of the workers in various aspects of radiation protection in general and also with respect to the specific areas of operation in which he is involved. The training is provided commensurate with the level of responsibility. The QIS is a continuous process and thus provides for the periodic retraining of the workers.

CONCLUSION

Radiological status of the nuclear fuel cycle facilities has been satisfactory and the personnel exposures have been under control. The environmental impact of the releases from the operation of these facilities is negligible in terms of public exposure. Adequate training of the radiation workers, on the radiation hazards, protection measures and emergency procedures, is a continuing procedure at the all the facilities. It is seen that the present methods and techniques are satisfactory to meet the regulatory requirements.

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