# Chapter 6: Radiation protection

**Audit Objective: Whether AERB was monitoring and discharging responsibilities relating to radiation exposure to occupational workers and members of the public and to the release of radioactive substances in the environment in an efficient and effective manner**

## 6.1 Introduction

According to the IAEA Safety Guide, exposure to radiation can occur as a result of various human activities, including work associated with different stages of the nuclear fuel cycle, the use of radioactive sources and radiation in medicine, research, agriculture and industry.

Exposure in excess of the limits prescribed based on medical research, has serious health implications for all living organisms and environment. Radiation protection is thus intended to ensure that the amount of radiation absorbed by an organism does not have negative consequences.

According to the IAEA Handbook, nuclear law must establish a legislative framework for the safe management of all sources and types of ionising radiation. It should, in particular, ensure that individuals, society and the environment are adequately protected against radiological hazards. Finally, it should impose restrictions on the dose that an individual may incur so that no person is subject to an unacceptable risk attributable to radiation exposure.

## 6.2 Radiation protection in India

The Constitution Order (1983) of AERB vide clause 2 (vii) entrusted the function of prescribing acceptable limits of radiation exposure to occupational workers and members of the public and approve acceptable limits of environmental release of radioactive substances to AERB.

As per the AERB guidelines for an occupational worker, the annual dose limit is 30 mSv[19], with the condition that it should not exceed 100 mSv in a span of five years. Authorised regulatory limits of radioactive effluents for the public are based on the apportionment of an effective dose limit of one mSv per year.

[19] Milli-Sievert (mSv) – derived unit of dose equivalent radiation which attempts to quantitatively evaluate the biological effects of ionising radiation.

As per the provisions of the Atomic Energy (Safe Disposal of Radioactive Wastes) Rules, 1987, the responsibility for safe disposal of radioactive waste is placed on the licencees and AERB has the mandate of ensuring that the licencees perform their responsibilities. RPR 2004 also specifies the responsibilities of various parties, viz. the employers, licencees, Radiological Safety Officers and workers, with respect to radiation protection. The Rules also specify the powers of the competent authority (AERB) with respect to (i) specifying requirements in respect of safety, health surveillance of workers, radiation surveillance and records to be maintained; (ii) issuing directives; (iii) inspections and (iv) enforcement actions.

## 6.3 Radiation protection in nuclear and radiation facilities

### 6.3.1 Nuclear Power Plants

We reviewed the adequacy and effectiveness of the procedures and practices in respect of radiological protection of workers, the public and the environment in respect of NPP, other nuclear fuel cycle facilities and other radiation facilities. We also reviewed the adequacy and effectiveness of the radioactive waste management system, which was one of the most vulnerable aspects of radiation protection. Our observations are as follows:

#### 6.3.1.1 Radiological protection of workers

Each NPP has a Health Physics Unit (HPU) which is entrusted with the responsibility of providing radiological surveillance and safety support functions; monitoring of areas, personnel, systems and effluents, as well as exposure control and exposure investigations. These HPUs were initially part of the BARC and were independent of the NPPs, with direct channels of communication with the top plant Management of the Nuclear Power Corporation of India Ltd (NPCIL) in enforcing the radiation protection programme.

The HPUs in all NPPs were transferred from BARC to NPCIL in May 2009 by DAE. This meant that the functions of monitoring of radiological exposure as well as the responsibility of radiological surveillance of NPPs now lay with NPCIL which was an operator of NPPs.

**In respect of the critical issues of radiological protection of workers, AERB's role in verification of compliance, an essential requirement for any regulator, has not been provided for, in a direct way. In view of AERB's role as the nuclear regulator of India, independent assessments and monitoring can be ensured only if these HPUs are placed under its direct control.**

#### 6.3.1.2 Radiological protection of public

The discharge of radioactive waste from NPPs is governed by the Atomic Energy (Safe Disposal of Radioactive Wastes) Rules, 1987 issued under the AE Act. It is mandatory for an NPP to obtain authorisation under the above rules from AERB for disposal of radioactive wastes. AERB prescribes the regulatory limits of radioactive effluents based on the apportionment of an effective dose limit of one mSv per year to the public, arising from nuclear facilities at a site, considering all the routes of discharges and significant radionuclides[20] in each route of discharge.

AERB reported that during the period from 2005 to 2010, the effective dose to the public was far less than the prescribed annual limit of one mSv in all the sites.

#### 6.3.1.3 Radiological protection of environment

The Environmental Survey Laboratories (ESLs) of the Health, Safety and Environment Group, BARC carry out environmental surveillance over an area of 30 km radius around the nuclear reactors at all the operating NPP sites. They provide AERB with periodic reports on radiological conditions of the NPPs and the results of environmental surveillance. The ESLs are, therefore, not under the direct control of AERB.

DAE stated (February 2012) that initially all the activities related to operation of NPPs and radiation protection functions were discharged by the Government. In 1987, the operation and maintenance of NPPs were transferred to NPCIL but the functions relating to occupational radiation protection and environmental surveillance continued to be discharged by BARC. In 2009, these functions were transferred to an Environment Group set up within the Safety Directorate of NPCIL. This arrangement provided for independent environmental surveillance by the ESLs established by the Health, Safety and Environment Group of BARC. Subsequent to this reorganisation, AERB had undertaken the process of authorising Radiological Safety Officers (RSO) at the NPPs and radiation facilities within the Government. The responsibilities of the employers, licencees and RSOs were clearly specified in RPR 2004.

DAE further stated that to fulfill their responsibility, AERB had instituted an aggressive inspection programme for checking compliance of the requirements by the utilities.

[20] A **radionuclide** is an atom with an unstable nucleus. The radionuclide is said to undergo radioactive decay, resulting in the emission of gamma ray(s) and/or subatomic particles and occur naturally, or can be produced artificially and present both real and perceived dangers to health.

The reply of DAE once again confirms the absence of any direct role of AERB in verification of compliance with regard to environmental surveillance issues. AERB, as is essential for any independent regulator, should have the authority to monitor the performance of the regulated entity. Accordingly, it should strengthen its role with adequate infrastructure and manpower to conduct independent surveillance of exposure control and exposure investigations.

### 6.3.2 Radiation facilities

As per RPR 2004, AERB has the responsibility for ensuring radiation protection by prescribing collective dose budgets[21], reviewing excess exposure cases, conducting regulatory inspections and reviewing radiological safety aspects of radiation facilities, mainly based on the prescribed reports submitted by the Radiological Safety Officers (RSO)[22] of the facilities. Our observations are discussed in the following paragraphs:

#### 6.3.2.1 Radiological protection from occupational exposure

As per AERB guidelines, the annual dose limit for an occupational worker is 30 mSv, with the condition that it should not exceed 100 mSv in a span of five years.

We observed that there were 89 cases of excess exposure, i.e. exceeding 30-mSv at radiation facilities during the period from 2005 to 2010. Out of this, the exposure was more than 50 mSv in 41 cases. This indicated that wrong work practices were prevalent among radiation workers and the excess exposures would have negative consequences and adverse effects on the health of workers in the short as well as long term.

Insofar as the verification of exposure to workers in a radiological facility is concerned, the RPR, 2004 envisages that the RSO should be responsible for radiological surveillance, including those relating to personnel. He is to accordingly furnish periodic reports on safety status to AERB.

DAE stated (February and June 2012) that the number of cases of doses exceeding the AERB limit had come down drastically in the recent years. They further stated that in case the specified annual dose limit was exceeded in the case of a worker, the case was reviewed to

[21] AERB approves the annual collective dose budget for each NPP. In the beginning of a calendar year, NPPs present the budget proposal along with planned activities for the year. These proposals are reviewed and approved by relevant AERB committees.

[22] A person who is so designated by an employer with the approval of the competent authority i.e. AERB under the Atomic Energy (Radiation Protection) Rules, 2004 and Atomic Energy (Safe Disposal of Radioactive Waste) Rules, 1987.

ensure that the dose received by the worker remained within the limit of 100 mSv over a period of five years.

It was also stated that in case the annual limit of 30 mSv was exceeded for a worker, he was engaged in non-radiation areas for the remaining period to keep the five yearly total dose within the limit of 100 mSv. For investigation of cases of overexposure, AERB took the help of RSOs appointed in the radiation facilities. Reports of the preliminary investigations carried out by the RSOs were first scrutinised and reviewed by AERB. AERB carried out further inspections and undertook investigations for the cases as necessary. Based on these investigations, improvements in the working conditions and safety culture at the facilities were considered. DAE further stated that the number of overexposures had been less than 0.1 *per cent* of the total number of radiation workers in the last five years.

The reply of DAE addresses post-exposure measures rather than preventive action. There is a shortage of RSOs and inadequacy in respect of RI of radiation facilities, impacting independent verification and review of radiological safety aspects in respect of the large number of radiation facilities available in the country. Thus, there is a need for efforts to prevent even a single case of over-exposure which could impair the health of the people in the affected areas. Further, insofar as the responsibility of reporting by RSOs is concerned, there was an acute shortage of such officers, particularly in the case of diagnostic radiology and nucleonic gauges, both of which are radiation facilities.

### 6.4 Radioactive waste management

As per the IAEA Handbook, when a sealed radiation source reaches the end of its useful life, it should be disposed off or returned to the manufacturer for recycling. However, at times, disused sources are often discarded and may give rise to accidents. It is, therefore, essential that the regulatory body be provided with the means necessary for effectively controlling all major sources in the country. It is also essential that the regulatory body maintains effective communication with the holders of licences for these sources.

The discharge of radioactive waste[23] from radiation installations in India is governed by the Atomic Energy (Safe Disposal of Radioactive Wastes) Rules, 1987. It is mandatory for every radiation installation to obtain authorisation under these rules from the competent authority, i.e AERB, for disposal of radioactive waste.

We examined the effectiveness of the systems and processes of disposal of radioactive waste i.e. disposal of sources that had outlived their utility (disused sources), radioactive

[23] Any waste material containing radionuclides in quantities or concentrations as prescribed by the competent authority by notification in the official gazette

sources that had gone out of regulatory control (orphan sources) and other waste including effluents. Our findings are discussed in the succeeding paragraphs.

### 6.4.1 Management of disused radiation sources:

#### 6.4.1.1 Disposal of sources that have outlived their utility (Disused sources)

According to Rule 3 of the Atomic Energy (Safe Disposal of Radioactive Wastes) Rules, 1987, no person should dispose of radioactive waste

(a) unless he has obtained an authorisation from the competent authority under these rules;

(b) in any manner other than in accordance with the terms and conditions specified in the authorisation issued under these rules;

(c) in any location different from those specified in the authorisation;

(d) in quantities exceeding those specified in the authorisation.

While the systems and procedures for the disposal of disused sources in respect of NPP and other nuclear fuel facilities were in place, the same were not so in the case of other radiation facilities due to inadequate monitoring on account of shortfalls in RIs and inadequate strength of RSOs in these facilities. This was also evident in case of the radiation incident in Mayapuri mentioned earlier, which is described below:

**Radiation incident in Mayapuri**

The University of Delhi procured radiation equipment containing a gamma cell in 1970, which was operated till 1985. AERB stated (June 2010) that this unused equipment containing the gamma cell was sold to a local scrap dealer in a public auction. Thereafter, the equipment was dismantled and the source assembly was handled by persons with bare hands. This resulted in serious radiation injuries to these persons, including the death of a person. These casualties occurred due to unsafe and unauthorised disposal of radiation equipment at Mayapuri, New Delhi in April 2010. It is apparent that the accident was the result of ignorance about practices for safe disposal of radioactive waste. AERB confirmed that Delhi University was not aware of the provisions of the Atomic Energy (RP) Rules, 2004 and the Atomic Energy (Safe Disposal of Radioactive Wastes) Rules,

1987. The nature of the incident was classified as level 4[24]. The AERB version of the incident is given in *Annex 4*.

AERB replied (February 2012) that the incident occurred primarily due to violations by Delhi University of the clear and unambiguous requirements specified in the applicable rules, about safe disposal practices of radioactive wastes.

The fact, however, remains that the sources mixed with scrap metal used for subsequent recycling, can lead to contamination of industrial plants and the environment. The contamination can possibly result in serious consequences.

#### 6.4.1.2 Database relating to radiation facilities

As stated earlier in para 6.4, the IAEA Handbook states that a regulatory body is to be provided with the means necessary for effectively controlling all major sources in the country. It is also essential that the regulatory body maintains effective communication with the holders of licences for these sources.

Prior to the establishment of AERB, radiation facilities were under the regulatory control of BARC. AERB did not obtain sufficient data relating to radiation facilities operating in the country when the regulatory work was assigned to it.

AERB stated (February 2012) that following the Mayapuri incident in April 2010, it had undertaken a vigorous campaign to establish and maintain an inventory of all the radiation sources used in the country and to improve their regulatory control. The measures taken as part of this included (i) sensitising all academic, medical and R&D institutions to prepare inventories of radiation sources under their possession and review their existing safety procedures, (ii) asking all the suppliers/manufacturers for details of the sources supplied by them till date, (iii) strengthening the AERB data base on source inventory by identifying and bringing on record, the legacy sources. AERB further stated that it had initiated a process of developing an advanced web-based interactive system for managing the regulation of radiation sources and facilities.

The fact remains that AERB still does not have an effective system in place to ensure continuous collection and updating of its inventory of all radiation sources, to ensure effective compliance of regulations for safe disposal of disused sources.

[24] The nature of radiation events are classified by IAEA under seven levels on the International Nuclear and Radiological Event Scale (INES) depending on the gravity of the incidents, with level seven being the highest level. Level four signifies accidents with local consequences

**AERB does not have a detailed inventory of all radiation sources to ensure effective compliance of regulations for safe disposal of disused sources. No proper mechanism is in place to ensure that waste radioactive sources have actually been disposed off safely after utilisation.**

#### 6.4.1.3 Absence of a proper mechanism to monitor safe disposal of radioactive material

AERB issues consents for disposal of decayed radioactive materials from medical, industrial and research institutes for safe disposal to the original supplier or to one of the approved radioactive waste disposal facilities[25] in India.

We observed that although a large number of consents for transport of radioactive material for safe disposal had been given so far, there was no proper mechanism in place to verify whether the sources had actually been disposed off in accordance with the safeguards prescribed in the consent letter. Records for all the sources disposed off so far at their facilities were being maintained by the National Waste Management Agency.

DAE stated (February 2012) that a computerised database of the sources disposed of at an authorised waste management agency with prior permission from AERB is maintained both at the waste management agency and AERB. It assured that once the advanced web-based interactive system for the management of radioactive sources (currently in advanced stage of development) became operational in AERB, it would be easier to track and complete the cradle to grave cycle of a radioactive source. This system would integrate the management of the sources by the user, AERB and the waste management agency.

**Though a large number of consents for transport of radioactive material for safe disposal have been given so far, there is no proper mechanism to verify whether the sources have actually been disposed off or not.**

The existing mechanism for safe disposal of radioactive material reveals weakness in verification of compliance and the lack of enforcement by AERB. This indicated departure from features that are essential for the functioning of a regulator.

[25] National Waste Management Agency, BARC

### 6.4.2 Orphan sources

The IAEA Safety Glossary defines an 'orphan source' as a radioactive source which is not under regulatory control, either because it has never been under regulatory control or because it has been abandoned, lost, misplaced, stolen or otherwise transferred without proper authorisation. The issue has engaged international attention, especially after the terrorist attack of 11 September 2001, in USA with the concern that such sources may be acquired and used for malicious purposes.

As per the provisions of RPR 2004, an employer has to inform AERB about losses of radiation sources under their custody. AERB included such cases in their reports as 'unusual occurrences'.

During the period 2005-06 to 2011-12, AERB had reported the following instances:

- Forty eight cases of loss, theft or misplacement of radioactive sources since 2000, in which radioactive material found its way into the environment and 15 cases where the source was never found. Details of these are listed in *Annex 5.*
- Several incidents of radioactive packages remaining uncollected at airports, including 67 unclaimed packages found at Chennai, Delhi, Kolkata and Mumbai airports in 2001.
- The mistaken handing over of a radioactive package containing 6.539 GBq[26] Y-90[27] to a waste disposal agency in 2004-2005, by the staff at Mumbai airport.

AERB stated (February 2012) that the radioactive sources in use in the country were large in number and were regulated through a graded approach, commensurate with their hazard potential. AERB dealt with cases of loss, theft and misplacement of sources through regulatory action, awareness programmes and help from the police and IG security (DAE). The reported cases of loss and theft of sources were mainly from radiation facilities having low hazard potential. AERB ensured that all the licencees immediately reported any incident of loss and theft or misplacement of sources to enable prompt action for tracing and recovering the sources. If the cases of loss, theft or misplacement of the sources were known to be due to negligence from the side of the licencees, appropriate regulatory action was initiated against them.

[26] Gigabecquerel (GBq) is a measurement unit of radioactivity.

[27] Yttriga-90 is a solution of Yttrium [90Y] chloride, which is a β-emitting radionuclide radiopharmaceutical.

AERB further stated that due to the increased awareness regarding radiation safety amongst airport Managements, Customs officials, importers and exporters, AERB got information on time and took prompt action to resolve the issues. AERB had been undertaking many campaigns through various awareness programmes about the safety and security of radioactive sources used in the country. In view of this, such incidents were expected to come down in the near future with proper monitoring of the sources with the help of the advanced web-based active system.

AERB should strengthen its current approach to deal with the issue of orphan sources. The IAEA Safety Guide envisages development of a national strategy for regaining control over orphan sources and improving control over vulnerable sources. AERB should adopt the best practices laid down by the IAEA.

**There is no effective mechanism in place to prevent radioactive sources from getting out of regulatory control. The regulatory response mechanism to trace and discover lost and/or orphan radioactive sources in the country is also not effective.**

### 6.5 Acute shortage of Radiological Safety Officers

According to Rule 7 of RPR 2004, no licence to handle radioactive material or to operate radiation generating equipment, should be issued to a person unless, in the opinion of the competent authority, an RSO is designated in accordance with Rule 19 of RPR, 2004.

The duties and functions of an RSO are defined in Rule 22 of RPR, 2004 and Rule 13 of Safe Disposal of Radioactive Waste Rules, 1987 as detailed in Annex *6*. We observed that RSOs had been assigned enormous responsibilities under these rules for radiation protection and safe disposal of radioactive waste and they were vital links between the licencees and the regulator in securing compliance of the rules for radiation protection and safe disposal of radioactive waste. The regulator was mainly dependent on the RSOs in ensuring the compliance of various provisions under these rules.

We observed that the total number of RSOs finally approved for various types of nuclear and radiation facilities was not adequate to cover all the units of nuclear and radiation facilities. The number of RSOs approved by AERB and the number of similar units of nuclear and radiation facilities as on 31 March 2012 are given in Table – 9.

**Table - 9**

**Number of RSOs approved by AERB and number of units of nuclear and radiation facilities as on 31 March 2012**

| Sl. No. | Type of facility/ Application | No. of registered units | No. of approved RSOs |
|---|---|---|---|
| 1. | Nuclear Power Plants and Research Reactors | 19 | 34 |
| 2. | Other DAE facilities | 3 | 3 |
| 3. | Nuclear Fuel Cycle Facilities | 15 | 7 |
| 4. | Non-DAE Facilities (Beach Sand Mineral Facilities) | 23 | 21 |
| 5 | Radiotherapy | 319 | 363 |
| 6 | Industrial Radiography | 472 | 689 |
| 7 | Nucleonic Gauges | 1710 | 628 |
| 8 | Nuclear Medicine | 179 | 247 |
| 9 | Research Applications | 288 | 279 |
| 10 | Diagnostic Radiology | 6041 | 395 |
| Total | | **9069** | **2666** |

As may be seen from the above table, there was an acute shortage of qualified RSOs in comparison to the total number of registered units, indicating that most of the units of radiation facilities were working without RSOs.

DAE stated (February 2012) that the country had been facing a shortage of RSOs for a larger number of facilities like nucleonic gauges and diagnostic X-ray units etc. where, however, the radiation hazard was low. Training courses for RSOs were conducted by the Radiological Physics & Advisory Division of BARC, Mumbai, with lectures from AERB officers on radiation safety, but there were constraints in terms of limited space, manpower and long waiting lists. AERB was also exploring other ways of spreading awareness on radiation protection, especially to the users of diagnostic X-ray equipment.

The fact remains that RSOs have been assigned enormous responsibilities under these rules for radiation protection and safe disposal of radioactive waste and they are a vital link between the licencees and the regulator in securing the compliance of the rules for radiation

protection and safe disposal of radioactive waste. In the absence of this link, the effectiveness of the safety procedures followed cannot be ensured in these facilities.

**There is an acute shortage of Radiological Safety Officers, who should be designated for all radiation units as per the Rules.**

### Recommendations

10. The regulatory role of AERB may be strengthened by bringing the monitoring agencies viz. Health Physics Units, Environmental Survey Laboratories etc. under the direct control of AERB.

11. AERB needs to strengthen its infrastructure and manpower to conduct independent surveillance of exposure control and exposure investigation.

12. AERB may strengthen its system to ensure continuous updating of its inventory of all radiation sources till date to prevent radioactive sources from going out of regulatory control and ensure safe disposal of disused sources.

13. AERB may enhance awareness regarding safe handling and disposal of radioactive waste in the country.

14. AERB may take proactive action to ensure that the existing acute shortage in designating Radiological Safety Officers for radiation installation is addressed.