India's Nuclear Security Regime: Physical Protection and Crisis Management Measures

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Abstract

The security of nuclear and radiological materials is a critical global issue due to the growing number of existing and emerging threats in the nuclear domain. Within the broad domain of nuclear security, several challenges and threats—such as the physical protection of nuclear materials, insider threat, transportation security, and cyber threats—have raised concerns among governments and the international community. This report focuses on the physical protection of nuclear facilities and materials, including the need to maintain an effective physical protection regime and radiological security.

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Introduction

The security of nuclear and radiological materials is a critical global issue due to a growing number of existing and emerging threats in the nuclear domain. The International Atomic Energy Agency (IAEA) refers to nuclear security as "the prevention and detection of, and response to, criminal or intentional unauthorized acts involving, or directed at, nuclear material, other radioactive material, associated facilities or associated activities."[1]

Within the broad domain of nuclear security, several challenges and threats—such as the physical protection of nuclear materials, insider threat, transportation security, and cyber threats—have raised concerns among governments and the international community. This report will focus on the physical protection of nuclear facilities and materials, including the need to maintain an effective physical protection regime and radiological security.

Physical Protection of Nuclear Facilities

The physical protection of nuclear and radiological facilities is a key concern within the scope of nuclear security. According to the IAEA, threats to physical protection of nuclear facilities and materials entail "(a) The unauthorized removal of nuclear material with the intent to construct a nuclear explosive device; and (b) The sabotage of nuclear material and nuclear facilities resulting in radiological consequences."[2] The IAEA also provides four objectives for a State to maintain an effective physical protection regime, which include "(a) To protect against unauthorized removal. Protecting against theft and other unlawful taking of nuclear material; (b) To locate and recover missing nuclear material. Ensuring the implementation of rapid and comprehensive measures to locate and, where appropriate, recover missing or stolen nuclear material; (c) To protect against sabotage. Protecting nuclear material and nuclear facilities against sabotage; and (d) To mitigate or minimize effects of sabotage. Mitigating or minimizing the radiological consequences of sabotage."[3]

Given this context, the topic of physical protection is often a key consideration in discussions on nuclear and radiological security at the national and international level. In terms of international efforts to ensure physical protection, the Convention on the Physical Protection of Nuclear Material (CPPNM) and its Amendment is the primary legal instrument that requires parties to establish legal obligations for the "physical protection of nuclear material used for peaceful purposes during international transport; the criminalization of certain offences involving nuclear material; and international cooperation, for example, in the case of theft, robbery or any other unlawful taking of nuclear material or credible threat thereof."[4] Additionally, the CPPNM's Amendment extends the scope to include domestic use, storage, and transport. It also criminalises trafficking and sabotage offences of nuclear material and nuclear facilities.[5]

It is also important for India to ensure the physical protection of nuclear and radiological materials. India's nuclear power programme consists of 23 operable reactors (with a capacity of 6885 MWe), with an additional eight reactors (with a potential capacity of 6028 MWe) under construction.[6] Nuclear power plays a crucial role in meeting the country's energy requirements and achieving global sustainable energy goals. Additionally, radiological materials are widely used in India's civilian sectors for medical, agricultural, and research purposes. Given the extensive use and need for radiological and nuclear materials in India, it is vital to prevent the use of these materials for non-peaceful or harmful purposes.

Nuclear Materials and Facilities

A physical protection system (PPS) for nuclear materials in use and storage at nuclear facilities must protect against the unauthorised removal of nuclear material or sabotage of nuclear facilities.[7] The key functions of a PPS include interior and exterior intrusion detection sensors, cameras for assessment, delay measures, access control devices, and response measures. These functions are usually designed as automated subsystems designed to pass information to central alarm stations (CAS),[8] where operators can use them to respond appropriately. A PPS must also include secure means for operators to communicate with onsite and offsite response forces and for guards to communicate with each other and the CAS. A PPS integrates all physical protection measures and subsystems. Additionally, subsystems may be integrated within a PPS; for example, the intrusion detection system may be integrated with the access control system.

Subsystems in a PPS include:

- *Access Control System*: The access control system is a time and attendance system that determines and enforces access to security and vital areas inside a nuclear plant. To maintain a controlled and secure environment, movement is based on predetermined requirements within a PPS and enforced through double fencing, patrolling, security posts and watch towers.[9]

- *Intrusion Detection System:* An intrusion detection system (IDS) raises an alarm in case of an unauthorised intrusion in any critical area and provides information to security personnel. IDS consists of CCTV cameras across double-fenced areas and are automatically honed in case of a security breach detected by the corresponding intrusion detectors. It also allows for real-time acquisition, online monitoring of control units, fault monitoring, and maintaining a fault log.[10]

- *CCTV Surveillance:* A CCTV system is used for surveillance purposes and to monitor the double-fenced perimeter, the entry points to vital equipment areas and the essential equipment inside the plant. CCTV systems may include equipment such as outdoor cameras (with or without pan, tilt, zoom), indoor cameras for vital equipment areas, monitors connected to a CAS, and recording equipment to maintain a log of security footage.[11]

- *Guard Tour Monitoring System:* This system is provided to ensure that security guards make regular rounds along the perimeter of the operating areas. This system also ensures and maintains checks on whether the guards are performing their duties per the security requirements.[12]

- *Distress Alarm System:* This system is provided to annunciate audiovisual alarms at strategic locations to indicate duress or distress at other sites without drawing the attention of the person causing duress or distress. The system is easily accessible in areas under distress for activation but remains hidden from outsiders.[13]

- *Metal Detector System:* Such systems include walk-through and hand-held metal detectors to inspect individuals for any suspicious materials or goods that could be hazardous to the area. The system must be placed at all entry/exit points to secure the location's perimeter.[14]

- *Explosives Detectors System:* Explosive detectors located across a facility can help detect different kinds of explosives and relay information to security personnel to determine appropriate actions and emergency measures to protect the area and individuals.[15]

- *X-Ray Baggage System:* X-ray machines for baggage, parcels, and goods are used to check for contraband such as weapons, forbidden arms, and forbidden materials. This system ensures that no harmful objects enter sensitive areas.[16]

Security Forces

In India, the Central Industrial Security Force (CISF) has a special task force in addition to its regular forces to meet potential security threats of nuclear and radiological materials. The task force is prepared, active, and available round the clock. Each unit has existing standing orders for each duty post describing timing, turnout, duties for sub-inspectors, head constables and so on. Additionally, the CISF has prepared contingency plans for potential security threats or situations. For example, regarding radiological substances, the CISF trains personnel from the Bhabha Atomic Research Centre on how to handle radioactive sabotage adequately. Similarly, contingency plans are in place to counter intrusion, potential explosives, bombs, and civil unrest. The CISF also regularly holds drills and exercises to improve efficiency.[17]

Management and Inspection

Standing orders are in place for material tracing, accounting, material screening, personnel screening, information protection, and document control. For example, locks and keys can be managed through a key deposit or issue register. Additionally, daily site inspections and records of any visits must be maintained.

Vital Areas

Critical or sensitive equipment located within vital or protected areas must have measures such as double fencing isolation, physical barriers to the area, and no parking inside protected areas. Additionally, access to vital areas must be coordinated through control posts, and secure walkie-talkies can be used to strengthen the communication networks.[18]

Emergency Preparedness

In case of emergencies, it is important to perform safety aid and security control functions such as locking all turnstiles in case of a security emergency through a single command. Furthermore, additional security measures such as the requirement of an entry PIN (personal identification number) for designated vital areas and a door switch to exit for a predetermined time are useful.

Radiological Materials and Medical Facilities

In India, over 100,000 packages are transported annually with radioactive materials. The first kind are 'Type A packages', used for transporting moderate-activity radioactive materials such as nucleonic gauge sources, some brachytherapy sources used in hospitals, and nuclear medicine sources used for diagnostic and therapeutic purposes. 'Type B(U)/B(M) packages' are used to transport large activity radioactive materials such as teletherapy sources, gamma irradiators sources, and industrial radiography sources, as per the approval of the Atomic Energy Regulatory Board (AERB). The third kind are 'Type C packages' that are used to transport materials of very high radioactivity by air. They are designed to withstand severe accident conditions of transport.[19] In India, the commonly used radiation sources are Cesium-137, Cobalt-60, Tritium (H-3), Sodium-24, Bromine-82, Anthanum-140, Iodine-131, Molybdenum-99, Scandium-46, and Krypton-79.[20]

Radiological sources are greatly beneficial in cancer treatment. Radiation used for cancer diagnosis and treatment can be a great hazard if not used safely and correctly.

Table 1:
Diagnostic and research facilities using radioactive materials registered with AERB, per state and union territory

S. No.	State/Union Territory	Diagnostic Facilities Using Radioactive Materials	Research Facilities Using Radioactive Materials
1	Andhra Pradesh	11	1
2	Arunachal Pradesh	0	0
3	Assam	1	2
4	Bihar	2	0
5	Chhattisgarh	2	0
6	Goa	1	1
7	Gujarat	10	5
8	Haryana	6	3
9	Himachal Pradesh	1	2
10	Jammu and Kashmir	2	1
11	Jharkhand	2	0
12	Karnataka	20	21
13	Kerala	15	7

S. No.	State/Union Territory	Diagnostic Facilities Using Radioactive Materials	Research Facilities Using Radioactive Materials
14	Madhya Pradesh	7	2
15	Maharashtra	35	14
16	Manipur	0	0
17	Meghalaya	0	2
18	Mizoram	0	0
19	Nagaland	0	0
20	Odisha (Orissa)	3	2
21	Punjab	11	2
22	Rajasthan	5	0
23	Sikkim	0	0
24	Telangana	13	16
25	Tamil Nadu	22	14
26	Tripura	5	0
27	Uttar Pradesh	13	5
28	Uttarakhand	2	1
29	West Bengal	15	8
30	Delhi	27	10
31	Puducherry (Pondicherry)	1	1
32	Andaman and Nicobar Islands	0	0
33	Chandigarh	2	2
34	Dadra and Nagar Haveli	0	0
35	Daman and Diu	0	0

Source: Lok Sabha starred question no. 274[21]

Protecting radiological sources, materials, and radiation equipment is a dynamic process, not necessarily an output that can be quantified. It requires appropriate technical and structural protection measures to avoid dangers. Therefore, in India, facilities such as hospitals are required to submit detailed security and layout plans to the AERB to address security requirements such as physical barriers. To guide radiological facilities and activities, the AERB has produced safety codes, guidelines, and standards for regulation in India.[22] As per the Atomic Energy Act of 1962, handling radiological materials requires a license from the AERB.[23] Facilities also must have adequate space, detection and monitoring systems, and trained personnel to monitor the use of such equipment. It is crucial to appropriately train teams and relevant personnel on site at radiological units to ensure safety and security of the equipment and maintain logs on activity, procurement, and wastage.

Radiotherapy

Radiotherapy is a vital aspect of cancer management and treatment. It is important to ensure the use of ionising radiation is not a risk to the population and environment. Therefore, radioactive sources and radiation technologies must be handled safely across their lifecycle. The AERB is responsible for ensuring the safety and regulation of facilities using ionising radiation. To ensure the safety and security of radiation facilities, the AERB established the e-Licensing of Radiation Applications (e-LORA), an online, transparent system of regulatory processes for such facilities. The e-LORA system is "designed to automate the comprehensive business processes of radiological application regulations targeted to large number of facilities involved in use of ionizing radiation as well as radiation workers working with them for safe service."[24]

The e-LORA system provides the platform for radiation facilities to adequately address regulatory requirements and guidelines such as registration of institutes/facilities, personnel monitoring, site and layout plan approval, customs clearance, transportation, and equipment commissioning. Such requirements are essential to keep radiation sources safe and secure for each facility.[25]

Procurement of Source and Decommissioning

Implementing a safe and secure system for source procurement and eventual decommissioning and disposal is essential. For example, in source procurement, facilities must go through the due process of obtaining procurement permission of radioactive sources, supervising source transfer operations, intimating receipt of radioactive sources, and providing relevant information of operations. In the case of source replacement, they must also go through the stipulations outlined by the AERB to ensure the safety of facilities, individuals, and sources.[26]

Decommissioning and disposal are key concerns when looking at radioactive materials. Decommissioning involves "planning, physical and radiological characterization, facility and site decontamination, dismantling, and materials management."[27] A primary requirement is to ensure the safety and protection of staff personnel and the general population from the risks of radiation during decommissioning and disposal. Radiation facilities must, therefore, obtain consent for decommissioning; supervise source transfer operation; obtain transfer permission of disused radioactive source; provide details of transfer to relevant authorities; and intimate export, transport or disposal of source and decommissioning of equipment to relevant authorities. Additionally, a prerequisite for decommissioning and disposal approval is acceptance from the supplier to carry out decommissioning operations and accepting disused radioactive sources from the disposal agency.[28]

Tomotherapy and Cyber Knife Installation

Linear accelerators such as tomotherapy and cyberknife are revolutionising cancer treatment. As these methods of cancer and non-cancerous tumour treatment become more prevalent, they will require more stringent regulations for installation, licensing, and decommissioning, like other methods using ionising radiation. Like radiotherapy, these linear accelerators require site and layout approval, radiation safety officers, procurement permission, commissioning approval, submission of radiation survey levels, and obtaining licenses for equipment operation. Furthermore, facilities must also periodically renew existing licenses to continue operations.[29]

In case of decommissioning, facilities must obtain consent for decommissioning and transport permission of depleted sources, and intimate the AERB on the disposal and decommissioning of equipment.

Brachytherapy

Brachytherapy is a "branch of radiation therapy which relates to the uses of sealed sources for: (a) implants and intra-cavitary insertions, and (b) external mould/surface applications, in which the source to skin distance is not more than 5 cm."[30] Regulatory processes similar to that of tomotherapy and cyberknife installation are applicable for brachytherapy.

Nuclear Medicine

Nuclear medicine uses minute amounts of radiopharmaceuticals to examine organ functions and structure.[31] Radiation safety in nuclear medicine must ensure safety in the normal exposure of staff personnel and patients and the safety of radiation sources from hazardous exposure to the public and environment.

As a result, nuclear medicine facilities and institutions must provide periodic status reports on the sources and equipment. Additionally, as determined by the AERB, when a source is no longer in use for authorised purposes upon useful life completion, sources must be allowed to decay sufficiently (in case of short half-life radioisotopes) or returned to the original supplier (in case of sealed and long half-life radioisotopes). For sources that are not in use or are pending disposal, facilities must store these in an exclusive safe and secured storage area.[32]

Sources should only be transported from the authorised location for their approved purposes after obtaining specific licenses from AERB and must adhere to the requirements for safe transport as specified by the regulator. Furthermore, the AERB must be informed of any incident that involves the safety and/or security of radioactive sources (such as loss, theft, or misplacement) within 24 hours of the event.

Blood Irradiators

Blood irradiators are a type of Gamma irradiation chamber (GIC) involving the irradiation of blood and blood products by gamma rays to eliminate the risk of post transfusion grafts versus the host disease.[33] They are used in universities, academic and research institutions for research and development. They are subject to similar regulatory and operational requirements as tomotherapy, brachytherapry, and nuclear medicine. GIC manufacturers and suppliers are required to seek AERB approval for design. Additionally, the AERB stipulates specific radiation safety and regulatory requirements, provides guidance during the design stage, onsite and layout installation, and commissioning, operating, decommissioning, and disposing of disused GIC units.[34]

Notable Incidents with Radioactive Sources

On 9 December 2011, a fire at the AMRI Hospital in Kolkata, India, affected its radiation therapy facility. The hospital was equipped with radiation generating equipment and a high dose rate brachytherapy unit containing Iridium-192 source, but it did damage in the fire.[35] However, as a precautionary measure, the unit was recovered from the basement and shifted to another hospital in Kolkata. In response to this incident, the AERB suspended AMRI Hospital's license for operation of the radiotherapy equipment on 12 December 2011 until further notice.[36]

On 14 June 2016, a vehicle carrying a consignment of fluorodeoxyglucose (FDG) from an institution in Bengaluru, India, was stolen enroute to a hospital in Kerala. However, the FDG was retrieved shortly after in a safe manner with no damage to the consignment. The incident was reported to the IAEA's Incident and Trafficking Database.[37]

Conclusion

The AERB identifies its mission as the need to "ensure the use of ionizing radiation and nuclear energy in India does not cause undue risk to the health of people and the environment."[38] As the use of radiation technologies grows and the nuclear power sector expands, the safety and security of the materials and the need to protect the public and environment become more important. In addition, the sensitive nature of nuclear and radioactive materials necessitates effective measures and adequate discussions to protect against theft and misuse to avoid dangerous outcomes, such as nuclear terrorism or accidents with radiological consequences.

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