Overview of Regulatory Control for Radioactive Sources and Nuclear Materials for Peaceful Applications of Nuclear Technology

A. S. Mollah

Nuclear Safety and Radiation Control Division
Bangladesh Atomic Energy Commission
PO Box 158, Ramna, Dhaka-1000Bangladesh
asmollah@agni.com

ABSTRACT

With an increase in the use of nuclear energy, radiation and radioactive substances it is essential to invigorate, reinforce and enhance the effectiveness of elements of national radiation protection and safety infrastructure. This also includes the addition of feasible and affordable ways and means in the national safety infrastructure with subsequent strengthening in the future. In order to control radiation risks associated with such usage, i.e. normal exposures and potential exposures, it is essential that activities involving radiation exposures, such as production of and use of radiation sources and radioactive materials, and the operation of nuclear installations, including the management of radioactive waste, be subjected to established radiation safety measures in order to protect individuals exposed to radiation. The organization of basic radiation protection infrastructure is very important for every country. A short general information for regulatory control of radioactive/radiation sources and nuclear materials will be presented. Important elements of nuclear regulatory authority infrastructure are described in the report and in particular those explaining the licensing system, the enforcement programme, the basic radiological safety and security requirements, effectiveness of regulatory authority, performance indicators for nuclear regulatory authority and the key actions considered for the appropriate control of radioactive sources/nuclear materials. The use of nuclear energy and applications of its by-products, i.e. radiation and radioactive substances, continue to increase in Bangladesh. We have presented an overview of the national radiation protection infrastructure of Bangladesh. In this regard following are briefly discussed: legislation and regulations, regulatory framework, licensing system, inspection practices, enforcement action, occupational exposure control, medical exposure control, public exposure control, training in radiation protection, preparedness to radiological emergencies etc.) of the Nuclear Regulatory Authority under Bangladesh Atomic Energy Commission (BAEC) will be given.

1 INTRODUCTION

The use of radioactive sources is now commonplace throughout the world. Such sources are in widespread use in medical practice, in agriculture, in research and education, and in numerous industrial applications. Although these sources are potentially useful, they are also potentially harmful if misused or if misplaced or stolen. Despite strong efforts by the IAEA and others, much work remains to establish effective national and international control over radioactive sources/nuclear materials.

Public attention is often more closely focused on the radiation and environmental hazards associated with the nuclear fuel cycle and particularly with the dangers arising from nuclear power reactors, than on those associated with radiation sources. Nuclear reactors contain substantial amounts of radioactive material under conditions of pressure and temperature that could cause very serious adverse consequences for a substantial number of people in an accident. Notwithstanding this focus of public attention on nuclear reactors, it should be mindful that the public health issues associated with radioactive sources also are important and should command attention commensurate with the radiation hazard pose.

The control of radioactive sources poses challenges on both national and international scales. The public is generally unaware of the widespread use of radioactive sources and the hazard that their misuse can pose. As a results, the public and political pressure in support of legislative or regulatory action in this area, in contrast to that brought to bear in the power reactor arena, has not been strong.

Under these circumstances regulatory authorities have not always been able to devote the resources to the control of radiation sources that the hazards deserve. Although all countries have a vested interest in protecting their citizens from radiation exposure due to misused, misplaced, or stolen radioactive sources, controls are not as effective as they should be. There is a lack of an awareness of the radiation hazards posed by these devices, limited experience in regulating such sources, and limited resources to do the job. The IAEA has noted that many countries are thought to lack effective control over radiation/radioactive sources because most do not have the required infrastructure [1]. Each of us also an interest in the adequacy of controls in other countries because commerce in radioactive/radiation sources and devices is conducted on a global scale and no country can effectively prevent contaminated products from crossing its borders. There is thus an international challenge to heighten the global awareness of the radiation hazard posed by radioactive/radiation sources, to attempt to bring some consensus on how these hazards are to be addressed, and to initiate improvements in the regulatory systems throughout the world. The IAEA is in the forefront of efforts to define the problem on a global scale and is helping Member States to work towards effective solutions. The International Basic Safety Standards (BSS) for Protection against Ionizing Radiation and for the Safety of Radiation Sources of 1996 became a milestone in international efforts towards harmonization of radiation protection and safety standards [2]. To be in compliance with BSS, a national radiation safety infrastructure should correspond to the level of usage of radiation and radioactive materials.

2 APPLICATIONS OF NUCLEAR TECHNOLOGY

Radioactive sources are used throughout the world for a wide variety of peaceful and productive purposes in industry, medicine, research and education. These sources utilize radioactive materials that are firmly contained or bound within a suitable capsule or housing; although some sources involve radioactive materials in an unsealed form. Until the 1950s, only radionuclides of natural origin, particularly radium-226, were generally available for sources. Since then, radionuclides produced artificially in nuclear reactors and accelerators have become widely available, including cobalt-60, strontium-90, technicium-99m, iodine-131, caesium-137, iridium-192, etc. Nuclear materials are used in nuclear reactors for research, isotope production and generation of electricity. The use of nuclear energy to produce electricity also has a significant impact on the economy. Research reactors comprise a wide range of civil and commercial nuclear reactors which are generally not used for power generation. The primary purpose of research reactors is to provide a neutron source for research and other purposes. Research reactors are simpler than power reactors and operate at lower temperatures. A nuclear reactor produces and controls the release of energy from splitting the atoms of certain elements. In a nuclear power reactor, the energy released is used as heat to make steam to generate electricity.
A brief information on peaceful applications of nuclear technology to different fields is given in the following sections.

2.1 Medical Application

The radioactive materials/radiation sources used in medical applications are either by-product material (produced in a reactor)/ accelerator produced material, or radiation-producing machines such as X-ray machines/accelerators. Medical use of radioactive materials/radiation producing machines falls broadly into two categories: diagnostic and therapeutic procedures. Diagnostic procedures using radioactive materials, such as those used in nuclear medicine, involve the use of relatively small amounts of radioactive materials to facilitate imaging of certain organs. Diagnosis is one of the main uses of nuclear medicine. When a patient is injected with a radioactive element, a special camera can take pictures of the internal workings of the organ. Radionuclides in a stronger form also can be used to treat disease. In diagnostic radiology, diagnostic procedures involve the use of X-ray machines to facilitate imaging of certain organs. Therapeutic uses of radioactive materials include teletherapy, brachytherapy and therapeutic nuclear medicine. In **teletherapy**, an intense beam of radiation, from a high-activity radioactive source/radiation producing machines external to the patient, is focused on the cancerous tissue. In **brachytherapy**, radioactive sources are placed close to, or

within, cancerous tissue, such as in the breast, prostate, or cervix. In **therapeutic nuclear medicine**, high dosages of radioactive materials are injected into, or ingested by, the patient.

2.2 Industrial Application

Today, practically every industry uses radioactive materials. Because radiation loses energy as it passes through substances, industry has been able to develop highly sensitive gauges to measure the thickness and density of many materials, as well as imaging devices to inspect finished goods for weaknesses and flaws. Small amounts of a radioactive substance are commonly used as tracers in process materials. They make it possible to track leakage from piping systems, monitor the rate of engine wear and corrosion of processing equipment, observe the velocity of materials through pipes and gauge system filtration efficiency.

2.2.1 Portable Moisture/Density Devices

These devices contain the sources, detectors and electronic equipment necessary for the measurement. The source is physically small in size, typically a few cm long by a few cm in diameter, and may be located either completely within the device or at the end of a rod/handle assembly. The small size of the device makes it susceptible to loss of control or theft.

2.2.2 Industrial Fixed Gauges

Industrial gauges are used for process control; for measurement of flow, volume, density, or material presence; and may be placed in locations unsuitable for continuous human presence (e.g.: in a blast furnace). The locations of such devices or sources within a facility may not be recognized, since the devices may be connected to process control equipment. This lack of recognition may result in a loss of control if the facility decides to modernize or terminate operations.

2.2.3 Industrial Radiography Cameras

The use of radiography sources and devices are very common, and their portability may make them susceptible to theft or loss. The small size of the source allows for unauthorized removal by an individual, and such a source may be placed into a pocket of a garment. Industrial radiography may also be performed in fixed installations, either using the same small portable devices, or using larger radiaiton generating machines.

2.2.4 Well Logging Devices

These devices are generally found in areas where exploration for minerals is occurring, such as coal, oil, natural gas. The sources are usually contained in long (1–2 m, typically) but thin (<10 cm in diameter) devices that also contain detectors and various electronic components. The actual size of the sources inside the devices is generally small which allows for unauthorized removal by an individual.

2.2.5 Other Industrial uses of Radioactive Materials

- The automobile industry uses radioactive materials to test the quality of steel in cars.
- Aircraft manufacturers use radiation to check for flaws in jet engines.
- Mining and petroleum companies use radionuclides to locate and quantify mineral deposits.
- Can manufacturers use radioactive materials to obtain the proper thickness of tin and aluminium.
- Pipeline companies use radioactive materials to look for defects in welds.
- Oil, gas and mining companies use radioactive materials to map geological contours, using test wells and mine bores, and to determine the presence of hydrocarbons.

- Construction crews use radioactive materials to gauge the density of road surfaces and sub-surfaces.

2.3 Agriculture

Radionuclides are a basic tool for agricultural scientists around the world. Among their many uses:

- Hundreds of new varieties of hardier, more disease-resistant crops—including peanuts, tomatoes, onions, rice, soybeans and barley—have been developed in agricultural research laboratories through the use of radioactive materials.
- Radioactive materials have been used to improve the nutritional value of some crops, as well as improve their baking or melting qualities or reduce their cooking time.
- To breed disease-resistant livestock, scientists use radioactive material to pinpoint where illnesses strike animals.
- By showing how plants absorb fertilizer, radioactive materials help researchers learn when fertilizer should be applied and how much is needed. This helps prevent the overuse of fertilizers, a major source of soil and water pollution.
- Radioactive materials help farmers and scientists control insect pests. Unlike chemicals, which can leave unhealthful residues in the soil, on plants and in water, this technology does not pollute.

2.4 Research and Development

Nuclear technology using radioactive materials/nuclear materials including radiation producing machines plays a key role in the development of national economy. Nuclear reactors and radioactive materials are being widely used for research and development activities. Radioactive materials are essential to the biomedical research that seeks causes and cures for diseases like AIDS, cancer and Alzheimer's disease. Radionuclides are also used extensively in metabolic studies, genetic engineering and environmental protection studies. Criminal investigators use radiation to examine physical evidence and to link suspects to crimes. Museums rely on radioactive materials to verify the authenticity of paintings and art objects.

3 REGULATORY CONTROL

In normal and regulated use, radioactive sources/nuclear materials pose no undue radiological hazard to workers or the public. Problems can arise if radiation sources are involved in accidents, and if they become damaged or lost. Some of these sources contain large amounts of radioactive material and have the potential to cause serious radiological harm if they were involved in accidents or used in malicious acts.The major challenge that will need to be addressed is how to regulate and control the radiation/nuclear activities in order to reduce radiological hazards. In this regard, the national nuclear regulatory authority can play a key role for controling of radioactive materials and nuclear materials for peaceful applications of nuclear technology.

3.1 Nuclear Regulatory Authority

The role of the nuclear regulatory authority (NRA) is well defined in the national law for peaceful use of atomic energy of each country. Institutional independence, capability and adequate resources are necessary requirements for an effective NRA. Different situations exist in various countries regarding the institutional status, the organization and the technical resources of the NRA. In terms of role and functions the NRA covers many aspects including among others:

- the regulatory activity related to definition of safety objectives, principles and criteria issuing regulations and regulatory guidelines;
- the licensing activity related to safety evaluation of design, construction

and operation of radiation/nuclear installation,

- the inspection and enforcement during construction and operation of radiation/nuclear installation

The NRA generally can not face all the aspects related to its role and function with only internal resources: the need for technical and scientific support becomes important, also considering the development of the international cooperation in all areas of concern to put together resources and experience for common programs and harmonize the regulatory approaches. The nuclear regulatory authority should be empowered to establish standards and enforce their application to the possession and use of radiation sources/nuclear materials [3-4]. The regulatory goals are:

- to ensure that radioactive/nuclear materials are imported, exported, produced, transferred, stored, used, or disposed of only by registrants or licensed persons at authorized licensed installation, as required by national regulations;
- to ensure that registrants or licensees do everything reasonable and within their capabilities regarding the safety and security of radiation sources;
- to ensure that radioactive materials are transferred to another user or disposed of as radioactive waste only when the transfer or disposal has been specifically authorized by the NRA;
- to keep an updated database on all the sealed radioactive sources/nuclear materials;
- to prevent illicit trafficking in radioactive/nuclear materials;
- to ensure the safety and security of disused sealed radioactive sources, doing whatever is necessary in order to maintain the required controls; and
- to ensure that the technical characteristics of imported and locally produced radioactive sources comply with international safety requirements.

In developing an appropriate regulatory system, consideration should be given to the diversity of radioactive sources and the relative hazards the sources pose to the public if loss of control occurs. In this way, the level of regulatory rigor applied to various devices can be commensurate with the radiation hazard they pose. Priority must be given to sources that represent a threat to human life from acute radiation exposure if they are misused, lost, or subject to improper disposal. Resources must be devoted not only to the development of the regulatory system, but also to undertaking inspections and ensuring accountability. An important and often overlooked component is the need to educate the users of sources about the dangers that the sources pose so as to encourage both safe use and proper disposal. Key to the success of all these activities is the dissemination of information through established lines of communication between and among licensees and regulators.

3.2 Licensing System

The regulation should stipulate that any person or organisation using radioactive sources in medicine, industry, agriculture and research must have an authorization or license issued by the NRA. The NRA may grant licences and authorizations only to applicants (responsible organizations) that fulfil the safety and security requirements established in the national regulations. The licensing system should require that potentially high-risk installations (e.g. industrial irradiation facilities, radiation therapy units, gamma radiography facilities etc.) be constructed, commissioned, operated or decommissioned only after the relevant license or authorization has been granted by the NRA. Licensees must comply with the conditions, standards and requirements established by the NRA. Workers must be qualified and adequately trained for the job. Under the sanctions regime in force, non-compliance may be enough for the NRA to suspend or cancel the licence. Lower risk installations (e.g. oil well logging units, gauges) may be operated only after the NRA has granted the corresponding authorization. The applicants (the responsible organization) must, as the person responsible for the safety and security of radiation sources, an individual who has a permit for the practice in question. The responsible organization must supervise that individual's performance and provide the support necessary for the performance of his/her duties.

3.3 Inspection and Enforcement System

The purpose of the inspections performed and enforcement actions taken by the NRA is to verify whether the responsible organization is complying with the regulations and requirements and doing all it can to avoid situations that could lead to radiological accidents. Deterrence through the possibility of sanctions imposed on persons or organizations for non-compliance with regulations helps to prevent accidents. Inspections can be performed periodically depending on the risk associated with the practice in question-for example, gamma radiography facilities and radiation therapy units are inspected (more or less at random) once a year, while oil well logging units and nuclear medicine centres are inspected every two years. The inspectors should look into safety issues such as user's individual permits, radioactive contamination, the shielding integrity, safety interlocks, approved sign displays, radiation monitors, occupational dose records, abnormal event log books etc. They also should look into security issues such as sealed source inventories and security measures to prevent burglaries at radioactive source storage sites.

Enforce actions fall into four broad categories:

1. The licensee or registrant is requested, usually during an inspection, to correct minor deviations from the regulations.
2. The licensee or registrant is required, immediately after a safety review, to correct safety problems or to stop committing minor safety violations and to take the necessary corrective action promptly.
3. The licensee's or registrant's authorization is withdrawn temporarily in order to avoid health risks to workers or the general public (inspectors can withdraw an authorization, but they should act cautiously in the case of medical practices owing to the possible detriment o the health of patients)
4. The licensee or registrant is required to dispose of or store any disused radioactive source at the national disposal site

4 KEY ACTIONS FOR THE APPROPRIATE CONTROL OF RADIOACTIVE SOURCES/NUCLEAR MATERIALS

- The NRA should work closely with the Customs Authority for importing and exporting radioactive materials;
- The NRA should work closely with the Border Security Force and the Coast Guard, for the purpose of preventing illicit trafficking in radioactive sources;
- The NRA promotes the installation of radiation monitors at points of entry (by sea or by road) in order to prevent illicit trafficking in radioactive sources, to detect orphan sources in imported scrap and to impede the importation of radioactively contaminated materials;
- The NRA encourages the installation of portal monitors at steel mills in order to detect orphan sources in the scrap used in steel-making; and
- The NRA should take the lead and enhance co-operation and co-ordination with stackholders and other government agencies for capacity building in case of radiological emergency.

5 REGULATORY PERFORMANCE INDICATORS

In order to identify meaningful and measurable performance indicators (PIs) it is necessary for a NRA to identify all of its stakeholders and the expectations that each stakeholder has about the interactions between them. Once a regulator has established such a suite of PIs it can use them to attempt to determine the added value that it contributes to the overall safety system. A performance-based management approach applied to decision making processes, which also permeates its organizational culture and performance history enables the regulatory body:

- To have a clear, well-defined and predictable regulatory regime;
- To focus attention on the most important risk-significant safety related activities of utility organizations;

- To establish objective criteria for evaluating the performance of utility organizations.
- To provide a feedback mechanism for evaluation of direct and indirect influences of regulatory actions on maintaining and improving the safety of nuclear power plants; and
- To identify utility organizational and cultural problems affecting safety.

5.1 Categorization of Performance Indicators

Performance indicators can be categorized in two headings: *direct* and *indirect* indicators.

- *Direct* performance indicators attempt to measure the regulator's own activities and tend to use data generated within the regulatory body itself, while
- *Indirect* performance indicators rely on the PIs of other stakeholders, principally the licensees, to deduce the performance of the regulatory body.

The advantage of direct PIs is that they can provide a relatively unambiguous measure of relevant aspects of the regulator's performance. The problem with most of them is that they do not provide insights into the regulatory body's fundamental mission and desired outcomes in terms of risk reduction or safety achievement amongst its licensees. On the other hand, while indirect PIs can shed light on such desired regulatory outcomes, they must be treated with great caution in order to isolate the contribution of the regulatory body to the achievement of the eventual outcome.

5.2 Possible Indicators of Regulatory Effectiveness

A regulatory authority is effective when it:

- Ensures that an acceptable level of safety is being maintained by the regulated operating organizations;
- Develops and maintains an adequate level of competence.
- Takes appropriate actions to prevent degradation of safety and to promote safety improvements.
- Performs its regulatory functions in a timely and cost-effective manner as well as in a manner that ensures the confidence of the operating organizations, the general public, and the government.
- Strives for continuous improvement in its performance.

5.3 Possible Indicators of Regulatory Efficiency

Though it is useful, for organizational analysis, to define *effectiveness* and *efficiency* as two separate attributes of a regulatory organization, there is no doubt that they merge together when one attempts to define possible direct indicators of regulatory effectiveness. So the regulatory body needs to analyze very carefully what are its expected (and, if possible, agreed) outputs with regard to each of its stakeholders before attempting to set up performance measures related to them. It might then utilize indicators such as:

- The timely and efficient processing of the licensees' "safety business" (meeting deadlines, avoiding inefficient interactions with licensees, having the correct regulatory expertise available in a timely/ properly trained way, using proper prioritization of safety issues, etc.).
- Creating an environment that makes it easier for licensees to get their safety submissions "right first time" (clarity of published regulatory standards and requirements, well-understood regulatory procedures, consistent and predictable regulatory decision-making and so on).
- Meeting internal standards of quality, cost and timeliness for producing technical reports, decision documents, public hearing documents and so on.
- Meeting internal standards of quality, cost and timeliness for informing/communicating with the public.
- Meeting internal standards of quality, cost and timeliness for necessary enforcement actions (working to an agreed enforcement strategy with pre-defined "success" criteria).

- Meeting agreed standards of quality, cost and timeliness for other activities such as assisting/advising other government departments, parliamentary select committees, international work, research activities, etc.
- Meeting agreed standards of quality, cost and timeliness for dealing with correspondence from members of the public, Concerned Action groups, etc.

6 BANGLADESH EXPERIENCE

Let me now turn to some of the initiatives [5-8] that the Bangladesh is taking to control over radioactive sources/nuclear materials.

6.1 Legislative and Regulatory Infrastructure

The Nuclear Safety and Radiation Control Act No. 21 of 1993 and the Nuclear Safety and Radiation Control Rules of 1997 (SRO-205/Law) are the main legal and administrative instruments in force in the area of nuclear safety and radiation control [9-10]. The Nuclear Safety and Radiation Control (NSRC) Rules are in general consistent with the International Basic Safety Standards for Protection Against Ionizing Radiation and for the Safety of Radiation Sources (BSS) [2]. In the legislation the Competent Authority has been given effective empowerment including the introduction of enabling rules and regulations to facilitate implementation of different provision of the law and the rules.

In Bangladesh, the NSRC Act establishes requirements for protection of health, safety, security, the environment and the fulfillment of international obligations. The Bangladesh Atomic Energy Commission (BAEC) is the regulatory authority that is mandated by the NSRC Act to:

- regulate the development, production and use of nuclear energy in Bangladesh;
- regulate the production, possession, use and transport of nuclear substances, and the production, possession and use of prescribed equipment and prescribed information;
- implement measures respecting international control of the development, production, transport and use of nuclear energy and nuclear substances, including measures respecting the nonproliferation of nuclear weapons and nuclear explosive devices;
- disseminate scientific, technical and regulatory information concerning the activities of the BAEC and the effects on the environment and on the health and safety of persons, of the development, production, possession, transport and use referred to above; and
- promulgate regulations, issues guidance, and disseminates information.

The existing NSRC Act entrusted Bangladesh Atomic Energy Commission (BAEC) with the responsibility to enforce it. BAEC in turn has established the Nuclear Safety and Radiation Control Division (NSRCD) to implement the Act. An amendment to the law is envisaged, which, among others, aims at establishing an independent regulatory authority. In order to enhance accountability, the BAEC has developed a registration programme for improved tracking for licensed sources that pose a significant hazard to public health and safety. Information required for registration includes the address or location at which the devices(s) are used and /or stored. Registration provides the BAEC with reasonable assurance of licensees continuing accountability. Among the major activities conducted by the BAEC staff organization is the development and maintenance of a clear, pragmatic and comprehensive regulatory framework. This framework not only includes the NSRC Act and its regulations but also regulatory standards, policies, guides and, in cooperation with Ministry of Foreign Affairs, international nuclear agreements for which the BAEC is the competent implementing authority.

All the above legislation is based on the IAEA standards and recommendations. Moreover, Bangladesh has ratified, signed or participates in a number of International Conventions, Protocols, Agreements and other Instruments in the area of nuclear energy and ionizing radiation

6.2 Regulatory System

The regulatory activities are designed in line with the main regulatory instruments, such as, Notification, Authorization, Inspection and Enforcement.

6.2.1 Notification

The system of notification for effectively identifying and locating radiation sources subject to regulatory control is very well in place. Users of radiation sources and machines notify the BAEC through application for import and authorization for practice. Arrangement is made with the Customs Authority of Bangladesh, so that any importation of radiation sources and equipment is subject to the clearance and approval of the BAEC. The BAEC has an organized inventory of sources and equipment and periodically update the source/equipment user and inventory status.

6.2.2 Authorization

According to the requirements of the NSRC Act, it is prohibited to produce, operate, market, store, assemble, maintain, repair, recycle, and transport sources of ionizing radiation and handle (collect, sort, treat, keep, recycle, transport, store and decontaminate) radioactive waste without a license issued by the BAEC. The BAEC has the right to suspend or repeal the license, when the licensee does not follow the licensing conditions until these conditions will be re-established. BAEC has developed a system of authorizing practices by registration or license. A final set of procedural guidance documents, which incorporates the radiation protection requirements, safety assessment protocols, as well as application forms, and practice specific guides are designed and currently put in practice.

6.2.3 Inspection

BAEC has established and activated inspection plan and priority listing, based on the degree of radiation hazard associated with the practices and past inspection history. Now all practice facilities and sources are routinely inspected once in a year and the frequency can be increased based on the degree of hazards associated with practices. Inspections are carried out following appropriate procedural and technical guidance documents and a system of monitoring are in place to ensure that inspection findings are communicated to the users in a timely and clear manner.

6.2.4 Enforcement

BAEC has developed a coherent set of strategies to progress enforcement actions in a step-by-step incremental manner. An enforcement guide is now in use to maintain consistency and objectivity. Regularly improving the enforcement guide document is also a follow-up task for BAEC to ensure continual improvement. On the basis of results of performed inspection the inspection protocol is filled in and time period for eliminating violations of the requirements of radiation protection and source safety is determined. If it is not done within prescribed time, the BAEC has the right to suspend or repeal the license and impose a fine.

6.2.5 National Inventory

Registration of radiation sources and radioactive materials has started in 1999 by distributing questioners to different institutions and departments in the country and simultaneously issuing calls by public media or by site visit. Since then the inventory has been regularly updated and currently the inventory of about 99% of radiation sources and radioactive materials in the country is accounted. The BAEC has now fully implemented the Regulatory Authority Information System (RAIS), which provides a systemic integration and will be instrumental to enhance the effectiveness of the regulatory system.

All users performing their activities with sources of ionizing radiation shall present all necessary data to the NRA after annual inventory of the sources, after installation, decommissioning or after disposal of the disused sources, after finishing the activities with the generators of ionizing radiation.

6.3 Control of Radioactive/Radiation Sources and Nuclear Materials

i. Radioactive/Radiation Sources

BAEC requires that anyone wishing to use a radioactive/radiation source be authorized to possess and use the source for specific reasons. In the case of high-risk sources, the BAEC verifies that the individuals or organizations are legitimate entities with valid reasons to possess the source, they are qualified to carry out authorized activities, and they will take adequate provisions to ensure health, safety and security. The BAEC also assesses the security risk associated with the storage and transportation of radioisotopes. Where warranted, BAEC staff has required licensees to enhance physical protection measures to reduce that risk.

The BAEC's risk-based regulatory program as it pertains to radioactive sources (sealed and unsealed) is consistent with internationally recognized principles, such as the International Atomic Energy Agency (IAEA) risk-based categorization of radioactive sources as documented in IAEA TECDOC-1344. The BAEC has adopted a life-cycle cradle-to grave approach to regulating radioactive sources to assure safety and security in the use of radioactive sources. Every stage of the lifecycle of radioactive sources -from production, distribution, use, possession and disposition - has its own unique needs for regulatory control and security. The BAEC has determined and assessed the nature and significance of the safety and security risks and acted accordingly. The BAEC processes are configured to ensure that regulatory controls and strategies are effective and appropriate for the levels of risk posed by different categories of sources at each phase of the source's lifecycle.

In September 2003, the IAEA Board of Governors approved the non-binding *Code of Conduct on the Control of the Safety and Security of Radioactive Sources.* Fundamental to this Code of Conduct is the principle that sources of differing magnitude designed for specific uses engender different risk to users and the public. Among other things, the Code of Conduct calls on regulatory bodies to develop national registries for high-risk radioactive sources that seek to track their location, movement and disposition. Such tracking will be a valuable component in providing safety and security controls over these types of sealed sources. During the transfer and use of radioactive sources regulatory bodies must ensure that adequate source tracking is carried out. This is accomplished by requiring the manufacturers and distributors to:

- manufacture sources with unique identifiers;
- obtain authorization information for the possession and use by users;
- provide transaction records to the regulatory body; and
- maintain record of disposition of the returned sources.

Bangladesh, along with many other Member States of the IAEA, has since undertaken to abide by the Code of Conduct and to work towards its full implementation. The BAEC is currently developing a tracking system for high-risk sealed sources over all phases of the source life-cycle, building on current industry experience and consulting with other regulatory bodies.

ii. Nuclear Materials

The BAEC ensures that measures are taken to ensure the physical protection of nuclear materials. As part of BAEC's continuous monitoring activities, a comprehensive review of physical protection measures at all nuclear facilities was recently undertaken using a risk-based approach. As a result of this review, nuclear facilities in Bangladesh were divided into several risk-related groups and the physical protection measures for each type of facility and nuclear material were enhanced accordingly. The security risks to nuclear facilities in Bangladesh have been further minimized as a result of enhanced physical protection measures required of licensees.

The BAEC is designated as the agency responsible for State System of Accountancy for and Control of nuclear material in Bangladesh and as the competent technical authority for implementing the relevant provisions of Safeguards Agreement and Additional Protocol with the IAEA. These provisions include accounting for and control of

nuclear material through a detailed accounting and reporting system. This system has recently been upgraded to meet contemporary IAEA requirements and future needs.

The BAEC processes information from nuclear facility operators and other users of nuclear materials reporting on inventories and transfers of materials subject to safeguards. Reports are submitted to the IAEA and form the basis for IAEA safeguards inspections in Bangladesh. The BAEC is also responsible for reporting and implementing regulatory control measures under the Additional Protocol which extends beyond the traditional nuclear material accountancy and verification framework
.

6.4 Control of International Transfers of Radioactive Sources and Materials

i. Export and Import of High-Risk Radioactive Sources

BAEC is the authority responsible for the regulatory control of all imports and BAEC licenses the import and export of radioactive sources (sealed and unsealed) by way of general licensing. The IAEA *Code of Conduct on the Safety and Security of Radioactive Sources* establishes specific requirements for controlling the export and import of high-risk radioactive sources. BAEC supports detailed harmonized guidance for this purpose, such as that put forth in the IAEA's *Guidance for the Import and Export of Radioactive Sources in Accordance with the IAEA Code of Conduct on the Safety and the Security of Radioactive Sources.* The BAEC is reviewing its practices to ensure that they fully reflect Bangladesh's commitment to the Code of Conduct, including in particular the licensing of exports and imports of high-risk radioactive sources.

ii. Export and Import of Nuclear Materials

Under the NSRC rules, a set of technical regulations have been established for controlling exports and imports of nuclear materials. These regulations establish licensing requirements over nuclear material (and other nuclear goods and technology) that enable the BAEC to implement Bangladesh's bilateral and multilateral obligations in treaties, conventions, agreements and other arrangements. Health, safety and environment considerations apply primarily to the intended end-use of imported nuclear material and to the transportation aspects of international transfers. Security requirements reflect Bangladesh's undertakings in the *Convention on the Physical Protection of Nuclear Material* and domestic nuclear security regulations.

7 PROVISION OF RADIATION PROTECTION SERVICES

BAEC provides a range of radiation protections services available to support the mandated regulatory functions of NSRCD and for the licensed radiation source users. A substantial progress has been made in the development and provision of support and technical services in the following areas:

7.1. Individual Monitoring and Calibration Services

Individual Monitoring of the exposed workers is an obligation of the licensee or the employer as per NSRC rules. Individual monitoring of radiation workers involved in radiological and other activities is being provided by BAEC with TLD technique. The current estimate of total number of radiation workers need to be monitored is about 4000 and a total of 3000 workers were so far getting this service monthly. The results for the recent years show a continuous improvement and the occupational exposure doses are generally very low, compared to the established dose limits.

BAEC has established a SSDL, obtained calibration factors from IAEA laboratory and embarked at a level of rendering a regular calibration services to the domestic users. This will enhance the quality and reliability of the radiation protection programme in place.

7.2 Medical Exposure Control

Management of Quality Assurance system in medical practices is one of the key systemic elements for ensuring effective medical exposure protection and control. Besides exercising direct regulatory control, for advancing the medical exposure control programme in a sustaining manner BAEC has placed emphasis on the establishment of a national capacity for quality control in medical practices.

7.3 Public Exposure Control

BAEC ensures adherence of the regulatory requirements to control any public exposure delivered by a practice or source. Through the regulatory programme ensures the establishment, implementation and maintenance of protection and safety policies, procedures and technical and organizational arrangements in relation to public exposures. Moreover, public exposure control was assured by through an effective authorization of the safety and design of buildings, plants and installations, approval of correct operational procedures, and safety and security inspections.

BAEC extends its regulatory control in the transport of radioactive materials in line with the IAEA transport regulations. The technical capabilities for ensuring public exposure control have been developed in the area of waste management, environment and food monitoring and consumer goods control.

7.4 Emergency Preparedness and Response

With the number of sources, which are in use at present and the possible increase in the future, the likely-hood of some emergency cannot be ruled out. An organized structure for emergency response does not exist. However, BAEC is the contact point in the event of such emergencies. To close this gap, NSRCD has already drafted a National Radiological Emergency Preparedness and Response Plan and elaborate the mechanism for subsequent approval by the appropriate bodies in the near future.

7.5 Training in Radiation Protection

Persons who are responsible for nuclear, radiation, transport or radioactive waste safety should have adequate level of understanding of concepts relating to protection and safety. Additionally persons engaged in any profession would need an appropriate level of work experience before they can adequately fulfill their task efficiently. Training and re-training of the radiation workers/regulatory staff is an essential component of a forward-looking radiation protection infrastructure. The BAEC offers a wide range of training courses in radiation protection and safety for radiation users.

8 CONCLUSION

Radiation sources and devices containing radioactive materials/nuclear materials can provide important benefits to individuals and societies when they are properly designed, safety used, and carefully managed. Effective national and international programmes are needed to ensure these characteristics, however, because these sources and devices can represent a significant hazard to public health and safety. International programmes to facilitate the exchange of information and experience among local, national, and international bodies are central to ensuring effective co-operation on the control and security of radioactive materials.

In Bangladesh, NSRC Act and Rules are now in place to control the use of radioactive/radiation sources and nuclear materials. In Bangladesh, during past 5 years a significant progress has been achieved regarding the harmonization of the national radiation protection infrastructure with the requirements of the Nuclear Safety and Radiation Control Act and Rules to cover the essential features such as implementation of NSRC Act, updating of the inventory of radiation sources, occupational exposure control, medical exposure control, public exposure control, emergency response plan and training of personnel. Intensive co-ordinated activity for establishing of the new law, independent regulatory authority is underway.

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