FNCA Consolidated Report on Radiation Safety

March 2014

Radiation Safety and Radioactive Waste Management Group, Forum for Nuclear Cooperation in Asia (FNCA)

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I. Preface

Through the activities of Radiation Safety and Radioactive Waste Management (RS & RWM) Group in the Forum for Nuclear Cooperation in Asia (FNCA), we present the book of “The Consolidated Report on Radiation Safety and Radioactive Waste Management in FNCA Countries”. The purpose of this report is a summary of this region based on the mutual understanding on RS & RWM in FNCA countries. The authors believe the reference of this book will cause further improvements of radiation safety and radioactive waste managing level in FNCA countries.

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Project Leader for Japan
Toshiso KOSAKO
(The University of Tokyo)

II. Framework of Regional Cooperation under FNCA

1. Introduction of FNCA

The Forum for Nuclear Cooperation in Asia (FNCA) has evolved from the International Conference for Nuclear Cooperation in Asia (ICNCA) which was established in 1990 with the aim of promoting the application of nuclear technology through collaboration among Asian countries. During this period the sharing of information, exchanges of scientific personnel and active cooperative research have been pursued in several fields.

2. Participating Countries

Australia, Bangladesh, China, Indonesia, Japan, Kazakhstan, Korea, Malaysia, Mongolia, Philippines, Thailand and Viet Nam

3. Goals

- To achieve socio-economic development by safe utilization of nuclear technology
- To utilize nuclear technology in those fields where it has a distinct advantage
- To respond to the needs of the FNCA countries

4. Operational Strategies

1) Framework of Operation

The basic framework of cooperation consists of the following three:

❑ **Forum meeting**

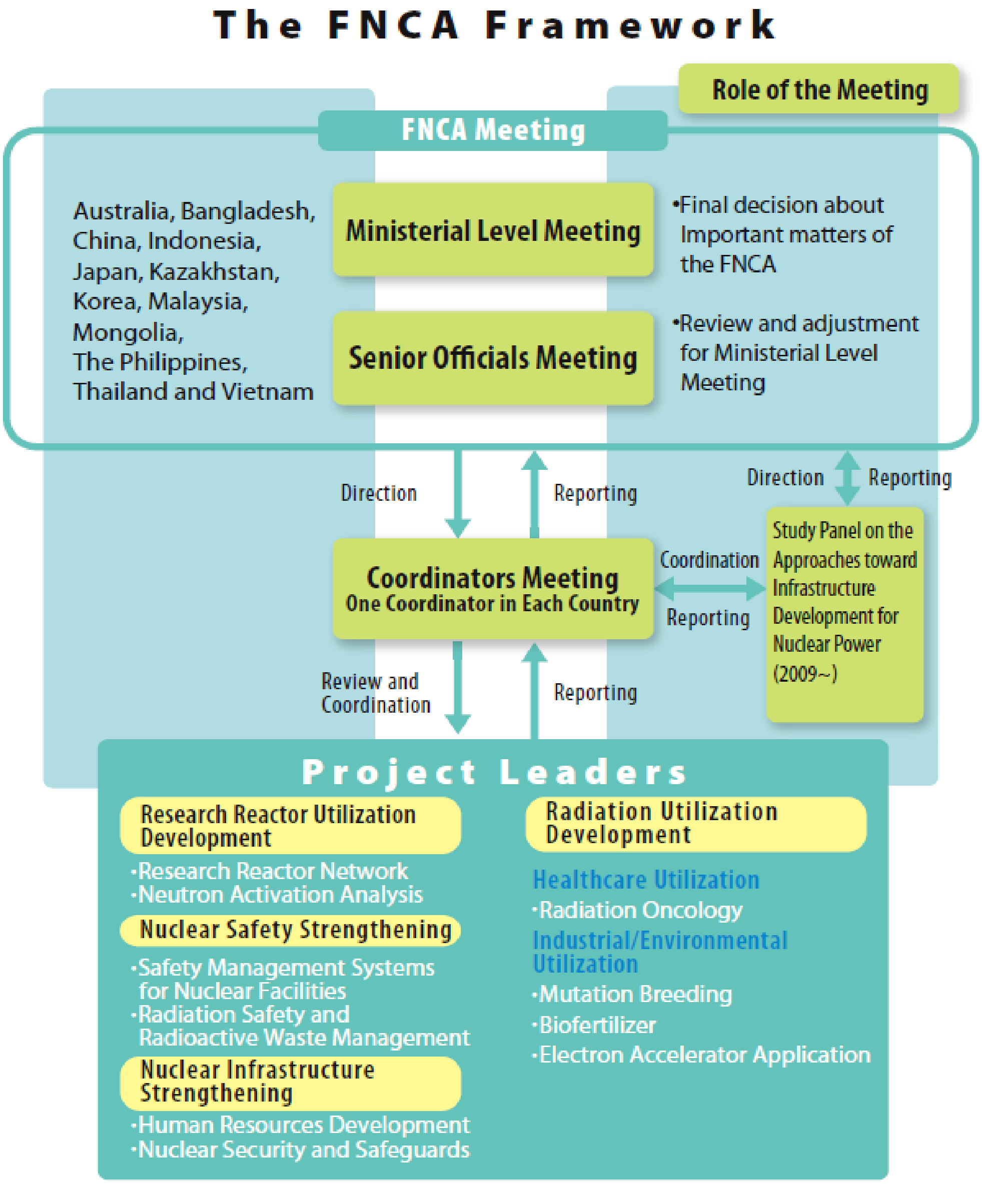
Discussion on cooperation measures and nuclear-energy policies. Forum meeting is comprised of a ministerial level meeting and a senior official level one.

❑ **Coordinators meeting**

Discussion on the introduction, revision and abolishment, adjustment, and evaluation of cooperation projects by an appointed coordinator from each country.

❑ **Cooperation activities for each project**

(See the figure on the next page):



5. FNCA Radiation Safety and Radioactive Waste Management Project

This project superseded Radioactive Waste Management Project and started in 2008 with the aims of sharing information and experiences in the area of Radiation Safety & Radioactive Waste Management processes and regulatory issues as well as facilitating safety improvement and understanding of RS&RWM to public perception in nuclear society.

In each member country, the use of radiation in industry, agriculture, medical treatment, and various other fields is rapidly increasing, and at the same time, several countries are looking into introducing nuclear power plants. In consideration of such tendency, member countries have been discussing how to promote the standardization (calibration) on personnel dosimeter, focusing on appropriate radiation exposure management.

The accumulated results acquired through these activities over ten years were published as a serried of FNCA RWM Consolidated Report on RWM/RS. These reports are available on the FNCA Website.

[URL: http://www.fnca.mext.go.jp/english/e_project.html]

III. Status of Radiation Safety in FNCA Member Countries

1. Australia

1. Australia

Part 1. Radiation Safety in Radiation Industry Facilities

1.1 General

1.1.1 Legislative Framework and Policy for Radiation Safety

There are nine jurisdictions for radiation protection in Australia - the federal government, six States, and two Territories. Radiation Safety legislation is implemented within each jurisdiction in Australia and is in compliance with the IAEA BSS and IAEA GS-R-1. A committee comprised of Commonwealth and State representatives ensures national coordination between jurisdictions.

1.1.2 Structure and System (Regulatory organizations)

Australia has a federal system of government, and the regulation of radiation safety and radioactive waste management and disposal comes under both Commonwealth (federal) and State/Territory regulation. The States and Territories are responsible for regulating the use, manufacture, transport and disposal of radioactive materials under their control or the control of private companies or individuals in accordance with State and Territory Acts and Regulations. These Acts and Regulations are administered by State or Territory radiation safety authorities such as the environmental protection authorities and health departments in each state.

Table 1: Legislative jurisdictions, Regulators and Regulations

Jurisdiction	Regulator	Acts/Regulations
New South Wales	NSW Environment Protection Authority	Radiation Control Act 1990, Radiation Control Regulation 2013
Australian Capital Territory	ACT Health	Same as Federal government
Victoria	Department of Health	Radiation Act 2005, Radiation Regulations 2007
Tasmania	Dept of Health and Human Services	Radiation Protection Act 2005 and Radiation Protection Regulations 2006
South Australia	Environment Protection Authority	Radiation Protection and Control Act 1982, Radiation Protection Control (Ionising Radiation) Regulations 2000, Radiation Protection and Control (Transport of Radioactive Substances) Regulations 2003
Western Australia	Radiological Council	Radiation Safety Act 1975-1999, Radiation Safety (General) Regulations 1983-2003, Radiation Safety (Qualifications) Regulations 1980-2000, Radiation Safety (Transport of Radioactive Substances) Regulations 2002
Queensland	Queensland Health	Radiation Safety Act 1999, Radiation Safety Regulation 2010.
Northern Territory	Department of Health	Radiation Protection Act 2012, Radiation Protection Regulations 2012.
Federal government	Australian Radiation Protection and Nuclear Safety Agency	Australian Radiation Protection and Nuclear Safety Act No. 133, 1998, Australian Radiation Protection and Nuclear Safety Regulations 1999.

Similarly, the Commonwealth Government is responsible for managing radioactive material in organisations under its control, including Departments, Agencies, Bodies Corporate and contractors. All activities undertaken by these organisations with respect to radiation (including nuclear activities, dealings, handling radioactive materials or transport) are regulated by the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA), which is funded by government as part of the Health and Ageing Portfolio. This includes regulating the management of nuclear activities and storage of radioactive waste at Commonwealth agencies such as the Australian Nuclear Science and Technology Organisation (ANSTO), the Commonwealth Science Industry and Research Organisation (CSIRO) and the Department of Defence.

Radiation protection legislation typically includes the following areas:

- Setting maximum dose limits
- Licensing of people to use radioactive substances or apparatus
- Registration of radiation emitting equipment
- Safety procedures
- Responsibilities
- Powers of inspection for the regulator
- Enforcement provisions and penalties

ARPANSA is also tasked with promoting uniformity of radiation protection and nuclear safety policy and practices across all jurisdictions (Commonwealth, the States and the Territories). In addition to the Acts and Regulations listed in the table above, a series of codes and standards on radiation protection have been issued by ARPANSA as the Radiation Protection Series and provide guidelines for handling, processing, transport and disposal of radioactive materials and waste. These codes and standards are issued following Commonwealth/State consultation and public comment.

As part of ARPANSA's Radiation Protection Series, A National Directory for Radiation Protection was established to provide an agreed framework for radiation safety, including both ionizing and non-ionizing radiation, together with clear regulatory statements to be adopted by the Commonwealth, States and Territories. The regulatory elements of the Directory are adopted and enforced by each jurisdiction using existing Commonwealth/State/Territory regulatory frameworks. The first edition of the directory was published in 2004 and an amended version released in 2011 for adoption by the States and Territories.

Within ARPANSA, the Radiation Health and Safety Advisory Council (RHSAC) was established under the Australian Radiation Protection and Nuclear Safety Act 1998 (ARPANS Act) with the following core objectives:

- To identify emerging issues and matters of major concern to the community in relation to radiation protection and nuclear safety;
- To provide high level advice to the CEO of ARPANSA on issues relating to radiation protection and nuclear safety; and

- To support the development of Codes, Standards and Guidance that promotes radiation protection and nuclear safety.

As such, the RHSAC publishes statements providing advice on a range of current radiation health and safety issues relating to medical radiation, radioactive waste and radiation protection.

1.2 Outline of Radiation Facilities and Radiation Sources

1.2.1 Number of Specialists and Workers in Related Organizations

The number of people working in radiation related industries in Australia is difficult to correctly define. ARPANSA provides a Personal Radiation Monitoring Service (PRMS) that enables radiation workers to monitor the radiation dose received in their occupations. Currently the Service monitors approximately 35,000 workers (approximately 70% of occupationally exposed persons in Australia) and maintains dose histories for over 125,000 people. The assessment of doses received by radiation workers enrolled in the PRMS is listed according to their occupational classification (including numbers of staff monitored) in the ARPANSA Technical Report 139, "Personal Radiation Monitoring Service and Assessment of Doses Received by Radiation Workers (2004)". Table 2 indicates that there are more than 5,800 organisations (medical and non-medical) registered to possess a radiation source or radiation apparatus in Australia. The number of work sites may be considerably more as one business licence can be given for multiple sites.

Table 2: Number of Registrations of organisations working with radiation apparatus/sources in Australia

Regulator	Total (medical and non-medical)	Estimated registered organisations in industrial field
NSW	242	50
VIC	335	12
QLD	2500	400
SA	172	35
WA	2050	1574
TAS	n/a	17
ACT	433	87
Commonwealth	93	20
TOTAL	5825	2195

NB: The data presented in the above table is indicative only, as it is gathered from different data sources in different years and makes assumptions about the extent of industrial radiation activity in each state which may not be correct for some jurisdictions.

1.2.2 Number of Radiation Facilities including Related Facilities

There are a number of small commercial and state run operators of radiation facilities associated chiefly with medical treatment. These include seven cyclotron facilities in operation in Australia: two in Victoria (Austin Hospital and Cyclotek), three in NSW (Royal Prince Alfred

Hospital, Sydney, Brain and Mind Research Institute, Sydney and PETNET, Sydney), one in Western Australia (Sir Charles Gairdner Hospital, Perth) and one in Queensland (Royal Brisbane and Women's Hospital). There are around 100 linear particle accelerators Australia wide which are located in cancer treatment facilities. There are also 3 commercial facilities for the irradiation of food which are located in NSW, Queensland and Victoria.

The largest radiation facilities are run by the Australian government. These include:

- OPAL, a 20 MW open pool light water research reactor and associated neutron scattering facilities at ANSTO. ANSTO produces radioisotopes for medical and commercial use from reactor operations and also operates the Gamma Technology Research Irradiator (GATRI).
- The Australian Synchrotron, a 3 GeV radiation facility built in Melbourne, Victoria

1.2.3 Activity and Number of Radiation Sources and Generators

Sources are registered with the relevant regulators in each state and territory however there are no inventories for these in each jurisdiction. ANSTO maintains inventories of its radioactive sources which are licensed by ARPANSA.

In Australia the main source and generation of spent and disused sources is in medical applications by hospitals and medical facilities typically for teletherapy and brachytherapy applications. Co-60 is the most common radionuclide used in teletherapy, although some Cs-137 sources are also in use. Gamma radiation is used to treat approximately half of all cancer patients with solid tumours. Category 1 Co-60 and Cs-137 teletherapy sources are among the higher activity sources in general use (37- 560 TBq and 19 – 56 TBq respectively).

Radioactive sources are also used in education and research and contain a wide variety of radionuclides including Co-60, Cs-137 and Am-241. Industrial applications typically use Ir-192 (0.19 -7.4 TBq) for non-destructive imaging of pipe welds. Co-60 sources are also used for industrial radiography (0.41 – 7.4 TBq). Category 3 neutron and gamma sources are used in mining, as well as in oil and gas well logging. The most common industrial radioactive sources are used in level and thickness gauges and in process control.

1.2.4 Radiation Source Management and Disposal

Within Australia, radioactive sources are managed by the licence holders according to the requirements of the regulator within their jurisdiction. In many jurisdictions it is a regulatory requirement that radioactive sources for which there are no foreseen use should be returned wherever possible to the supplier, either for recycling or disposal. In some states there are small disposal facilities where waste sources are held (Table 6). Whilst Australia does not lack the necessary infrastructure to manage its disused sources the absence of a centralised storage or disposal facility for such radioactive sources is not ideal. In the RHSAC Scoping Review of Issues Related to the Management of Intermediate Level Radioactive Waste in Australia (2011), it states that “The long term storage of radioactive waste at many sites throughout Australia, without a clearly defined disposal pathway, leaves the potential for significant health, safety and environmental issues to arise. These include occupational health risks in the management of radioactive waste, public health risks and security issues. For example, security of sources is a significant consideration when waste is stored at many sites, as it may lead to a high risk of orphan (lost, stolen or abandoned) sources and the potential for serious accidents, safety and security risks.”

From 2004 – July 2013 ANSTO coordinated and funded the S-E Asia Regional Security of Radioactive Sources Project (RSRS) to address awareness of poorly controlled or vulnerable radioactive sources in S-E Asia and the Pacific, a lack of border controls, detection capability and regulation. The goal of the ANSTO project was to prevent acquisition of sources by unauthorised persons, and prevent serious accidents from uncontrolled sources. The strategy of the RSRS project was to "enhance the technical and organisational capacity and capability of partner countries' government organisations and other entities to develop and deliver their own effective and sustainable programs for the physical protection and security management of radioactive sources and their associated facilities, and for radiological emergency preparedness and response, consistent with international standards and guidance." Implementation of the strategy specifically involved strengthening regulatory and legislative controls, applying standards and training regulators, developing capabilities in equipment and provision of training in their operation, and identification and addressing of situations involving vulnerable or orphan radioactive sources. Outcomes of the project in cooperation with counterparts in South East Asia included:

- Development, implementation and updating of specific source security regulations and associated standards, codes and guidance in several countries.
- Regular development and conduct of training courses and training development workshops, including practical exercises, with support provided to the country's relevant agencies for subsequent development and conduct of their own training programs.
- Regulators and operators implementing their respective roles and responsibilities for ensuring the requirements for physical protection and security management of radioactive sources, such as facility security plans, are satisfied.
- Peer-review of regulators' and operators' practices and materials, and the development of new materials by the country's relevant agencies.
- Regular development and conduct of practical exercises and the provision of radiation detection, monitoring and identification equipment for use in orphan source searches, and in preparation for and response to "dirty bomb" or sabotage situations.

This project ended in July 2013, however there remains an on-going need to raise and maintain awareness of the need to protect and control radioactive sources from a radiation safety and security viewpoint.

1.3 Education and Training

1.3.1 Radiation Industry Usage

The ARPANSA National Directory for Radiation Protection requires that all occupations and professions who use radiation sources meet the relevant professional competency requirements. In most cases, competency is evidenced by formal qualification in their field and radiation safety training is incorporated in the overall curriculum. Health related occupations include medical practitioners, dental practitioners, veterinary surgeons, diagnostic radiographers, radiation therapists, nuclear medicine technologists, health and medical physicists and chiropractors. Industry related occupations include industrial radiographers, borehole loggers, radiation source testers and persons servicing, installing, commissioning, maintaining, repairing or manufacturing radiation sources. The evidence of qualification required for each of these occupations is listed in RPS 6 National Directory for Radiation Protection. An example is given in the table below.

Table 3: Authorisation to use Radiation Sources for Specified Practices – taken from Schedule 6 of the National Directory for Radiation Protection

Occupation/Practice	Required Evidence of Qualification
Use of X-ray equipment by chiropractors for plain film diagnostic radiography of the spine and pelvis	– graduates in Chiropractic from RMIT University, Bundoora, Victoria (or forerunner Phillip Institute of Technology) – graduates in chiropractic from Macquarie University, NSW (or forerunner Sydney College of Chiropractic, Ashfield, Sydney, NSW since 30 Nov 1983) – For overseas trained chiropractors, one of the following: – satisfactory assessment by RMIT University or Macquarie University – individual Assessment by the relevant State/Territory Authority against a protocol agreed by the Radiation Health Committee
Use of intra-oral X-ray equipment by dentists for radiography of teeth and facial bones	– current registration by the relevant Dental Board
Use of intra-oral X-ray equipment by dental hygienists for dental radiography	– current registration as a dental hygienist by the relevant Dental Board; and one of the following: – Diploma of Dental Hygiene from Oral Health Centre of WA or Torrens Valley College of TAFE (Gilles Plains SA) – for Overseas trained dental hygienists, satisfactory assessment from Oral Health Centre of WA or Torrens Valley College of TAFE (Gilles Plains SA)
Use of intra-oral X-ray equipment by dental therapists for dental radiography	– current registration as a dental therapist by the relevant Dental Board, and satisfactory assessment at course in dental therapy accredited by the Authority.
Use of X-ray equipment by diagnostic radiographers for diagnostic radiography	Must provide evidence of *one of the following*: • Australian Institute of Radiography (AIR) Statement of Accreditation (AIR Statement of Accreditation) • Certificate of Competence issued by the Conjoint Board of the Royal Australasian College of Radiologists (RACR) and the AIR • Diploma of Qualification issued by the Conjoint Board of the RACR and the AIR • 1984 Assoc. Diploma in Diagnostic Radiography Graduates from Sydney TAFE

	Persons undertaking the Professional Development Year (PDY) at an accredited institution or practice must provide evidence of the following to obtain a restricted authorisation: • AIR Provisional Statement of Accreditation
Use of radiation equipment by radiation therapists for radiation therapy	Must provide evidence of *one of the following*: • AIR Statement of Accreditation in therapeutic radiography(AIR Statement of Accreditation) • Certificate of Competence in therapeutic radiography issued by the Conjoint Board of the RACR and the AIR • Diploma of Qualification in therapeutic radiography issued by the Conjoint Board of the RACR and the AIR Persons undertaking the Professional Development Year (PDY) at an accredited institution or practice must provide evidence of the following to obtain a restricted authorisation: • AIR Provisional Statement of Accreditation
Use of radioactive materials by nuclear medicine technologists for nuclear medicine purposes	Must provide evidence of the following: • Statement of Accreditation by ANZSNM Persons undertaking the Professional Development Year (PDY) at an accredited institution or practice must provide evidence of the following to obtain a restricted authorisation: • Provisional Statement of Accreditation from Australian and New Zealand Society of Nuclear Medicine (ANZSNM)
Use of radiation sources by veterinary surgeons for veterinary purposes	• diagnostic X-ray equipment use for small animal radiography – current registration by the relevant Veterinary Board • sealed radioactive source use: – current registration by the relevant Veterinary Board, and satisfactory completion of an accredited examination on the principles and practices of radiation protection in the proposed use of radioactive materials • unsealed radioactive source use: – current registration by the relevant Veterinary Board, and satisfactory completion of an accredited examination on the principles and practices of radiation protection in the proposed use of radioactive materials.

1.3.2 Radiological Protection

Education and training in radiation safety and radiological protection is provided by numerous companies, health departments and institutions within Australia with training providers and formal training courses approved by the relevant jurisdictional regulator. There are around forty providers of radiation safety training courses covering subjects including general radiation awareness, radiation protection, use of radionuclides, use of gauges, transport, and use of radiation in medical procedures. ARPANSA have initiated a project with Government Skills Australia to develop competency based training units in radiation safety for incorporation into radiation safety training programs. The objective of developing these competencies was to establish a nationally consistent training and skills recognition system that would result in the delivery of courses to meet workplace requirements and recognize current skills and competencies of employees already working in this area (who did not previously have formal qualification in this area). These competencies are in alignment with the various levels of qualifications offered in Australia's Vocational Educational Training (VET) system which operates under the Australian Qualifications Framework (AQF) for regulating the standard of education across the country.

The Accreditation in Ionising Radiation Safety within Australia is administered by the Australasian Radiation Protection Accreditation Board which is sponsored by the following professional societies:

- Australasian College of Physical Scientists and Engineers in Medicine (ACPSEM),
- Australasian Radiation Protection Society (ARPS), and
- Australian Institute of Occupational Hygienists Incorporated (AIOH).

Radiation Protection Advisors are accredited by the Australasian Radiation Protection Accreditation Board following successful completion of the required set of practical and theoretical components. In order to complete the theoretical component of the accreditation, the candidate must satisfy the Board that he/she has a suitable level of education, complete a self-paced reading and numerical problem solving program and pass a written examination based on the prescribed reading material and the requirement for adequate skills in numerical computation. In order to complete the practical component of the accreditation, a candidate must gain practical experience in the use of radiation monitoring equipment and complete an assignment (approximately 5000 words) in which the candidate prepares a radiation

Candidates are usually recent graduates in science or engineering. The standard for accreditation has been set so that the syllabus can be completed with part- time study to enable accreditation within one year of taking up an appointment where the relevant experience is gained. Other graduates and non-graduates will be accepted as candidates provided they can show adequate evidence that they have the ability to achieve the required entrance standard which includes skills in physics, chemistry, mathematics, computation, anatomy and physiology. Accreditation in Ionising Radiation Safety is for a period of three years. In order to maintain their accreditation for a further three years, candidates must demonstrate that they are actively maintaining their expertise.

1.4 Standardization on Radiation and Radioactivity

Calibrations of dosimeters and radiation monitoring equipment through service providers are traceable to national standards. ARPANSA and ANSTO dosimetry services have participated in the IAEA/RCA intercomparisons study held under IAEA/RCA RAS/9/029 Harmonization of Radiation Protection, Phase IV – RCA Project completed in 2008.

There may be varying radiation protection recommendations and exemption criteria across the State/Territory jurisdictions (some are based on total activity and others are on activity concentration). However, the approaches to radiation protection are generally consistent and the dose limits in line with those stated in the National Directory for Radiation Protection. Table 3 below summaries the current applicable dose limits.

Part 2. Status of Radiation Safety Management

2.1 Radiation Safety Management in various Radiation Industries

2.1.1 Radiation Safety Management System

The management of radiation safety within various radiation industries is governed by the jurisdictional regulator according to their regulations, standards and codes. Federally, the management of radiation safety is governed by the specific standards, codes and guides in the Radiation Protection Series (RPS) published by ARPANSA and readily accessible on their website.

These encompass all radiation management considerations for research, industrial and medical related facilities as follows:

- Recommendations for Limiting Exposure to Ionizing Radiation (1995) and National Standard for Limiting Occupational Exposure to Ionizing Radiation (republished 2002) (RPS 1)
- Code of Practice for the Safe Transport of Radioactive Material (2008 Edition), Safety Guide for the Safe Transport of Radioactive Material (2008 Edition) and Safety Guide for Approval Processes for the Safe Transport of Radioactive Materials (2012) - (RPS 2, 2.1 and 2.2)
- Radiation Protection Standard for Maximum Exposure Levels to Radiofrequency Fields - 3 kHz to 300 GHz (2002) - (RPS 3)
- Recommendations for the Discharge of Patients Undergoing Treatment with Radioactive Substances (2002) - (RPS 4)
- Code of Practice and Safety Guide for Portable Density/Moisture Gauges Containing Radioactive Sources (2004) - (RPS5)
- National Directory for Radiation Protection, July 2011 - (RPS 6)
- Recommendations for Intervention in Emergency Situations Involving Radiation Exposure (2004) - (RPS 7)
- Code of Practice for the Exposure of Humans to Ionizing Radiation for Research Purposes (2005) - (RPS 8)
- Code of Practice and Safety Guide for Radiation Protection and Radioactive Waste

Management in Mining and Mineral Processing (2005) - (RPS 9)

- Code of Practice and Safety Guide for Radiation Protection in Dentistry (2005) - (RPS 10)
- Code of Practice for the Security of Radioactive Sources (2007) - (RPS 11)
- Radiation Protection Standard for Occupational Exposure to Ultraviolet Radiation (2006) – (RPS12)
- Code of Practice and Safety Guide for Safe Use of Fixed Radiation Gauges (2007) - (RPS 13)
- Code of Practice for Radiation Protection in the Medical Applications of Ionizing Radiation (2008), Safety Guide for Radiation Protection in Diagnostic and Interventional Radiology (2008), Safety Guide for Radiation Protection in Nuclear Medicine (2008) and Safety Guide for Radiation Protection in Radiotherapy (2008) - (RPS 14, 14.1, 14.2 and 14.3)
- Safety Guide for the Management of Naturally Occurring Radioactive Material (NORM) (2008) - (RPS 15)
- Safety Guide for the Predisposal Management of Radioactive Waste (2008) - (RPS 16)
- Code of Practice and Safety Guide for Radiation Protection in Veterinary Medicine (2009) - (RPS 17)
- Safety Guide for the Use of Radiation in Schools (2012) – (RPS 18)
- Code of Practice for Radiation Protection in the Application of Ionizing Radiation by Chiropractors (2009) – (RPS 19)
- Safety Guide for Classification of Radioactive Waste (2010) – (RPS 20)

2.1.2 Radiological Protection for Radiation Workers

An increase in a person's exposure to ionizing radiation, even at low doses, is assumed to increase the risk of harm to that person's health. As such, all radiation industries and facilities are required to implement a system of radiation protection which limits possible detrimental effects arising from occupational radiation exposure. This ALARA approach involves the design of processes in such a way as to minimise exposure and to ensure that occupational dose limits are met. Radiological protection is achieved through the following hierarchy:

- avoidance of exposure, where practicable;
- isolation of sources of radiation, where practicable, through shielding,
- containment and remote handling techniques;
- engineering controls, such as local exhaust ventilation to remove contaminants from the workplace environment;
- adoption of safe work practices, including work methods which make appropriate use of time, distance and shielding to minimise exposure; and
- where other means of controlling exposure are not practicable, the use of approved personal protective equipment.

ARPANSA has derived dose limits for ionizing radiation to be adopted nationwide as follows:

Table 4: Radiation Dose Limits

	Dose limit[1]	
Application	**Occupational**	**Public**
Effective dose	20 mSv per year, averaged over a period of 5 consecutive calendar years[2,3]	1 mSv in a year[4]
Annual equivalent dose in the lens of the eye	20 mSv	15 mSv
the skin[5]	500 mSv	50 mSv
the hands and feet	500 mSv	-

1 The limits shall apply to the sum of the relevant doses from external exposure in the specified period and the 50-year committed dose (to age 70 years for children) from intakes in the same period.
2 With the further provision that the effective dose shall not exceed 50 mSv in any single year. In addition, when a pregnancy is declared by a female employee, the embryo or foetus should be afforded the same level of protection as required for members of the public.
3 (Deleted in amendment)
4 In special circumstances, a higher value of effective dose could be allowed in a single year, provided that the average over 5 years does not exceed 1 mSv per year.
5 The equivalent dose limit for the skin applies to the dose averaged over any 1 cm^2 area of skin, regardless of the total area exposed.

Regulatory requirements are in place in all jurisdictions for controlling exposure to personnel who may be occupationally exposed to radiation. Within medical facilities these are implemented by a well-qualified workforce of medical and hospital physicists who interact well with each other through professional bodies.

Doses to radiation workers are measured either through thermoluminescent dosimeters or electronic personal dosimeters. ARPANSA provides a national dosimetry service for some 35,000 radiation workers nationally on a cost recovery basis. Australian Nuclear Science and Technology Organisation (ANSTO) provides an in-house service for 937 radiation workers. There are also a number of other commercial personal dosimetry service providers (international companies based in Australia).

In 2011 Australia established the National Radiation Dose Register (ANRDR) to ensure that records of a worker’s radiation dose are maintained in a centralised register regardless of where the individual is working. The ANRDR is an electronic database designed to collect and store radiation dose information for workers who are occupationally exposed to radiation. These workers can request a record of their radiation dose history from the ANRDR. Currently, the ANRDR only maintains records for workers in the uranium mining and milling industries however expansion of the ANRDR to include workers exposed to radiation in other industries is in progress.

Within other industries, worker dose records are held by the operator and the dosimetry service provider and this data is reviewed by the relevant regulator. ANSTO and ARPANSA maintain whole body monitoring and bioassay radionuclide intake dose records for their registered individuals.

2.1.3 Radiological Protection for Radiation Area

Monitoring of workplace areas is required to be performed by the operator with regulatory inspectors having the capacity to check this. Commercial consulting services are also available to carry out such monitoring for operators who do not have the required in-house expertise.

Radiological protection measures for specific radiation areas are implemented by the operators in order to comply with the relevant regulations.

Through their Radiation Health and Safety Advisory Council, ARPANSA have also identified the need to assess the radiation levels in workplaces not normally associated with radiation activities and to provide technical support. These include potential radiation exposure from:

- Naturally Occurring Radioactive Minerals from historic mineral sands operations.
- Radioactive scale from off-shore oil and gas.
- Mineral processing activities where radiation levels are higher than background.
- Orphan sources which are discovered within the recycling industry.
- Elevated radon levels from decay of naturally occurring radioactive minerals

2.1.4 Radiological Protection for the Public

Radiological protection measures are implemented by the states, territories and federal government for members of the public as an inherent part of applying their regulations regarding general radiation safety. Dose limits for the public are to comply with those specified in ARPANSA's National Directory for Radiation Protection (see Table 3).

ARPANSA have carried out characterisation studies within Australia of radon and natural background to determine expected doses to the public. ARPANSA also assesses radiation doses to the Australian population from medical radiation practices through national surveys. Advice is provided to medical professionals, patients and the public on medical exposures and risks. Additionally, ARPANSA conducts a quality assurance test program to monitor the quality of radiopharmaceuticals and undertakes for the Therapeutic Goods Association (TGA) the evaluation of the chemistry, manufacture, quality control and radiation dosimetry aspects of new drug applications and variations to conditions of TGA registration.

The capability to monitor foodstuffs for radioactivity is available within Australia for specific potential threat situations. ARPANSA is the national competent authority for dealing with such threats, for doing check monitoring and issuing guidance advice to all stakeholders.

2.1.5 Radiation Emergency Preparedness

The following organisations are responsible for managing and planning the response to emergencies that may involve radiation:

- Attorney Generals Department Crisis Coordination Centre (AGDCCC), 24h/d which is managed by Emergency Management Australia (EMA).
- National Competent Authority - Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) - on call
- Bureau of Meteorology - on call
- State and Federal Police (Victoria, New South Wales, Queensland, Northern Territory, South Australia, Western Australia, Australian Capital Territory, Tasmania, Commonwealth)
- State and Federal Combat Agencies (Fire, Ambulance, State Emergency Services etc.,)

- Australian Defence Force (ADF)

The following plans are in place in the event of a radiological emergency:

- Nuclear Powered Warships (NPW) accidents - OPSMAN1 (Defence Operations Manual 1 edition 9). The following plans are put into effect in escalating order:
    - Port Safety Plans
    - State plans and arrangements for NPW accidents
    - EMPLANS or COMDISPLAN (Australian Government Disaster Response Plan)
- Accident/misuse of Radioactive/Nuclear material
    - State/Territory response (most States/Territories have a Chemical, Biological, Radiological, and Nuclear (CBRN) or HAZMAT equivalent State plan or State/Territory Emergency Plans (EMPLANS). If State/Territory resources are tapped they can request additional national resources through the Attorney Generals Crisis Coordination Centre (AGCCC). This inevitably invokes the COMDISPLAN.
- Specific RN hazards
    - Space debris re-entry (COMDISPLAN SPRED)
    - Maritime R/N (COMMARRPLAN)
    - Radiological/Nuclear Terrorism (National Counter-Terrorism Plan)
- International Response under Convention for Requesting Assistance

ARPANSA maintains two offices with Scientific (Melbourne) and Regulatory (Sydney) units. Radiation Emergency Planning is coordinated by the Health Physics Section of the Environmental and Radiation Health Branch, Melbourne. The coordination of Commonwealth response to State requests for radiation emergency support is through Emergency Management Australia (EMA).

In the event of a radiation accident or radiation emergency, and when requested by the responsible State or Commonwealth authorities, ARPANSA can provide Health Physics Advisors and Health Physics monitoring teams. In 1989, ARPANSA was designated jointly with the Peter MacCallum Cancer Institute as a Collaborating Centre for Radiation Protection. The Collaborating Centre is one of 13 centres internationally (Armenia, Australia, Brazil, France, Germany, Japan, the Russian Federation, United Kingdom, Ukraine and USA) that form the WHO Radiation Emergency Medical Preparedness and Assistance Network (REMPAN). This role requires that ARPANSA assist in training and dissemination of information on response to radiation accidents and emergencies, as well as respond to WHO requests for assistance for radiation accidents and emergencies in neighbouring countries. Specific objectives of Australia's Collaborating Centre are to:

- help Member States in elaborating their plans for medical preparedness
- promote training of personnel in developing countries in medical preparedness and first aid
- define optimal methods for diagnosis or treatment of over-exposure
- provide medical assistance to exposed persons both on site and in specialised clinics,

subject to bilateral agreement between Australia and the country(s) concerned.

ARPANSA and ANSTO both have accredited IAEA RANET (Response Assistance Network) teams for assistance in international response to radiation emergency. ARPANSA maintains an Australia-wide network of fallout monitoring stations as part of the Comprehensive Test Ban Treaty (CTBT) network of monitoring stations.

2.2 Radiation Safety Management in Research Reactors

2.2.1 Radiation Safety Management System

Australia's only nuclear reactor (OPAL) is operated by the Australian Nuclear Science and Technology Organisation and is funded by the federal government. As such, ANSTO is regulated by ARPANSA and its safety management system must comply with their requirements. ANSTO is dedicated to implementing international best practice in this area and adopts the relevant recommendations given by the IAEA. ANSTO has adopted an ALARA approach to radiation exposure and have implemented a more stringent internal occupational dose constraint of 15 mSv in comparison with the IAEA and ARPANSA limit of 20 mSv per year effective dose.

2.2.2 Radiological Protection for Radiation Workers

ANSTO designs and operates all processes involving radioactivity with the aim of keeping doses ALARA and within their internal dose constraint of 15 mSv per year effective dose. Radiation protection controls are implemented according to the hierarchy described in section 2.1.2. Processes involving radiation include radioisotope production, research, radioactive waste management and storage of radioactive materials. Dose rates are monitored both through use of area radiation monitors and through personal dosimetry. Health Physics Surveyors are employed to provide radiological advice to personnel, to give on the job monitoring during tasks and to assess the radiological status of work areas. Radioisotope production areas, reactor operations and waste management have on-call access to health physics support with some operations unable to be carried out without a health physics surveyor in attendance.

ANSTO provides an in house dosimetry service for 937 radiation workers which involves a whole body monitoring program for internal dose and external dose measurement using thermoluminescent detectors. Whole body monitoring (internal dose monitoring) is carried out three to four times a year for reactor operators, radioisotope production staff, radioisotope delivery drivers, handlers of nuclear fuel and waste management staff. External dosimetry data collected from thermoluminescent detectors is reviewed on a monthly basis by ANSTO's personal dosimetry service. Any anomalous or unusually high levels of effective dose are investigated to determine the cause of exposure. Through this process of review and investigation, improvements to practices and equipment are identified and implemented in order to prevent continued or potential abnormal high exposure. Radiation workers at ANSTO are also equipped with electronic personal dosimeters which are used to measure their cumulative dose during a certain task or over the course of the day and help them to manage their dose exposure. Urine sampling is carried out for personnel during specific operational campaigns involving exposure to tritium. Thyroid monitoring and urine sampling is carried out for personnel who are involved in the production of Iodine-131.

Radiation workers are equipped with the personal protective equipment (PPE) required for the particular work area (depending on its radiation classification) and for specific tasks. In classified radiation areas compulsory PPE include overshoes, overcoats, and safety shoes. For tasks involving radioactive contamination the PPE required may include gloves, disposable overalls, safety glasses, face shields, full face masks with filters and full suits with breathing air.

2.2.3 Radiological Protection for Radiation Area

Work processes and areas are designed to keep radiation exposure to a minimum. Where the potential for exposure to radiation or contamination still exists, shielding and mechanical ventilation with HEPA filtration are employed to minimise the dose received. Areas are classified according to the potential radiation and contamination level.

Table 5: Classification Levels for Radiation and Contamination Areas

Radiological Area Colour Code	**Potential Radiation Exposure Levels (individual, effective mSv per year)**	**Removable Surface Contamination Levels (averaged over 2000 h per year)**	**Potential Airborne Contamination Levels (averaged over 2000 h per year)**
RED	6 to 20	0.3 to 1 DL	0.3 to 1 DAC
BLUE	1 to 6	0.05 to 0.3 DL	0.05 to 0.3 DAC
WHITE	<1	< 0.05 DL	<0.05 DAC

Table 6: Maximum Permitted Activity in Contamination Areas in Terms of Annual Limits on Intake (ALIs)

Location	**Nature of Operation**		
	Volatile or dry and dusty	**Slightly volatile or dry, non-dusty**	**Non-volatile wet operations**
Red Contamination Area			
Open Room	10^{-3} ALI	10^{-1} ALI	10^{1} ALI
Fume Cupboard	10^{2} ALI	10^{3} ALI	10^{4} ALI
Glove-box	10^{4} ALI	10^{5} ALI	10^{6} ALI
Blue Contamination Area			
Open Room	10^{-4} ALI	10^{-2} ALI	1 ALI
Fume Cupboard	10^{1} ALI	10^{2} ALI	10^{3} ALI
Glove-box	10^{3} ALI	10^{4} ALI	10^{5} ALI
White Contamination Area Open Room	Not Permitted	Not Permitted	0.1 ALI

Local area radiation monitors are used within all 'Red' classified work areas and 'Blue' areas where higher than background radiation levels are to be expected. These monitors are configured to raise an alarm when an upper radiation set point has been reached to alert personnel to discontinue the process, make safe or evacuate. Red and Blue contamination classified work areas are also equipped with contamination detectors for checking personnel on exiting the area. All contamination and radiation monitors are calibrated annually by ANSTO's calibration services.

Dose and contamination surveys are carried out by health physics surveyors as scheduled and also at request. Items that are transferred from a Red or Blue classified area (radiation and/or contamination) to another building are monitored by health physics and a clearance certificate issued to advise the receiver of the item's dose, contamination level and any special handling requirements.

2.2.4 Radiological Protection for the Public

Through the safety assessment process (Safety analysis reports for facilities and safety approval submissions for new and ongoing processes) ANSTO addresses any radiological issues that may have an impact on the public. As such, processes and modifications are only allowed once the operator can prove the safety of their process/facility from the perspective of design, use of equipment, maintenance, operational and administrative controls in place.

The main ways in which members of the general public may be exposed to radiation is through:

- potential release of radionuclides into the environment from atmospheric discharges from stacks (tritium, volatile fission products, activation products and noble gases released from isotope production facilities, research laboratories and waste management areas)
- Discharge of low level liquid effluent via the Sydney Water Corporation sewer to the ocean.
- Radionuclide transport by surface/ground water and/or contaminated airborne particulate dispersion from buried waste in a small low level radioactive waste disposal site

Stack monitoring for radionuclides is carried out continually to determine compliance with the limits imposed by the regulator and to fulfill the duty to protect members of the public. A program of environmental sampling of air, ground water and sediments at various locations around the ANSTO site has been carried out for more than a decade and consistently demonstrates that ANSTO's activities have no impact on public radiological safety or the environment. Radioactivity discharge limits are set for liquid effluent to meet the WHO Guidelines for Drinking Water Quality (2011) for radioactive species at the point of the receiving sewage treatment plant (Cronulla). Waste water is analysed for gross alpha and beta radioactivity concentration and must comply with the derived limits (based on a dilution factor of 25 prior to the sewage plant) before it is released. Annual sampling at the sewage treatment plant and outfall has always shown that the levels of radioactivity detected are below those set in the WHO guidelines. The information collected from environmental monitoring is published annually and made available to the public and the regulator (ARPANSA).

2.2.5 Radiation Emergency Preparedness

ANSTO has Emergency Planning arrangements in place to enable effective management and response in the event of a radiation emergency. The five main components to the emergency planning arrangements include:

- Response plans
- Standing Operating Procedures (SOPs)
- Communication and consultation
- Testing and review
- Emergency response training

The response plan was developed by ANSTO and the ANSTO Local Liaison Working Party (LLWP) in accordance with the State Emergency and Rescue Management Act.

ANSTO provides specific emergency response training to ANSTO's emergency response staff and includes regular workplace exercises focusing on various emergency procedures and response. The objective of these exercises is to continually improve ANSTO's emergency arrangements and to identify further emergency response training needs.

There are a number in plans in place which would come into effect in the event of a radiation emergency where there may be possible off-site consequences:

- NSW State Disaster Plan (DISPLAN)
- NSW State Lucas Heights Emergency Sub-Plan
- NSW State CBRN Hazardous Materials Emergency Sub-Plan
- NSW Sydney Metropolitan Emergency Management District Disaster Plan (District DISPLAN)
- Sutherland Shire Local Disaster Plan (Local DISPLAN)
- OPAL Reactor Facility Emergency Plan

In such an event ANSTO would continue to provide technical advice and assistance to the NSW authorities that would be in control.

2.3 Safe Management of Radioactive Waste

Radioactive waste in Australia is generated by research, industry, medical applications, research reactor operation and radiopharmaceutical production. Naturally occurring radionuclides (NORM) and technologically enhanced naturally occurring radioactive materials (TENORM) are produced in Australia by the mining, mineral sands processing and other resources sectors. Australia has no nuclear power plants.

Australia has a number of radioactive waste management facilities where radioactive wastes are held in storage and/or processed. The largest waste management facility is run by ANSTO for the processing of wastes arising from activities associated with its nuclear research reactor. Other small waste stores and processing facilities are managed by the Department of Defence and State governments (comprising of waste arising mostly from public hospitals). Radioactive waste management facilities in Australia range from custom built decontamination facilities and radioactive waste stores, such as those at ANSTO, to temporary storage facilities where radioactive material is held in transit. Current operational radioactive waste management facilities in Australia are listed in Table7.

Table 7: Radioactive Waste Management Facilities

Location	*Main Purpose*	*Essential Features and estimated waste inventory*
ANSTO, Lucas Heights, NSW	Treatment and Packaging	Management of waste from research reactor operation, radiopharmaceutical production, research and development
ANSTO Lucas Heights, NSW	Storage	1844 m^3 low level waste 441 m^3 intermediate level waste
Mt Walton East Intractable Waste Facility, WA	Disposal	Near surface disposal of low level radioactive waste generated in the State of Western Australia
Woomera Protected Area, SA	Storage	Storage of low level and intermediate level waste owned by Department of Defence
Woomera Protected Area, SA	Storage	Storage of 2010 m^3 contaminated soil owned by CSIRO
Esk Storage Facility, Qld	Storage	Storage of radioactive waste (sources and low volume material) generated in the State of Queensland.
Others	Storage	Over 100 locations around the country where low level, short-lived and/or long-lived intermediate level radioactive waste is stored

Australia is in the process of developing and implementing a National Radioactive Waste Management Facility (NRWMF) to safely manage radioactive wastes generated in Australia. On 25 February 2010 the Senate referred the National Radioactive Waste Management Bill 2010 for inquiry and report. The purpose of the Bill is to repeal the Commonwealth Radioactive Waste Management Act 2005.

It is internationally accepted that centralised radioactive waste management facilities offer substantial safety and security benefits by minimising risk of accidental loss of control of radioactive waste, thereby protecting the community and environment from any adverse effects. In 2012, the Australian Government introduced the National Radioactive Waste Management Act 2012. The Act establishes a legislative framework for siting a facility for managing radioactive waste arising from medical, industrial and research uses of radioactive material at a single site on volunteered land. Currently Australia's radioactive waste is stored at more than 100 less than ideal sites around Australia. This approach will promote the consistent, safe and responsible management of radioactive waste, in accordance with Australia's obligations as a party to the *Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management.* Two volunteer nomination processes are provided for by the Act. The first allows for a Land Council in the Northern Territory to volunteer Aboriginal land on behalf of its Traditional Owners. If, for any reason, a facility cannot be sited on Aboriginal land nominated by a Land Council in the Northern Territory, a nation-wide volunteer process for siting a facility will be initiated. Under both processes, extensive consultation will be undertaken. The Act will also ensure that the selected site undergoes full environmental, heritage and other approval processes.

2.3.1 Radiation Safety in the Management of Radioactive Waste

The radiation safety management system for handling wastes and managing waste processing operations would generally be covered within the facility radiation safety management system. There are however some additional considerations in relation to the classification of radioactive wastes based on their physical form, chemical nature and radioactivity. These waste classifications provide guidance as to what radiation safety measures are required for both processing and storage.

In April 2010, ARPANSA issued a Safety Guide on the Classification of Radioactive (RPS 20) waste to be adopted nationally in order to standardise the classification of radioactive waste with reference to the IAEA General Safety Guide, Classification of Radioactive Waste (No. GSG-1). Six classes of waste have been derived as the basis for the classification scheme:

- ❑ **Exempt waste (EW)**: Waste that meets the criteria for exemption from regulatory control for radiation protection purposes. Exemption activity concentrations and exempt activities of each radionuclides are listed in the Schedule 4 of the National Directory for Radiation Protection (RPS 6) which is readily available on ARPANSA's website.

- ❑ **Very short lived waste (VSLW)**: Waste that can be stored for decay over a limited period of up to a few years and subsequently exempted from regulatory control according to arrangements approved by the relevant regulatory authority, for uncontrolled disposal, use or discharge. This class includes waste containing primarily radionuclides with very short half-lives often used for industrial, medical and research purposes.

- ❑ **Very low level waste (VLLW)**: Waste that does not meet the criteria of EW, but does need a moderate level of containment and isolation and therefore is suitable for disposal in a near surface, industrial or commercial, landfill type facility with limited regulatory control. Such landfill type facilities may also contain other hazardous waste. Typical waste in this class includes soil and rubble with low activity concentration levels. Concentrations of longer-lived radionuclides in VLLW are generally very limited.

- ❑ **Low level waste (LLW)**: Waste that is above exemption levels, but with limited amounts of long lived radionuclides. Such waste requires robust isolation and containment for periods of up to a few hundred years and is suitable for disposal in engineered near surface facilities. This class covers a very broad range of waste. Low level waste may include short lived radionuclides at higher activity concentration levels and long lived radionuclides, but only at relatively low activity concentration.

- ❑ **Intermediate level waste (ILW)**: Waste that, because of its content, particularly of long lived radionuclides, requires a greater degree of containment and isolation than that provided by near surface disposal. However, ILW needs little or no provision for heat dissipation during its storage and disposal. Intermediate level waste may contain long lived radionuclides, in particular alpha emitting radionuclides, which will not decay to an activity concentration acceptable for near surface disposal during the time for which institutional controls can be relied upon. Therefore waste in this class requires disposal at greater depths, in the order of tens of metres to a few hundred metres.

- ❑ **High level waste (HLW)**: Waste with activity concentration levels high enough to generate significant quantities of heat by the radioactive decay process or waste with large amounts of long lived radionuclides that need to be considered in the design of a disposal facility for such waste. Disposal in deep, stable geological formations usually several hundred metres or more below the surface is the generally recognised option for disposal of HLW.

In 2010 ARPANSA also issued a technical report (TR-152) titled the *Classification and Disposal of Radioactive Waste in Australia – Consideration of Criteria for Near Surface Burial in an Arid Area*. This report provides guidance on the selection of sites for near-surface disposal of waste and describes procedures for the development of qualitative and quantitative criteria for the three disposal categories of waste, Category A, Category B and Category C.

For operational purposes, ANSTO has also adopted the following working definition described in IAEA Safety Series No. 111-G-1.1, Classification of Radioactive Waste 1994 (section 318):

- Low level wastes (liquids and solids) have a dose on contact < 2 mSv/h
- Intermediate level wastes (liquids and solids) have a dose on contact > 2 mSv/h.

Shielding must be employed for all processes and storage facilities where intermediate level wastes are involved

For long term waste disposal purposes offsite (to the proposed National Radioactive Waste Management Facility), the above definition does not apply and all wastes are to be reclassified and managed in accordance with ARPANSA's RPS 20 Safety Guide for Classification of Radioactive Waste.

2.3.2 Radiological Protection for Radiation Workers

ANSTO personnel involved in the management of radioactive waste are classified as radiation workers and are protected according to the radiation protection management system and measures described in sections 2.2.1 and 2.2.2. All other personnel involved in the management of radioactive waste within Australia are to adhere to the relevant radiation safety regulations within their jurisdiction. The radiation safety management principles and radiation protection measures would generally be in line with ARPANSA's Radiation Protection Standards and Codes (see sections 2.1.1 and 2.1.2).

2.3.3 Radiological Protection for Radiation Area

The radioactive waste management facilities at ANSTO apply radiation protection and contamination control measures in harmony with the rest of the organisation as described in section 2.2.3. Other radioactive waste management operators and facilities within Australia apply radiation protection and contamination controls in accordance with their jurisdictional regulations, which would largely accord with the measures specified in ARPANSA's Radiation Standards and Codes.

2.3.4 Radiological Protection for the Public

Radioactive waste management controls and the control of radioactive discharges are in place in all jurisdictions to current international standards as required by the relevant regulator. ARPANSA's Radiation Protection Standards and Codes provide guidance on all management aspects of radioactive waste (exposure limits, classification, transport, NORM, radioactive waste in mining, radioactive source security predisposal management) to ensure appropriate measures are in place for the radiological protection of the public.

2.3.5 Radiation Emergency Preparedness

For emergency preparedness in relation to radioactive waste management at ANSTO see section 2.2.5. For emergency preparedness in relation to radioactive waste management at other facilities see section 2.1.5.

2. Bangladesh

2. Bangladesh

Part 1. Radiation Safety in RI Facilities

1.1. General

Bangladesh Atomic Energy Commission (BAEC) follows the IAEA Safety Series No. 115 (1996), USNRC Code for radiation protection, the recommendations of the international Commission on Radiological Protection (ICRP) and the Nuclear Safety and Radiation Control Rules (SRO NO. 205 –Law/97). The overall safety objective is to protect operating personnel, society and the environment by establishing and maintaining an effective defense against radiological hazards. The safety objectives of the radiation protection policies are as follows:

- ❑ To ensure that the operation and utilization of nuclear/radiation facilities is justified under radiation protection consideration
- ❑ To ensure that during normal operation radiation exposure of site personnel and public remains below limits prescribed by national authorities and is kept ALARA

1.1.1 Legislative and Statutory Framework

The Regulatory Authority of Bangladesh is authorized for issuing rules and regulations and conducting licensing and supervisory processes for issuing licenses, and thereby regulating nuclear and radiation safety for siting, design, equipment manufacturing, construction, commissioning, operation and decommissioning of nuclear/radiological facilities. Nuclear Safety and Radiation Control Division (NSRCD), now called Bangladesh Atomic Energy Regulatory Authority (BAERA) is responsible for the regulation of issues related to accounting and control of nuclear materials, radioactive substances and physical protection. The BAERA is the competent authority for licensing shipments out of Bangladesh and giving consent to shipments into Bangladesh.

The basic legal and statutory framework for Nuclear Safety and Radiation Control is in place. A draft Nuclear Safety Law has been submitted to the Agency for comments and it is currently under the Agency's review (October 2008). It is expected that the draft Nuclear Law when promulgated will have full provisions for public and environmental radiological protection, although the regulations of public exposure is presently covered by an existing NSRC Rule-97.

1.1.2 Legal Background

National policy is to provide adequate protection for man and the environment against undue exposure to ionising radiation from radiation sources and radioactive wastes for the present and future generation. Nuclear Safety and Radiation Control Act 1993 was duly approved and enacted (1993) and the Regulations have been put into force (1997).

The following acts that address the basic nuclear activities have already been approved by the Government of Bangladesh. This act will establish the set up basic requirements for management of radioactive waste; define basic requirements, licensing procedures and responsibilities of different organizations involved in nuclear activities and related radioactive waste management.

- Nuclear Safety and Radiation Control Act 1993, Act No. XXI of 1993,
- Nuclear Safety and Radiation Control Rules – 1997 SRO. 205 – Law/97, Date: September 04, 1997

The Radiation Protection Regulations contains information on clearance and sets up clearance levels and limits for authorized discharges of radioactive substances from nuclear facilities. In addition, Nuclear Safety and Radiation Control Division (NSRCD) presently known as BAERA have prepared new rules for the 'Radioactive Waste and Spent Fuel Management – 2008, which is currently under the Agency's review.

Present Status:

A new act, called 'Bangladesh Atomic Energy Regulatory (BAER) Act-2012', has been passed 29 March 2012 by the parliament. As per act there is provision to establish an independent Regulatory Authority under the Ministry of Science and Technology to perform its regulatory activities. New Act will empower the regulatory authority to develop safety principles and criteria. The New Act and NSRC Rules-1997 include exclusion, exemption and clearance criteria. The new act allows appeal against regulatory decisions. Under the proposed act, a five-member regulatory body, titled 'Bangladesh Atomic Energy Regulatory Authority' headed by a chairman, will be constituted to supervise the activities of the operator of Rooppur Nuclear Power Plant to be constructed with the assistance of Russian Federation. Besides, an advisory committee will be formed with experts from related sectors. The issues of definition, goals and activities of the authority, determination of compensation, security and safety of the power plants as well as safety measures against radiation and management of nuclear waste have been mentioned in the proposed act.

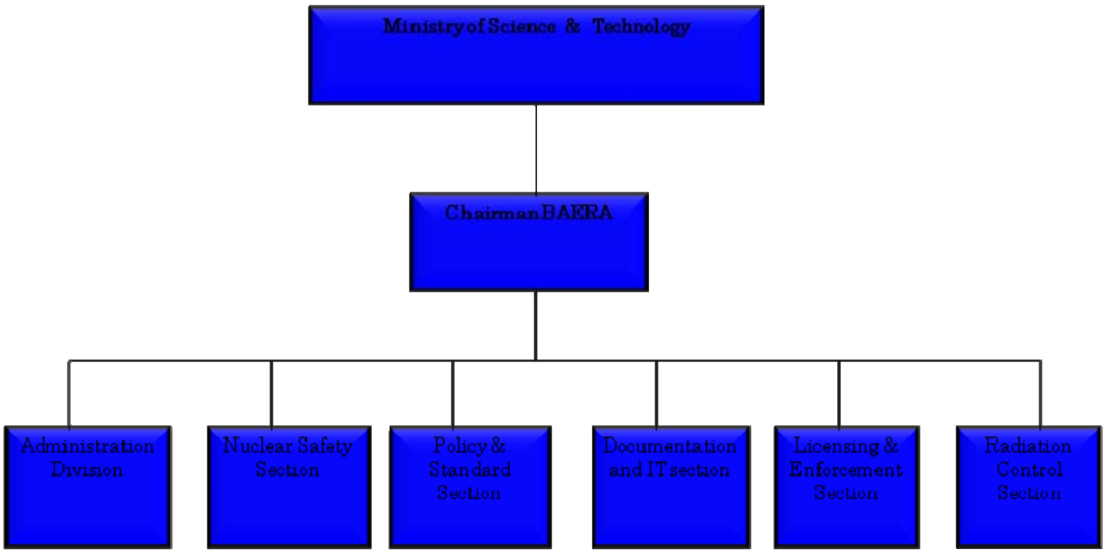


Figure 1: Present Structure of Bangladesh Atomic Energy Regulatory Authority (BAERA)

1.2 Outline of Radiation Facilities and Radiation Sources

1.2.1 Number of Specialists and Workers in Related Organizations and Radiation Facilities including Related Facilities: Refer to the table 1

Table 1: Number of specialists and workers in related organizations and radiation facilities

Radiation Facilities	Numbers (Installation/unit)	Approximate Number of specialist/worker
Diagnostic X-ray units	4200	5500
Research Reactor	1	20
Dental X-rays	190	380
Nuclear medicine departments	18	122
Radiotherapy facilities	14	100
Teletherapy	9	100
Brachytherapy	7	25
Industrial radiography facilities	14	-
Industrial or research irradiators	3	16
Nuclear gauges	38	-
Well-logging devices	7	-
neutron generator	1	2
Radioisotope production unit	1	12
Tandem accelerator	1	15
Beach sand mineral processing plant	1	10
Waste storage facility	1	19
Research laboratories	12	109
Linear Accelerator	9	20

1.2.2 Activity and Number of Radiation Sources and Generators

Refer to the following table 2-5.

Table 2: Nucleonic Gauge Practices

Sl. No	Source/Machine	Activity	Units
01	^{241}Am	50 mCi – 03 Ci	18
02	^{60}Co	10-50 mCi	04
03	^{137} Cs	20-500 mCi	06
04	^{90}Sr	25 mCi each	10
05	^{85} Kr	50 mCi – 01 Ci	08
06	Am-Be	10- 50 mCi	08
07	^{55}Fe	100 mCi	01
08	^{63} Ni	200 mCi	01

Table 3: Nuclear Well-logging Practices

Sl. No	Source	Activity	Units
01	Am-Be	20µCi- 20 Ci	12
02	^{137}Cs	50 mCi- 02 Ci	07
03	^{232} Th	0.23 µCi	02
04	^{226}Ra	2.5 µCi	02
05	^{60}Co	01- 2.5 µCi	30

Table 4: Industrial Radiography practices

Sl. No	Source	Activity	Units
01	^{192}Ir	45 – 102 Ci	09
02	^{137}Cs, for controlling X-ray Crawlers	20 mCi each	04
03	Industrial X-ray Machines	upto 300 kVp	07

Table 5: Nuclear Medicine Facility

Sl. No.	Source	Activity
01	^{125}I	02µCi – 02mCi
02	^{131}I	20 – 200 mCi
03	^{99m}Tc	100 – 405 mci
04	^{90}Sr	55mCi each – 13 units
05	^{137}Cs	11 µCi – 345 mCi
06	^{32}P	10 – 100 mCi, 3 units
07	^{67}Ga	10 – 50 mCi, 3 units
08	^{201}Tl	10 – 20 mCi, 3 units
09	^{186}Re ^{90}Yt, ^{133}Xe, ^{51}Cr, ^{57}Co, ^{58}Co, ^{60}Co, ^{153}Sm	

1.3 Education and Training

BAEC regularly arranges 3 months long Basic Nuclear Orientation Course for its newly recruited scientists. This course covers the fundamentals of all the areas of BAEC programs. Short duration specialized courses involved lectures, practical classes, workshop, seminar, conferences etc. are arranged. In addition, government of Bangladesh or other agencies like International Atomic Energy Agency (IAEA), Ministry of Education, Sports, Science and Technology (MEXT), Germany Academic Exchange Service (DAAD), Colombo Plan, International Centre for Theoretical Physics (ICTP) and other international organizations also provide the training for BAEC Scientist.

The training programme for the radiation protection and management are provided by the BAERA for the Radiation Control Officers (RCO's), radiation protection management staff and other facility personnel. In order to formulate training and education policies that are involved the application of the nuclear science and technology, BAEC has recently established a training institute in AERE, Savar for the scientists and engineers.

Figure 2: Training Institute at AERE Savar

1.3.1 RI Usage:

- **Production of radioisotopes**: (e.g.^{99m}Tc,^{131}I)
- **Agriculture**: ^{65}Zn, ^{32}P, ^{54}Mn, ^{3}H, ^{35}S and ^{14}C
- **Research:** ^{137}Cs,^{60}Co,^{226}Ra,^{241}Am,^{131}I,^{90}Sr,^{22}Na,^{192}Ir, ^{152}Eu etc.
- **Industrial Radiography practices:** ^{192}Ir, ^{137}Cs
- **Nuclear Well-logging Practices**: Am-Be, ^{137}Cs, ^{232}Th, ^{226}Ra, ^{60}Co
- **Nucleonic Gauge Practices:** ^{241}Am ^{60}Co, ^{137}Cs, ^{90}Sr, ^{85}Kr, Am-Be, ^{55}Fe, ^{63}Ni
- **Nuclear Medicine Facility:** ^{125}I, ^{131}I, ^{99m}Tc, ^{90}Sr, ^{137}Cs, ^{32}P, ^{67}Ga, ^{201}Tl, ^{186}Re ^{90}Yt, ^{133}Xe, ^{51}Cr, ^{57}Co, ^{58}Co, ^{60}Co, ^{153}Sm

1.3.2 Radiological Protection

The legislative basis for radiation protection in Bangladesh consists primarily of the President's Order No.15 of 1973 establishing the Bangladesh Atomic Energy Commission (BAEC); the Nuclear Safety and Radiation Control Act No.21 of 1993; and the Government Order HM/hospital-1/ap-2/2001 issued on 01/12/2001 transferring the control of x-ray machines from the Ministry of Health and Family Welfare to the BAEC. The regulatory function is exercised by the Bangladesh Atomic Energy Regulatory Authority (BAERA) which is a separate body now. The Nuclear Safety & Radiation Control (NSRC) Act of 1993 and the NSRC Rules–1997, (SRO NO-205-Law/97) stipulate that licensees engaged in activities involving normal exposure or potential exposure are responsible for the protection of the employees from occupational exposure. The provision of individual monitoring services is mandatory. A national system (logistics and/or technical capabilities) for monitoring the levels of radioactivity in foodstuffs and selected commodities before they are traded exists.

1.4 Standardization on Radiation and Radioactivity

Standardization and Calibration of radiation measuring instruments and dosimeters for performance tests are carried out using SSD laboratory at Atomic Energy Research Establishment (AERE), Savar. The Calibrated instruments and sources traceable to a primary standard laboratory. Participation in the IAEA intercomparison programs largely contributed to the improved accuracy and reliability on radiation and radioactivity measurement.

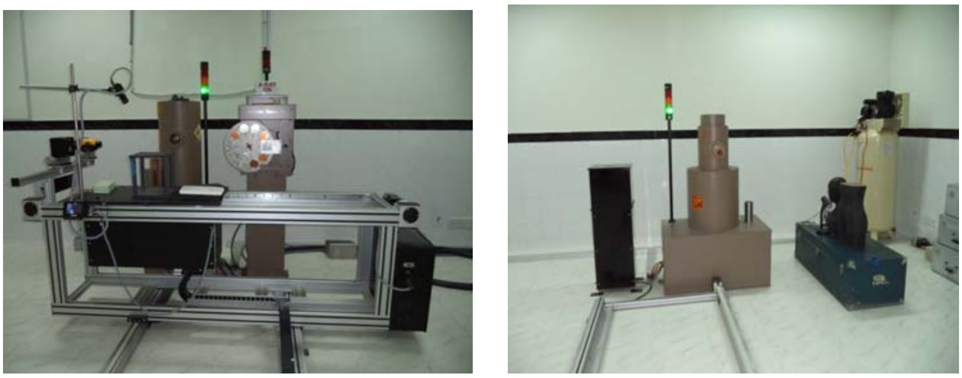


Figure 3: Secondary Standard Dosimetry Laboratory at AERE, BAEC

Part 2. Status of Radiation Safety Management

2.1 Radiation Safety Management in various RI Usage

The operating organizations establish and implement a radiation protection programme to ensure that all activities involving radiation exposure are compliance with regulatory requirements.

2.1.1 Radiation Protection Programme

The operational radiological safety programme of the research reactor and other nuclear/radiation facilities are carried out following the IAEA/NSRC regulation. Bangladesh Atomic Energy Commission (BAEC) ensures the safety and radiation protection of man and the related environment through the following radiological protection services:

- Radiation/contamination survey of all potentially radioactive/contamination areas
- Personnel monitoring of all radiation workers: TRF, casual workers and visitors
- Classification of supervised and controlled areas
- Environmental monitoring of all work places where air-borne radioactivity is likely to be generated
- Records keeping pertaining to all kinds of monitoring
- Safety evaluation of radiation workers and assessment of radiological risks
- Approval of activities, which involve actual or potential exposure to radiation or release of radioactive material to the environment
- Regular calibration of radiation monitoring instruments and records keeping
- Formulation of safety procedures for the safe handling of radioactive materials and radiation sources
- Safe management of radioactive waste
- Control over the internal movement of radioactive materials to and from the TRF radiation areas
- Advice on matters related to radiation protection

- Medical services
- Training

To ensure that accidents are generally prevented, the legal dose limits for both occupationally exposed personnel and the general public, as mentioned in the NSRC Rules 1997 are described in the table below:

Table 6: Effective dose and annual dose limit for occupational worker and general public

Application	Dose limits	
	Occupational workers	General public
Effective dose	20 mSv per averaged over five consecutive years	1 mSv in a year
Effective dose	50 mSv in any single year	5 mSv in any single year, in special circumstances, provided that the average dose over five consecutive years does not exceed 1 mSv/yr.
Annual equivalent dose to The lens of the eye The skin The extremities	 150 mSv 500 mSv 500 mSv	 15 mSv 50 mSv 50 mSv

2.1.2 Radiation Emergency Preparedness

The Nuclear Safety and Radiation Control Division (NSRCD) now called BAERA in cooperation with BAEC's Health physics and radiation-monitoring laboratories has been assigned to provide expertise and services in radiation protection. Capabilities for regular training of emergency personnel are being developed under national emergency plan. However, some capabilities have already been developed through training of relevant manpower in home and abroad. A draft national radiological plan is currently under review. One national committee, two subcommittees and one local subcommittee have been formed to perform responsibilities during radiological emergency.

Recently an act named Bangladesh Atomic Energy Regulatory (BAER) Act-2012 has been passed in the National Parliament of Bangladesh. A nuclear or radiological emergency preparedness and response related separate Chapter (Chapter-VI) has been incorporated in this Act. According to the new Act, Bangladesh Atomic Energy Regulatory Authority (BAERA) is responsible for coordinating the preparation of the national emergency plan regarding nuclear and radiological emergency.

2.2 Radiation Safety Management in Research Reactors

The operational radiological safety programmes of the research reactor are carried out following the IAEA/NSRC regulation. All radiation surveys are carried out by group member of radiation protection and RCO (Radiation Control Officer) maintain proper record.

2.2.1 Radiological Protection for Radiation Worker, Radiation Area, and Public

Assessment and control of radiation exposure to occupational workers and the public are performed under the ERM program. Radiation measurement for TRF (tritium reduction facility) worker is currently carried out by TLD (Thermoluminescent Dosimeter) techniques on a quarterly basis. All TLD's are checked/measured for evaluation of dose level for all occupational workers at TRF. Pocket dosimeters are also used if high dose rates are probable.

- The frequency of radiation surveys are determined by RCO depending on the nature and scale of operations carried out in the area
- Area in which radiation sources are used or stored interim storage room, heat exchange room, ion exchange resin bed, primary pump room, decay tank entrance door, fresh fuel storage room, reactor control room, reactor hall, reactor top, neutron spectrometry laboratory, tangential beam port area, piercing beam port, radial beam ports, rabbit room, etc. are monitored in regular intervals.
- A high-resolution gamma spectrometry system is used to analyze food and environmental samples.
- The gaseous radioactive effluents from TRF discharged through the stack are monitored before discharging to atmosphere

[Access control and zoning]

Areas where potential radiological risks from radiation or contamination are designated as control areas, which are further, classified as radiation area, contamination area or both. Areas in which sealed radiation sources are used or stored and radiation generating apparatus are in operation classified as radiation zones. Similarly, the areas in which unsealed radioactive materials are handled designated as radiation and contamination zones. Supervised areas are any areas where occupational exposure conditions need to be kept under review even though specific protective measures and safety provisions are not normally needed.

All controlled areas are marked with appropriate warning signs in order to indicate the presence of ionising radiation or radioactive contamination or both. All the person entering the controlled areas are required to wear radiation personnel monitoring devices such as TLD's or pocket dosimeters and protective clothing.

On account of external and internal radiation risks the areas have been declared controlled/supervised areas:

Table 7: Location of radiation control and supervised area at TRF

Location	Designated Areas
Reactor top	Controlled area
Reactor Hall	Controlled area
Control room	Supervised area
Public gallery	Supervised area
Reactor Manager Office	Supervised area
Laboratory room	Supervised area
Staff Sitting room	Supervised area
Senior reactor operator sitting room	Supervised area
Officers sitting room	Supervised area
Spare parts store room	Supervised area
Neutron spectrometer lab	Supervised area
Staff sitting room (Ground floor)	Supervised area
Health physics control room	Supervised area
Rabbit room (ground floor)	Controlled area
Fresh Fuel storage room	Controlled area
Radioactive waste storage room	Controlled area
Heat exchanger room (ground floor)	Supervised area
Primary pump & decay tank room	Supervised area
Stack (Ground floor)	Supervised area
Stack (1^{st} floor)	Supervised area
Stack (2^{nd} floor)	Supervised area
Stack (3^{rd} floor)	Supervised area

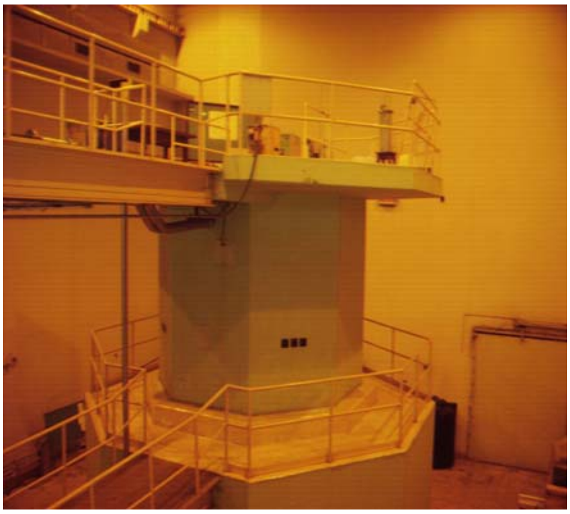


Figure 4: 3 MW TRIGA Mark II Research Reactor at AERE, Savar

2.2.2 Radiation Emergency Preparedness

The availability of the resources and tools required for responding to the emergencies has been ensured. The personnel are being trained continuously through testing of the emergency plans and procedures, taking part in the emergency exercises and publishing the appropriate information. As a result of the feedback of the experiences gained during the exercises, the emergency plans are being reviewed and improved. A complete organizational infrastructure of radiation emergency preparedness is in the development process.

2.3 Radiation Safety Management in Nuclear Power Plants

Currently, there is no power reactor in Bangladesh. It has one 3 MW TRIGA Mark II research reactor at Savar site.

2.4 Radiation Safety Management in Radioactive Waste Management

❑ **General Safety Provisions for Radioactive Waste**

In Bangladesh, radioactive wastes generated mainly from activities of research reactor operation, radioisotope production, nuclear medicines, industrial applications and other nuclear researches. These wastes are classified into low level radioactive waste and intermediate level radioactive waste. Criteria used to define and categorize radioactive wastes bases on the classification system as recommended by the IAEA. All radioactive wastes, including disused sealed sources, are kept to a minimum, adequately processed, stored or disposed of under regulatory control.

❑ **Radiation Protection Policy**

During all operation states, the main aim of radiation protection is to avoid any unnecessary exposure to personnel and to keep unavoidable exposure as low as reasonably achievable (ALARA). The radiation exposure of site personnel and members of the public conforms to the requirements of relevant authority (Rules).

For accident conditions the radiological consequences are mitigated by appropriate engineered safety features, by accident management procedures and by the means provide in the emergency plan.

Operating organization is responsible for :

a) Appropriate control of radiation doses to persons resulting from the operation.
b) Appropriate control of the amounts of radioactive substances released to the environment from the facility and off – site radiation dose levels.
c) Preparations for the management of on-site emergencies and co-operation with appropriate authorities during off - site emergency

The radiation protection programme includes adequate administrative measures, which take account of the design provision for:

a) Restricting the exposure of site personnel and of the general public within, established limits and the ALARA concept.
b) Ensuring that there is sufficient and appropriate instrumentation and equipment for personnel monitoring and protection.
c) Ensuring that there is on site radiological monitoring and surveying.
d) Ensuring that there is on - site cooperation between the radiation protection staff and operating staff in establishing operating and maintenance procedures when radiation

hazards are anticipated and direct assistance will be provided when required.

e) Providing for environmental radiological surveillance
f) Providing for decontamination of personnel equipment and structures
g) Controlling compliance with applicable regulation for the transport of radioactive materials.
h) Detecting and recording any release of radioactive material
i) Recording the inventory of radiation sources.
j) Providing adequate training in radiation protection practices.

All facility personnel are individually responsible for putting into practice the exposure control measures within their area of activity, which are specified in the radiation protection programme. Consequently, particular emphasis is given to all facility personnel to ensure that they are fully aware of both the radiological hazards and the protective measures available. Special attention is given to the fact that, personnel at the facility may include persons not permanently working there (e.g., experimenters, trainees, visitors and outside workers).

The operating organization verifies by means of surveillance, inspection and audits, that the radiation protection programme is being implemented and that its objectives are achieved, and undertakes corrective action if necessary.

If reference level is exceeded, the operating organization investigates the matter for the purpose of taking corrective action.

All personnel who may occupationally be exposed to significant levels of radiation have their exposure measured, recorded and assessed as determined by the relevant authority and this record is available to the regulatory body or to any other body designated by the national regulations.

If the limits for either personnel exposure or radioactive release are exceeded, the regulatory body and/or relevant authority informs in accordance with the requirements.

The radiation protection programme provide for the medical surveillance, the personnel who may be occupationally exposed to significant radiation doses. The legal dose limits for both occupationally exposed personnel and the general public are described in the table below:

Table 8: Effective dose and annual dose limit for occupational worker and general public

Application	Occupational	Public
Effective dose per year	20 mSv (averaged over defined period of 5 years)	1 mSv (averaged over any consecutive years 5mSv
Annual equivalent dose in the lens of the eye	50 mSv in any single year	15 mSv
Annual equivalent dose to extremites (hand or feet) or the skin	500 mSv	15 mSv

- **Personal Monitoring**

The essential aim of radiological protection is to prevent injury from ionizing radiation. It's basis respects for the recommended maximum permissible doses, but also calls for systematic observation to detect any radiation or irradiation effect. Radiation measuring devices e.g., pocket dosimeter, TLD and a whole body counter provide an individual radiation measurement for the facility personnel. Gamma spectrometry and radiation detectors system are also available in this unit for determination of the presence and quantity of radioactivity.


Figure 5: Individual Radiation Exposure Control

- **Area Monitoring**

For administrative purposes, disposal to the environment during routine operation is limited to clearance level for all radioisotopes. It is the policy of Central Radioactive Waste Processing and Storage Facility (CWPSF) operation group does not to release radioactive material above naturally existing amounts to any stream or ground water under normal operation conditions. The content of radioactivity in the treated wastes is checked to determine the concentration of radioactivity.

The solid wastes are collected and located on controlled area of the CWPSF for accumulation of clean and low - level contaminated waste.

Air sampling of site are taken weekly by health physics staff and the results are recorded. All equipment and areas are monitored by group member of radiation protection and reported to RCO for proper record keeping.

The Gamma Area Monitoring System is used for monitoring of radiation level in various parts of operation area. Each detector has a Geiger Muller detector as radiation sensor. The following is a list of equipment available area monitoring:

a. Portable survey meters
b. Portable air sampler
c. Geiger Muller Counter
d. Portable gamma analysis
e. Portable Dose - rate meter

Figure 6: Radiation survey meters used for the measurement of dose rate

❑ Environmental Monitoring

Air samples are collected and analysed in several locations within CWPSF, AERE and evaluation of radioactivity in these samples is done in regular basis. Background radioactivity around the setting locations of CWPSF, AERE are measured and evaluated every month.

Figure 7: Environmental Radioactivity Monitoring

❑ Emergency Preparedness

The operating organization is developing the capabilities for protection of the public and the environment by establishing policies, strategies and programme involving radiation exposure and radiological consequences due to accident conditions.

Bangladesh Atomic Energy Regulatory Authority (BAERA) in cooperation with BAEC's relevant laboratories is presently dealing radiation emergency situations. There are adequate arrangements for radiation workers and staff to be aware of the medical symptoms of radiation exposure and notification procedures. Regular basis trainings are being conducted in order to make the facility personnel and public aware of radiation and radiological emergency.

3. China

3. China

Part 1. Radiation Safety in RI Facilities

1.1 General

1.1.1 Legislative and Regulatory Framework

The legislative framework in China regarding radiation safety is composed of national laws, administrative regulations, and department rules.

The existing national laws applicable to the field of nuclear safety and radiation safety are:

1) The Law of the People's Republic of China on Environmental Protection;
2) The Law of the People's Republic of China on Prevention and Control of Radioactive Pollution; and
3) The Law of the People's Republic of China on Environmental Impact Assessment

The Law of the People's Republic of China on Environmental Protection was promulgated in 1989 by the Standing Committee of the National People's Congress. It is a specific law applicable to protecting and improving accessible environment, preventing and controlling pollution, protecting health of people, and advancing social progress. The Law of the People's Republic of China on Prevention and Control of Radioactive Contamination was promulgated in 2003 by the Standing Committee of the National People's Congress. This law is applicable to the prevention and control of environmental pollution that are caused by the discharge of gaseous, liquid and solid wastes in the context of nuclear energy expansion, nuclear technology applications, mining of uranium/thorium resources and ores associated with radioactivity, so as to attain the goals of preventing and controlling radioactive pollution, protecting the environment and health of people, and accelerate the development and peaceful use of nuclear energy and nuclear technology.

1.1.2 Regulatory Body

In China, the independent regulatory bodies which are relevant to radiation safety are Ministry of Environment Protection (MEP(NNSA-National Nuclear Safety Administration)), Ministry of Health and Ministry of Public Security.

❑ **MEP/NNSA Responsibilities**

MEP (NNSA) undertakes the overall regulation of the country-wide prevention and control of Radioactive Pollution, through review and authorization, supervision and inspection, and supervisory monitoring of the activities associated with license holders. Thus it can be ensured that the license holders assume the responsibility of safety and conduct activities in compliance with relevant laws and regulations. MEP (NNSA) is principally responsible for:

1) Drafting and establishing policy, strategy and regulations relevant to nuclear safety, radiation safety, prevention and control of radioactive pollution, and coordinating development and publication of relevant standards;
2) Licensing and regulating of nuclear safety, radiation safety and prevention and control of radioactive pollution;
3) Investigating and tackling nuclear safety accident and radiation safety accident, in cooperating with other relevant organizations in providing guidance on, and supervision of the preparation and implementation of NPP emergency plan, and working with other

relevant organization in participating with nuclear accident emergency through the conciliation and resolution of the dispute relating to nuclear safety;

4) Conducting review, authorization, supervision and inspection of environmental impact assessment;
5) Supervisory monitoring the discharge of radioactive effluents and radiation environmental release; and
6) Planning and coordinating relevant scientific research and promoting dissemination of relevant knowledge.

- **Ministry of Health**

The main responsibilities of the Ministry of Health

1) Developing health related regulations and standards for radiological workers;
2) Supervising the doses that may be received by the radiological workers;
3) Reviewing and authorizing occupational health/hygiene assessment; and
4) Organizing the radiological injury diagnosis and treatment and the medical rescue in the case of nuclear and radiation accident.

- **Ministry of Public Security**

The Ministry of Public Security is principally responsible for investigating and recovering the lost radioactive sources, and for the security of road transport of radioactive materials.

- **Functions of China Atomic Energy Authority**

In addition to the forgoing mentioned regulatory bodies, the China Atomic Energy Authority (CAEA) is one of the primary governmental agencies relevant to radiation safety, with the following functions:

1) To research and draft out policies and regulations for peaceful utilization of atomic energy in China;
2) To research and establish developing program, planning, and nuclear industry standard for peaceful utilization of atomic energy in China;
3) To organize demonstration, review and approval of relevant science and technology research project on peaceful utilization of nuclear energy in China; be in charge of surveillance and coordination of the implementation of science and technology projects;
4) To be in charge of control of nuclear materials and physical protection of nuclear installations;
5) To be in charge of review and management of nuclear export;
6) To be in charge of communication and cooperation in nuclear energy field among governments and also among international organizations; take part in the IAEA and its related activities on behalf of Chinese government;
7) To undertake emergency management of state nuclear accidents and lead on organizing the National Coordinating Committee for nuclear Emergency, be in charge of developing, preparing and implementing national nuclear accident emergency plan;
8) To be in charge of the decommissioning of nuclear installations and the treatment of radioactive waste.

1.2 Outline of Radiation Facilities and Radiation Sources

1.2.1 Authorization

All radiation sources-related production, sale, transfer, use, import, and export shall be subjected to the licensing system. MEP(NNSA) and the bureaus of environment protection at provincial level, observing principles of categorizing radiation sources and regulations in this respect, separately exercise rights of approval and documentation.

The categorization of radiation source in China is principally equivalent to the IAEA's categorization. Based on the potential hazards on human and environment, radiation sources are divided into five categories. For organizations that produce radioisotopes or sell and use category sources, MEP(NNSA) takes direct responsibilities of reviewing, approving and granting licenses. Authorities concerned at provincial level grant licenses for the rest of radioactive sources.

1.2.2 Workers and Specialists in Radiation Facilities

1.2.2.1 Radiation Workers

The number of people working with radiation related industry in China is difficult to correctly define, according to an incomplete statistics, 300 thousand people are engaging in the utilization of nuclear technology.

1.2.2.2 Radiation Protection Supervisors

The MEP(NNSA) is the government authority responsible for radiation safety. The MEP(NNSA) has six regional branches in Shanghai, Shenzhen, Chengdu, Beijing, Lanzhou and Dalian, respectively, which are responsible for routine supervision of nuclear safety and radiation safety in designated areas. In order to fulfill a better implementation of regulatory functions, MEP (NNSA) set up a Nuclear and Radiation Safety Center as technical support and guarantee for itself. An expert panel concerning nuclear safety and the environment was set up to provide technical support in aspects of drafting nuclear safety and radiation safety laws and regulations, decision-making, technical development, technical review and supervision. MEP (NNSA) has nearly 1000 staff in total now.

In order to ensure and maintain the capability of regulatory staff, it is required that the staff shall meet the follow conditions:

1) Have a bachelor's degree or above or at the same educational level;
2) Have gained more than 5 years of practical experiences or more than 3 years of experiences in nuclear(radiation) safety management, being able to fulfill the task of nuclear(radiation) safety supervision under the rule of relevant law and regulations independently, and be able to make correct judgment and write qualified report;
3) Be familiar with national nuclear (radiation) safety regulations and complying with the relevant national laws and regulations; and
4) Be honesty, just, devoted and modesty.

1.2.2.3 Activity of Radiation Sources and Number of Generators

In China, application of sealed sources started in the 1930's. Documentation has shown that the earliest radioactive source found in China is radium needles used in a hospital in Beijing. With the dramatic expansion of nuclear technology and the increasing development of economy, in particular since the 1980's, the use of sealed radioactive sources is rapidly expanding in China. According to an incomplete statistics, the number and quantity are increasing at 10% rate per year in the recent years. As of December 31, 2006, the total number of the producers, vendors and users of radioisotopes amount to about 13051 across the country, with more than 140,000 of sealed sources involved in total.

1.2.3 Recent Movement Concerning Radioisotope Sources

1.2.3.1 Develop Conditioning Capability for Spent Radioactive Source

Spent radioactive sources are currently held in the provincial nuclear application wastes storage facilities and in the centralized radioactive source storage facility or at user's premises. These radioactive sources have not been conditioned into a stable form, which occupy large storage space and pose high potential risk. China is making effort to establish a research and development base to develop radioactive source conditioning technology as soon as possible for the purpose to improve the safety of radioactive source storage. At the same time, China is exploring options for disposal of spent radioactive sources, it is expected to seek a long term solution for spent radioactive sources.

1.2.3.2 Promote Disposal of LILW

In accordance with the *Law of the People's Republic of China on Prevention and Control of Radioactive Pollution*, China is organizing to develop the siting program for solid radioactive waste disposal. This will help analyze the demands for solid LILW disposal in a comprehensive manner and direct the development trend of solid LILW disposal and promote the development of regional disposal site for LILW.

1.2.3.3 Promote Minimization of Radioactive Waste

One of the principles and objectives for radioactive waste management is to control the generation of radioactive waste so as to achieve the minimization of radioactive waste in China. The expansion of nuclear power in China raised a high requirement for safety of radioactive waste management. As a result, facilitation of radioactive waste minimization is a sustainable work Chinese government faces. Compared with advanced countries, there are still larger potentials to reduce waste generated at NPPs. However, the minimization of radioactive waste is a combined effort balancing factors of technology, safety and economy. China will take more action in controlling generation of waste, upgrading management, introducing advanced waste reduction technology, promoting specialization and socialization in radioactive waste treatment service.

1. 4 Education and Training

1.4.1 The Law Concerning Prevention of Radiation Hazards Due to Radioisotopes, etc.

Under Article 28 of Regulations on Safety and Protection against Radioisotope and Ray-generating Installations, any undertakings who produce, distribute and use the radioisotope and ray-generating installations shall provide training in nuclear safety and protection knowledge to the workers who is directly associated with production, distribution and use of them. Examination shall be given to the trainee. The worker who does not passed the given examination is not fit the job post with radiation safety related responsibility. The training program, in conjunction with training materials, was developed by the MEP in such a way as to have an enhanced training management and consistent training and examination requirements. Training organizations have been accredited with whole process supervision being provided of training and examination.

1.4.2 The Nuclear Reactor and Fuel Law

Recruitment, training and re-training of nuclear facility operational personnel and authorization are subject to the nuclear safety guideline "Staffing, Recruitment, Training and Delegation at NPPs".

As required by the relevant regulations, guidelines, and standards, the requirements for post qualification is defined, on the basis of the post-specific task analysis, and the training and retraining program and procedures are developed and implemented. The personnel working in nuclear facilities can carry out the relevant post with responsibility only after appropriate training, qualification examination, and acquirement with post qualification certificate or authorization granted.

Validity period management is applied to the qualification and authorization for nuclear facility personnel. After expiration of effective period, the extension and renewal of qualification certificate shall be made in accordance with the post-specific requirements. Furthermore, additional training and re-training are needed to ensure for the personnel to meet the post-specific requirements.

With the expansion of nuclear power production in China, systematic training approach is being drawn on at nuclear facilities. Training demand analysis is based on the actual work conditions. With focus on the safe operation of nuclear facilities, different types of training and technical support activities are carried out in so far as to continue to raise the level of knowledge and competence of nuclear facility' personnel. Training resources are optimized through standardizing teaching material preparation. Trainer management and cultivation are strengthened by many approaches. The internal and external evaluation and feedback are conducted to continue the improvement of the existing training system.

1.4.3 Examples of Education and Training

In order to raise the quality of the technical staff for nuclear safety related activities, Chinese government, in November 2002, issued the Temporary Regulations on Registration qualifications for Nuclear Safety Engineer under which the occupational qualification system was established for the technical staff working on the key nuclear safety related posts who are providing nuclear safety related technical services for the nuclear energy and nuclear technology applications. It was issued consistent with the relevant provisions of the Law of the People's Republic of China on Prevention and Control of Radioactive Pollution to enhance the management of the key posts with nuclear safety related responsibility, ensure nuclear and radiation environmental safety, and maintain national and the public's interests. Subsequently, Nuclear Safety Engineer Registration Management Rules was issued in 2004, and the Temporary Regulations on Continued Education of Registered Nuclear Safety Engineer was issued in 2005.

Country-wide examination is sponsored annually for applicants for registration qualification after being given systematic training and qualification certification. The subjects to be examined cover nuclear safety related laws and regulations, nuclear safety related comprehensive knowledge, nuclear safety related practices and nuclear safety case analysis. Qualification Certificate of the People's Republic of China for Registered Nuclear Engineer is granted to the qualifier after his or she passed the given examination. The validity period of a registration is 2 years. Continued educational regime is performed for the registered nuclear safety engineers.

The occupational scope of a registered nuclear safety engineer covers review of nuclear safety case, supervision of activities affecting nuclear safety, manipulation and operation of nuclear facilities, quality assurance, radiation protection, radiation environmental monitoring, and other nuclear safety closely related fields prescribed by the MEP(NNSA) .

1.5 Standardization on Radiation and Radioactivity

In China, standard is one part of the legislation and regulation. Chinese government has attached high degree of importance to the legislation and regulation of nuclear and radiation activities, thus leading to the continued improvement of the legislation and regulation system. In 1960, the Regulation on Health and Protection for Work with Radioactivity was promulgated. Subsequently in 1974, Regulation on Radiation Protection（GBJ8-74）was issued. In 1979, the Law of the People’s Republic of China on Environmental Protection (for trial) was promulgated for implementation, stipulating that the design, construction and operation of a main project must be simultaneous with those of the facilities used for preventing pollution and other public hazards. In 1986, the State Council issued the Regulation on the Safety Control for Civilian Nuclear Installations, establishing the nuclear facility licensing system, and setting up independent regulatory body for nuclear facility safety. In 1989, the State Council issued the Regulations on Safety and Protection of Radioisotope and Ray-generating Installations, stating that licensing system shall be applied to the production, distribution and use of radioactive sources and the recovery and storage of disused radioactive sources. Various administrative departments under the State Council relating to health, environmental protection and public security shall apply phased regulation to the radiation protection in the production, distribution and use of radioisotopes. The environmental protection competent authority under the State Council is responsible for the regulation of the recovery and decommissioning of radioactive sources. In 1992, the State Council approved and circulated the Environmental Policy on LILW Disposal in China (State Council [1992]45), which strongly boosts the matters relevant to radioactive waste disposal. In 1993, the State Council issued the Regulations on Accidental Emergency Management at Nuclear Power Plant, setting out the policies, strategies and measures to be adhered to in the event of an emergency. In 2003, the Law of the People’s Republic of China on Prevention and Control of Radioactive Pollution was promulgated for enforcement. It defines that the environmental protection competent authority under the State Council has the overall responsibilities for the country-wide prevention and control of radioactive pollution by virtue of the relevant national laws and that other administrative departments under the State Council shall implement their allocated duties in this regard. In 2004, the State Council caused the Regulations on Protection against Radioisotope and Ray-generating Installations of 1989 to be revised, and renamed Regulations on Safety and Protection of Radioisotope and Ray-generating Installations. It lays out that the previous by-stage, multi-sector regulatory approach was changed to a unified regulatory system by the environmental protection competent authority of radioactive sources. In 2002, the Basic Standards for Protection against Ionizing Radiation and for the Safety of Radiation Sources (GB18871-2002), a Chinese Standards, was issued.

Part 2. Status of Radiation Safety Management

2.1 Radiation Safety Control in RI facilities

2.1.1 Radiation Safety Control System

In 2005, the State Council issued the Regulations on the Safety and Protection of Radioisotopes and Ray-generating Installations (the State Council Order No. 449). These regulations, fully observing requirements stated in the IAEA Code of Conduct on the Safety and Security of Radioactive Sources and the Basic Safety Standards on Ionizing Radiation Protection and radioactive Sources(Chinese Standards GB18871-2002), have constructed a spectrum of regulation mechanism. These include:

a) Practicing a licensing system abided by organizations producing, selling, or using radioactive sources;
b) Full-traced control over applications of radioactive sources;
c) Reviewing and documentation of radiation-related transfer, export and import;
d) Documentation of sources applications in different locations from originally assigned places;
e) Specifying the procedures of retrieving disused radioactive sources to manufacturers.

MEP(NNSA) supervises and administers the safety and security of radioisotope and radioactive equipments throughout the country in centralized manner, including the practicing and monitoring of foresaid systems, construction of information system for monitoring and controlling radioactive sources, management of training radiation workers and monitoring dose information to persons exposed to radiation, response to emergencies, and inspection of radiation safety and security.

MEP(NNSA) takes direct responsibilities of reviewing, approving and granting licenses for Category sources.

The provincial government authorities take responsibilities for the rest categories of radioactive sources.

For local environment authorities (at level of city or county), special offices or technicians are assigned to control and manage the applications of nuclear technologies within their jurisdiction.

MEP(NNSA) is responsible for establishing an information management system regarding the production and use of radioisotope. Since 2004, MEP(NNSA) has commenced to localize IAEA's Radioactive Source Information System(RAIS), and now this system has been put into operation throughout China.

2.1.2 Radiation Protection of Workers

In accordance with China's laws and regulations, those organizations which produce, sell or use radioisotope and radioactive equipments shall monitor radiation dose exposed to those staffs who directly involves in activities of producing, selling or using those radioactive isotopes or devices , and give the staffs occupational physical examinations, establish files of personal radiation dose and occupational health caring.

As regulator, the environmental protection authority is free from involving in tasks of monitoring personal radiation dose, nevertheless, the licensed organizations are required to file personal radiation dose documents and give an annual report to authorities granting the license. By this mean, the authorities will be promptly informed with that if the safety and protection of radiation work sites meets the requirements.

2.1.3 Radiation Protection of Working Area

According to China's regulation, obvious radioactive sign should be set at the workplace in which radioisotope or ray-generating installations are produced, sold, used or stored, the radiation protection facilities, necessary safety interlock and alarming devices should be set up at the entrance. Safety measures to prevent mis-operating and unexpected radiation exposure for the employee or the public should be taken.

The requirements for the monitoring of the workplace are consistent with the IAEA BSS in China. Program for the monitoring of the workplace under supervision should be established, maintained and kept. The nature and frequency of monitoring workplace should be determined according to the radiation level and the potential exposures, to enable: i) evaluation of the radiological conditions in all workplace; ii) exposure assessment in controlled areas and supervised areas and iii) review of the classification of controlled and supervised areas. The program for monitoring of the workplace shall specify: i) the quantities to be measured; ii) where and when the measurements are to be made and at what frequency; iii) the most appropriate measurement methods and procedures; iiii) reference level and the actions to be taken if they are exceeded.

2.1.4 Public Radiation Protection

In China, the dose limits required by the standards for public exposure is as the followings:

1) An effective dose of 1 mSv in a year;
2) In special circumstances, an effective dose of up to 5 mSv in a single year provided that the average dose over five consecutive years dose not exceed 1 mSv per year;
3) An equivalent dose to the lens of the eye of 15 mSv in a year;
4) An equivalent dose to the skin of 50 mSv in a year.

The registrants and the licensees are responsible for any public exposure which is delivered by the practice or source. The responsibilities are as the followings:

1) To establish protection and safety policies and organizational arrangements in relation to public exposure in fulfillment of the requirements of the standards;
2) Take measures to ensure the optimization of the protection of members of the public, and the limitation of normal exposure of the relevant critical group, which is attributable to such sources, in order that the total exposure be not higher than the dose limits for member of the public;
3) To ensure the safety of such sources, in order that the likelihood of public exposure be controlled in accordance with the requirements of the Standards;
4) To provide suitable and adequate facilities, equipments and services for the protection of the public;
5) To provide appropriate protection and safety training to personnel having functions relevant to the protection of the public;
6) To provide appropriate monitoring equipment and surveillance programmes to assess public exposure ;
7) To keep adequate records of the surveillance and monitoring ;

8) To establish emergency plans or procedures;
9) To ensure the optimization process for measures to control the discharge of radioactive substances from a source to the environment.

2.1.5 Emergency Action

According to the nature, severity, controllability and impact extent of a radiation accident, they are classified into exceptionally serious radiological accidents, major radiological accidents, serious radiological accidents and ordinary radiological accidents, with exceptionally serious radiological accidents as the most serious and ordinary radiological accidents as the least.

The MEP is responsible for emergency response to radiation accidents, and for investigation and classification of the accident. For this reason, Radiation Accident Emergency Plan is specially established. Under the *Council of State Decree 449*, the environmental protection agencies of the people's governments at or above county-level should work with the agencies responsible for public security, health and finance at the same level to make joint effort to prepare radiation accident emergency plan within their own administrative areas. The plan is subject to approval of county-level people's governments to ensure their legality and validity and should make them available to the public in an appropriate form.

The license holder shall prepare emergency plan for its facility based on potential accident risk and make emergency preparedness.

Once a radiation accident occurs, the holder of radiation safety license shall initiate emergency plan that has been prepared in advance and take emergency measures to check the effectiveness of the measures taken from time to time. Within two hours after an accident occurring or being discovered, report shall be made to the agencies responsible for the environment, health and public security. After receiving such a report, the agencies should dispatch personnel to the accident site to conduct emergency fieldwork in a way consistent with the provisions, and at the same time report the information to their respective upper level competent agencies in a prescribed way. The personnel that have arrived at the accident site should carry out their own respective responsibility through taking effective measures, controlling and eliminating accidental impacts. In the case of an exceptionally serious radiological accident or a major radiological accident, the people's governments at the level of province, autonomous region and municipality directly under the State shall report to the State Council not later than 4 hours after the accident occurs.

2.2 Radiation Safety Management in Nuclear Facility (Nuclear Power Plant, Research Reactor, Radioactive Waste Treatment Facility)

2.2.1 Radiation Safety Management System

A wide spectrum of laws, regulations and national standards are promulgated in China to ensure the achievement of the goals of radiation protection. On 8 June 2003, the Standing Committee of the National People's Congress promulgated the Law of the People's Republic of China on Prevention and Control of Radioactive Pollution, laying down prevention and control of radioactive pollution as follows:

1) The operator of a nuclear facility shall be responsible for the prevention and control of radioactive pollution arising from such a facility and subject to the regulatory control of the competent authority of environmental protection and other relevant agencies, and take the liability of radioactive pollution arising from such a facility;

2) The operator of any nuclear facility shall monitor the types and concentrations of radionuclides in the surrounding environment and the quantity of radionuclides in effluents from such a facility, and report the monitoring results to the competent authorities of environmental protection both under the State Council and at the provincial level;
3) The operator of any nuclear facility shall make the effort to reduce the radioactive waste generation as low as reasonably achievable. Release of gaseous and liquid radioactive wastes into the environment shall be consistent with national standards on radioactive pollution prevention and control, and the quantitative results of release shall be reported to the competent authorities of environmental protection.

Any nuclear facility is required to set dose limits as management goals under the GB18871-2002 taking account of economic and social factors, which should be lower than the relevant national limits. The GB18871-2002 requires that release of radioactive materials into the environment shall be controlled in such a way to determine the important pathways through which the public are exposed to radioactive material and that the impacts upon the human and the public shall be assessed. The GB18871-2002 also sets up the following individual dose limits:

- ❑ Occupational exposure

(1) Effective dose of 20 mSv per year is prescribed by regulatory body, averaged over defined 5 year periods, rather than any traceable average;
(2) The effective dose should not exceed 50 mSv in any single year;
(3) Annual equivalent dose for Lens of the eye is 150 mSv;
(4) Annual equivalent dose for hands and fee is 500 mSv;

- ❑ Public exposure

(1) Annual effective dose limit is 1 mSv
(2) In special circumstances a higher effective dose value of 5 mSv could be allowed in a single year, provided that the average over defined 5-year periods does not exceed 1 mSv per year;
(3) Annual equivalent dose for lens of the eye is 15 mSv;
(4) Annual equivalent dose for skin is 50 mSv.

2.2.2 Radiological Protection for Radiation Worker

According to the monitoring results of occupational exposures, the average annual dose equivalent to workers in the operating NPPs in China is far below the national limits given in standards, as shown in the following Table 1.

Table 1: Monitoring results of occupational exposures

NPP	Year	Annual average individual effective dose (mSv)	Annual maximum individual effective dose (mSv)	Annual collective effective dose (Man.Sv)	Normalized collective effective dose (Man.mSv/GWh)
Qinshan NPP	2007	0.650	8.450	0.997	0.450
	2008	0.153	3.577	0.149	0.057
	2009	0.336	4.257	0.453	0.192
Guangdong Daya Bay NPP	2007	0.378	9.476	1.053	0.068
	2008	0.307	5.988	0.826	0.051
	2009	0.278	5.240	0.715	0.044
Qinshan Phase II NPP	2007	0.347	8.164	0.785	0.088
	2008	0.300	4.881	0.588	0.059
	2009	0.345	7.899	0.710	0.071
Guangdong LingAo NPP	2007	0.456	8.533	1.231	0.083
	2008	0.600	12.169	1.772	0.116
	2009	0.502	10.568	1.531	0.099
Qinshan Phase III NPP	2007	0.277	5.900	0.572	0.050
	2008	0.364	9.102	0.788	0.070
	2009	0.327	6.415	0.748	0.064
Tianwan NPP	2007	0.136	2.693	0.327	0.033
	2008	0.209	3.460	0.557	0.040
	2009	0.244	3.200	0.548	0.038

2.2.3 Radiation Area Management

Principles and requirements of radiation protection were provided for by national nuclear safety regulatory bodies in a wide spectrum of regulations governing the siting, design and operation of nuclear facilities at any stages:

1) At the stage of siting, the public and the environment should be protected from excess radiation exposure from emerging radioactive accidents, simultaneously with due account being taken of normal release of radioactive materials from NPPs;
2) Full consideration should be given to radiation protection requirements, such as optimized facility deployment, installation shielding, in such a way to make the activities and occupancy time of persons within radiation areas as less as possible;
3) Taking necessary measures to reduce quantity and concentrations of radioactive materials within plant area or released to the environment;
4) Taking into careful consideration possible accumulation of radiation level with time within occupancy area in such a way as to as less radioactive waste as possible to be generated;
5) Carrying out, on the part of operating nuclear facilities, assessment and analysis of radiation protection requirements and their implementation, making and implementing radiation protection programs to ensure the implementation of such programs and the verification of their goal achievement, and if necessary taking necessary corrective actions; and

6) Making and implementing, by radiation protection functional departments, radioactive waste management programs and environmental monitoring program to assess environmental impacts of radioactive release.

The Technical Policies Governing Several Important Safety Problems in Design of Newly Built NPPs was issued in August 2002, where nuclear safety analysis should be accomplished in designing NPPs to assess the possible doses to both NPP's workers and the public and potential environmental consequences. Various measures are required to be taken for controlling radiation exposure and reduce possibility of an accident.

2.2.4 Radiation Protection for Public

The Regulations on Radiation Protection for NPPs GB6249-86, clearly sets out effective dose equivalent to any adult individuals of the public arising from released radioactive materials into the environment from NPPs and the annual release limits of airborne and liquid radioactive effluents:

1) Effective dose equivalent to any adult individuals of the public arising from a NPP should be less than 0.25 mSv;
2) In addition to meeting the above provisions, the airborne and liquid radioactive effluent from a PWR NPP should be also less than the control values listed in the following Table 2.

Table 2: Annual discharge limits under operational conditions of a PWR Nuclear Power Plant (Bq)

Airborne radioactive effluent			Liquid radioactive effluent	
Noble gas	Iodine	Particle (half-life≥8d)	Tritium	other
2.5×10^{15}	7.5×10^{10}	2.0×10^{11}	1.5×10^{14}	7.5×10^{11}

Monitoring was made in the surrounding environment in provinces where China' NPPs are located. The results show that the discharged quantities of effluents in operational NPPs caused the maximum individual doses to the public in the proximity far lower than national limits.

Environmental monitoring program was developed by nuclear facilities for key nuclides, exposure pathways (transfer) and key populations as defined in the environmental impact report with a view to carrying out environmental radioactivity monitoring to ensure compliance with the provision of the relevant national laws and regulations, satisfaction with radioactive waste discharge limits and protection of the public from radiation impacts arising from nuclear facility operation. Environmental radioactive monitoring data shall be used to assess and analyze the validity of controlling radioactive material release into the environment, the public exposure from nuclear facility' effluent, long term trend in variation in environmental radioactivity, migration and dispersion of radioactive material in the environmental media and the reality of environmental model used for establishing authorized limits.

Environmental radioactive monitoring includes pre-operation monitoring, routine environmental radiation monitoring, radioactive effluent monitoring and meteorological monitoring.

Pre-operation monitoring means a two-year long survey of radioactive background and ocean ecology through which the information on key nuclides, key exposure (transfer) pathway and key populations can be obtained. The investigated media comprise air, surface water, groundwater, terrestrial and marine organisms, foods, soils among other things. Environmental gamma radiation level is investigated within 50 km of the proposed sites with others within 20 km of the proposed sites.

What to be analyzed and measured includes environmental radiation level and radionuclides released from nuclear facilities. Before operation of NPPs in China, environmental radioactivity backgrounds are measured and the results preserved in such a manner as to ensure the representative of environmental monitoring extent and frequency that meet the relevant requirements.

Routine environmental radiation monitoring means that as much optimization as possible is achieved by nuclear facilities through making full use of pre-operation survey information on the premise to meet the needs of environmental assessment. Environmental monitoring focuses on what is deemed to be maximum risks to the key populations.

Radioactive effluent monitoring refers to the monitoring of gaseous and liquid radioactive effluents after nuclear facilities come into operation, involving total quantity and concentrations of nuclides released and the main nuclides to be analyzed. Monitoring results show that the quantity of radioactive effluents discharged is not in excess of national limits.

Meteorological monitoring aims to atmosphere diffusion monitoring. Meteorological monitoring programs have been prepared with the aim of making continuous monitoring of wind direction, velocity and air temperature, precipitation and air pressure at varying heights above ground at the typical selected locations. In addition, lines of communication are established between NPPs with meteorological observatory stations in provinces where they are situated so as to obtain the needed meteorological data.

Accident emergency monitoring means the environmental emergency plan prepared by NPPs prior to their operation, where derived intervention levels are provided for in order to assess monitoring results and decide whether or not to take necessary action as early as possible.

NPPs are equipped with radiation monitoring meters, radiation surveillance meters, contamination monitoring meters, air sampler and environmental media sampler among others, with regular test and calibration. All emergency equipment is, as required, tested for reliable use.

Assessment of public dose and environmental impact is performed at NPPs based environmental monitoring data. Accumulated gamma radiation monitoring data at the plant boundary are used, together with data in respects of atmosphere fly dust, terrestrial organisms, soils, water quality and other environmental media, to assess the dose equivalent to the public and environmental impact arising from the operation of NPPs under normal and abnormal conditions

Effective environmental monitoring and assessment have been completed by NPPs under the auspices of NNSA. The measurement and analysis of samples from biology, air, soils and ocean in the surrounding environment show that NPPs have caused no adverse impacts on the environment.

2.2.5 Nuclear Emergency Response

Three-level emergency organizational system which has been established in China, which consists of national nuclear emergency organization, provincial emergency organizations (including autonomous region, municipality directly under central government where nuclear facilities are located) and the nuclear facility’s emergency organizations.

National Nuclear Accident Emergency Coordination Committee (NNAECC) organizes and coordinates the country-wide nuclear emergency management arrangement. National Nuclear Accident Emergency Office (NNAEO) is the management body for country-wide nuclear accident emergency arrangements

If necessary, the State Council shall lead, organize and coordinate country-wide nuclear accident emergency arrangements.

The MEP (NNSA) executes independent supervision of NPPs’ nuclear accident emergency arrangements, and overseeing the development and implementation of NPP nuclear accident emergency plan.

The competent authorities of environmental protection, health, army and other related agencies shall make every effort to implement nuclear accident emergency response arrangement within the scope of their responsibilities.

Nuclear accident emergency committees of provincial governments where nuclear facilities are located are responsible for nuclear accident emergency arrangements within their administrative areas.

Nuclear accident emergency organizations of nuclear facilities have the following responsibilities:

1) Enforcing national regulations and policies on nuclear accident emergency arrangements;
2) Preparing onsite nuclear accident emergency plan and making nuclear accident emergency arrangements;
3) Determining nuclear accident emergency classification, commanding nuclear accident emergency response actions;
4) Timely notifying information on nuclear accident situation to the higher competent authorities, the MEP (NNSA) and the agencies designated by provincial governments and making suggestions on initiating off-site emergency actions and protective actions; and
5) Assisting and helping the agencies designated by provincial governments in making nuclear accident emergency arrangements.

The following four emergency classes are used in China, in order of increasing severity.

1) Emergency standby: Certain types of special conditions and external events that could endanger the safety of nuclear facilities are expected to have occurred. Nuclear facility emergency personnel are in standby and some of the offsite emergency organization may be notified;
2) Plant emergency: Radiation consequences is only limited to part of in-plant area. In this case, onsite personnel may take actions under emergency plan and relevant offsite emergency organizations may be notified;
3) Plant area emergency: Radiation consequences are only limited to in-plant area. In this case, onsite personnel put into action and offsite emergency organization may receive notifications, also with some have potential to take actions; and
4) Offsite emergency: Radiation consequences are expected to have exceeded plant boundary. Onsite and offsite personnel start to take actions, and onsite and offsite emergency plans start up.

When in the emergency standby situation, emergency organization of a nuclear facility shall timely report to higher competent department and MEP (NNSA) and to nuclear accident emergency committee of the province where such nuclear facility is located where appropriate. When any releases of materials are expected to be in process or have occurred, plant emergency or plant area emergency shall be initiated timely where appropriate and shall report to the higher competent department, the MEP (NNSA) and provincial accident emergency committee.

When radioactive materials are expected to be in process or have dispersed to outside the plant area, suggestions shall be made on entering into plant area emergency situation and taking protection actions. After receiving notification on accident, provincial nuclear accident emergency committee shall take emergency countermeasures and prompt actions and report timely to national nuclear accident emergency committee. Determination to enter into offsite emergency situation is subject to approval from the NNAECC. In some special conditions, provincial nuclear accident emergency committee can determine to enter into offsite emergency situations prior to approval and then report timely to the NNAECC.

When entering into an offsite emergency situation, the NNAEO, MEP (NNSA) and other agencies involved shall dispatch persons in a timely manner to the field and provide guidance to the nuclear emergency response actions.

4. Indonesia

4. Indonesia

Part 1. Status of Radiation Safety Management

1.1 Radiation safety management in Radioactive Waste Management

1.1.1 Radiation Safety Management System

Radioactive waste management technology center (RWMTC) at BATAN Serpong is responsible on managing any kinds of radioactive wastes generated by all radiation and nuclear facilities in Indonesia. In Serpong, the wastes mostly come from research reactor, chemical processing facilities including radioisotope and radiopharmacy production facilities, and fuel element and radiological laboratories.

Radioactive waste management technology center (RWMTC) is a centralized facility at Serpong site for solid and liquid waste treatment. Solid radioactive wastes collected in standard 100 liter drums from the different source are brought to RWMTC at Serpong site. They are segregated into combustible and non-combustible, and compressible and non-compressible types. The low active combustible wastes are incinerated and the compressible ones are compacted in 200 liter drums. Non-combustible and non-compressible wastes are packed into 200 liter concrete drums and stored in an interim storage. Liquid waste transported from generating facility to RWMTC through mobile tank for evaporation and/or chemical treatment. Sludge generating from evaporation or chemical chemical treatment and ash from incineration treatment are cemented in 200 liter standard drums. Liquid radioative effluent below clearance levels is discharged to Cisalak river.

1.1.2 Radiation Safety Survrilliance

RWMTC is designed to provide adequate radiological safety for operating staff, members of the public and the environment. Contamination control is applied by zoning policy, and suitable protective clothing is provided at appropriate locations. Liquid effluent generated from facility operation is discharged by pipelines through integrated waste control (IWC/PBT). Ventilation system is also designed so that the facility areas are kept under negative pressure. The exhaust air is discharged to atmosphere through a bank of high efficiency particulate air (HEPA) filters.

1.1.2.1 Area Monitoring

The radiation fields of all working areas including those outside the waste processing facility are monitored routinely. Working areas are also checked for radioactive contamination by swiping (smear tests), with special attention given to areas like corridors, worker rooms, etc. Location where radiation field is excessive are identified and classified. Adequate shielding is provided for equipments which show high dose rates. Occupancy in high radiation field areas is controlled by the system of special work permit (SWP). Area radiation monitors with alarm setting are installed at few locations in the facilities. A routine air sampling programme is in place, employing discontinuously operated air samplers at fixed location, and by batch air samplers during routine and specific operations.

1.1.2.2 Personnel Monitoring

Personnel monitoring for external exposure is routinely carried out using thermo luminescent dosimeters (TLD). In addition, digital personnel dosimeters are used for immediate assessment of radiation dose. Average exposure per worker in 2009 is less than 5,0 % of the national annual dose limit, and the maximum individual annual dose around 8.5 % of this limit, i.e. 20 mSv.

Monitoring for internal contamination to radiation workers at Serpong Nuclear Area are carried out through bioassay and in-vivo counting. Bioassay by urine analysis is carried out once a year as routine, and more frequently in case of suspected internal contamination. In-vivo counting, for estimation of gamma radionuclides is carried out for certain workers potentially expected contaminated, has revealed no occurences of internal contamination in 2009 at Serpong.

1.1.2.3 Effluent Monitoring

Liquid effluent from Serpong Nuclear Facilities is collected in a pond and released by RWMTC. Before discharging through river, the liquid effluent is analyzed to determine radionuclide concentrations and their chemical and physical forms, and then compared with the appropriate environmental radioactivity level standards. Environmental monitoring carried out every 3 months on Cisadane river. Analysis results of effluent samples has revealed that ^{60}Co and ^{65}Zn in the liquid effluent. Most of the effluent is generated by the Serpong Research Reactor.

1.1.2.4 Monitoring Public Exposure

Surface water from Cisadane river and other environmental components are regularly monitored for their radioactivity concentration. Estimated maximum possible radiation exposure of member of public due to consumption of foodstuff and occupancy of bank areas (critical group), is estimated to be negligibly low when compared to recommended annual dose constraint of 300 Sv for public. Monitoring results showed that there was no increase in radiation dose in the environment, only the background radiation dose from terrestrial exposure and cosmic ray.

1.1.2.5 Environmental Monitoring

Monitoring of environment around the facility is carried out by background radiation survey, and analysis of ground water and surface soil samples. Any abnormal increase in radiation field is investigated for its causes, and corrective actions taken. Samples of ground water and surface soil from around RWMTC are collected with a defined periodicity and analyzed for radionuclide quantification.

1.1.2.6 Emergency Preparedness

RWMTC is part of the Serpong Nuclear Area Emergency Preparedness and Response Arrangements, so that the emergency preparedness refers to emergency preparedness programmes of Serpong Nuclear Area.

5. Japan

5. Japan

Part 1. Radiation Safety in RI Facilities

1.1 General

1.1.1 Legislative and Regulatory Framework

The basic law on the utilization of nuclear energy in Japan is the Atomic Energy Basic Law (AEBL) that was established in 1955. The objectives of the law are quoted as "to secure future energy resources, achieve progress in science and technology, and promote industry by encouraging research, development and utilization of nuclear energy, and thereby contribute to the improvement of the welfare of human society and the national living standard." The basic policy here is prescribed as follows: "The research, development and utilization of nuclear energy shall be limited to peaceful purposes, on a basis of ensuring priority to safety, and performed on a self-disciplined basis under democratic administration, and the results thereof shall be made public and actively contribute to international cooperation." The law was reformed on 27th June 2012 according to experiences and lessons learned from the accident at Fukushima Dai-ichi Nuclear Power Station (NPS) of TEPCO due to the Tohoku District-off the Pacific Ocean Earthquake and the resulting tsunamis.

In order to attain these objectives and achieve the basic policy, the law prescribes the following:

- Establishment of the Nuclear Regulation Authority (NRA) as an external organization of the Ministry of the Environment (MOE) and the Nuclear Emergency Preparedness Commission (NEPC) under the Cabinet
- Establishment of the Atomic Energy Commission (AEC) and its duties, organization, administration, and authorities
- Regulations on the nuclear fuel materials
- Regulations on the construction, etc. of reactor facility
- Prevention of radiation hazards

The law also prescribes the assignment of these matters to the respective laws. Major laws established for the purpose of providing safety regulations on the utilization of nuclear energy and related laws include "Law for the Regulation of Nuclear Source Material", Nuclear Fuel Material and Reactors (Reactor Regulation Law)", "Electricity Utilities Industry Law", "Law Concerning Prevention of Radiation Hazards due to Radioisotopes, etc. (the Radiation Hazards Prevention Law)" and "Medical Care Law" etc. Also included are the "Basic Law for General Emergency Preparedness," "Special Law of Nuclear Emergency Preparedness (Special Law for Nuclear Emergency)," "Law for Technical Standards of Radiation Hazards Prevention" and "Specified Radioactive Waste Final Disposal Act" etc.

1.2 Regulatory Body

The mandate of the regulatory bodies is to ensure public safety through securing the safety of the nuclear facilities. Their obligations are to implement the above-described legislative and regulatory framework. The regulatory bodies are responsible for conducting regulatory activities prescribed in the Reactor Regulation Law, the Radiation Hazards Prevention Law, etc. on the basis of the Atomic Energy Basic Law. Their organizations and assigned obligations are clearly defined in their respective establishment laws, and their financial resources are covered by the national budget.

Until Sep. 18, 2012, the Ministry of Economy Trade and Industry (METI) had served as the competent ministry for safety regulation on activities concerning utilization of nuclear energy, and the Nuclear and Industrial Safety Agency (NISA) had administered the regulatory activities as a special organization for METI.

Until Apr. 1, 2013, the Ministry of Education, Culture, Sports, Science and Technology (MEXT) had served as the competent ministry for the safety regulation over the nuclear utilization associated with science and technology and the utilization of radioisotopes (except medicines), and the Science and Technology Policy Bureau (STPB) had administered its regulatory activities. The Ministry of Health, Labor and Welfare (MHLW) had governed the safety regulation concerning medical facilities as the competent ministry, and the Pharmaceutical and Food Safety Bureau (PFSB) and the Health Policy Bureau (HPB) administering its regulatory activities.

Table 1: Regulatory bodies and Assigned Facilities and Activities up until Sep. 18, 2012.

Regulatory body	Assigned Facilities and Activities
NISA *(Nuclear and Industrial Safety Agency)* METI *(Minister of Economy Trade and Industry)*	Activities for utilization of nuclear energy. Namely, nuclear power reactor facilities and related nuclear fuel cycle facilities
STPB *(Science and Technology Policy Bureau),* MEXT *(Ministry of Education, Culture, Sports, Science and Technology)*	Utilization of nuclear power for science and technology, and utilization of radioisotopes etc. (except for medical supplies etc.). Namely, test and research reactor facilities, facilities handling radioisotopes, etc.
HPB *(Health Policy Bureau)* PFSB *(Pharmaceutical and Food Safety Bureau)* MHLW *(Ministry of Health, Labor and Welfare)*	Activities at facilities for medical treatment and medical cares. Namely, manufacturing, handling, storage and disposal of radiopharmaceuticals.

These regulatory bodies had clearly defined duties on safety regulation, and their independence is ensured both in legislation and in substance.

Until Sep. 18, 2012, the Nuclear Safety Commission (NSC), consisting of members whom the Prime Minister had appointed with consent of the diet, observed and audited activities of these regulatory bodies in a Regulatory Review. The NSC established the basic policy for safety regulations to maintain the consistency among the regulations. The consistency of the technical standards for prevention of radiation hazard was discussed at the Radiation Review Council under the MEXT until Apr. 1, 2013.

On Sep. 19 2012, the NRA was newly established as an external organization of the MOE to resolve the problem caused by having both the “promotion of utilization” and “safety regulations" under the same organization. The safety regulation division was separated from METI since NISA, which was responsible for nuclear safety "Regulations," had been placed under the auspices of the METI, tasked with promoting the utilization of nuclear power.

The affairs for nuclear power regulations assumed by each related government agency and the affairs for protecting nuclear material and the like（nuclear security） have been unified into the NRA. Furthermore, the NSC of Japan was abolished and the necessary functions have been integrated into the NRA. On Apr. 1, 2013, the regulations, such as for the nuclear nonproliferation safeguards*, radiation monitoring and the use of radioisotopes, which had been the responsibility of the MEXT were also transferred and the "regulation" related functions have been centralized under the responsibility of the NRA.

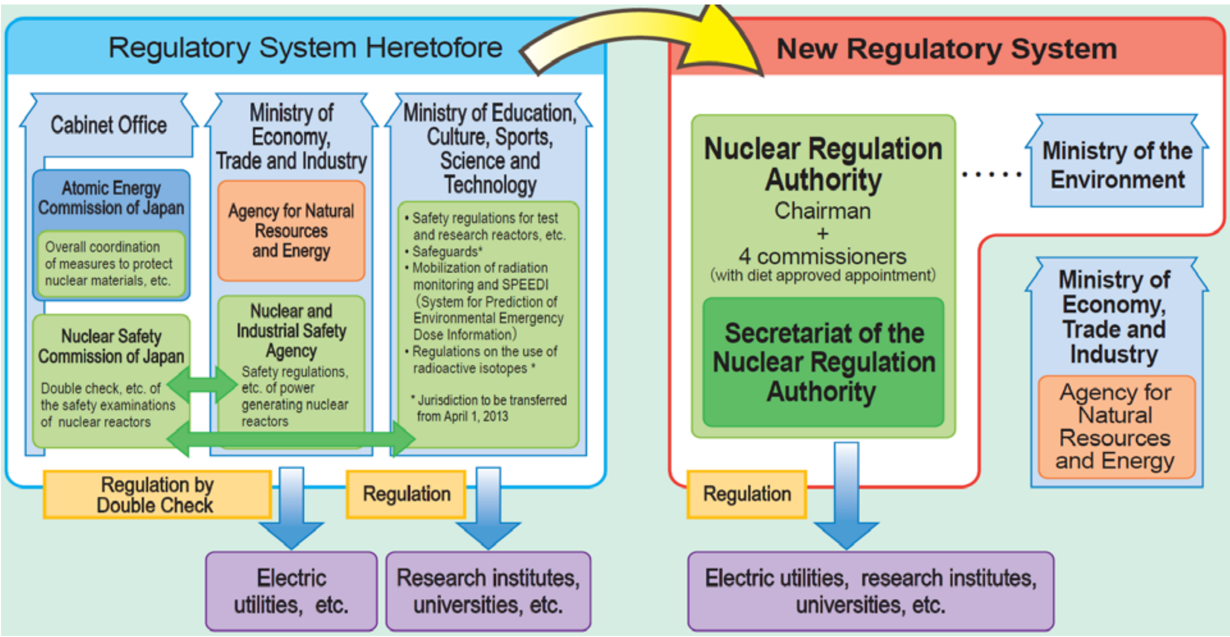


Figure 1: Change of Regulatory System

The current relationship between regulatory bodies and assigned facilities and activities is shown by the following table.

Table 2: Regulatory bodies and Assigned Facilities and Activities after Apr. 1, 2013

Regulatory body	Assigned Facilities and Activities
NRA *(Nuclear Regulation Authority)*	Activities for utilization of nuclear energy. Namely, nuclear power reactor facilities and related nuclear fuel cycle facilities
	Utilization of nuclear power for science and technology, and utilization of radioisotopes etc. (except for medical supplies etc.). Namely, test and research reactor facilities, facilities handling radioisotopes, etc.
	Activities at facilities for medical treatment and medical cares. Namely, manufacturing, handling, storage and disposal of radiopharmaceuticals.

Reference:

- *Government of Japan, Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management, National Report of Japan for the Second Review Meeting Oct. 2005.*
- *Nuclear Regulation Authority, Japan- Nuclear Regulation for People and the Environment, Pamphlet of Nuclear Regulation Authority.*

1.3 Outline of Radiation Facilities and Radiation Sources

Laws and Ordinances apply uniformly regardless of the category of the organization. It is appropriate to think of them as stipulating the minimum standards that the organizations and the radiation workers should observe, and each organization, while of course meeting the legally prescribed standards, should implement radiation control appropriate for its own activities.

The Law Concerning Prevention of Radiation Hazards was drafted and modified in line with recommendations of the ICRP, its provisions on radiation control are not significantly different from those in other countries.

The purpose of the Law Concerning Prevention of Radiation Hazards is to prevent radiation hazards to radiation workers and the public and to protect the environment in the use of radiation or radioisotopes. In order to attain this purpose, the Law provides for the regulation of facilities and for the regulation of people's actions, etc. (requirements for facilities and actions).

1.3.1 Authorization

Permission by or notification to the Nuclear Regulation Authority (NRA) is required for the use of radioisotope sources and radiation generators.

(1) Permission: The use of unsealed radioisotope sources, sealed radioisotope sources of more than 1,000 times the Lower Activity Limits, radiation generators, and the disposal of radioisotope wastes.

(2) Notification: The use of sealed radioisotope sources equal to or less than 1,000 times the Lower Activity Limits and the sale of radioisotope source.

(3) Notification of Certification Equipment: The use of approved devices (ECD, calibration source etc.) which is received the design certification before manufacture and attached with certification label on the surface after manufacture.

Fig.2 shows the number of users categorised by organizations that were permitted by or has notified the Authority since 1959 when the Law was enforced. The sudden increase in the number of users from 2007 is due to the introduction of the certification equipment notification system in 2005. Table 3 shows the number of radiation generators in Japan where most of the cyclotron and the linear accelerator are used for medical purposes.

The use of radiopharmaceuticals is regulated by the Medical Service Law which is established by the Ministry of Health, Labor and Welfare. The number of users of radiopharmaceuticals is shown in Table 4.

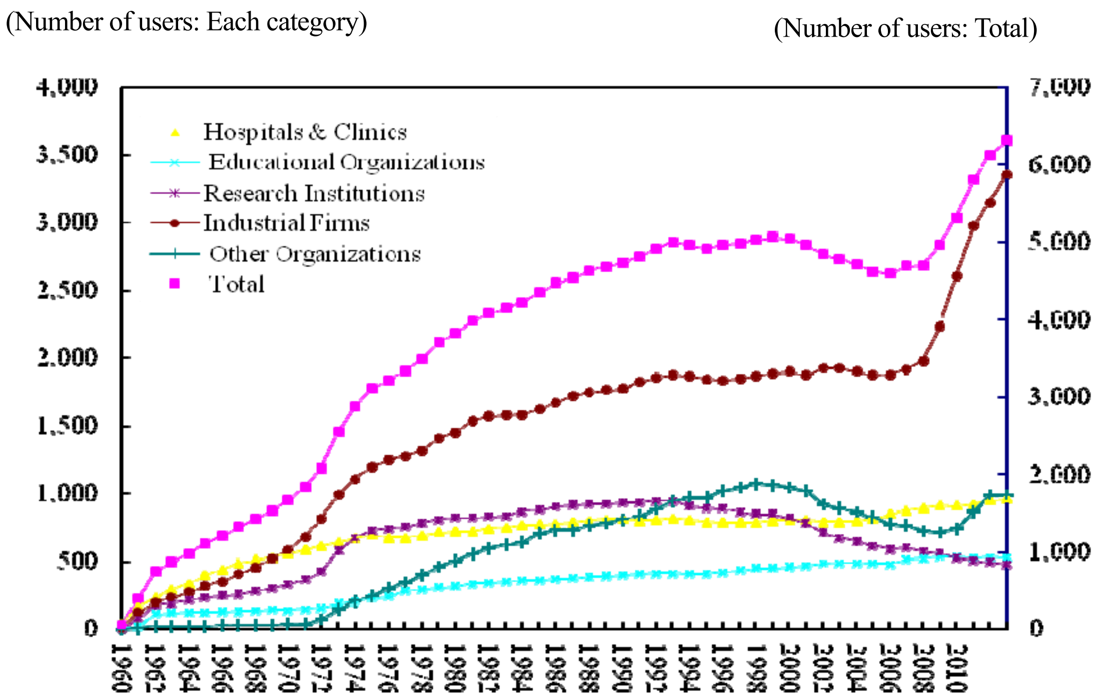


Figure 2: Number of users by category of organizations permitted by and notified to NRA

Table 3: Number of radiation generators permitted by NRA

(2012)

Generator	Number
Cyclotrons	206
Synchrotrons	40
Synchrocyclotrons	0
Linear Accelerators	1,144
Betatrons	3
Van de Graaff Accelerators	37
Cockcroft-Walton Accelerators	72
Transformer-type Accelerators	16
Microtrons	9
Plasma Generators	1
Total	1,528

Table 4: Number of licensed hospitals and clinics for using radiopharmaceuticals

Year	2007	2008	2009	2010	2011
Hospitals & Clinics	1,297	1,293	1,278	1,281	1,273

1.3.2 Workers and Specialists in Radiation Facilities

1.3.2.1 Radiation Workers

Those who are given permission to use and dispose of radioisotopes, or who submit a notification for the use, sale and rental of radioisotopes, or who are given permission to use radiation generator, must comply with a series of standards for safety control for effective management of radiation hazards.

Specific requirements for workers entering controlled areas include: Education and training, measurements of personal dose and special medical examinations for radiation exposure. The round number of radiation workers including x-ray device handlers is shown in Table 5. This round number adds up the number of person that wore a personal dosimeter in published.

Table 5: Round number of radiation workers (Including x-ray device handlers, 2011)

Organization	Number
Medical (including veterinary medicine)	275,000
Research and Education	69,000
Industry	63,000
Total	407,000

1.3.2.2 Radiation Protection Supervisors

In order to conduct appropriate and thorough radiation safety control, it is necessary to set up a management structure responsible for radiation protection control within the establishment. The radiation protection supervisor plays a key role in radiation protection control. Radiation protection supervisors are the person responsible for undertaking the supervisory role in ensuring the radiation hazards are effectively managed. They are appointed by all establishment where radiation or radioisotopes are handled for use, sale, lease, or disposal.

To be qualified as a radiation protection supervisor, he or she must pass a national examination and completes a training course. There are three classes of radiation protection supervisors – first class, second class and third class. The class is required by a particular establishment depends on the type of radioisotopes and level of radiation being handled. In addition, radiation protection supervisors must attend seminars which are held regularly, in order to keep abreast with the latest information in the field of radiation protection.

Contents of the National Examinations and the Regulatory Training Courses for radiation protection supervisors are shown in Tables 6 and 7 respectively. The number of successful applicants in the national examinations for radiation protection supervisors (first class and second class) is given in Fig. 3 and 4.

Table 6: Contents of the national examinations for radiation protection supervisor (2012)

Class	Days	Subjects	Subject Items
First	2	6	Law, Physics, Chemistry, Biology, Measurements and safety control for radiation protection
Second	1	3	Law, Safety control techniques for radiation protection (1) and (2)
Third	-	-	No Examination

Table 7: Regulatory training course for radiation protection supervisor (2012)

Class	Days	Enforcement Organization	Remarks
First	5	JRIA, JAEA and ESC	
Second	3	NUSTEC and ESC	
Third	2	JRIA, JAEA, NUSTEC and ESC	No Examination

JRIA: Japan Radioisotope Association
JAEA: Japan Atomic Energy Agency
NUSTEC: Nuclear Safety Technology Center
ESC: Electron Science Institute

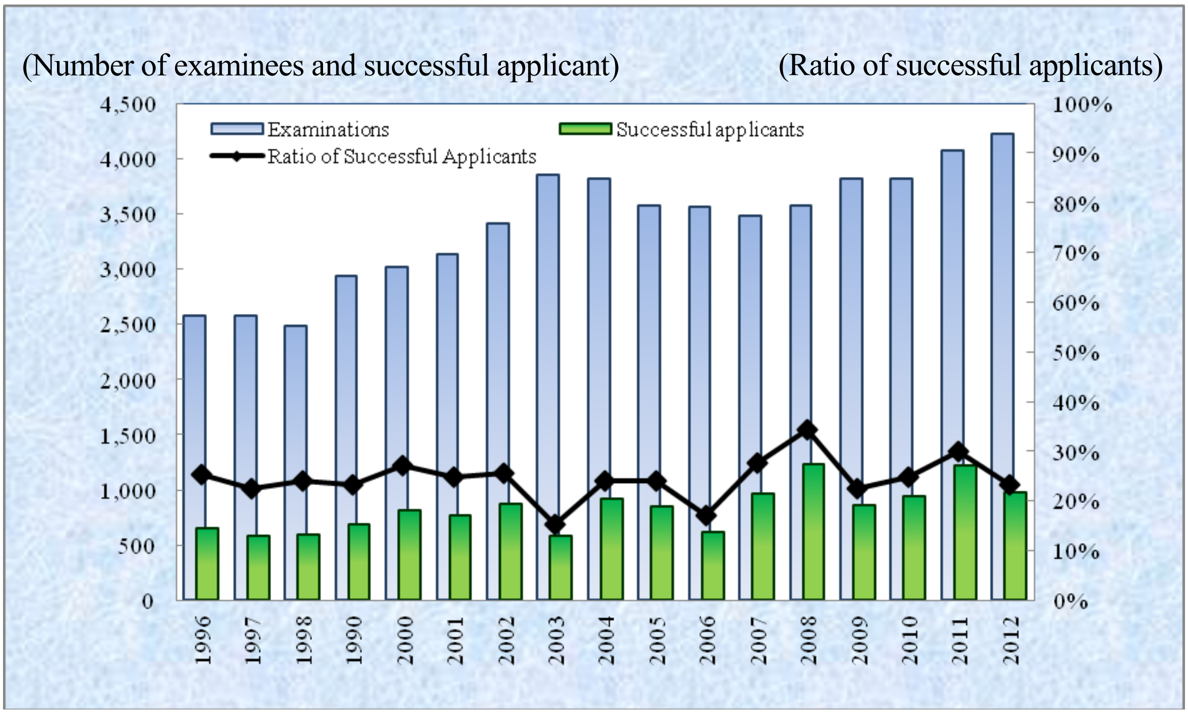


Figure 3: Number of successful applicant in national examinations for radiation protection supervisors (First class)

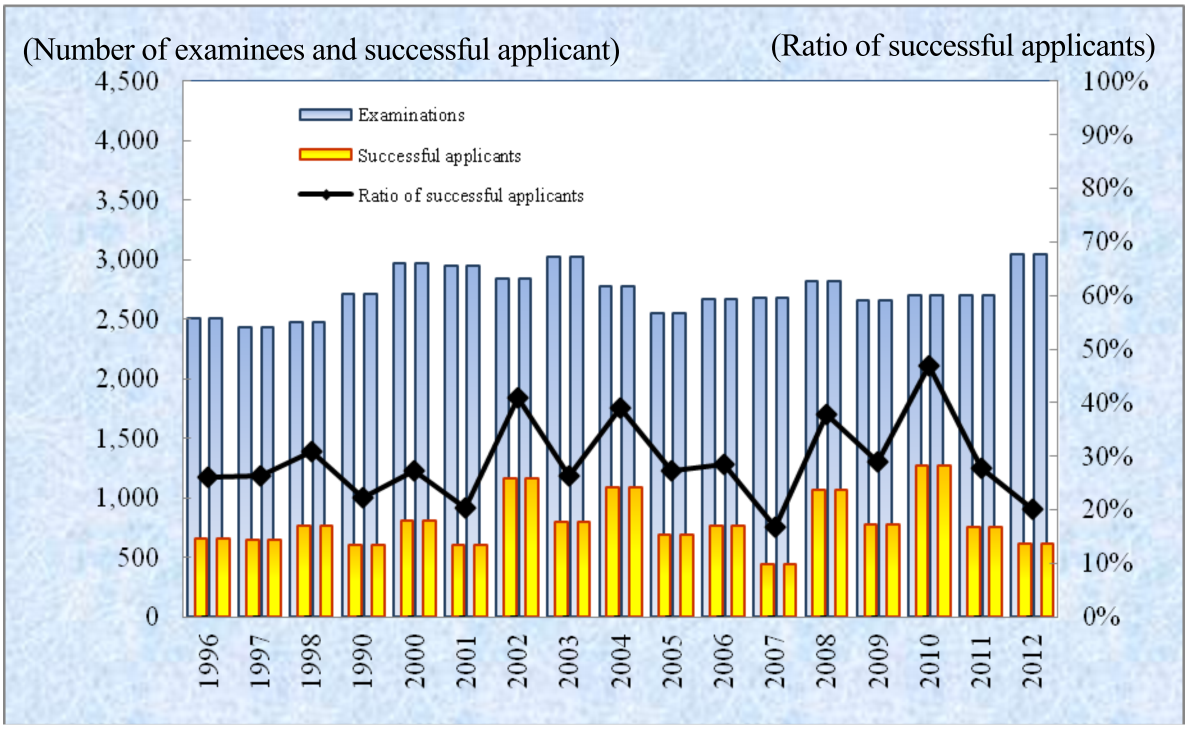


Figure 4: Number of successful applicant in national examinations for radiation protection supervisors (Second class)

1.3.3 Activity of Radioisotope Sources and Number of Radiation Generators

The total radioactivity of the main unsealed radioisotopes, sealed radioisotopes and radiopharmaceuticals distributed by Japan Radioisotope Association (JRIA) are shown in Figs. 5, 6 and 7, respectively. A general decline in the yearly total radioactivity distribution by JRIA over the last several years can be observed.

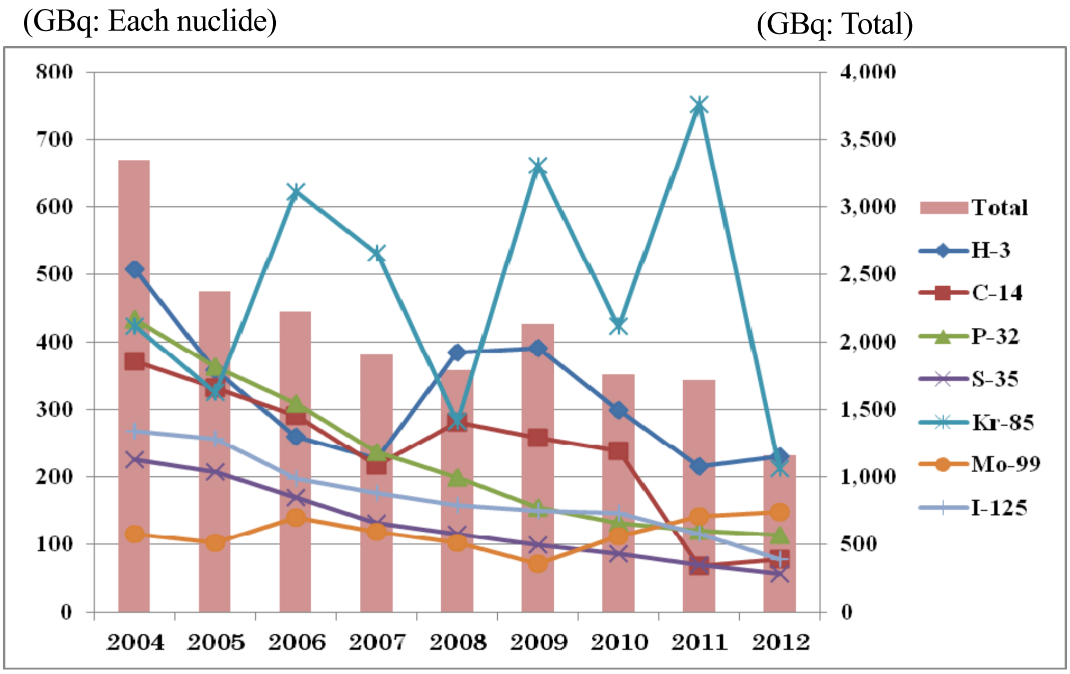


Figure 5: Amounts of major unsealed radioisotopes distributed by JRIA

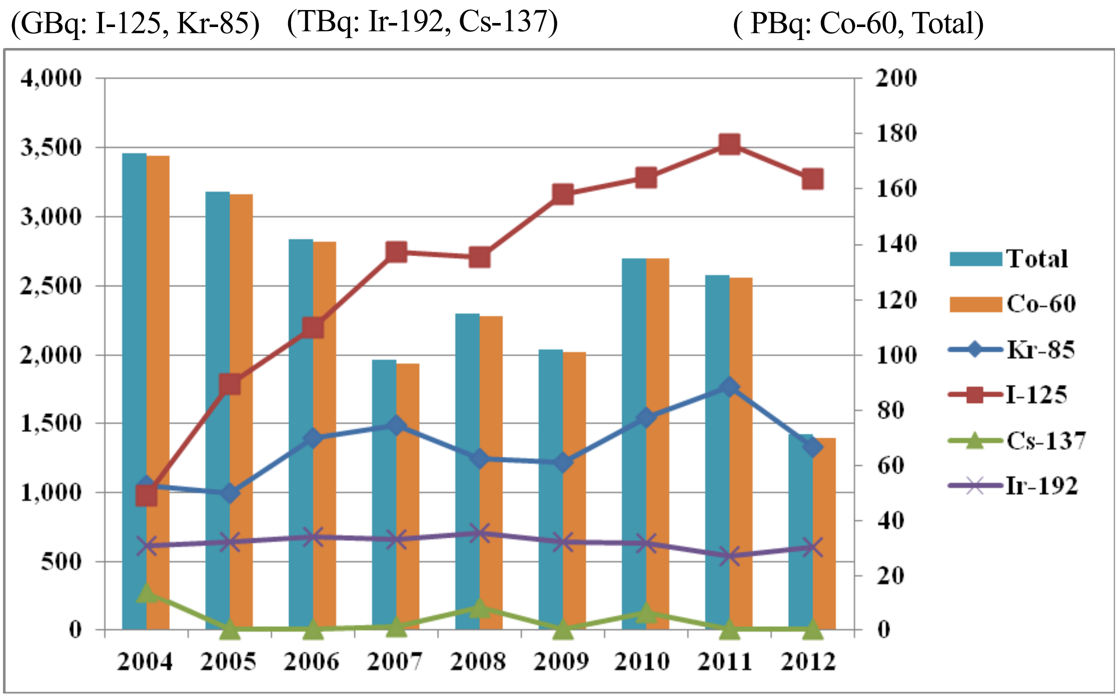


Figure 6: Amounts of major sealed radioisotopes distributed by JRIA

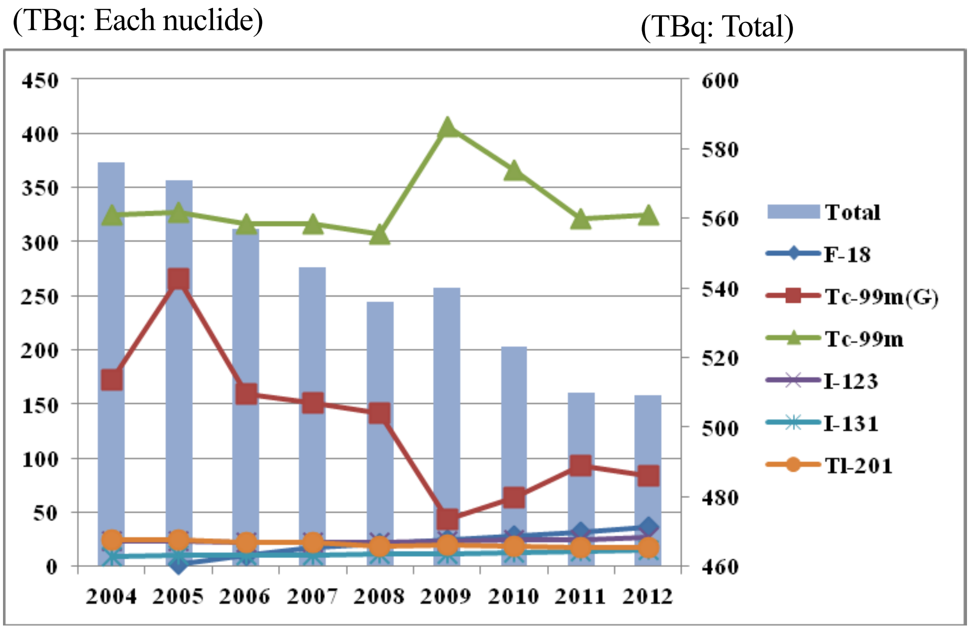


Figure 7: Amounts of major radiopharmaceuticals (medical nuclides) distributed by JRIA

1.3.4 Recent Movement Concerning Radioisotope Sources

1.3.4.1 New Regulator

The regulatory role was transferred from the Ministry of Education, Culture, Sport, Science and Technology (MEXT) to the NRA on April, 2012. The NRA was established to absorb and learn the lessons from the Fukushima Daiichi Nuclear Accident of March 11, 2011. The NRA is the regulator responsible for the safe management of nuclear power plants and radiation facilities.

1.3.4.2 Emission Material

By the Law, any material that is activated by a radiation generator to an energy level above natural background, such as a target or a collimator, are regulated and must be collected by a dedicated disposal service provider.

1.3.4.3 Discovery of Radiation Sources

Many beginners measure radiation using radiation detector since the Nuclear Power Plant Accident. Because many people performed radiation measurement of the private or public place where nobody had measure before the accident, some radiation sources which were not managed were discovered. The radiation sources were Ra-226 which was used as luminous paints before the laws are established.

1.4 Education and Training

1.4.1 The Law Concerning Prevention of Radiation Hazards Due to Radioisotopes, etc.

Radiation users provide radiation workers with education and training, (1) prior to their first entry into controlled areas; and (2) at least once a year thereafter (re-education). Through the re-education, radiation workers obtain the latest knowledge on regulations, radiation effects, and techniques for safe handling, as well as have an opportunity to regularly reaffirm the importance of safe handling.

Radiation users shall educate inexperienced radiation workers on the items listed in the Table 8. The minimum education time for each item is clearly determined by the law. Sometimes OJT (on-the-job-training) or special curriculum of practical training specific to each facility are provided for a more effective education.

Table 8: Items and minimum time on education and training for radiation workers, determined by the Law Concerning Prevention of Radiation Hazards Due to Radioisotopes, etc.

Items for education	A	B
Effects of radiation on human body	30 min	30 min
Safe handling of radioisotopes and radiation generators	4 hrs	1.5 hrs
Laws and ordinances on prevention of radiation hazards by radioisotopes and radiation generators	1 hr	30 min
Local radiation protection rules in the facility	30 min	30 min

A: Radiation workers
B: Workers who do not enter controlled areas

1.4.2 The Nuclear Reactor and Fuel Law

For users of special nuclear materials (SNM, defined by the law), users shall give the workers additional education. The education items and frequency shall follow the local rule of each facility. The education items shall include;

- Laws and ordinances on the Nuclear Reactor and Fuel Law
- Structure, specification, and operations of the related facilities and equipment
- Radiation management
- How to handle contaminated materials
- Emergency plan
- Nuclear security including physical protection, etc.

The minimum time for these education items is not determined by the law.

1.4.3 The Labor Standards Law

When a new worker is employed, the employer shall give the worker health and safety education relevant to his scope of work. This is required by the Ordinance of the Ministry of Health, Labor and Welfare. In addition, when a worker is to be involved in several special operations designated by the Ordinance of the Ministry of Health, Labor and Welfare, the employer shall give the worker the special health and safety education related to those operations. These special operations include works carried out using X ray generators, or in nuclear fuel facilities or nuclear reactors.

1.4.4 Examples of Education and Training

Below are examples of education or training offered in workplaces or universities to radiation workers.

1.4.4.1 Nuclear Power Plant

- ➢ Fundamental and practical knowledge (5 hours)

1) Nuclear fuel materials, spent fuel, or materials contaminated with them
2) Works and operations in nuclear reactor facilities
3) Structure of, specification of, and how to handle, the related facilities and instruments
4) Effects of radiation on human body
5) Laws and ordinances on the Nuclear Reactor and Fuel Law

- Practical skills (2 hours)
  1) Works and operations in nuclear reactor facilities and handling of equipment relating to the facilities
- Overall practical education (OJT) (10 days)

1.4.4.2 University (users of radioisotopes, accelerators, and X ray generators)

- Knowledge of radioisotopes and their utilization (90 min)
- Laws and ordinances (2 hours)
- Radiation measurements (60 min)
- Effects of radiation on human body (60 min)
- Local radiation protection rules in the facility (30min)
- Practical trainings using radioisotopes with low activity (OJT) (3 hours)

1.5 Standardization on Radiation and Radioactivity

Radiation safety and radioactive waste management must be based on the reliable and precise measurement of the quantities associated with ionizing radiation such as dose (Sv) and radioactivity (Bq). For radiation safety, various dose meters are being used such as electric or passive dosimeters for personal dose and survey meters for ambient dose. Dose meters must be calibrated regularly for accuracy in order to ensure the safety and security of the people working with ionizing radiation. Measuring instrumentations such as ionization chambers, scintillation counters and semiconductor detectors are important in radioactive waste management and need to be calibrated using reference radioisotope sources. Normally calibrations are performed by calibration laboratories, where measuring devices are calibrated using reference instruments. These reference instruments are in turn calibrated by reference instruments with higher accuracy (lower uncertainty). The chains of the relative calibrations never loop to avoid circular reference and end up to the reference instruments with highest accuracy, called national standards. From the viewpoint of accuracy and reliability in measurement, it is essential to calibrate measuring instruments and secure the traceability of measurement to national standards.

In Japan, national standards on ionizing radiation are maintained and provided at the National Metrology Institute of Japan (NMIJ)[1] in the National Institute of Advanced Industrial Science and Technology (AIST). Table 9 shows the national standards on ionizing radiation and primary instruments used in absolute measurement of each quantity. Accuracy and worldwide consistency of the national standards were verified in multiple participations (about 100 times) in the international key comparisons organized by the Consultative Committee for Ionizing Radiation (CCRI) of the International Committee of Weights and Measures (CIPM) in the International Bureau of Weights and Measures (BIPM) as well as the Technical Committee for Ionizing Radiation (TCRI) in the Asia Pacific Metrology Program (APMP). The results of these

[1] http://www.nmij.jp/english/

comparisons are documented in the BIPM web page[2]. The national standards are being operated with the quality management system conforming to ISO/IEC 17025 (General requirements for the competence of testing and calibration laboratories) and peer-reviewed by experts from major foreign national metrology institutes every four years. The calibration certificates issued on these standards can be accepted worldwide within the range specified in the Calibration and Measurement Capabilities (CMCs)[3] in the framework of the CIPM Mutual Recognition Arrangement (CIPM-MRA).

With regard to the traceability of measurement, the measurement act introduced the Japan Calibration Service System (JCSS) in 1993, consisting of the national standards provision system and the calibration laboratory accreditation system. In the national measurement standards provision system, the Ministry of Economy, Trade and Industry (METI) designates national primary standards and NMIJ calibrates the reference standards of accredited calibration laboratories (i.e. secondary standards) with national primary standards. In the calibration laboratory accreditation system, calibration laboratories are assessed and accredited as accredited calibration laboratories to meet the requirements of the measurement act, relevant regulations and ISO/IEC 17025. Calibration laboratories are also required to periodically take assessment as well as proficiency testing. Calibration certificates with a JCSS symbol issued by accredited calibration laboratories assure the traceability to National Measurement Standards as well as a laboratory's technical and operational competence and are acceptable worldwide through the MRA of the International Laboratory Accreditation Cooperation (ILAC) and the Asia Pacific Laboratory Accreditation Cooperation (APLAC).

2 http://kcdb.bipm.org/AppendixB/
3 http://kcdb.bipm.org/AppendixC/

Table 9: Quantities and primary standard instruments for the national standards on ionizing radiation in Japan

Air kerma, Exposure (X, γ-ray)
  10-50 kV (Low), 30-300 kV (Medium),
  20-25 kV (Mammography): Free air ionization chamber
  Co-60, Cs-137: Graphite wall cavity chamber
Absorbed dose (β-ray)
  Sr-90/Y-90, Kr-85, Pm-147: Extrapolation chamber
Fluence (neutron)
  Thermal: Gold foil activation
  144 keV, 565 keV: Hydrogen proportional chamber
  2.5 MeV, 5.0 MeV, 8.0 MeV: Thick radiator detector
  14.8 MeV: Associate alpha particle counting
  Am-Be, Cf: Standard Am-Be source
Emission rate (neutron)
  Am-Be, Cf: Standard Am-Be source
Radioactivity, Emission rate (α, β, γ-ray)
  Radioactive nuclides (74 species): 4π β-γ coincidence counter

Part 2. Status of Radiation Safety Management

2.1 Radiation Safety Control in RI facilities

2.1.1 Radiation Safety Control System

There are about 4,900 RI facilities (research laboratories of universities and companies, nuclear medical facilities etc.) in Japan.

These facilities are required to calculate whether dose in the controlled areas or within the boundary of the facility, concentrations of discharged air and liquid effluent from the facilities are respectively lower than dose and concentration references. It is also required by the law to submit applications and documents to the relevant government ministries before operating the facility.

The facilities are required to record and check the measurements during practical operation using a radiation monitor such as gas monitor. Therefore, almost all RI facilities in Japan employ radiation control systems to simplify the management and automation of record keeping.

The radiation safety control system is employed in combination with the following systems in accordance with intended use.

a. Radiation Monitoring System (Fig.8)

The radiation monitoring system consists of an area monitor that monitors equivalent dose in a controlled area and a room gas monitor that monitors radioactive concentration in the operating room. In addition, a gas monitor that monitors radioactive concentration of gas discharged from facilities to the public, and a liquid monitor that monitors radioactive concentration of effluent are part of the system.

Since the latest radiation monitoring system has been computerized, each monitor is centrally controlled by the central monitor (computer) which automatically creates daily, monthly and yearly reports, trend graphs of the alarm settings and measurement data according to the control levels. (Fig.9).

Figure 8: Configuration of Radiation Monitoring System

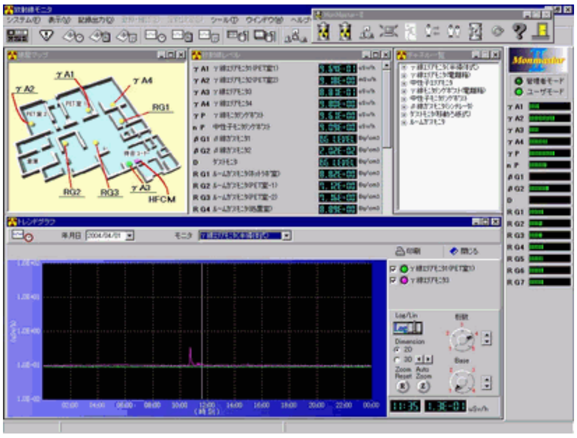


Figure 9: System Control Screen

b. RI Liquid Effluent Control System

The RI liquid effluent control system is installed to control discharged water from those facilities. The system automatically controls and remotely monitors storage, decay, and dilution of RI effluent.

By interfacing with the radiation monitoring system, many of those facilities perform automated effluent sampling and control radioactive concentration in the effluent using a liquid monitor in accordance with the amount of water in storage tank.

c. Access Control System

The access control system automatically restricts access of qualified personnel that access RI facilities and controls access records by identification (ID) card (magnetic/contactless smart card FeliCa system etc.) or biometrics (fingerprint/vein matching) authentication.

Generally, the system only permits access of authorized personnel to the controlled area of RI facilities. The system can be set up to define the authorized access area and period for each qualified radiation worker.

At the time of exit from the controlled area, each radiation worker is checked with a hand-and-foot monitor and can exit the controlled area only if no contamination is detected.

The system is used in combination with limit switches on doors or key switches as personnel access the facilities where interlocks are required. It is used as a part of an interlock system to prevent accidental startup of equipment when radiation workers are in specific restricted areas relative to the equipment.

The central monitoring system generates daily, monthly, and yearly reports as well as displaying lists of workers who are currently in the controlled area.

Internal exposure of workers can be calculated by checking the data of personnel working in controlled areas including their access times in the controlled area on specified dates and times. In addition, contamination or a loss of radiation sources can be determined with data traceability.

d. Unsealed Radioisotope Stock Control System

The unsealed radioisotope stock control system is mainly used in RI facilities because the system unifies the management of procurement, acceptance, storage, utilization, disposal and delivery of waste for unsealed radioisotopes in compliance with laws.

At the time of procurement or acceptance, the system easily checks that purchased or accepted quantities are within regulated quantities (maximum quantities per day, 3 months or year) for storage and specifies by whom, when, and where each source is used and the quantity of each used source. In addition, the residual quantity of sources and what container the waste is in is checked, which allows the RI facility manager to easily generate control reports in compliance with laws (Fig.10).

Recently, a stock check system using the RI stock list, noncontact IC tag and handy terminal was introduced (Fig.11). The system is useful for daily source control as well as periodic stock control because the system reduces the stock check time (check for loss of stock).

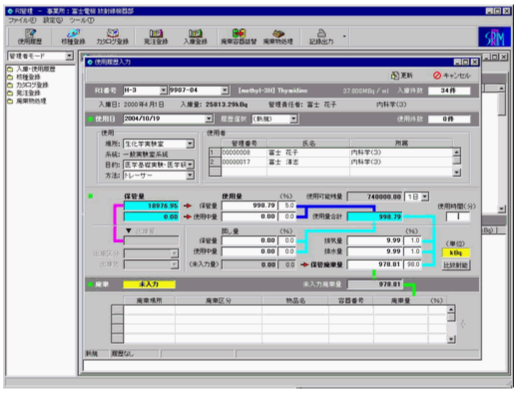


Figure 10: System Control Display

Figure 11: Stock Control System

e. Personal Dose Control System

The purpose of the personal dose control system is to streamline the evaluation of effective dose at the facility. Measurements of personal dosimeters and the results of periodic health check-ups can be input into the system. By interfacing with the access control system, workers who have not taken the periodic health check-up and those who have exceeded the dose limit can be detected so as to prevent them from entering the access control area.

In addition, a personal dose control system utilizing an electronic dosimeter, which is also used in the dose evaluation at nuclear power plant etc., has started to become widely used.

2.1.2 Radiation Protection of Worker

Radiation Protection for the radiation work personnel is provided by the evaluation of external exposure dose using personal dosimeter (It is measured and evaluated every month with glass badges and other methods. This work is generally outsourced.) and by the periodic health check-up set forth by law, in order to check that the total amount of external and internal exposure dose does not exceed yearly effective dose limit. However, these methods merely identifies/quantifies exposure after the occurrence. It is important to emphasize radiation protective measures based on exposure minimization in work area more assertively.

Therefore, employment of aforementioned personal dose control system using the electronic dosimeter is also effective so that plant manager can take appropriate measures by detecting radiation exposure promptly.

2.1.3 Radiation Protection at Work Area

Environmental monitoring at the work area is conducted for radiation protection and the methods employed are described below. The monitoring is required in order to not exceed the monthly-base limit set within the laws and regulations. The monitoring can be conducted by Manager, but it is mostly outsourced.

2.1.3.1 Measurement of Airborne Radioactive Concentration

Airborne Radioactive Concentration is measured by filtration method with movable dust sampler. It is used to measure internal exposure and is implemented in a room where there is a possibility the worker would inhale the RI, such as rooms using RI. For area with high airborne contamination level, room gas monitor or iodine monitor is installed for real-time monitoring.

2.1.3.2 Surface Contamination Measurement

Surface Contamination is measured directly by smearing or the survey meter. It is required to measure the surface contamination of the monitoring room (which is the entrance to the restricted area), room using RI and disposal work room.

Measurement points are determined, focusing on points with high chance of contaminations such as tables, hoods, floor around sink or on highly used point eg. entrance of each operating room. Hand foot monitor detects floor surface contamination by measuring personnel wearing work area slippers, so that contamination status is immediately recognized.

If any contamination was detected, the area is immediately secured to prevent further spreading of the contamination and to enable the decontamination of the area to be carried out.. Results of contamination surveys of the work areas are provided to all workers to provide awareness.

2.1.3.3 Measurement of Leak Dose Equivalent Rate

Leak Dose Equivalent Rate is measured by ionization chamber or scintillation survey meter.

It is required to measure operational, storage and disposal facilities, and at the boundaries of controlled areas and site.

Area monitors are installed in areas of potential high dose equivalent rate, areas with large dose rates fluctuations, in locations where personnel stay most of time and at boundaries of controlled area. In many cases, the area monitor provides real-time data to the radiation monitoring display system.

2.1.4 Radiation Protection of the Public

2.1.4.1 RI Usage Facilities etc.

Dose criteria (levels of radiation or concentration of radioisotopes in air or surface) in controlled areas as well as the concentration limits for the releases and discharges of effluents from RI facilities are stipulated and prescribed in the existing rules and regulations. For the protection of the general public against exposure to radiation, the law requires the use of appropriate material and thickness for shielding to achieve the desired dose limits for the general public. The law also requires radioisotopes (RI) facilities to establish an exclusion boundary area (reasonable distance from public domain) including the residential area for RI facilities workers, with an effective dose level not to exceeding 250 uSv per 3 months.

2.1.4.2 Medical Sector

Guidelines (residual radioactivity and dose rate) and safety instructions related to the release of patients administered with unsealed radionuclides and brachytherapy are established for the safety of the family, patient comforters and carers, and the general public.

2.1.4.3 Scrap and Metals, etc.

Now that the scrap metals are distributed worldwide by cross border trade, not only workers engaged in ironworks and in metal production industries but also general public may be exposed in radiation from recycled products including orphan sources mixed in scrap metals. Thus, the government's customs agency installs radiation monitors at the points of entry and exit of the shipping ports, scrap metal companies install radiation monitors in a yard entrance so as to ensure that every truck carrying scrap metals are properly monitored for orphan sources and radioactively contaminated scrap metals.

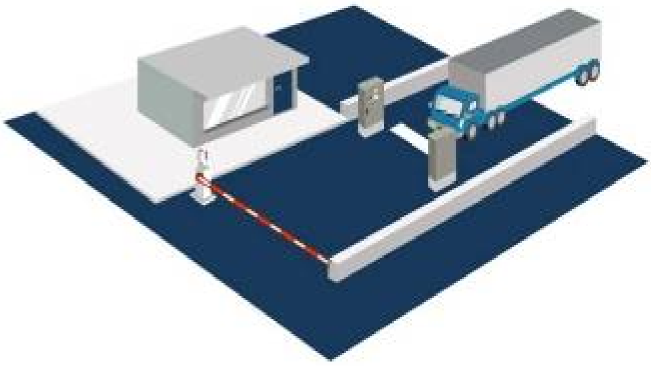


Figure 12: Image of truck radiation

2.1.5 Radiation Emergency Response

2.1.5.1 Definition of Accident (emergency situation)

A radiation accident is a situation caused by an unexpected event that deviates from the normal operations of a facility, for example the loss of regulatory control of a radiation source. This accident may be caused by earthquake, fire and other hazards/disasters (flood and power failure etc), deliberate offense like theft and pilferage, and machine failure.

Measures in the event of accidents and emergencies are defined by the regulations of the Ministry of Education, Culture, Sports, Science and Technology (MEXT) and the Ministry of Health, Labour and Welfare (MHLW), as well as other government agencies. Should these events occur, the employer is required to report promptly to a jurisdiction ministry and related organizations.

2.1.5.2 Examples of Accidents while Using RI at a Nuclear Medicine Facility and Transporting (emergency situation)

Below are examples of possible emergency situations whilst using RI:

a) The possibility of a fire causing vaporization and evaporation of radioactive materials.

b) Inability to terminate irradiation promptly due to damage of shielding materials caused by an earthquake during the irradiation process.

c) A radiation source has fallen out of its container.

d) Inability to return the radiation sources back to their containers due to malfunction of remote controllers.

e) A radiation source is missing due to theft or loss.

f) Faults or damage to local exhaust ventilation system or the emission source enclosure system.

g) Loss of radioactive substance due to leakage or spillage.

2.1.5.3 Reporting

The line of reporting varies according to jurisdiction or cases. Relevant authorities may include the Ministry of Education, Culture, Sports, Science and Technology (MEXT), labor standards offices in the respective jurisdiction, police stations, fire departments, Ministry of Land, Infrastructure, Transport and Tourism, public health department, and the National Personnel Authority.

2.1.5.4 Medical Examination etc. (Ordinance on Prevention of Ionizing Radiation Hazards)

The employer shall ensure workers falling under any one of the following categories receive immediate medical attention and submit a report to the relevant head of the labor standards office.

- Those who were in the area when the accident occurs.
- Those who have been exposed above the effective dose or equivalent dose limit.
- Those who have accidentally inhaled or ingest radioactive materials.
- Those whose external contamination level fails to fall below one tenth by means of washing and so on.
- Those who has contaminated wounds.

2.1.5.5 Discovery of radioactive materials (response to accidents regarding orphan sources)

According to the radiation hazards prevention law, a permission or notification is required for the use radiation materials above a specified quantity. MEXT requests, both on their website and through other media, for the public to report on any suspected radioisotopes materials they find and warns against touching or moving them without authorized direction.

The following information are to be collected by MEXT if a radioactive material is reported:

a) Name and contact details of reporter

b) Time when it was found

c) Place where it was founded

d) State and label of the matter found etc.

e) Approximate dimension, weight, and quality of the material

f) Dose rate measured, radiation survey meter or measuring instrument used, and measurement method employed

g) Description of the area surrounding the suspected source (if there is a house or not etc.)

2.1.5.6 Preparation of radiation emergency response manuals

In RI applications facilities, radiation emergency response manuals and checklists are prepared and disseminated among the workers in case of an accident. The following cases are considered in the document.

a) Fire
b) Earthquake
c) Need for Ambulance vehicle
d) Radiation exposure (loss of radiation sources, irradiation shutdown failure due to equipment malfunction, inadvertent external and internal exposure, personal contamination)
e) Dispersion of contamination of unsealed sources （gas, dust, and liquid）
f) Loss or theft of sources
g) Discovery of orphaned RI
h) Accident during transportation
i) Communication system and contact information （in and out of the facilities）

2.2 Radiation safety management in Research Reactors

2.2.1 Radiation Safety Management System

The safety management system in research reactors is regulated in the Act on the Regulation of Nuclear Source Material, Nuclear Fuel Material and Reactors of Japan as well as Nuclear Power Plants. The radiation safety procedures are ruled in the inside-rule of every facility, but much simple relative to those of NPPs.

The radiation safety management at the reactor facility consists of the management of radiation workers, radiation control of work area, control of contamination level on carry-out goods and control of radioactive discharge (gas and liquid) to the environment.

2.2.2 Radiation Protection for Radiation Worker

The reactor room is designated as a controlled area equipped with radiation protection equipment, such as radiation monitors (gamma and neutron), survey meters (gamma, neutron, beta etc.) and radioactive air concentration monitors. The air pressure of reactor room is kept at a lower level relative to the outside so that radioactive materials cannot flow out to the general area. For most research reactors, the criticality monitoring is not necessary except at special critical assembly facilities. Access control for workers is restricted and all workers entering the reactor room are logged for the duration of their stay in the room. On exiting the reactor room, both staff and items removed from the room are monitored and cleared for radioactive contamination. Exposures of workers above a set exposure value are reported.

All radiation workers have to wear an experimental or working suit and safety shoes to avoid contamination of their own bodies and clothes. The radiation workers must also wear either one or two types of personal dosimeters to measure and record their exposure values. Direct reading personal dosimeters are useful for individual exposure control. The radiation and air contamination (dust or gas) monitoring equipment are often used to monitor the status of the working area. If the air contamination level exceed a designated criterion, appropriate radiation protection measures, such as wearing air mask etc. are taken. When work is finished, contamination surveys are carried out on work surfaces, tools, floors and personnel using survey meters.

2.2.3 Radiological Protection for Radiation Area

Radiation protection officers regularly monitor the radiation and air contamination levels at the work area. These data are collected by radiation monitors and electronically recorded. In an event of an abnormal excursion from the set limits, the radiation protection officers would notify the workers of the situation and direct them to take the necessary protective measures. Figure 13 shows an example of air contamination monitoring at a controlled area.

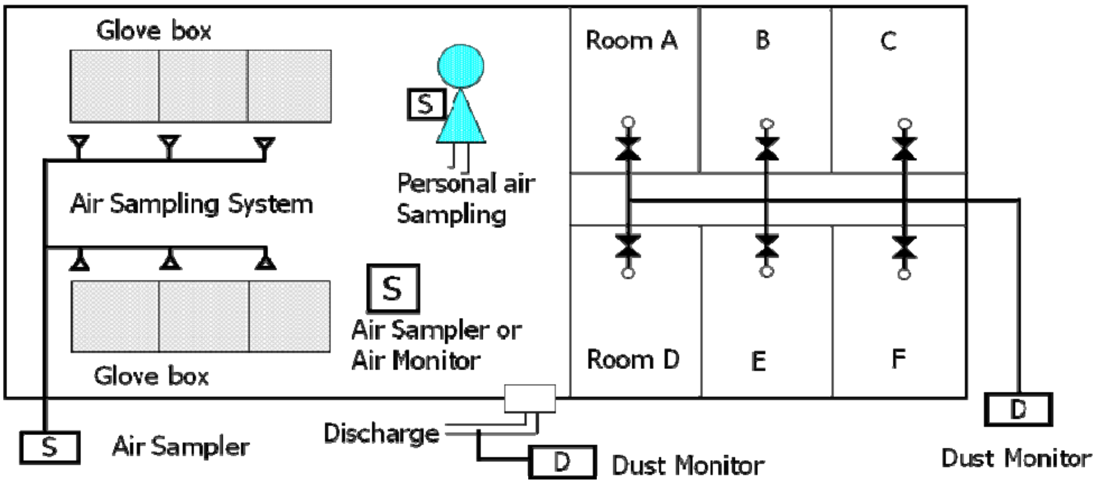


Figure 13: An Example of Air Contamination Monitoring at a Controlled Area

The control of radioactive materials discharge to the general environment is also important for research reactors. The discharge limit for each facility is governed by its respective license held. However the actual radioactivity discharge is often much lower the set limit. For some research reactors, the main radionuclides in their atmospheric and effluent discharges are Ar-41 and tritium (H-3). Fission products, such as I-, Xe-, etc., are discharged into the atmosphere from general water-cooled type research reactors. Figure 14 shows an example of the air monitoring system for a research reactor facility. The radioactivity level in the air is constantly monitored using dust or gas monitors. Dust and volatile materials are also sampled with air filters. The filters are measured using devices such as Ge detectors and/or gas flow counters to provide a comprehensive radioactivity concentration level.

The liquid waste from the controlled area is first stored in a holding tank at each facility and sampled to determine the activity level. If the level of radioactivity in the liquid waste is less than a designated level, the liquid waste is discharged into the sea. If the designated value is exceeded, the waste is transferred to the disposal treatment facility.

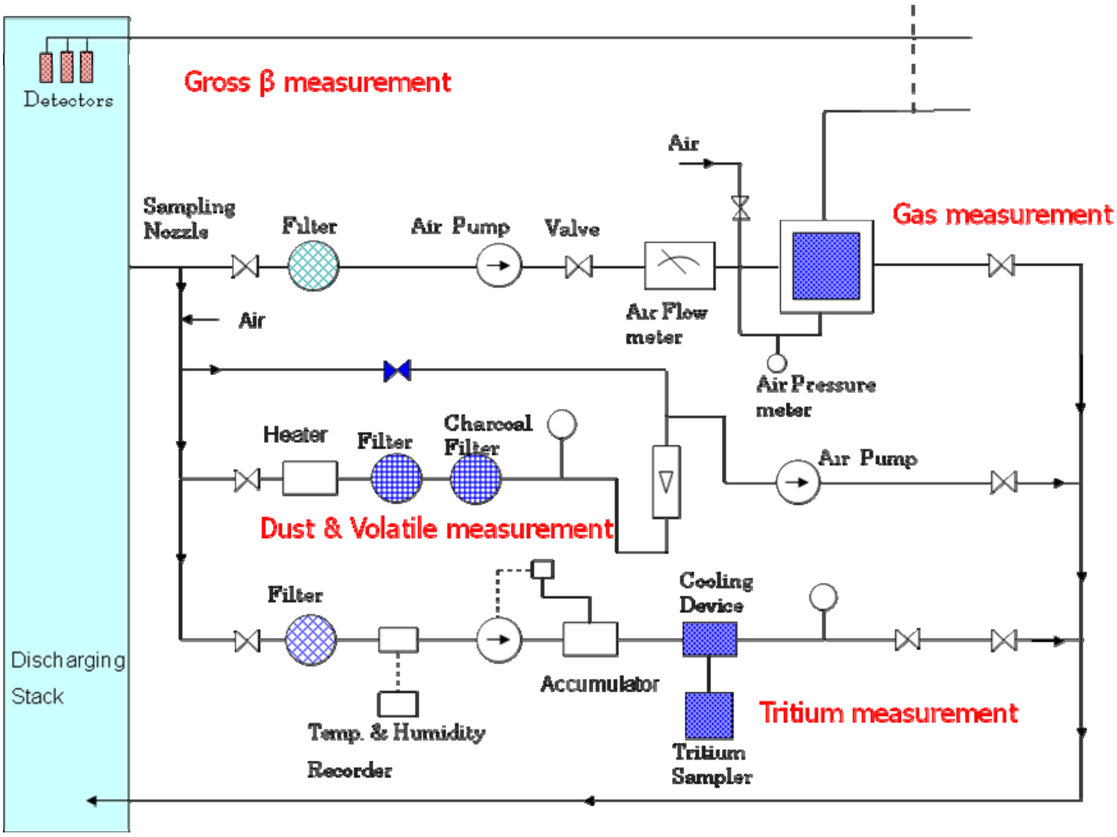


Figure 14: An example of monitoring system for airborne radioactive waste at research reactor facility

2.2.4 Radiological Protection for the Public

Exposure to the public is evaluated based on atmospheric and liquid discharges. The amount of radioactivity discharge and the evaluated dose to the public are reported to the Government and the local governments. In addition, most of the organizations that operate research reactors set up environmental stations or posts both internally and external to the site, for ongoing observation of parameters such as radiation level and others.

2.2.5 Radiation Emergency Preparedness

In emergency situations, such as fire, earthquake or any disturbances within the facility, all of that facility must gather immediately and engage in the recovery work. The training on emergency preparedness is also conducted once or twice every year to maintain workers' motivation.

2. 3 Radiation Management in Nuclear Power Plants

2.3.1 Radiation Safety Management System

The radiation safety management system of nuclear power plants is headed by the director. Fig.15 shows an example of the system.

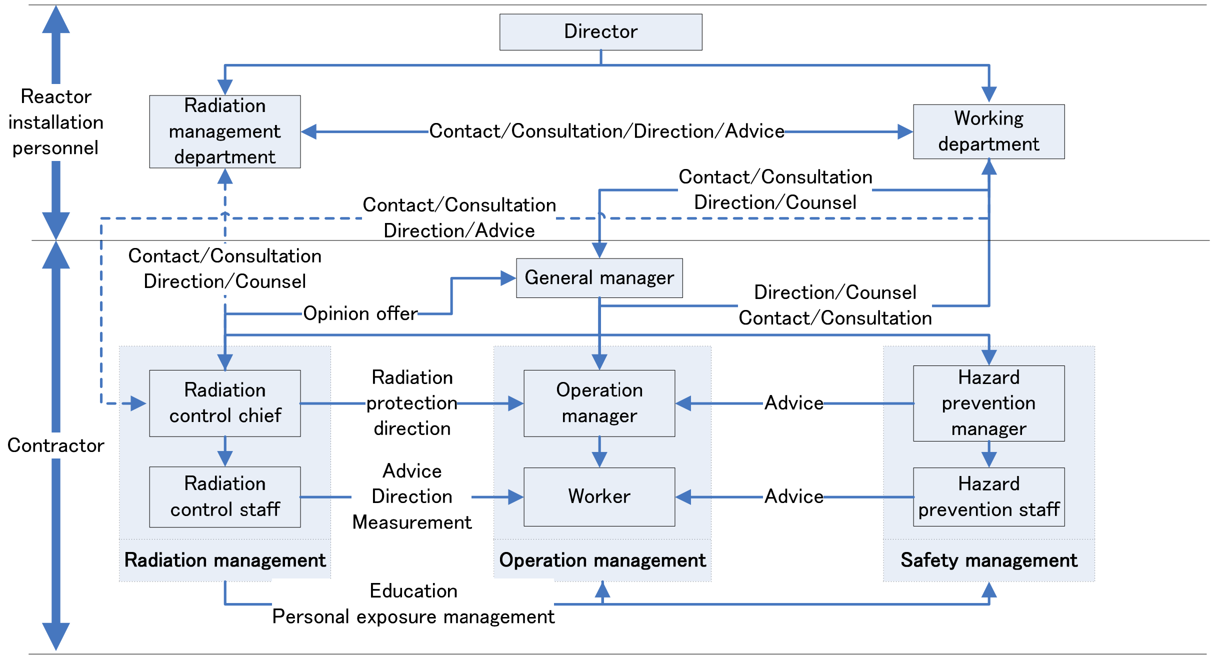


Figure 15: Radiation Safety Management System

2.3.2 Radiological Protection for Radiation Worker

In the nuclear power plants, the doses for radiation workers are managed within the legal dose limits of 100 mSv over 5 consecutive years and 50 mSv in a single year, as well as the planned doses which are directed every work. In this way, we try to aim at the doses as low as reasonably achievable (ALARA).

People who work in radiation-controlled areas are supposed to register as "Radiation Workers". At the time of registration, they are required to provide their past dose history, medical reports, education records demonstrating knowledge of radiation and rules for working with radiation and so on. Only after verification of the above, they can be permitted to work in radiation-controlled areas.

After the registration, they undergo periodic medical examinations, external dose checks by electronic type pocket dosimeter or glass badge and internal dose checks by whole body counters. Then the total amounts of personal exposure doses are reported to each individual worker.

The Radiation Dose Registration Center for Workers (RADREC) collects personal dose records for radiation workers periodically. Therefore their dose records are centralized and managed uniformly, even if they work in other places. This system is called "Radiation Dose Registration and Management System" (Fig.16). For each person, Radiation Dose Record Booklet (Radiation Passport) is issued by agencies authorized by the RADREC. The booklet contains necessary information for radiation protection management such as the worker's identification, historical exposure results, educational records and so on.

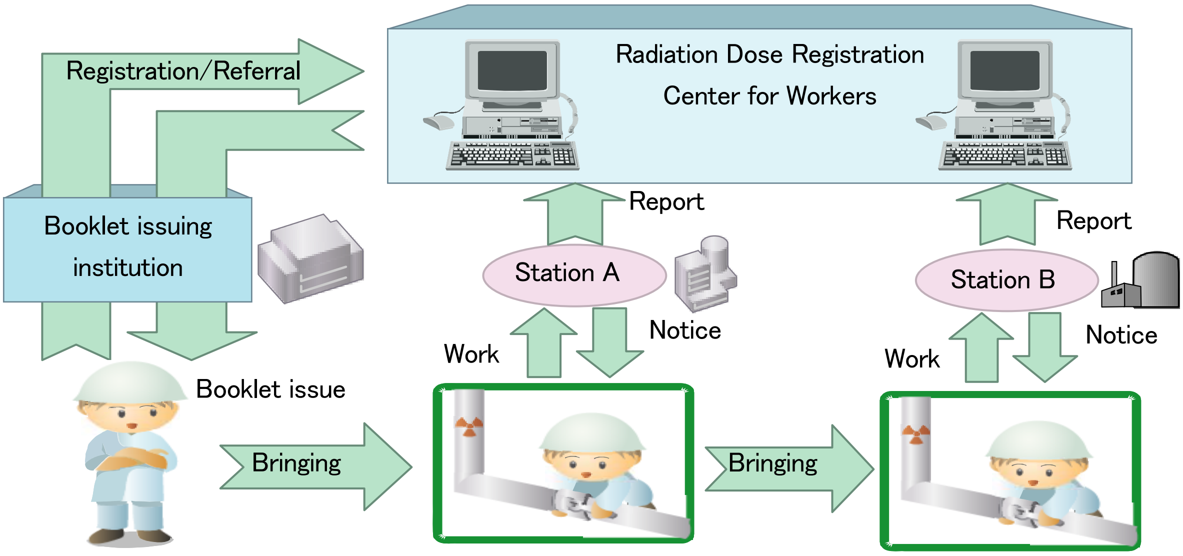


Figure 16: Radiation Dose Registration and Management System

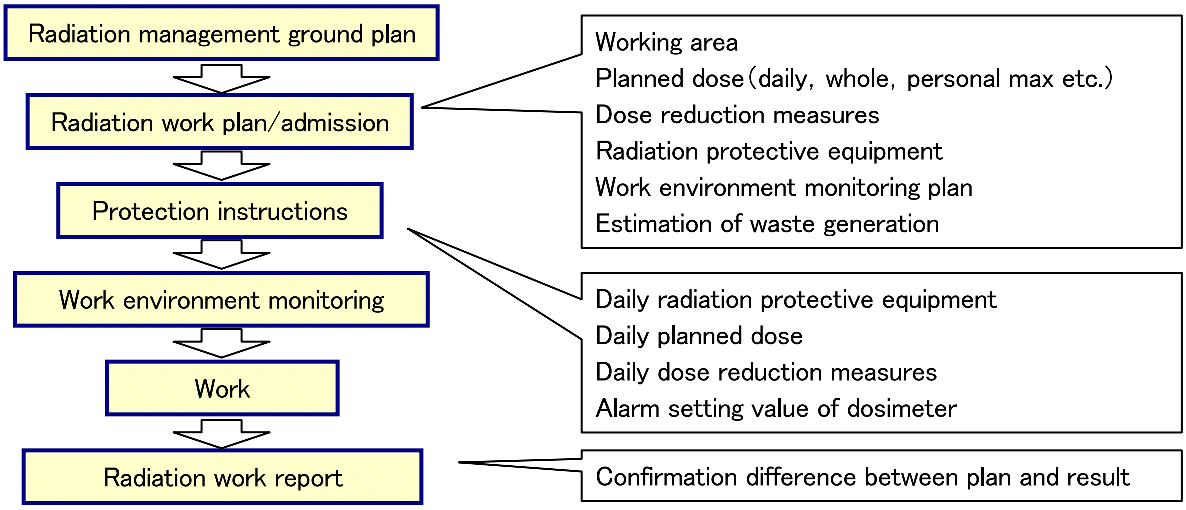


Figure 17: Radiation Management Work Flow (From plan to report)

Fig.17 shows the radiation management work flow. By each step, the Plan-Do-Check-Action (PDCA) is repeated conventionally to reduce exposure dose.

2.3.3 Radiation Area Management

Unnecessary exposures are prevented by setting radiation-controlled areas where the total effective dose from external radiation or radioactive materials in air and surface density of radioactive materials can exceed or be suspected to exceed the legal limits. The dose rates in the radiation-controlled areas are determined by setting up radiation monitors for continuous measurements and monitoring. To determine the level of the contamination, surface contamination level of the structural objects or in the air are measured and monitored. According to the dose rates and contamination levels, the radiation-controlled areas are divided into different categories using walls and fences with signage.(Fig.18)

To prevent accidental taking out of radioactive materials from radiation controlled areas, radiation worker are required to remove the personal protective clothings and shoes etc. upon exiting, and check themself for contamination when they exit from the radiation controlled areas. Items removed from a controlled areas have to be checked also.

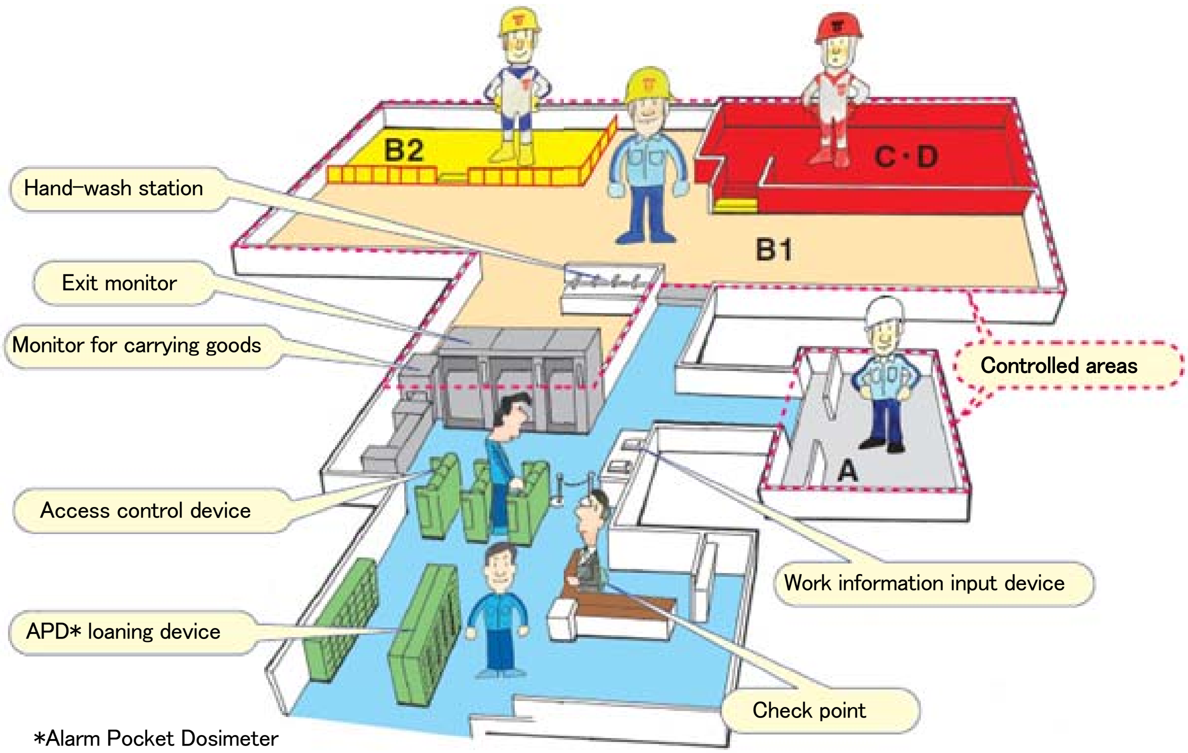


Figure 18: Divisions of Areas inside the Radiation-controlled Areas

2.3.4 Radiological Protection for the Public

2.3.4.1 Regulation and Guideline

(a) During normal operation

Table 1 shows the annual dose limit (1mSv/y) for the public. The limit is set by the regulation to ensure the protection of the public against radiation from nuclear power stations in Japan. This is based on ICRP recommendation in 1990.

To allow for compliance with the regulation by a wide margin, a dose target of only 50μSv/y has been set for the public in a separate guideline, described in the Nuclear Energy Special Committee report. This is the target public dose value for the radioactive materials released from nuclear power stations. And this is a criterion to judge that releases reduction systems are arranged so as to keep doses to the public as low as reasonably achievable (ALARA).

(b) Under accident condition

To protect the public from significant radiation effects, dose criteria for postulated nuclear power station accidents are also stipulated in the guidelines in view of reactor site suitability and design adequacy.

As criteria for reactor site suitability, the target values of individual dose and population dose for severe accidents and hypothetical accidents are established as shown in Table 10. The severe accident is defined as an accident that is less likely to occur. The hypothetical accident is defined as an accident that is unlikely to occur from a technical viewpoint.

On the other hand, as criteria for design adequacy, the target value of dose is established for the design basis accident.

Table 10: The dose limits for the public in the Japanese regulation and guidelines.

<table>
<tr><th colspan="4">Type</th><th>Dose criterion</th></tr>
<tr><td colspan="2">Regulation (limit)</td><td colspan="2">Annual dose</td><td>1 mSv/y</td></tr>
<tr><td rowspan="8">Guideline (target values)</td><td rowspan="2">During normal operation</td><td colspan="2">Annual dose for release of radioactive materials</td><td>50 μSv/y</td></tr>
<tr><td colspan="2">Annual dose for radiation from facilities</td><td>50 μGy/y</td></tr>
<tr><td rowspan="6">Under accident condition</td><td>Design basis accident</td><td>Effective dose</td><td>5 mSv</td></tr>
<tr><td rowspan="2">Severe accident</td><td>Whole-body dose</td><td>0.25 Sv</td></tr>
<tr><td>Thyroid dose (child)</td><td>1.5 Sv</td></tr>
<tr><td rowspan="3">Hypothetical accident</td><td>Whole-body dose</td><td>0.25 Sv</td></tr>
<tr><td>Thyroid dose (adult)</td><td>3 Sv</td></tr>
<tr><td>Population dose</td><td>20000 man·Sv</td></tr>
</table>

2.3.4.2 Nuclear power plant design

(a) Policy of radiation safety design

Releases reduction systems, radiation protection equipment, and radiation monitoring and sampling systems are provided at nuclear power stations to establish radiation safety for public and radiation workers. The releases reduction systems and the radiation protection equipment are designed based on the ALARA concept, with specifications for reducing release or exposure dose to a level as low as reasonably achievable. Judging ALARA approach is accomplished by compliance with the dose target based on the guidelines.

In case of an abnormal event, the systems and the equipment are designed to achieve "shutdown of the reactor," "cooling of the reactor," and "confinement of radioactive materials". They are also laid out to attain habitability in the control room and the technical support center to allow operational actions. Furthermore, the releases reduction systems and the radiation shielding facilities are provided to ensure compliance with the dose targets set in the guidelines for abnormal condition.

(b) Radiation protection design

(i) Releases reduction systems

Releases reduction systems are designed so as to contain radioactive gaseous waste emitted as a result of the degassing process of the reactor coolant, to monitor the concentration of radioactive materials and to release the waste gas after its radioactivity is sufficiently reduced.

The ventilation systems are intended to remove radioactive materials from the exhaust generated in radiation controlled areas by using iodine filters or high-performance particle filters. The systems also monitor concentrations before releasing waste gas.

Reactor coolant, equipment drains, floor drains and effluents from hand-washing, laundry, and hot shower systems are filtered, demineralized and concentrated by the evaporator. This is to ensure that the concentration of radioactive materials in the liquid waste is sufficiently reduced. The liquid waste is then diluted and released after a final check on the radioactivity level. The concentrated liquid waste generated from the evaporator is solidified. The miscellaneous solid waste and the spent exhaust filters are compacted for volume reduction. The low level spent resin, low level concentrated liquid waste, and combustible miscellaneous solid waste are incinerated for volume reduction. These solid wastes are put in packed drums for temporary storage. Sufficient storage capacity has been reserved for the storage of high level spent resin generated throughout the life of the plant.

Releases mitigation systems corresponding to postulated events are provided so as to keep doses below the target levels for site suitability and design adequacy. Moreover, event mitigation manuals have been developed with the aim of reducing the amounts of releases under severe accidents.

(ii) Shielding facilities

In Japan, since it is difficult to secure a sufficiently large site for a nuclear power station, it is critical to reduce radiological effects on the public to as low as reasonably achievable by ensuring effective shielding of the radiation equipment or facilities. In reactor facilities, the shielding designs of the containment vessel, turbine system (BWR), and waste disposal and storage facilities are important. For reactor auxiliary buildings, reasonable shielding designs are implemented by optimizing equipment layouts.

Currently, large components are being replaced for facility maintenance after about 20 years of operation.

Accordingly, additional waste storage facilities to store large-size radioactive waste arising from the replacement are being built with a satisfactory shielding design that eliminates the harmful effects of radiation on the public.

(iii) Radiation monitoring systems

In operating reactor facilities, monitoring systems are designed to ensure that the amounts of releases are below the prescribed releases targets for gaseous and liquid waste. At the same time, these systems are intended to perform sampling and measurement before discharging of wastes. Depending on the monitored level, the effluents can be returned to the radioactive material processing systems as necessary.

Furthermore, dose rates in the vicinity of the plant and the concentration of radioactive materials in the environment (samples) are measured so as to monitor the impact on the environment.

To detect any anomaly at a nuclear power station as soon as possible, and to prevent any abnormal release of radioactive materials, radiation monitors for leakage detection are installed in the reactor coolant, main steam, waste treatment, and ventilation systems.

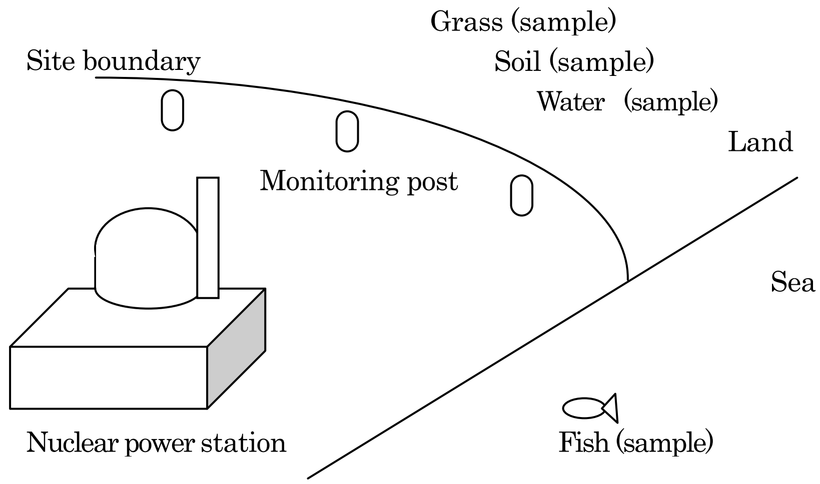


Figure 19: Environmental monitoring and sampling during normal operation

2.3.5 Radiological Emergency Response

2.3.5.1 Legislation and guidelines

Following the critical accident at the reprocessing facility in Tokai-mura (Japan) in September 1999, the Special Law of Emergency Preparedness for Nuclear Disaster was enacted in December of the same year, whereby a disaster prevention scheme at the time of emergency at a nuclear installation was established.

The law clearly defines the duties of the nuclear operator in case of emergency, notification obligations during the abnormal event, declaration of a nuclear emergency, mechanisms for setting up Nuclear Emergency Response Headquarters and Local Nuclear Emergency Response Headquarters, and the roles of an Off-site Center.

An abnormal event should be notified when the dose rate near the site boundary reaches 5 μSv/h or if the event may develop into a nuclear emergency involving the activation of the emergency core cooling system (ECCS). A nuclear emergency is declared when the dose rate near the boundary of the plant site reaches 500 μSv/h or if the event has evolved into the loss of all reactor shutdown functions.

In the wake of the Three Mile Island reactor accident in 1979, emergency preparedness guidelines were established in 1980 under the Basic Law for Emergency Preparedness, and they were revised in May 2000. They clearly define technical elements in nuclear emergency activities as well as tasks to be fulfilled in the area of emergency monitoring, emergency preparedness, emergency exposure, medical treatment, and so on.

2.3.5.2 Nuclear disaster emergency countermeasures

Upon notification of an abnormal event at a nuclear power station from the operator according to the Special Law, an Off-site Center will be set up.

As the event progresses, the central government declares a nuclear emergency, which prompts the organization of Nuclear Emergency Response Headquarters within the government, Local Nuclear Emergency Response Headquarters at the Off-site Center, and a Joint Council for Nuclear Emergency Response.

The central government, local government, police, fire defense authorities, self-defense forces, operator, and experts will be summoned to take part in disaster response countermeasures in multiple functional groups under the leadership of Joint Council for Nuclear Emergency Response.

The central government is now implementing the technical assistance necessary for developing a system in which the government participates in the prediction and countermeasures management of the accident progression. This includes ascertaining the abnormal state of the reactor facility based on online information from the nuclear power station, operates a system that predicts the evolution of the event, predicts radiation exposure effects resulting from released radioactive materials in the vicinity of the site using local meteorological information on the basis of the SPEEDI system, and issues evacuation advisories to the local residents in an appropriate manner if necessary. Additionally, to establish a thorough preparedness structure in case of nuclear disaster, nuclear emergency response drills are regularly conducted jointly by the central government, local governments, operators, and other parties concerned to make sure that the communication system, command system, decision-making process, evacuation process, and roles and functions of individual participants work effectively.

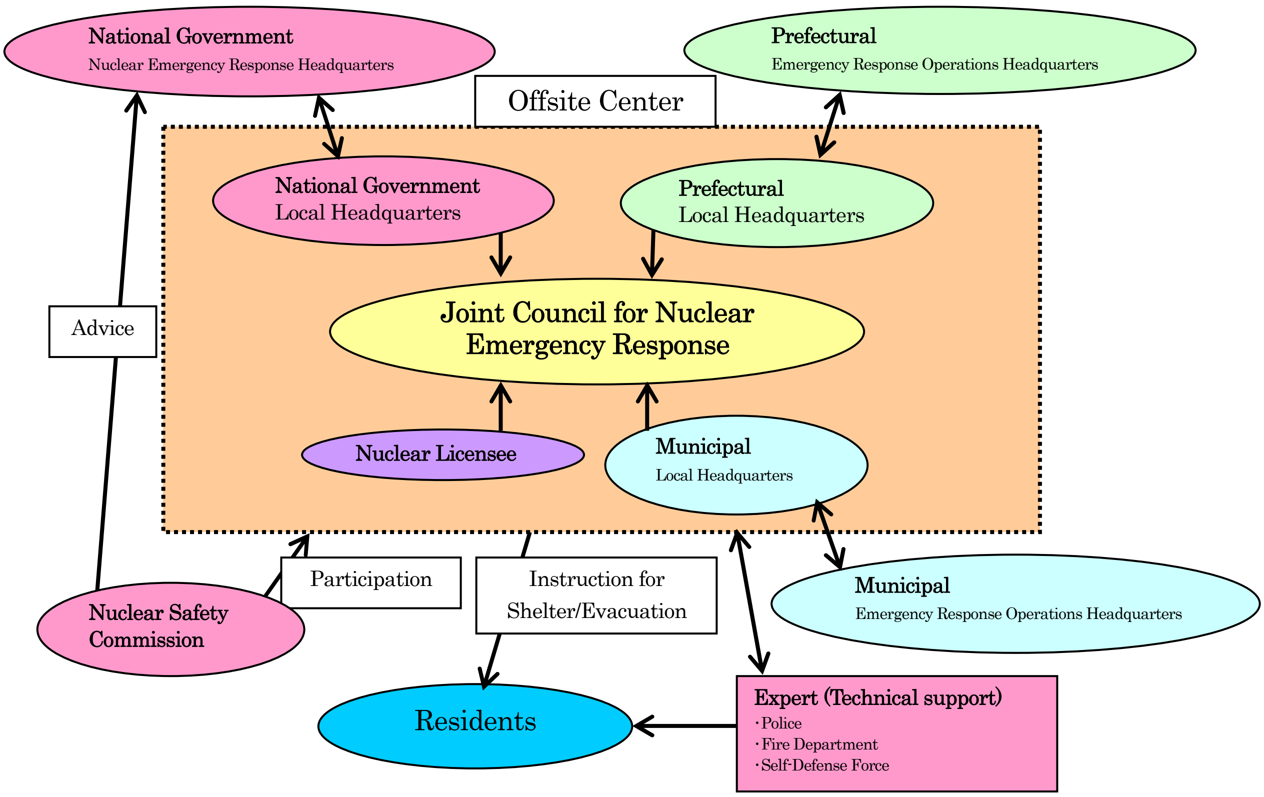


Figure 20: Emergency Preparedness Organization

2.3.5.3 Response to a radiation accident

Possible radiation accidents at nuclear power stations include excessive exposure and radioactive contamination during normal operations inspections, periodic inspections of radioactive equipment, and handling of spent resin, spent filters and other radioactive waste.

To prevent these radiation accidents, radiation measurement and contamination inspection are performed in advance, as necessary; work plans are prepared and planned doses are preset for radiation work, and activities are performed under radiation control.

Importantly, education and training sessions and mockup tests are conducted in pursuit of high safety awareness and reduced exposure time.

In case a radiation accident occurs, the top priority is placed upon the safety of humans and lifesaving. If there is critical contamination or exposure, treatment by physicians is mandatory. In the meantime, the plant manager and workers around the accident site should be notified of the occurrence of the accident, and measures necessary for preventing expansion of the accident or spread of contamination must be put in place.

2.4 Radiation Safety Control at the Radioactive Waste Treatment Facility (Regarding Radiation Safety Control of the Low-Level Radioactive Waste Disposal Facility)

2.4.1 Radiation Safety Management System, Radiological Protection for Radiation Worker, and Radiological Protection for Radiation Area

Radiation safety control applied at Japan Nuclear Fuel Ltd. (JNFL)'s Low-Level Radioactive Waste Disposal Center located at Rokkasho-Mura, Aomori Prefecture, is different from the one applied to nuclear power plants in that its applied method changes in accordance with the attenuation of radioactivity of radioactive waste. This is described as the "Phased Management".

❑ **Regarding Waste Packages**

At present, there are two facilities at the Low-Level Radioactive Waste Disposal Facility at Rokkasho, namely, No. 1 Disposal Facility and No. 2 Disposal Facility, where two different types of waste packages are buried. In No.1 Facility, liquid waste such as water used in rinsing the floor of nuclear power plants is evaporated, concentrated and solidified, then put into drums after being homogenously solidified by cement, asphalt or plastic. Waste packages disposed in No. 2 Disposal Facility consist of metal（pipes and plates etc.） and concrete scraps produced as result of periodic inspection works. These are cut, compacted or dissolved as necessary, and are placed in drums and solidified with mortar.

Among waste packages to be disposed, there is incongruity in radiation levels in each waste package, but the level is below the upper concentration limit defined by law. The actual activity is confirmed before transportation from nuclear power plants, with proper signage indicating its content (ie. radioactive waste) and identification number on the package. Upon arrival at Rokkasho Disposal Facility, Government confirmation that each package conforms to technical standard required by law regarding its outward appearance and identification number is given before being disposed.

The principal technical standard for waste package consists of the following:

1) That the waste is solidified inside the package.
2) That the waste does not exceed the maximum radioactive concentration.
3) That there is sufficient strength for load bearing ability.
4) That signs and identification numbers are in place.

❑ **Regarding the disposal facility**

Waste packages are placed inside the disposal facility (pit) made of reinforced concrete.

When fixing waste packages inside a pit, attention should be paid so as to balance the concentration and types as facility as a whole, by not placing waste packages extremely close to the type other than that which is solidified by cement.

, After confirmation of waste packages upon reception, the individual packages do not need to be verified after their disposal, since radioactive waste in principle attenuates according to its half-life, and since the evaluation and control of dose to the general public is conducted on the disposal ground as a whole.

After waste packages are fixed fully inside a pit, spaces between the drums are filled in with mortar, and further cover made of reinforced concrete is placed over the entire disposal facility, providing shielding for the radioactive waste completely. The entire facilities is covered with water-impervious Bentonite clay. This is then backfilled with the original soil and overlay with grass, and will remain a controlled site for approximately 300 years.

❑ **Regarding Phased Management**

In "Phased Management" the waste disposal facility is managed differently according to the following three phases:

In the First Phase, where the radiation level at the start of burial is not sufficiently low, waste packages are shielded by means of artificial barriers such as concrete pits and drums, so as to prevent radiation and radioactive material leakage.

In the Second Phase, upon completion of the First Phase, radioactivity becomes low after the passage of certain period of time, stabilizing measures of the surrounding soil is effected, since it becomes possible to restrain the transfer of radioactive material sufficiently by means of the surrounding soil even if the disposal facility is deteriorated.

In the Third Phase, upon completion of the Second Phase, when radioactivity declines sufficiently after the passage of certain period, the situation becomes safe enough only by interdicting digging. After 300 years, the radiation level of the waste packages becomes very low, safe enough to negate the regulatory control of the waste packages as radioactive material.

Figure 21: Attenuation by aging of total radioactivity

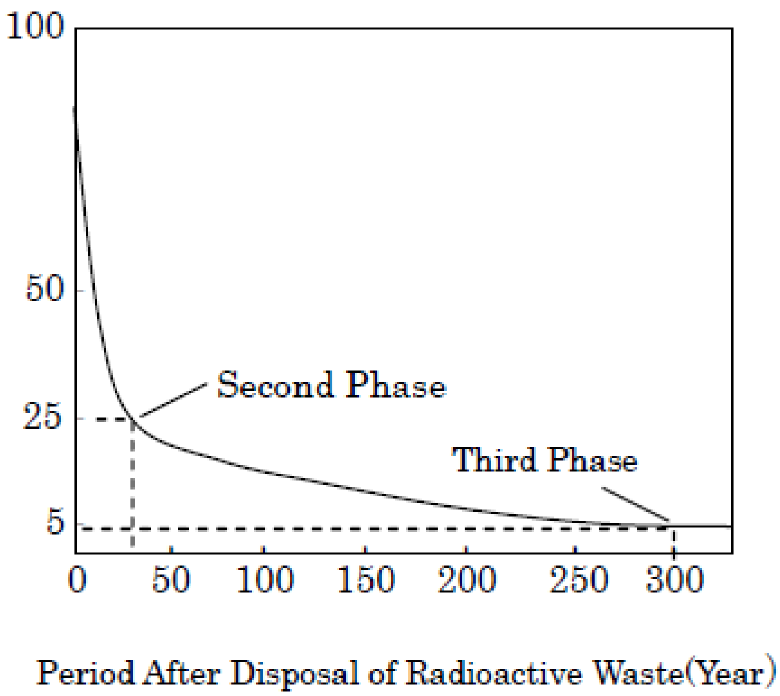


Table 11: Way of Thinking of Phased Management

	1st Phase	2nd Phase	3rd Phase
Scheduled Period	Time elapsed after initial disposal No.1:30-35 years No.2:25-30 years	Time elapsed after 1st Phase:30 years	Time elapsed after 1st Phase:300 years
Purpose	Containment within disposal facilities	Prevention of transfer using disposal facilities and cover soil	Prevention of transfer primarily through cover soil
Control Management	・Establishment of disposal maintenance area, monitoring of waste burial, restoration of cover soil ・Environmental monitoring		
	・Establishment of supervised area ・Monitoring of density of radioactive substances in groundwater ・Drainage of water, supervisory facilities water drainage		・Restrictions on excavation, etc.
	・Monitoring for any leakage ・Repairs of disposal facilities, etc.	・Monitoring of leakage conditions	

❑ **Regarding Measures for reducing occupational exposure**

Measures relative to both the facility and management are undertaken as follows:

Related to facility:

・Shielding, in accordance with the area of access by workers.

Design criteria for shielding are as follows:

Table 12: Design Criteria for Shielding

Areas		Dose Rate Equivalent (μSv/h)
Outside of Radiation Controlled Area		≦ 6
Inside Radiation Controlled Area	・48 hours entry /week	≦ 10
	・24 hours entry/week	≦ 20
	・10 hours entry/week	≦ 50
	・1 hour entry/week	≦ 500
	・Entry normally unrequired	＞ 500

The actual thickness of the shielding wall is 20cm～90 cm for the Control Building.
For the Disposal Facility, shielding is by concrete of approximately 50 cm.
Further, after fixing the drums in pits, by placing a temporary cover of 50 cm thickness, exposure from the pit opening is reduced.

・Crane for the handling of waste packages and inspection equipment of waste packages are automated and remote controlled.

・Entry-exit Control Units and Radiation Measurement Equipment are installed for the management of occupational exposure.

Table 13: Measures for Radiation Protection Equipment

Items	Example of measures
Shielding	Thickness of concrete of the Facility ・Control Building（Principal Parts） Approx. 20～90cm ・Disposal Facility Approx. 50cm
Remote Controlled Automated	Various cranes Inspection Units for Waste Package
Radiation Control Facility	Access Control Facility Radiation Measurement Units, etc.

Related to management:

- Unitary management of Company employees and subcontractors' personnel by professionalization of Radiation Management Sector.
- Limiting access by establishing "Radiation Controlled Area"
- Access control of workers entering "Radiation Controlled Area".
- Personal dose control of workers.
- Radiation protection education to workers.
- Radiation work management such as monitoring of dose rate in work area.

These measures are basically similar to those implemented at nuclear power plants.

❑ **Regarding the evaluation of environmental impact**

(Radiation protection of the general public)

Considering the impact on the environment due to the leakage of radioactive material from the Disposal Facility, it is important that there should not be harmful impact on human environment through groundwater.

The Rokkasho Disposal Facility is located in an impermeable bedrock called the "Takahoko Layer" which is distributed several meters below the land surface, hence the groundwater flows mainly near the surface only. Since the landscape is a plateau surrounded by rivers and marshes, the groundwater consists mainly of rainwater which has seeped slowly underground. Groundwater is not abundant in this area.

Given that waste packages are placed in pits made of concrete, where the spaces inside the pit are filled by mortar, and pits are surrounded by soil mixed with bentonite, sufficient measures are taken to prevent seepage of groundwater. Also, even in the unlikely event of groundwater seepage into the Disposal Site, the water seeping through the surrounding porous concrete can be drained before it can reach the waste packages until the Second Phase. It is therefore unthinkable that the radioactive material can leak easily out of the Disposal Facility.

Table 14: Ground Water at the location of the Disposal Facility/Safety of locating below Ground Water

Ground Water at the location of Disposal Facility

① Distributed in comparatively shallow spots of the impermeable Takahoko Layer.

② Groundwater originates mainly from the rain water which seeped slowly to underground

Safety of locating below groundwater

① Radioactive waste is solidified into drums by cement, etc.

② Disposal Facility is made of reinforced concrete.

③ Mortar is filled in.

④ Disposal Facility is covered by the Takahoko Layer and the soil mixed with bentonite, which do not pass water easily.

⑤Water which seeps into the Disposal Facility can be drained（Up to the Second Phase）

Radioactive Material does not easily leak.

Table15： Comparison of Water Permeability Factor

Division	Water permeability Factor (cm/S)
Quarternary	Approx. 10^{-4}
The Takahoko Layer	Approx 10^{-5}
Bentonite Mixed Soil	Approx 10^{-7}
Concrete	Approx 10^{-10}

However, assuming the worst case scenario where radioactive material leaks prematurely, evaluation of the impact on consuming maritime products from the marsh (which is the end point of the ground water migration) has been undertaken.

Condition of evaluation is maximum 0.075 micro Sv per year, upon estimating the premature deterioration of the Disposal Facility, the routes through which marsh products are eaten, namely: from the groundwater to the stream to the marsh, from the marsh water to marsh products. This is well below the yearly dose criteria of 0.10 micro Sv which is the provisional target.

Dose equivalent evaluation is undertaken based on the assumption that the marsh water near the Disposal Facility may be used for drinking by the general public or for the cattle, after the expiration of the management period (300 years). This evaluation result shows that even taking into account the multiple intake routes, the dose equivalent is 0.13 micro Sv/year, a value too to effect an impact.

Table 16: Dose Equivalent Evaluation for eating maritime products

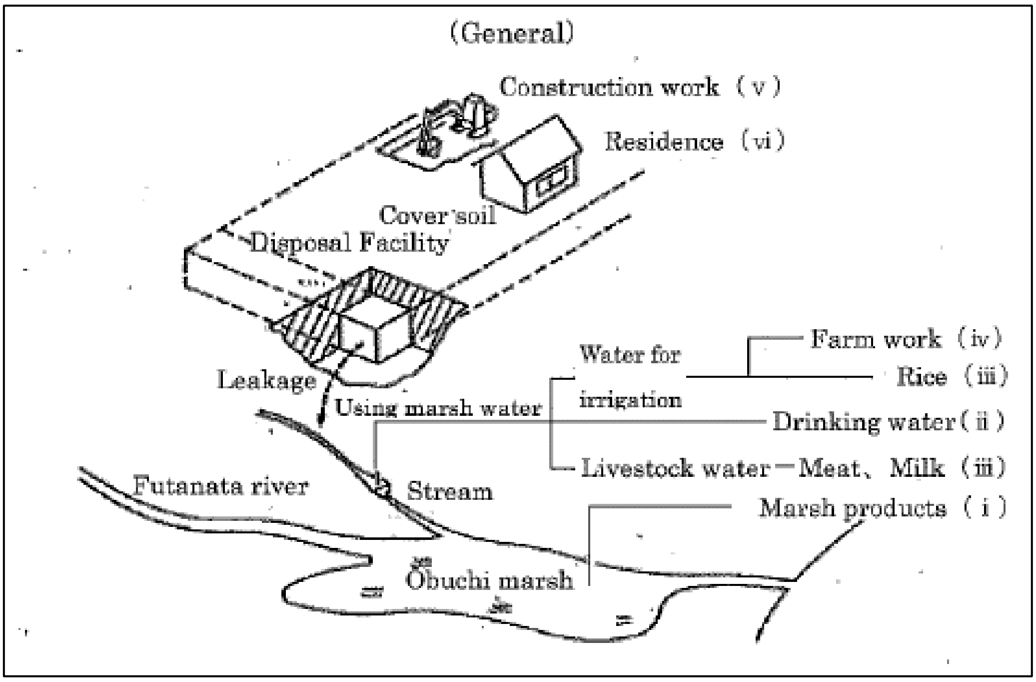
Condition for evaluation	Premature deterioration of Disposal Facility → Carried by groundwater to marshes Marsh water to marsh product → Eating marsh products daily & continuously
Result of evaluation	Max. 7.5×10^{-3} mSv/ y
Impact on maritime products	Sent to the sea from Obuchi Marsh → Big volume of diluted water → Impact can be fully ignored

Table 17：Evaluation Result After Expiration of the Management Period(General)

Unit(mSv/y)

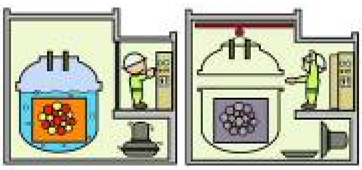
Evaluation Route of Dose Equivalent	Dose Equivalent	Judgment Dose
(i) Internal Exposure due to eating marsh product	Approx.7.5×10^{-5}	0.01 m Sv/y defined in "the Basic Way of Thinking" as a provisional target (For reference) Natural radiation Approx.1mSv/Year
(ii) Internal Exposure due to drinking marsh water	Approx.1.3×10^{-4}	
(iii) Internal Exposure due to eating dairy products produced by using marsh water	Farm products Approx. 9.1×10^{-5} Dairy Products Approx. 2.9×10^{-5}	
(iv) External & Internal Exposure due to farm work using marsh water for production	Approx. 5.5×10^{-5}	
(v) External & Internal Exposure for construction works of housing	Approx. 8.3×10^{-5}	
(vi) External & Internal Exposure due to residence in the area	Approx. 0.0015	

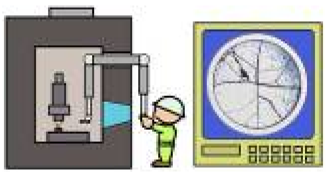
Figure 22: Evaluation Result after Expiration of the Management Period

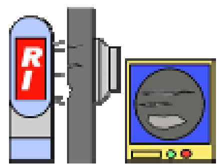


2.4.2 Radioactive Waste Management in the Research Facilities

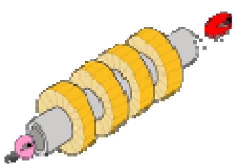
In the research facilities, radioactive waste is generated from research reactors, hot laboratories, nuclear fuel laboratories, radioisotope laboratories, accelerators, facilities modification and decommissioning, etc. This waste varies in materials and radioactivities.

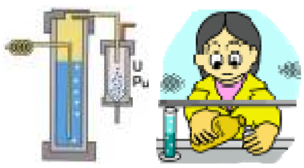

Operation & Maintenance


Post Irradiation Examination

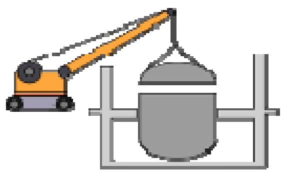


Application Research


Accelerator Operation



Radiochemical Experiment

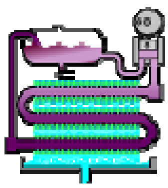

Modification & Decommissioning

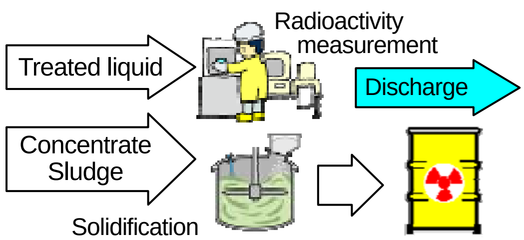
Gaseous waste is treated at the generating facilities by filtration, dilution, decay, etc. prior to discharge under the radiation monitoring into the atmosphere.

Liquid waste with radioactivity concentration below the discharge limits is released into the environment. Other liquid waste is treated at the liquid waste treatment facilities.The concentrate and sludge are solidified into a container (drum), and the treated liquid is discharged into the environment.


Evaporation

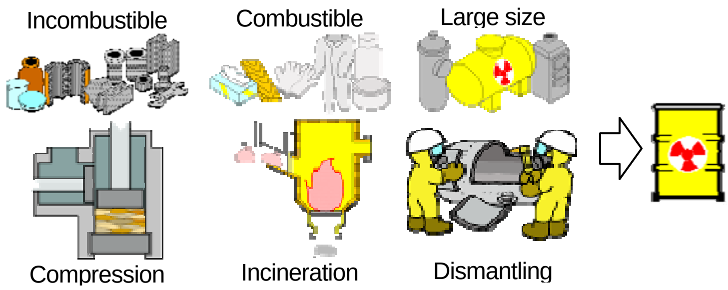

Sedimentation


Filtration

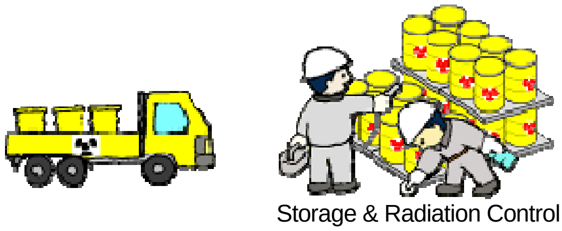


Solidification

All of solid waste is transported to the waste treatment facilities. Incombustible waste is compressed, combustible waste is incinerated, and large size waste is cut and sorted before being packed into containers. High radiation dose waste is handled in shielded cells and packageed into a shielded containers.



The packaged waste is stored in the storage building. They are checked periodically on a regular basis and maintained in a safe condition.



2.4.3 Radioisotope Waste Management Generated from the Use of Radioisotope and Radiation

In Japan, Japan Radioisotope Association (JRIA) supplies sealed radioisotopes and unsealed radioisotopes including radiopharmaceuticals to users all over the county. Radioisotope waste and disused sealed radioisotope sources are generated after the use of unsealed radioisotopes and sealed radioisotopes. JRIA is also in charge of collection and treatment of the radioisotope wastes, and return of disused sealed radioisotope sources. JRIA maintains the complete system from supply of radioisotope products to treatment of their wastes. JRIA takes a special part in the distribution of radioisotopes in Japan. The Japanese system of radioisotope use and JRIA's role is shown in Fig.23.

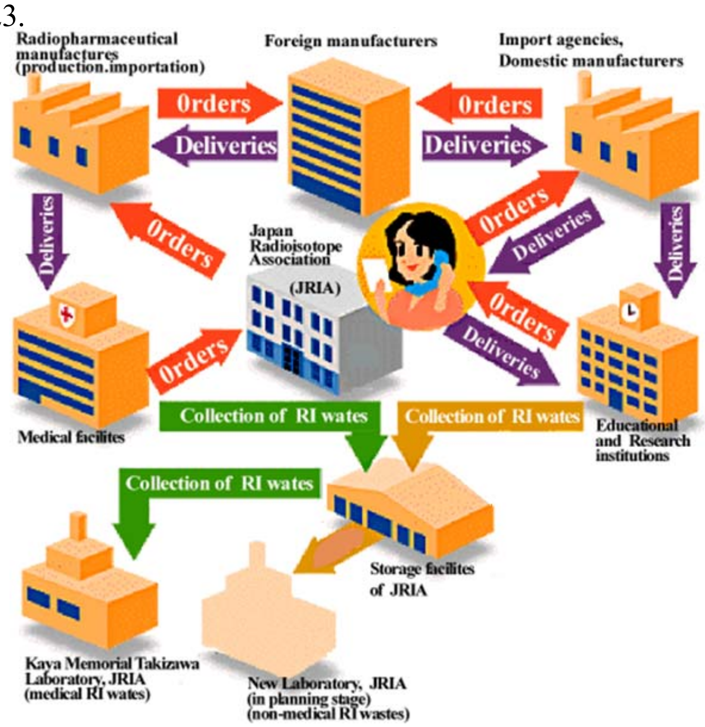


Figure 23: The Japanese system of radioisotope use and the JRIA's role

Users sort out the radioisotope wastes according to the prescribed categories such as combustibles, compressible, animal carcasses and so on and put them into the special containers provided by JRIA beforehand. Users supplies registration card describing the contents within the waste containers. The packaged radioisotope waste containers with the registration cards are collected by JRIA. The categories of radioisotope wastes are shown in Table 18. They are shipped from the users' establishments to the JRIA's storage facilities by truck and stored until their treatment. Only a proportion of the radioisotope waste collected from research and industrial establishment (non-medical radioisotope waste) is treated by JRIA. However all the radioisotope waste from medical establishment (medical radioisotope waste) is treated at Kaya Memorial Takizawa Laboratory of JRIA. A large proportion of the non-medical radioisotope wastes is stored for further treatment at the several storage facilities belonging to JRIA. The final disposal route of the treated wastes is currently under being evaluated and the government will make its decisions in the near future.

JRIA collected about 9,000 drums (200 liter drum) of radioisotope wastes in 2012. About 3,900 drums of those were shipped from medical establishments. Forty percent of which were combustible.

Table 18: Categories of Radioisotope Wastes

	Category	Materials	Container
Solid	Combustibles Ⅰ	Paper, Cloth, Wooden, chips, etc.	50 L Steel drum
	Combustibles Ⅱ	Plastic tube, Plastic vial, Polyethylene sheet, Rubber glove, etc.	50 L Steel drum
	Incombustibles (Compressible)	Glass vial, Glass ware, Syringe, Needle, PVC tube, etc.	50 L Steel drum
	Incombustibles (Non-compressible)	Soil, Sand, Pebble, Concrete garbage, Scrap metal, etc.	50 L Steel drum
	Animal carcasses	Dried animal carcasses	50 L Steel drum
	Filter (Combustibles)	HEPA filter, Pre filter, Charcoal filter	50 L/ unity
	Filter (Incombustibles)	HEPA filter, Pre filter	50 L/ unity
	Charcoal filter (Incombustibles)	Charcoal filter	50 L/ unity
Liquid	Inorganic liquid	Liquid waste generate by experimental use	25 L PE bottle
	Organic liquid	Liquid scintillator waste	25 L Stainless drum

6. Kazakhstan

6. Kazakhstan

Part 1. Radiation Safety in RI Facilities

1.1. General

The Committee of Atomic Energy of the Ministry of Industry and New Technologies of the Republic of Kazakhstan is the legal successor of the Atomic Energy Agency of the Republic of Kazakhstan established in 1992.

In accordance with its statute the Committee executes control and supervision in the field of safety and security in peaceful use of atomic energy. Hence the main tasks of the Committee are regulation of the safety issues, supervision over the nuclear and radiation safety and nuclear security and also over provision of the regime of nuclear weapons nonproliferation when executing any activity related to the use of atomic energy.

The State licensing performed by the Committee is one of the ways to provide safety of the nuclear activities in Kazakhstan. Licensing is performed with the aim to ensure execution of the legislation requirements, safety standards and rules in the field of atomic energy peaceful use. The approved Rules of licensing are one of Committee's anti-corruption activities describing the order and terms of licensing procedures including the work with received license applications, their preliminary and final processing, conclusion on application and license issue in case of positive conclusion on application. Any attempt of illegal charging, assistance in registration of Committee`s license or other illegal activities undertaken by either its staff and outside organizations or individuals shall be immediately reported to Committee's administration.

The matters of Committee`s work are related to its primary functions implementation:

- the nuclear and radiation safety;
- nuclear security including physical protection of nuclear and other radioactive materials, nuclear facilities, transport, combating illicit trafficking of the nuclear and other radioactive materials, preventing potential acts of nuclear terrorism (within the competence of the Committee);
- emergency readiness and emergency response measures including international and interstate cooperation in case of any transboundary nuclear or radiological incidents;
- staff training and staff certification in organizations engaged in nuclear or potentially dangerous radioactive activities;
- researches sponsoring to prove the safety of nuclear activities;
- international cooperation within the Committee`s competence sphere.

The Committee is responsible for maintenance of state systems for accountancy of nuclear materials and radiation sources. All Committee`s Licensees shall regularly provide data regarding to the presence and circulation of relevant materials and sources which are in their balance. The national chart of radiation sources is compiled on the basis of provided data after the verification. The data on nuclear materials quantity are used to maintain the chart and nuclear materials circulation record in the zones of material balance of the Republic of Kazakhstan. The reports concerning the nuclear materials presence and circulation are regularly submitted to the International Atomic Energy Agency (IAEA) to implement the Agreement between the Republic of Kazakhstan and IAEA with regard to safeguards application in connection with Nuclear Weapons Nonproliferation Agreement which came into force on August, 1995. The Additional Protocol to the above Agreement came into force in 2007 and the Committee is also in charge of its implementation.

Republic of Kazakhstan is a member of Nuclear Suppliers Group (NSG). The legislation, standards and rules for nuclear export control therefore correspond to all NSG recommendations. All nuclear export and import applications shall be agreed by the Committee – the license is issued by the Ministry of Industry and Trade. It shall be noted that sale of nuclear or other radioactive materials and radiation sources is to be licensed.

1.1.1 Legislative Framework and Policy for Radiation Safety

The main aim of Committee's activity is sustainable and cost-effective safety provision in atomic energy peaceful use, protection of population and humans` habitat from possible negative impact of atomic energy use.

Factors determining the radiation conditions on the territory of the Republic of Kazakhstan:

- Activities of uranium mining and processing enterprises and associated geological works;
- Activities of mining and processing enterprises producing the raw material with a high content of radioactive elements;
- Activities of uranium industry enterprises;
- Power and research nuclear reactors, radioisotope products use;
- Nuclear tests carried out in the past.

Nuclear energy use is widespread in Kazakhstan – not only nuclear fuel cycle enterprises but also wide number of medicine, scientific and other establishments use the radioactive sources. Therefore Committee controls not only scientific and industrial nuclear complex enterprises but all establishments engaged in hazardous nuclear and radiation activities in the field of atomic energy use. Isotope products are used in various fields of economy mainly as so-called ampoule sources of radiation.

Some of the most important conditions for the safe use of atomic energy are legal regulation, responsibilities allocation between organizations engaged in atomic energy use and state bodies monitoring the nuclear and radiation safety.

The Committee is entitled to grant license for activities related to atomic energy use and to supervise over the licensing requirements execution within its jurisdiction.

The primary activities in the field of atomic energy are defined by Article 13 of Law "About licensing" No. 214 dated to January 11, 2007., and Article 5 of Law "About atomic energy use" No. 93 dated to April 14, 1997 and Resolution of Government of the Republic of Kazakhstan No. 716 dated July 10, 2013.

The Law "About the Atomic Energy Use" (No.93 dated to April 14, 1997) establishes legal standards and principles for regulation of public relations in the field of atomic energy use and aimed to protect humans` health and life, environment and to provide nuclear weapons nonproliferation and nuclear and radiation safety in atomic energy use.

The Law establishes the basic rights of authorized state bodies and officials in the field of atomic energy activities and establishes the necessary licensing of all types of atomic energy activities.

The Law "About Radiation Safety" (No. 219 dated to April 23, 1998) regulates public relations in the field of radiation safety to protect the health of population from negative impact of radiation and sets the main principles of radiation safety.

The Law establishes the jurisdiction of the state bodies on provision of radiation safety, general requirements for radiation safety assessment and radiation safety when using the radiation sources.

The Law "About Licensing" (No.214 dated to January 11, 2007) regulates the state licensing procedures for any activity or defined activities subject to licensing, sets the basic licensing principles, types and forms of licenses and sets the list of documents necessary to get the license.

The Law "About Radiation Safety" (No. 219 dated to April 23, 1998) regulates public relations in the field of radiation safety to protect the health of population from negative impact of radiation sets the main principles of radiation safety. The Law establishes the jurisdiction of the state bodies on provision of radiation safety, general requirements for radiation safety assessment and radiation safety when using the radiation sources.

The Resolution of the Government of the Republic of Kazakhstan (No. 716 dated July 10, 2013) "Qualification Requirements to Activities Subject to Licensing in the field of the use of Atomic Energy" establishes the list of activities subject to licensing by the Committee of Atomic Energy (in compliance with the Law "About Atomic Energy Use"), qualification requirements to applicants for activities related to atomic energy use and the list of documents necessary to get the license.

The number of staff works for Committee is 60 persons including the Chairman and two Deputies. There are 11 divisions under the Committee–Licensing, Review and Inspection, Material Control and International Guarantees, Nuclear Physical Security, Technical Cooperation, Informative Provision, Atomic Industry, Atomic Energy, Scientific and Technical Development, Administrative and Legal, and Financial.

1.2 Outline of Radiation Facilities and Radiation sources

1.2.1 Number of specialists and workers in related organizations

The total number of people working with radiation related industry in Kazakhstan is difficult to define correctly now. However a number of workers and a number of radiation workers under the personal radiation monitoring service are available for basic Kazakhstan`s organizations in the field of atomic energy such as National Atomic Company "Kazatomprom" (the national operator of the Republic of Kazakhstan for import and export of uranium, rare metals, nuclear fuel for power plants, special equipment and dual-purpose materials), National Nuclear Center of the Republic of Kazakhstan and Institute of Nuclear Physics. Currently the total number of workers in these organizations is approximately 28,000 and 6,500 of which is under the personal radiation monitoring service.

1.2.2 Number of radiation facilities including related facilities

National Nuclear Center (NNC) was created by presidential decree in May 1992. The NNC is responsible for conducting research on the peaceful use of nuclear energy and radiation safety and is also responsible for evaluating the consequences of nuclear tests at the now-closed Semipalatinsk Test Site.

In accordance with the Government Decree three independent enterprises were created in November 2012 under the NNC. They are Republican State Enterprise, National Nuclear Center, Republican State Enterprise "Institute of Nuclear Physics" and Republican State Enterprise "Institute of Geophysical Research."

Institute of Nuclear Physics operates the VVR-K research reactor in Alatau.

NNC oversees the following institutes:

- Institute of Atomic Energy: Includes the following nuclear research reactors: IVG-1M, non-operational RA, and IGR;
- Institute of Radiation Safety and Ecology.

The pool type reactor on the thermal neutrons VVR-K uses demineralized water as a heat-carrier, moderator and reflector. It was put into operation in 1967 and worked on thermal capacity of 10 MWt till 1988 without any deviation from the normal modes. From 1988 to 1998 works on strengthening the safety in conditions of high seismicity (calculations and substantiations, strengthening of designs, duplication of the systems responsible for the safety, registration of the new documentation) had been done. By the configuration change of the active zone, the thermal capacity has been reduced to 6 MWt without loss of neutron flows.

Water-cooled reactor IVG.1M which is an upgraded version of high-temperature gas-cooled reactor IVG.1 commissioned in 1975 and initially intended for of fuel pins and NJP FA tests. During the upgrading period gas-cooled reactor core was replaced by water-cooled one.

Impulse research reactor, IGR, is high-temperature self-quenched uranium-graphite homogeneous thermal neutron reactor. Today IGR reactor is used for test conduction in support of concept of controlled fuel melt moving into the fast reactors to prevent re-criticality at severe core meltdown accidents.

Spent ionizing radiation ampoule sources (IRAS) repository in Kazakhstan was installed in 1995. The repository allowed the long-term safe storage (about 50 years), handling and disposal of spent IRAS, widely applied in industry, science, medicine etc.

The repository is located at research reactor complex "Baikal-1" on the territory of former Semipalatinsk Test Site. Complex "Baikal-1" is situated at 75 km from nearest inhabited locality. It is bounded by protective perimeter, provided with up-dated physical protection and guarded by forces of Ministry of Internal Affairs Republic of Kazakhtan.

Spent IRAS , accepted for long-term storage from different establishments and enterprises in Kazakhstan, are transported in protective containers by special-purpose vehicles. Spent IRAS are extracted from protective containers, dismantled in hot cell and enclosed in steel casing, which is then sealed. Filled casing is loaded into repository cell and covered by ferroconcrete 40-ton lid. For transportation and shifting the special-purpose equipment, including the frame crane with load capacity of 125 tons is used. Permanent radiation monitoring is carried out at the territory of complex "Baikal-1".

The repository allows the improvement of ecological environment in many regions of Kazakhstan and revives the cancer detection centers. By now over 40000 spent IRAS, including 30 oncological ones and over 2000 Cu each are accepted.

After shutdown of BN-350 reactor facility (MAEC site, Aktau), the issue of packing and disposal of spent nuclear fuel (SNF) assemblies is arisen for the Government of Kazakhstan.

Research reactor (CRR) Complex "Baikal-1" situated at 75 km from Kurchatov was chosen by the Republic of Kazakhstan Government to locate long-term spent nuclear fuel storage

(LTSNFS) facility. The spent fuels were placed in packaging storage sets (PSS). Eight-seat ferroconcrete dual-use casks (DUC) were used as suggested by the USA as a PSS. Spent fuels were placed into the 60 containersand were shipped by rail transport.

RD Construction of SNF handling site including transfer site and storage site had been developed by RD department. The main requirements to the repository and functional area are the following:

- capacity of the storage site - 60 PSS upright;
- unloading of the duel-use casks from highway freighters;
- DUC tipping to the vertical position;
- PSS extraction from the protective casing;
- placement of PSS with SNF for the storing;
- long-term storage of PSS with SNF;
- provision with power resources, physical protection system and supervisory control system.

Transportation and placement for long term storage of 60 PSS with SNF were completed in November 2010. Physical protection of nuclear material, radiation safety and optimal technical storage conditions are provided.

1.2.3 Activity and number of radiation sources and generators

The number and activity of sources in use now have not yet been clarified. These information will be presented after analyzing and summarizing them.

1.2.3.1 Future plans and issues to be solved

A feasibility study for the project "Creation of the radiation protective chamber and the long-term storage facility of SRW (solid radioactive wastes) at CRR "Baikal-1" IAE NNC RK is developed to increase the volume and nomenclature of RAW accepted for processing and storage.

1.3 Education and Training

Radiation workers and personnel having access to radiation facilities shall attend appropriate radiation protection training courses in both theoretical and practical aspects to acquire radiation-handling skills neededfor access to controlled areas. There are 20 organizations in different regions of Republic of Kazakhstan which provide radiation protection officers training courses. The duration of courses is usually 1-2 weeks. The Kazakhstan Atomic Energy Committee has issued the document named "Common Requirements for Organizations Providing Training for Personnel Involved in the Field of Atomic Energy in the Republic of Kazakhstan". The purpose of this document is to state the regulatory requirements for training centers to establish and maintain training and qualification programmes for personnel involved in activities in relation with the use of atomic energy in Kazakhstan. These requirements are applied to training centers who provide training for nuclear facility personnel, permanent or temporary employees, including contractors, experts and consultants at a site of any nuclear facility.

1.4 Standardization on radiation and radioactivity

Metrology laboratory of Institute of Atomic Energy of National Nuclear Center of

Kazakhstan was officially recognized by authorized state governmental agency as qualified and authorized legal entity to implement the prescribed metrological examinations.

The laboratory has a right to implement the following metrological efforts:

- instrumentation checkup in compliance with licensing spheres (heat, electrical, radio, physical and linear-angular engineering , ionizing radiation);
- instrumentation maintenance;
- metrological examination of technical and design documentation.

The most popular metrological services introduced by Institute's metrology laboratory, amid Kazakhstan's enterprises is ionizing radiation instrumentation checkup.

Representation, storage and transfer of unit sizes in metrology laboratory are carried out by means of working and reference standards and standard samples (measures).

All working standards and standard samples (measures) are checked (assessed) at certain interval before usage.

Part 2. Status of Radiation Safety Management

2.1 Radiation safety management in various RI usage

2.1.1 Radiation Safety Management System

The management of radiation safety within various radiation facilities is governed by the specific standards, codes and guides.

Basic list of normative technical documents of Atomic Energy Committee related to fuel and radiation safety use in Republic Kazakhtan:

- Hygienic regulations "Sanitary–Epidemiological requirements to Radiation Safety Assurance", Government Decree, *February 3, 2012, №201*
- Sanitary rules "Sanitary–Epidemiological requirements for Radiation Safety Assurance", Government Decree, *February 3, 2012, №202*
- Sanitary rules "Sanitary–Epidemiological requirements for Radiation Dangerous Facilities", Government Decree, *March 11, 2012, №308*
- Technical requirement "Nuclear and radiation safety of research nuclear facilities", Government Decree, *July 1, 2010*
- Technical requirement "Nuclear and radiation safety of NPP", Government Decree, *July 1, 2010*
- Technical requirement "Nuclear and radiation safety", Government Decree, *July 30, 2010*

2.1.2 Radiological Protection for Radiation Worker

Radiation protection of workers need to be monitored to ensure that the total amount of external and internal exposure does not exceed yearly limit of effective dose by using personal a dosimeter and regular medical check need to be done in accordance with the applied regulations.

Table 1: Radiation dose limits for radiation worker and public

	Dose limit	
Application	Occupational	Public
Effective dose	20 mSv per year, averaged over a period of 5 consecutive calendar years but not more than 50 mSv per year	1 mSv in a year, averaged over a period of 5 consecutive calendar years but not more than 5 mSv per year
Annual equivalent dose in		
the lens of the eye	150 mSv	15 mSv
the skin	500 mSv	50 mSv
the hands and feet	500 mSv	50 mSv

2.1.3 Radiological Protection for Radiation Area

Work processes and areas are designed to keep radiation exposure to a minimum. Where the potential for exposure to radiation or contamination still exists, shielding and mechanical ventilation are employ to minimize the dose received. Areas are classified according to the potential radiation and contamination level.

2.1.4 Radiological Protection for the Public

The licensee shall ensure that exposure to public is in accordance with the Kazakhstan norms and rules. Annual dose limit (1mSv/y) for the public given in Table 1 in accordance with Kazakhstan regulation ensure the protection of the public against radiation from RI in Kazakhstan.

2.1.5 Radiation Emergency Preparedness

Organizations, individuals conducting radiation activities shall develop their plans for radiation and nuclear incident response.

One important element in the investigation and emergency response is radiation monitoring, which pulled a problem in the following:

- Assessment of effects of ionizing radiation on personnel and individuals from the population;
- Determination of pollution levels in the environmental, equipment, clothing, industrial and residential premises.

Particular attention should be paid:

- Choice and optimal use of dosimetric and radiometric equipment;
- The choice of modes of operation of radiation equipment, the establishment of the victim's location in relation to the radiation source, during his stay in the radiation field (to simulate a radiation accident);
- On the amount of radiation control, depending on group accident.

7. Malaysia

7. Malaysia

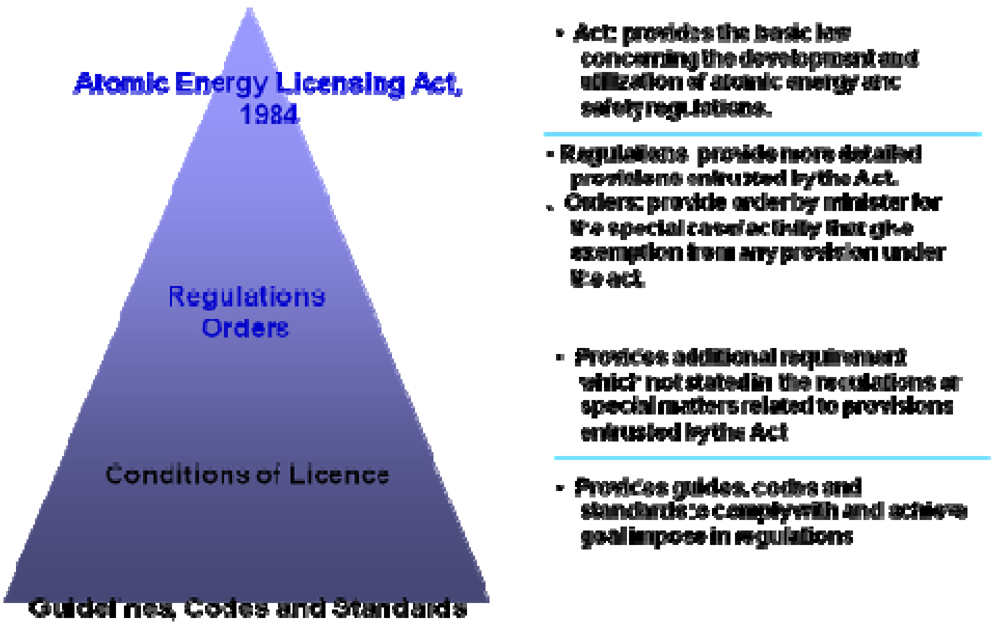
Part 1. Use of Radiation Sources and Radiation

1.1 General

1.1.1 Legislative framework and policy for radiation safety

Control over the use of radioactive substances in Malaysia began in 1968 when the Parliament passed the Radioactive Substances Act 1968. Due to rapid development of atomic energy activities in Malaysia which requires more effective control, inspection and enforcement, the Atomic Energy Licensing Bill was drafted and was passed by Parliament in April 1984 as the Atomic Energy Licensing Act (Act 304).

Figure 1: Hierarchy of Legal System



There are three main regulations made under the Act 304 namely:

Radiation Protection (Licensing) Regulations 1986;
Radiation Protection (Transport) Regulations 1989
Atomic Energy Licensing (Basic Safety Radiation Protection) Regulations 2010;
Atomic Energy Licensing (Radioactive Waste Management) Regulations 2011

1.1.2 Structure and System (Regulatory organizations)

In line with Section 3 of the Act 304, the Atomic Energy Licensing Board (AELB) was established under the Prime Minister's Department on 1 February 1985. The AELB acts as an enforcement body for the implementation of the Act. However on 27 October 1990 the Board was placed under the Ministry of Science, Technology and Innovation (MOSTI).

The functions of AELB as stated in Act 304 are as follows:

- To advise the Minister and the government of Malaysia on matters relating to the Atomic Energy Licensing Act 1984 and developments pertaining thereto with particular reference to the implications of such developments for Malaysia;

- To exercise and supervision over the production, application and use of atomic energy and matters incidental thereto ;
- To establish, maintain and develop scientific and technical co-operation with such other bodies, institutions or organizations in relation to nuclear matters or atomic energy as the Board thinks fit for the purposes of the Atomic Energy Licensing Act 1984 ;
- Where so directed by the government of Malaysia, to perform or provide for the performance of the obligations arising from agreements, conventions or treaties relating to nuclear matters or atomic energy to which Malaysia is a party where such agreements, conventions or treaties relate to the purposes of the Atomic Energy Licensing Act 1984 ;and
- To do such other things arising out of or consequential to the functions of the Board under the Atomic Energy Licensing Act 1984 which are not inconsistent with the purposes of this Act, whether or not directed by the Minister.

Since the enforcement of the Act 304, a major part of the responsibility was under the jurisdiction of the Atomic Energy licensing Board. However, the control of application in medical purposes is under the jurisdiction of the Director General of Health, Ministry of Health.

1.2 Outline of Radiation Facilities and Radiation sources

1.2.1 Number of specialists and Workers in related organizations

In Malaysia, the number of specialists and workers involved with radiation related industry are maintained by the AELB and MOH. However, the exact total number of workers involved with radiation is very difficult to estimate.

1.3 Education and Training

1.3.1 Radiation Industry usage

Under the Atomic Energy Licensing (Basic Safety Radiation Protection) Regulations 2010, all licensees are required to have a Radiation Protection Officer (RPO). RPO is defined as a technically competent person approved and recognized by the regulatory body. The RPO shall go through special radiation protection course at recognized institutions and shall pass an examination before can be approved as RPO by the regulatory body.

The Licensee is also required to employ and engage well trained radiation workers. The workers shall be provided with appropriate retraining for updating their skill and knowledge. Industry related occupations include industrial radiographers, borehole loggers, industrial gauges user, seller and trader, radiation source testers and persons servicing, installing, commissioning, maintaining, repairing or manufacturing radiation sources and equipment, lecturers and technician at higher leaning institutions, researchers at research institutes etc.

Health related occupations include medical practitioners, dental practitioners, veterinary surgeons, diagnostic radiographers, radiation therapists, nuclear medicine technologists, health and medical physicists.

1.3.2 Radiological protection

Numerous companies, institutes and universities provide education and training in radiation safety, radiological protection and related courses. There are approximately seven providers and around 100 radiation safety training courses covering subjects that include including general radiation awareness, radiation protection, use of radionuclides, use of gauges, transport, and use of radiation in medical procedures.

1.4 Standardization on radiation and radioactivity

1.4.1 External radiation andpersonnel dosimetry

External radiation quantity can be measured in terms of exposure, air kerma, absorbed dose, dose equivalent, ambient dose equivalent and directional dose equivalent by using radiation measuring instruments. Various kinds of radiation measuring instruments such as survey meters, area monitors, personal dosimeters, contamination monitoring instruments are used in the radiation facilities for radiation protection purposes. For implementation of proper monitoring, radiation monitoring survey meters e.g. ionization chambers, Geiger-Muller (GM) counters and scintillation counters should be calibrated in terms of dose equivalent quantities. Area dosimeters or dose ratemeters should be calibrated in terms of the ambient dose equivalent, H*(10), or the directional dose equivalent, H'(0.07). In radiotherapy centres, the radiation dosimeters are normally used for determination of the output of Cobalt-60 teletherapy units and medical linear accelerators (linacs) should be calibrated in terms of exposure, air kerma or absorbed dose to water. Radiation measuring instruments need to be calibrated to ensure that they give accurate and correct reading with a certain uncertainty and to comply with the regulations imposed by the relevant authority. They should be calibrated annually or after major repair. In Malaysia, calibration of radiation measuring instruments is a legal requirement under the Atomic Energy Licensing (Basic Safety Radiation Protection) Regulations 2010. The SSDL-Nuklear Malaysia was established in 1980 and a member of the IAEA/WHO Network of SSDLs. The laboratory had acquired the status of national standard laboratory with the basic aim of improving accuracy in radiation dosimetry in the country. It is also the national focal point for the calibration of radiation measuring instruments used in radiation protection and radiotherapy. More than 1500 radiation instruments are normally calibrated every year. The laboratory has also the responsibility to ensure that the calibration services provided ollow internationally accepted metrological standards. This is achieved by calibrating the protection and therapy level dosimeters that belong to SSDL-Nuklear Malaysia against the Primary Standard Dosimetry Laboratories (PSDLs) or the International Atomic Energy Agency (IAEA) or by participating in the international comparison on dosimetry measurements.

1.4.2 Calibration Facilities

1.4.2.1 Irradiation facilities.

The calibration of radiation instruments used for radiation protection and radiotherapy purposes requires appropriate irradiation facilities capable of providing air kerma rates up to approximately 1Gy/min. The SSDL-Nuklear Malaysia has four irradiation rooms or bunkers to accommodate radiation sources and to perform calibration of radiation protection survey instruments and therapy level dosimeters. The dimensions of the irradiation rooms were approximately 9m x 4.8m x 3.2m high. The floor, walls and ceiling are concrete. The design of the irradiation rooms are in accordance with the relevant national and international safety regulations. The shielding of the rooms is sufficient to ensure that the radiation doses to the staff and the public are kept as low as reasonably achievable and that the given dose limits are not exceeded. The irradiation rooms are equipped with radioactive and x-ray sources that are operated remotely in the control room. This room also contains monitors coupled to video cameras in the irradiation rooms. The rooms are provided with calibration benches running on a pair of rails to carry out the measurements of radiation at various distances from the sources and calibrate the radiation measuring instruments. The ionization chambers or radiation survey instruments are positioned on the calibration benches where they can be moved into a required distance from the source. Their position is fixed at the calibration distance using a telescope or laser. Laser alignments are also installed at each irradiation room to ensure that the radiation survey meters and dosimeters are placed in the centre of the radiation beam during the measurements. The irradiation rooms are also provided with appropriate safety equipment and accessories such as warning light for each irradiation unit, door interlocks and continuously operating radiation monitors.

1.4.2.2 Radiation sources.

(i) X-radiation.

Calibration at photon energies below 300 keV is usually carried out using an x-ray system. SSDL-Nuklear Malaysia has created a series of x-ray beam qualities which were selected to match the beam qualities offered by the International Bureau of Weight and Measures (BIPM) and based on ISO Narrow Spectrum Series. The Yxlon constant potential x-ray systems type MG 325 with a 320 kV tube is used to generate ISO narrow spectrum series x-ray reference radiation for the calibration of radiation protection instruments. Their beam characteristics are shown in table 1, where the values of the mean energies have been adopted from the ISO document. X-rays generated between 100 kV and 250 kV in accordance with the BIPM therapy qualities are used for calibration of therapy level dosimeters.

Table 1: ISO Narrow Spectrum Series X-ray Beams at the SSDL-Nuclear Malaysia

Radiation quality	Mean energy	Tube potential	Additional filtration [mm]				HVL [mm]
	[keV]	[kV]	Al	Cu	Sn	Pb	Cu
N-40	33	40	4.0	0.2	-	-	0.09
N-60	47	60	4.0	0.6	-	-	0.25
N-80	65	80	4.0	2.0	-	-	0.59
N-100	83	100	4.0	5.0	-	-	1.15
N-120	100	120	4.0	5.0	1.0	-	1.78
N-150	117	150	4.0	-	2.5	-	2.58
N-200	164	200	4.0	2.0	3.0	1.0	4.13
N-250	207	250	4.0	-	2.0	3.0	5.34
N-300	248	300	4.0	-	3.0	5.0	6.33

Table 2: Therapy Qualities X-ray Beams at the SSDL-MINT

Tube potential [kV]	Additional filtration [mm]		HVL [mm]	
	Al	Cu	Al	Cu
100	3.5	-	4.05	-
135	1.0	0.3	-	0.50
180	1.0	0.6	-	1.01
250	1.0	1.6	-	2.51

(ii) Gamma radiation.

Radionuclide sources are used to perform calibration at photon energies above 300 keV. There are several gamma sources i.e. Caesium-137, Cobalt-60 and Americium-241 with different activities available to provide radiation standards for protection and therapy level dose rates. Two irradiation rooms are equipped with two collimated gamma irradiators model OB 85 which consists of ^{137}Cs (740 GBq) and ^{60}Co (37 GBq) and two panoramic gamma irradiators model OB 34. The panoramic gamma irradiator contains a total of seven ^{137}Cs and ^{60}Co gamma sources with activities ranging from 3.7 MBq to 7.4 GBq that produce uncollimated radiation fields. Table 3 shows the specification of protection level gamma sources used to calibrate radiation survey instruments. The reference gamma radiation fields are determined in terms of air kerma rate. A teletherapy ^{60}Co unit model Eldorado 8 is used to provide national standards for air kerma and absorbed dose to water at therapy level and calibration service for therapy level dosimeters.

Table 3: Protection level gamma sources

Gamma irradiator	Nuclide	Activity range	No. of source	Covered air kerma rate range	Source distance [m]
OB 34	Cs-137	7.4MBq-7.4GBq	4	0.49 µGy/h - 1.59 mGy/h	0.5 – 2.5
	Co-60	3.7MBq-370MBq	3	0.29 – 38.94 µGy/h	0.5 – 2.5
OB 85	Cs-137	740 GBq	1	16.53 µGy/h- 150.48 mGy/h	0.5 – 5.0
	Co-60	37 GBq	1	5.76 µGy/h – 5.54 mGy/h	0.5 – 5.0
OB 6	Cs-137	74 GBq	1	0.22 – 14.56 mGy/h	0.5 – 4.0
-	Am-241	11.1 GBq	1	5.08 – 119.92 µGy/h	0.4 – 2.0

(iii) Beta radiation

The beta radiation sources of the Pm-147, Kr-85 and Sr-90/Y-90 nuclides of the PTB Beta Secondary Standard (BSS 2) developed by the Physikalisch-Technische Bundesanstalt (PTB), Germany are used to calibrate radiation survey instruments. The radiation qualities are in compliance with the series of standards ISO 6980. The sources are calibrated by PTB at the specified distances in terms of absorbed dose rate to tissue surface, directional dose equivalent rate and personal dose equivalent rate. The dose rate at the calibration distance is between 7 µGy/s and 38 µGy/s. The irradiation procedure is controlled by a personal computer which stores the calibration data for the source used. The specifications of beta sources are summarized in table 4.

Table 4: Beta Secondary Standard Sources.

Source	1	2	3
Radionuclide	Pm-147	Kr-85	Sr-90/Y-90
Nominal activity	3.7 GBq	3.7 GBq	460 MBq
Beam flattening filter	Yes	Yes	No
Mean beta energy (MeV)	0.06	0.24	0.8
Calibration distance (cm)	20	30	11, 20, 30 & 50
Reference date	07.02.2003	27.02.2003	28.03.2003
Half-life (years)	2.62	10.72	28.8 years

(iv) Neutron

The collimated neutron calibrator model OB 26 manufactured by Buchler GmbH, Germany which consists of 185 GBq Americium-241/Beryllium neutron source is available to carry out calibration of neutron survey instruments and personal dosimeters. The neutron emission rate quoted by manufacturer was 1.1 x 10^7 n/s on July 20, 1984.

1.4.2.3 Dosimetric equipments

The SSDL-Nuklear Malaysia is equipped with secondary standard dosimeters and working standard dosimeters to provide exposure and air kerma standards used for calibrating radiation survey instruments while the air kerma and absorbed dose to water standards for calibrating therapy level dosimeters. The secondary standards for radiation protection are based on 1,000 cm^3 and 10,000 cm^3 spherical ionization chambers, LS-01 and LS-10 designed and manufactured by PTW, Germany and the Austrian Research Centre, Austria, respectively. The chambers are calibrated in terms of air kerma at ^{137}Cs, ^{60}Co and a number of x-ray beam qualities at the IAEA Dosimetry Laboratory and the Austrian Research Centre Seibersdorf. A 0.6 cm^3 ionization chamber NE 2571 has been selected as reference chamber for the calibration of therapy level dosimeters. The chamber had been calibrated in terms of absorbed dose to water at ^{60}Co and air kerma at ^{60}Co and x-ray beam qualities at the IAEA Dosimetry Laboratory. The ionization current from the ionization chambers is measured with a PTW-Unidos Universal Dosimeter and Digital Currentintegrator DCI 8500 with calibration traceable to the National Metrology Laboratory, SIRIM Berhad. The leakage current for the system ionization chamber plus electrometer is considered negligible. The stability of the chamber plus electrometer system is checked at regular intervals using a ^{90}Sr and ^{241}Am check source. Working standard dosimeters used for protection and therapy levels at SSDL are calibrated against secondary standard dosimeters. They are routinely used for the calibration of radiation protection survey instruments and therapy level dosimeters.

1.4.3 Calibration of Radiation Instruments

1.4.3.1 Radiological protection instruments.

Radiation protection survey instruments such as ionization chamber, Geiger-Muller counter, scintillation counter and solid state detector are calibrated in terms of exposure, air kerma, dose equivalent and ambient dose equivalent as well as directional dose equivalent. Reference photon radiation selected from ISO Standard 4037-1[9] are used for calibration of radiation survey instruments and for determination of their energy response. For the x and gamma radiation qualities, the conversion coefficients given in ISO Standard 4037-3 were used for conversion from air kerma to ambient dose equivalent, H*(10) or directional dose equivalent, H' (0.07). Reference conditions are temperature = 20.0 ^{0}C, pressure = 1013.25 mbar and relative humidity (RH) = 50 %. H*(10) and H'(0.07) are new operational quantities for area monitoring for external radiation sources introduced by ICRU Report 39 and intended mainly for the measurements of strongly penetrating and weakly penetrating radiation, respectively. Calibrations are performed either by the substitution method (comparing the response of the instrument to be calibrated with that of a reference standard instrument) or simultaneous method (both instrument to be calibrated and reference standard instrument are placed in the radiation beam at the same time and irradiated together). These methods are normally used when the radiation survey meters are calibrated at x-ray beams. Calibration is performed in a known radiation field when the survey meters are calibrated against gamma, beta and neutron beams. Standardization of ^{137}Cs, ^{60}Co, and ^{241}Am gamma sources (protection level) at various distances using reference standard dosimeters are performed once a year with accuracy better than ± 2%. Calibration with beta radiation is performed using beta secondary standard sources which the absorbed dose rates at particular distances of each sources i.e. ^{90}Sr/^{90}Y, ^{85}Kr and ^{147}Pm have been determined by the PTB, the national standard laboratory of Germany or by using PTW extrapolation ionization chamber. Portable survey instruments are calibrated at least at one point on each measuring range i.e. at approximately half of their full scale value or in each decade for an instrument with a logarithmic scale or with digital indication. The calibration factor or coefficient is defined as the ratio of the value of stated true exposure or dose equivalent rate at the position of the centre of the detector in the absence of the instrument to the instrument indication. The stated true exposure or dose equivalent rate was measured using reference standard dosimeters.

1.4.3.2 Therapy level dosimeters

Radiotherapy centres must possess an ionization chamber with a calibration factor or coefficient traceable to a secondary standard dosimetry laboratory. SSDL has provided air kerma calibration coefficient, N_K or exposure calibration coefficient, N_X and absorbed dose to water calibration coefficient, $N_{D,W}$ at a single high energy photon beam which is normally referred to ^{60}Co gamma rays.

The ionization chamber is calibrated in air with build-up cap. The reference point of the chamber is positioned on the central axis of the beam so that the chamber axis was perpendicular to the central axis of the beam. Source to the chamber distance(SCD) is 100 cm and the field size (FS) at SCD was 10 x 10 cm^2 in the ^{60}Co gamma beam or focus to the chamber distance (FCD) is 100 cm and the field size diameter (ϕ) is 10 cm in x-ray beam. The air kerma calibration factor N_k [mGy/nC] of the chamber was determined as the ratio of the air kerma standard, K_{air} obtained by the SSDL standard and the electrical charge Q (nC) produced in the chamber under calibration. The charge is measured by the electrometer which belongs to the users. The results of the calibration is normalized to the standard atmospheric conditions (i.e. T = 20 ^{O}C, P = 1013.25 mbar and R.H. = 50%). The calibration is performed by the substitution method using the SSDL reference standard chamber.

1.4.4 Accreditation of Laboratory

The laboratory is well known as the national focal point for the calibration of radiation measuring instruments used in radiation protection and radiotherapy. To maintain the radiation dosimetry standard in accordance with an international standard, a comprehensive quality assurance programme based on the ISO/IEC 17025 was adopted and implemented. In July 23rd 2004, the SSDL-Nuklear Malaysia has been accredited as a calibration laboratory for radiation survey meters and therapy dosimeters by the Department Standard of Malaysia (The Malaysian accreditation body) under the Laboratory Accreditation Scheme of Malaysia (SAMM). The scheme would provide solid foundation for the SSDL-Nuklear Malaysia to earn strong status in strengthening and maintaining public and customers confidence in the measurements of ionizing radiation.

Part 2. Status of Radiation Safety Management

2.1 Radiation Safety Measurement in Various Radioisotope Usages

2.1.1 Radiation Safety Management System

The management of radiation safety within various radiation industries is governed by the regulator according to the regulations, order, license conditions, code of practice, and guidelines, established under the Act 304 and regulatory directive published by the AELB from time to time.

These include all radiation management considerations for research, industrial and medical related facilities as follows:

- Radiation Protection (Licensing) Regulations 1986
- Radiation Protection (Transport) Regulations 1989;
- Atomic Energy Licensing (Basic Safety Radiation Protection) Regulations 2010;
- Atomic Energy Licensing (Radioactive Waste Management) Regulations 2011;
- Guideline on Radiological Monitoring for Oil and Gas Facilities Operators Associated with Technologically Enhanced Naturally Occurring Radioactive Materials (TENORM).
- Code of Practice on Radiation Protection of Industrial Radiography.
- Guideline on Preparation and Exercises of Nuclear and Radiological Emergency Plan
- Guideline to conduct leak test for sealed source
- Guideline on Preparation of Security Plan for Radioactive Source
- Guideline for HS Code: Strategic Item Under Strategic Trade Act 2010 (Act 708)
- Recognition and Duty of Radiation Protection Adviser (RPA)
- Duties and Responsibilities of Radioactive Materials Carrier.
- Guideline for Testing X-Ray Apparatus.
- Code of Practice on Radiation Protection of Non Medical Gamma & Electron Irradiation Facilities
- Code of Practice on Radiation Protection Relating to Technically Enhanced Naturally Occurring Radioactive Material (TENORM) in Oil and Gas Facilities
- Guideline on Radiological Monitoring for Oil and Gas Facilities Operators Associated with Technologically Enhanced Naturally Occurring Radioactive Materials (TENORM)'
- Guidance on Scheme Towards the Recognition of a Radioactive Laboratory by Atomic Energy Licensing Board.

- Guideline for Decommissioning of Facilities Contaminated with Radioactive Materials.
- Guideline on Preparation of Radiation Protection Programme

2.1.2 Radiological Protection for Radiation Workers

It has been recognised that exposure to a certain level can cause clinical damage to human tissues. It is therefore essential that activities involving radiation exposure shall be subjected to certain standards of safety in order to protect individual worker exposed to radiation. As such, all radiation industries and facilities are required to implement ALARA concept limits that will lead to detrimental effects arising from occupational radiation exposure. This concept can be achieved through:

- No practice within a practice should be authorised unless the practice produce sufficient benefit to the exposed individuals or society
- avoidance of exposure, where practicable;
- use shielding to isolate of sources of radiation, where practicable,
- keep the distance by remote handling techniques;
- Use appropriate personal protective equipment whether deal with sealed or unsealed sources.
- Use fume hood if deal with volatile material or liquid.

Under the Atomic Energy Licensing (Basic Safety Radiation Protection) Regulations 2010 radiation dose limitation for worker and public are as stated in Table 5.

Table 5: Radiation Dose Limits

	Annual Dose limit		
Application	**Occupational**	**Public**	**Apprentices and students**
Effective dose	20mSv	1mSv	6mSv
Lens of the eye	150mSv	15mSv	50mSv
Skin	500mSv	50mSv	150mSv
Hands and feet	500mSv	-	150mSv

2.1.3 Radiological Protection for Radiation Area

Radiation area programme should be established by the operator in the supervised area and controlled area. Monitoring of workplace areas is required to be performed by the operator under the supervision of radiation protection officer. The monitoring programme shall include—

- measurements of external radiation levels and contamination levels (where appropriate) at specified places, times and frequencies at all appropriate locations so as to evaluate the radiological conditions in all work places;
- exposure assessments in controlled areas and supervised areas;
- assessment of the levels of radiation risks associated with an accident or emergency situation;

2.1.4 Radiological Protection for the Public

The licensee whose radiation sources are under his responsibility shall ensure that exposure attribute to the general public is optimised and shall not exceed the dose limits as stated in Table 1. Therefore the licensee shall ensure that the public exposures are be controlled in accordance with the requirement of the regulations and guideline.

The licensee is also responsible for ensuring that the optimization process for measures to control discharge of radioactive substances to the environment comply with the requirement of the regulatory body taking into account exposure pathways, changes in the habitats or distribution of the population, modification of critical group or changes in environmental dispersion conditions.

For visitors to enter controlled area, they must be accompanied by a person knowledgeable about the protection and safety measures for that area. They must also be provided with adequate information and instruction before they enter a controlled area to ensure appropriate their protection

2.1.5 Radiation Emergency Preparedness

The licensee shall make suitable arrangements to prevent as far as possible, any accident that could reasonably be foreseen for any radiation source which is in his possession or under his control, and to limit the consequences of any accident that occurs. It is the obligation of the operator to establish radiological emergency inside their premises.

The National Security Council (NSC) which is under the Prime Minister's Department, is responsible for managing the whole operation of nuclear and radiological emergency, whether it is a national, state or district level, if the emergency is considered a disaster. The AELB is the lead technical agency while Nuclear Malaysia will provide the technical assistance during emergency, if necessary. In the event of a radiological emergency the following plans are in place:

- Radiological Emergency Response Plan (RAD Plan)
- Directive No 20 of National Security Council – The Policy and Mechanism on National Disaster and Relief Management
- Convention on Assistance in the Case of Nuclear Accident and Radiological Accident
- Convention on Early Notification of a Nuclear Accident.

2.2 Radiation Safety Management in Research Reactor

2.2.1 Introduction

Malaysian Nuclear Agency or Nuclear Malaysia, which was established in early 1970's, is an institution that develops, promotes and enhances the peaceful uses of nuclear technology in agriculture, medical, manufacturing, industry, health and the environment. In order to enhance research and development activities, a TRIGA MARK II research reactor, called Reaktor TRIGA PUSPATI (RTP), was built. It came into operation in 1982 and reached its first criticality on 28 June 1982.

The reactor was designed to effectively implement the various fields of basic nuclear science and education. It incorporates facilities for advanced neutron and gamma radiation studies as well as for application, including Neutron Activation Analysis (NAA), Delayed Neutron Activation Analysis (DNA), radioisotope production for medical, industrial and agricultural purposes, neutron radiography and Small Angel Neutron Scattering (SANS).

2.2.2 RTP Technical Specifications

RTP was supplied by General Atomic of the USA and installation programme was started on 9 November 1981. RTP is a pool type reactor where the reactor core sits at the bottom of 7 metre high aluminium tank which is surrounded by a biological shielding made of high density concrete (see Figure 2). The reactor uses solid fuel elements in which a zirconium-hydride moderator is homogeneously combined with enriched uranium. Demineralised water acts both as coolant and neutron moderator, while graphite acts as reflector. The following are brief descriptions of RTP:

Figure 2: Nuclear Malaysia's Reactor TRIGA PUSPATI

- Type: TRIGA Mk II, pool type
- Fuel: Uranium Zirconium Hydride Alloy
- Coolant: Light Water
- Moderator: Light Water
- Reflector:Graphite
- Control Rods: Boron Carbide
- Status: Operating
- Operational Mode: Steady State (1MW)
- Operation: 6hrs/day weekdays

2.2.3 Safety Objective

Since its establishment, the safety of RTP operation is a prime concern of the management and staff of Nuclear Malaysia. These safety considerations include during operation, repair and maintenance, radiation doses to workers, radioactive waste management and environmental management. The fundamental safety objective is to protect people, both individually and collectively (workers and public at large) and the environment from harmful effects of ionizing radiation. However, this should be achieved without unduly limiting the operation of facilities or the conduct of activities that give rise to radiations risks. In order to achieve the fundamental safety objective, Nuclear Malaysia has implemented the ten safety principles formulated by International Atomic Energy Agency (IAEA) on the basis of which safety requirements are developed and safety measures are to be implemented.

2.2.4 Organisation and Management of Safety

2.2.4.1 Nuclear Malaysia's Occupational Safety, Health and Environment Policy Statement

Nuclear Malaysia, an agency which is esponsible for the promotion, development and application of nuclear technology and nuclear related technology for the national development, is committed to continually improve and prevent pollution, incidents, accidents and occupational illness in its operation. This is the commitment of the management in ensuring safety at Nuclear Malaysia complex. Towards this end, Nuclear Malaysia will:

- Comply with all applicable environmental, occupational safety and health, legal and other requirements.
- Minimize release of pollutants to air, water, land and promote waste minimization through reduction, recycling and reusing activities.
- Optimize the use of materials and natural resources.
- Ensure that all radiation exposures are kept as low as reasonably achievable.
- Ensure that all other occupational hazards and risks are prevented, where practicable, and controlled and managed through the adoption of proper management measures.

- Stress on environmental, occupational health and safety aspects in our facilities operation, equipment, field work, building construction and modification through appropriate assessments at the planning stage.
- Promote environmental, occupational health and safety awareness among employees, contractors, vendors and visitors.
- Ensure that all employees, contractor, vendors and visitors on site comply with Nuclear Malaysia's environmental, occupational health and safety requirements at all times.

This safety policy statement is displayed at all notices boards within the Nuclear Malaysia premises to inculcate safety culture to all staff and contract workers, and to show that management is serious in managing safety.

2.2.4.2 Safety Management System

In ensuring the above safety policy implemented in daily work, Safety, Health and Environmental Management System (SHE-MS) Committee was established in year 2005 to review all aspects of safety, including occupational, nuclear and radiological safety. This committee is responsible to report all safety activities in Nuclear Malaysia to the highest management committee headed by the Director General. Safety Audit Team performs auditing functions and reports its finding to the SHE-MS committee on a regular basis.

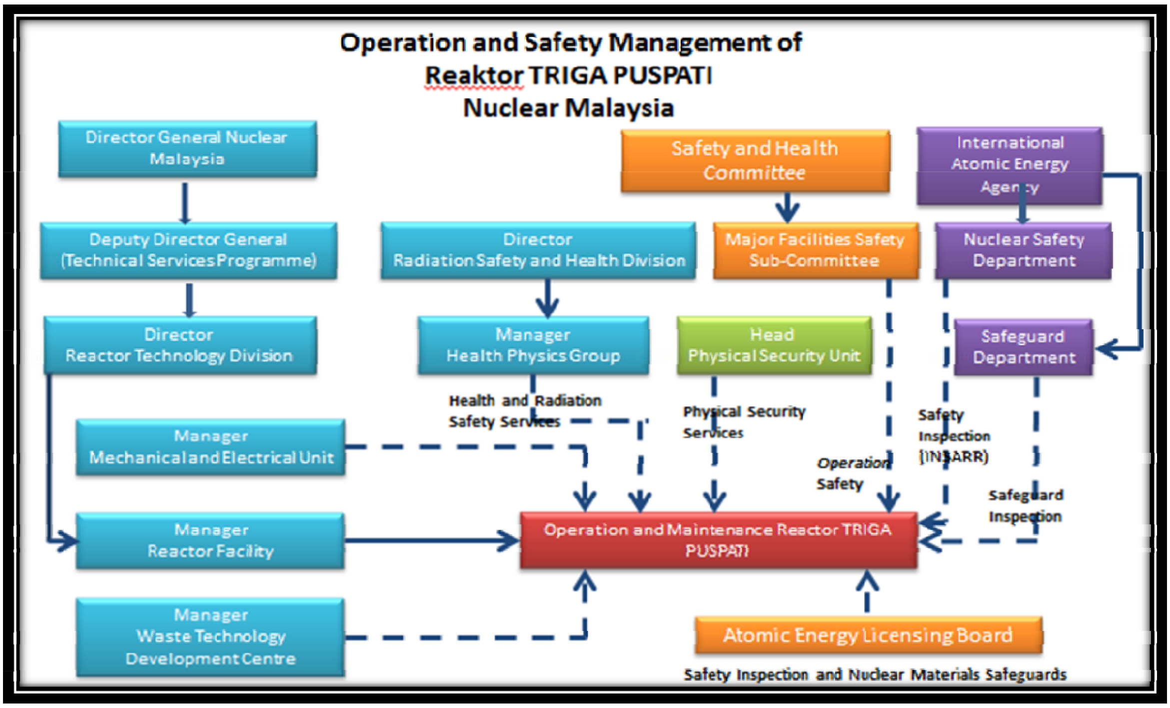


Figure 3: RTP Safety Management System

For RTP, the set-up of organization safety management is shown in Figure 3. The RTP is headed by a Reactor Manager who irectly reports to the Director of Nuclear Power. To maintain high level of safety, the operation and maintenance of RTP are supported by other groups such as Radiation Safety and Health Division, Waste Technology Development Centre, Mechanical and Electrical Unit and Physical Security Unit.

2.2.5 Safety Analysis Report

Safety analysis report (SAR) is an essential document when talking about safety in nuclear installations. Nuclear Malaysia's first SAR document for RTP was prepared in 1982. Since then, the document had not been revised until 2007 when the new SAR document was prepared in accordance with the IAEA safety standards and recommendations [3]. The SAR document has been submitted to the regulatory body for approval. In preparing this document, Nuclear Malaysia had engaged experts from abroad to help prepare the document due to lack capability and expertise to conduct analysis especially on risk analysis.

2.2.6 Quality Assurance Programme

Quality Assurance Programme (QAP) is very important in running nuclear reactor and it is not exceptional with RTP. QAP for RTP has been reviewed and approved by SHE-MS Committee in 2013 and will be submitted to the regulatory body this year for comment. Some of the contents of the QAP are Operational Control, Emergency Response and Preparedness, Safety and Health, Physical Security, Infrastructure Maintenance, Reactor Maintenance, Experiment and Modification, Measurement and Monitoring Device Control, Human Resource Management, Waste Management, Special Nuclear Material Counting Control and refueling.

2.2.7 Radiation Protection Programme

Radiation exposure is set-out in the safety manual approved by the SHE-MS Committee. It is based on the Atomic Energy Licensing (Basic Safety Radiation Protection) Regulations 2010 and IAEA safety documents. In the manual, radiation exposure is managed using radiation protection principles such as policy on As Low As Reasonable and Achievable (ALARA), annual dose limit, annual limit of intake (ALI), Derived Air Concentrations (DAC), classification of area, personal dosimetry etc.

All radiation workers are provided with TLD badges for personal monitoring which are assessed on monthly basis. Staff working with unsealed sources or using hand on most of their work wear wrist and finger TLDs as well. On the other hand, area monitoring using TLDs is performed at all control areas. Medical surveillance of radiation workers are also carried out at least once in three years.

Environmental samples such as water, sediments, soils, vegetables from areas surrounding Nuclear Malaysia complex are collected and analysed. External radiations from the nuclear installation are monitored using TLDs which are changed on a monthly basis.

2.2.8 Emergency Preparedness and Response

Emergency preparedness means being ready to react or respond to a broad range of emergency situations that can occur at anytime and anywhere. Widespread use of nuclear technologies in application as diverse as industry, medicine, agriculture etc. in Malaysia, means that more possibility of accident can happen. In recent year, most countries including Malaysia are very concern about emergencies arising from malicious use of radioactive material or 'dirty bomb'.

In Nuclear Malaysia, emergency preparedness and response are given very top priority by the top management. On-site Emergency Response Plan (ERP) is in place and has been recently revised. On the other hand the off-site emergency plan is under the jurisdiction of the regulatory body which is the lead technical agency to handle any radiological emergency at national level under the Directive No. 20, National Security Council. Emergency drill is performed at least twice a year.

2.2.9 Operation and Maintenance

Without a doubt, a good design, manufacture and construction of reactor are pre-requisites for high levels of safety. However, the ultimate responsibility for safe operation lies with the operating organization (Safety Principles 1). Therefore, Nuclear Malaysia is really emphasized on this issue. RTP reactor building, equipment and facilities are well maintained, generally clean and tidy and in good condition. The annual and semi-annual maintenance are carried out in June and December, respectively. Any change in operation and maintenance plan must be approved by the Reactor Supervisor. However, any unplanned maintenance works must be approved by the Reactor Manager upon recommendation of the Reactor Supervisor.

2.2.10 Reactor operation supervisors, radiation protection supervisors and trainees

As safety is a prime concern of Nuclear Malaysia, therefore education and training on nuclear and radiological safety to staff are very important. For new staff, they are required to attend an induction course while the existing staff are encouraged to attend a radiation safety awareness training course conducted by Nuclear Malaysia. Nuclear Malaysia also sends their staff to, either local institutions or a broad for updating their skills and knowledge.

For a reactor operator, a training programme which is based on the guidelines issued by the AELB is conducted by Nuclear Malaysia while the examination and issuance of operator license are managed by the AELB in accordance with a guidelines on Standards for Certification and Recertification of Research Reactor Operator (LEM/TEK/54). The reactor operator license can only be renewed after the licensed operators have successfully undergone a refresher course.

2.2.11 Regulations and Licensing

Principle 2 of the safety objectives is clearly stated that there shall be an independent regulatory body in each country to control and supervise all atomic energy activities. Therefore, to maintain independency, Nuclear Malaysia is licensed by the Atomic Energy Licensing Board (AELB), which is an independent body established under the Atomic Energy Licensing Board 1984 (Act 304). This is to ensure that the safety is kept in high standards and consistent with the IAEA's nuclear safety standards. The AELB regularly inspects RTP to ensure that all requirements under the law and regulations are being complied with.

Alongside inspections, yearly dialogue and direct meeting between the Nuclear Malaysia and AELB are made to exchange information and resolution on of issues raised. This meeting is alternately chaired by the Director General of AELB and Director General of Nuclear Malaysia. A part of that, the AELB is reviewing their regulations and guidelines related with nuclear safety in accordance with to the latest IAEA's safety standards and guidelines.

2.2.12 Peer Review

Peer review is necessary to achieve and maintain a high level of nuclear safety and safety culture. For this purpose, international peer review group on safety culture and nuclear safety are welcome. In 2005, the implementation of nuclear safety culture at RTP has been reviewed by Forum for Nuclear Cooperation in Asia (FNCA) review team. Recommendations from this team have been implemented.

2.3 Radiation Safety Management in Radioactive Waste Management

Nuclear Malaysia is committed to minimize release of pollutants to air, water, land and promote waste minimization through reduction, recycling and natural resources. All precautions are taken into account to minimise the generation of unnecessary activation radionuclides to minimise waste generation. This is evaluated when request for irradiation is received.

There is also a specific procedure for collection, control and treatment of radioactive waste activities as specified in the Nuclear Malaysia's safety, health and environment manual. The Waste Technology Development Centre (WasTeC), an organization within Nuclear Malaysia, is give responsibility to manage radioactive waste and chemical waste. WasTeC is recognized as a national centre for management of radioactive waste in Malaysia. In this centre, radioactive wastes are categorized and separated based on their types, solid or/and liquid according to the standard classification of radioactive waste established by the AELB in the Atomic Energy Licensing (Radioactive Waste Management) Regulations 2011. Radioactive waste in Malaysia is classified in accordance with the above regulation.

Table 1: Classification of radioactive waste according to the Atomic Energy Licensing (Radioactive Waste Management) Regulations 2011

Class	Decription
Cleared waste	Materials containing level of radionuclides at activity concentrations less than those specified in the Second Schedule
Low Level (Short Lived)/Decay Waste	Low level radioactive waste containing short lived radionuclides only (half lives less than 100 days) that will decay to clearance levels within three years after the times of its generation.
Low and Intermediate Level Short Lived Waste (LILW-SL)	Radioactive waste which will not decay to clearance levels within three years containing beta/gamma emitting radionuclides with half lives less than thirty years or alpha emitting radionuclides with an activity concentrations less than 400Bq/g and a total activity less than 4000Bq in each radioactive waste package.
Low and Intermediate Level Long Lived Waste (LILW-LL)	Radioactive waste containing radionuclides with activity concentrations more than LILW-SL but which does not generate heat at above 2kW/m^3
High Level Waste (HLW)	Radioactive waste containing radionuclides with activity concentrations more than LILW-SL but which generate heat at above 2kW/m^3

There are various facilities available for managing the various types of waste received by the WasTeC. Facilities that are available at WasTeC include:

- Low-Level Effluent Treatment Plant (LLETP) - The treatment of mainly low-level aqueous liquid waste is by chemical process (coagulation-flocculation). Compartments are also available for handling and storage of liquid organic waste on mild steel racks (Fig. 4).
- Laundry facility - two heavy-duty washing machines, one dryer, one unit press-ironing equipment
- Laboratory for analysis and research - related equipment for necessary effluent analysis and research work. Gross beta-gamma counter and gamma spectrometer
- Solid waste processing area - Solid wastes are collected, segregated, decay storage is applied where possible and further treatment done accordingly - including cementation and

compaction. A segregation cabinet is available for waste segregation.

- Decontamination area
- Conditioning area - conditioning of waste including spent sealed sources in cement matrix is done using a batch cement mixer. Currently, only 200-liter steel drums are used in the conditioning process.
- Waste Compactor - an in-drum compactor for volume reduction of solid waste in 200-liter drum was acquired in the first quarter of 2000.
- Transport - a vehicle for transporting waste
- Waste Storage Facility - a pretreatment storage facility and an interim long-term storage facility are available at the center. The construction of the long-term storage facility was completed in August 2000. The facility was designed to accommodate 2,400 drums of 200-liter waste package after treatment and immobilization. Stacking of the drums is limited to three drums high - and further expansion of storage area is possible

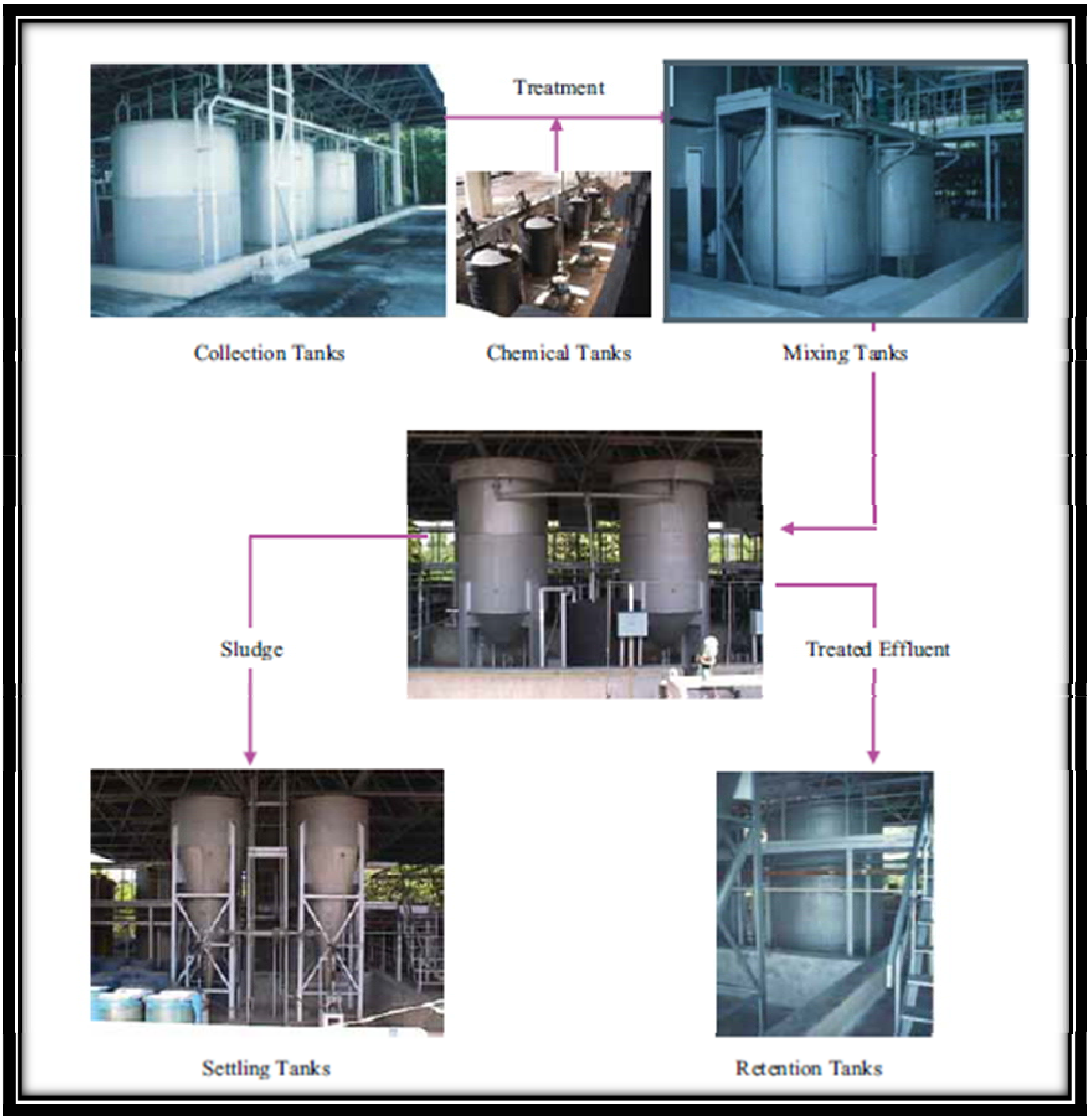


Figure 4: Low level effluent treatment plant

Currently Nuclear Malaysia has no spent fuel at all. However, the RTP was designed in such a way that it can be used as a storage facility for spent fuels before these spent fuels are sent back to the supplier.

Figure 5: In-drum Compactor

2.4 Radiation Safety Management in Transport of Radioactive Material

The regulation of the transport of radioactive material in Malaysia has, for many years, been based on international requirements published by the International Atomic Energy Agency (IAEA). The regulatory framework of Malaysia currently applies the Radiation Protection (Transport) Regulations 1989, which adopts the IAEA's *Regulations for the Safe Transport of Radioactive Material*. The transport regulations apply to any activities involving transportation of radioactive materials in Malaysia whether they transport by air, water-ways or inland (road and railways). The regulation is also applied on any activities at economic exclusive zone. The Atomic Energy Licensing Board (AELB) is the regulatory body who has the jurisdiction to enforce the transport regulation.

In 1996, 2003, 2005 and 2012, the IAEA published revisions of their regulations for the safe transport of radioactive material and recommended that adoption of these revised regulations in member states to achieve worldwide harmonization of their application. However, in Malaysia, since gazetted in 1989, the transport regulation has never been amended even though the IAEA's regulation for the safe transport of radioactive material has been amended. Nevertheless, the AELB has made initiative to amend the regulation and the new amended regulation is waiting to be gazetted.

8. Mongolia

8. Mongolia

Part 1. Radiation Safety in Radioisotope Facilities

1.1 General

Mongolia is a landlocked country in Northern Asia between Russia and China with a population of 2.9 million and an area of 1.5641 million square kilometers. It is one of the least densely populated countries in the world.

Mongolia became a Member State of the IAEA in 1973 and is a member of FAO, ILO and WHO.

Figure 1: Map of Mongolia

1.1.1 Legal and Regulatory Infrastructure

1.1.1.1 Mongolia's nuclear weapon - free status

Mongolia declared itself a nuclear-weapon-free zone in 1992. This self-declared status has been recognized internationally through the adoption of UN General Assembly resolution 55/33S on "Mongolia's international security and nuclear weapon free status. A law was also enacted in Mongolia to institutionalize this nuclear-weapon-free status.

1.1.1.2 International legal framework

Mongolia has been an IAEA Member State since 1973 and is a party of the following IAEA Multilateral Agreements:

- Agreement on the Privileges and Immunities of the IAEA
- Convention on the Physical Protection of Nuclear Material
- Convention on Early Notification of a Nuclear Accident
- Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency
- Revised Supplementary Agreement Concerning the Provision of Technical Assistance by the IAEA (RSA)
- Third Agreement to Extend the 1987 Regional Co-operative Agreement for Research, Development and Training Related to Nuclear Science and Technology (RCA)
- Application of safeguards in connection with the Treaty on Non-Proliferation of Nuclear Weapons (with Protocol)
- Protocol Additional to the Agreement between Mongolia and the International Atomic Energy Agency for the Application of Safeguards in Connection with the Treaty on the Non-Proliferation of Nuclear Weapons

Mongolia is currently considering joining the Convention on Nuclear Safety and Joint Convention on the Safety of Spent Fuel Management and the Safety of Radioactive Waste Management. Some of the necessary arrangements have been made.

1.1.1.3 Nuclear Fuel Cycle Aspects

Currently, Mongolia has no power reactors or research reactors. In the next few years it is possible that current uranium exploration and development in Mongolia will progress to operational mining. This might include the re-establishment of open-cut and underground mining, and the development of new in-situ recovery (ISR) acid leach mines.

The Nuclear Energy Agency (NEA) is responsible for all aspects of uranium mining including exploration, mine/mill construction and operation, radiation protection, environmental protection, transport, decommissioning and remediation. Mongolia has not yet develop the regulation for uranium mining and processing.

1.1.1.4 Legislative Framework

The Parliament of Mongolia has passed the Nuclear Energy Law, which entered into force in August, 2009. The law on Radiation Protection and Safety was repealed on 15 August 2009. The Nuclear Energy Law now regulates both nuclear and radiation safety issues. The powers and activities of the Nuclear Energy Agency and its regulatory functions is described in the Nuclear Energy Law. The relevant guides and regulations within this legislative framework are:

- Radiation Safety Standard (1983)
- Basic Regulation on Radiation Sanitation (1983)
- Transport Regulation for Radioactive Sources (1987)

  Draft of updated regulations for IAEA BSS conformity has been prepared.
- Mongolian National Standard. MNS 6240-2011. Technical Requirements for the Packaging of Radioactive material /Updated by the IAEA Regulation (1996)
- Radiation Safety Regulation on Diagnostic Radiology (2011)
- Safety Regulation for the Use of Density/Moisture Gauges in Road and Dam Construction (2011)
- The dose limits in the Radiation Safety Standard (1983) have been superseded by the Mongolian National Standard MNS 5631:2006 and MNS 5630:2006.

NEA has also developed the NORM Regulations for Oil-Gas Industry, and is now awaiting Government approval. Safety regulations for Uranium Exploration and Processing are in development stage. Security regulation for radiation sources was drafted in 2013.

1.1.1.5 Regulatory body and its functions

Mongolia has participated in activities of IAEA Inter-Regional Model Project INT/9/143 since June 1996. Under this project Mongolia has made good progress in the establishment of an independent regulatory body and in the obtaining of Parliament approval of the first law on Radiation Protection and Safety.

The Nuclear Regulatory Authority (NRA) was established as the Regulatory Body in Mongolia by Governmental Resolution No 180 on 13 August 1997 under the Nuclear Energy Commission (NEC) of the Government of Mongolia. It has since been restructured under the State Specialized Inspection Agency (SSIA) during 2003-2005 to be an independent regulatory body separated from promotional activities. However the status of NRA within the SSIA was not very effective nor competent.

In January 2009, the Nuclear Energy Agency (NEA) was established under the competence of the Prime Minister to serve as the government regulatory agency by the Government Resolution No.64 (24 Dec 2008) “Establishing Regulatory and Implementing Agency of the Government”. In this Government decision, the regulatory body NRA was separated from SSIA and incorporated into NEA as the Nuclear and Radiation Regulatory Authority (NRRA) .

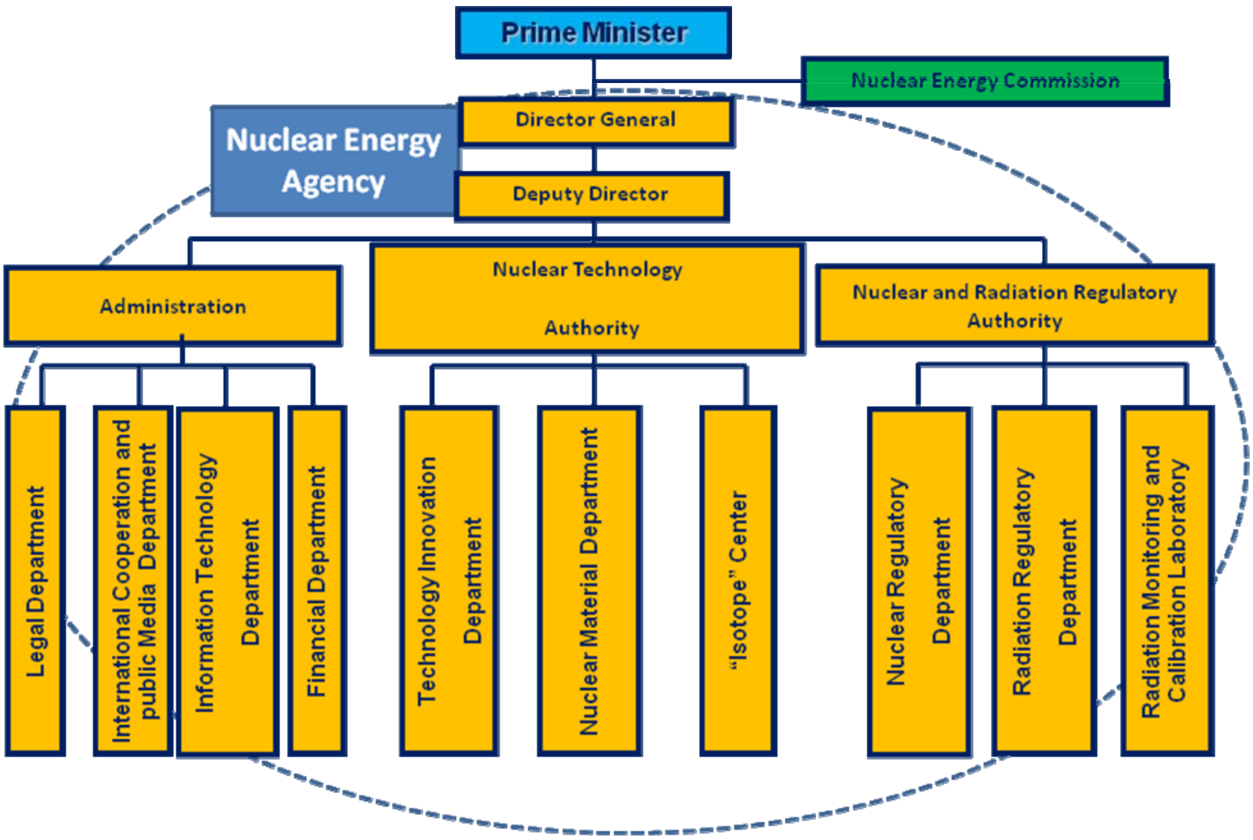
Parliament Decision No.45 of 2009 adopted State Policy of Mongolia on the Exploitation of Radioactive Minerals and Nuclear Energy.

The Governmental Regulatory Agency - Nuclear Energy Agency (NEA) under the Prime Minister is responsible for development of policy for the activities related to the development of nuclear research and technology, radiation protection and nuclear safety, use of radiation sources and coordination of uranium mining activity with other relevant organizations.

NEA has the following departments:

- Administration
- Nuclear Technology Authority
- Nuclear and Radiation Regulatory Authority (NRRA).

Figure 2: Organizational Structure of Nuclear Energy Agency(NEA)



NRRA operates as the regulatory body responsible for the implementation of regulatory functions of the NEA as described in the Nuclear Energy Law.

- **Authorization**

Authorization system complies with international standards and the NRRA has implemented an authorization program that covers all practices and applies a risk based approach to authorization which commensurates with the potential magnitude and nature of the hazard presented by the practices, including separate requirements for registration and licensing.

- **Inspection**

The NRRA has established a planned and systematic inspection program. The inspection frequency depends on the risks and results of previous inspection findings. It includes planned, announced and unplanned, unannounced and follow-up inspections carried out in accordance with established procedure.

- **Enforcement**

The authority for enforcement is specified in the Nuclear Energy Law and the Law of Mongolia on State Inspection. The Nuclear Energy Law has a provision on the responsibility to be assumed by violator of any nuclear energy legislation.

The enforcement policy has been established in the NEA procedure. This policy provides for a range of sanctions commensurate with the seriousness of the non-compliance. The NEA has also established formal arrangements with relevant government agencies where enforcement requires the involvement of the police, ministry of justice or other authorities.

The Nuclear Energy Law and the Law on Inspection empower inspectors to take on-the-spot enforcement actions.

1.1.1.6. Inventory of Radiation Sources

The NRRA of NEA registers all identified sources, irrespective of whether they fall under the exemption category. It has a complete inventory of all radiation sources and it has a centralized database for all identified facilities and sources in the country. Regulatory information including source and facility data stored in Regulatory Authority Information System (RAIS) software and the hard copy versions in parallel. Small calibration sources were also registered. The inventory is updated with information from inspection findings as well as from annual inventory reports from the users.

Radiation sources are used in the following fields:

- Medicine (radiotherapy, nuclear medicine and diagnostic radiology)
- Industry and mining
- Geology
- Science and Education
- Agriculture

Table 1: Radiation Facilities and Radiation Sources

Facilities	No. of organizations/No. of units
Research Reactor	0
Isotopes Production	0
Synchrotron	0
Research Gamma Irradiator	1 unit /27 sources
Industrial Gamma Irradiator	0
Gamma Tele-therapy	1hospital/2 units
X-ray devices- Diagnosis and Therapy in medicine	157 hospitals/332 units
X-ray devices – Industry	1
Linear accelerator (LINAC)	0
Medical Brachytherapy	1
Level/density thickness or conveyor gauge	7 company/191 units
Density/moisture gauge	10 company/21units
Industrial Radiography	4/7
Education and Research Laboratories	20 organizations/149 sources
PET cyclotron	0
Electron beam (education)	1
Electron beam (Irradiator)	0
Neutron Generator	1
Radioactive Waste Storage Facility (Long term storage)	1 center
Well logging	23 company/82 units
Veterinary X ray device	2
X ray scanners for customs and security control	34/88 units
X ray analysers	21

1.1.2 Emergency planning and response

Nuclear and radiation emergency responses in Mongolia are coordinated by the National Emergency Management Agency (NEMA) where NEA plays a role within a multi-agency response. The first responders from NEMA received training abroad in radiation emergency planning, preparedness and response. A general law requires users of radiation sources to notify NEA and NEMA in the event of an emergency and an accident.

1.1.3 Control of orphan source

An inquiry into what effort, if any, was made to determine if there were abandoned sources in Mongolia. Source abandonment may be due to industrial economic disruptions, transition from centralized to market economy or government changes of the 1990's. By working closely with potential users of radiation sources (survey through a system of notification), about 20 orphan sources are identified and secured during 1995-2008 with cooperation from authorized users and other relevant Agencies. Mongolia's law and regulations stipulates that all orphan or abandoned radiation sources must be secured and stored at the Isotope office without any charge.

Requirements on reporting loss of control and to encourage awareness of, and monitoring to detect, orphan sources has been described in the Nuclear Energy Law.

1.1.4 Strengthening of export import control

Mongolia covers a vast territory and shares a long border with its two neighbors. For a country with this geography and a small population, border management is becoming a serious challenge at a time of increased concerns over trans-national crimes, including trafficking of nuclear-related items. Mongolia's efforts to respond to the threat of nuclear smuggling have been beset by a shortage of trained personnel and necessary equipment.

Mongolia has decided to focus on developing effective border controls to detect cross-border smuggling of nuclear-related items in light of the adoption of United Nations Security Council Resolution 1540.

Under the Memo of Understanding, the US Department of Energy is providing Mongolia technical assistance in the form of equipment, materials and training for use at border ports for the purpose of detecting and interdicting illicit trafficking of special nuclear material and other radioactive material. The deployment is being carried out under its Second Line of Defense Program. A total of 83 radiation portal monitors for gamma/neutron detection have been installed at 15 main border ports for passenger, vehicle and rail monitoring as of 2013.

Figure 3: Gamma/neutron detection at the border ports for passenger, vehicle and rail monitoring

1.1.5 Occupational exposure control (Monitoring for radiation workers)

NEA provides:

- Occupational exposure control (external exposure only)
- About 1235 radiation workers from 161 organizations are under the regular personal dosimetry control as of 2013 (95%)

Figure 4: Occupational Exposure Control Radiation Workers in Different Practice

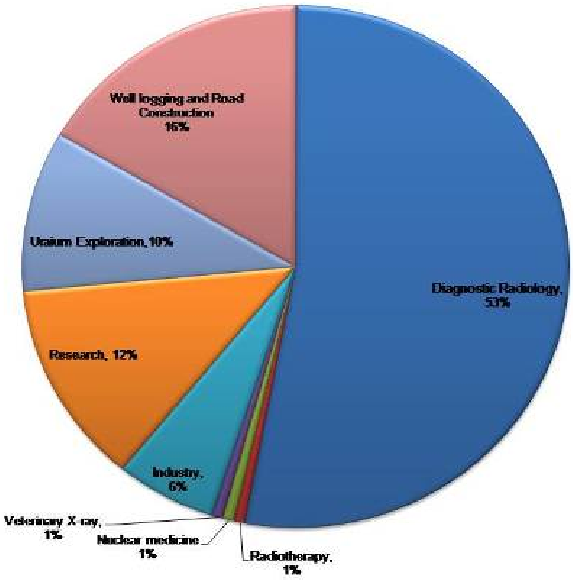
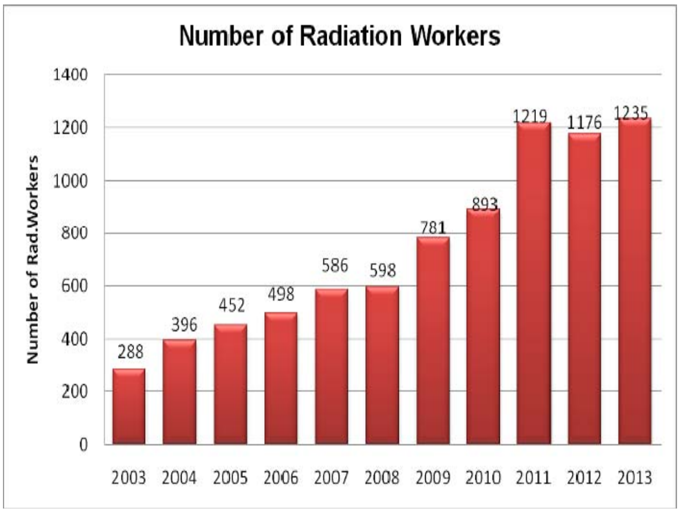


Figure 5: Number of Radiation Workers



Weaknesses:

- Internal dosimetry is not yet established
- Personal monitoring for radon and neutron are not yet available

1.1.6 Public exposure control

1.1.6.1 Environmental Monitoring

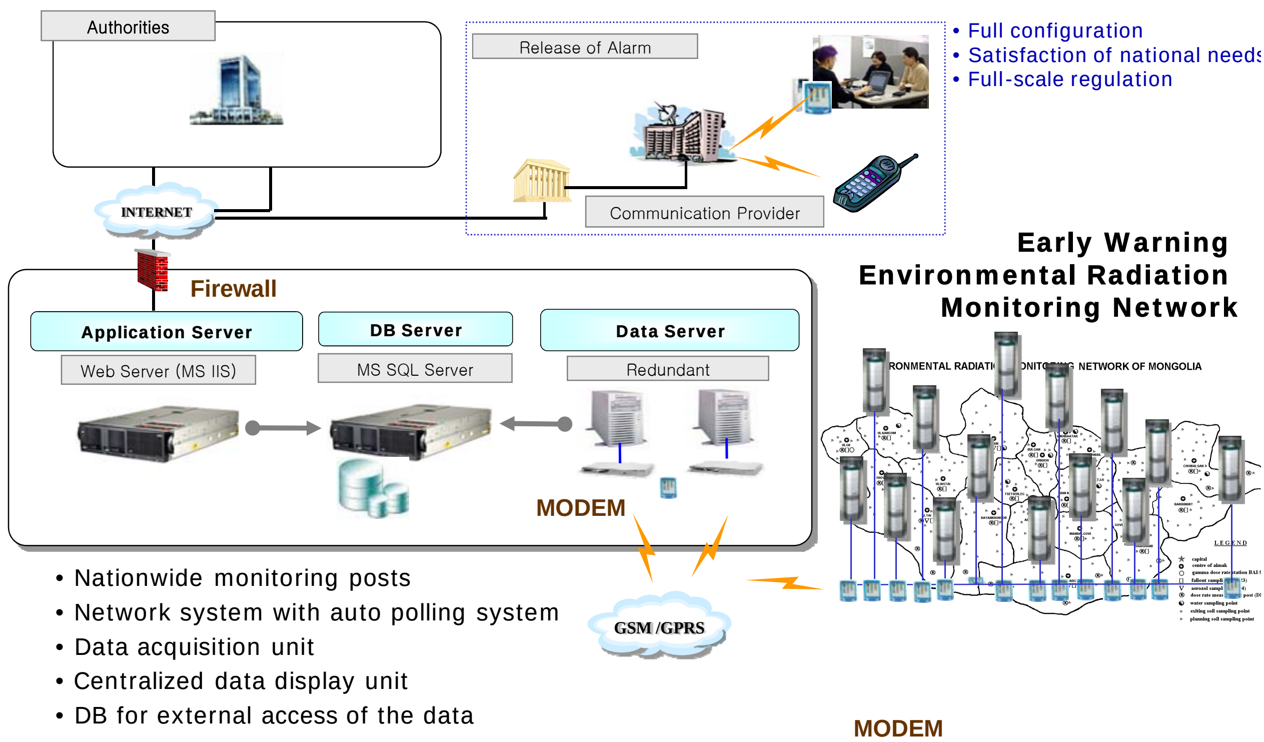
Environmental monitoring is carried out by the Radiation Laboratory of the NRRA of NEA using the environmental monitoring network of the Ministry of Environment. There is need to strengthen the environmental monitoring network to ensure emergency preparedness.

Air fallout samples for gross beta measurement are collected in 23 local stations. Aerosol gross beta activity measurement are carried out on filter samples of typically 100-130 m^3 of air daily in Ulaanbaatar city. In addition, at 35 meteorological stations, ambient gamma dose rates are measured twice a day with portable dose rate meters and transmitted to the meteorological centre in Ulaanbaatar three times a month. NEA submitted a Project Proposal for the Establishment of an Online Environmental Radiation Monitoring Network in 2011 to the Government for approval.

Due to the large scale nuclear weapons testing programs in 1970 near Mongolia's borders, the environmental monitoring program in these regions was focused on the analysis of air, water and soil samples. There is an urgent need for more enhanced measurements for alpha and beta contamination.

It is very important to develop an online environmental monitoring network for Mongolia given its geographical location between two nuclear countries and also for emergency response planning purposes. NEA has prepared a project proposal to establish an effective and internationally compatible national capabilities in preparedness, timely response to potential damages against global fallout, occupational hazard in the mining industry and effective protection of environment, homeland and social securities. This proposal was submitted to the Government for approval in 2012.

Figure 6: System Configuration for Full-scale Regulation



1.1.6.2 Control of Foodstuffs

A national system (logistics and/or technical capabilities) for monitoring the levels of radioactivity in foodstuffs and selected commodities before they go for trading exists and controls appear to have been established by the Regulatory Body.

The food samples are initially screened with a food contamination monitor (Berthold LB200) measuring gross gamma activity. Food samples showing unreasonably high gross gamma activity are measured again with a high-resolution HPGe gamma spectrometer. Between 1000-2000 samples of domestic and imported foodstuffs are monitored for radionuclide contamination by the Radiation Laboratory of NRRA of NEA annually. In addition, Ulaanbaatar city tap water is monitored daily, and water samples from 8 other regions are regularly monitored.

1.1.6.3 Control of Chronic Exposures

Mining is one of main economy sector in Mongolia. There are 65 coal mines/deposits, 22 mines of other mineral resources and 144 building material factories under the regular sampling program by the regulatory body.

Regulatory control of NORM in workplaces other than uranium projects is not in place due to shortage of manpower, resources and analytical capabilities. NORM in these workplaces is not regulated by any legislation.

Potential chronic exposure scenarios have been identified in the country but they are not sufficiently characterized. NORM generating industries in the country have not been fully identified.

There is an urgent need for continuing indoor radon measurements due to the extensive use of coal ash as a building material. Radiation Laboratory provides limited service for determination of radon content in water, soil, home and workplaces.

1.1.6.4 Control of Radioactivity in Materials For Recycling

In 2007, Mongolia had one iron manufacturing factory in Darkhan city which also process scrap metals. Portal monitors were used to detect the presence of significant amounts of radioactive substances in materials going for recycling.

As the scrap metal dealers do not have their own radioactivity monitoring equipment, China has requested NRRA to provide Radiation Certificate for all scrap metals exported to China by rail. NRA fulfils this condition by measuring the scrap metal with monitors when it is being loaded onto the railcars.

Radiation Portal Monitors installed at main Port of Entries (PoE), including the entry/exit points for rail and road have proven to be very useful in the detection of any orphan sources in materials for recycling and screening for radioactivity in materials at each PoE.

1.2 National Waste Management Policy and Strategy

Mongolia's national radioactive waste management strategy described under the Exploitation of Radioactive Minerals and Nuclear Energy has been approved in the Parliament Decision No.45 (2009). A Waste Management Program for Mongolia has been drafted but not yet approved by the Government. Draft regulations for waste management and safety are currently being developed.

1.2.1 Source of radioactive waste

Mongolia uses the IAEA classification system for radioactive wastes. Radioactive waste exists in solid and liquid forms. Liquid wastes, which generated from nuclear medicine hospitals, have very short half-life. When the activity of liquid waste falls below the IAEA clearance level, it is discharged into the sewerage system. Most radioactive wastes are in the form of solid sealed sources.

The sources of radioactive wastes are:

i) Research facilities
ii) Medicine, Industrial and Military
iii) Decommissioning of contaminated installations
iv) Mining and Milling

At present, the generation of unsealed radioactive waste material is not considered to be a problem, but the situation could change with the development of new phosphate, oil, gas and uranium industries.

1.2.2 Long-term storage facility for spent or disused sources

The Isotope Centre of the NEA has a national long term waste storage facility located about 20 km from Ulaanbaatar in Mongolia. NEA has taken considerable measures in upgrading the physical protection features of the Isotope Centre since 2008**.** This facility has a camera surveillance system and is under security guard for 24 hours a day.

Mongolia has no disposal facilities for these sources. NEA has a long-term plan to convert this storage facility into a disposal facility. Due to the small quantity of radioactive waste in Mongolia, waste processing is not carried out on a regular basis. There is also no procedure in place for the characterization and segregation of radioactive waste. Several Co-60 sources of disused irradiator are stored in the Institute of Physics and Technology of the Academy of Sciences. Radionuclides use in nuclear medicine and radio-immunoassay (I-131, Tc-99m and I-125) are decayed in storage.

1.2.3. NORM residue management

NORM workplaces are not identified and there is strong need to establish a regulatory criteria for the uranium industry as well as other NORM residues-generating activities in Mongolia.

There are no special regulations for waste management in the uranium industry and NORM workplaces, however appropriate international standards are applied for safety assessment and enforcement.

1.2.4 Clearance Regime for Radioactive Waste

Limits and conditions for the removal of regulatory control over materials containing radionuclides exist and are in agreement with international recommendations.

Liquid waste, generated from nuclear medicine hospitals, has a very short half-life. When the activity of liquid waste falls below the IAEA clearance level, it is discharged into the sewerage system.

1.2.5 Disposal of Radioactive Waste

Currently, there is no waste management policy and strategy with respect to disposal in Mongolia. Plans are underway to create a disposal facility within the Isotope Centre of the NEA. The Isotope Centre had a small burial area where contaminated material from a previous Sr-90 incident was buried in 1993. This is covered in a brief report submitted to the IAEA.

1.2.6 Decommissioning of Nuclear and other Facilities Containing Radioactive Materials

As there is no national waste management policy and strategy, the funding mechanisms for decommissioning need to be addressed.

There are no plans for the shutdown and decommissioning of any nuclear and other facilities. However the research irradiator from the Institute of Physics and Technology is in need of decommissioning.

Recently, the Nuclear Research Centre of the National University of Mongolia requested assistance for the decommissioning of a neutron generator. The neutron generator, which has been out of service for 15 years, was made in the former USSR and was used for research and training.

1.2.7 Remediation

Mongolia needs to carry out uranium ore remediation near the former Mardai Uranium Mine which is located in the Dornod province,,situated on the eastern part of Mongolia. The

Radiation Laboratory of the NRRA performs environmental monitoring measurements in order to assess the potential risk from the tailings pile at the former uranium mines.

IAEA TC Project on Environmental Impact Assessment and Remediation of the Uranium Mining Legacy MON/9/005 has been implemented by the Ministry of Environment and the NEA since 2005 and was completed in 2010. IAEA experts had visited this legacy site under the project.

1.2.8. Education and training

Education and training on radiation protection in Mongolia includes:

- Internal education and training
- International workshops and meetings on nuclear and radiation safety
- Programs for multilateral cooperation
  - IAEA long- and short-term training courses
  - International long- and short-term training courses

The Nuclear Research Centre of the National University of Mongolia provides Bachelor and Master degree education on nuclear physics and nuclear technology. University of Science and Technology contributes in education of engineering on non-destructive testing (NDT) and mining practices. Currently, there is no specific education system on radiation protection or health physics in Mongolia. Regulatory staff training has been provided by IAEA as well as via other bilateral cooperation programs.

Radiation protection training for radiation users poses some difficulties in Mongolia due to the lack of service providers. The Regulatory Body has provided limited training to radiation users over the last several years. Since 2013, some non-governmental organisations such as the Mongolian Radiation Protection Society (MRPS) has been established, providing radiation safety and protection training to the users,

1.2.9. Calibration of Monitoring Equipment for External Radiation

Dosimetry Calibration Laboratory was established in 1998 and is responsible for the calibration of gamma radiation protection monitoring instruments. This is the only laboratory in the country operating as the national laboratory for radiation standards and calibration of radiation monitoring instruments. Secondary standard dose meter and chambers have been calibrated against the IAEA standards which are traceable to primary standards. The Laboratory was accredited in December 2010 by the Mongolian Agency for Standardization and Metrology.

❑ **Equipment and facilities for calibration**

Dosimetry Calibration Laboratory has facilities to calibrate radiation instruments and devices for photon energies between 662keV and 1250keV.

❑ **QA/QC program and Performance of Equipment**

Reference instruments with chambers have been calibrated against the IAEA standards at the IAEA dosimetry laboratory in October 2010. Regular performance tests and stability checks for instruments with chambers are done to ensure the accuracy and reliability of these reference instruments. Percentage of deviation of the stability check source for the therapy chamber is maintained within +/-0.5 and protection level of +/-1. All electrometer and chambers are kept in a dry cabinet when not in use. Decay correction is applied to all the data at calibration.

1.3 Future goals and priorities

- Strengthening of regulatory infrastructure and regulatory control of radioactive materials;
- Revision of legislations and developing regulations for different practices;
- Implementation of an effective system for detecting and preventing illicit trafficking of nuclear and radioactive material;
- Strengthening of radiological emergency response and planning at national level;
- Upgrading of Environmental Monitoring capabilities and Radiation Protection Technical services
- Establishment of internal dosimetry control and nationwide radon survey
- Strengthening of radioactive waste storage facility and establishment of disposal facility
- Upgrade the emergency preparedness and response capability in the country
- Establishment of education and training system on radiation protection

9. The Philippines

9. The Philippines

Part 1. Radiation Safety in Radioisotope Facilities

1.1 General

The Philippine Nuclear Research Institute (PNRI) was formed from the previous agency, the Philippine Atomic Energy Commission (PAEC) when the then Philippine President re-organized the Department of Science and Technology (DOST) in early 1987. In this reorganization, the PAEC was transferred from National Science and Technology Authority (NSTA) to DOST and was re-organized to become the PNRI. PNRI retains both the promotional mandate and regulatory powers and authorities of PAEC.

Cognizant of the need to update existing laws governing the peaceful use of atomic energy in the country, a new law has been drafted and is currently undergoing the legislative mill process. The proposed Act aims to rationalize and strengthen the regulatory powers of the Philippines over Nuclear Energy Facilities and the Peaceful Applications of Ionizing Radiation Sources thru the creation of the Philippine Nuclear and Radiation Safety Commission. The law will basically address the need to have an independent regulatory body for all nuclear matters in the country. This will ensure that the Philippine national legislative and regulatory framework is consistent with the nation's obligations under relevant international instruments and that it provides an adequate basis for further development of nuclear technology for peaceful purposes.

1.1.1 Legislative Framework and Policy for Radiation Safety

The Philippines legislative framework on radiation safety includes a hierarchy of laws, executive orders and regulations under the National Constitution. The Science Act of 1958 (Republic Act of 2067) created the PAEC, the predecessor of the now PNRI, was mandated to promote the peaceful uses of atomic energy and promulgate rules and regulations to ensure the safe use and application of radioactive materials in the different fields of application. Ten years later, RA 5207 was enacted to provide for the licensing and regulation of atomic energy facilities and materials.

In parallel, Presidential Decree (PD) 480 (1974), as amended by PD 1372, Executive Order (EO) 119 and EO 102 established the Department of Health (DOH) as the Regulatory Authority for the regulation of X-ray units and other electronically generated radiation devices, including non-ionizing radiation.

1.1.2 Structure and System (Regulatory Organization)

The regulatory framework considers nuclear facilities and radioactive materials separately from radiation emitting devices, with separate jurisdictions for each. The PNRI through its Nuclear Regulatory Division (NRD) regulates the former, while the DOH through its Food and Drugs Administration's (FDA) Center for Device Regulation, Radiation Health and Research regulates the latter (CDRRHR).

The PNRI has the roles of promoting nuclear science and technology, providing services, and regulating the peaceful application of nuclear and radioactive materials. PNRI's own nuclear and radiation activities, however are exempt from licensing as stated under the current laws. To address this specific issue, PNRI has established an internal regulatory control program which essentially delegated to the NRD of PNRI the authority and responsibility of regulatory control over PNRI radiation facilities and research laboratories. An Office Order signed by the PNRI Director in 2004 clearly stated, among other things, that all PNRI radiation facilities and laboratories must be authorized by the NRD at the end of 2006. A system of authorization is now in place for all of these facilities.

The DOH is responsible for the administration and funding of about seventy two (72) DOH hospitals. The CDRRHR provides radiation protection services in addition to regulating ionizing and non-ionizing radiation devices and technology.

1.2 Outline of Radiation Facilities and Radiation sources

1.2.1 Number of Specialists and Workers in Related Organizations

The number of specialists working in the two regulatory organizations accounts to less than 500. The Philippines has two (2) Secondary Standard Dosimetry Laboratories (SSDLs) which are being operated by the PNRI and the CDRRHR, respectively. Both SSDLs are under a National SSDL Organization, a member of the IAEA-WHO SSDL Network, The PNRI operates and maintains a SSDL for national standard radiation dosimetry. It continues to provide a national monitoring service for external exposure to radiation to about 10,000 workers occupationally exposed to ionization radiation using film badges, OSL and TLD. Internal monitoring is not routinely conducted but in cases of probable exposure, monitoring can be done by whole body counting or bioassay technique.

1.2.2 Number of Radiation Facilities including Related Facilities

The PNRI owns and operates few radiation facilities as follows:

- A 3 MW TRIGA converted research reactor (PRR-1), which became critical in 1963. The PRR-1 became the principal facility for many research and manpower activities in the field of radioisotope production, neutron spectrometry, neutron activation analysis, and reactor physics. By the early 1970's routine production of some 30 radioisotopes and labeled compounds was undertaken. The PRR-1 was converted into a TRIGA Facility designed for 3 MW operation in 1984 and was expected to be operational in 1989. However, the PRR-1 has been shut down since 1988 immediately after a successful critical testing when the reactor pool lining developed a leak. Eventually, the PNRI Management decided to decommission PRR-1 and have accepted to host the IAEA Research Reactor Decommissioning Demonstration Project (R^2D^2P).
- Multipurpose Irradiation Facility (MIF) and the Gammacell-220 irradiator. The PNRI provides gamma irradiation services to clients from industry, the academe and research institutions. The MIF was upgraded in 2011 that includes addition of 150,000 curies of Co-60 source from MDS Nordion of Canada.
- Technetium-99m Medical Radioisotope Facility. The PNRI Tc-99m facility was installed by the Isotope Technologies, Dresden, Germany. The facility consists mainly of 2 hot cells intended for the loading of the generators and dispensing of the Mo-99 solution to the alumina column Tc-99m generators.

Authorized practices and uses of ionizing radiation in the Philippines include the following.

- Medical uses include: a gamma knife facility; a medical cyclotron/PET facility; two (2) PET/CT facility, twenty six (26) LINACs, seven (7) Cobalt-60 teletherapy units, twenty

(20) HDR brachytherapy facilities, two (2) blood irradiators and forty-one (41) nuclear medicine facilities with SPECT capabilities; and around five thousand six hundred forty (5,640) registered diagnostic X-ray units.

- Industrial uses include: a high energy electron beam machine and a Co-60 irradiator which was upgraded with support from the IAEA TC project and from the US Department of Agriculture; two hundred twenty one (221) industrial x-ray facilities and ninety four (94) anti-crime X-ray facilities; one hundred thirty one (131) industrial radiographic exposure devices; and about seven hundred (700) sources used in industrial gauging applications.

1.2.3 Activity and Number of Radiation Sources and Generators

Table 1 gives the typical uses of radioisotopes in the Philippines while table 2 displays the category of PNRI licensees based on types of use or application. The PNRI adopted through an Administrative Order the IAEA recommendation on categorization of radioactive sources and has classified the sources in its national registry according to this categorization system. Special attention was given to Category 1 and 2 sources as a first priority in terms of risk based inspection program for purposes of determining compliance with regulatory requirements.

To automate and enhance the licensing, inspection and enforcement processes, PNRI has adopted the Regulatory Authority Information System (RAIS) developed by the IAEA. PNRI installed and implemented RAIS 3.1 Web in 2010 and is presently in the process of migrating to the new version RAIS 3.2 Web. Through the Management Information System Section, in coordination with the Nuclear Regulatory Division, PNRI is currently configuring the new system and working on the migration of existing data. Rollout and routine use of the new system is expected by the end of 2013. The implementation of RAIS is expected to help PNRI achieve a more efficient national regulatory control program in the country.

Table 1: Typical Uses of Radioisotopes in the Philippines

USES	RADIOISOTOPES
Hospitals	I-131, I-125,Co-60, Ba-133, Sr-90, Cs-137, I-131, Tl-201, Ga-67, Tc-99m, I-129, Ra-226, C-14
Industrial Radiography	Ir-192, Se-75, Co-60
Research and Education	Co-60, Cs-137, Sr-90, Ra-226, Th-232, Co-60, Cs-137, Cs-137/Ba-133m
Industry (Fixed and portable gauges)	Sr-90, Kr-85, Po-210, Am-241, Cs-137, Am-241, Co-60, Cf-252, Am-241:Be, Cd-109

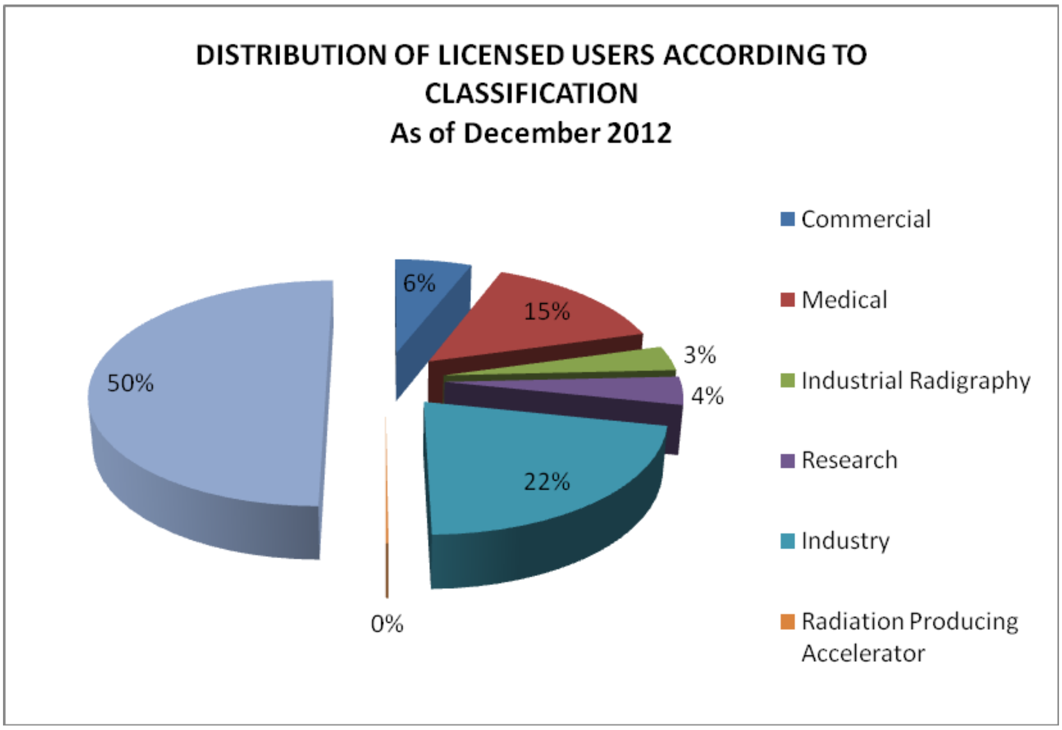


Figure 1: Category of PNRI licensees based on types of use or application

Disused radioactive sources are generated from the medical and industrial application of radioactive materials. While the licensees have the option to return disused sources to the manufacturers, a considerable number of these disused sources are monitored and stored at PNRI interim radioactive waste facility. Table 2 and 3 presents these inventory by source category and radionuclide content, respectively.

Table 2: Inventory of Disused Sources by Source Category in the Philippines

Source Category	No. Of Units
1	3
2	25
3	12
4	232
5	909

Table 3: Inventory of Disused Sources by Radionuclide content in the Philippines

Radio-nuclides	Units	Radio-nuclides	Units
Am-241	78	Kr-85	33
Cd-109	8	Ni-63	10
Cf-252	8	Pm-147	22
Co-57	20	Po-210	10
Co-60	149	Pu-238	11
Cs-137	208	Ra-226	121
Fe-55	23	Sr-90	377
Ge-68	12	Tl-204	8
H-3	15	others	7
Ir-192	61		

1.2.3 Future Plans and Issues to be Resolved

Radiation control and safety is continuously being updated and introduced by PNRI through, among others, its training program for all prospective users of radioactive materials in the country. The modules include topics on radiation protection standards, dosimetry, personnel monitoring, radiation control practices, emergency planning, and radioactive waste management, among others. Theoretical work is usually followed by experiments and case studies.

Standards and regulations are also continuously being updated to consider not only safety but also security of radioactive sources and facilities. Several initiatives like for instance, the implementation of a Nuclear Safety Caravan was undertaken to promote the open exchange of safety and security information among the various stakeholders involved in the peaceful application of the atom. Effective communication and exchange of information are important tools to achieve a sustainable high level of safety and security awareness for nuclear and radiation facilities and related nuclear infrastructure in the country. The PNRI strives for the public's proper understanding of nuclear technology and the establishment of safety culture. This is normally achieved by providing opportunities for information exchange and addressing the public's concerns as well as by using the collected efforts of all those involved to resolve any public issue concerning nuclear science and technology.

1.3 Education and Training

1.3.1 Radioisotope usage

The PNRI provides different technical services to other government agencies, private companies, medical institutions, the academe, and the general public. One of these services is the provision of training courses in nuclear science and technology, and nondestructive testing techniques in cooperation with the Philippine Society for Nondestructive Testing.

The training program of the PNRI on nuclear science and technology aims to familiarize participants with fundamentals of nuclear science and technology, the basic principles of radiation protection, and the peaceful applications of nuclear technologies in agriculture, in medicine, in industry, in research and the environment. Some of these courses have been accredited by the Commission on Higher Education (CHED) with masteral units.

These training courses are offered every year to different groups such as medical practitioners, science educators, researchers, engineers, and technicians. The courses consist of lectures, experiments, film showings, demonstrations, workshops and case studies. Examinations are given to assess the participants' understanding of the subject matter being taught. Certificates of satisfactory completion are issued to participants who have demonstrated satisfactory knowledge of the subject matter presented and the ability to apply it.

Laboratories and facilities of the different research units in PNRI are made available to the trainees. For certain training courses, PNRI makes arrangements with other private companies, government agencies, universities, and hospitals for PNRI training participants to use their facilities. The PNRI also provides its trainees with manuals containing lectures and laboratory experiments written by Filipino scientists.

Participants in any course must be endorsed by the head of office if they belong to a government agency or a private company. Those participating on their own have to submit a written request to join the course.

Nomination forms and/or application forms should be submitted together with the following:

- Transcript of academic records
- Medical certification by nominee's Medical Officer as to his/her physical fitness to undergo training.

❑ **Workshops /Seminars**

Local workshops and seminars include specialized subjects such as the safe transport of radioactive materials and emergency planning and preparedness

❑ **Thesis Advisorship Program**

This is open to any deserving and qualified graduate or undergraduate university/college student who may wish to undertake the laboratory research portion of his/her thesis at the PNRI, making use of PNRI facilities, equipment and instruments.

❑ **Apprenticeship/On the Job Training**

The PNRI formally accepts on-the-job training and apprenticeship for college/university students and workers from other agencies who would like to learn nuclear techniques.

1.3.2 Radiological Protection

Education and training in radiation safety and radiological protection is provided mainly by the PNRI. As mentioned above, the PNRI training basically aims to familiarize participants with the fundamentals of nuclear science and technology, the basic principles of radiation protection, and the applications of nuclear technologies in all peaceful applications. Private societies like the Philippines Association for Radiation Protection (PARP), the Radioisotope of the Philippines (RSP) and the Philippine Organization for Medical Physicist (POMP) also provide specialized courses in radiation protection and technology as part of their programs and activities.

1.3.3 Standardization on Radiation and Radioactivity

The PNRI provides dosimetry laboratory services for the calibration and standardization of radiation measurements in the country through its Secondary Standards Dosimetry Laboratory (SSDL). The SSDL was established in 1974 and is a member of the International Atomic Energy Agency-World Health Organization (IAEA-WHO) network of SSDLs. Metrological controls and certification of measuring equipment for ionizing radiation are conducted at the PNRI's SSDL to ensure compliance of radiation protection and dosimetry practices with international measurement standards. Beneficiaries of the SSDL services are the different radiation facilities of PNRI and PNRI-licensees in private and government institutions using radiation and radioactive materials in medicine, industry, agriculture, research, and training.

The Radiation Protection Services of PNRI maintains the SSDL with its equipment and source standards for the provision of services for the calibration of radiation monitoring instruments and dosimeters (i.e. survey meters, pen dosimeter, contamination meter, personal monitors; output calibration of brachytherapy, teletherapy and activity meters in hospitals; and radiation monitoring and hazards evaluation of radiation facilities).

Efforts to strengthen the capability for providing dosimetry and calibration services are being exerted to have a wider range and more practice-specific technical service. This will ensure the accuracy and control of occupational and medical radiation exposures in the country. Some of the areas that are to be pursued and improved include: beam quality measurements and characterization of the X-ray generator; establishment of protection level radiation dosimetry standards using X-ray, Co-60 and Cs-137 radiation qualities; calibration for dose and energy response of personnel and area monitoring instruments for gamma ray and X-ray standards in the low, medium and high energy range; standardization and calibration of quality assurance measurement tools for medical, X-ray, radiotherapy and nuclear medicine applications; and development of neutron and beta dosimetry protocols.

Part 2. Status of Radiation Safety Management

2.1 Radiation Safety Management System

As mentioned in Part I of this report, the PNRI and the CDRRHR are the main agencies responsible for the management of radiation safety in the Philippines. The PNRI manages the safe utilization of radioactive and nuclear materials while the CDRRHR takes charge of all electrically generating radiation devices including non-ionizing radiation matters.

Table 4 presents the various regulations currently issued by the PNRI. These regulations are practiced specific and covers all applications in the fields of medicine, industries, research and education. The Institute continues to develop practice-specific Code of PNRI Regulations (CPRs) which are reviewed and revised periodically through a system of consultations involving a number of stakeholders. The CPRs are referenced and updated against the recommendations of the International Atomic Energy Agency (IAEA), the International Commission on Radiation Protection (ICRP) and the various Code of Federal Regulations (CFR) of the United States Nuclear Regulatory Commission (USNRC), especially those referring to the licensing of the nuclear power plant.

Table 4: Code of PNRI Regulations

CPR Part 0	PNRI as Regulatory Authority For Radioactive Materials in the Philippines
CPR Part 2	Licensing of Radioactive Materials
CPR Part 3	Standards for Protection Against Radiation
CPR Part 4	Rules and Regulations on the Safe Transport of Radioactive Materials in the Philippines
CPR Part 5	Reactor Site Criteria
CPR Part 6	Rule of Procedure for the Licensing of Atomic Energy Facilities
CPR Part 7	Licensing of Atomic Energy Facilities (under its original title- “Regulations for the Licensing of Atomic Energy Facilities”)
CPR Part 8	Atomic Energy Facility Operator’s Licenses
CPR Part 9	Physical Protection of Nuclear Power Plants and Materials
CPR Part 10	Financial Security and Government Indemnity
CPR Part 11	Licenses for Industrial Radiography and Radiation Safety Requirements for Radiographic Operations
CPR Part 12	Licenses for Medical Use of Sealed Radioactive Sources in Teletherapy
CPR Part 13	Licenses for Medical Use of Radiopharmaceuticals
CPR Part 14	Licenses for Medical Use of Sealed Radioactive Sources in Brachytherapy
CPR Part 15	Licenses for Large Irradiators
CPR Part 16	Licenses for the Use of Sealed Sources Contained in Industrial Devices
CPR Part 17	Licenses for Commercial Sale and Distribution of Radioactive Materials
CPR Part 18	Licenses for Use of Radioactive Materials in Research and Education
CPR Part 19	Licenses for Use of Radioactive Materials In-Vitro Clinical and Laboratory
CPR Part 20	Licenses to Manufacture and Dispense Radiopharmaceuticals
CPR Part 21	Licensing and Safety Requirements of Particle Accelerator Facilities for the Production of Radioisotopes
CPR Part 22	Fees and Charges for Radioactive Material Licenses and Other Related Regulatory Services, Rev.1
CPR Part 23	Licensing Requirements for Land Disposal of Radioactive Waste
CPR Part 25	Licenses for Commercial Providers of Nuclear Technical Services
CPR Part 26	Security of Radioactive Sources
CPR Part 27	Security Requirements in the Transport of Radioactive Material

Currently, a number of these CPRs are being reviewed to ensure consistency with the current IAEA International Basic Safety Standards (IBSS) and the Code of Conduct for the Safety and Security of Radioactive Sources including the additional guidance for the export and import of radioactive sources. Appropriate security requirements in addition to safety requirements are included for purposes of granting authorization for the various usages of radioactive. Priority is given to practices using Category 1, 2 and 3 sources. Categorization of sources is practically based on the IAEA recommendation "Categorization of Radiation Sources" which was published in 2000 and revised in 2003. In the interim period, these security requirements are imposed as additional specific conditions of licenses subject to inspection and audit for compliance monitoring.

Regulatory guidance documents, information notices and regulatory bulletins are issued to promote a common understanding of the regulations and to facilitate regulatory inspections and audits for compliance monitoring purposes.

2.2 Radiological Protection for Radiation Workers

PNRI regulations clearly define exposure limits involving sources of ionizing radiation to both radiation workers and members of the public. These limits strictly adhere to the IBSS recommendations. The regulations also prescribe the appropriate corrective measures to be implemented to control the release of radioactive materials into the environment and mitigate its effects.

The licensees are also required to comply with the administrative and technical requirements which include functions, responsibilities, and qualification and training of the authorized personnel.

The PNRI ensures that the following dose limits will not be exceeded by an occupational worker.

a) An effective dose of 20 mSv per year averaged over five consecutive years;
b) An effective dose of 50 mSv in any single year; and
c) An equivalent dose to the extremities (hands and feet) or the skin of 500 mSv in a year.

2.3 Radiological Protection for Radiation Area

As part of the regulatory requirements of PNRI, all licensed stakeholders are required to perform monitoring of their workplace from radioactive contamination. The PNRI conducts regulatory inspections and verifies that the work areas are free from contamination.

The licensees can also request technical services from the PNRI to ensure safety in their facilities. Among the services provided by the Institute are the following:

a) Leak testing of sealed radiation sources;
b) Radiation hazards evaluation of radiation facilities; and
c) Collection, treatment, and management of disused radioactive sources, solid, and liquid radioactive wastes.

These services, provided by the Radiation Protection Section of the PNRI entail corresponding fees. The schedule of fees for the different services of PNRI has been published and codified as CPR Part 22 for ease of reference of the stakeholders.

2.4 Radiological Protection for the Public

Public and environmental safety is implicitly stated as a matter of government policy for all projects or undertakings. This is emphasized in the specific provisions in the Codes of PNRI Regulations which the Institute follows in its licensing process. Dose limits to the public follows the recommendations stated in the IBSS. Each licensee shall ensure that the estimated average dose to any member of the public does not exceed the following dose limits:

a) An effective dose of 1 mSv in a year;
b) In special circumstances, an effective dose of up to 5 mSv in a single year provided that the average dose over five consecutive years does not exceed 1 mSv per year;
c) An equivalent dose to the lens of the eye of 15 mSv in a year; and
d) Equivalent dose to the skin of 50 mSv in a year.

The PNRI's Health Physics Section has been actively involved in the management of an international monitoring system to verify compliance to the Comprehensive Nuclear Test Ban Treaty which was ratified by the Philippine Senate in 2001. The radionuclide monitoring station (RN52) which is co-located with one of our meteorological station within Metro Manila is now part of the 321 global network of the International Monitoring System (IMS) that collect data on evidence of nuclear tests.

Several nuclear research projects that seek to protect environmental and public safety are also being implemented by PNRI. These projects include the following.

- Access to Clean Drinking Water
- Control of Harmful Algal Bloom
- Air Pollution Characterization
- Radiological Impact of TENORM
- Environmental Radioactivity Surveillance

In addition, the PNRI also provides services, upon requests, on the certification of radioactivity content of foodstuffs for export and monitoring and clearance of scrap metals for export.

2.5 Radiation Emergency Preparedness

Emergency Planning and Preparedness is part of the licensing process. All licensees including PNRI authorized facilities are required to prepare and submit a facility emergency response plan for approval of the PNRI NRD. The level of preparedness is commensurate to the level of hazards expected in the facility.

2.5.1 The National Radiological Emergency Preparedness and Response Plan

The PNRI in collaboration with 16 government agencies developed and maintains the National Radiological Emergency Response Plan (RADPLAN) which covers any peacetime radiological emergency that has or is expected to have a significant radiological effect within the Philippines, and its territorial waters and which requires a response by several government organizations. There are five major types of radiological emergencies that are covered by this RADPLAN. These are:

a) Emergencies from fixed nuclear or radiation facilities

An emergency of this type is one that occurs at a facility with licensed or regulated radioactive sources in their installations. Included in this category are the following:

- Nuclear Facilities owned and operated by the PNRI;
- Nuclear Reactors;
- Industrial or Medical Facilities licensed to use, possess, or import radioactive

materials or equipment containing radioactive materials; and
- All other facilities or establishments using or possessing radioactive materials.

b) Emergencies Occurring in the Transport of Radioactive Materials

An emergency of this type is one that involves radioactive materials or wastes being transported by land, sea, or air inside Philippine territories. This includes the hazards from lost, missing or stolen radiation sources

c) Emergencies from foreign sources having environmental impact on Philippine territories

This type of emergency is one in which radiation from a foreign source poses an actual, potential, or perceived threat to any area within the territorial limits of the Philippines. The source may be an accident from a foreign nuclear power reactor (for example, Chernobyl, Fukushima Daiichi), radioactive waste repositories, fuel reprocessing plants, or from the testing of nuclear weapons. This includes the possible entry of contaminated food, plants and other commodities from affected areas outside the country.

d) Emergencies from Satellites with Nuclear Materials as component

This is a special type of emergency in which a spacecraft with nuclear materials would land within the territory of the Philippines.

f) Emergencies from Nuclear Ships.

This type of emergency is one that involves radioactive material or wastes from nuclear powered sea craft including nuclear submarines.

The level of the government response to a specific emergency will depend on the type and the amount of radioactive material involved the location of the emergency, the potential for impact on the public and the size of the affected area.

The RADPLAN is now undergoing review and revision to integrate security of radioactive sources and lessons learned from the Fukushima Daiichi nuclear reactor accidents.

2.6 Radiation Safety Management in Research Reactors

2.6.1 Radiation Safety Management System

The PNRI have decided to decommission the only research reactor in the country. This reactor called the Philippine Research Reactor (PRR-1) is one of the research reactors considered as a test case under the IAEA Research Reactor Decommissioning Demonstration Project (R^2D^2P). In 1999, all the 50 spent fuel elements were shipped back to the USA under a US program to recover all spent enriched uranium fuel of US origin. The only irradiated fuel elements that remained were those from the TRIGA core.

There are about 115 slightly irradiated TRIGA fuel rods, plus 15 fresh TRIGA and 2 MTR type fuel rods remaining at PNRI. The slightly irradiated fuel rods are stored in a wet stainless steel storage tank with a diameter of 12 ft. and a height of 16 ft. The fresh fuels are stored in the dry gamma room. These fuels are all currently stored inside the research reactor building. After the proposed decommissioning of the PRR-1, a storage facility that meets the radiological, safety and security requirements for special nuclear material is planned to be built near the PNRI interim storage facilities for conditioned wastes. All the fuel rods will be kept in storage until a more definite plan is made for its use.

The regulatory process for the decommissioning of PRR-1 and related activities is defined by the PNRI Internal Regulatory Control Program, which is the internal authorization process set up in 2004 through PNRI Office Order 002 series of 2004. The Regulatory Safety and Security Board was instituted to coordinate the request for authorization on the operator side and serve as the link between the NRD and the radiation facility operators. Nuclear safety and radiological protection are a primordial pursuit, much as adherence to international standards and criteria in the area of decommissioning and compliance with local regulatory requirements, such as those embodied by the relevant CPRs.

With respect to local regulations, the decommissioning effort is committed to comply with the following: CPR Part 2, on Licensing of Radioactive Material; CPR Part 3, on Standards for Protection Against Radiation; CPR Part 4, on Regulations for the Safe Transport of Radioactive Materials in the Philippines; and CPR Part 26, on Security of Radioactive Sources. The administrative limits applied to PRR-1, which are at levels lower than the regulatory limit on radiation exposure of workers, will also be adhered to.

In addition, the decommissioning of the PRR-1 will also comply with appropriate IAEA safety standards. The project receives technical assistance from the IAEA, and the IAEA requires such compliance as a condition for assistance. This requirement has been published in IAEA Information Circular 127, *The Revised Guiding Principles and General Operating Rules to Govern the Provision of Technical Assistance by the Agency*, March 1979.

The IAEA Safety Requirements that will notably be applied (among others) to PRR-1 Decommissioning are:

- Safety Series No. 115, International Basic Safety Standards for Protection against Ionizing Radiation and for the Safety of Radiation Sources. February 1996. STI/PUB/996.
- Safety Standards Series No. WS-R-2, Predisposal Management of Radioactive Waste, Including Decommissioning. July 2000. STI/PUB/1089.
- Safety Standards Series No. WS-R-5, Decommissioning of Facilities Using Radioactive Material. October 2006. STI/PUB/1274.

The following IAEA Safety Guides, Safety Reports, and Technical Reports are also notably being used (among many others) to guide compliance with the IAEA Safety Requirements:

- Safety Standards Series No. RS-G-1.7, Application of the Concepts of Exclusion, Exemption and Clearance. August 2004. STI/PUB/1202.
- Safety Standards Series No. WS-G-2.1, Decommissioning of Nuclear Power Plants and Research Reactors. October 1999. STI/PUB/1079.
- Safety Standards Series No. WS-G-5.1, Release of Sites from Regulatory Control on Termination of Practices. November 2006. STI/PUB/1244.
- Safety Standards Series No. WS-G-6.1, Storage of Radioactive Waste. November 2006. STI/PUB/1254.
- Safety Reports Series No. 45, Standard Format and Content for Safety Related Decommissioning Documents. July 2005. STI/PUB/1214.
- Safety Reports Series No. 50, Decommissioning Strategies for Facilities Using Radioactive Material. March 2007. STI/PUB/1281.

- Technical Reports Series No. 389, Radiological Characterization of Shut Down Nuclear Reactors for Decommissioning Purposes. October 1998. STI/DOC/010/389.

2.7 Radiation Safety in Radioactive Waste Management

2.7.1 Radiation Safety Management System

Radioactive wastes in the Philippines are generated from the various applications of radioactive materials in medicine, industries, and research. All licensed facilities are expected to manage the waste generated from their application in accordance with the radioactive waste management provisions in practice specific CPRs. For short lived radioactive wastes,

The Philippines has only one (1) operating centralized facility for radioactive waste treatment, conditioning and interim storage for all radioactive waste generated throughout the country. This facility is owned and operated by the PNRI inside its compound in Quezon City. The facility has a total land area of about 4,000 m^2 and a floor area of about 600 m^2. The facility includes the following: wet laboratory for R&D activities, shielded cell and decontamination rooms, compressive strength testing area for concrete specimens, decay storage room, chemical precipitation area, cementation area for conditioning process and compaction area for compactible wastes. The storage room for decay has a volume of about 100 m^3. Two above ground roofed trenches with a maximum capacity of 315 m^3 and 220 m^3, respectively serve as the interim storage for conditioned radioactive waste prior to final disposal. The interim storage has an opening on one end with access from the Radioactive Waste Management Facility (RWMF) building. The facility has a truck entrance leading to the basement level of the building. This serves as the only entrance for large and heavy waste packages for management and also serve as the emergency exit for personnel in case of any untoward incident. An additional roofed trench is underway to accommodate incoming wastes particularly those generated from the PRR-1 decommissioning project. These conditioned sources are now safely stored at the PNRI interim storage facilities awaiting final disposal. The PNRI continues to pursue the upgrading of its centralized facility for low to intermediate level radioactive waste treatment facility with assistance from the United States Department of Energy (USDOE) relative to the improvement of the physical protection and security aspects.

The PNRI adopts two (2) basic waste treatment and conditioning options for radioactive waste. These are (a) waste collection and packaging for decay storage for final disposal as ordinary refuse; (b) waste collection, segregation, treatment, conditioning and packaging, followed by interim storage awaiting final disposal in a repository. The last option includes compaction, as appropriate and chemical precipitation, ion exchange of aqueous wastes. Depending on chemical composition and physical properties, wastes are appropriately treated and immobilized in cement prior to interim storage. Conditioned wastes are then coded in accordance with a system established for the purpose.

Authorization to operate, treat, and condition radioactive waste has been granted for the waste store facility by the NRD of PNRI pursuant to PNRI Policy Instruction No. 02 Series of 2001, “Radiological Health and Safety Policy” and PNRI Office Order No. 002 Series of 2004 “Regulatory Control Program for PNRI Nuclear and Radiation Facilities and Laboratories”. Regular inspections are also carried out to verify regulatory compliance.

Two important regulations govern the safe management practices of radioactive waste in the

Philippines. These are:

1) The Code of PNRI Regulations (CPR) PART 3 entitled *Standards for Protection Against Radiation* provides for the general requirements involving waste management and disposal of licensed radioactive material include (a) storage under controlled conditions, (b) control and monitoring of environmental discharges, (c) regulatory limit for airborne and waterborne discharges adopting the IAEA Clearance Levels for waste resulting from medical, industrial and research application of radioactive materials and the IAEA Safety Guide No. RS-G-1.7 entitled “Application of the Concepts of Exclusion, Exemption and Clearance” for solid waste materials. In the case of disused sources, the licensee has the following options in the management of disused sealed sources: (a) return to the principal, original manufacturer or supplier, (b) transfer of source to another licensee for application or use at the current activity level, (c) decay storage of short half life disused sources. These options should be thoroughly considered prior to disposal at the PNRI Centralized Radwaste Treatment and Storage Facility.
2) The CPR Part 23 *entitled Licensing Requirements for Land Disposal of Radioactive Waste* contains technical and procedural provisions applicable to all phases of the lifecycle of a LLW Facility. This includes specific technical requirements involving siting, design, operations and closure, monitoring, waste classification, and institutional requirements. The requirements were basically based on international best practices and accepted guidelines such as those recommended by the IAEA.

2.7.2 Criteria to define Waste Category

The present regulations do not specifically define the criteria for waste category. However, guidance from the IAEA is being used whenever practical to ensure safety and regulation.

2.7.3 Managing sources at the end of their life cycles

All authorized users of radioactive sources have the following options in the management of disused sealed sources: (a) transfer of source to another licensee for application or use at the current activity level, (b) decay storage of short half life disused sources, (c) return to the original manufacturer or supplier. These options should be thoroughly considered prior to final management at the PNRI Centralized Radwaste Treatment and Storage Facility.

In March 2013, the IAEA through a contract with NECSA and funded under the Nuclear Security Program managed to transport and assemble its mobile hot cell unit inside the PNRI compound to condition Specific High Activity Radioactive Sources (SHARS) currently in storage. Over a six-week period, NECSA successfully conditioned 13 units of teletherapy sources and 3 irradiator sources. The conditioned sources are now safely stored in two (2) long term storage containers awaiting final disposal. All other disused sources returned to PNRI for management are conditioned in 200 liter concrete lined drums and placed at the interim storage.

The PNRI in collaboration with the interagency technical committee on radioactive waste has been undertaking a national project to find a final and sustainable solution to the country’s low to short lived intermediate level radioactive waste. The strategy adopted was to co-locate 2 disposal concepts that will address the types of radioactive waste generated from the use of radioactive materials. Given the small volumes of waste expected as compared to a country with an advance nuclear program, the strategy adopted is deemed commensurate and feasible for the country to pursue. It will also take advantage of the benefits of a shared infrastructure and R&D works that accompany such project.

A preferred site located in the northern part of the country was selected and is currently the subject of detailed investigation. The footprint of the site has about 40 hectares for potential development. The geology of the site is characterized by andesitic pyroclastic

All activities take into consideration not only the requirements set out in the appropriate PNRI regulations mentioned above but also international best practices practicable in the selection, design and operation of the envisioned co-located radioactive waste repositories.

10. Thailand

10. Thailand

Part 1. Radiation Safety in Radioisotope Facilities

1.1 General

Thailand set up the first nuclear institution "Office of Atomic Energy for Peace" (OAEP) in 1961, following the enactment of the Atomic Energy for Peace Act (B.E.2504). Then, the Thai research reactor went to criticality in October 1962. Thus the first step was taken in research and development of nuclear technology and towards a better standard of living. Since 1961, the OAEP has had the roles of promoting nuclear technology, providing services, as well as regulating.

Recently, the R&D tasks on nuclear applications and related nuclear service activities has been separated from the OAEP. The nuclear application and R&D activities are carried out by the Thailand Institute of Nuclear Technology (TINT), as an implementer of nuclear research activities and nuclear technology services. In addition, the OAEP was renamed to be the"Office of Atoms for Peace "(OAP), plays as the regulatory body arm to control the use of radiation and nuclear applications in Thailand by the authorization from the Thai Atomic Energy Commission (Thai AEC).

At present, there are about 20,000 licenses including X-ray and radioactive source possessions and utilizations in the country. These licensees are a heterogeneous mixture of individual and governmental institutions which possess the radionuclide of activity ranging from a few kBq up to some more than GBq. The type of nuclear facilities, radiation generation facilities and radionuclide utilizing facilities are vary on the development of the atomic energy techniques and applications. At present, Thailand has no nuclear power plant (NPP), but the feasibility study on NPPand some NPP preparation activities was conducted by the Ministry of Energy and the Electricity Generation Authority of Thailand (EGAT).

1.1.1 Legislation and regulations

The main laws and regulations regarding control of radiation sources and Atomic Energy are as follows:

- Atomic Energy for Peace Act B.E.2504 (1961) and B.E.2508 (1965)
- MOST Ministerial Regulations B.E. 2550 (2007) on the Condition and Procedure of Licensing Process on Radioactive Materials, Nuclear Materials, and Atomic Energy.

  MOST Ministerial Regulations (2007) is as the requirements for the licensing process of the possession and utilization of radioactive materials, nuclear materials, and atomic energy from radiation generators and from nuclear reactor. This regulation covers in board areas. The main issues are the basic requirements for those licensee to prepare their documents as well as their general radiation safety procedure for their workers and also for the public; such as the radiation protection training to radiation workers, radioactive waste management, dose limits, decommissioning, and etc.
- MOST Ministerial Regulation B.E. 2546 (2003) on Rules and Procedures of Radioactive Waste Management. This regulation is as guidance for the radioactive material users to manage their radioactive wastes. The main issues are for preparation of radioactive

waste before transport to the centralized RWM in the country (it was the OAP in that time). However, since Dec 2006, the centralized RWM has been conducted by Radioactive Waste Management Center (RWMC), Thailand Institute of Nuclear Technology (TINT). This regulation included the recommendation to manage disused sealed radioactive sources, which written that DSRS should be returned back to their original manufacturers. The regulation also covers several important issues, such as waste classification, clearance level of solid, liquid, and gaseous waste. However, this regulation need to be revised for the up to date conditions in the present time as well as for the harmonization with the development of international standard in several issues. Up to now, there is no specific regulation for RWM facilities, such as the licensing system of RWM facilities.

1.1.2 Structure and System (Regulatory organizations)

Regarding to the Atomic Energy for Peace Act (1961), the Thai AEC plays role of National Regulatory Body. The OAP, Ministry of Science Technology (MOST) plays as a regulatory functional arm of Thai AEC. The OAP Secretary General is as the secretariat of the Thai AEC. There are several sub-committees appointed from external experts and OAP staff to review all matters related to the regulatory function. The OAP has been authorized by the Thai AEC to regulate, control as well as pre-review the license of the production, possession, and utilization of radioactive materials, research reactor, including radiation generators, such as X-ray machines, then submit to the sub-committee and the Thai AEC for further permits.

Since 1961, the OAP has had the roles of promoting nuclear technology, providing services, and regulating. Up to now, the promoting activities and some services are still done by OAP. However, some issues are exempt from licensing as stated under the current regulations. To address this specific issue, the new Atomic Energy Act should be established. The regulatory control program needs to be revised and improved.

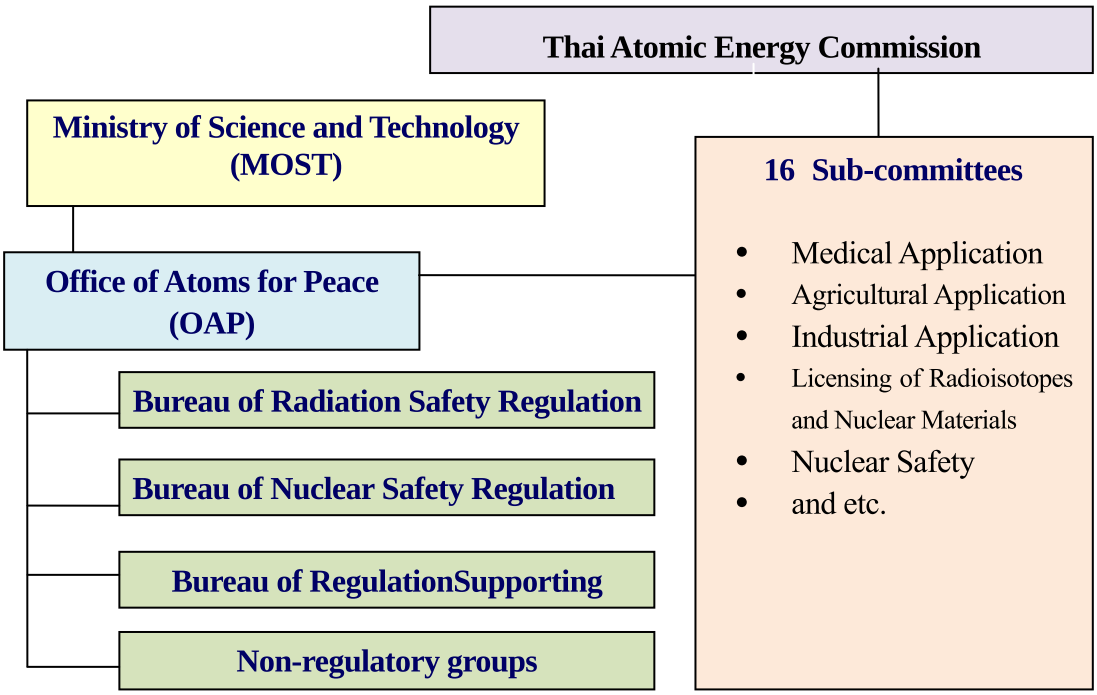


Figure 1: Nuclear Regulatory Organizations in Thailand

1.2 Outline of Radiation Facilities and Radiation sources

Table 1: Type of Radiation and Nuclear Facilities in Thailand

Facilities	Number of Facilities/unit
Research Reactor	1
Isotopes Production	2
Synchrotron	1
Research Gamma Irradiator	5
Industrial Gamma Irradiator	5
Gamma Tele-therapy	25 facilities, 44 units
X-ray devices- Diagnosis and Therapy in medicine	About 8500
X-ray devices - Industry	About 1500
Linear accelerator (LINAC)	45
Medical Remote after-loader and Brachytherapy	56 units, 25 facilities
Level/density thickness or conveyor gauge	350
Industrial Radiography	23
Education and R&D Laboratories using radionuclides	~250
PET cyclotron	3
Electron beam (education)	1
Electron beam (Gems-Irradiator)	1
Neutron Generator	1
Radioactive Waste Processing and Storage	1 center

Utilization in each category

❑ **Radio-isotopes**

Radio-isotopes of activity ranging from a few k Bq up to some GBq are possessed in many areas of applications. There are several radionuclides produced in the country by Radio-Isotope Production Center,TINT, such as I-131, P-32 and Sm-153.

Several radionuclides are used in R&D, medicine, and industry, such as Am-241, C-14, H-3, I-125, I-131, Sm-153, Cs-134, Cs-137, Co-60, Sr-90, Kr-85, and etc.

❑ **Accelerators**

There are several accelerators in uses for educational and R&D institutes, such as synchrotron, neutron generator, and electron beam.For the hospitals and clinic, linear accelerators (LINAC) and PET cyclotron are usedfor radio-therapy.

❑ Distribution of radioisotopes

Table2: Distribution of radionuclide use by its applications.

Category by application	Radionuclide	Percent (%)	Remarks
Medical	Ga-67,Cr-51,Tc-99m, Co-60,I-125, I-131,Tl-201, H-3,C-14,P-32, S-35,Ra-226, Sm-153, Sr-90 and etc	13	SRS and RI
Education and Research	P-32,S-35,Cr-51,Ca-45, Tc-99m,I-131,Co-60, Sr-90,Cs-137, Am-241, Be and etc.	30	SRS and RI
Industrial	Fe-55,Kr-85,Sr-90, Cd-109,Cs-137,Co-60, Ir-192,Am-241, Am-241/Be, H-3 and etc.	40	Most are SRS
Others/consumer products	Am-241 Ra-226 (lightning preventer)	17	SRS

Table 3: Number of Radioactive Source Users and Radiation Users(OAP, Nov2010)

Radioactive Sources User (Licensee)	
Medicine	**129**
Industry	**377**
Research & Education	**280**
Others (smoke detector, lightning preventer)	**160**
Radiation User Licensee	
Medical X-ray devices	**8500**
Industrial and Security X-ray devices	**1500**
Medical Electron accelerators (LINAC)	**35**
Custom Electron accelerators	**10**
PET cyclotron(medical)	**3**
Synchrotron (R&D)	**1**
Neutron Generator (education)	**1**
Electron beam (education)	**1**
Electron beam (industrial irradiator)	**1**
Nuclear research reactor	**1**

1.3 Education and Training

The OAP and the TINT have experiences to arrange the national training courses related to the radiation protection for radiation users, and another safety aspects, such as safe managing of radioactive waste, emergency preparednessand etc, as follows:

- Training Course on Radiation Protection for General Radiation Workers (Level 1).
- Training Course on Radiation Protection for General Radiation Workers (Level 2).
- Training Course on Radiation Protection for Radiation Supervisors (Level 3).
- Training Course on Emergency Preparedness for General Workers.
- Training Course on Radioactive Waste Management for Radioactive Material Users.
- Training Course on Radiation Safety Officer (RSO)
- Training Course on Emergency Preparedness for TINT Emergency Team staff.
- Refreshment Course on Radiation Protection for TINT staff (every 2 years)

and etc.

TINT- In House Radiation Protection Training

The radiation protection training is conducted by the Academic Service Unit, TINT, which cooperated with the Safety Unit. It is structured at different levels in order to meet the needs of staff and researchers using radioactive materials and the operators of research reactor. All personnel and visitors entering the TRR-1/M1 facility receive training in radiation protection sufficient for the work/visit, or shall be escorted by an individual who has received such training. The levels of training are as follows:

- ❑ Initial Training – All personnel permitted unescorted access in the TRR-1/M1 facility shall receive training in radiation protection as required by the Ministerial Regulation. Initial training shall cover the following areas in sufficient depth for the work being done:

  a) Storage, transfer, and use of radiation and/or radioactive material in portions of the restricted area, including radioactive waste management and disposal.

  b) Health protection problems and health risks (including prenatal risks) associated with exposure to radiation and/or radioactive materials.

  c) Precautions and procedures to minimize radiation exposure (ALARA).

  d) Purposes and functions of protective devices.

  e) Applicable regulations and license requirements for the protection of personnel from exposure to radiation and/or radioactive materials.

  f) Responsibility exposure to radiation or radioactive materials.

  g) Appropriate response to warnings in the event of an unusual occurrence or malfunction that involves radiation or radioactive materials.

  h) Radiation exposure reports which workers will receive or may request.

- ❑ Specialized Training – Certain personnel (e.g., reactor operators) require more in-depth training than that described above. Such individuals shall successfully complete training over the following outlined topics in sufficient depth for the work being done and pass a written examination with a minimum grade of 70%.

a) Principles of Atomic Structure
b) Radiation Characteristics
c) Sources of Radiation
d) Interaction of Radiation with Matter
e) Radiation Measurements
f) Biological Effects of Radiation
g) Radiation Detection
h) Radiation Detection Practices
i) ALARA
j) Radioactive Waste Management and Disposal

- Annual Refresher Training – All personnel permitted unescorted access in the TRR-1/M1 facility shall receive annual radiation safety refresher training. The annual training shall cover the following areas in sufficient depth for the work being done:

a) Review of proper radiation safety practices, including radioactive waste management and disposal
b) Occurrences at TRR-1/M1 facility over the past year
c) ALARA summary
d) Notable changes in procedures, equipment, facility, etc.

Part 2.Status of Radiation Safety Management

2.1 Radiation Safety in various RI usage

Radiation Safety Management in various RI usage, is regulated in accordance with the Atomic Energy for Peace Act B.E.2504 and Ministerial Regulation B.E. 2550. The main issues are comprised of the licensing system and requirements of radiation safety and security.

- The Act B.E.2504 (1961) is the main law governing radiation safety in Thailand. It is stated in section 12 that all radiation sources have been subjected to licensing:
- OAP Orders B.E.2552 (2009) on the Forms for licensing of radioactive materials, nuclear materials, and the use of atomic energy from radiation generators and the use of atomic energy from nuclear reactor.

There are 4 types of License

- License for production, possession or utilization of radioactive materials
- License for utilize Atomic energy from radiation generator and from nuclear rector
- License for modification of source materials from the natural chemical form
- License for export and import of nuclear materials and radioactive materials

2.1.1 Inspection Program

The OAP has established a planned program for inspections of radioactive sources. The frequency and extent of inspection depend on:

- potential magnitude and nature of the hazard presented as determined by Thai radioactive source categorization system
- the categorization system is used to set the duration of the licence which corresponds with

the categorization number

Table 4: Radioactive Source Categorization System (OAP, 2007).

Category	Source and practice	Duration of License/Inspection
1	Radioisotope thermoelectric generators Irradiators Teletheraphy Fixed multi-beam teletherapy (gamma knife) Industrial gamma radiography Nuclear Medicine (except Radioimmuno Assay)	1year/annually
2	High/medium dose rate brachytherapy Fixed industrial gauges(level gauges, density gauges, Well logging gauges Portable gauges (moisture/density gauges)	2years/ every 2 years
3	Low dose rate brachytherapy Thickness/fill-level gauges Sealed source for research , activity > 400 MBq Unsealed source for research, activity > 40 MBq	3years/ every 2 years
4	Low dose rate brachytherapy eye plaques and permanent sources Analytical Device Static eliminators Bone densitometers Sealed source,40 MBq< activity <400 MBq Unsealed source, activity < 40 MBq	4years/ every 2 years
5	Lightening preventer, smoke detector Standard sealed source, activity < 40 MBq	5years/ every 2 years

Radiation licensee are required to submit radiation protection and safety program which includes functions, responsibilities, and qualification and training of individuals.

2.1.2 Dose Limit of Radiation Workers

a) An effective dose of 20 mSv per year averaged over five consecutive years

b) An effective dose of 50 mSv in any single year

c) An equivalent dose to the extremities (hands and feet) or the skin of 500 mSv in a year

In addition, the safety culture was introduced to radiation users. They are enforced to follow the radiation safety requirements and code of conducts which are mainly based on IAEA SS 115, International Basic Safety Standards and the Code of Conduct for the Safety and Security of Radioactive Sources.

2.1.3 Radiological Protection for the RI User

2.1.3.1 Dose Monitoring

The occupational radiation monitoring service for external exposure to about 25,000 workers using films, TLD and OSL has provided by Department of Medical Science, Ministry of Health which has the accreditation following ISO-17025.

The Department of Medical Science is to providedosimetry laboratory services for radiation workers in the country through its Secondary Standards Dosimetry Laboratory (SSDL) since 1971. The Department of Medical Science's dosimetry laboratory is a member of the International Atomic Energy Agency and World Health Organization. It has an excellent cooperation network in South-East Asia.

The OAP-dosimetry laboratory carries on Metrological controls and certification of measuring equipment for ionizing radiation. The Bureau of Regulation Supporting maintains the SSDL with its equipment and source standards for the provision of services for the calibration of radiation monitoring instruments and dosimeters (i.e. survey meters,rate meter, personal monitors, etc.).

2.1.3.2 Radiation Safety Service

The users can also request technical services from the TINT to ensure safety in their facilities.

Among the services provided by the institute are the followings:

(i) Leak testing of sealed radiation sources/ Contamination checking
(ii) Certify of the Packaging of Sealed Radioactive Source.
(iii) Survey Meter
(iv) Collection and management of disused radioactive sources, solid and liquid radioactive wastes
(v) Transportation of radioactive wastes and disused radioactive sources.

These services are provided by the TINT for service charges. The schedule of service-charge for the different services of TINT has been published as a reference for the stakeholders convenience.

2.1.4 Radiological Protection for the Public

Dose limits to the public follows the recommendations stated in the OAP- regulation based on International Basic Safety Standards. Each licensee shall ensure that the estimated average dose to any member of the public does not exceed the following dose limits:

(i) An effective dose of 1 mSv in a year;
(ii) In special circumstances, an effective dose of up to 5 mSv in a single year provided that the average dose over five consecutive years does not exceed 1 mSv per year;
(iii) An equivalent dose to the lens of the eye of 15 mSv in a year; and
(iv) Equivalent dose to the skin of 50 mSv in a year

Note :

1. In addition, the TINT provides services, upon requests, on the certification of radioactivity content of food stuffs for export.
2. The OAP has provided services on Internal Dose checking during the Fukushima Daiichi Nuclear Power Plant Accident in 2011, as shown in Fig.2

Internal radiation dose check at the OAP

- I-131 dose check for several public groups
  - General public
  - Private company employees
  - Government officials such as air force personnel
- No contamination found

Figure 2: Service on Internal Radiation Dose Checking at the OAP

2.1.5 Radiation Emergency Preparedness

Emergency Planning and Preparedness is a part of the licensing process. All licensees including OAP authorized facilities are required to prepare and submit a facility emergency response plan for approval of the regulatory body. The level of preparedness is commensurate to the level of hazards expected in the facility.

❑ **National Nuclear and Radiological Emergency Plan**

As a specific regulation in the emergencypreparedness and response field, the *"Act of Disaster Prevention and Mitigation"* has been promulgated in 2007.

At the top level there is a national emergency plan for an integrated response to any combination ofhazards. *The National Preparedness Plan* which includes the *National Nuclear and Radiological Plan* (NNREP) is part of this "allhazards" plan.

The Bureau of Radiation Safety Regulation, Office of Atoms for Peace (OAP) acts as a National Competent Authority and Technical Support which coordinate to both regulatory bodies and response organizations. The Department of Disaster Prevention and Mitigation (DDPM) is the principle government agency for the National Disaster Prevention and Mitigation acts as 1st Responder and/or Decision maker. The structure of the national preparedness plan and the photos of emergency preparedness and response exercises are shown in Fig.3 and Fig.4 respectively

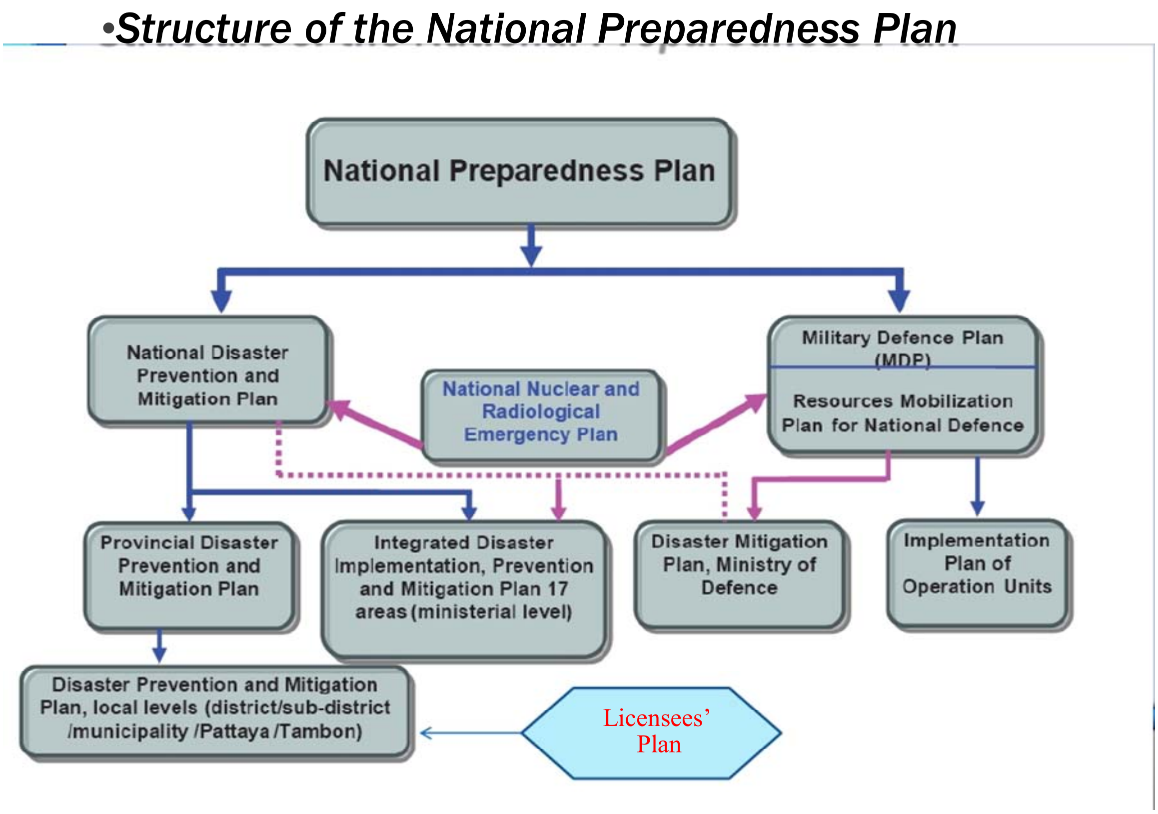


Figure 3: Structure of the National Preparedness Plan

Figure 4: Emergency Preparedness and Response Exercises under the National Preparedness Plan

❑ Radiation Monitoring Program around the country

There are 12 monitoring stations throughout country including 2 stations in the sea at the Gulf of Thailand and the Andaman sea, and the real time radiation level is available at the OAP as shown in Fig.5.

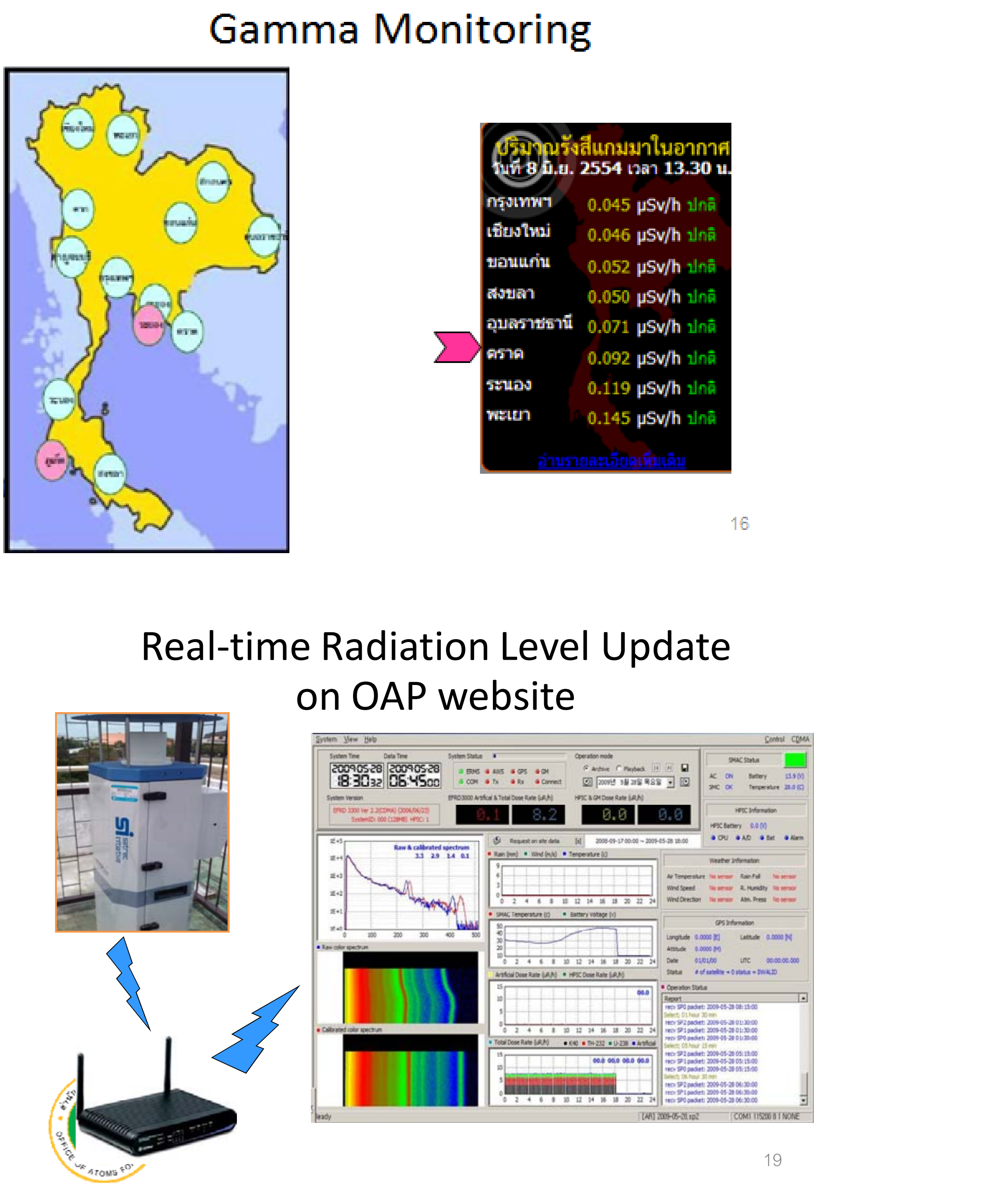


Figure 5: Real-Time Radiation Monitoring around the Country.

2.2 Radiation Safety Management in Thai Research Reactor-1 / Modification1 (TRR-1/M1)

TRR-1/M1 Safety Management System, regulated in accordance with the Atomic Energy for Peace Act B.E.2504 and Ministerial Regulation B.E. 2550, is comprised of the Radiation Protection program, the Radiation Monitoring program, the ALARA program and Access control. The system was established by the Reactor Operation Section and the Safety Unit, which are supervised by the TINT Executive Director. The Safety Unit is an administrative organization for radiation protection management, which is performed by health physicists.

The goal of the Radiation Protection program of TRR-1/M1 is to allow the maximum beneficial use of radiation sources with minimum radiation exposure to personnel. Requirements and procedures set forth in this program are designed to meet the fundamental principles of radiation protection, which are *Justification, Optimization* and *Limitation*. The legal dose limit for both occupationally exposed personnel and the general public are 20 mSv and 1 mSv, respectively.

The Radiation Monitoring program was established to ensure that all radiation sources are detected and assessed in a timely manner. To achieve this, the monitoring program is organized so that two major types of radiation surveys are carried out; referring as routine radiation level and contamination level surveys of specific areas and activities within the facility, and special radiation surveys necessary to support non-routine facility operations such as shutdown periods.

The Gas tight area of the reactor is classified as a Controlled area and is equipped with a permanent monitoring system for both Gamma and Neutron (so-called RAM-Radiation Area Monitoring). Effluent and airborne radiation monitors are located in the Gas tight area and the Ventilation system. The monitoring systems are continuously measuring radioactive dust/particle and volatile gas during reactor operation. The data is recorded with electronic devices and is transferred to the monitor and data storage system in the control room. The air pressure in Gas tight area is negative pressure to ensure the radioactive materials are kept inside the Gas tight area during reactor operation.

The water in the primary coolant system is sampled once a week and measured for fission products by HP-Ge detector gamma spectrometer. Radioactive particle/gas and dust are also sampled with an activated charcoal air filter. Hand and Shoe monitoring, including a portable contamination survey meter are located in the Reactor hall entry and near the emergency door exit. A decontamination facility shower- room is also located at the Reactor hall entry.

Radiation surveys inside and outside the controlled area are routinely performed by health physicists as per health physics procedures. Sample irradiation procedures and forms require checks of radiation level each time a sample is removed from an irradiation facility by a health physicist. Experiment reviews and approvals require radiation surveys for new experiments and modifications of ongoing experiments.

Radiation workers are required to wear protective clothing when they enter the Gas tight area. Protective clothing, shoes and shoe covers are provided for all individuals who enter the gas tight area, including visitors, to avoid contamination. Everyone is checked for contamination upon exit. Radiation workers must also wear at least one type of personal dosimeters. TLD’s are issued to each radiation worker every 3 months. Digital dosimeters-direct reading personal dosimeters are provided for both radiation workers and visitors. Visitors must be escorted by an Operator. The number of visitors in a single occasion must not be greater than 20 persons.

The ALARA program is based on the guidelines found in Basic Safety Standards for Radiation Protection. It incorporates a review of all TRR-1/M1 operations with an emphasis on operational procedures and practices that might reduce TRR-1/M1 staff and operators' exposure to radiation and lower potential radioactive effluent releases to unrestricted areas. Personnel radiation doses at the TRR-1/M1 are minimized by considering use of the following ALARA actions when performing work with radiation or radioactive materials.

- Reviewing records of similar work previously performed
- Eliminating unnecessary work
- Preparing written procedures
- Using special tools
- Installing temporary shielding
- Performing as much work as possible outside of radiation areas
- Performing mockup training
- Conducting pre-work briefings and post-work critiques
- Keeping unnecessary personnel out of areas where radiation exposure may occur

In addition to the above actions, the TRR-1/M1 ALARA program also contains the following elements which are designed to enhance the effectiveness of the overall program:

- Exposure investigations are conducted when an individual receives greater than 1 mSv in one month or 3 mSv in one quarter. The investigation is focused on determining the cause of the exposure so that appropriate ALARA actions, if any, can be applied.
- ALARA dose trend analysis charts are prepared quarterly and posted for review by all TRR-1/M1 personnel.
- An annual inspection of the TRR-1/M1 ALARA program is conducted by an individual who has no operational responsibilities at the TRR-1/M1. This individual is appointed by the RSC and inspection findings are presented to the RSC within 30 days after completion of the inspection.
- A health physicist is required to be involved during planning, design approval, and construction of new TRR-1/M1 instruments and facilities; during planning and implementation of TRR-1/M1 reactor use; during maintenance activities; and during management and disposal of radioactive waste. In addition, written procedures are required to be reviewed by Health Physics Supervisor.

The procedures for radiation protection are written by Safety Unit in accordance with the relevant Quality Assurance program of the Institute, which is ISO9001 certified. All the procedures are approved by the TINT Executive Director and reviewed by the Radiation Safety Committee. The procedures include the policy, methods and frequencies for conducting radiation surveys and air sampling; effluent monitoring; administrative measures for controlling access to radiation area; control of contamination of personnel and equipment; control of radioactive materials transportation within facility; methods of handling and storage of sources, radioisotopes and other radioactive material.

Radiation protection training is conducted by the TINT Technology Transfer Section which cooperated with the Safety Unit. It is structured at different levels in order to meet the needs of different categories of facility staff and researchers using the reactor. All personnel and visitors entering the TRR-1/M1 receive training in radiation protection appropriate for their work/visit, or shall be escorted by an individual who has received such training. All personnel permitted unescorted access in the TRR-1/M1 facility shall receive annual radiation safety refresher training.

The Access controls are installed at various locations including the reactor gate, the reactor building entrance, the reactor registration area, the water treatment area, the reactor gas tight area and the refresh fuel storage room. All staff must be authorized at the level relevant to their work by the reactor manager and the head of the Safety Unit.

Emergency plans and procedures are implemented in two different levels, which are emergency for operator in-house developed by reactor operation section and emergency preparedness plan for institute (TINT) developed by the Safety Unit activated in the case of a critical situation which Reactor Operators cannot handling. The training on emergency preparedness is conducted once a year and is compliant with Ministerial Regulations.

2.3 Radiation Safety in Radioactive Waste Management

Radioactive waste in Thailand is generated by R&D laboratories, the operation of a 2 MW research reactor, nuclear medical applications, radio-pharmaceutical production, industries and others. At present, Thailand has no nuclear power plants.

The Radioactive Waste Management Center (RWMC), Thailand Institute of Nuclear Technology (TINT) has been separated from the Office of Atoms for Peace (OAP) to act as the centralized radioactive waste management service in the country.

- ❑ **Radioactive Waste Management Operation**

The main waste management facility is located in Chatuchak, a part of Bangkok. It is composed of solid waste treatment facilities (such as incineration and compaction), liquid waste treatment facilities (such as chemical precipitation and filtering systems) and storage facilities (Table 5.) Currently, there is no disposal facility in Thailand. The RWM process is shown in Fig. 6.

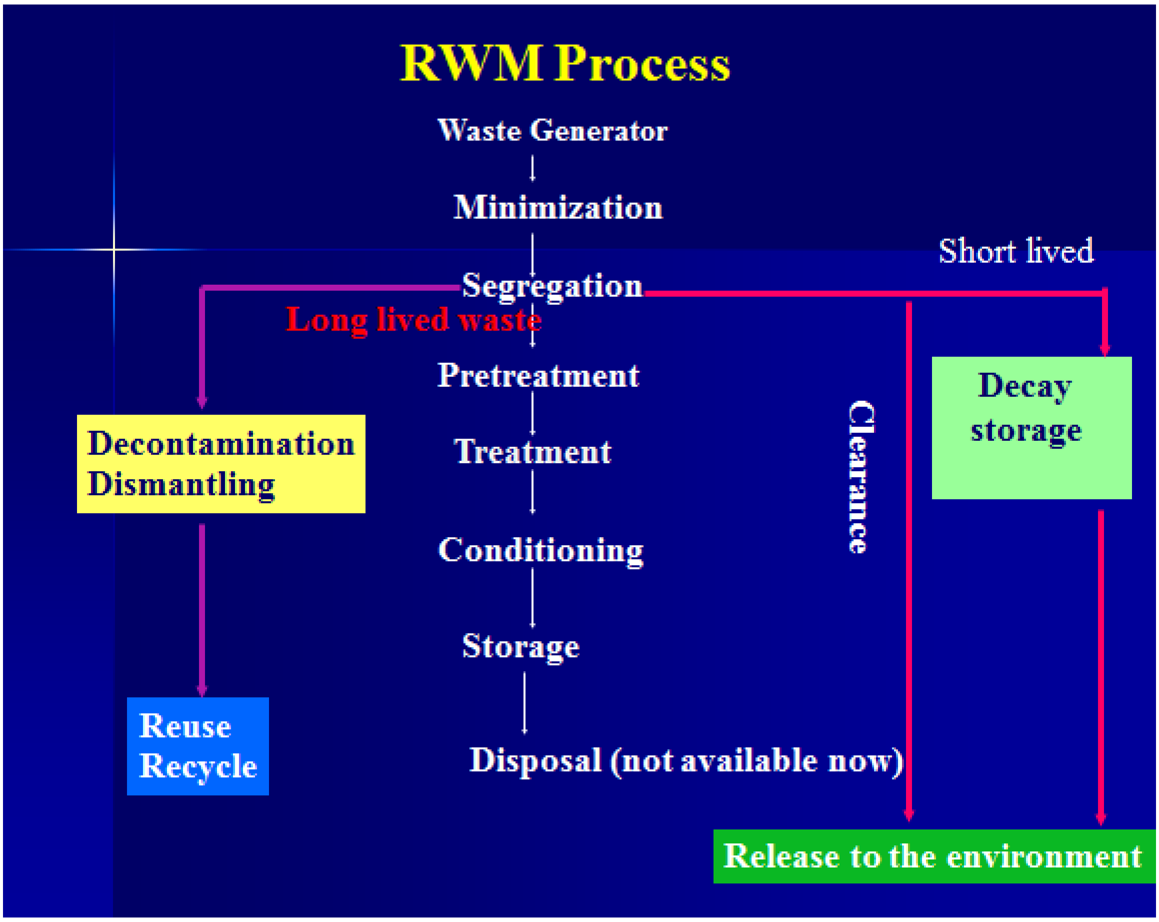


Fig.6 Radioactive Waste Management Process in Thailand

- ❑ **Regulatory Framework**

The nuclear regulatory function is conducted by the OAP. The RWM regulation and guidance was first implemented in 2003, under the Atomic Energy for Peace Act B.E.2504 (1961) and the Ministerial Regulation on Rules and Procedures of Radioactive Waste Management B.E.2546 (2003). Up to now, there are no specific regulations on licenses for radioactive waste operation facilities.

2.3.1 Related law and regulation on Radiation Safety and Radioactive Waste Management

- The Atomic Energy for Peace Act B.E.2504 (1961)
- Ministerial Regulation on Condition and Procedure Requirements for License of the Possession of Related Nuclear Materials, Radioactive Materials or Atomic Energy B.E.2550 (2007)
- Ministerial Regulation on Rules and Procedures of Radioactive Management B.E. 2546 (2003)
- OAEP-1 Clearance Level of RW (Solid, Liquid and Gas)
- OAEP-2 Measure on Radiation Area
- OAEP-6 Measure on Safety of Radioactive material Nuclear material and X-ray Working Area
- OAEP-7 Measure on Installation of Radiation Generator
- OAEP-10 Measure on Transportation of radioactive materials and wastes
- OAEP-18 Radiation Safety Officer

- OAEP-20 Guides of RW Segregation, Collection, Container and Label
- OAEP-21 Guides of Temporary Storage for RW Generator

Table 5: Radioactive waste management facilities in Thailand

Facilities	*Items*	*Capacity*	*Type of Waste*
Solid waste treatment	Incinerator equipped with off gas cleaning system	15 kg/hr	Burnable waste
	Compactor	40 ton	Compactable waste
Liquid waste treatment	Chemical precipitation plant	5 m^3/batch	Aqueous waste with low salt content
	Stainless steel container	2 x 5 m^3	Organic liquid waste
Conditioning	In drum cement mixer	200 Liter	Ash, sludge
Storage	Storage facility No.1	65 m^2 x 4.5 m 81 m^2 x 4 m	Disused SRS
	Storage facility No.2	80 m^2 x 4.5 m	Treated Waste in drums;ashes, sludge
	Storage facility No.3 (at Pathumthani Province)	300 m^2 x 5 m	Treated Waste in drums: DSRS
Note: the new storage will be operated soon	Storage facility No.4 (at Ongkarak site, NakhonNayok Province)	1050 m^2x 6 m	Treated Waste in drums: DSRS

2.3.2 Safety assessment of Thailand Radioactive Waste Management Facility.

The TINT-RWMC (Radioactive Waste Management Center) has participated in several IAEA international/regional projects. TINT- Radioactive Waste Management facility was selected to be a Test Case under the IAEA Safety Assessment Driving to Radioactive Waste Management Solutions. A methodology for preparing the safety case and safety assessment for predisposal waste management facilities or activities is provided in IAEA Safety Guides DS284. The recommended approach to safety assessment is outlined in Fig 7 and 8. It includes the following key components:

(i) Specification of the assessment context (including the purpose, scope, regulatory framework, assessment endpoints, target audience, and philosophy of the assessment);

(ii) Description of the predisposal waste management facility or activity and waste, as well the neighbouring areas;

(iii) Development, selection and justification of scenarios;

(iv) Identification and justification of models and data needs;

(v) Calculation, their verification and evaluation of results;

(vi) Analysis of safety measures and engineering, comparison against assessment criteria;

(vii) Independent verification of safety assessment results (by peer review and/or independent assessment by Regulator), and

(viii) Review and modification of the assessment if necessary (iteration).The steps outlined in Figure 2 are interdependent and should be performed in an iterative manner. Solid black lines indicate the typical sequence of activities but this sequence is not mandatory. Dotted lines indicate possible changes to this sequence, for example if a hazard is screened out there is no need for further modelling. Similarly the "Assessment Context" may change as a result of subsequent stages in the safety assessment process.

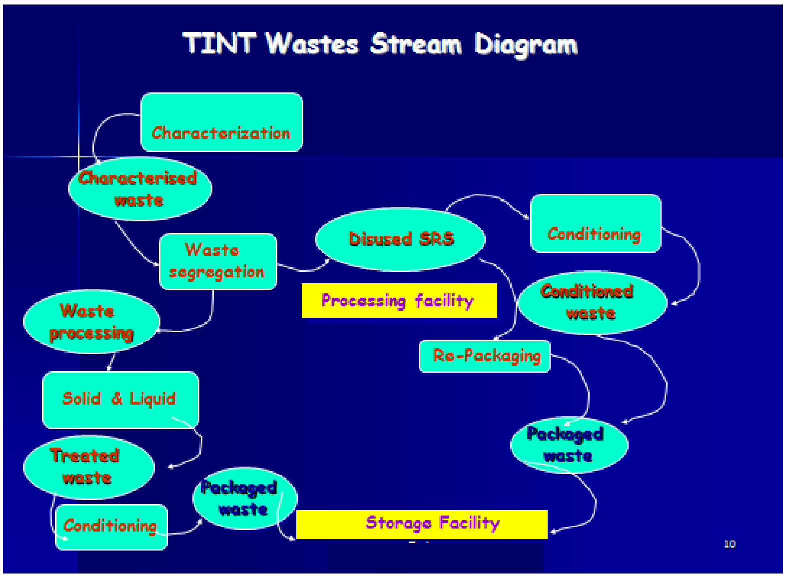


Figure 7: TINT Waste Stream Diagram.

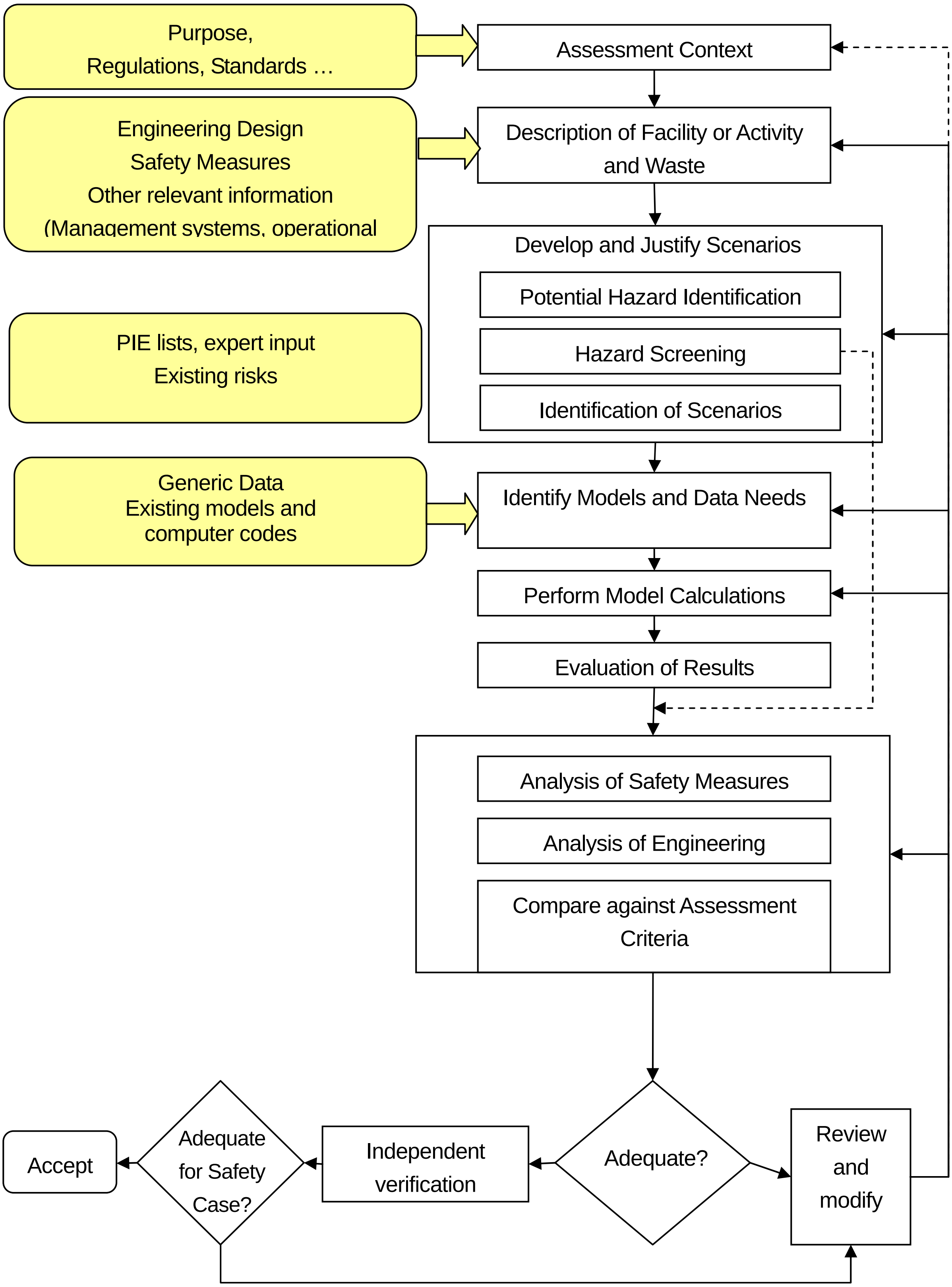


Figure 8: The Safety Assessment Process for Predisposal Waste Management

2.3.3 Assessment Endpoints

The safety assessment takes the following endpoints into consideration for the normal operation of the facilities:

- The radiation exposure of workers in the waste management facilities is considered as an endpoint to be compared to the worker dose limit.
- Radiation exposure of the general public can arise from atmospheric releases and from aquatic discharges. Respective endpoints for members of the general public are considered and compared to the public dose limit.
- For accident conditions, analogous endpoints are considered. These are not compared to any quantitative criteria, however, but evaluated against the ALARA principle.

In accordance with the scope of the safety assessment, receptors for other endpoints than dose are not considered. Also, no endpoints relating to non-human species are taken into account since this is not required by the current regulations.

2.3.4 Safety Management of Disused Sealed Source

There was a serious radiological accident occurred in Thailand in the year of 2000. Consequently ,the 400 Ci disused Co-60 teletherapy sources became open. The Co-60 source was dropped down in a scrap metal shop. The OAP emergency team successfully recovered the source and then the subsequent management, conditioning operation of the source have been successfully completed in 2001.

During the year 2000-2002, all the disused Radium-226 around the country collected by the Thailand team with the cooperation of an IAEA expert. All the collected Radium-226 were successfully conditioned in the year of 2004. In addition, the conditioning operation of 4 Ci Ra-226 external source was also successfully conditioned by OAP team (TINT at present) in the year of 2005.

These conditioned sources are now safely stored at the TINT interim storage facilities awaiting final disposal. The TINT- RWMC continues to pursue the upgrading of its centralized facility for low to intermediate level radioactive waste treatment and storage facilities. Moreover, the TINT-RWMC in collaboration with other government agencies, such as MEXT/JAEA, FNCA, KAERI, and US-DOE is working for the safety management of radioactive waste development projects.

2.3.5 Radiological Protection for Radiation Workers

The TINT ensures that the following dose limits will not be exceeded by TINT radiation workers; an effective dose of 20 mSv per year averaged over five consecutive years.

❑ **Summary of Radiation Safety in Radioactive Waste Management**

- Radioactive Waste Management Center, TINT acts as the centralized Radioactive Waste Management Facility in Thailand
- The Radioactive Waste Management Center is in charge of waste management operation such as collection, transportation, segregation, treatment, conditioning, and storage
- Low level solid wastes are treated by incineration and compaction

- Low level aqueous wastes are treated by chemical flocculation-precipitation, and ion-exchange method.
- The treated wastes are solidified by cementation in 200 liter-drums.
- Treated Wastes in Drums are kept in the TINT storage facilities.
- New Radioactive Waste Storage facility is located at the new site, Ongkharak District and will be operated around the mid of 2014.

11. Vietnam

11. Vietnam

Part 1. Radiation Safety in Radiation Industry Facilities

1.1 General

Now in Vietnam, radiation and radioisotopes have been applied in health care, agriculture, industry, geology, mining, meteorology, hydrology, transport, construction, oil and gas industry, etc.

There is only one nuclear installation in the country is the Dalat nuclear research reactor with capacity of 500 kW.

In order to meet the energy demand in the future, the first nuclear power plant (NPP) will be put in operation in 2020 with capacity of 2000 MW and the second NPP with capacity of 2000 MW will be put in operation in 2021.

In November 2011, Vietnam and Russia signed an inter-government agreement on the construction of the nuclear science and technology center to help develop Vietnam's nuclear power program. with the investment capital of $500 million. The capital would be loaned by the Russian government at preferential interest rate.

Atomic Energy Law had been approved at the twelfth National Assembly Session 3 on 3rd June 2008 and come to enforce on 1st January 2009. The Atomic Energy Law includes 11 Chapters with 93 Articles.

1.1.1 Legislative framework and policy for radiation safety

According to articles 91, 103 of Statute of the Socialist Republic of Vietnam, the order of legislative framework is as following:

- Laws will be enacted by the National Assembly of the Socialist Republic of Vietnam.
- Ordinances will be enacted by the Standing Committee of the National Assembly.
- Decrees will be enacted by the Prime Minister of the Socialist Republic of Vietnam.;
- Circulars, Guidance, Codes of practices will be enacted by the Minister or some Ministers.
- Atomic Energy Law, Article 6, Principles for activities and the assurance of safety and security in the field of atomic energy.
- Any activities in area of atomic energy shall ensure that public health, human life, environment and social security are protected. State management on safety and security shall be independent and scientifically based.

1.1.2 Regulatory Body:

MOST: Under the Article 29 of Ordinance and the Article 34 of Decree 50/CP the MOST was designated as the Regulatory Authority for Radiation safety and control. MOST is a Regulatory Body being responsible to Government for the exercise of unified State management over radiation safety and control throughout the country, responsible for organizing and directing all radiation safety and control activities within the scope its function and duties.

VINATOM: Under direction of the MOST, the VINATOM is responsible for conducting all R&D activities in the field of the application of nuclear energy in Vietnam and assisting the VARANS on technical aspects.

VARANS: Under direction of the MOST, the VARANS is responsible for building of legislative documents, code of practice, procedures and regulations for radiation and nuclear safety & control; organizing and implementing the notification, registration, license, renewal, amendment and withdrawal of licenses for radiation and nuclear establishments,...; conducting regulatory inspections on radiation and nuclear safety according to law.

VAEA: Vietnam Atomic Energy Agency under MOST, which advise and assist the Minister to fullill the State management functions for research, use and develope nuclear energy nationwide carry out professtional activities in the Agency's management function.

DOST: The 63 Provincial Departments of Science & Technology (DOSTs) are responsible for radiation protection and nuclear safety within the province under supervision by VARANS.

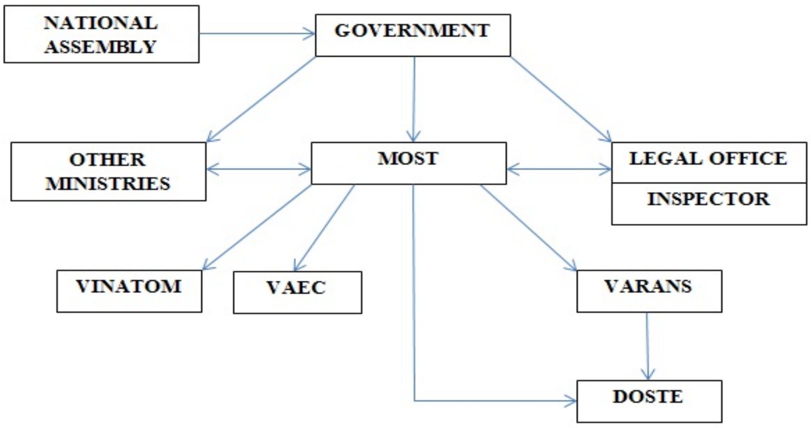


Figure 1: Structure and resources of regulatory body and supporting organizations

1.2 Outline of Radiation Facilities and Radiation Sources

1.2.1 Number of specialists and Workers in related organizations

The number of people working with radiation related industry in Vietnam is difficult to correctly define however a number is available and is referenced in the VARANS's report. In 2008, there are more than 5,300 radiation workers belong to radiation installation and related organisations. In the South, more than 3,500 radiation workers belong to radiation installation. In the North, more than 1,800 radiation workers belong to radiation installation.

Currently the Service monitors approximately 6,000 workers. The results of personal exposure are reported to VAEI and VARANS, to the supervisors of radiation workers.

1.2.2 Uses of radiation and nuclear in Vietnam

Accoring to inventory data from VARANS in July 2013, in Vietnam , there are 803 radiation facilities and 2,930 X-ray diagnose facilities. There are 1413 radioactive sources in storage and 1797 radioactive sources in use in difference areas, including:

- Industry: 1121
- Health care: 91
- Education & Research: 293
- Others: 292

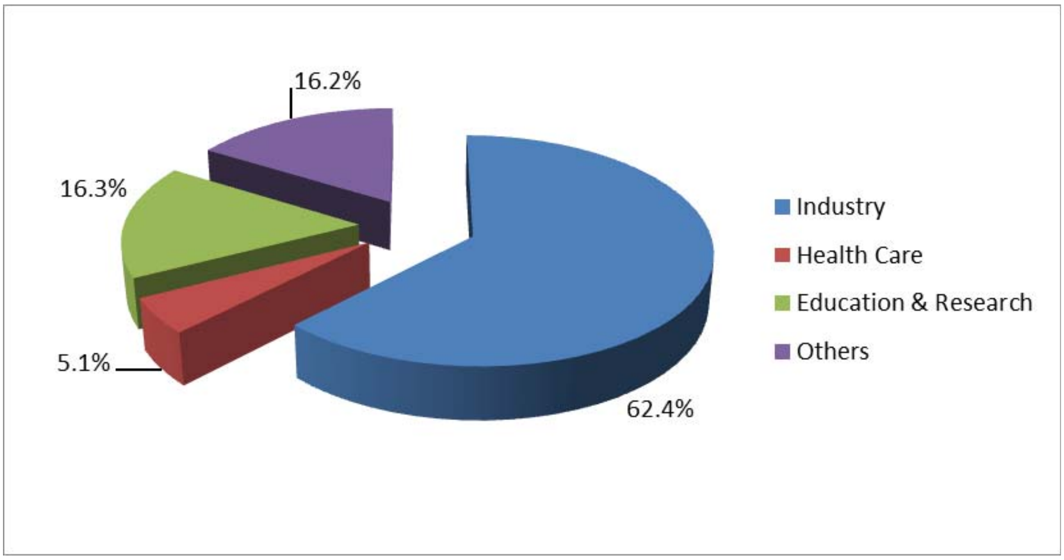


Figure. 2: The percentage of radioactive source in use in different areas

The largest radiation facilities are:

- There is only one nuclear installation in the country is the Dalat nuclear research reactor with capacity of 500 kW.
- One cyclotron 30 Mev built in 108 Military Hospital (Hanoi city) and the PET-CT & Cyclotron in Cho Ray Hospital (Ho Chi Minh city) in operation in 2009

There are 824 radioactive facilities in operation in Vietnam by July 2013 (inventory from VARANS) including:

- Industry: 441
- Health care: 65 (without X ray facilities)
- Education & Research: 49
- Radiation Safety Services: 11
- Business: 202
- Others: 56

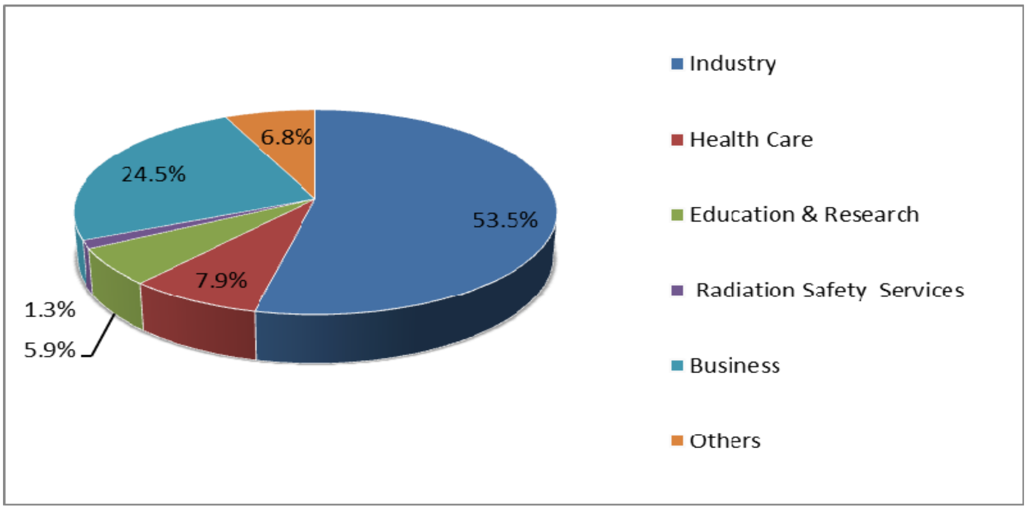


Figure. 3: The percentage of radioactive facilities in operation in different areas

Accoring to inventory data from VARANS in July 2013, there are 803 radiation equipments (without X ray equipments) in operation in different areas in Vietnam:

- Industry: 406
- Health Care: 169
- Education & Research : 54
- Other: 174

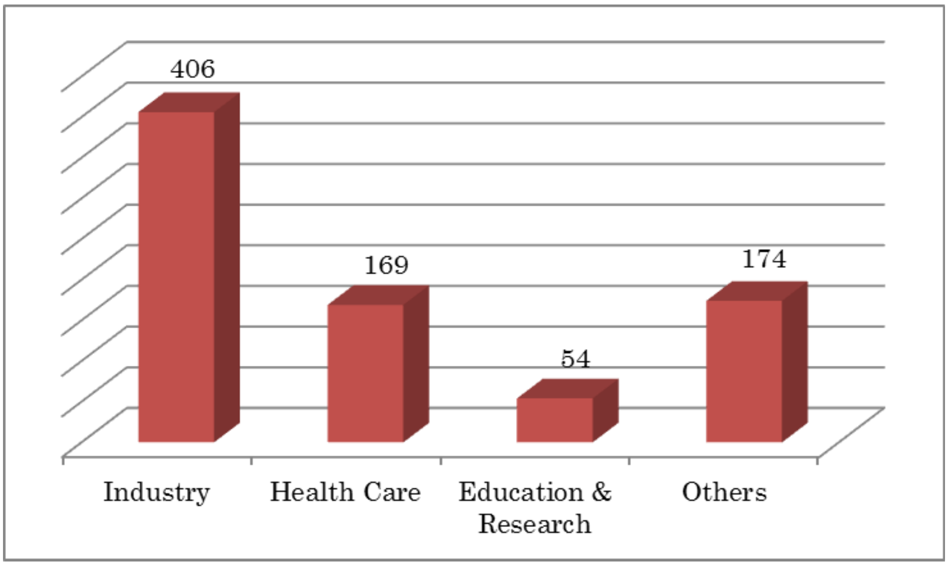


Figure 4: The number of radiation equipment in operation in different areas

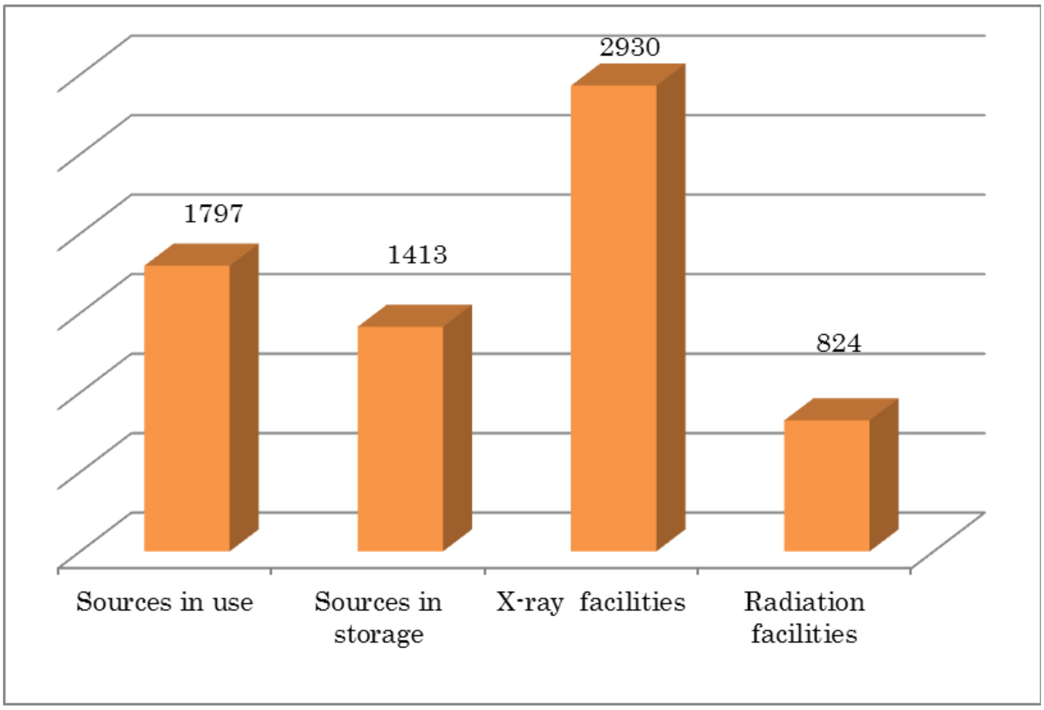


Figure 5: The number of radioactive sources and radiation facilities in operation in Vietnam

Table 1: Number of facilities in health-care

No.	Application	Number of Facilities		Planned
		In operation	Not in operation	
1	Tele-therapy (sealed source)	14	3	2
2	Tele-therapy (accelerator)	6	-	-
3	Brachy-therapy (HDR)	3	2	-
4	Brachy-therapy (Low & Medium dose rate)	0	4	-
5	X-Ray Diagnose	1900	-	-
6	Nuclear Medicine	23	-	1
7	Blood Irradiation	1	1	3
8	Radioisotope Production (cyclotron)	3	-	1

Table 2: Number of sealed sources in health-care

No.	Application	Sealed Source		X-Ray	Unsealed Source	Accelerator
		In Use	In Storage			
1	Tele-therapy	19	5	0	0	9
2	Brachy-therapy (HDR)	3	~15	2	0	0
3	Brachy-therapy (Low & Medium dose rate)	0	658	0	0	0
4	X-Ray Diagnose	0	0	2752	0	0
5	Nuclear Medicine	0	0	0	0	x
6	Blood Irradiation	1	1	0	0	0
7	Radioisotope Production	0	0	0	X	3 (Cyclotrons)

Table 3: Number of facilities in industry

No.	Application	Number of Facilities		Planned
		In operation	Not in operation	
1	Sterilization Irradiation (sealed source)	4	0	2
2	Sterilization Irradiation (accelerator)	49		
3	NDT (X-ray)	33	0	
4	NDT (radioactive source)	23	0	
5	Gauge (fix)	158		
6	Well logging	12	0	
7	Tracer	1	0	
8	X-ray fluorescent analysis	59	0	
9	Main-board Scanner	1	0	

Table 4: Number of sources in industry

No.	Application	Sealed Source		X-Ray	Unsealed Source	Accelerator
1	Sterilization Irradiator	6	0	0	0	2
2	NDT	67	>180	50	0	0
3	Gauge	422	71	51	0	0
4	Well logging	88	30	0	X	0
5	Tracer	0	0	0	X	0
6	X-ray fluorescent analysis	59	0	18	0	0
7	Main-board Scanner	0	0	7	0	0

Table 5: Number of facilities in education, research& others

No.	Application	Number of Facilities		Planned
		In operation	Not in operation	
Education & Research				
1	Education & Research	27	0	
Others				
1	Agricultural irradiators	0	2	1 gamma field (Da Lat)
2	Geology	1	3	
3	X-Ray scanner (security & customs)	8	0	
4	Radiothermal generators (RTG's)	0	0	

Table 6: Number of sources in education, research& others

No.	Application	Sealed Source		X-Ray	Unsealed Source	Accelerator
		In Use	In Storage			
Education & Research						
1	Education & Research	327	105	11	X	1
Others						
1	Agricultural irradiators	0	2			
2	Geology	4	120	0	X	0
3	X-Ray scanner (security & customs)	0	0	97	0	0
4	Radiothermal generators (RTG's)	0	0	0	0	0

1.3 Education and Training

The radiation workers and the personnel having frequent access to Radiation Facilities shall take appropriate radiation protection training courses in both the theoretical and practical aspects to acquire radiation-handling skills needed for radiation worker, or for access to controlled areas.

- Training trainers
- Establishing training programme for RPO, radiation workers
- Conducting the courses for radiation protection and radiation measurements
- Conducting training courses on Licensing and inspection for 128 staffs from 63 DOST, who are in charge of radiation protection in provinces/cities

Table 7: Type of Services

No.	Type of Services	Number of Facilities
1	Providing personal Dosimeter	2
2	Calibration of Radiation Survey meter	2
3	Radiation Monitoring (measuring the dose rate)	21
4	Calibration of X-ray Machine in Health Care	17
5	Training in the radiation protection	VINATOM + VARANS + DOSTs

- National Education and Training on Nuclear Safety

- The Hanoi National University (HNU) which is the largest university in Viet Nam to provide human resources related to nuclear activities has a Department of Nuclear Physics. This department was established in 1956 and currently produces around 50 graduates annually with a basic degree in nuclear physics.

- The Hanoi University of Technology (HUT) has a Department of Nuclear Engineering and Environmental Physics. The department was established in 1970 and currently produces about 20 graduates annually with a basic degree in engineering.

- Ho Chi Minh City University of Science has a Department of Nuclear Physics. It was established in March, 1996. Currently provides around 50 graduates annually with a basic degree in nuclear physics for the South of Vietnam.

- Dalat University is the other university which offers courses on nuclear science and it produces about 20 graduate students annually.

- On 26 October 2001, the Ministry of Education and Training decided to upgrade the Electrical Engineering School No. 1 to Electric Power College. On 19 May 2006, the Prime Minister issued a decision to establish Electric Power University (EPU) formerly the Electric Power College, operated directly under Electricity of Vietnam (EVN). EVN is the country"s economic group operating in the field of electricity. In respond to the training needs, for the energy sector, especially nuclear energy, EPU has developed curriculum on nuclear power.

1.4. Standardization on Radiation and Radioactivity

Radiation safety and radioactive waste management must be based on the reliable and precise measurement of the quantities associated with ionizing radiation such as dose (Sv) an radioactivity (Bq). For radiation safety, various dose meters are being used such as passive dosimeters for personal dose and survey meters for ambient dose. Dose meters must be calibrated regularly and always must show a right value in order to ensure the safety and security of the people related to ionizing radiations. Measuring instruments such as ionization chambers, scintillation counters and semiconductor detectors are important in radioactive waste management, which need to be calibrated using reference radioisotope sources.

In the personal dosimetry network, VINATOM and VARANS are presented as authority. In this network, there are two recognized personal dosimetry service centers: INST (Hanoi) and NRI (Dalat), which will provide individual monitoring service for the radiation workers in the whole country.

- In the South, more than 3,500 radiation workers belong to radiation installation are examined annually. Read-out frequency: Once in 3 months and in 1 month (for some organization).
- In the North, more than 1,800 radiation workers belong to radiation installation are examined annually. Read-out frequency: Once in 3 months and in 1 month (for some organization).

The results of personal exposure are reported to VINATOM and VARANS, to the supervisors of radiation workers.

Secondary Standard Dosimetry Laboratory (SSDL)

INST(Hanoi) operates and maintains a SSDL for national standard radiation dosimetry and calibration of radiation protection instruments such as survey meter, pocket dosimeter but it is limited in scale.

Intercomparison and international supports in increasing accuracy and personal dosimetry management are essential. The intercomparisons were good way and very useful for finding the problems in our system and help us to gain confidence and improve the accuracy of personal dose equivalent estimation.

Figure 6: The TLD Reader HARSHAW 4500

Figure 7: Calibration Instruments

Part 2. Status of Radiation Safety Management

2.1 Radiation Safety Management System

The Ministry of Science and Technology (MOST) is the Regulatory Body responsible for the unified State management of radiation protection and nuclear safety throughout the country; organizing and directing all radiation and nuclear safety activities

The management of radiation safety within various radiation facilities is governed by the specific standards, codes and guides.

These encompass all radiation management consideration for research, industrial and medical related facilities as follows:

Table 8: List of Vietnam standards on radiation safety

1.	TCVN 3727 – 82	Radioactive Wastes, Radioactive Dirt, Decontamination, Radioactive sol – Glossary
2.	TCVN 1638 – 75	Symbol on electrical diagram. Ionizing radiation detector
3.	TCVN 4397 – 87	Ionizing radiation safety standards
4.	TCVN 4498 – 88	Collective protection measures against ionizing radiation
5.	TCVN 4985 – 89	Safe Transport Standards of Radioactive Materials
6.	TCVN 5134 – 90	Radiation safety – Glossary
7.	TCVN 6053 – 95 (ISO 9696:1992)	Water quality – Total amount of beta radiation measurement in unsalted water – Thick-source method
8.	TCVN 6053 – 95 (ISO 9697:1992)	Water quality – Total amount of beta radiation measurement in unsalted water
9.	TCVN 6561:1999	Radiation Protection for Medical Installations
10.	TCVN 6730-1:2000	X-ray shielding materials – Lead rubber
11.	TCVN 6866:2001	Radiation Safety – Occupational Radiation Dose Limits for radiation worker and public
12.	TCVN 6867:2001	Radiation Safety – Safe Transport of Radioactive Materials – Part 1: General Provisions
13.	TCVN 6868:2001	Radiation Safety – Safe Management and Treatments of radioactive Wastes – Classification of Radioactive Wastes
14.	TCVN 6869:2001	Radiation Safety – Medical exposure – General Provisions
15.	TCVN 6870:2001	Radiation Safety – Exemption of declaration, registration and licensing
16.	TCVN 7077:2002 (ISO 1757:1996)	Radiation Safety – Personal photographic dosimeters
17.	TCVN 7078-1:2002 (ISO 7503-1:1988)	Radiation Safety – Evaluation of surface contamination – Part 1: Beta-emitters (maximum beta energy greater than 0.15 MeV) and alpha-emitters
18.	TCVN 7173:2002 (ISO 9271:1992)	Radiation Safety – Decontamination of radioactively contaminated surfaces – Testing of decontamination agents for textiles
19.	TCVN 7174:2002 (ISO 9271:1992)	Nuclear Energy – Radiation protection – Individual thermo luminescence dosimeters for extremities and eyes
20	TCVN6941:2013	Nuclear Safety – External human induced events in site evaluation for nuclear power plant
21	TCVN6942:2013	Nuclear Safety- Survey and evaluation radioacive dispersions

		in air, water, - Consider population distribution in site avaluation for nuclear power plant
22	TCVN6943:2013	Nuclear Safety- Geotechnical problems in foundation & site avaluation for nuclear power plant
23	TCVN6944:2013	Nuclear Safety-Survey and Evaluate the dangerous of earthquake for nuclear power plant
24	TCVN6945:2013	Nuclear Safety-Survey and Evaluate of meteorology, hydrology in site avaluation for nuclear power plant

2.2 Radiation Safety Management

VARANS: Under direction of the MOST, the VARANS is responsible for building of legislative documents, code of practice, procedures and regulations for radiation and nuclear safety & control; organizing and implementing the notification, registration, license, renewal, amendment and withdrawal of licenses for radiation and nuclear establishments,…; conducting regulatory inspections on radiation and nuclear safety according to law.

2.2.1 Radiological Protection for Radiation Workers

An increase in a person's exposure to ionizing radiation, even at low doses, is assumed to increase the risk of harm to that person's health. As such, all radiation industries and facilities are required to implement a system of radiation protection which limits possible detrimental effects arising from occupational radiation exposure. This ALARA approach involves the design of processes in such a way as to minimise exposure and to ensure that occupational dose limits are met. Radiological protection is achieved through the following hierarchy:

- Avoidance of exposure, where practicable;
- Isolation of sources of radiation, where practicable, through shielding,
- Containment and remote handling techniques;
- Engineering controls, such as local exhaust ventilation to remove contaminants from the workplace environment;
- Adoption of safe work practices, including work methods which make appropriate use of time, distance and shielding to minimise exposure; and
- Where other means of controlling exposure are not practicable, the use of approved personal protective equipment.

Radiation Protection of workers has to be monitored to make sure that the total amount of external and internal exposure doesn't exceed yearly limit of effective dose by personal a dosimeter and regular medical check in accordance with the applied regulations.

Table 9: Radiation dose limits for radiation worker

	Dose limit	
Application	Occupational	Public
Effective dose	20 mSv per year, averaged over a period of 5 consecutive calendar years	1 Sv in a year
Annual equivalent dose in		
the lens of the eye	150 mSv	
the skin	500 mSv	
the hands and feet	500 mSv	

Reference: Occupational Radiation limits for radiation worker were given by TCVN 6866:2001.
About 6,300 of radiation workers in the country are monitored occupational dose. The duties and responsibilities of the radiation service centers and radiation institution were defined by the Atomic Energy Law 1, 2009.

2.2.2 Radiological Protection for Radiation Area

Work processes and areas are designed to keep radiation exposure to a minimum. Where the potential for exposure to radiation or contamination still exists, shielding and mechanical ventilation are employ to minimise the dose received. Areas are classified according to the potential radiation and contamination level.

Dose and contamination surveys are carried out by Radiation Safety Officer (RSO) as scheduled and also at request

2.2.3 Radiological Protection for the Public

Monitoring for radionuclides is carried out continually to determine compliance with the limits imposed by the regulator and to fulfill the duty to protect members of the public. The environmental radiation monitoring network have been established with goals:

- Provides systematically data on ambient levels of radiation in the environment (during routine as well as emergency conditions) - Provides data for nuclear emergency response assessments (making decision necessary to ensure the protection of public health)

- Provides data for professional studies and Informs the general public and public officials.
- Provides national database of environmental radiation for serve the State management in the field of atomic energy and nuclear safety

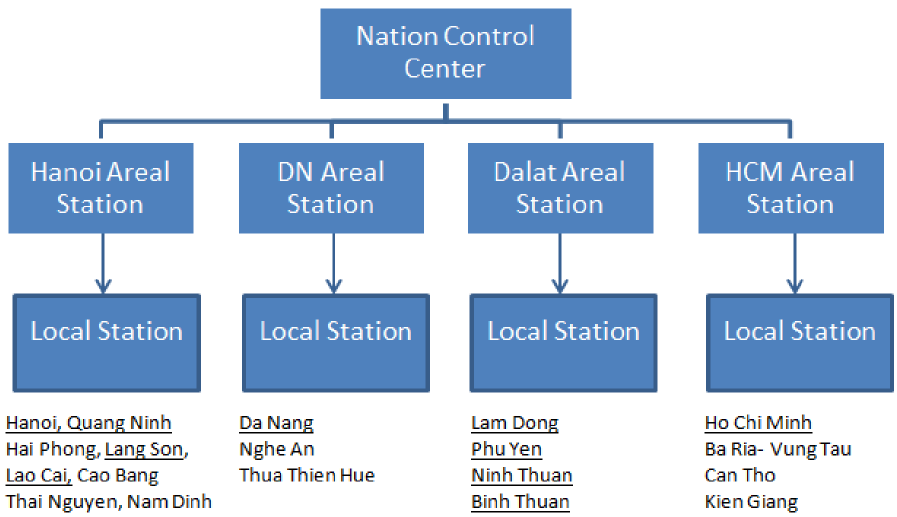


Figure 8: The structure of the National Network

❑ Construction & Management of the Network

Circular No 27/TT-BKHCN-MOST (30/12/2010)

- VINATOM will be responsible for building and managing the National control Center and the areal Monitoring Station. Annually, VINATOM report the environments radiation status to MOST and report immediately when there is abnormal phenomenon of radiation.

- DOST of the provices and center cities will be responsible for building and managing Local Station on the basic of the network.
- Organization and individuals operating the nuclear facilities (NPP, research reactor, uranium enrichment facilities, nuclear fuel fabrication, disposal facilities, storage and burial of radioactive waste and energy nuclear materials used) will build and manage their own monitoring station.

❑ Roadmap and Network Building

Period 2010-2015

- Develop and put in to operation National Control Center
- Consolidate the 4 areal stations and six local stations and set up a working group at the stations
- Gradually increase the capacity of technical support of emergency response
- Set up station at areas where we build NPPs
- Organize training and retraining staff for environmental radiation monitoring and analysis
- Complete regulations on organization and operation of network building legal documents standards technical regulations.. for environmental radiation monitoring and analysis
- Set up a National database of environmental radiation monitoring

Period 2016-2020

- Build and put in to operation the station and the rest in planning
- Consolidate the comprehensive and unified commissioning the entire network
- Continue investing in capacity building monitoring and analysis of the network ensure reasonable consistent uniform, mordern network monitoring & warning of advanced countries in the region Southeast Asia
- Concentrate investment in technical capacity of the network to support emergency response operations of nuclear power plants
- Further improve the national database on environmental radiation

2.3 Emergency Plan for Radiation Accident

2.3.1 Plans for radiation incident response

Organizations, individuals conducting radiation activities shall develop their plans for radiation and nuclear incident response.

Provincial People's Committee shall develop provincial plans for radiation and nuclear incidents response; the MOST shall provide guidance on planning and approving the provincial plans for radiation and nuclear incidents response.

The MOST shall collaborate with the Ministry of Industry, Ministry of Health, Ministry of Defense, Ministry of Public Security, Provincial People's Committees in which radiation facilities, nuclear facilities are operating and related organizations and individuals to develop nationals plans for radiation and nuclear incident response to submit to the Prime Minister for approval.

In advent of extremely severe incidents that may cause serious disaster, the emergency announcement and response plan shall be executed in accordance with the law on emergency.

2.3.2 Responsibilities of related organizations individuals in case of incidents

1. Responsibilities of organizations, individuals conducting radiation practices:
   - Mobilising forces and means within the facilities to overcome incidents, mitigate the out spread and consequences, conduct first-aid to injured persons, isolate the dangerous areas, and execute security control measures;
   - Providing information, documents and supports for remedy and investigation of the cause of the incident.
2. Responsibilities of the agencies, organizations, superior to the organizations, individuals conducting radiation activities:
3. Responsibilities of Province People's Committees:
4. Responsibilities of the Ministry of Science and Technology:
5. Responsibilities of the National Committee for Search and Rescue:
6. Responsibilities of the Ministry of Defense:
7. Responsibilities of the Ministry of Public Security, The Ministry of Foreign Affairs, The Ministry of Public Health, related organizations, individuals.

2.3.3 Training and Practical Exercises

Medical response in the case of Radiological Emergencies:

- Training – about 50 hours every year for pre-hospital radiation emergency response team
- Exercises – Each Team consists about 12-15 responders and has Lectures and Practical exercises every three months
- Drill – often have one radiation emergency drill on-site per year with different scenarios.

National Training Course of Front Line Control with practical exercises for detection and response in the case of illicit trafficking and incident/accident on import/export control.

Drill/Exercises for VINATOM and Hanoi local officials: missing sources accident.

Improved DNRR Emergency Plan: include fresh fuel transportation for conversion program.

2.4 Radiation Safety Management in Radioactive Waste Management

2.4.1 Radioactive Waste Management

Radioactive waste in Vietnam is generated by research, industry, medical applications, research reactor operation and radiopharmaceutical production. Naturally occurring radionuclides (NORM) and technologically enhanced naturally occurring radioactive materials (TENORM) are produced in Vietnam by the mining, mineral sands processing and other resources sectors. Vietnam has no nuclear power plants.

So far, Vietnam has no national used radioactive sources and radioactive waste storage facility There are four largest RWM facilities, they belong to nuclear or radiation facilities in Vietnam:

1) The system for RWM at the DNRI (Dalat Nuclear Research Institute)

DNRI is responsible for the management of radioactive waste at the national level in Vietnam, and collects, transports, treats, conditions, and stores radioactive waste generated from operations from radiation facilities in the South of Vietnam. In order to carry out this mission, DNRI has employed a system for radioactive waste management based on the former USSR regulations valid since the beginning of the 1980s. This system was renovated and modified during the years of 1995-1997 by IAEA TC projects and national projects. After conditioning, the waste drums are stored in building #5 (radioactive storage building).

The Institute generates a total of about 100-150 m^3 of radioactive liquid waste and around 5 m^3 of dry and wet solid radioactive waste each year, mainly from reactor operation and radioisotopes production activities.

The system for radioactive waste management at DNRI consists of 2 main buildings:

- The radioactive liquid waste treatment station is located underground at minus 4 m, and includes storage tanks, an evaporation system (currently installing), and a distilled water system. There are also two Laboratories, and a control room on the ground floor.
- An interim storage building (referred to as Building #5) has a compaction system, and eight concrete cells for storage of compacted solid waste and used radioactive sources.

Figure 9: An interim storage building in Dalat Nuclear Research Institute

2) The Interim Storage Facility at the Institute for Technology of Radioactive and Rare Elements (ITRRE) at Phung, Hanoi City;

In this facility, all radioactive waste from research activities of ITRRE, mainly from uranium, rare - earth ore processingare are collected, classified, treated and stored in interim storage. There are 733 reinforced 200l drums.

Annually 3 month, the environmental radioactivity monitoring are carried out by radiative officer of ITRRE to ensure the radioactive safety for worker and surrounding areas.

Figure 10: The RWM facility at Phung, Hanoi (inside)

3) The sealed sources store at Luong son, Hoa binh, (40km from Hanoi)

It was constructed in 1983. The used sealed sources and standard sources using in the geological and industrial areas are stored in the reinforced concrete pits

Figure 11: The sealed sources store at Luong son, Hoa binh

4) The sealed sources store in Institute for Nuclear Science and Technology (INST) (Hanoi)

This facility stores used radioactive sources from research activities of INST and other radioactive facilities in the North of Vietnam

5) The sealed sources store in NEAD (be long to VINATOM) – 140 Nguyen Tuan street – Hanoi.

It was constructed in 2003 and in operation in 2004. It stores about 250 used sources, from other radioactive facilities, activity total: 43.69 Ci (21/6/2010) (the data from VARANS, July, 2013)

2.4.2 Site selection for Low Level Radwaste Central Facility

On the 3rd of January 2006, the Prime Minister has approved the Strategy for Peaceful Uses of Atomic Energy up to 2020 in Vietnam. According to that, Vietnam will set up the first nuclear power plants in 2020 year. Site selection for low level radioactive waste repository is essential task for activities in the fields of atomic energy and for NPP in future. Official studies on meteorological, geological and hydrogeological conditions of Vietnam show that on the territory of Vietnam, the only Coastal Region of South-Central Area might be considered as relevant and the most suitable region for construction of the future national near surface disposal facility of low and intermediate levels radioactive wastes.

There are 3 most suitable candidate sites: Tu Thien village, Son Hai village, Ninh Phuoc district and Thai An village, Ninh Hai district, Ninh Thuan Province. They are near the site for building of the first nuclear power plant .

IV. Contributors

Australia

Mr. Lubi Dimitrovski
Australian Nuclear Science & Technology Organisation (ANSTO)

Ms. Lynn Tan
Australian Nuclear Science & Technology Organisation (ANSTO)

Bangladesh

Dr. M. Moinul Islam
Bangladesh Atomic Energy Commission (BAEC)

China

Dr. Zhang Jintao
China National Nuclear Corporation (CNNC)

Indonesia

Dr. Syahrir
National Nuclear Energy Agency of Indonesia (BATAN)

Japan

Prof. Toshiso Kosako
The University of Tokyo

Mr. Akira Suzuki
Tokyo Electric Power Company

Dr. Hideki Harano
National Institute of Advanced Industrial Science and Technology (AIST)

Mr. Hiroyuki Murakami
Japan Atomic Energy Agency (JAEA)

Mr. Seiichi Kudo
Mitsubishi Heavy Industries, Ltd

Dr. Shouji Futatsugawa
Japan Radioisotope Association (JRA)

Ms. Takako Shiraki
Mitsubishi Heavy Industries, Ltd

Dr. Takatoshi Hattori
Central Research Institute of Electric Power Industry

Dr. Takeshi Iimoto
The University of Tokyo

Mr. Teruyoshi Iizuka
Toshiba Corporation

Mr. Tomohiro Kuroki
Fuji Electric Co., Ltd.

Mr. Toshiharu Miyakawa
Japan Nuclear Fuel Limited (JNFL)

Dr. Yuji Matsuzoe
Fuji Electric Co., Ltd.

Malaysia

Dr. Mohd Abdul Wahab Yusof
Malaysian Nuclear Agency (Nuclear Malaysia)

The Philippines

Ms. Maria Visitacion B. Palattao
Philippine Nuclear Research Institute (PNRI)

Thailand

Ms.Nanthavan Ya-anant
Thailand Institute of Nuclear Technology (TINT)

Mr. Sutat Thiangtrongjit
Thailand Institute of Nuclear Technology (TINT)

Vietnam

Dr. Le Ba Thuan
Vietnam Atomic Energy Institute (VINATOM)

Ms. PHAM Thi Quynh Luong
Vietnam Atomic Energy Institute (VINATOM)

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5-18-7, Shinbashi, Minato-ku, Tokyo, Japan
Tel: +81-3-5470-1983　Fax: +81-3-5470-1991　Email:fnca@fnca.mext.go.jp