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GOVERNMENT OF INDIA

AERB SAFETY GUIDE

INDUSTRIAL RADIOGRAPHY

ATOMIC ENERGY REGULATORY BOARD

AERB SAFETY GUIDE NO. AERB/RF/SG/IR

INDUSTRIAL RADIOGRAPHY

Atomic Energy Regulatory Board
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FOREWORD

The Atomic Energy Regulatory Board (AERB) was constituted in 1983, to carry out certain regulatory and safety functions envisaged under Section 16, 17 and 23 of the Atomic Energy Act, 1962. AERB has powers to lay down safety standards and frame rules and regulations with regard to the regulatory and safety requirements envisaged under the Act. The Atomic Energy (Radiation Protection) Rules, 2004, provides for issue of requirements by the Competent Authority for radiation installations, sealed sources, radiation generating equipment and equipment containing radioactive sources, and transport of radioactive materials.

With a view to ensuring the protection of occupational workers, members of the public and the environment from harmful effects of ionizing radiations, AERB regulatory documents establish the requirements and guidance for all stages during the lifetime of nuclear and radiation facilities and transport of radioactive materials. These requirements and guidance are developed such that the radiation exposure of the public and the release of radioactive materials to the environment are controlled; the likelihood of events that might lead to a loss of control over a nuclear reactor core, nuclear chain reaction, radioactive source or any other source of radiation is limited, and the consequences of such events, if they were to occur are mitigated.

The Regulatory documents apply to nuclear and radiation facilities and activities giving rise to radiation risks, due to the use of radiation and radioactive sources, the transport of radioactive materials and the management of radioactive waste.

Fig. 1 Hierarchy of AERB Regulatory Documents

The Safety Code(s) specify minimum safety requirements that are required to be complied with by utility organizations for facilities and activities. The Safety Standard(s) specify quantitative technical requirements on any particular aspect/ practice/ equipment. These include specific methods, specific formulae, particular empirical mathematical models, data libraries, computational aids and tools, standard graphs, curves and look-up tables etc. The Safety Guide(s) elaborate various requirements specified in Safety Code(s) and Safety Standard(s) and furnish recommended approaches for their implementation. Safety Manuals detail instructions/safety aspects relating to a particular application. Hierarchy of Regulatory Documents is shown in Figure 1.

The recommendations of international expert bodies, notably the International Commission on Radiological Protection (ICRP) and the International Atomic Energy Agency (IAEA) are taken into account while developing the AERB Regulatory safety documents.

The principal users of AERB regulatory safety documents are the applicants, licensees, and other associated persons in nuclear and radiation facilities including members of the public. The AERB regulatory safety documents are applicable, as relevant, throughout the entire lifetime of the nuclear and radiation facilities and associated activities. The AERB regulatory safety documents also form the basis for AERB's core activities of regulation such as safety review and assessment, regulatory inspections and enforcement.

The Industrial Radiography (IR) facilities / agencies are required to obtain licence from AERB under Atomic Energy (Radiation Protection) Rules, 2004 and other regulatory consents at various stages starting from design approval of radiography enclosure, source storage room approval, No Objection Certificate (NOC) for import or procurement of Industrial Radiography Exposure Devices (IRED), operation of the industrial radiography facility including transport of radioactive sources right up to the decommissioning of radiography equipment/facility and safe management of disused radioactive sources. For aspects not covered in this code, applicable national and international standards, codes and guides acceptable to AERB and applicable AERB safety directives should be followed. Non-radiological aspects of industrial safety and environmental protection are not explicitly considered in this code. Industrial safety shall be ensured by compliance with the applicable provisions of the Factories Act, 1948 and the Atomic Energy (Factories) Rules, 1996.

Safety related terms used in this Safety Code are to be understood as defined in the AERB Safety Glossary (AERB/GLO, Rev.1). The special terms which are specific to this Safety Code are included under section on 'Special Terms and Interpretation'. In addition, the terms already defined in AERB Safety Glossary AERB/GLO, Rev.1, and being used in this Safety Code with a specific context and which require interpretation or explanation are also included in this section.

This Safety Code has been drafted by an In-House Working Group (IHWG). The draft was further reviewed by a working group with specialists drawn from technical support organisations and institutions, and other consultants. The Comments obtained from stakeholders and experts have been suitably incorporated. The Safety Code has been vetted by the AERB Advisory Committee on Nuclear and Radiation Safety (ACNRS). AERB wishes to thank all individuals and organizations who have contributed to the preparation, review and finalization of this Safety Code.

D. Shukla.

(Dinesh Kumar Shukla)
Chairman, AERB

SPECIAL TERMS AND INTERPRETATION

Contract awarding party
The person / institution awarding contract to radiography agencies for carrying out radiography work.

Crawler Equipment
Self-powered remote-controlled equipment containing X-ray/gamma ray source, which can be introduced in a pipeline for radiographic inspection of welds.

Design
The process and results of developing the concept, detailed plans, supporting calculations and specifications for a nuclear or radiation facility.

Disused Source
A radioactive source that is no longer used or is not intended to be used, for the practice for which an authorization has been granted.

Field Radiography
Radiography operations carried out on shop floors, erection sites or other such areas, with provisions for adequate radiological safety for radiography personnel and others, including members of the public.

Industrial Radiography Exposure Devices (IRED)
An assembly of components necessary to make radiographic exposure such as an Industrial Gamma Radiography Exposure Device, an X-ray unit or a particle accelerator.

Industrial Radiography Installation
A radiation installation employed for industrial radiography operation. It can be either an open-field radiography site or an enclosed radiography installation.

Operator of radiography equipment
Operator is a person who is certified in compliance with the eligibility criteria as specified by AERB and is required to operate the industrial radiography Exposure Device as per written instructions and established standard operating procedures.

Pigtail
A short flexible cable/ metallic assembly connecting the source holder with the operating end of the drive cable in a remotely operated gamma exposure device.

Safety Interlock
A safety interlock is an engineered device for precluding likely exposure of an individual to ionising radiation, either by preventing entry to the controlled area or by automatically removing the cause of the exposure.

Shielding
Protective shielding in the form of attenuating material provided for radiological protection.

Source holder
Holder, or attachment device, by means of which a sealed source or simulated source can be directly included in the exposure container (category I apparatus), or fitted at the end of the control cable (category II apparatus).

Category-I
The exposure device which does not allow the source assembly to be moved out of the source housing, but causes exposure by opening a shutter and/or by moving the source assembly within the device.

Category-II
The exposure device in which the source assembly is driven out of its secured position in the source housing to an essentially unshielded position at its working position for radiography exposure, either mechanically, electrically, pneumatically or by other means by an operator at a distance away from the source housing. This type of exposure device using a remote control (remote control means a device enabling the source assembly to be moved to and from the exposure device to the working position by operation from a distance away from the exposure device) mechanism should also require source guide tube.

Category-X
Exposure devices for gamma radiography designed for special applications where the unique nature of the application precludes full compliance with the Safety Standard 'Testing and Classification of Sealed Radioactive Sources', [AERB/SS-3 (Rev-1)] issued by AERB. These are self-propelled intra-tubular gamma radiography exposure devices such as pipeline crawler and gamma radiography exposure devices for under-water use.

NOTE: Source holders may be an integral part of the source assembly or may be capable of being dismantled for sealed source replacement.

Sky-shine
Sky-shine is the radiation scattered by air molecules after emerging more or less vertically from the shielded enclosure with or without a ceiling.

X-ray Equipment
Equipment consisting of a combination of X-ray generator, X-ray tube and associatedequipment.

Note: Words and expressions used in this document and not defined, but defined in the Act, the Rules, and AERB Glossary shall have the meanings as assigned in the Act, Rules, and AERB Glossary.
Reader may also refer AERB Safety Code on 'Radiation Sources, Equipment and Installations' AERB/SC/RF and AERB Safety Glossary, No. AERB/GLO, Rev.1 forDefinitions of specific terms used in this Guide.

CONTENTS

1. INTRODUCTION

1.1 General

Radiation sources find many beneficial applications such as uses in medicine, industry, agriculture and research. Industrial Radiography (IR) is one of the most widely used non-destructive testing (NDT) methods for the examination of internal defects and discontinuities in materials and structures such as vessels, pipes, welded joints and castings. It is also a suitable technique for detecting changes in material composition and locating unwanted or defective components hidden in an assembled part.

The basic advantage of using industrial radiography technique arises from the fact that the objects to be examined can range in size and shapes from micro-miniature electronic parts to huge components of rockets / missiles or power plant structures. Further, the method can be used on a variety of materials, and no priorpreparation of the specimen surface is necessary, unlike other NDT methods. At the same time, ionising radiation sources, if not handled safely, may give rise to radiation risk resultingin an unacceptable health hazard to the radiation workers as well as to the members of public.

Industrial Radiography equipment utilizes either a high activity sealed source (tens of GBq to hundreds of GBq) housed in a shielded exposure device or radiation generating equipment (X-ray). The radiography gamma source remains shielded in the exposure device when not in use. The source is brought to exposed condition from its shielded position and retracted after desired exposure time, remotely by means of a flexible cable and a driving unit. The Industrial Radiography Exposure Device (IRED), commonly known as "radiography camera" typically consists of several components such as driving unit (often called as 'cranking unit') for remote operation of camera, radiography source (often called as 'source pigtail / pencil'), shielded housing of source, guide tube and adaptor. The design and operation of these components are interrelated.

Safety should not be compromised by using components that do not meet the design specifications. The radiation generating equipment normally employed in industrial radiography practice are conventional industrial X-ray devices (usually energy ranges from 70 keV to 450 keV) and accelerators (usually energy ranges from 4 MeV to 15 MeV).

Use of radiation sources in an unsafe manner entails health risk and hence it is essential that proper care is exercised throughout the life cycle of the radiography equipment i.e. manufacture, supply, installation, operation, maintenance, servicing and decommissioning.

Industrial radiography can be performed in a safe manner in accordance with the radiation safety requirements. However, experience also shows that certain incidents involving industrial radiography sources have resulted in high doses to workers, sometimes resulting in severe health consequences such as radiation burns.

Members of the public can also become innocent victims of radiation overexposures if radioactive sources used for industrial radiography are not properly handled. Contamination of people and the environment mayalso result from corroded or damaged sources. Due to the nature of the work, industrial radiography is often carried out under difficult working conditions, such as in confined spaces, difficult terrains, and extreme weather conditions. Working under such adverse conditions might pose a challenge to the principle of keeping doses as low as reasonably achievable. All of these aspects indicate that there is need to promote safety culture within theradiography institution to ensure that safety comes first.

1.2 Objective

This Safety Guide provides guidance to meet the relevant regulatory requirements prescribed inAERB Safety Code on 'Radiation Sources, Equipment and Installations' AERB/SC/RF, 2025, pertaining to industrial radiography by specifying relevant procedures andelaborating radiation safety requirements for design, procurement, commissioning, operation and decommissioning**.**

1.3 Scope

This Safety Guide provides guidance on compliance with the radiological safety requirements for regulated entities such as manufacturers, suppliers and users of radiography equipment. This Safety Guide does not deal with radiographic techniques for Non Destructive Testing (NDT) and safety aspects related to neutron radiography or underwater gamma radiography, which are practiced rarely in public domain.

The use of radiation for the inspection of baggage, mail, cargo, vehicles, food items, and other such detection purposes is excluded from the scope of this Safety Guide as it is covered in Safety Guide on 'X-Ray Generating Equipment Used for Research Education Inspection and Analysis', AERB/RF/SG/XGE. The Safety Guide (AERB/RF/SG/XGE) also covers self-shielded (cabinet type) X-ray based industrial radiography equipment.

This Safety Guide does not elaborate on the specific measures required for ensuring security of radiography sources all the time. For this purpose, AERB Safety Guide on ‘Security of Radioactive Sources in Radiation Facilities’ AERB/RF-RS/SG-1 and AERB Safety Guide on ‘Security of Radioactive Material during Transport’, AERB/NRF-TS/SG-10 should be followed.

2. RADIATION PROTECTION AND SAFETY

2.1 General

Dose rates from IRED sources are of the order of hundreds of mGy/h or more at one meter distance from the source. Direct exposure to sources at close distances should be avoided. Workers using such sources must ensure adequate protection to minimise doses arising from accidental exposures and unsafe work practices. Safe work practices will protect not only the individual worker but also others in the vicinity and the public from serious consequences arising from the loss or uncontrolled use of these sources.

Licensee is responsible for the establishment and implementation of the radiation protection programme to ensure protection and safety and for compliance with the regulatory requirements. The licensee has overall responsibility for radiation safety and verifying that industrial radiography work is carried out in accordance with regulatory requirements. Licensee should ensure that procedures are developed for the protection of workers, public and the environment, and for ensuring that doses are kept below the prescribed dose limits (Appendix 1). All policies and procedures with regard to protection of people and safety of sources should be documented, and should be made available to all staff. It should also be made available for verification during regulatory inspection. The radiation protection and safety principles apply to the design, manufacture or construction, operation, maintenanceand decommissioning of radiography equipment, fixed radiography installation and transport of radiography camera incorporating sealed sources for industrial radiography.

2.2 Justification

It is to be ensured that any practice or the activity involving exposure to radiation produces sufficient benefit to society in comparison to harm or damage it causes. The use of radiography sources for industrial radiography purposes brings substantial benefitsto society, by providing a method of assessment of the integrity of industrial equipment e.g. vessels, industrial boilers, pipelines, etc., offsetting any harm that may result from exposure to radiation, and is more suitable than other conventional methods.

2.3 Optimization

The licensee should ensure that radiation exposures to workers, public and environment are kept As Low As Reasonably Achievable (ALARA), economic and social factors being taken into account. Licensee should ensure that procedures are in place for the protection of radiography personnel (RSO, Radiographer and Intern), auxiliary staff, the public and the environment. Licensee must also ensure that the dose limits are not exceeded.

Optimization is achieved through (i) in-built safety i.e. design safety features and (ii) operational safety requirements. The optimization process should also consider minimizing the number of individuals exposed and magnitude for likelihood of potential exposure i.e. the principle of as low as reasonably achievable (ALARA) to be followed. The radiation protection measures should be as per the need of radiography institution.

2.4 Dose Limits

Licensee should ensure that the exposure to radiography personnel / worker or public due to the industrial radiography practice is so restricted that neither the effective dose nor the equivalent dose to tissues or organs exceeds the dose limits prescribed by AERB from time to time. It is to be ensured that radiation doses to individual radiography personnel are assessed on a regular basis (monthly). The dose limits prescribed by AERB is mentioned in the **Appendix-1**

2.5 Management for Safety

The management structure of the institution, policies, responsibilities, procedures and arrangements should be in place to control radiation hazard, to optimize radiation protection measures, to prevent/reduce exposures, and to mitigate the consequences of incidents associated with industrial radiography practice. The management system also has to ensure promotion of safety culture, regular assessment of performance and the application oflessons learned from experience including any unusual occurrences. A safety committee should be constituted by the facility, with RSO as one of the member, to review the operational safety of the facility, quality assurance and regulatory compliance on a continual basis.

The following should be ensured for establishing Radiation Protection Programme in the institution during normal operation, maintenance, decommissioning, and in emergency situations:

(i) the radiation exposure of both workers and the public is kept As Low As Reasonably Achievable (ALARA) principle;

(ii) the radiation exposure of both workers and the public is kept below the relevant dose limits prescribed by AERB time to time.

(iii) the probability of events giving rise to significant exposures and the magnitude of such exposures are kept as low as reasonably achievable.

A safety culture is fostered and maintained among all workers involved in the industrial radiography facility. This is necessary to encourage a positive attitude towards protection and safety and to discourage complacency / negligence.

In order to achieve overall safety during the handling of radiation sources used for Industrial Radiography, an effective management system should be in place so that the safety requirements, which include health, human performance, quality, protection of the environment, security, promotion of safety culture, assessment of safety performance and lesson learned from experience, are fulfilled.

The radiography institution, through its management should establish and implement technical and organizational measures to ensure protection and safety for handling radiography equipment. Organizational and technical measures should include the following:

(i) The licensee should have overall responsibility for overseeing radiation safety, and that industrial radiography is carried out in accordance with the regulations.

(ii) A good safety culture should be promoted by the management and workers' attitude, to foster a safe approach to the performance of the work

(iii) A Radiation Protection Programme (RPP) should be developed, documented and implemented. The RPP should include information on the radiation protection arrangements, the safety assessment, the measures to implement the arrangements and the mechanism for the review and updating the arrangements

(iv) A quality management system, which defines the responsibilities of all relevant persons, details the requirements of the institution, personnel and equipment, should bedeveloped, implemented, assessed and continually improved. It should be ensured that suitable facilities and equipment are available to enable radiography to be carried out safely. In particular, radiography equipment should incorporate all the relevant safety and warning features. An adequate number of radiography personnel (there should be atleast one industrial radiographer for each industrial radiography equipment in operationper shift) and assistants, should be available and provided with appropriate radiation monitoring equipment to enable the work to be carried out safely and effectively.

3. DESIGN OF RADIATION SOURCES, EQUIPMENT AND INSTALLATION

3.1 General

This chapter is useful for the users for understanding the design safety aspects of radiation sources, radiography equipment and radiography installations. Different kinds of radiation sources and exposure devices are widely used for carrying out industrial radiography work. It should be ensured that the design of these are approved by AERB. Exposure devices or radiation source used for industrial radiography should be purchased only from manufacturer/supplier authorized by AERB. In case of transfer by sale or otherwise of exposure devices, prior approval from AERB is mandatory. It should also be ensured that safety accessories such as guide tube, driving unit, control cable for X-ray machine etc. are supplied by the original equipment manufacturer (OEM) or those that meet the regulatory requirements.

Radiography installations are either a shielded enclosure or an open site where field radiography is carried out. The operation of the installations should be done based on different safety parameters such as type of radiation source (radionuclide / radiation generating equipment); source strength (maximum activity / maximum output of radiation generating equipment); energy of radiation emitted by the radionuclide / radiation generating equipment; material used for shielded enclosure; dimension of the enclosure / space available for field radiography work etc. The design of the installation should be planned by a radiationsafety professional such as RSO in Industrial radiography.

3.2 Sealed Source

Gamma radiography should be carried out using only sealed sources that meet national/ international standards as detailed in subsequent paragraph.

The manufacturer should provide a recommended working life (RWL) for a sealed source, which is an indication of the period of time over which the source assembly may be expected to retain its integrity. It is recommended to discontinue the use of the source beyond its RWL. However, user may use it further subject to certification by the original source manufacturer or any other agency recognized by AERB for this purpose.

3.2.1 Encapsulation

The sealed source should comply with the Safety Standard ‘Testing and Classification of Sealed Radioactive Sources’, [AERB/SS-3 (Rev-1)] issued by AERB or equivalent International Standard (ISO-2919). The supplier of the source should demonstrate compliance with the test requirements as specified in AERB/SS-3 (Rev-1) or equivalent standard.

The radiography sealed source should meet the requirements of:

(i) ‘special form’ radioactive material;

(ii) Leak-test in accordance with the national / international standard (e.g. ISO 9978) and have a valid leak-test certificate that is traceable to each individual source.

Sealed sources used for industrial radiography are normally part of a source assembly (often called a ’pig-tail‘). The Source assemblies should be as per AERB standard AERB/RF- IR/SS-1 (Rev.1) or ISO-3999.

3.2.2 Encapsulation Material

The materials used for encapsulation should be so chosen that the material remains unaffected by ionising radiation and the conditions in which it is expected to be used. The encapsulation material should be physically and chemically compatible with the radioactive material. Generally stainless steel (SS-316L) is used as encapsulation material.

3.2.3 Contamination Test

The manufacturer should carry out surface contamination test for each sealed source before supply. This test should be in accordance with AERB/SS-3 (Rev.1). If the detected activity, after conducting the test is less than 185Bq (5 nCi), the sealed source is considered to be free from surface contamination.

3.2.4 Source Identification

The connector end of the source assembly should have serial number, symbol of radionuclide, radiation trefoil sign, serial number and manufacturer’s name or logo. Wherever possible, the source capsule should be marked with the radiation trefoil sign and a legend “RADIOACTIVE”. Marking of the capsule / source assembly should be done prior to the loading of the sealed source. The marking should be legible and durable.

3.3 Source Housing

The sealed source is housed in a specifically designed exposure device that incorporates safety features designed to reduce the risk of human error or equipment malfunction. Source housing can be either an industrial radiography exposure device or source changer. The industrial radiography exposure devices should be capable of remote operation and control and their design should comply with the Safety Standard titled ‘Industrial Gamma Radiography Exposure Devices and Source Changers’, [AERB/RF-IR/SS-1 (Rev.1)] issued by AERB or international standards. Only an industrial radiography exposure device or a source changer which has valid design approval from AERB, should be sold, procured and used, with prior consent of AERB.

3.3.1 Shielded Source Housing

The radiography camera is classified as portable, mobile and fixed, depending on its overall weight as specified in AERB/RF-IR/SS-1 (Rev.1). Mostly portable and mobile type of radiography cameras are being used. Shielding provided by the source housing should be such that when the control mechanism is securely locked in 'OFF' condition and a radiography source of maximum rated activity is in the housing, the leakage radiation outside the housing should not exceed the levels given in Table-3.1, which is reproduced from AERB/RF-IR/SS-1 (Rev.1). In order to establish compliance, the radiation level at a distance of 5 cm from the surface of the radiography camera should be measured over an area of 10 cm^2 with no linear dimension greater than 5 cm. At 1 meter, the area of measurement should not be more than 100 cm^2 with no linear dimension greater than 20 cm.

TABLE 3.1: LIMITS ON LEAKAGE RADIATION LEVELS

Class of Radiography Camera	On the External Surface of Source Housing (mSv/h)	At 5 cm from External Surface of Source Housing (mSv/h)	At 100 cm from External Surface of Source Housing (mSv/h)
Portable (upto 30 kg weight)	2	0.5	0.02
Mobile	2	1.0	0.05
Fixed	2	1.0	0.10

For a source changer the maximum radiation level on the external surface is 2 mSv/h and the corresponding limit at 100 cm is 0.1 mSv/h.

Source housing should be so designed as to serve also as transport package. The activity limits for transport of radioactive material in a Type-A package for some selected radioactive sources in special form are given in Table 3.2. The source housing should comply with the applicable design requirements for Type-A package, provided activity limit does not exceed as given in Table 3.2, which is reproduced from AERB/NRF-TS/SC-1 (Rev.1). Otherwise it should be designed as a Type-B (U/M) package as specified in the requirements for the safe transport of radioactive material.

TABLE 3.2: ACTIVITY LIMITS FOR SPECIAL FORM RADIOACTIVEMATERIAL PERMITTED IN A TYPE A PACKAGE

Radionuclide	Activity Limit in TBq
^{60}Co	0.4
^{75}Se	3.0
^{170}Tm	3.0
^{192}Ir	1.0

In addition to the permanent marking affixed by the manufacturer, as specified in AERB/RF-IR/SS-1 (Rev.1), the licensee should affix on each radiography camera a, legible, and clearly visible label displaying:

(i) chemical symbol of the radionuclide in the radiography camera,

(ii) activity and the date on which this activity was measured,

(iii) radiation symbol (trefoil symbol),

(iv) serial number of the radiography camera provided by the manufacturer, and

Similarly, the licensee should affix on each source changer a durable, legible, and clearly visible label displaying:

(i) number of sources, chemical symbol and mass number of the radionuclide(s) in thesource changer,

(ii) activity and the date of measurement for each source,

(iii) manufacturer of the sealed source(s),

(iv) radiation symbol (trefoil symbol),

(v) serial number of the source changer, and

Many radiography cameras and source changers use depleted uranium (DU) as shielding material that is radioactive, which means that even when 'empty' (i.e. not containing a radiography source), these types of containers need to be stored safely and accounted for. Radiography institutions should therefore identify their cameras / containers which contain depleted uranium and ensure that these cameras / containers are durably marked to identify the above fact. Further safe management of empty radiography cameras or source changers containing DU should be done with prior approval of AERB.

3.3.2 Locking of source in the housing

It is to be ensured that locking mechanism is available in the radiography camera and the source changer to prevent unauthorized operation, and that it should not be possible to operate the lock of the camera unless the source or the source assembly is in fully shielded position. The locking mechanism should be such that it should not be possible to remove the source from the camera without having knowledge on proper coupling of cranking unit and guide tube and appropriate position of the "lock" in the camera, and also the source cannotbe removed from rear-end (connector end of the pigtail) of the camera.

3.3.3 Radiation Warning Sign

The source housing should be clearly and permanently marked with radiation warning sign on the outer surface of the Industrial radiography exposure device and source changer. The radiation symbol for radioactive source is different from X-rays. Therefore, correct radiation symbol should be chosen depending upon the type of radiation source. The trefoil with central circle should be used as radiation symbol with 'CAUTION RADIOACTIVITY' as Warning sign for radioactive sources. The equilateral triangle radiation symbol with 'CAUTION-X-RAY' as the warning sign should be used for X-ray sources. Specification of radiation symbol and warning sign is provided in the safety directive issued by AERB, which is reproduced in Appendix-2.

In addition, for radioactive source based radiography equipment, a warning message is to be fixed on the device and a stainless steel tag is to be tied to the device. The specifications of warning message and stainless steel tag are given in Appendix-3.

3.4 Design of Radiation Equipment

Manufacturer/supplier of radiography equipment should ensure that design/type approval of the equipment is obtained from AERB prior to its supply. Applicant should ensure that radiography equipment have necessary design approval from AERB prior to its procurement.

3.4.1 Design compliance of Radiation Equipment

The design philosophy of the radiation equipment should be based on the principle of defence in-depth. There should be multiple levels of safety systems in the radiation equipment to prevent any undue exposure to workers and members of public.

Design of industrial gamma radiography exposure devices should meet the requirements specified in AERB/RF-IR/SS-1 (Rev.1) or equivalent international standard (e.g. ISO-3999). Design of Industrial X-ray machines or accelerators for industrial radiography purpose should meet the requirements of relevant national/international standards. Conformity of the Industrial X-ray machines or accelerators with national or international standard on electro- mechanical compatibility should be established and authenticated document (such as CE certification, IEC or equivalent) in this regard should be provided to AERB during design approval of the device as well as to the end user of the machine. Wherever feasible the CE or equivalent marking should be conspicuously displayed on the machine.

(i) X-Ray Equipment:

Radiation generating equipment consists of X-ray tube(s) housed under adequateshielding, electrical cable and control panel. Mostly two types of X-ray tube assemblies (also called tube heads) are in use; those for performing panoramic (radial beam) exposures and those for performing directional exposures. The tube assembly is connected by cable to the control panel, which provides the means for activation and operation of the X-ray equipment, and for the pre-selection and indication of operating parameters. The dose to the radiography personnel can be affected by the cable length, operating parameters and the tube assembly. The design of X-ray equipment should be such that:

a) The X-ray tube should be contained in a housing that provides shielding from radiation in all directions other than the useful beam direction. The protective tube housing should be so constructed that the stray radiation in any direction should not exceed 10 mGy/h at a distance of 1 meter from the X-ray target, with the beam portal shielded adequately with the tube operating at its maximum rating.

b) A key switch should be fitted to the X-ray control panel to prevent unauthorized use. The key should be removable only when the switch is in the ‘OFF’ position. The function of the key switch and its ‘ON’ and ‘OFF’ positions should be clearly marked on the control panel.

c) X-ray ‘ON’ and ‘OFF’ control should be physically separate from the key switch. Their functions, and the beam ‘ON’ and ‘OFF’ status, should be clearly markedon the control panel.

d) There should be separate provision to terminate radiation generation automatically after pre-set time and manually at any time.

e) A red or amber indicator lamp should be provided on the control panel and should get automatically illuminated when the X-ray tube is energised. This type of indicator lamp should also be provided on the X-ray tube housing and should be visible from a distance of at least 10 meter. An interlock should be provided such that if either of the ‘beam ON’ indicator lamp fails, then the X-ray tube cannot be energised.

f) The control panel should be equipped with a device or devices indicating the X-ray tube potential (kVp), current (mA), duration of exposure and X-ray beam status. Energising the X-ray equipment should be key-controlled to prevent unauthorised use. For equipment that is used for open field radiography, the values indicated should be clearly visible in bright sunlight.

g) The length of cable connecting the control panel with the X-ray tube should meet the specifications given in Table 3.3 unless the X-ray equipment is located in an adequately shielded radiography enclosure and operated from outside.

TABLE 3.3: LENGTH OF CABLE FROM CONTROL PANEL TO X-RAYTUBE AS A FUNCTION OF TUBE POTENTIAL

Tube potential of the X-ray Unit	Minimum Length of the Cable from the Control Panel to the X-ray Tube (m)
Up to 100 kVp	7
Up to 200 kVp	10
Up to 250 kVp	15
More than 250 kVp	20

h) An X-ray equipment that is used for fluoroscopy (real time radiography) should be shielded such that the stray radiation level at any position that can be occupied by a person does not exceed 10 μSv/h.

i) Directional X-ray tube assemblies should, wherever practicable, be fitted with collimators (also called ‘cones’ or ‘diaphragms’) to limit the beam size. The equipment should incorporate beam filters to enable the filtration to be matched to the work being undertaken.

Some X-ray equipment emit very short pulses of X-ray radiation, and the exposure duration is set in terms of the number of pulses required for the exposure. Such flash X-ray units are often small, portable, battery driven units used for the radiography of low density or very thinwall thickness items. Large, static flash X-ray units are sometimes used in shielded facilities where a high output and an extremely short exposure time are required. The same precautionsthat are used for regular X-ray equipment should be used along with additional safetyprecautions as determined by the safety assessment, if any by the manufacturer. For the measurement of radiation level around x-ray equipment, ionisation chamber based radiation survey meter with integrated mode option should be used.

(ii) Accelerator Equipment:

Accelerators such as Betatron and Linear Accelerator, are being used in industrial radiography, generate high energy X-rays up to 15 MV. The dose rate in the main beam of an accelerator normally range from 50 mGy / min to 40 Gy / minute at a distance of 1 meter. Hence comprehensive control measures are needed to restrict the exposure to the radiography personnel and members of the public.

The design of the Accelerator should be such that:

a) It meets the requirements of relevant current national and/or international standards.

b) Protective housing should be so constructed that the stray radiation at any direction other than the primary beam direction should not exceed 0.5% of the primary output at a distance of 1 meter from the target when the accelerator operates at its maximum energy and Pulse Repetition Frequency (PRF) with the beam portal shielded adequately.

c) Key-controlled system should be provided on the control console to prevent unauthorised use.

d) The beam limiting system of a portable/mobile accelerator equipment meant for use on shop floor or elevated locations should restrict the primary beam divergence to a cone of not more than 30° apex angle.

e) An emergency push button should be prominently located on the control panel to stop the radiation generation in case of an emergency.

f) The high energy accelerator generating X-rays should also meet the requirements as specified in subsection 3.4.1.1 (ii) to (vii)

(iii) Crawler Equipment:

Crawler equipment is used generally to radiograph welds on pipelines. The machines carry either an X-ray tube assembly or a gamma source on a mobile carriage that crawls along inside the pipe. The crawler is activated and controlled from outside the pipe by using a control source. This normally consists of a low activity ^{137}Cs sealed source mounted in a hand-held device and collimated. Radiation from the control source is received by a detector on the crawler. The container used for transporting the radioactive source should meet the requirements of a Type-A package. In addition, the radiation level at 5 cm from the surface should not exceed 0.5 mSv/ and the radiation level at 1 meter from the surface should not exceed 0.02 mSv/h. There should be proper mechanism to bring the source to 'ON' condition and the source should not come to 'ON' condition unintentionally.

As crawler equipment uses gamma or X-ray source for radiography purposes, it should comply with the following requirements in addition to the requirements specified for X-ray equipment and radiography cameras (in case of gamma crawler)in this guide:

a) There should be a provision for external indication of the crawler location in a pipeline.

b) There should be a provision to prevent exposure when the external position indicator fails to function as intended.

c) It should shut 'OFF' automatically in the event of any malfunction during use; that is, X-ray crawler should switch off the beam and the gamma source should retract to shielded position.

d) The crawler should have a provision of warning, such as horn fitted to it such that after the crawler has reached the exposure position, it should automatically sound a warning for a period of 10 seconds immediately, prior to the commencement of the exposure. While the exposure is taking place, the horn should continue to operate in a manner that is distinguishable from the 10 seconds warning.

e) The warning sound should be loud and distinctive enough to be heard clearly above all other noise sources in the vicinity of the crawler.

f) An X-ray crawler, for which exposures are initiated by remote control or by an automatic device such as a trip wheel, should have a safety device fitted to it which prevents the remote control or the automatic device from initiating an exposure unintentionally.

g) An X-ray crawler should incorporate a safety device which disconnects power from the propulsion unit in the event of a malfunction during operation.

(iv) Servicing and Maintenance:

In case of radiography exposure devices-

a) Inspection and routine maintenance of radiographic exposure devices should be done at intervals not exceeding 6 months. Replacement components should meet design specifications. If the equipment is found malfunctioning, the same should be removed from use until repaired.

b) Each licensee who uses a sealed source should have the source tested for leakage at intervals not exceeding 12 months.

c) Each exposure device using depleted uranium (DU) shielding should be tested for DU contamination at intervals not exceeding 24 months.

d) Servicing and maintenance of devices should be done by the persons trained and certified by the original equipment manufacturer.

3.4.2 Fail-Safe Mechanism

Wherever X-ray based radiography equipment is controlled by electrical / mechanical / pneumatic system, it should be so designed that in the event of a breakdown or malfunction of the actuating force, or in the event of undesirable conditions the equipment should attain safe situation and should continue to remain so, even if the desired condition is restored, until the appropriate mechanism is operated from the control panel.

3.4.3 Safety Interlocks

Wherever radiography equipment, is controlled by electrical / mechanical / pneumatic system, it should be so designed that undesirable safety situations can be prevented by suitable safety interlock systems as enunciated below:

(i) It should not be possible to lock the exposure container unless the source assembly is inthe secured position.

(ii) For a category II exposure container, it should not be possible to release the source assembly from the secure position unless a secure attachment is made between the control cable and the source assembly, between the control-cable sheath and the exposure container, and between the projection sheath and the exposure container.

(iii) For an exposure container using a remote control, it should not be possible to completely detach the remote control unless the source assembly is in the secured position.

The apparatus should be so designed that it is possible for the operator to determine if the source holder is in the secured position from a distance of at least 5 meter. If these indicationsare on the container, they should be clearly recognizable at a distance of 5 meter in the direction of the attachment of the remote control in normal conditions of use. If colours are used, then green should indicate that the source holder is in the secured position and red should indicate that the source holder is not in the secured position. Colours should not be the sole means of identification. All indications shall be clear and reliable.

(iv) It should be possible to connect or disconnect the source assembly from the end of the control cable without use of any tool.

(v) The remote control should have a stop on the control cable to prevent loss of control and disengagement of the cable from the remote control.

3.4.4 Emergency control mechanism

(i) The industrial radiography X-ray machine should have provision of emergency stop button/switch on the control panel. The function of emergency stop button/switch is to de-energize the X-ray beam in case of emergency situation, such as radiography person entering the cordoned area when the radiographic exposure is in progress.

(ii) The provisions given in para 3.4.4(i)1 are applicable to Betatron when used in field radiography. When Linear accelerator or Betatron is used inside a radiography enclosure, a suitable warning signal should be provided to alert the person inside the enclosure that exposure is about to commence. Emergency stop buttons or pull-cords with manual resets should be installed to enable the person within the shielded enclosure to terminate the operation of the exposure device. The emergency stop buttons and pull-cords should be so located that they can be reached without passing through the primary radiation beam. They should be labelled with clear instructions/legend on their use.

(iii) When radiation generation is stopped, either by breaching an interlock or by action of emergency stop button, it should not be possible to restart the radiography equipment unless the radiography exposure control is reset manually.

3.4.5 Conventional safety

The conventional safety may have implications on radiation safety therefore the design of the radiography equipment should comply with the conventional safety requirements such as those applicable to mechanical, electrical, fire and environmental, to prevent danger and / or personal injury. Electrical safety may contribute to radiation safety, since electrical faults in x-ray generators can result in accidents, with possible radiological consequences. The application while applying for obtaining “No Objection Certificate” or “Type Approval” of radiography equipment should be accompanied by appropriate certificates complying conventional safety as applicable. International organisations giving conventional safety standards are International Standards Organizations (ISO), International Electrotechnical Commission (IEC) etc. Certificates based on National standards such as Bureau of Indian Standards (BIS), or International standards should be provided in support of application to obtain ‘NOC’ or Type Approval of radiography equipment.

3.5 Shielded Enclosure

A shielded enclosure is an enclosed space designed to provide adequate shielding from ionising radiation to persons in the vicinity. It should incorporate engineering controls to prevent or to minimize the potential exposure of persons who might enter the enclosure when the sources are exposed or energized.

Industrial radiography should be carried out in shielded enclosure(s) unless the nature of work is such that it has to be carried out in an open field. A properly designed and constructed enclosure should be used for radiography work, with appropriate safety systems and warnings, which are regularly tested and maintained. Such an enclosure can be very effective in preventing incidents / radiological emergency and keeping radiation doses as low as reasonably achievable. A shielded enclosure should be designed to take account of the radiation sources that are to be used, and the work that is to be carried out. Design of the enclosure should take account of immediate and foreseeable future needs before commencingconstruction.

Design approval of the enclosed installation should be obtained from AERB before its construction. Radiation protection survey should be performed by the RSO to verify shielding adequacy of the enclosure and approval for the routine use of the enclosed installation should be obtained from AERB.

For introducing any changes in the approved design of the enclosed facility, prior approval from AERB should be obtained. Typical layout drawings of shielded enclosures are given in **Annexure -1**.

3.5.1 Structural Shielding

The radiography installation, requiring shielded enclosure, should provide adequatestructural shielding for walls/doors, ceiling and floor so that the radiation levels outside the shielding do not exceed the annual dose limits or any other regulatory constraints for occupational workers and general public. In case of open top enclosed radiography installations, the scattered radiation (including air scatter i.e. sky-shine should also be considered and necessary measures should be implemented to minimize the exposure).

Following are some important design aspects of radiography enclosure:

(i) The design of the shielded enclosure includes installation and its surroundings. The drawing should include dimensions, as well as the thicknesses, densities and types of shielding materials on all sides, above and below the exposure area. Entrances should be identified and distances to potentially occupied areas adjacent to, above, and below the exposure area should be indicated, including information on the workload, use factor and occupancy factor (i.e. the frequency, and the average duration that a person stays in an area).

(ii) Direct radiation exposure and scatter arising from the operation of shielded enclosures should be limited by adequate shielding. A comprehensive calculation of the required thicknesses requires the use of detailed radiation attenuation data for the relevant shielding material, and the assistance of a suitable expert / RSO may be needed in carrying out these calculations.

(iii) The radiography enclosure for housing of radiography equipment (i.e. radiography camera / X-ray equipment / accelerators) should be in a location where the occupancy is as low as practicable and should be located in industrial area. The enclosure should not be located in residential areas and commercial complex. The exposure controlling system for the radiography equipment /X-ray equipment / accelerator should be located outside the exposure room. Identification of each control should be distinct and unambiguous.

(iv) Some openings of the shielding will be necessary for personnel entry and exit points; cranes to place and remove heavy objects to be radiographed; and ventilation. These openings should be designed with great care to avoid or minimise exposure to scattered of radiation. Deficiencies may occur after a period use due to wear and tear, shielding damage etc. Various design techniques should be used to prevent or minimize these deficiencies. In case of x-ray based real time radiography (RTR) room / fluoroscopy room, if there is a lead glass viewing window on the wall between control room and exposure room, it should be confirmed that it provides adequate shielding. It is also necessary to confirm that there is no radiation streaming through the fixing frame of the viewing window. For this the dose rate at the operator's position should not exceed 10 μSv/h.

(v) There should be a 'last man out switch' in an enclosure housing an accelerator at such location from where person can view inside the room to ensure that no person remains in the exposure room when the accelerator is energised. There should be an audio and visual indicator inside the radiography room during radiation generation.

(vi) There should be a suitable provision, such as a storage pit, inside the enclosed radiography installation for safe and secure storage of gamma radiography equipment when not in use.

(vii) The control room and the shielded enclosure room (inside) should be designated as controlled area. Depending on the situation it might be necessary to designate the area surrounding the shielded enclosure as supervised area.

(viii) Effective physical security provisions (Security Level-B for industrial radiography sources) should be incorporated in the design of radiography enclosure as per the guidance provided in AERB Safety Guide on 'Security of Radioactive Sources in Radiation Facilities' (AERB/RF-RS/SG-1).

(ix) In case of high energy accelerators, non-radiological hazards such as production of ozone may also be considered.

3.5.2 Measures to minimize Sky-shine radiations

In the case of open-top enclosure, a proper estimation should be made of the radiations scattered (sky-shine) by the air volume and other intervening materials above the enclosure. Exposure due to sky-shine may be minimised by –

(i) Using a source of low activity.

(ii) Reducing the area of the radiography enclosure

(iii) Increasing the effective height of the walls, that is, height above the position of the source (recommended effective height more than 6 meters)

(iv) Using collimators and lead-umbrellas / shielding above the radiography jobs

(v) Controlling access around 5 meters from the enclosure wall.

3.5.3 Shielding material

Materials for construction of shielded enclosure should be such that it provides sufficient shielding to ensure that dose outside the enclosure does not exceed annual dose limitsprescribed by AERB. Normally concrete, steel, lead etc. are used as shielding material for radiography enclosure. In case lead shielding is used (in door or in wall), the lead material should be sandwiched between mild steel (MS) plates to avoid sagging of the lead due to longer duration of use. In case concrete blocks / stone blocks are used for constructing walls, it should be ensured that the filling material between the blocks provides the equivalent shielding to avoid streaming of radiation through that material.

3.5.4 Control Room

An enclosed radiography installation should have a control room from where the operation of the radiography equipment within the shielded enclosure is remotely controlled. The shielding of the control room (in case of a common wall with the shielded enclosure) should be such that the dose limits for radiation workers (400 µSv in one week) is not exceeded.

3.5.5 Conduit / Opening

Underground conduits should be provided, for cables, between the control room and the exposure room. There should not be any through and through opening or hole in any of the walls of exposure room. A conduit of 5 cm or less diameter may be provided in the wall to enable drive cables of gamma radiography device or control cables of X-ray device/accelerator to pass through the control console to the exposure room. The conduit should be fixed in the specified wall at an angle between 20^0 to 45^0 to the horizontal.

The lower end of the conduit should be located in the room at a height of about 20 cm from the inside finished floor level.

3.5.6 Door locks / interlocks

There should be only one door for entry as well as exit of persons in an enclosed radiography installation. In enclosed radiography installations where radiography equipment is operated, all the doors to the exposure room should be provided with suitable locks / interlocks to ensure that radiographic exposure would not be possible if the door is not closed. A mechanical or electrical interlock system should be installed to ensure that the source cannot be exposed unless the door is closed. The system should automatically retract or shield the source in the event of the door being opened. It is not always possible to install interlock systems of this nature with manually operated gamma camera, and hence locking mechanism should be available on the doors, which are locked / closed by the radiography personnel immediately prior to the radiographic source exposure.

A radiation monitoring system with built-in fail-safe features should ideally be integrated with the door interlocks to prevent entry when the radiation monitor detects radiation in excess of a pre-set level, although this may not be possible with manually operated gamma camera. In this case, the installed radiation monitor should trigger visible and audible signals when the source is exposed. Even when such automatic systems are used persons entering theshielded enclosure must always use a survey meter to confirm that the source is fullyshielded.

Door interlocks should not hinder people movement, i.e. from leaving out of the enclosure in case of an emergency. Interlock systems should be fail-safe, so that X-rays cannot be generated in case of failure or breakage of any of the component of the interlock system. Redundancy, diversity and independence of interlock systems should be used as necessary to provide additional levels of safety.

3.5.7 Audio-Visual Indicator

Wherever radiography equipment/source, is operated, provision should be made for appropriate audio and/or visual indicators during operation at appropriate location. A pre-warning signal, which may be either visual and/or audible, should be made immediately prior to exposure. This signal should be clearly audible and visible to any person inside and at the entrance to the enclosure and should last sufficiently long to enable persons to vacate the enclosure. A red warning light should be provided above the entrance door, as well as inside the exposure room and this light should be switched ‘ON' whenever the radiography work is carried out. In case of open-top enclosure, red warning lights should be installed at the top of the corners of all the walls and should be switched ‘ON” during radiography exposures.

3.5.8 Radiation Zone Monitor

Wherever the radioactive source is handled a zone monitor should be provided to serve as an audio-visual indicator. It should be provided at a location near the entrance as a caution to prevent entry of persons to the radiation area inadvertently. A zone monitor that provides audio and visual indication, and gets switched 'ON' when the radiation level at the location of the zone monitor, exceeds a certain preset level should be installed at the radiographyenclosure. The detector probe of the monitor should be fixed at an appropriate location (e.g.in the maze wall / side wall) inside the enclosure and the display unit should be installed outside the enclosure, near the entrance.

The zone monitor should be suitable to detect gamma / X-ray or pulsed beam as per the requirement. The zone monitor should have proper pre-set value for audio visual alarm. It should not be possible to easily change the pre-set value. The zone monitor should withstand / work in all weather conditions. Calibration of zone monitor should be carried out with a periodicity not exceeding two years or immediately after the repair, or as stated in the calibration certificate issued by the accredited lab, whichever is earlier. The functional test of zone monitor can be checked periodically by using stray radiation level (which should be more than the pre-set value of the zone monitor), due to the radiography device (source in shielded condition) by keeping the radiography device near the zone monitor or using a reference source.

3.5.9 Radiation Symbol or Warning Sign at Entry point

The radiation symbol specified in the safety directive issued by AERB should be conspicuously posted at the entrance and inside the enclosure. Radiation symbol and warning signs should be preferably positioned at eye level. Specification of radiation symbol and warning sign provided in the safety directive issued by AERB is given in Appendix-2. A placard indicating ‘RADIATION: RESTRICTED ENTRY’ should be posted, along with its equivalent in Hindi as well as in local language, alongside the radiation symbol. The warning signs should be made from materials that are durable under the prevailing environmental conditions and should be replaced as necessary.

3.5.10 Ventilation systems

There should be no windows on the walls of the exposure room. Any Openings for ventilation or air conditioners should be provided on walls on the side of unoccupied areas. Such openings should be provided with their lower end located at a minimum height of 2.5 meter from the finished floor level of the radiography enclosure/ground level outside and should further be covered with baffles. The length of the vertical portion of the baffle should be such that 30 cm wide overlap is available all around the opening. In case air-conditioningis to be provided in the radiography enclosure, a conduit, of minimum necessary diameter, to allow the cables to pass through the wall should be provided in the wall as stated in 3.5.5. In the case of high energy accelerator installations (with high intensity of radiation output) special ventilation arrangements may be required due to production of ozone / noxious gases inside the enclosure. Special ventilation arrangement, if any, should be ensured as per the specifications of the manufacturer / supplier of the accelerator.

3.5.11 Field Radiography

Field radiography can be performed with gamma radiography devices, X ray equipment or mobile accelerators (e.g. Betatron). Safety in field radiography is achieved by operational safety measures and strict administrative control measures.

The location for field radiography work may be, for example, at the premises of the client (e.g. in a refinery, an offshore location or a construction or fabrication workshop), in an urbanarea (eg. at a gas pipeline) or in an open field (eg. a pipeline through a rural or an uninhabitedarea). Field radiography work is influenced by a number of site specific conditions. Planning for safe operation includes consideration of the location, the occupancy in the location and proximity of members of public, weather conditions, the time of day, and whether work is required to be carried out at a height, in confined spaces or under other difficult conditions. Prior to radiography work, a thorough assessment of the working environment should bemade by the licensee to identify any site specific issues that should be addressed.

3.5.12 Source Storage Facility (pit room)

A suitable source storage facility is one that provides protection from the prevailing environmental conditions and an adequate level of security. The store should be resistant to fire in order to minimize the potential for loss of shielding and containment in the event of a fire in the vicinity. The store should be located at a remote distance from corrosive and explosive hazards.

Radiography equipment should be stored in an approved source storage facility (pit room) with adequate locking arrangement. The radiography institutes should have source storage facility at the premises of contract awarding party. In addition the radiography institutes should also have a source storage facility which may be either be self-owned or leased.

Adequate physical security measures should be provided to the source storage facility. A typical layout drawing of the source storage facility is provided in Annexure-1.

The following requirements should be complied with for the storage of the radiography source:

(i) An exclusive storage room should be provided for safe and secure custody of sources contained in radiography camera during periods when the radiography source is not in use.

(ii) The room in which radiography cameras are stored should be in a location where effective physical security of the radiography camera can be ensured.

(iii) The room in which radiography cameras are stored should not be located in a residential building or a commercial complex and should be constructed in industrial area or commercial industrial gala. However, if the storage facility is in commercial industrial gala, necessary permission should be obtained from the society of the complex for storage of the radiography cameras.

(iv) The source storage room should be constructed as per the specifications and drawing, given in Annexure-2.

(v) The storage room should have suitable pit(s) to house the radiography equipment. The pit should be provided with a lid of adequately thick metal plate which can be fastened and locked so as to ensure the safety and security of the devices stored within.

(vi) The radiation level outside the source storage room should the not exceed 1 μSv/h.

(vii) The radiation level on the lid of the pit should not exceed 10 μSv/h. This can be achieved either by putting a very thick metal plate as a pit cover or by putting a lead sheet over the IGREDs kept on the pit.

(viii) The storage room should have only one entrance and it should be kept under lock and key and key should be held only by authorized personnel

(ix) The walls (typically 23 cm brick) and the ceiling (typically 15cm RCC) of the source storage room should be of adequate thickness to ensure the physical security of the source and radiological safety of the personnel.

(x) The storage room should be surrounded by a fence, as applicable.

(xi) The storage room should be so constructed that water seepage would be prevented. The radiation symbol specified by AERB should be conspicuously posted at the entrance and on the pit covers. Radiation symbol and warning signs should be preferably positioned at eye level. Specification of radiation symbol and warning sign that is provided in the safety directive issued by AERB is given in Appendix-2. A placard indicating 'RADIATION: RESTRICTED ENTRY' should be posted, along with its equivalent in Hindi as well as in local language, alongside the radiation symbol. The warning signs should be made from materials that are durable under the prevailing environmental conditions and should be replaced as necessary.

(xii) The source storage room should be used by only one radiography agency at a time.

4. OPERATIONAL SAFETY

4.1 General

Radiation safety can be achieved through engineering design of equipment/facilities as well as through operation control. In industrial radiography practice, operational safety plays a major role in ensuring radiation safety. For operational safety, trained and qualified manpower, proper operating procedures, its compliance and necessary infrastructure areimportant.

In industrial radiography practice, both enclosed and open field radiography are carried out. Open field radiography may be undertaken only when it is not practicable to carry out enclosed radiography. During exposure, the radioactive source is driven out of the shielded container of the exposure device. Hence, protection of operating personnel and public depends a lot upon operational control.

X-ray sources are used in enclosures and field radiography. When X-ray sources are used in enclosures, there should be a provision for door interlock mechanism. Safety measures should also be taken when X-ray source is used in open field radiography.

4.2 Manpower Requirement

Trained and certified personnel play an important role in achieving operational safety. There are mainly 5 types of personnel involved viz. Employer, Licensee, RSO, Radiation Worker and Interns. The number of staff members and their qualifications should be in compliance with the requirements prescribed by the relevant authority specific to each practice. Suggested provisions are given in Annexure-3, which mentions, the minimum qualifications of radiography personnel (RSO, Radiographer, intern), radiation safety training, adequate numbers of radiography personnel (there should be at least one industrial radiographer for each industrial radiography equipment in operation per shift) required for ensuring radiation safety.

Employees, who are likely to receive an effective dose in excess of three-tenths of the average annual dose limits prescribed by the competent authority should be designated as classified workers. Such employees should be informed that they have been so designated.

4.2.1 Radiological Safety Officer (RSO)

For each authorized site of a radiography institution, a Radiological Safety Officer (RSO) should be available to ensure compliance with the requirements specified in AERB Safety code on 'Radiation sources, equipment and installations' AERB/ RF/SC. A single RSO of the radiography institution can be utilised to ensure radiological safety for more than one site provided the RSO can reach any of the sites within the shortest possible time, preferably not more than one hour time period.

Where more than one RSO has been appointed, the duties and responsibilities of each RSO should be well defined.

4.2.2 Industrial Radiographer

There should be one industrial radiographer for each industrial radiography exposure device (IRED) in operation per shift. The operation of radiography equipment should be done by the radiographer himself.

4.3 Trainees/Interns

A person undergoing internship should not be allowed to handle radiation sources except under direct supervision of qualified personnel. The RSO should instruct the intern to ensure that the dose received by them does not exceed the dose limits prescribed for apprentice by AERB (Appendix-1). Prior to employing a person as an intern, the RSO should instruct him/her about radiation and its risks, details about the exposure devices, safe operatingprocedure, proper use of dosimeters (TLDs, DRDs) and survey meters, probable emergency scenarios and the response measures.

4.4 Monitoring, Protection and Safety Tools/accessories

4.4.1 Personnel Monitoring

Radiography institutions should ensure that radiation doses to radiography personnel are monitored to confirm that doses are kept as low as reasonably achievable and are below the dose limits. An assessment of the doses could also highlight good or unsafe working practices, faulty equipment, or the degradation of shielding or engineered safety systems.

All the radiography personnel should be provided with Personnel Monitoring Services (PMS). The PMS should include the chest and wrist badges. Dose records should be maintained by the radiography institution. RSO should ensure proper use of TLD badges. In addition, Licensee in consultation with RSO should provide PMS (TLD) to auxiliary staff who frequently access the controlled area for work such as job and film setting.

TLD card should be replaced once in a month and should be stored at a designated radiation free area when not in use. Detailed instructions for proper use of TLD are given on AERB website (https://aerb.gov.in/english/aerb-advertisement).

In addition to TLD, all the radiographers should be provided with Direct Reading Dosimeters (DRD) preferably personal alarm monitors, which are small electronic radiation detectors that emit a warning signal (audio/visual/vibration) when a pre-set dose and/or dose rate is exceeded. The number of DRDs (personal alarm monitors) should be at least equal to the number of devices available in the facility. Proper use of the dosimeters should be ensured bythe RSO. The readings of the DRDs should be maintained in a log book.

4.4.2 Investigation of reported Excessive Exposure cases

In order to ensure that radiation dose to the workers does not exceed the dose limit, investigation level of 10 mSv in a given monitoring period (i.e. monthly for industrial radiography) is recommended. If the dose recorded by the personnel monitoring badge of the personnel exceeds the level mentioned above, the Radiological Safety Officer (RSO) of the institution should submit an investigation report with a statement from the personnel reported to be excessively exposed. In case the reported dose is greater than 100 mSv, the biological dosimetry i.e. chromosomal aberration (CA) test report of the individual should be conducted if so directed by AERB to determine the genuineness of the dose.

Following are the some of the points that should be considered by the radiography institutions to minimize the excessive exposure cases:

(i) Standard operating procedure for each radiography equipment should be provided to the operator.

(ii) Awareness among the Radiography Personnel regarding handling of Personnel Monitoring badge should be provided by the RSO.

(iii) Site specific emergency handling procedure should be established and the same should be implemented while handling any kind of incident involving radiation source.

(iv) Helpers should not be allowed to handle radiography exposure devices. Use of safety tools and monitoring instruments while handling radiography equipment should be ensured.

(v) The storage of Personnel Monitoring badge in radiation free area should be ensured by the RSO. A standard operating procedure (SOP) for use and storage of TLD badges should be developed by the institution.

(vi) The RSO should ensure that radiation monitors are in proper working condition and are duly calibrated.

(vii) While carrying out critical jobs (such as erection job where likelihood of the exposure is relatively higher) personnel should be deployed on a rotation basis so as to ensure that the individual dose is optimized.

4.4.3 Personnel Protective Equipment: This section is not applicable for this safety guide on Industrial Radiography

4.4.4 Monitoring Instrument

Suitable radiation survey meters should be used and the same should be maintained in good working condition with valid calibration.

Radiation survey meters are required to ensure that:

(i) the source is in safe position in the radiography camera, after the radiography work,

(ii) the radiation level outside the established cordoned area/enclosure is within prescribed limit,

(iii) measurement of surface radiation level and determination of Transport Index of the package before transport of the radiography equipment.

There should be at least one Radiation Survey Meter (RSM) for each radiography equipment and the radiography institution should have adequate spare RSMs in working and calibrated condition. In industrial radiography (Gamma / X-ray) suitable GM type / Ionization type / scintillator type RSM can be used. In accelerator radiography installation, Ionization detector based RSM should be used. The range of RSM should be preferably between 0.1 μSv/h to 500 mSv/h. During handling incident involving radiography source, high range RSM (range up to 10 Sv/h) should also be used. The drawback of certain GM based RSM is that in high radiation field, no reading will be seen due to paralyzed effect of the GM detector. Therefore, user should be alert while entering in suspected high radiation field.

Radiation monitors should be kept in good working condition. It should be periodically checked to confirm that it indicates reliable readings with radiation sources.

It should also be checked after any servicing or repair. The simplest method of checking the performance of monitoring instruments is to use the instrument just after it has been calibrated by the manufacturer and record for future reference the exposure rate at a specific distance from a radiography camera containing source of known activity. Performance check can then be made at any time by comparing the recorded reading with check readings made at the same distance from the source, after making necessary correction for radioactive decay of source. If the check reading after corrections varies considerably, the instrument should be sent for servicing and re-calibration. In addition, the operational and handling instruction should be conscientiously observed to ensure prolonged and trouble free performance of the instrument. Calibration of RSM should be carried out from authorized laboratories (once in two years) and immediately after the repair/servicing, and a certificate of calibration should be obtained. The instruments received after re-calibration should be checked for performance tests mentioned above. The readings so received should be recorded and kept for future reference.

4.4.5 Handling Tools

All the tools used for handling the radiation sources should be provided such that adequate protection can be achieved without hampering convenience and speed of operation. However in Industrial Radiography practice special kind of handling tools are not required for normal operating conditions.

4.5 Operation of Radiation Sources/equipment

Prior to use of radiation source, the operator should ensure that necessary arrangements are in place to offer adequate protection to the worker and public around the radiography installation (i.e. enclosed radiography or field radiography).

4.5.1 Open Field Radiography

The RSO should ensure that:

(i) The radiographer is familiar with radiography equipment, it’s mode of operation and potential problems,

(ii) Adequate distance is available for cordoning and maintained,

(iii) Nobody is inside the cordoned area,

(iv) Audio/visual warnings are in place. (These signals may be operated manually when radioactive sources are being used, but should be operated automatically with X-ray units),

(v) Occupancy around the cordoning area is minimum,

(vi) Effective patrolling and monitoring the boundary is carried out for preventing un-authorized entry,

(vii) The radiography equipment is not left unattended during radiography work,

(viii) Wherever possible, collimators are used,

(ix) Particular care is taken where radiography work is being performed in an industrial plant or on a construction site with several floors that can be occupied by people and where there are ladders, stairways, etc. Radiographers should ensure that access is prevented in areas on floors above and below the radiation work area,

(x) At least one portable survey meter is available for each radiography source. Prior to commencing radiography, the meter should be tested, either against a check source or against the exposure container to obtain a reference reading. This will show that the meter is working correctly and will also confirm that the radiographic source is in the shielded position.

(xi) At the end of the exposure, it is ensured that the source has returned to the shielded position or that the X-ray emission has ceased after each exposure,

(xii) During radiography the drive cable and the guide tube of the gamma exposure device and the electric cable of the X-ray machine / portable accelerator should be extendedto the fullest extent possible to enable the workers to take maximum advantage of distance for protection from the source of radiation. Once the radiography exposure commences, the radiographer should move quickly to, and remain at, a location where the dose rate is as low as practicable. The dose rate at the position taken up by the radiographer during radiography should be checked regularly by means of a survey meter,

(xiii) The radiography device and its surrounding should be clearly visible from the source control position and from the position taken up by the operator during radiography. The cordoned area of an open site should be under observation at all times during exposure to ensure that no person enters the area during radiography,

(xiv) One or more warning lights and an audible alarm located at the immediate vicinity of the exposure position should be used to indicate, when an exposure is in progress,

(xv) On completion of the radiography work, radiographers should use a radiation monitor to ensure that gamma source has been fully retracted into the exposure device and that the source is not left in the exposed position or become detached,

(xvi) Before leaving the site, the radiographer should carry out visual examination to ensure that equipment has not been damaged. Exposure devices should be made ready for transport by locking the devices and putting the protective covers in place. The exposure device and the ancillary equipment should be physically secured in the vehicle to avoid damage during transport,

(xvii) Where radiography work is to be carried out in the premises of the contract awarding party, the agency should be consulted regarding the preparation and planning of execution of radiography work. This should include selection of a suitable location, proper infrastructure, adequate illumination and time for carrying out the radiography work in a safe manner. The notices, warning signals and alarms to be used in the radiography work should be discussed between the parties, to avoid any possible confusion at the site,

(xviii) The radiographer should be aware of the site specific hazards. Work permit system (if any) established by the contractor/operating organization should be followed,

(xix) The industrial radiography institute and the contract awarding party should agree on the planned timescale of the work and the duration of the period over which radiography work will be performed. It should be ensured that the contract awarding party should allow the radiographer sufficient time for the radiography work to be performed safely and for all the required safety measures to be taken,

(xx) The industrial radiography institution should inform the contract awarding party about the type of radiation source that it is planning to use on the site. It should be ensured that proper storage is available for radiography sources that are intended to be stored at the site,

(xxi) While using the crawler equipment the width of useful beam on the pipe surface should not be greater than 20 cm at the circumference of the pipe within which the crawler is operating. As the crawler is used for taking panoramic exposure of thepipe, restricting 20 cm width at pipe (annular width 20 cm) can avoid the chances of exposure to the nearby operating workers.

4.5.2 Enclosed radiography

The RSO should ensure that:

(i) the radiographer is familiar with the radiography equipment, it's mode of operation and potential problems,

(ii) the job entry and personnel entrance door are closed during radiography,

(iii) radiation zone monitor is installed at proper position with audio and visual warning,

(iv) nobody is present inside the enclosure,

(v) the device is operated from outside the enclosure,

(vi) in case of open top enclosure, exposure due to sky shine radiation is minimised,

(vii) in case of open top enclosure, over-head crane operators are not exposed to direct radiation beam,

(viii) doors of the enclosure are locked / electrically interlocked with radiography equipment.

4.6 Source Location and Storage

4.6.1 Change of Premise / Location

Radiography work should be undertaken in the approved sites/enclosures and radioactive sources should be stored in approved source storage facilities. Before relocation of the radiography camera to another site / supplier, for storage at the centralized source storage room etc., permission from AERB should be taken. The source storage facility should not be used by any other radiography agency without prior approval of AERB.

4.6.2 Transfer of Radioactive Source / Equipment

An employer / licensee should not loan, sell or otherwise transfer a radiography equipment to another person without obtaining prior permission from AERB. The radiography equipment should be subjected to all the necessary Tests for Quality Assurance for confirming that the device could be operated safely by the original owner of the device before transfer of the device.

4.6.3 Safe and Secured Storage

When the radiography equipment are not in use, the same should be kept in an approved source storage facility (commonly known as pit room). The source storage room should be located in an industrial area / commercial gala. Adequate security provisions such as locking arrangement inside the pit, locking arrangement on the pit cover, locking arrangement at the door of the room, fencing with locking arrangement, CCTV and security guards should be provided. In enclosures, lockable pits should be made.

4.6.4 Emergency Storage Container

Detachment and stuck-up of source pencil/pigtail are the most frequent occurring incidents in industrial radiography practice. Normally for managing such emergencies a CV Tong, lead sheets and an emergency source storage container are required. Hence, at each site there should be at least one CV Tong, one compatible source storage container, appropriate RSMs (low-range; high range; GM/Ionization chamber based) and adequateshielding material should be available.

4.6.5 Source movement within the facility

For movement of the radiography camera within an approved site, transport regulations are not applicable. However, there should be an internal safety procedure available with the radiography facility and the same should be followed during movement of the radiography cameras. If the radiography camera are moved to the approved radiography site through public domain, from the approved source storage room assigned for that site, then no separatetransport permission is required; however, the transport regulations should be complied with. Intimation of relocation of each radiography camera should be sent to AERB.

4.6.6 Security of Radioactive Material

The employer should make necessary arrangement to ensure security of the radioactivematerial all the time viz. during use, storage and transport. The employer should also undertake proper background check before employment of the staff. It should also be ensuredthat credible transporters are engaged for transport of radiography cameras. For security during use and storage, the AERB guide on 'Security of Radioactive Sources in Radiation Facilities', AERB/RF-RS/SG-1, (2011) should be followed. As per this security Guide, the security plan (Level-B for radiography sources) should be prepared and implemented at radiation facility. The security measures during transport of gamma radiography sources should be provided in accordance with “Security of Radioactive Material during Transport”, Safety Guide No. AERB/NRF-TS/SG-10 (2008).

4.6.7 Source handling in other’s Premise/Facility

For handling radiography equipment/source at a site or premises that does not belong to the radiography institution, prior approval of AERB should be obtained. In the event of such handling, the owner of the premise should also be responsible for safety and security of radioactive source or radiography equipment and follow the procedure prescribed by AERB. There should be a written agreement between the owner of the premises of radiography site and the radiography agency with regard to safety and security aspects of radiation sources.

4.7 Safety Checks, Quality Assurance and Maintenance

4.7.1 Safety Check

The design of devices should be as per AERB standard specifications viz. ‘Standard for Industrial Gamma Radiography Exposure Devices and Source Changers’, Safety Standard No. AERB/RF-IR/SS-1 (Rev.1), 2007. Fail safe mechanisms should be in place for the radiography equipment. A fail-safe mechanism means an engineering design feature, in the event of a specific type of failure, which inherently responds in a way that will cause no or minimal risk to the environment or to people. Adequate arrangements should be there to avoid unintended exposure. Periodic checks as specified by the manufacturer should be carried out and records should be maintained. In the event of detecting a defect in the radiography equipment/source, it should not be used till it is repaired.

4.7.2 Quality Assurance Tests

The original manufacturer should establish the Quality Assurance Procedures (QAP) and the frequency of checks for the radiography equipment/source including their systems and components. The frequency of checks should commensurate with the nature and probability of failure. The records of all the QA checks should be maintained. In the event of detecting any defect in the radiography equipment / source, it should not be used till it is repaired.

The licensee should prepare a document / manual on QAP. This manual may include, management systems, process of manufacturing, tests at different stages, checks and provisions for servicing and maintenance. All these aspects should be covered in the manual on radiation safety. In case the manufacturer of radiographic equipment has provided the manual covering the aforesaid aspects, it can be used as such by the radiographic institution. The operating institution may also prepare a manual for safety or follow the procedure as provided by manufacturer.

4.7.3 Servicing and Maintenance

In order to maintain reliability of radiography equipment (X-ray equipment/ accelerator/ radiography camera / source changer) periodic servicing should be done throughout the lifetime of the equipment. The periodicity of servicing should be as prescribed by the manufacturer of the equipment. The servicing of the equipment should be done by person(s) trained by OEM, authorized by the supplier/manufacturer and recognized by AERB. In radiography equipment, use of spare parts and accessories meeting original specifications, is very important from radiation safety view point as there have been incidents due to use of duplicate / spurious parts and accessories. The manufacturer or supplier is responsible for supply of original spare parts and accessories. The accessories and spare parts should meet standards such as International Standards Organization (ISO), Indian Standards (IS), International Electrotechnical Commission (IEC), Conformité Européenne (CE).

The equipment (including all ancillary equipment) should be subject to both routine checks by the radiography institutions, and servicing and maintenance by the manufacturer / supplieror recognized agency. Any replacement parts procured from the manufacturer / supplier orany other agency should satisfy the design requirements in order to meet the original safety specifications. Routine checks of equipment should be carried out every three months. Periodic routine checks should include the following:

(i) Checks of cranking unit, drive cable including crimping of male coupling part,

(ii) Checks of female coupling part of source assembly / pigtail and male coupling by using GO-NO-GO gauge. Also checks of different crimped portion (excluding source capsule),

(iii) Checks of guide tube and snout portion,

(iv) Checks of shielding adequacy of the camera,

(v) Checks of locks of the camera,

(vi) Availability of shipping plug and its fittings in the camera,

(vii) Check for X- ray leakage from the tube / accelerator head leakage,

(viii) Checks to ensure that all cables are in good condition, with no fraying or exposed wires,

(ix) Tests on electrical insulation of cables,

(x) Other routine checks and maintenance recommended by the supplier,

(xi) Tests on all interlocks and emergency cut-out switches.

Inspection and routine maintenance of radiographic exposure devices including radiation generating equipment should be done at intervals not exceeding 6 months. Replacement components should meet design specifications. Faulty equipment must be removed from use until repaired and functions satisfactorily.

Each licensee who uses a sealed source should have the source tested for leakage at intervals not exceeding 12 months.

Each exposure device using Depleted Uranium (DU) shielding should be tested for DU contamination at intervals not exceeding 24 months.

Servicing and maintenance of devices should be done by the persons trained and certified by the original equipment manufacturer. For radioactive source based devices, servicing and maintenance should be done with the empty device (after keeping the source in a suitable source storage container). A record of servicing and maintenance should be maintained. Servicing and maintenance should be done under the supervision of RSO.

4.8 Safe Management of Disused Source/Decommissioning of Equipment/installation

4.8.1 Management of disused radioactive source

Source(s) which are not in use and/or not intended to be used should be considered as disused source. Disused radioactive sources should be returned to the supplier for safe management / ultimate disposal with prior approval from AERB and there should not be any undue delay with regard to its safe management. The safe custody of the disused source should be ensuredtill it is sent back to the supplier/manufacturer.

4.8.2 Management of disused unsealed source (Radioactive waste)

In IR practice, unsealed wastes are normally not generated. Such waste may be generated in case when there is damage to the sealed source and same should be managed, with prior approval of AERB.

4.8.3 Decommissioning of Radiation Equipment/Facility

When the radiography equipment is no longer to be used, after safe management of radioactive source, the licensee should ensure that depleted uranium, contaminated parts/ activation products (in case of high energy accelerators), are duly returned to the authorized supplier for safe management. Once the removal of the radioactive material is done, the equipment should be formally decommissioned with prior approval of AERB.

4.8.4 Provision for safe management / Decommissioning

The employer should make adequate financial provision for decommissioning of the industrial radiography equipment and to meet the cost of disposal of the radioactive source, including any potential cost escalation, in the unlikely event of the facility becoming non- operational due to any reasons like manpower or management issues, financial or other constraints including bankruptcy. It also includes the cost of preparation of the package, transport cost and charge for disposal of radioactive material. This provision should be made prior to obtaining the license for operation, so that in case the source is rendered disused in future, prompt action can be initiated for its safe disposal in the interest of public safety.

4.9 Transport of Radioactive Material

In Industrial Radiography practice transport of radioactive source is required from one site to another, for source replacement/disposal, and during import / export. Radioactive sources should be transported only with the prior approval of AERB and in accordance with the provisions of national/international Transport Regulation. Shipment approval should be obtained with regard to transport of radiography camera involving radioactive material. The consignor should be responsible for safe and secure transport of radioactive material till the consignment is received by the consignee. Requirements for the safe transport of radioactive material are specified in AERB Safety Code on “Safe Transport of Radioactive Material” [AERB/NRFTS/SC (Rev.1), 2016], issued under Atomic Energy (Radiation Protection), Rules 2004.

The security aspects during transport of radioactive material is covered in the AERB Safety Guide on "Security of Radioactive Material During Transport" AERB/NRF-TS/SG-10, 2008. Transport of radioactive material is governed as per AERB Safety Code on "Safe Transport of Radioactive Material', (AERB/NRF-TS/SC Rev.1), 2016 made under Atomic Energy (Radiation Protection), Rules 2004.

While transporting the consignor / licensee need to ensure that, marking and labelling is proper (the old labels need to be removed), the package is locked and sealed, proper immobilization of the package (properly anchored/fixed to the vehicle) and all the transport documents viz. Consignor's Declaration, Transport Emergency Card (TREM Card), Instructions to the Carrier and movement/transport permission from AERB should be handedover to the carrier. The ancillary equipment should be disconnected from the radiography camera, and all required plugs and caps installed prior to transport. The radiography sources should only be moved in certified packages that are locked and the keys removed.

Radiography cameras should not be transported in public vehicles, shared taxis, motor cycles, auto rickshaws and other open vehicles. The radiography cameras should always be booked as an item of cargo and it should be clearly declared in the documents that consignment contains Class 7 Dangerous Goods namely radioactive material. The industrial radiography facility should ensure that reliable transport agency is engaged for transport of the radiography cameras.

5. MEDICAL EXPOSURES

The chapter on ‘Medical Exposure’ is kept intentionally blank since the same is not applicable to ‘Industrial Radiography’.

6. HANDLING INCIDENTS/EMERGENCY SITUATION

6.1 General

Radiation sources used for industrial radiography purposes, if handled in an unsafe manner, could lead to potential exposure situations. Incidents in Industrial Radiography occur mainly due to operator error or equipment failure. In the past, some incidents have resulted in workers and members of the public receiving avoidable radiation doses. Excessive exposures can also occur when untrained workers mishandle an unshielded source. The further guidance with regard to handling of emergencies in radiation facilities, having radiological impact in public domain, is provided in the AERB Safety Guide on Management of Radiological Emergency in Radiaiton Facilities, AERB/RF/SG/NRE-2 [DRAFT].

6.2 Emergency Preparedness and Response

Guidance on Emergency Preparedness and Response is provided in Safety Guide on 'Management of Emergency arising from radiation sources, equipment and installations', AERB/RF/SG/NRE-2 (under development). Provisions with regard to radiological emergency are given in AERB Safety Code on 'Management of Nuclear and Radiological Emergencies' AERB/NRF/SC/NRE, 2022. The emergency response plan is required to be submitted to AERB prior to the commissioning of the installations. A typical template for emergency preparedness and response plan is given in Annexure-5. The Licensee, in consultation with Radiological Safety Officer, should prepare suitable Emergency Response plan to mitigate the consequences of foreseeable emergency conditions and maintain emergency preparedness. Plan should include possible emergency scenarios, infrastructure requirements (tools, equipment, list of response personnel with responsibility, communicationdetails, coordinators, procedures to initiate response and protective actions) and response functions (action plans for pre-identified personnel to undertake response and protective actions). The emergency response plan should specify the responsibility of each stakeholder involved including the principal contractor (client) and sub-contractors, if applicable, who awards the radiography work. The emergency response plan should be site-specific and should have the concurrence of the principal contractor in whose premises the radiography work will be carried out.

For gamma radiography, action plan for all foreseeable emergencies including and not restricted to the following contingencies should be prepared:

(i) Source failing to return to safe shielded position within the exposure device,

(ii) Loss / theft of radiography source at the installation / site during use, in storage, intransport, or during natural calamities,

(iii) Physical damage to the shielding of the device,

(iv) Decoupling of a source from drive cable and resulting in the source remaining in theguide tube,

(v) Off normal Exposures to radiation worker or members of public.

For X-ray generators, all foreseeable emergencies and not restricted to the following contingencies should be considered:

(i) Failure of radiation generation to terminate even after the intended period of exposure,

(ii) An X-ray generator getting unintentionally energized,

(iii) Malfunctioning of a safety system or warning system.

(iv) Physical damage that affects the shielding or filtration etc,

(v) Excessive-Exposure to radiation worker or members of public due to unsafe radiography work, etc.

The following measures should be implemented by the radiography personnel in order to minimize exposures and to allow for proper response:

(i) Restrict access to the vicinity of the source – ensure that cordon-off area barriers are inplace; Avoid panic;

(ii) Inform the RSO;

(iii) Move to a safe distance and keep watch over the source; plan subsequent actions;

(iv) Never enter areas of potentially high or unknown dose-rates without carrying a functional survey meter and direct reading dosimeter;

(v) Never touch a radioactive source;

(vi) Seek assistance from a qualified expert or the supplier of the radiography equipmentsource, if needed;

(vii) Inform AERB about the incident within 24 hrs of occurrence.

In many cases, emergencies/incidents involving industrial radiography sources could have been avoided or the consequences could have been minimized if the following precautions had been taken:

(i) Radiography personnel should be qualified, competent and properly trained;

(ii) Calibrated survey meters in working condition should be used before, after and during every exposure;

(iii) Periodic inspections of radiography equipment and survey meters prior to use should be carried out;

(iv) Periodic maintenance should be conducted to ensure that ancillary equipment such as control unit, drive cable, guide tube, snout, connectors and the coupling portion of the source assembly are in good working condition.

If it is suspected that the source capsule is damaged, extra care must be taken as radioactive material could escape from the source, potentially contaminating persons and objects. The detection and measurement of radioactive contamination requires specialized monitoring equipment and expertise which most radiography institutions are unlikely to have. If it is suspected or known that a source capsule is ruptured, the radiography institutions should seek advice from manufacturer / supplier / appropriate qualified expert / AERB.

Typical situations which have led to emergencies / incidents, include damage to the source or exposure device resulting in a radioactive source being jammed in the exposed position, and the separation of a source pigtail from the wind-out cable resulting in the source being inadvertently left on site.

Examples of typical incidents (which may occur) involving radiography equipment are given in Annexure-6.

6.3 Response to Emergency/Incidents

Although prevention is the first defence, emergencies can still happen. Therefore,radiography institutions should prepare emergency plans as stated above.

The licensee, with the assistance of the Radiological Safety Officer, should prepare response procedures to mitigate foreseeable incidents. All radiation workers associated with the radiography installation (i.e. enclosed radiography or field radiography) should be made familiar with these procedures.

The procedures should identify personnel to be contacted, tools to be utilized and safety instructions to be followed. The procedure should be displayed at a conspicuous location. Further, the equipment required for handling emergencies should be well-maintained and placed at identified locations and easily accessible.

An updated list of persons to be contracted in an emergency should be maintained and made easily accessible.

The licensee, on the advice of Radiological Safety Officer, should ensure handling of incidents in such a manner that the exposures to the personnel are minimized. The incident and the remedial actions taken should be informed to AERB

6.3.1 Emergency Handling Tools

The following emergency handling tools (working and calibrated, if applicable) should be available with the institution for handling any radiological incident / emergency involving radiography source(s):

(i) Appropriate radiation survey meters to measure both high and low dose rates;

(ii) Direct reading dosimeters and chargers;

(iii) Bags of lead shot, and extra lead sheet;

(iv) CV tongs (more than 1.5m length);

(v) Cordoning materials and notices;

(vi) Lead pot or temporary shielded source container;

(vii) A metal cutting shears;

(viii) Radiography equipment manual;

(ix) Communication equipment (e.g., mobile phones).

6.3.2 Reporting an Emergency

After safe handling of the emergency, a report should be prepared including a critical review of how well the procedures were implemented, what lessons can be learned, what measures have to be implemented to prevent similar emergencies / incidents in the future and how response plans might be improved.

The employer should:

(i) Inform AERB about the incident within 24 hours of its occurrence and submit a detailed report on the incident after carrying out investigations; and

(ii) Lodge a written complaint immediately with the police, in case of loss or theft, if the radiography source(s) are not traced.

Licensee Should:

Investigate and inform AERB of any incident / radiological emergency involving radiography source and maintain record of investigations.

7. PUBLIC SAFETY

7.1 General

AERB has prescribed dose limits for members of the public which is given in Appendix-1. To ensure public safety, the design and operation of the facility should be such that radiation exposure to the members of the public is kept at a minimum and well within the prescribed limits. To further strengthen public safety, suitable security procedures and display of warning symbols should be employed to alert / prevent public before coming closer to hazardous areas of the facility. These efforts should be supported by carrying out regular radiation surveillance around the facility.

7.2 Measures for Public Safety

The Radiation Protection Programme established by the Licensee, in consultation with the RSO, should include the safety of the general public. In industrial radiography practice safety of general public may be achieved by means of periodic monitoring program of the public exposure due to use of radiography sources. The monitoring program should be sufficient to verify and demonstrate compliance to prescribed limits. Various aspects with regard to achieving public safety are elaborated in section 4.5 of this guide. The radiation exposure of the public due to industrial radiography and other possible sources of radiation, if any, should not exceed 20μSv in one week considering an annual dose limit of 1 mSv.

7.3 Protection of Foetus / breastfed infants

A female worker should, on becoming aware that she is pregnant, should notify the employer, licensee and Radiological Safety Officer so that her working conditions may be modified suitably, to ensure that the dose to the foetus does not exceed the dose limit prescribed for general public.

There is no additional requirement for lactating radiation worker in industrial radiography practice.

Appendix-1: Dose Limits for Exposures from Ionising Radiations for workers and the members of the public

AERB Directive No. 01/2011 [Under Rule 15 of the Atomic Energy (Radiation Protection) Rules 2004] Ref. No.CH/AERB**/ITSD/125/2011/1507 dated April 27, 2011**

In exercise of rule 15 of the Atomic Energy (Radiation Protection) Rules, 2004, the Chairman, Atomic Energy Regulatory Board, being the competent authority under the said rules, hereby issues an order prescribing the dose limits for exposures from ionising radiations for workers and the members of the public, which shall be adhered to.

Dose Limits:

General:

- The limits on effective dose apply to the sum of effective doses from external as well as internal sources. The limits exclude the exposures due to natural background radiation and medical exposures.
- Calendar year shall be used for all prescribed dose limits.

Occupational Dose Limits:

Occupational Workers:

The occupational exposures of any worker shall be so controlled that the following limits are not exceeded:

- an effective dose of 20 mSv/yr averaged over five consecutive years (calculated on a sliding scale of five years);
- an effective dose of 30 mSv in any year;
- equivalent dose to the lens of the eye of 150 mSv in a year;
- an equivalent dose to the extremities (hands and feet) of 500 mSv in a year and
- an equivalent dose to the skin of 500 mSv in a year.

Limits given above apply to female workers also. However, once pregnancy is declared the equivalent dose limit to embryo/fetus shall be 1 mSv for the remainder of the pregnancy.

Apprentices and Trainees: The occupational exposure of apprentices and trainees between 16 and 18 years of age shall be so controlled that the following limits are not exceeded:

- an effective dose of 6 mSv in a year;
- an equivalent dose to the lens of the eye of 50 mSv in a year;
- an equivalent dose to the extremities (hands and feet) of 150 mSv in a year and
- an equivalent dose to the skin of 150 mSv in a year.

Dose Limits for Members of the Public:

The estimated average doses to the relevant members of the public shall not exceed the following limits:

- an effective dose of 1 mSv in a year;
- an equivalent dose to the lens of the eye of 15 mSv in a year; and
- an equivalent dose to the skin of 50 mSv in a year.

Appendix-2: Specifications for Radiation Symbol and Warning Sign

AERB Directive No. 02/2011 [Under Rule 14(3) of the Atomic Energy (Radiation Protection) Rules 2004, Ref. No. CH/AERB**/ITSD/125/2011/1508 dated April 27, 2011**

In exercise of rule 14(3) of the Atomic Energy (Radiation Protection) Rules, 2004, the Chairman, Atomic Energy Regulatory Board, being the competent authority under the said rules, hereby issues an order prescribing the specifications for the radiation symbol and warning sign.

Specifications for radiation symbol/warning sign:

- The radiation symbol for radioactive sources other than medical diagnostic and industrial x-ray radiography equipment shall conform to the specifications given hereunder;
  - The relative dimensions of the trefoils and the central circle shall be as shown in Fig.1.
  - The trefoils and the circle shall be of magenta colour.
  - The background of the above symbol shall be yellow.
  - The symbol should be accompanied by appropriate legend in English, Hindi and local language indicating radiation hazard and restricted entry, e.g. CAUTION – RADIOACTIVITY.
  - Small objects, containing radioactive material may, however, have on them only the aforesaid trefoil symbol engraved in a conspicuous colour when their dimensions do not permit compliance with the above.
- The radiation symbol for radiation generating equipment such as medical diagnostic X-ray equipment, industrial x-ray radiography equipment and accelerators shall have a warning sign as illustrated in Fig.2 and the warning sign shall conform to the specifications given hereunder;
- The triangle shall be equilateral.
- The ratio of the outer to the inner sides of the triangle shall be 1.5.

- The area between the outer and inner triangle shall be in yellow colour on white background.
- The printing on the area between the outer and inner triangle and figure inside the inner triangle shall be bold, proportional and red in colour.
- The area between the outer and inner triangle should be accompanied by appropriate legend in English, Hindi and local language indicating radiation hazard and restricted entry.

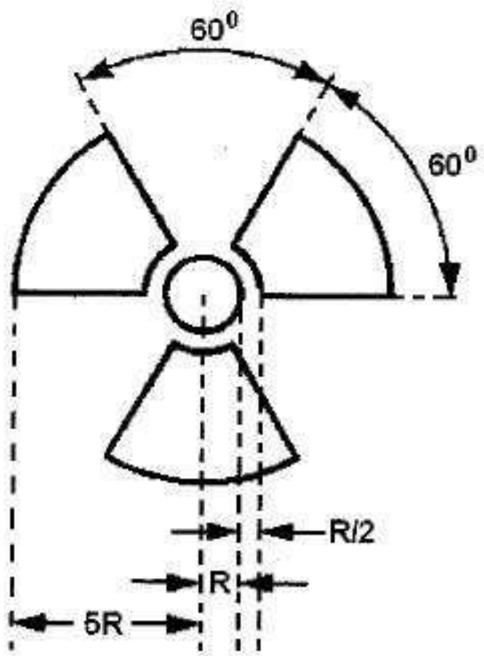


Fig. 1.
Radiation Symbol for Radioactive Sources

Fig. 2.
Radiation Symbol and Warning Sign for Radiation Generating Equipments

CAUTION: *RADIATION, KEEP AWAY*

सावधान: विकिरण दूर रहिये

Local Language:

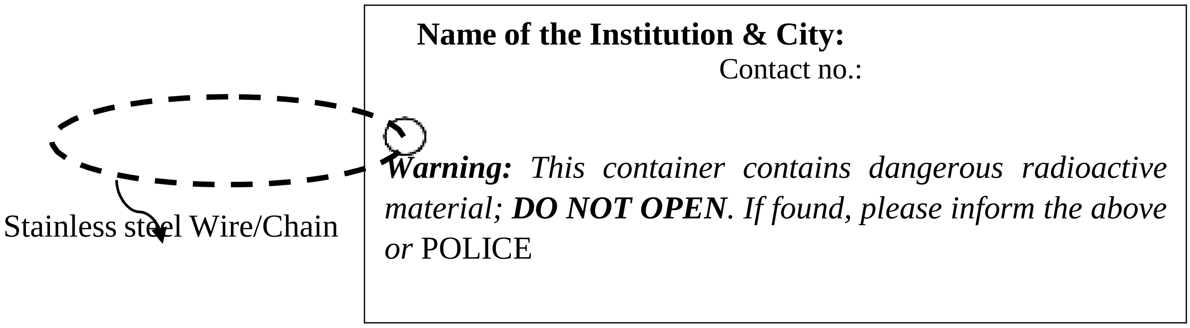
Fig. 3

RADIATION WARNING SIGN

To be AFFIXED on the Exposure Device

Appendix-3: Stainless Steel Tag

STAINLESS STEEL TAG to be tied with the device



Tag to be tied with metallic string / chain with the handle of container, so that it can't be removed easily. The information engraved should be visible from at least a distance of 1 m.

Annexure-1: Typical design of radiography enclosure

Design sketches of radiography enclosures

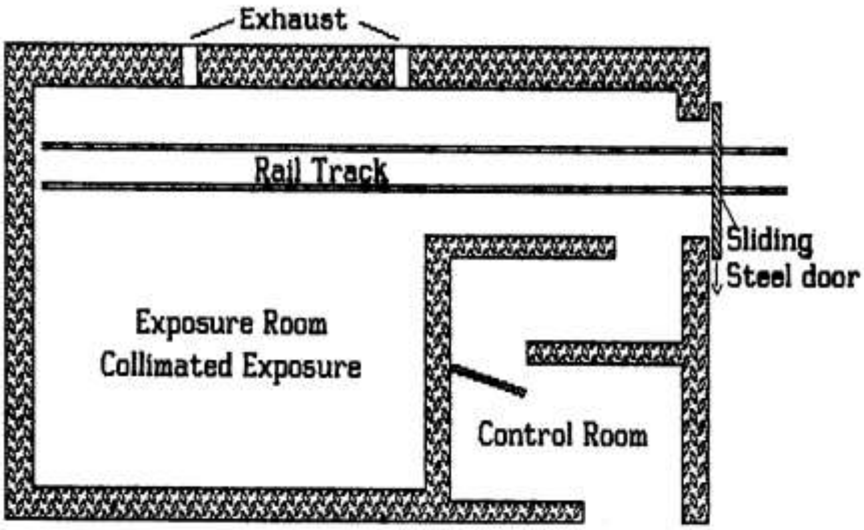


Fig: 1: Enclosed Installation (Radiography Room with sliding door Entry System)

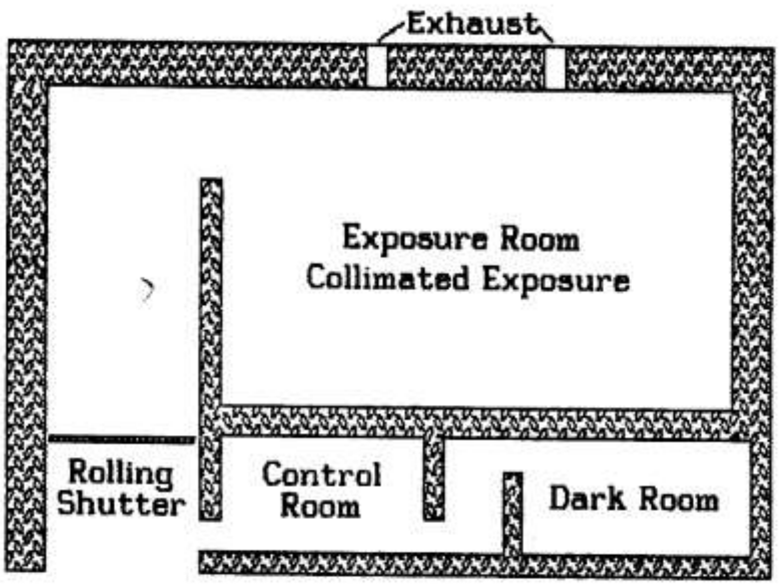


Fig: 2: Enclosed Installation (Exposure Room with Maze Entry System)

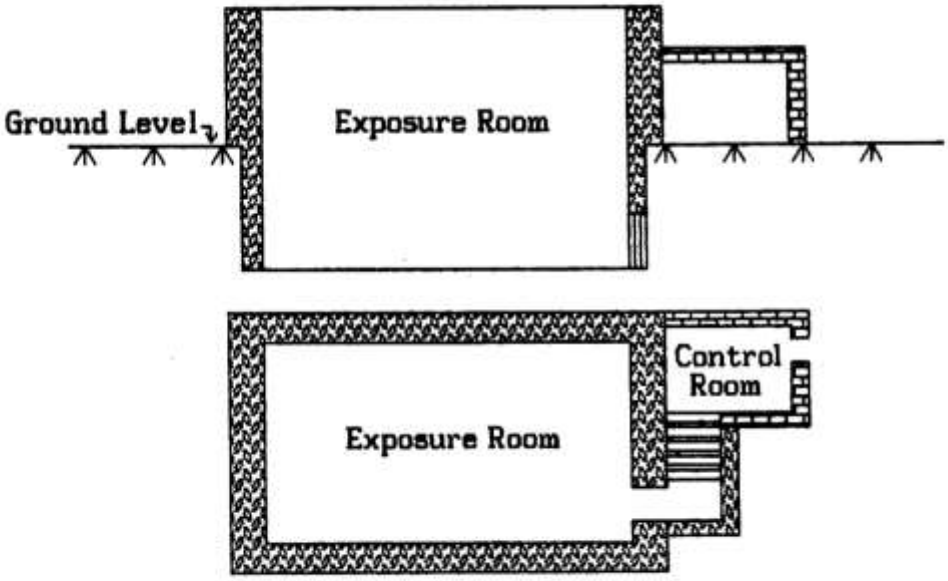
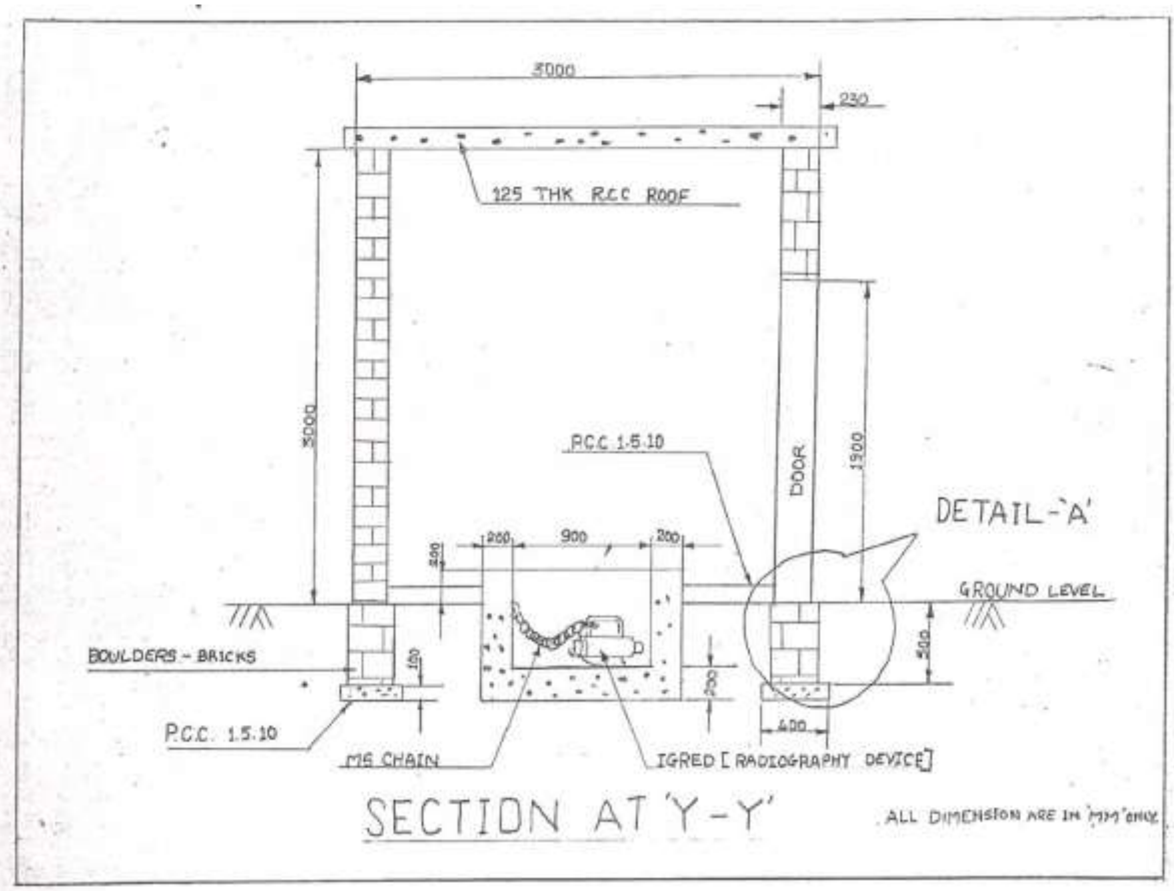


Fig: 3: Enclosed Installation (Pit type - Open top)

Annexure-2: Typical sketch of source storage facility

Design sketch of Source storage facility (Pit room)



Annexure-3: Qualification, training and adequacy of personnel

There should be an introductory sentence here stating that qualifications of professionals are stipulated/ prescribed by the relevant authorities. Where such stipulations are not available, the qualifications suggested below may be considered.

Minimum qualification, training and adequacy for personnel:

a) Industrial Radiographer:

The minimum Qualification and Training of an industrial radiographer is:

(i) 10+2 or equivalent examination passed with Science subjects, and Mathematics in 10^{th} standard or equivalent from a recognized Board;

OR

ITI course of one year duration passed from a recognized institute and Mathematics in 10^{th} standard or equivalent from a recognized Board; and one year of experience in industrial job (applicable only for ITI course of less than two years duration);

AND

Successful training in radiological safety for industrial radiographer or its equivalent recognized by the Competent Authority and field experience of six months in an approved radiography institution as an intern after completion of the training.

Adequacy of Personnel:

(i) One industrial radiographer for each industrial radiography exposure device (IRED) in operation per a shift.

b) Radiological Safety Officer (RSO):

Minimum Qualification and Training of an RSO is:

(i) diploma in engineering or degree in science with Physics and Mathematics from a recognized university/institution;

OR

10+2 or equivalent examination passed with Science subjects, and Mathematics in 10th standard or equivalent from a recognized Board for industrial radiographercandidate with requisite experience in the field, AND

(ii) Successful training in radiography testing and safety (Radiography Testing Level - II/IRG-1 or equivalent) or a post-graduate degree/diploma in radiological physics or equivalent from a recognized university/ institution and acceptable to the Competent Authority.

Adequacy of Personnel:

(i) Each radiography site should have a Radiological Safety Officer.

(ii) Each manufacturer / supplier of IREDs / radiography sources should have aRadiological Safety Officer.

c) Intern

Minimum Qualification and Training for an Intern is:

(i) 10+2 or equivalent examination passed with Science subjects, and Mathematics in 10th standard or equivalent from a recognized Board;

OR

ITI course of one year duration passed from a recognized institute and Mathematics in 10th standard or equivalent from a recognized Board; and one year of experience in industrial job (applicable only for ITI course of less than two years duration);

AND

(ii) Training in radiological safety for industrial radiographer or its equivalent recognized by Competent Authority.

Appendix-IV: RESPONSIBILITIES

1.1 General

There are various stakeholders involved in handling the radiation sources and equipment in the complete life cycle of a radiation facility. This includes personnel involved in the manufacture, supply, installation, commissioning, operation, maintenance, and decommissioning of the radiation equipment or radiation facility. Responsibilities are assigned to these personnel for ensuring radiation safety in the facility. All the personnel should understand and fulfill their responsibilities to ensure radiation safety effectively. The responsibilities of the employer, licensee, RSO, Industrial Radiographer, apprentice, manufacturer /suppliers, of IR Equipment,servicing/maintenance personnel and contract awarding party are provided in this Annexure.

1.2 Responsibilities of Licensee (Employer)

The person responsible for any facility or activity that gives rise to radiation risks should have the prime responsibility for safety. The prime responsibility of ensuring radiation safety in handling IR equipment/sources should rest with the Licensee (Employer) who has obtained the licence and this responsibility cannot be delegated.

The licensee should:

(i) ensure compliance with all the applicable provisions of Atomic Energy Act, 1962 and the relevant rules made there under, and the requirements stipulated in regulatory documents/ conditions referred to or contained in the licence or Safety Directives/Orders from AERB or otherwise applicable;

(ii) designate, with the written approval of AERB, a person or persons, as required, having qualifications as specified in this guide, as Radiological Safety Officer (RSO);

(iii) ensure that relevant provisions of this guide are implemented by the RSO and other worker(s);

(iv) ensure that no person under the age of 18 years is employed as a worker or as an apprentice for radiation work;

(v) provide facilities and equipment to the RSO and other worker(s) to carry out their functions effectively in conformity with the regulatory constraints;

(vi) prior to employment of a worker, obtain the dose records and health surveillance reports, from his/her former employer. Also upon termination of service of worker provide his/her dose records and health surveillance reports on request to his/her new employer;

(vii) arrange for and maintain health surveillance of workers as specified under Rule 24 & 25 of Atomic Energy (Radiation Protection) Rules, 2004;

(viii) arrange for personnel monitoring of radiation workers, proper implementation and also to maintain the individual dose records as prescribed by AERB;

(ix) furnish dose records and health surveillance reports to each worker annually, and also as and when requested by the worker and at time of termination of service;

(x) inform AERB if the licensee or the RSO leaves employment;

(xi) ensure that written procedures and plans are established for controlling, monitoring and assessment of exposure for ensuring adequate protection of workers, members of the public and the environment, during normal operation and emergency situations and site specific emergency plans should be available;

(xii) ensure submission of periodic safety status report of the facility in the prescribed format to AERB;

(xiii) ensure radiation monitoring is carried out in accordance with this safety guide;

(xiv) ensure radiation monitoring equipment is/are regularly inspected, maintained and periodically calibrated at least once in two years and all systems/components are regularly serviced and maintained in good working order as per the manual provided by the manufacturer / designer and records are maintained. Records should also be maintained for replacement of components, if any;

(xv) ensure periodic tests and inspections of safety systems and control mechanisms are carried out; the records are maintained and are available for inspection by AERB;

(xvi) ensure adequate instruction/training is imparted to employees concerning the radiation hazards associated with their work, the precautionary measures necessary to limit radiation exposure to persons and to avoid radiation accidents and injuries;

(xvii) ensure necessary supervision is provided to all employees in the performance of their work in accordance with the provisions of this guide;

(xviii) in consultation with the Radiological Safety Officer, investigate any case of exposure in excess of regulatory constraints received by individual workers and maintain records of such investigations;

(xix) inform AERB promptly of the occurrence of actual or suspected radiation exposure of personnel in excess of regulatory constraints in prescribed format followed by reports of detailed investigations and follow up actions to prevent recurrence of such incidents;

(xx) inform AERB, within twenty four hours, of any accident involving a source or loss of source of which he/she is the custodian;

(xxi) ensure all applicable requirements of other relevant regulatory authorities are met;

(xxii) make financial arrangement for disposal of disused sources sufficiently in advance;

(xxiii) ensure that loading, replenishment or disposal of sources is carried out only by/through the authorized source supplier;

(xxiv) ensure that Standard operating procedures (SOP) are developed and implemented during operation of IR equipment. This SOP should include specific Dos and Don'ts;

(xxv) ensure that no person is permitted to operate the IR equipment unless he/she has been adequately trained and is competent to operate the unit in accordance with the safety procedures;

(xxvi) carry out physical verification of IR equipment periodically and maintain inventory;

(xxvii) inform appropriate law enforcement agency(police authority) in the locality, and AERB in case of any loss of source;

(xxviii) in case of permanent termination of the use of unit with radioactive source/radiation generator due to any reason, decommission the unit and return the source to the supplier or dispose of, as appropriate, with prior permission of AERB;

(xxix) keep the documents/history of IR equipment in safe custody;

(xxx) obtain prior approval of AERB in case of transfer of ownership of IR equipment;

(xxxi) obtain prior approval from AERB for any modifications in location of installation;

(xxxii) ensure adequate numbers of approved radiography personnel are appointed; for each IR equipment there should be at least one radiography personnel available;

(xxxiii) ensure adequate radiation monitoring instruments are available; for each IR equipment there should be one suitable radiation survey meter and one direct reading dosimeter available.

(xxxiv) ensure that radiography sources and other radioactive materials are transported in accordance with the national/international regulations for safe transport of radioactive material and not transported by public transport like passenger compartments of bus, train, shared taxi etc.

(xxxv) Ensure procurement of only type approved radioactive source/IR equipment.

1.3 Responsibilities of Radiological Safety Officer

The Radiological Safety Officer should:

(xxxvi) ensure that the relevant provisions of Atomic Energy (Radiation Protection) Rules, 2004, are implemented;

(xxxvii) advise and assist the licensee in ensuring regulatory compliance for obtaining consent from the competent authority for procurement, use, transport or disposal of radioactive material;

(xxxviii) implement all radiation surveillance measures including display of radiation symbol and warning at the entrance door of the room where the unit is installed and at appropriate locations;

(xxxix) implement continuous display of the radiation symbol, warning, marking and labeling on the unit;

(xl) advise licensee to establish and maintain an effective radiation protection programme to ensure safety of workers, members of the public and the environment;

(xli) train the operators and associated servicing /maintenance personnel on basic radiation safety, hazard potential and biological effects of radiation;

(xlii) instruct all operators/users on relevant safety measures, provide adequate training in radiation protection and safety methodologies, use of personnel monitoring devices (eg. TLD badges);

(xliii) ensure that personnel monitoring devices are issued to radiation workers in the facility, as applicable, are used as required and are securely stored in radiation-free zone;

(xliv) ensure that radiation monitoring instruments are kept in proper working condition and are periodically calibrated;

(xlv) assist the licensee in developing suitable emergency response plans to deal with emergencies and ensuring appropriate emergency preparedness;

(xlvi) conduct periodic radiation protection surveys and maintain records;

(xlvii) assist in maintaining inventory of sources including initial and present activity, operational logbook and associated QA records;

(xlviii) furnish to the licensee the necessary particulars for the submission of the periodic reports on safety status of the unit to AERB;

(xlix) investigate any situation that could lead to potential exposures and submit report to AERB;

(l) advise employer on implementation of physical protection measures;

(li) assist licensee in maintaining personnel monitoring records, analyse personnel exposure records to ensure that there are no abnormal exposure trends;

(lii) prepare the standard operating procedures (SOP) in-line with the instruction manual provided by manufacturer/supplier of the unit;

(liii) assist licensee for periodic servicing and preventive maintenance of the unit as prescribed by manufacturer/supplier and maintain records;

(liv) ensure safe work practices during source replenishment and safe management of disused source; the RSO of the radiography institute should ensure that the source replacement/ transfer operations, if any, are carried out safely;

(lv) ensure that report on all hazardous situations along with details of any immediate remedial actions taken are made available to the employer and licensee for reporting to the Competent Authority;

(lvi) advice the licensee on the modification in the working condition of female worker after her notification about pregnancy; and

(lvii) inform the competent authority when he/she leaves the employment.

(lviii) maintain the logbook in respect of use and operation of the IR equipment as per the prescribed format.

1.4 Responsibilities of Industrial Radiographer

The industrial radiographer should:

(lix) provide to the licensee information about his/her past radiation work, if any;

(lx) be familiar with the IRED and its technical specification, safety interlocks, safety accessories and its routine use, safe radiography work procedures, emergency procedures and physical security measures appropriate to his or her work, and the relevant requirements of this safety code;

(lxi) on removing an IGRED from the storage room, verify that the source is duly contained in the gamma radiography exposure device with proper survey meter and maintain the record;

(lxii) refrain from any act that could be detrimental to himself /herself, other workers and/or members of the public;

(lxiii) prior to operating the equipment, ensure that all interlocks, shielding, collimators, signs, barriers and other protective devices are properly positioned; that all persons not involved in the operation are at safe locations;

and that a suitable radiation survey meter is available;

(lxiv) make proper use of protective equipment, radiation monitors and personnel monitoring devices provided;

(lxv) operate the equipment in accordance with the operating instructions recommended by the device manufacturer and the Competent Authority and ensure that all persons remain at safe locations outside the cordon during operation, refrain from operating any equipment which is known or suspected to be malfunctioning, to have deteriorated or to be damaged, and report such circumstances promptly to the Radiation Safety Officer for appropriate investigative action;

(lxvi) under the conditions listed below, immediately cease operation of industrial radiography equipment by returning the source to its fully shielded position or by de-energising the X-ray tube, as applicable:

(a) if a malfunction occurs during operation;

(b) if any unauthorised person enters in controlled area; or

(c) if the only available survey meter fails to function;

(d) during worst environmental conditions.

(lxvii) promptly inform the RSO of any accident or potentially hazardous situation that may come to his/her notice;

(lxviii) comply with instructions of RSO/licensee concerning radiation protection; and

(lxix) ensure that trainees operate any IRED and handle the exposure devices or source changers for transportation observing all safety precautions under the direct physical supervision of radiographer/RSO.

(lxx) at the completion of each exposure, ensure, by using an appropriate radiation survey meter, that the source has been returned to the fully shielded position in the case of IGRED or, in the case of X-ray based radiography equipment, that the equipment is no longer energised;

(lxxi) on returning gamma-radiography equipment to the storage, ensure that the source control or shutter mechanism is locked or otherwise secured in the fully shielded position and that all port plugs are firmly secured in place, and check with a survey meter that the source is correctly located in the fully shielded position;

(lxxii) a female worker should, on becoming aware that she is pregnant, notify the employer, licensee and Radiological Safety Officer in order that her working conditions may be modified, if necessary.

1.5 Responsibilities of Manufacturer and Supplier

The manufacturer/supplier should:

(lxxiii) obtain licence from the Competent Authority for the manufacture and supply of IRED, source changer and the accessories;

(lxxiv) supply IGRED/source changer/X-ray equipment/accelerator only after obtaining a Type approval/NOC from the Competent Authority and only to users authorised by the Competent Authority;

(lxxv) provide the user along with the equipment:

(a) technical specifications;

(b) operating/servicing/ maintenance manuals;

(c) instructions for handling emergencies; and

(d) training on operational aspects and maintenance of above exposure device.

(lxxvi) provide user with detailed procedures for Quality Assurance and be carried out with specified frequency to verify correct performance of the device/equipment;

(lxxvii) be responsible for installation, commissioning, servicing and maintenance, decommissioning/dismantling of equipment and for arranging disposal of the disused/decayed radiography sources and any other radioactive material in the shielding;

(lxxviii) keep a record of radiography exposure devices/source changers supplied, together with performance, quality assurance and safety status of the device/source changer;

(lxxix) not offer for sale any X-radiography equipment or gamma radiography equipment unless authorised to do so by the Competent Authority;

(lxxx) submit periodic reports to the Competent Authority in the format prescribed by the Competent Authority;

(lxxxi) provide to the owner or prospective owner:

(a) copy of Type Approval certificate/NOC issued by the competent Authority;

(b) details of the equipment to be supplied, including shielding, and operation of interlocks and shutters;

(c) details of source type, activity and encapsulation of gamma-radiography equipment, including copies of relevant certificates; and

(d) details of the X-ray generator characteristics of X-ray radiography equipment, including maximum tube potential difference [kV(peak)] and current (mA), or maximum X-ray energy (keV) and maximum output (dose rate).

(lxxxii) when supplying a replacement gamma radiography source in a source container, inspect the pigtail and couplings for wear and replace unacceptably worn, frayed or damaged components;

(lxxxiii) provide to the purchaser of a sealed radioactive source, a dummy source(clearly marked as such), and a source holder, if applicable, of the same appearance, or photographic or other documentation necessary to enable the operator to recognise an accidentally detached source, by size and appearance, in an emergency;

(lxxxiv) assist the user for handling radiological emergencies in case any such emergency arises because of use of the radiography equipment/devices/source changers;

(lxxxv) ensure the security of radiography source(s); and

(lxxxvi) also be responsible for facilitating the safe disposal of radiation source

(lxxxvii) Submit periodic report in prescribed format to AERB and also report any unusual occurrences/incidents occurring in models supplied anywhere worldwide.

(lxxxviii) Ensure that incident reports pertaining to the equipment/sources are made available to the relevant user institutions in the country and corrective actions required, if any, are implemented in the supplied units in the country.

1.6 Responsibilities of Radiography Apprentice

The apprentice should:

(lxxxix) provide to the licensee information about his/her past radiation work, if any;

(xc) operate IRED under the direct physical supervision of radiographer/RSO;

(xci) make use of proper radiation monitoring instruments and personnel monitoring devices and protective accessories provided;

(xcii) comply with the instructions of radiographer/RSO on radiation protection; and

(xciii) should refrain from committing any act that could be detrimental to himself/herself, other workers and/or members of the public.

1.7 Servicing/Maintenance Personnel

The servicing and maintenance personnel of radiography equipment should ensure that no repair and maintenance is carried out on radiography exposure device/source changer when it contains radiography source. After repair and maintenance, he should test the safety of the equipment, certify its safety and enter details of repair and maintenance in a logbook. While handling the equipment with radioactive sources, he should wear personnel monitoring devices and direct reading dosimeters. He should use radiation monitoring instruments for ensuring safe radiation levels during work.

1.8 Responsibilities of Radiography Contract Awarding Party (Client)

Radiation surveillance is required at a site where radiography work is carried out. The organisation awarding contract to an industrial radiography institution to conduct industrial radiography operations should co-ordinate with radiography agencies and should:

(xciv) permit only the radiography agency that is duly authorized by AERB to work at the particular site of contractor;

(xcv) ensure that radiography personnel deployed by the radiography agency for carrying out radiography work have valid certificates to work as radiographers and RSO;

(xcvi) provide adequate illumination, scaffolding and other facilities required to facilitate safe radiography work by radiography agency;

(xcvii) provide safe and secure storage room as approved by AERB with round the clock effective physical security arrangements for storing radiography devices, emergency accessories and other associated equipment;

(xcviii) ensure that the radiography agency has emergency plans, preparedness and contact numbers in case of emergency/incidents involving radiography devices;

(xcix) ensure that any other measures required to ensure safety and security of radiography sources handled within the premises of radiography site are met;

(c) ensure that whenever authorised representatives of the Competent Authority visit the radiography site under the control of the contract awarding party to conduct a regulatory inspection, such facilities as may be required to facilitate entry to the site without delay during any part of the day or night with or without prior notice are extended to the inspectors;

(ci) ensure that full support is extended to the radiography agency in establishing security plan including contact nos. of concerned persons and other requirements necessary to ensure physical security of IR equipment all the time; and

(cii) assist radiography agency in ensuring safe recovery of radiography source(s), in case of theft/loss/misplacement of IR equipment.

Annexure-4: Typical Emergency Preparedness and Response Plan

EMERGENCY PREPAREDNESS AND RESPONSE PLAN

(Requirements as per Atomic Energy Radiation Protection Rules, 2004)

The typical action plans prescribed in this manual should be implemented in the event of occurrence of any emergency involving radiography equipment.

a) Emergency Response Committee:

Members of the Emergency Response Committee of our institution is as follows:

Shri/Smt........................ Chairman

Shri/Smt........................ Member

……………………….. "

Shri/Smt........................Site-In-Charge/RSO, Member-Secretary

b) List of RSO/Site-in-charges responsible for each site:

Name of radiography Site	RSO/Site In Charge Name	Contact Numbers

The above Radiation Safety Officers/Site in charges are responsible for handling emergencies involving radiography equipment and Radiography sources at their respective radiography sites. All the emergencies and subsequent operation for handling emergency should be intimated to AERB.

c) List of Emergency Handling Equipment at Site

(i) ....

(ii) ....

(iii) ....

(iv) ....

Radiation Monitoring Instruments for Handling Emergencies available at site. (Site-wise distribution)

a) Radiation Survey Meter:

Name of the Radiation Survey Meter	Model/Sr. No. of Survey Meter	Range of Survey meter	Date of calibration

b) Pocket Dosimeters:

Pocket Dosimeters	Model & Sr. No.	Range	Date of calibration

RSO is responsible for carrying out maintenance of the emergency handling accessories regularly at site.

c) Procedure for Reporting Emergency:

(i) RSO to report to employer/licensee of the Institution with copy to Head, RSD, AERB;

(ii) Employer/Licensee to report the incident to AERB within 24 hours of its occurrence. Format for reporting Emergency will be used as provided by AERB;

(iii) RSO to carry out investigations and submit report to AERB;

(iv) Lodge a written compliant with the Police in case of loss/theft if IGRED is not traced within 24 hours;

d) General Guidelines to handle emergency situations:

(i) Rescue of personnel is primary concern;

(ii) Cordon off the area;

(iii) In case of fire, fighting fire from upwind direction;

(iv) Notification to the Responsible person;

(v) Monitoring of radioactive contamination;

(vi) Security of the area.

e) Emergency Situations:

The occurrence of any one or more of the following situations may be deemed to constitute an emergency:

(i) Loss/theft of radiography sources from storage / radiography sites;

(ii) Loss of radiography sources during transport;

(iii) Failure to retrieve the source pigtail into the source housing

due to either; - Source getting stuck in the Guide Tube

- Source Detachment

(iv) Over-Exposure due to unsafe radiography work practices;

(v) Contamination due to damaged source.

Anyone noticing any of the above instances should immediately bring the matter to the notice of RSO available at the site. The RSO is the only person at site who is the responsible person for handling any emergency taking place at site. The radiographer should cordon off the area and act as per the instructions and guidance of RSO.

f) Action Plans for handling the above emergency scenarios:

The following are the action plans for each of the above emergency scenarios:

(i) <u>Loss/theft of radiography sources from storage / radiography sites:</u>

- Gather information regarding the Source;
- Collect handling & monitoring equipment;
- Inform the security.

<u>Procedure to be followed:</u>

If the location of the source is known;

- Determine with survey meter presence of source
- Cordon off the area

- Switch on survey meter & move in direction where radiation level increases
- Bring the lead pot and transfer the source with 2 m CV tong to the container
- Bend the female coupling portion of the pigtail and connect the drive cable and draw the pigtail back into the camera

If the location of source is not known;

- Search for the source in suspected areas
- Deploy more search teams
- Intimate AERB
- Lodge police complaint
- Make public announcement after getting clearance from AERB
- Contact nearby Government & Municipal Hospitals.

(ii) <u>Loss of radiography sources during transport</u>

- Gather information regarding the source.
- Collect handling & monitoring equipment
- Inform the carrier official immediately

<u>Procedure to be followed</u>:

If location of the source is known;

- Cordon off adequate area
- Switch on survey meter & move in direction where radiation level increases
- Bring the lead pot and transfer the source with 2 m CV tong to the container
- Bend the female coupling portion of the pigtail and connect the drive cable and draw the pigtail back into the camera.

If location of the source is not known;

- Search for the source in suspected areas
- Deploy more search teams
- Intimate AERB

- Lodge police complaint
- Make public announcement after getting clearance from AERB
- Contact nearby Government & Municipal Hospitals

(iii) Failure to retrieve the source pigtail into the source housing

Source Stuck in the Guide Tube;

Procedure to be followed:

- Locate the source using survey meter
- Cover the source assembly with lead sheet /or with suitable means
- Straighten the guide tube if the same is bent
- Apply force to retrieve the source assembly
- If retrieved ensure that the source assembly has reached the safe position
- If the source is stuck in the guide tube because a heavy object had fallen on the guide tube and caused a constriction in the passage of the source through the guide tube, the guide tube has to be carefully cut using a metal-cutting shears.

Source Detachment;

- Locate the pigtail assembly position in the guide tube with the help of Survey meter
- Cover the Pigtail assembly location with lead sheet /or with suitable means
- Disconnect the guide tube from camera
- Arrange lead pot /shielding container
- Lift the guide tube using CV-tong and make it vertical and allow falling of the pigtail assembly on the ground
- Lift the pigtail assembly using CV-tong and put in to lead pot/Shielding container
- Connect the pigtail with control cable and retract back the pigtail assembly to the camera
- Measure the radiation level for safe return of pigtail assembly in camera
- Disconnect the control unit and lock the camera.

(iv) Over-Exposure due to unsafe radiography work practices:

- Check the pocket dosimeter reading
- Verify the measurement by using radiation survey meter
- Inform employer/ RSO
- If overexposure to radiography personnel is suspected, send the TLD for immediate monitoring
- Provide first aid to the injured, if any
- Do a detailed investigation of the exposed personnel
- Reconstruct incident/accident for calculating Dose received
- Arrange alternative work for exposed personal, if dose exceeds the prescribed limit till the confirmation of dose from PMS
- Submit the detailed report to AERB on overexposure.

(v) Contamination due to damaged source:

Carry out radiation protection survey all around any incident/accident.

Carry out radiation protection survey around the IGRED and its associated accessories.

Procedure to be followed;

- Take radiation survey meter and carry out radiation protection survey of the guide tube, IGRED, and other material which may be contaminated
- Examine all the suspected areas with a contamination monitor, if contamination is suspected, collect all material
- Packed this carefully in polyphone bag
- Intimate to employer/ AERB. The IGRED should be sent for decontamination/ disposal with prior approval from AERB.

PERSONS TO BE CONTACTED IN THE EVENT OF AN EMERGENCY

(To be displayed in the dark room and source storage facility at every site)

Name of Persons	Designation	Mobile number	Address		Telephone No	
			Office	Residence	Office	Residence
Radiation Safety Officer						
Site-in-charge						
Head of the Institute						
Security Officer at Site						
Representative of Contract Awarding Party at site						
Police						
Local Hospital						
Head, RSD, AERB						

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LIST OF PARTICIPANTS

IN-HOUSE WORKING GROUP

Dates of meeting: July 4, 11, 17, 24, 25, 31, 2018; August 7, 8, 9, 2018

Dr. Pankaj Tandon, RSD, AERB	Convenor
Shri R. K. Yadav, RSD, AERB	Member
Smt. Mahalakshmi, RSD, AERB	Member
Shri Amit Sen, RSD, AERB	Member
Smt. V. Anuradha, DRA&C, AERB	Member
Shri B.K. Singh, DRA&C, AERB	Member
Shri Pravin Patil, RDD, AERB	Member
Shri D.M. Rane, RSD, AERB	Member
Shri J.V. K Sunil kumar, DRI	Member
Shri Pradip Kumar, DRI, AERB	Member
Shri Ashish Ramteke, RSD, AERB	Member
Shri Rajoo Kumar, RDS, RDD, AERB	Member-Secretary

Dr. P.K. Dash Sharma, Former, Head, RSD, AERB (Guidance & Supervision)

TASK FORCE

Dates of meetings: April 15, 24, 2019, May 9, 21, 2019, June 14, 21, 2019

Dr. A.N. Nandakumar, Former Head, RSD, AERB	Convener
Shri S.A. Hussain, Former Head, RSD, AERB	Co-Convener
Dr. A.U. Sonawane, Head, DRA&C, AERB	Member
Shri P.K. Gaur, Ex-RP&AD, BARC	Member
Shri K.D. Pushpangadan, Ex-RSD, AERB	Member
Dr. S.D. Sharma, Head, MPS, RP&AD, BARC	Member
Shri R.K.B.Yadav, RSSD, BARC	Member
Dr. P.K. Dash Sharma, Head, RSD, AERB	Member
Dr. Pankaj Tandon, Head, IATS, RSD, AERB	Member
Dr. Ghansyam Sahani, Head, MAS, RSD, AERB	Member
Dr. Alok Pandey, RSD, AERB	Member
Shri Pravin Kumar, BRIT	Member
Shri Rajoo Kumar, RDS, RDD, AERB	Member
Shri Neeraj Dixit, RSD, AERB	Member Secretary
Shri Pravin Patil, Security Cell, AERB	Member Secretary
Shri Amit Sen, RSD	Invitee
Shri G.K. Panda, RSD	Invitee
Smt. V. Anuradha, DRA&C	Invitee

TASK GROUP (HARMONIZATION)

Dates of meetings: October 23, 2024

Dr. R. B. Solanki, Head, RDS, R&DD, AERB	Convener
Dr. G. Sahani, Head, MAS, RASD, AERB	Co-Convener (MA-REGDOCs)
Smt. Mahalakshmi, Head, IAS, RASD, AERB	Co-Convener (IA-REGDOCs)
Shri Rajoo Kumar, RDD, AERB	Member (RDS-RO)
Smt. Swathy K. Nair, R&DD	Member (RDS-RO)
Shri Amit Sen, RASD	Nodal Officer (NG)
Shri G.K. Panda, RASD	Nodal Officer (IR,CP)
Shri D.M. Rane, RASD	Nodal Officer (GRAPF)
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Shri Subrata Pathak, DRA&ER	Nodal Officer (NM)
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Shri Nidhip Chodankar, RASD	Nodal Officer (IARPF & PARF)
Shri Neeraj Dixit, RASD	Member-Secretary (assigned guides)
Shri Pravin Patil, R&DD	Member-Secretary (assigned guides)

ADVISORY COMMITTEE ON NUCLEAR AND RADIATION SAFETY
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Date of meeting: December 13, 2021, September 29, 2022

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Shri A. R. Sundararajan, Former Director (RSD), AERB-	Member
Dr. N. Ramamoorthy, Former CE, BRIT & AD, BARC	Member
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Shri G.K. Panda, RASD, AERB	Invitee

ADVISORY COMMITTEE ON NUCLEAR AND RADIATION SAFETY (ACNRS)

Dates of meeting: December 17, 2021, October 28, 2022

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