

AERB SAFETY CODE NO. AERB/RF-IR/SC-1 (Rev.1)

INDUSTRIAL RADIOGRAPHY

Approved by the Board in November 2015

**Atomic Energy Regulatory Board
Mumbai 400094
India**

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Price:

Orders for this safety code should be addressed to:

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FOREWORD

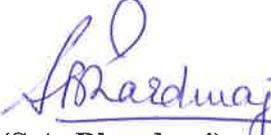
Activities concerning establishment and utilization of nuclear facilities and use of radioactive sources are to be carried out in India in accordance with the provisions of the Atomic Energy Act, 1962. In pursuance of the objective of ensuring safety of occupational workers, members of the public and protection of the environment, the Atomic Energy Regulatory Board (AERB) has been entrusted with the responsibility of laying down safety standards and enforcing rules and regulations for such activities. The Board has, therefore, undertaken a programme of developing safety standards, safety codes, and related guides and manuals for the purpose. While some of these documents cover aspects such as siting, design, construction, operation, quality assurance and decommissioning of nuclear and radiation facilities, other documents cover regulatory aspects of these facilities.

Safety codes and safety standards are formulated on the basis of internationally accepted safety criteria for design, construction and operation of specific equipment, structures, systems and components of nuclear and radiation facilities. Safety codes establish the objectives and set requirements that should be fulfilled to provide adequate assurance for safety in nuclear and radiation facilities. Safety guides elaborate various requirements and furnish approaches for their implementation. Safety manuals deal with specific topics and contain detailed scientific and technical information on the subject. These documents are prepared by experts in the relevant fields and are extensively reviewed by advisory committees of the Board before they are published. These documents are revised, when necessary, in the light of experience and feedback from users as well as new developments in the field.

The safety code on 'Industrial Radiography', (AERB/SC/IR-1), issued by AERB in 2001, specified mandatory requirements for industrial radiography institutions, covering the entire spectrum of operations ranging from setting up of a industrial radiography facility to its ultimate decommissioning, including procedures to be followed during radiological emergency situations. The safety code also stipulated the mandatory requirements for radiography equipment and sources, and personnel requirements and responsibilities. In view of the advancement in radiography equipment, revision in basic educational qualification for certified radiographer, regulatory requirements for ensuring security of radiography sources at radiation facilities and during their transport, and in the light of experience and feedback from users, AERB has revised this safety code. This revised safety code supersedes the earlier version and consolidates all the regulatory requirements relevant to industrial radiography.

It has been reviewed experts in the field. Standing Committee for Review and Revision of AERB Radiation Safety Documents (SC-RR-RSD) and Advisory Committee on Radiological Safety (ACRS) have further reviewed and vetted it for issue. The draft safety code was placed on AERB website for public comments.

AERB wishes to thank all individuals and organisations who have prepared and reviewed the draft and helped in its finalisation. The list of experts, who have participated in this task, along with their affiliations, is included for information.


(S.A. Bhardwaj)
Chairman, AERB

DEFINITIONS

A₁ (Transport of Radioactive Materials)

Maximum activity of special form radioactive material permitted in a Type A Package.

A₂ (Transport of Radioactive Materials)

Maximum activity of radioactive material, other than special form radioactive material, permitted in a Type A package.

Accelerator

A device in which charged particles are accelerated. Conventional X-ray tube is not considered as an accelerator.

Accident

An unplanned event resulting in (or having the potential to result in) personal injury or damage to equipment which may or may not cause release of unacceptable quantities of radioactive or toxic/hazardous chemicals.

Activity

The quantity 'A' for an amount of radionuclide in a given energy state at a given time, defined as:

$$A = dN/dt$$

where 'dN' is the expectation value of the number of spontaneous nuclear transformations from the given energy state in a time interval 'dt'. The SI unit of activity is the reciprocal second, s⁻¹, termed the Becquerel (Bq).

Adequate Protection

Protection against radiation so provided that the prescribed operational limits on levels of radiation or contamination are not exceeded.

Applicant

Any person who applies to the Competent Authority for consent to undertake any of the actions for which the consent is required.

Approval

A type of consent issued by the regulatory body to a proposal.

Authorisation

A type of regulatory consent issued by the regulatory body for all sources, practices and uses involving radioactive materials and radiation generating equipment (see also "Consent").

Becquerel (Bq)

(See 'Activity').

Becquerel is the unit of activity.

1 Bq = one disintegration per second

or

1 Bq = one nuclear transformation per second (as defined under activity)

Collimator or Field Limiting Diaphragm

A device used for limiting the size and shape of the primary radiation beam.

Competent Authority

Any officer or Authority appointed, approved or recognised by the Government of India for the purpose of the Rules promulgated under the Atomic Energy Act, 1962.

Contamination

The presence of radioactive substance on a surface in quantities in excess of 0.4 Bq/cm² for beta and gamma emitters and low toxicity alpha emitters and 0.04 Bq/cm² for all other alpha emitters.

Dose

A measure of radiation received or absorbed by a target. The quantities termed absorbed dose, organ dose, equivalent dose, effective dose, committed equivalent dose or committed effective dose are used depending on the context. The modifying terms are used when they are necessary for defining the quantity of interest.

Effective Dose

The quantity E, is defined as a summation of the tissue equivalent doses, each multiplied by the appropriate tissue weighting factor:

$$E_T = \sum_T w_T \cdot H_T$$

where H_T is the equivalent dose in tissue T and w_T is the tissue weighting factor for tissue T.

Emergency

A situation which endangers or is likely to endanger safety of the site personnel, the nuclear/radiation facility or the public and the environment.

Employer

Any person with recognised responsibility, commitment and duties towards a worker in his or her employment by virtue of a mutually agreed relationship (A self-employed person is regarded as being both a worker and employer).

Enclosed Installation

In the case of industrial radiography, installation in which radiography operations are carried out in an enclosure, which has walls providing adequate radiation protection to persons working outside the

enclosure, and which prevents unauthorised entry of persons into the enclosure during radiography operations. Such installations may include open top installations also.

Equivalent Dose ($H_{T,R}$)

The quantity ' $H_{T,R}$ ' is defined as :

$$H_{T,R} = D_{T,R} w_R$$

where ' $D_{T,R}$ ' is the absorbed dose delivered by radiation type ' R ' averaged over a tissue or organ ' T ' and ' w_R ' is the radiation weighing factor for radiation type ' R '. When the radiation field is composed of different radiation types with different values of ' w_R ', the equivalent dose is

$$H_T = \sum w_R D_{T,R} .$$

Industrial Gamma Radiography Exposure Devices (IGRED)

An assembly of components necessary to make radiographic exposure and which includes source housing, source assembly mechanism for securing source assembly control, and other components associated with positioning the source, such as source guide tubes.

Industrial Radiography

Non-destructive testing of materials employing ionising radiation.

Leakage Radiation

Any radiation coming from the source/tube housing, other than useful beam or primary beam.

Licence

It is a type of regulatory consent, granted by the regulatory body for all sources, practices and uses for nuclear facilities involving the nuclear fuel cycle and also certain categories of radiation facilities. It also means authority given by the regulatory body to a person to operate the above facilities.

Licensee

A person to whom Licence has been issued under the relevant Rules.

Multilateral Approval (Transport of Radioactive Materials)

Approval by the Competent Authority of the country of origin of the design or shipment and of each country through or into which the consignment is to be transported. The term 'through or into' specifically excludes over, that is, the approval and notification requirements shall not apply to a consignment which is carried in an aircraft, provided there is no scheduled stop in that country.

Occupancy Factor (T)

For the purpose of calculating protective shielding, the factor by which workload is multiplied, in order to take account of the degree of occupancy.

Package

The packaging with its radioactive contents as presented for transport.

Packaging

The assembly of components necessary to enclose the radioactive contents completely. It may, in particular, consist of one or more receptacles, absorbent materials, spacing structures, radiation shielding, service equipment for filling, emptying, venting and pressure relief devices for cooling, absorbing mechanical shocks, providing handling and tie-down capability, thermal insulation and service devices integral to the package. The packaging may be a box, drum, or similar receptacle, or a freight container, tank or intermediate bulk container.

Personal Monitoring

Determination or estimation of the dose received by a person from external and internal radiation.

Quality Assurance

Planned and systematic actions necessary to provide adequate confidence that an item or a facility will perform satisfactorily in service as per design specifications.

Radiation Level

The dose rate expressed in millisieverts per hour (mSv/h).

Radioactive Waste

Material, whatever its physical form, remaining from the practices or interventions and for which no further use is foreseen: It can be (a) that contains or is contaminated with radioactive substances and has an activity, or activity concentration, higher than the level for clearance from regulatory requirements; and (b) exposure to which is not excluded from regulatory control.

Radiography Source

A source sealed in one or more capsules, or an X-ray tube, or an electron accelerator or a neutron source used for industrial radiography.

Radiological Safety Officer (RSO)

Any person who is so designated by the employer and who, in the opinion of the Competent Authority, is qualified to discharge the functions outlined in the Atomic Energy (Radiation Protection) Rules, 2004.

Regulatory Body

(See 'Competent Authority')

Rules

Atomic Energy (Radiation Protection) Rules, 2004.

Scattered Radiation

Radiation that, during passage through matter, gets deviated in direction. (It may have been modified by a decrease in energy).

Sealed Source

Radioactive source material that is (a) permanently sealed in a capsule, or (b) closely bounded and in a solid form. The capsule or material of a sealed source shall be strong enough to maintain leak tightness under the conditions of use and wear for which the source was designed, as also under foreseeable mishaps.

Secured Position

Condition of the exposure device and source assembly when the source is fully shielded in the source housing and the exposure device is rendered inoperable by locking and/or other means.

Source

Anything that causes radiation exposure by emitting ionising radiation or releasing radioactive substances or materials.

Source Assembly

An assembly of components consisting of gamma radiography source and a mechanism for connecting the drive system.

Source Changer

A device for transfer of radiography source(s) from or to exposure device, and suitable for transport and storage of the source(s).

Source Drive Mechanism

A remotely operating mechanism which drives a radiography source out of, or into, a storage container.

Source Guide Tube

A flexible or rigid tube through which the source holder moves from its secured position in the source housing to its working position.

Special Form Radioactive Material

Either an indispersible solid radioactive material or a sealed capsule containing radioactive material conforming to the requirements specified and approved by the Competent Authority as special form radioactive material.

Stray Radiation

The sum of leakage radiation and scattered radiation.

Type A Package

A package designed to withstand normal conditions of transport without loss or dispersal of its contents or loss of shielding integrity. The radioactive material may be transported in a Type A package either in special form radioactive material or other form with the provision that the activity shall not exceed the applicable limits specified by the Competent Authority in the relevant regulatory provisions for the Safe Transport of Radioactive Materials.

Type B(M) Package

A package, whose design or shipment requires multilateral approval because it does not meet all requirements of a Type B(U) package.

Type B(U) Package

A package designed to contain an activity in excess of A1, if special form radioactive material, or in excess of A2 if not special form radioactive material, that is designed to withstand normal and accidental conditions of transport specified in the relevant Code on 'Transport of Radioactive Materials'.

Type Approval

Approval issued by the Competent Authority based on evaluation of the device to ensure that it conforms to Safety Standards.

Worker

Any person, who works, whether full-time, part-time or temporarily, for an employer and who has recognised rights and duties in relation to occupational radiation protection (self-employed person is regarded as having duties of both an employer and worker).

Workload (W)

For the purpose of shielding computation, the radiation output or equivalent quantity integrated usually over a working week.

SPECIAL DEFINITIONS
(Specific for the Present Safety Code)

Act

The Atomic Energy Act, 1962 or an amended version thereof.

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.

Disused Source

A radioactive source that is no longer used or is not intended to be used, for the practice for which an authorisation 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.

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.

Radiation Monitoring Instrument

An active device or instrument used for detecting radiation fields and measuring air kerma/exposure rate.

Radiographer

A worker who performs radiography operations employing radiography sources and possesses a valid qualification/ certificate duly recognised by the Competent Authority for the specific purpose.

Shielding

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

Sky-shine

Sky-shine is the radiation scattered by air molecules after emerging more or less vertically from the shielded enclosure. It causes elevated radiation field outside the shield.

X-ray Equipment

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

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LIST OF PARTICIPANTS

STANDING COMMITTEE FOR REVIEW AND REVISION OF AERB RADIATION SAFETY DOCUMENTS (SCRRRSD)

ADVISORY COMMITTEE ON RADIOLOGICAL SAFETY (ACRS)

LIST OF REGULATORY SAFETY DOCUMENTS RELEVANT TO INDUSTRIAL RADIOGRAPHY

1. INTRODUCTION

1.1 General

A variety of industrial radiography exposure devices (IRED) are used for non-destructive testing (NDT). These devices incorporate sources of radiation and therefore requirements for safe handling need to be complied with. This safety code prescribes the regulatory requirements from radiation protection standpoint, in respect of safe handling of industrial radiography equipment including, Industrial Gamma Radiography Exposure Devices (IGRED), X-ray units and accelerators.

1.2 Objective

Radiation safety in handling radiation sources is governed by sections 14, 16 and 17 of the Atomic Energy Act, 1962, and the Atomic Energy (Radiation Protection) Rules, 2004 issued under the Act. The objective of this Code is to stipulate the requirements specific to radiation safety of persons handling industrial gamma radiography exposure devices and X-ray generating equipment for industrial radiography, in order to:

- (a) ensure that radiography workers and members of the public are not exposed to radiation in excess of the limits specified by the Competent Authority under the Atomic Energy (Radiation Protection) Rules, 2004, and under the safety directives issued from time to time;
- (b) reduce radiation exposures below the limits to levels as low as reasonably achievable (ALARA);
- (c) ensure safety of radiography sources and equipment in custody, use, transportation, and disposal; and
- (d) provide for prevention of hazardous situations and initiate appropriate actions to mitigate consequences of radiation emergencies.

1.3 Scope

This safety code gives the provisions applicable to radiological safety of industrial radiography operations and security of radiography devices/ sources. This safety code addresses the regulatory controls specific to radiation protection.

For radiography techniques not included in this safety code (such as neutron radiography in any form), specific additional directions shall be obtained from the Competent Authority.

2. RADIOGRAPHY EQUIPMENT AND SOURCES

2.1 Industrial Gamma Radiography Exposure Devices (IGRED)

2.1.1 General

The industrial gamma radiography exposure devices shall be capable of remote operation and control and shall be designed and built to comply with the AERB Safety Standard titled 'Industrial Gamma Radiography Exposure Devices and Source Changers', [AERB/RF-IR/SS-1 (Rev.1)] or equivalent international standard. Only an industrial gamma radiography exposure device or a source changer in respect of which approval of design has been duly accorded by the Competent Authority, shall be marketed, sold, transferred, procured and used, with prior approval of the Competent Authority

2.1.2 Source Housing

The IGRED is classified as portable, mobile or fixed, depending on its overall weight as specified in AERB/RF-IR/SS-1 (Rev.1). Shielding provided by the source housing shall be such that when the control mechanism is securely locked in its 'OFF' condition and a radiography source of maximum rated activity is in the housing, the leakage radiation outside the housing shall not exceed the levels given in the Table 2.1. In order to establish compliance, the radiation level at 5 cm from the surface of the IGRED shall be measured over an area of 10 cm² with no linear dimension greater than 5 cm. At 1 m, the area of measurement shall be not more than 100 cm² with no linear dimension greater than 20 cm. The levels are averaged over these measurement areas.

TABLE 2.1: LIMITS ON LEAKAGE RADIATION LEVELS

| Class of IGRED | 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 | 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 shall be so designed as to serve also as transport package (either Type A or Type B(U)/(M)), as appropriate. 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 2.2. The source housing shall comply with the applicable design requirements for Type A/Type B(U/M) package as specified in the requirements for the safe transport of radioactive material.

TABLE 2.2: ACTIVITY LIMITS FOR SPECIAL FORM RADIOACTIVE MATERIAL PERMITTED IN A TYPE A PACKAGE

| Radionuclide | Activity Limit in TBq |
|---------------------|------------------------------|
| ⁶⁰ Co | 0.4 |
| ¹³⁷ Cs | 2.0 |
| ⁷⁵ Se | 3.0 |
| ¹⁷⁰ Tm | 3.0 |
| ¹⁹² Ir | 1.0 |

2.1.3 Marking and Labelling

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

- (i) chemical symbol of the radionuclide in the IGRED,
- (ii) activity and the date on which this activity was measured,
- (iii) manufacturer of the sealed source,
- (iv) radiation symbol (trefoil symbol),
- (v) serial number of the IGRED provided by the manufacturer and package design approval Identification number, provided by Regulatory Body, and
- (vi) maximum leakage radiation level at 5 cm from the surface of the IGRED and the date of measurement.

2.1.4 Security and Safety

The IGRED shall have tamper-proof lock for physical security of the source to prevent unauthorised operation. It shall not be possible to operate the lock unless the source or source assembly is in the fully shielded position. The industrial gamma radiography IGRED shall incorporate the safety systems and the handling facilities specified in AERB/RF-IR/SS-1 (Rev.1).

2.2 Source Changer

2.2.1 Source Housing

Source changer shall comply with the requirements specified in AERB/RF-IR/SS-1 (Rev.1). Leakage radiation (on the surface, and at 1 m) with source(s) of maximum authorised activity in the source changer shall not exceed the levels specified in sub section 2.1.2.

2.2.2 Marking and Labelling

The licensee shall 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 the source 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 package design approval identification number, and
- (vi) maximum leakage radiation level at 5 cm from the surface of the source changer and the date when it was measured

2.2.3 Security and Safety

Source changer shall have tamper-proof lock for physical security of the source and to prevent unauthorised operation. It shall not be possible to operate the lock unless the source or source assembly is in the fully shielded position. Measures to ensure proper and firm connection of the guide tube to the source changer shall be provided.

2.3 Sealed Source

The sealed source shall comply with the AERB Safety Standard ‘Testing and Classification of Sealed Radioactive Sources’, [AERB/SS-3 (Rev-1)] or equivalent. The radiography source shall at least meet requirements for 4-3-3-1-3 classification of AERB/SS-3 (Rev-1) as given in Table 2.3. The supplier of the source shall demonstrate compliance with the test requirements as specified in AERB/SS-3 (Rev-1).

TABLE 2.3: TEST CONDITIONS FOR 4-3-3-1-3 CLASSIFICATION OF SEALED SOURCES

| S. No. | Test | Conditions |
|--------|-------------------|--|
| 1 | Temperature | -40°C (20 minutes), +400°C (1 hour) and thermal shock +400°C to 20°C |
| 2 | External pressure | 25 kPa absolute to 2 MPa absolute |
| 3 | Impact | 200 g* from 1 m |
| 4 | Vibration | No test |
| 5 | Puncture | 10 g* from 1 m |

* g: acceleration due to gravity

2.4 X-Ray Equipment

2.4.1 Selection of X-ray Radiography Equipment

Industrial X-ray radiography equipment shall be appropriate to the application for which it is intended with regard to the maximum X-ray energy and dose rate or maximum tube potential difference (kV(peak)) and maximum current (mA).

2.4.2 Design and Construction

2.4.2.1 The design of the industrial X-ray equipment shall meet the requirements of relevant current national and/or international standards.

2.4.2.2 The X-ray tube shall be contained in a housing that provides shielding from radiation in all directions other than the beam direction. The protective tube housing shall be so constructed that the stray radiation in any direction, averaged over an area of not more than 100 cm² with no linear dimension greater than 20 cm, shall not exceed 10 mGy in one hour at a distance of 1 m from the X-ray target when, with the beam portal shielded adequately, the tube operates at its peak kilovoltage (kVp) and maximum rated current at that kVp.

- 2.4.2.3 The X-ray tube shall incorporate filtration to increase the effective energy radiation.
- 2.4.2.4 A key switch shall be fitted to the X-ray control panel to prevent unauthorised use. The key shall be removable only when the switch is in the off position. The function of the key switch and its ON and OFF positions shall be clearly marked on the control panel.
- 2.4.2.5 X-ray ON and OFF controls shall be physically separate from the key switch. Their functions, and the ON and OFF positions, shall be clearly marked on the control panel.
- 2.4.2.6 There shall be separate provision to terminate radiation generation automatically after pre-set time and manually at any time.
- 2.4.2.7 A red or amber indicator lamp shall be provided on the control panel and shall be automatically illuminated when the X-ray tube is energised. This lamp shall be duplicated on the X-ray tube housing and operate in parallel with its counterpart on the control panel and shall be visible from a distance of at least 10 m. An interlock shall be provided such that if either of the ‘beam ON’ indicator lamps fails, the X-ray tube cannot be energised, and replacement of the lamp will not automatically re-energise the X-ray tube.
- 2.4.2.8 The control panel shall be equipped with a device or devices indicating the X-ray beam energy and output in terms of the X-ray tube potential difference kVp and current (mA) or electron energy and dose rate, as appropriate, duration of exposure and X-ray beam status. Energising the X-ray equipment shall be key-controlled to prevent unauthorised use. For equipment that is used for open field radiography, the values indicated shall be clearly legible in bright sunlight.
- 2.4.2.9 The length of cable connecting the control panel with the X-ray tube shall meet the specifications given in Table 2.4 unless the X-ray equipment is within and operated from outside, an adequately shielded radiography enclosure:

TABLE 2.4: LENGTH OF CABLE FROM CONTROL PANEL TO X-RAY TUBE AS A FUNCTION OF THE PEAK VOLTAGE

| Peak Voltage 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 |

- 2.4.2.10 X-ray equipment that is used for direct-viewing fluoroscopy shall be shielded such that during radiography, the stray radiation level at any position that can be occupied by any person does not exceed 10 μ Sv/h.
- 2.4.2.11 Fluoroscopic imaging devices shall be positioned such that the primary X-ray beam is totally intercepted, and the exposure configuration shall be arranged such that it is not possible for any part of the body of any person to be inserted into the beam.

2.5 Crawler Equipment

The crawler equipment shall comply with the following requirements:

- 2.5.1 The gamma radiography crawler shall comply with requirements specified in 2.1.2, and X-ray crawler shall comply with requirements specified in sub-section of 2.4.2, as applicable.
- 2.5.2 Means shall be provided for external indication of the crawler location in a pipeline. There shall be means to prevent exposure when the external position indicator fails to function as intended.
- 2.5.3 The width of useful beam on the pipe surface shall not be greater than 20 cm at the circumference of the pipe within which the crawler is operating.
- 2.5.4 It shall shut 'OFF' automatically in the event of any malfunction during use; that is, X-ray crawler shall switch off the beam and the gamma source shall retract to shielded position.
- 2.5.5 The crawler shall have a warning provision such as a horn fitted to it such that after the crawler has reached the exposure position, it shall 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 shall continue to operate in a manner that is distinguishable from the 10 second warning.
- 2.5.6 The warning sound shall be loud and distinctive enough to be heard clearly above all other noise sources in the vicinity of the crawler.
- 2.5.7 An X-ray crawler, for which exposures are initiated by remote control or by an automatic device such as a trip wheel, shall have a safety device fitted to it which prevents the remote control or the automatic device from initiating an exposure unintentionally.
- 2.5.8 An X-ray crawler shall incorporate a safety device which disconnects power from the propulsion unit in the event of a malfunction during operation.

2.6 Accelerator Equipment

The accelerator equipment shall comply with the following requirements:

- 2.6.1 Protective tube housing shall be so constructed that the stray radiation at any direction other than the primary beam direction shall not exceed 0.5% of the primary output at a distance of 1 meter from the target when, with the beam portal shielded adequately, the accelerator operates at its maximum energy and pulse rate frequency (PRF).
- 2.6.2 The design of the accelerator equipment shall meet the requirements of current national and international standards.
- 2.6.3 The high energy accelerator generating X-rays shall meet the requirements specified in sub-section 2.4 for X-ray equipment.
- 2.6.4 Key-controlled interlock shall be provided on the control console to prevent unauthorised use.
- 2.6.5 The beam limiting system of a portable/mobile accelerator equipment meant for use on shop floor or elevated locations shall restrict the primary beam divergence to a cone of not more than 30° apex angle.
- 2.6.6 An emergency push button shall be prominently located on the control panel to stop the radiation generation.

- 2.6.7 When radiation generation is stopped, either by an interlock or by action of emergency push button, it shall not be possible to restart unless the exposure control is reset manually.

2.7 Servicing and Maintenance

Servicing and maintenance of X-ray equipment/ accelerator/ IGRED/source changer shall be provided throughout the useful life by manufacturer/ supplier or by persons with appropriate qualification and training and certified by the Competent Authority where manufacturer/ supplier has ceased to operate. The manufacturer or supplier shall be responsible for supply of original spares and accessories.

3. INDUSTRIAL RADIOGRAPHY INSTALLATIONS

3.1 General

Industrial radiography shall be carried out in shielded enclosure(s) unless the nature of work is such that it has to be carried out in the open field. Prior approval of the Competent Authority shall be obtained for carrying out radiography operations in any facility whether an enclosed installation or the site where open field radiography is proposed to be carried out.

3.2 Enclosed Radiography

The following requirements in respect of enclosed radiography shall be complied with:

- 3.2.1 The room housing of IRED (i.e. IGRED/ X-ray equipment/accelerators) shall be in a location where the occupancy is as low as practicable and shall be located in industrial area. The installation shall be fully enclosed and shielded, or enclosed on all sides with the exception of open top.
- 3.2.2 The enclosed radiography installation shall provide adequate structural shielding for walls/doors, ceiling and floor so that the radiation levels outside the shielding do not exceed the annual dose limits for occupational workers and general public. In case of open top enclosed radiography installations, the scattered radiation (sky-shine) shall also be considered and necessary measures shall be implemented to minimize the sky-shine radiation.
- 3.2.3 An enclosed radiography installation shall provide for a control room from where the operation of the radiography equipment within the shielded enclosure shall be controlled remotely.
- 3.2.4 The conduit/opening for cables provided in the wall between the control room and exposure room shall be so designed as to prevent direct streaming of radiation.
- 3.2.5 In enclosed radiography installations where X-ray equipment or accelerator is operated, the door between the control room and the exposure room shall be provided with an electrical interlock so as to prevent operation of X-ray equipment or accelerator when the door is open or improperly closed. The interlock shall activate an audio and visual alarm and a placard to caution persons during exposure.
- 3.2.6 Exposure controls for the IGRED/X-ray equipment/accelerator shall be located outside the exposure room. Identification of each control shall be distinct and unambiguous.
- 3.2.7 The concentration of ozone in an accelerator installation shall not exceed 0.1 ppm at the time of entry in the exposure room.
- 3.2.8 The radiation symbol specified in the Rules shall be conspicuously posted at the entrance. A placard indicating 'RADIATION:RESTRICTED ENTRY' shall be posted, along with its equivalent in Hindi as well as in local language, alongside the radiation symbol. An X-ray hazard symbol as prescribed in the Rules, shall be conspicuously posted in case an X-ray machine is used.
- 3.2.9 There shall be sequentially operated search buttons in accelerator installations with long maze which does not offer direct view from the control panel or entry door to ensure that no person remains in the exposure room when the machine is energised. A trip wire shall be provided at an easily accessible height around the inside periphery of the accelerator room so that a person

inadvertently present in the room when the machine is 'ON' may pull the wire to trip off the operation of the accelerator. There shall be an audible alarm inside the radiography room during radiation generation.

- 3.2.10 A suitable zone monitor, preferably with extended radiation detector with pre-set audio-visual alarm provision, shall be installed in the enclosed radiography installation. The display unit of the zone monitor shall be in the operator's location and the detector probe shall be affixed appropriately inside the exposure room.
- 3.2.11 Prior to commissioning a radiography installation, approval shall be obtained by the licensee from the Competent Authority. Also, approval shall be obtained from the Competent Authority prior to movement of IRED for undertaking radiography work in the enclosed radiography installation.
- 3.2.12 There shall be a suitable provision, such as a storage pit, inside the enclosed radiography installation for safe and secure storage of IGRED when not in use.
- 3.2.13 A logbook shall be maintained in the prescribed format, in respect of each IRED at the radiography enclosure, so that an up-to-date record of the location of all sources is always available.
- 3.2.14 Effective physical security shall be provided for the source(s) at all times as per the guidance provided in AERB Safety Guide on 'Security Of Radioactive Sources In Radiation Facilities' (AERB/RF-RS/SG-1).

3.3 Field Radiography

The following requirements in respect of field radiography shall be complied with:

- 3.3.1 Field radiography shall be carried out in locations where occupancy and traffic are as low as practicable. Field radiography includes radiography in shop floors, construction/erection sites, public areas and radiography operations outside an enclosed installation.
- 3.3.2 The licensee shall obtain specific approval from the Competent Authority prior to movement of IREDs for undertaking open field radiography at any site. If the radiography institution carries out open field radiography work in their own workshops / shop floors, construction/erection sites, specific approval shall be obtained.
- 3.3.3 Before commencing open field radiography operations at a site, a well-defined and clearly visible boundary shall be established using warning signs and devices such as barriers all around the site as appropriate. The actual dose rates at the boundary shall be measured during exposure using a calibrated survey meter and the location of the boundary shall be rectified as necessary before subsequent exposures.
- 3.3.4 During radiography, adequate distance shall be cordoned off around the radiation source and placards shall be displayed at the boundary to warn against unauthorised presence inside or near the radiography site. The cordon-off distance shall be determined on the basis of workload, occupancy factor outside the boundary and limitation of annual dose specified for public by the Competent Authority.

- 3.3.5 The radiation symbol and placards with the legend 'RADIATION --KEEP AWAY' and its equivalent in English / Hindi as well as in local language shall be posted along the cordon. A warning light shall be displayed at night.
- 3.3.6 Field radiography shall not be carried out without the use of an appropriate collimator except in case where it is not physically possible.
- 3.3.7 Before undertaking any field radiography work, appropriate safe working procedure shall be established by the licensee.
- 3.3.8 The boundaries of adjacent radiography sites shall not overlap.
- 3.3.9 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 shall be extended to the fullest extent possible to take maximum advantage of distance for protection from the source of radiation. Once the radiography exposure commences, the radiographer shall 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 shall be checked regularly by means of a survey meter.
- 3.3.10 The immediate environment of the source position shall 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 shall be under observation at all times during exposure to ensure that no person enters the area during radiography.
- 3.3.11 One or more warning lights and an audible alarm located immediately adjacent to the exposure position shall be used to indicate when an exposure is in progress.
- 3.3.12 The following requirements shall be complied with for the storage of the radiography source:
- (a) An exclusive storage room shall be provided for safe and secure custody of sources contained in IGRED during periods when the radiography source is not in use.
 - (b) The room in which IGRED are kept stored shall be in a location where effective physical security of the IGRED can be ensured.
 - (c) The room in which IGRED are kept stored shall not be located in a residential building or a commercial complex and shall be constructed in industrial area.
 - (d) The source storage room shall be constructed as per the specifications and drawing approved by the Competent Authority.
 - (e) The storage room shall have suitable pit(s) to house the IGRED. The pit shall be provided with a sufficiently thick metal plate as lid which can be fastened and locked so as to ensure the safety and security of the devices stored within.
 - (f) The radiation level on the lid of the pit shall not exceed $10 \mu\text{Sv/h}$.
 - (g) The storage room shall have only one entrance and it shall be kept under lock and key.
 - (h) The walls and the ceiling of the source storage room shall be of adequate thickness to ensure the physical security of the source and radiological safety of the personnel.
 - (i) The storage room shall be surrounded by a fencing.

- (j) Warning legends reading, 'RADIATION - KEEP AWAY' inscribed in English / Hindi and the local language and the radioactivity symbol shall be displayed on the exterior walls of the storage room.
- 3.3.13 Prior approval for commencing the use of the source storage room shall be obtained from the Competent Authority.
- 3.3.14 Any modification in the design of the source storage room which may have an impact on the safety and security of radiography source(s), shall be carried out with the prior approval of the Competent Authority.
- 3.3.15 A logbook shall be maintained in the prescribed format, in respect of each IGRED at the radiography site, so that an up-to-date record of the location of all sources is always available.
- 3.3.16 Effective physical security shall be provided for the source(s) at all times as per the guidance provided in AERB Safety Guide on 'Security Of Radioactive Sources In Radiation Facilities' (AERB/RF-RS/SG-1) and 'Security of Radioactive Material during Transport' (AERB/NRF-TS/SG-10).

4. PERSONNEL REQUIREMENTS AND RESPONSIBILITIES

4.1 General

The personnel requirements of organisations handling radiography exposure devices, which include industrial radiography facilities, suppliers of radiography sources, manufacturers/vendors of radiography exposure devices and contract awarding parties, are specified in this section. The concerned persons are described as employer, licensee, RSO, and workers including an industrial radiographer, trainee and servicing and maintenance personnel. The responsibilities of the employer, licensee, RSO and worker are specified in the Atomic Energy (Radiation Protection) Rules, 2004 and this section stipulates the responsibilities of the personnel in detail. The respective responsibilities of personnel working in a radiation facility shall be duly complied with.

4.2 Employer

The employer shall ensure that:

- (i) a person having appropriate qualifications is designated as Radiological Safety Officer, with the written approval of the Competent Authority
- (ii) licence is obtained from the Competent Authority for handling and operation of industrial radiography exposure devices
- (iii) only radiography equipment in respect of which a valid type approval certificate or a No Objection Certificate issued by the Competent Authority has been obtained, is procured
- (iv) prior to construction of a radiography enclosure, plans and details of construction and of proposed operations are submitted to the Competent Authority for approval
- (v) prior to installation of the industrial radiography equipment at the enclosure the Competent Authority is provided with information about the plans of the location in which the equipment is to be operated, including the position of the equipment relative to occupied areas, and the expected dose rates outside the enclosure during exposure
- (vi) prior to commencing routine operation of industrial radiography equipment in the enclosure, commissioning approval for the enclosure is obtained from the Competent Authority
- (vii) radiography work is done with prior approval from the Competent Authority
- (viii) a Radiation Protection Programme (RPP) is prepared
- (ix) site-specific emergency response action plan including facilities and equipment is made available for implementation by the site staff at each site and updated as necessary
- (x) prior to its first use and before every source replacement the radiography equipment is inspected as recommended by the manufacturer / supplier to confirm that all interlocks, shutters and control mechanisms operate effectively and that no components are unacceptably worn or damaged;
- (xi) abnormal situation, if any, in the performance of IRED is brought to employer's attention for ensuring following actions:

- (a) the equipment is not further used until inspected by RSO and subsequently, if needed, by the Supplier
- (b) after repair, as necessary, the equipment is tested for proper functioning and, before re-use, checked for compliance with the requirements of this safety code to the satisfaction of the Competent Authority and details of repairs are kept and made available to the Competent Authority upon request
- (xii) adequate numbers of approved radiography personnel are appointed
- (xiii) any person below 18 years of age is not employed as RSO, an industrial radiographer or a trainee radiographer
- (xiv) the measurements, investigations and assessments necessary to properly monitor radiation exposures of persons are made, and that reports and records are kept in accordance with the requirements of this safety code
- (xv) logbook is maintained for each IRED under employer's control, so that an up-to-date record of the location of all sources is always available
- (xvi) the appropriate fire authority, and other relevant emergency services are notified as to the existence of radioactive sources on the site premises
- (xvii) reports on all incidents, along with details of any immediate remedial measures that may have been initiated, are sent to the Competent Authority within 24 hours
- (xviii) the dose records and health surveillance reports are :
 - (a) Procured from his former employer, where applicable, prior to employment of a worker
 - (b) Furnished to each worker in his employment annually, as and when requested by the worker and at the termination of his service
 - (c) Provided to his new employer, on request, upon termination of service of worker.
- (xix) health surveillance of workers is arranged as specified under rule 25 of the Atomic Energy (Radiation Protection) Rules, 2004
- (xx) the Competent Authority is informed if the licensee or the Radiological Safety Officer or any worker leaves the employment and
- (xxi) adequate security arrangements are provided.

4.3 Licensee

Licensee shall:

- (i) engage adequate number of radiography personnel (RSO & industrial radiographer) taking into consideration the IRED (IGRED, X-ray machines, Accelerator) at each radiography site.
- (ii) provide adequate facilities and resources to the RSO and industrial radiographer to discharge their duties and safety functions in accordance with this safety code.
- (iii) provide adequate facilities and resources to ensure that all workers and trainees are provided with personnel monitoring devices and these persons are instructed in writing to wear the personnel monitoring devices while working with radiation

- (iv) inform the Competent Authority immediately if RSO or industrial radiographer leaves the institution and suspend the radiography work until the replacement personnel have assumed charge of their tasks
- (v) ensure that industrial radiography installation is constructed according to the design approved by the Competent Authority
- (vi) ensure that IGRED /X-ray equipment/accelerators/source changers to be used are type approved by the Competent Authority
- (vii) ensure that the dose limits for workers, trainees and members of the public are not exceeded during storage, use and transport of the source
- (viii) investigate and initiate prompt remedial measures in respect of any situation that could lead to personnel dose in excess of limits
- (ix) ensure that any incident is reported to employer immediately
- (x) ensure that the ultimate disposal of radiography sources is carried out in a manner approved by the Competent Authority
- (xi) ensure that at least one calibrated radiation monitoring instrument in working condition is earmarked for every IRED
- (xii) ensure implementation of RPP, establish an internal inspection/audit procedure or other management control to ensure that safe operating and emergency procedures are observed by workers and the emergency procedures are rehearsed
- (xiii) ensure that every worker is subjected to medical examination as specified in the Rules prior to commencing radiation work, and subsequently at intervals stipulated by the Competent Authority
- (xiv) maintain complete and up-to-date records of
 - (a) occupational exposure
 - (b) medical examinations, and
 - (c) occupational histories of workers of the site.
- (xv) maintain health surveillance reports as specified in (xiii) and (xiv) above for inspection
- (xvi) advise the employer about the modifications in working condition of a pregnant worker
- (xvii) not share with or loan to or borrow from another radiography agency, any of its radiography facilities, e.g. radiography enclosure, storage room, radiography equipment, radiation monitors and radiography personnel, except when permitted to do so by the Competent Authority
- (xviii) ensure the availability of site authorisation granted by the Competent Authority and emergency procedures at the place of radiography work
- (xix) maintain records of radiography exposures carried out in the format prescribed by the Competent Authority from time to time
- (xx) submit information regarding location details of the industrial gamma radiography exposure devices in the format prescribed by, periodicity specified by, the Competent Authority

- (xxi) dispose/transfer any IRED only after obtaining permission from the Competent Authority and as specified in this safety code and
- (xxii) bring the requirements of this safety code to the notice of the contract awarding party to ensure that regulatory inspection of the radiography site by persons authorised by the Competent Authority is facilitated during any part of the day or night with or without prior notice
- (xxiii) ensure safe disposal of disused radioactive source(s) and other decayed source(s) (of activity < 50 GBq) at an authorised waste management facility or return it to the country of origin with prior approval of the Competent Authority; action for the safe disposal of such source(s) shall be initiated without any delay
- (xxiv) ensure that while appointing a trainee, an undertaking is furnished to the Competent Authority in the prescribed format and that the trainee undergoes an approved training course for industrial radiographers (e.g. Radiography Testing Level - I) after completing six months of field experience/training.

4.4 Radiological Safety Officer (RSO)

- 4.4.1 A radiography institution shall appoint a Radiological Safety Officer (RSO) at each authorised radiography site to ensure compliance with the requirements specified in this safety code and specific approval from the Competent Authority shall be obtained for a RSO.

The minimum qualification for RSO shall be:

- (a) 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 recognised Board for industrial radiographer candidate with requisite experience in the field, and
- (b) 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 recognised university/ institution and acceptable to the Competent Authority.

- 4.4.2 The application for the approval of an RSO, in the prescribed format, shall be submitted to the Competent Authority. The RSO shall perform the functions as RSO specified in 4.4.3

- 4.4.3 RSO shall:

- (i) provide to the licensee information about his/her past radiation work, if any;
- (ii) advise and assist the licensee on all aspects of radiation safety;
- (iii) obtain and maintain knowledge of the principles and practices of radiation protection and of the potential radiation hazards associated with industrial radiography equipment, which is sufficient to undertake measurements of radiological parameters, investigations and assessments and other duties required of him or her by this safety code;

- (iv) ensure that, during the installation, removal, maintenance, repair, relocation, translocation and operation of industrial radiography equipment where he or she has responsibility for radiation safety, each radiation worker who may be exposed to radiation in the course of these operations uses appropriate radiation monitoring devices, including a personnel radiation monitoring device, a survey meter and a personnel dosimeter issued for the worker's exclusive use;
- (v) be familiar with:
 - (a) the provisions of this safety code and relevant regulation on industrial radiography;
 - (b) the radiation monitoring and protective equipment in use to meet the requirements of this safety code;
 - (c) the nature and physical appearance of any gamma-radiography sources for which he or she has radiation protection responsibility; and
 - (d) the detailed working rules and emergency procedures approved for use in accordance with this safety code, and participate in the development and revision of working rules and emergency procedures, as necessary;
- (vi) carry out radiation surveys periodically, to ensure that safe radiography work procedures are being followed at the site(s) for which he or she is responsible;
- (vii) ensure that personal radiation monitoring equipment, survey meters, source containers, shutters and source control mechanisms, X-ray equipment indicators and interlocks, door interlocks of enclosed radiation installation and area monitors, and other appropriate equipment related to radiation safety are inspected and tested regularly;
- (viii) instruct workers on safety measures and safe work practices aimed at minimising exposure to radiation and contamination;
- (ix) ensure safe movement of IRED and ensuring that packages containing radiography sources are properly packed, labelled and declared as per the national / international requirements for the safe transport of radioactive material currently in force;
- (x) ensure that radiography sources and other radioactive materials are not transported by public transport;
- (xi) investigate and initiate suitable remedial measures in situations that could lead to potential radiological risk;
- (xii) ensure that reports of all hazardous situations along with details of any immediate remedial actions taken are made available to the licensee for reporting to the Competent Authority;
- (xiii) arrange for safe disposal of disused radioactive source (s) and other decayed source (s) (of activity < 50 GBq) at an authorised waste management facility or return to the country of origin, as applicable, with prior approval of the Competent Authority;
- (xiv) maintain inventories of IRED / radiography sources at all times, and records of the following:
 - (a) day-to-day radiography work in the format advised by the Competent Authority,

- (b) calibration of radiation monitoring instruments,
 - (c) personnel monitoring,
 - (d) periodic survey of installation or site,
 - (e) periodic contamination checks of guide tubes/ exposure device,
 - (f) disposal of disused / decayed radiography sources,
 - (g) performance and safety functions of the device regularly and after servicing and maintenance,
 - (h) movement of exposure device to different site(s), and
 - (i) unusual occurrences, if any.
- (xv) ensure that:
- (a) all necessary personal radiation monitoring devices and radiation survey meters are available and are in good working order, and that the survey meters are calibrated, on a regular basis, for the energy range of the radiation in use;
 - (b) no person receives radiation exposure in excess of the limits prescribed by the Competent Authority and that all radiation exposures are kept as low as reasonably achievable (ALARA);
 - (c) direct reading dosimeters such as personnel dosimeters are issued, as necessary, used properly, collected and assessed;
 - (d) personal dosimeters are promptly submitted for assessment after use, in accordance with the requirements of the Competent Authority;
 - (e) investigation of reported occupational exposure more than 10 mSv in a monitoring period is carried out and the investigation report submitted to the Competent Authority
 - (f) all radiographic equipment and emergency handling tools are periodically serviced and maintained in proper working condition.
- (xvi) advise the licensee about the modifications in working condition of a pregnant worker
- (xvii) carry out QA tests for the IGRED before sending it for re-loading of source and ensure that the safety systems and shielding of the exposure device are functional, as required;
- (xviii) refrain from any act that could be detrimental to himself/herself, other workers and/or members of the public;

4.5 Industrial Radiographer

4.5.1 The minimum qualifications of an industrial radiographer shall be:

- (i) 10+2 or equivalent examination passed with Science subjects, and Mathematics in 10th standard or equivalent from a recognized Board; and
- (ii) training in radiography testing and safety (RT level-I or equivalent) or its equivalent recognised by the Competent Authority with a prior experience of six months as a trainee in an approved radiography institution.

4.5.2 The radiographer shall:

- (i) provide to the licensee information about his/her past radiation work, if any;
- (ii) 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;
- (iii) on removing an IGRED from the storage room, verify that the source is duly contained in the gamma radiography exposure device with a proper survey meter and maintain the record;
- (iv) refrain from any act that could be detrimental to himself /herself, other workers and/or members of the public;
- (v) 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;
- (vi) make proper use of protective equipment, radiation monitors and personnel monitoring devices provided;
- (vii) 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;
- (viii) 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.
- (ix) promptly inform the RSO of any accident or potentially hazardous situation that may come to his/her notice;
- (x) comply with instructions of RSO /licensee concerning radiation protection; and
- (xi) 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.
- (xii) 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-radiography equipment, that the equipment is no longer energised;

- (xiii) 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.

4.5.3 A female worker shall, 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.

4.6 Trainee

4.6.1 The minimum qualifications of a trainee shall be:

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

4.6.2 A female worker shall, 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.

4.6.3 The trainee shall:

- (i) provide to the licensee information about his/her past radiation work, if any;
- (ii) operate IRED under the direct physical supervision of radiographer/ RSO;
- (iii) make use of proper radiation monitoring instruments and personnel monitoring devices and protective accessories provided;
- (iv) comply with the instructions of radiographer/ RSO on radiation protection; and
- (v) shall refrain from committing any act that could be detrimental to himself/herself, other workers and/or members of the public.

4.6.4 The trainee shall furnish an undertaking from his Employer that upon completing six months of training he shall undergo the prescribed course of industrial radiographer.

4.7 Radiography Source Supplier

4.7.1 The radiography source supplier shall obtain Licence from the Competent Authority for supply of radiography source. No person shall sell or otherwise transfer any radiography source unless authorised to do so by the Competent Authority. The radiography source supplier shall provide a certificate specifying dimensional drawing of the source capsule and materials of construction, radionuclide, activity with date of measurement, leak test results and method. Only sources in respect of which design approval certificate has been obtained from the Competent Authority shall be supplied.

4.7.2 The source supplier shall:

- (i) be responsible for the safe disposal of disused / decayed radiography sources;

- (ii) ensure that before the source replenishment, all the safety systems interlocks and functional performance of IGRED are checked and found satisfactorily;
- (iii) report any major malfunctioning / anomaly in respect of IGRED;
- (iv) submit periodic report on the supply of radiography source(s) including details about disused/decayed source(s) to the Competent Authority; and
- (v) ensure the security of radiography source(s).

4.8 Manufacturer/Vendor of Equipment

A manufacturer / vendor of radiographic equipment shall:

- (i) obtain licence from the Competent Authority for the manufacturing and supply of IRED, source changer and the accessories;
- (ii) 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;
- (iii) 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.
- (iv) provide user with detailed procedures for quality assurance tests and checks to be carried out with specified frequency to verify correct performance of the device/equipment;
- (v) 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;
- (vi) keep a record of radiography exposure devices/source changers supplied, together with performance, quality assurance and safety status of the device/source changer;
- (vii) not offer for sale any X-radiography equipment or gamma radiography equipment unless authorised to do so by the Competent Authority;
- (viii) submit the periodic reports to the Competent Authority in the format prescribed by the Competent Authority;
- (ix) 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-radiography equipment, including maximum tube potential difference [kV(peak)] and current (mA), or maximum X-ray energy (keV) and maximum output (dose rate).
- (x) 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;
- (xi) 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;
- (xii) assist the user for handling radiological emergencies in case any such emergency arises because of use of the radiography equipment/devices/source changers;
- (xiii) ensure the security of radiography source(s); and
- (xiv) also be responsible for facilitating the safe disposal of radiation source.

4.9 Servicing/Maintenance Personnel

The servicing and maintenance personnel of radiography equipment shall 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 shall 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 shall wear personnel monitoring devices and direct reading dosimeters. He shall use radiation monitoring instruments for ensuring safe radiation levels during work.

4.10 Responsibilities of Radiography Contract Awarding Agency

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

- (i) permit only the radiography agency that is duly authorized by AERB to work at the particular site of contractor;
- (ii) ensure that radiography personnel deployed by the radiography agency for carrying out radiography work have valid certificates to work as radiographers and RSO;
- (iii) provide adequate illumination, scaffolding and other facilities required to facilitate safe radiography work by radiography agency;
- (iv) 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;
- (v) ensure that the radiography agency has emergency plans, preparedness and contact numbers in case of emergency/incidents involving radiography devices;

- (vi) ensure that any other measures required to ensure safety and security of radiography sources handled within the premises of radiography site;
- (vii) ensure that whenever authorised representatives of the Competent Authority visit the radiography site under the control of the contract awarding agency 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;
- (viii) 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 IGRED all the time; and
- (ix) assist radiography agency in ensuring safe recovery of radiography source(s), in case of theft/ loss / misplacement of IGRED.

5. REGULATORY CONTROLS

5.1 General

The requirements in respect of regulatory consent, approval of installation layout and radiography site, procurement of radiography sources, commissioning of radiography installation/ radiography site, operation and use of radiography sources, transport of radioactive material, change of radiography site, safe custody of radiography sources and radioactive material and safe disposal of radioactive sources and radioactive material are specified in this section.

5.2 Regulatory Consent

5.2.1 Possession, use, import, export, transport and disposal of a radioactive material/substance by any person is prohibited except in accordance with the terms and conditions of a written consent granted under sections 14, 16 and 17 of the Atomic Energy Act, 1962. The written consent may be a licence granted in accordance with Rule 3 of the Atomic Energy (Radiation Protection) Rules, 2004. The consents are not transferable.

5.2.2 The applicant for consent shall provide evidence that:

- (i) the radiography equipment meets the requirements of applicable standard as specified in this Code;
- (ii) the installation/site is according to the requirements specified in this Code;
- (iii) radiography personnel specified in this Code are available;
- (iv) personnel monitoring devices are provided to all workers; and
- (v) radiation monitoring instruments are available and are in good condition for use.

5.3 Approval of Installation/Site Plan

Layout plan for radiography installation shall provide radiation safety of workers and members of public as specified in this Code. Approval shall be obtained by the licensee from the Competent Authority prior to construction. Detailed drawings showing the layout of rooms (with dimensions), position of radiation source (exposure device/X-ray equipment/accelerator), doors and windows, control room, work-areas and public areas shall be submitted to the Competent Authority. Any change in radiation shielding or modification to the approved plan shall be carried out only with the written concurrence of the Competent Authority.

5.4 Type Approval of Radiography Equipment/Exposure Devices, Source Changers

The following requirements in respect of radiography equipment/exposure devices, source changers shall be complied with to qualify for type approval certification:

5.4.1 Any X-ray equipment, accelerator or gamma radiography exposure device/source changer shall be handled only after it is Type Approved by the Competent Authority. For import of the radiography unit, prior to granting Type Approval, the Competent Authority may grant a No Objection Certificate (NOC) and require that the unit be subjected to a thorough technical assessment for compliance with the prescribed Safety Standards.

5.4.2 For gamma radiography exposure device / source changer manufactured abroad, Type Approval shall be obtained by providing evidence of their conformance to AERB/RF-IR/SS-1

(Rev. 1) or an updated version thereof and evidence that the device has the approval of Type A/Type B(U)/(M) package design by the Competent Authority of the country of origin.

- 5.4.3 Exposure device shall need to be approved as package of appropriate type for transport in public domain. Where the type approval of the device is based on the source in special form, the gamma radiography source shall need to be certified as meeting the requirements of special form of radioactive material for transport in accordance with the requirements currently in force.
- 5.4.4 The manufacturer/supplier seeking type approval shall submit an application along with detailed drawings of the equipment/device and a report on safety analysis for type approval.
- 5.4.5 Safety analysis report shall provide evidence of compliance with AERB/RF-IR/SS-1 (Rev. 1), or an updated version thereof and with applicable requirements of this Section and the results of tests carried out on the prototype. The report shall provide evidence of the quality assurance (QA) programme.
- 5.4.6 Type Approval may be granted after evaluating the safety of the equipment/device, indicating therein the terms and conditions of the approval including the period of validity of the approval certificate.
- 5.4.7 Industrial Radiography Exposure Devices (IRED) such as X-ray equipment, accelerator or IGRED/source changer, or transport package shall not be manufactured or supplied after expiry of validity period specified in the type approval certification/package design approval unless the approval is revalidated.
- 5.4.8 IGRED/source changer, or transport package shall not be used after expiry of validity period specified in the type approval certification/package design approval unless the approval is revalidated.

5.5 Procurement of Radiography Sources

The licensee shall obtain an authorisation from the Competent Authority prior to procuring radiography sources on the first occasion and also replacement sources subsequently.

5.6 Commissioning of Radiography Installation / Radiography Site

- 5.6.1 Approval shall be obtained by the licensee from the Competent Authority prior to commissioning and routine use.
- 5.6.2 Any new radiography installation or site shall not be commissioned unless compliance with the requirements of section 3 of this Code is verified and certified by the Competent Authority.
- 5.6.3 Verification of compliance with provisions of this Code shall be re-assessed prior to re-commissioning when:
- (i) an installation is structurally modified, or
 - (ii) the equipment is repaired or modified, or
 - (iii) any change in radiography procedure is adopted.
- 5.6.4 The commissioning or re-commissioning shall be subject to terms and conditions specified in the approval issued by the Competent Authority.

5.7 Operation and Use of Radiography Sources

- 5.7.1 The exposure device shall be operated by a industrial radiographer as per the instructions laid down by the RSO.
- 5.7.2 During field radiography, collimators shall be used as specified in sub-section 3.2 of this safety code. The primary beam shall not be directed towards occupied areas.
- 5.7.3 The radiographer shall ensure smooth operation of exposure device prior to commencement of radiography work on each day. Operational checks shall be recorded. The radiographer shall measure the radiation levels around the radiography premises and record the results. The safety requirements for storage, transport, operation and disposal of IRED specified in the safety code shall be duly implemented.
- 5.7.4 Radioactive contamination in any accessible area of source housing and source guide tube shall be checked at least once in six months to verify the integrity of the sealed source. In case the contamination is in excess of 185 Bq the device shall not be used, and the Competent Authority shall be informed.

5.8 Transport of Radioactive Material

Transport of radioactive material in public domain shall be in accordance with the current national / international requirements for safe transport of radioactive material, safety code for Transport of Radioactive Material (AERB/ SC/ TR/ 1/Rev. 1) (Under preparation).

5.9 Change of Radiography Site

- 5.9.1 Radiography source(s) shall not be used in/ a radiography installation or site without obtaining prior approval of the Competent Authority.
- 5.9.2 When urgent radiography work has to be carried out at a site which has not been approved by the Competent Authority in the past, the licensee shall notify the Competent Authority of the intention to shift the radiography device(s) to the site and obtain permission for carrying out radiography operations at the site. The records of such movements shall be maintained as specified in this safety code.

5.10 Safe Custody of Radiography Sources and Radioactive Material

- 5.10.1 The licensee shall be responsible for keeping the radiography source and radioactive materials in his/her possession for safe custody and providing adequate physical security. Exposure device containing radiography source shall be kept under lock and key when not in use and the key of the exposure device kept in the custody of the certified personnel. The physical security of exposure device shall be ensured at all times by storing it in an approved storage room.
- 5.10.2 Radioactive sources shall not be lent/leased, gifted or otherwise transferred to any other person except with the permission of the Competent Authority.
- 5.10.3 The licensee shall submit periodically to the Competent Authority statement of sources in his/her custody in the format prescribed by the Competent Authority.

5.11 Disposal of Radiography Sources and Radioactive Material

Radiography sources and radioactive material shall be disposed off only after obtaining an authorisation from the Competent Authority.

6. SECURITY OF RADIOGRAPHY DEVICES AND SOURCES

The employer of the radiography organisation is responsible for the safety and security of the source(s) supplied to him. The employer shall ensure that appropriate measures for security level B (to minimize the likelihood of unauthorized removal of a source) [Security of Radioactive Sources in Radiation Facilities', Safety Guide No. AERB/RF-RS/SG-1, (2011)] are implemented for the sources in his possession at each site all the time. The security measures shall include the following salient features:

- (i) General administrative measures
- (ii) Weekly accounting
- (iii) Deterrence provided by : Two measures (one technical measure and one administrative measure) to deter/discourage the adversary/unauthorised person from committing the malicious act
- (iv) Access control to source location allowing timely detection of unauthorised access
- (v) Delay mechanism to interrupt unauthorised removal of radiography source(s), generally through barriers or other physical means
- (vi) Emergency contact numbers of plant security personnel, contract awarding agency, nearby police station, etc. shall be displayed in the radiation installation
- (vii) Background checks of personnel involved in handling radiation source(s)
- (viii) Security plan shall be prepared and submitted to the Competent Authority
- (ix) Provision for upgradation of security for increased threat
- (x) Timely detection shall be provided by local alarm
- (xi) Timely response to an alarm
- (xii) Lodging of FIR to the concerned police authorities in case of theft / misplacement of radiography source

The employer of the radiography organisation is responsible for security during transport of the source(s) supplied to him. The employer shall ensure that appropriate measures for security level 3 – enhanced security measures [Security of Radioactive Material during Transport', Safety Guide No. AERB/NRF-TS/SG-10, (2008)] are implemented for the source(s) in his possession during transport.

The responsibilities of the various agencies involved in ensuring the security of the source(s) shall be clearly defined in the security plan prepared by the licensee and the concerned agencies and the individuals shall be duly informed thereof.

7. EMERGENCY RESPONSE AND PREPAREDNESS

7.1 General

While working with radiation sources an emergency situation may arise. The emergency situation shall be handled effectively in order to ensure that the resulting dose to individuals is kept as low as reasonably achievable. For this purpose the licensee and employer shall be in a state of preparedness for handling emergency situations.

7.2 Emergency Response Plan and Preparedness

7.2.1 An emergency plan as contained in RPP shall be submitted to the Competent Authority.

7.2.2 The licensee shall prepare response plans for all foreseeable emergencies including and restricted to the following contingencies:

- (i) Source failing to return to safe shielded position
- (ii) Loss/theft of radiography source at the installation/site during use, in storage, in transport, or during natural calamities
- (iii) Fire.

7.2.3 The licensee shall ensure that all workers are familiar with the emergency response plan.

7.2.4 The response plan shall specify:

- (i) Persons familiar with emergency action plan and responsibilities and functions, line of Authority and line of communication
- (ii) Initial training and periodic re-training of persons in their respective tasks
- (iii) Appropriate tools, radiation monitoring instruments, and personnel monitoring devices to be kept and maintained in working condition
- (iv) Most direct and alternative means of communication
- (v) Authorities to be contacted at the initial phase, during progress and at termination of an emergency.

7.2.5 If a source is lost, the appropriate public authorities shall be informed promptly.

7.3 Reporting an Emergency

7.3.1 RSO shall:

- (i) immediately report to the licensee on any emergency situation and initiate remedial actions and endorse a copy to the Competent Authority; and
- (ii) carry out prompt investigation on causes of the emergency, evolve means to prevent recurrence and submit a detailed report on the incident to the Competent Authority.

7.3.2 The employer shall:

- (i) inform the Competent Authority of 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.

8. DECOMMISSIONING

8.1 General

The term decommissioning refers to set of actions at the end of the useful life of a particular facility, or when a facility ceases to be utilised for its intended purpose. Such facility shall be duly decommissioned before the site and building are made available for other uses. Decommissioning needs to be carried out in a systematic manner to ensure safety of the workers, environment and public. The decommissioning process involves removal of radioactive materials and sources, decontamination and dismantling, subsequent waste management, final radiation survey and release of the facility for unrestricted use and documentation.

8.2 Regulatory Consent for Decommissioning

An industrial radiography facility shall be decommissioned upon completion of the authorised work at the approved location before it is released for other uses. Consent for decommissioning shall be obtained from the AERB when the radiography exposure device is no longer to be used. A plan of the decommissioning operation shall be submitted by the licensee to the Competent Authority while applying for the necessary consent from the Competent Authority. The decommissioning operation shall be carried out in complete conformity with the procedure approved by the Competent Authority. If it is necessary to modify the procedure, prior approval shall be obtained by the licensee from the Competent Authority.

8.3 Equipment Containing Depleted Uranium

The licensee shall arrange to remove the radioactive source and return it to the source supplier for safe disposal. If the exposure device contains depleted uranium, the entire device has to be returned to the supplier for safe disposal or transferred to an authorised waste management agency for safe disposal. For this purpose, the licensee shall apply for authorisation from the AERB, in the prescribed format.

8.4 Disposal of Radioactive Waste

- 8.4.1 The radiography exposure device shall be checked for radioactive contamination. If no contamination is present in the source housing/guide tube the same can be decommissioned. If contamination is present, the contaminated components shall be disposed off as radioactive waste. For this purpose, the licensee shall obtain an authorisation from AERB for transfer/disposal of radioactive waste to authorised waste management agency.
- 8.4.2 Any radioactive waste that may arise incidental to the decommissioning operation shall be disposed of in accordance with the prior approval of the Competent Authority. Upon completion of the decommissioning operation, a comprehensive survey of the facility shall be conducted by the RSO. It shall be confirmed that the radiation level, fixed and non-fixed contamination level, if any, at the facility are within the limits stipulated by the Competent Authority.

8.5 Decontamination Report

A report of the survey prepared by the RSO shall be submitted by the licensee to AERB on completion of decommissioning, detailing safe disposal of the devices or the source and other active components and personnel doses received during the decommissioning operation. Licensee upon receiving, from the Competent Authority, the final clearance of the decommissioning operation, issued based on the report submitted by the RSO, may release the decommissioned facility to the public.

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Date(s) of meeting: May 16, 2013
December 8-11, 2014

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Date(s) of meeting : May 13, 2015

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**LIST OF REGULATORY SAFETY DOCUMENTS RELEVANT TO INDUSTRIAL
RADIOGRAPHY**

| Safety Series No. | Title |
|----------------------------|--|
| AERB/SC/IR-1 (Rev. 1) | Industrial Radiography |
| AERB/SC/G | Regulation of Nuclear and Radiation Facilities |
| AERB/RF-IR/SS-1 (Rev.1) | Standard for Industrial Gamma Radiography Exposure Devices and Source Changers |
| AERB/SS-3 (Rev.1) | Testing and Classification of Sealed Radioactive Sources |
| AERB/RF/SG/G-3 | Consenting Process for Radiation Facilities |
| AERB/RF-RS/SG-1 | Security of Radioactive Sources In Radiation Facilities |
| AERB/NRF-TS/SG-10 | Security of Radioactive Material during Transport |
| AERB/RF/SM/G-3 | Regulatory Inspection and Enforcement in Radiation Facilities |