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GOVERNMENT OF INDIA

AERB SAFETY GUIDE

CONTAINER SCANNER

ATOMIC ENERGY REGULATORY BOARD

AERB SAFETY GUIDE: AERB/RF/SG/CS

CONTAINER SCANNER

Atomic Energy Regulatory Board
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Order for this Guide should be addressed to:

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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 Section16, 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 Safety Documents (REGDOCs) establish the requirements and guidance's for all stages during the lifetime of nuclear and radiation facilities and transport of radioactive materials. These requirements and guidance's 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 (REGDOCs) apply to nuclear and radiation facilities and activities giving rise to radiation risks, the use of radiation and radioactive sources, the transport of radioactive materials and the management of radioactive waste.

Fig. 1 Hierarchy of Regulatory Documents (REGDOCs)

Safety Codes establish the objectives and set requirements that shall be fulfilled to provide adequate assurance for safety. Safety Standards provide models and methods, approaches to achieve those requirements specified in the Safety Codes. Safety Guides elaborate various requirements specified in the Safety Codes and furnish approaches for their implementation. Safety Manuals detail instructions/safety aspects relating to a particular application. The hierarchy of Regulatory Documents depicted 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 REGDOCs. .

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

Use of radiation sources in Container Scanner (CS) Facilities are required to obtain licence from AERB under Atomic Energy (Radiation Protection) Rules, 2004. Container Scanner facilities are required to obtain regulatory consents at various stages such as design and construction, permission for procurement of radiation equipment, commissioning, operation of the facility, decommissioning of the equipment/facility and transfer of the radioactive sources for safe management after their useful life. This document provides guidance on the pre-requisites for licensing of Container Scanner Facilities and its safe use. This, in effect, provides an approach through which compliance to the mandatory requirements can be implemented by the utilities. The requirements are given in AERB Safety Code on 'Radiation Sources, Equipment and Installations' (AERB/RF/SC, 2025). This Safety Guide is effective from the date of its issue.

Safety related terms used in this safety guide are to be understood as defined in the AERB Safety Glossary (AERB/GLO, Rev.1). The special terms which are specific to this safety guide are included under the 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 guide with a specific context and requires interpretation or explanation are also included in this section.

Consistent with the accepted practice, 'should' and 'may' are used in the Guide to distinguish between a recommendation and a desirable option respectively. Appendices are an integral part of the document. Bibliography provides further information on the subject that might be helpful to the user(s).

The initial draft was prepared by an In-House Working Group (IHWG) of AERB, which was then reviewed by the Task Force (TF) with specialists drawn from technical support organizations and institutions, and other consultants. The Comments obtained from domain experts and relevant stakeholders have been suitably incorporated. The Safety Guide has been reviewed and concurred 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 the Safety Guide. The list of experts, who have participated in this task, along with their affiliations, is included for information.

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(Dinesh Kumar Shukla)
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SPECIAL TERMS S AND INTERPRETATION

Container Scanner

Container scanner is a system using high energy X-rays or Gamma rays for non-intrusive inspecting of goods in transportation systems or other locations.

Contents

1. INTRODUCTION

1.1 General

Radiation sources find many beneficial applications in medicine, industry, agriculture and research. At the same time, ionizing radiation sources, if not handled safely, may give rise to potential exposures leading to an unacceptable risk to the radiation workers as well as members of public. One such application of ionizing radiation is container scanner. Most of customs departments worldwide employs scanning of cargo for import and export at various ports. Governments and society expect Customs to provide an effective control of imports, exports and transit traffic. Global terrorist activities are also a concern and hence there are high expectations from security and custom authorities for safety and security. To cope with this situation, new technologies, in particular X-ray or gamma ray based Non-Intrusive Inspection (NII) help to meet the objectives by increasing efficiency in inspections. NII system are usually termed as container scanners.

Generally a Cobalt-60 source of 37 GBq- 1.1TBq or an accelerator based X-ray source between 3 MV and 9 MV are used in container scanners to detect concealed or contraband objects. Some accelerators use dual energies in the interlaced mode for imaging of container where high variations in atomic number and density of materials are expected. A container scanner may be used in a drive through mode, in which a container is scanned while moving through a scan tunnel or drive by mode, in which the driver gets down from the vehicle carrying container, before it is scanned. The driver is not exposed to primary radiation in drive through systems. However, the driver receives a negligible amount of dose from the scattered radiation.

The radiation output of a container scanner is very high i.e. in the range of 10mGy/h - 390 mGy/h for Co-60 and 30-120 Gy/h for X-ray units at a distance of 1 meter from the source/target. Therefore, for ensuring radiation safety, emphasis on shielding of enclosure and operational control are important. Certain additional measures are required for drive through container scanners for the safety of the driver. In the case of container scanners using Cobalt-60, physical protection measures for the radioactive source should also be taken into account.

1.2 Objective

This safety guide provides guidance pertaining to container scanner on meeting the relevant regulatory requirements prescribed in AERB Safety Code on ‘Radiation Sources, Equipment

and Installations' AERB/SC/RF, 2025, by specifying relevant procedures and elaborating radiation safety requirements for design, construction, commissioning, operation, maintenance and decommissioning of container scanners**.**

1.3 Scope

This Safety Guide elaborates the applicable radiological safety requirements for manufacturers, suppliers and users of container scanners, and provides guidance on ensuring compliance with the applicable regulatory pre-requisites in order to obtain consents /approvals/ licences.

The use of radiation for the inspection of individual baggage, mail, vehicles, food items, and other such detection purposes is excluded from the scope of this Guide as it is covered in safety guide on 'X-Ray Generating Equipment Used for Research Education Inspection and Analysis' AERB/RF/SG/XGE, 2025. This Guide does not elaborate the measures required for ensuring security of radioactive sources all the time. For this purpose, the provisions in AERB Safety Guide on 'Security of Radioactive Sources in Radiation Facilities' AERB/RF-RS/SG-1, 2011 and AERB Safety Guide on 'Security of Radioactive Material during Transport' AERB/NRF-TS/SG-10, 2008 should be followed.

2. RADIATION PROTECTION AND SAFETY

2.1 General

Accelerator and Cobalt-60 based container scanner system use high energy photons during scanning. The high dose rate of these scanners requires safety systems and procedures to minimize radiation risks to the operators, general public and drivers (in case of drive through system) and to minimize accidental risk during operation of the system. Radiation safety of members of the public engaged in container scanning activities is one of the important factors to be considered in the operation of such scanners. For mobile container scanning systems, it is necessary to specifically identify and ensure control over the physical arrangements, and areas where radiation fields may be present.

2.2 Justification

The use of radiation sources for container scanner practice brings substantial benefits to the society, by providing a reliable and time saving method of scanning of containers as compared to other conventional methods to detect presence of any unwanted material, offsetting any radiation harm that may result from exposure to radiation. The practice or activity involving container scanning should be planned such that it produces more benefit to the exposed individuals and to society than risk it causes.

2.3 Optimization

The licensee should ensure that radiation exposures to workers and public are kept As Low As Reasonably Achievable (ALARA), economic and social factors being taken into account. Radiation protection and safety should be optimized through proper design of the container scanner. Optimization can also be applied through the use of procedural controls.

The optimization process should also consider minimizing the number of individuals exposed and magnitude for likelihood of potential exposure. The radiation protection measures should be customized to meet the need of the institution.

Measures should be implemented to restrict the presence of members of the public in the vicinity of scanning areas, who may get exposure due to stray radiation during operation of the container scanner.

2.4 Dose Limits

Licensee should ensure that the radiation exposure to the workers and public due to the container scanning practice is restricted so that neither the effective dose nor the equivalent dose to tissues or organs exceeds the dose limits prescribed by AERB. It is to be ensured that radiation doses to individual radiation worker are assessed on a regular basis (quarterly). The dose limits prescribed by AERB are given in Appendix-I.

2.5 Management for Safety

In order to achieve overall safety during handling of radiation sources used in container scanners, an effective management system should be in place so that the safety requirements and guidance covering health, human performance, availability of appropriately qualified personnel and necessary equipment, quality management, protection of the environment, security, promotion of safety culture, assessment of safety performance and lesson learned from experience, are fulfilled. A Radiation Protection Programme (RPP) should be established in the institution and following should be ensured for implementing RPP in the institution during normal operation, maintenance and 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 probability of events giving rise to significant exposures and the magnitude of such exposures are kept as low as reasonably achievable

(iii) the radiation exposure of both workers and the public is kept below the dose limits prescribed by AERB.

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

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

1. The licensee should have overall responsibility for overseeing radiation safety, and to ensure that container scanning is carried out in accordance with the regulations. However, a responsible person (may be an identified RSO) may be designated to have overall

responsibility for radiation safety, ensuring that container scanners are operated in accordance with the regulations and Standard operating procedures (SOP).

2. Institution should prepare SOP for each equipment type, with the help of guidance from the manufacturer.
3. Develop, implement, assess and continually improve a quality management system, which defines the responsibilities of all relevant persons and details out the requirements of the institution, personnel and equipment.
4. It is ensured that suitable facilities and equipment are available to ensure safety during container scanning.

The responsibilities of various personnel are specified in Appendix -VI.

3. DESIGN OF RADIATION SOURCES, EQUIPMENT AND INSTALLATION

3.1 General

This chapter addresses guidance to the persons who are involved in design, manufacture and supply of radiation sources and equipment. Further, this chapter is useful for the users for understanding the design safety aspects of radiation sources, equipment and installations.

The design requirements for sources, radiation generating equipment and radiation installations play a major role in ensuring radiation safety. In the design of sources, radiation generating equipment and radiation installations, provisions should be made to prevent any undue exposure to personnel and occurrence of incidents or emergency situations.

Container scanners equipment should be purchased only from manufacturer/supplier authorized by AERB. In case of transfer by sale or otherwise of container scanners, prior approval from AERB is mandatory.

3.2 Sealed Source

The radioactive source used in container scanner should be a sealed source that meets national/ international standards as detailed in subsequent paragraphs.

3.2.1 Working Life

The manufacturer of radioactive source should provide a recommended working life (RWL) for a sealed source. The RWL is based on the number of factors, including the half-life of the source and the properties of the source capsule, and is an indication of the period of time over which the source is expected to retain its integrity. It is recommended to discontinue use of source beyond RWL. However, user may use it beyond its RWL subject to certification by radioactive source manufacturer or other Agency recognized by AERB for this purpose.

3.2.2 Encapsulation

The design of the sealed source and the material of encapsulation should be in compliance with the Safety Standard 'Testing and Classification of Sealed Radioactive Sources', [AERB/SS-3 (Rev-1)] specified by AERB or equivalent International Standard (ISO-2919). The licensee/manufacturer/supplier of the source should demonstrate compliance with the test requirements as specified in AERB/SS-3 (Rev-1) or equivalent standard.

3.2.3 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.

3.2.4 Contamination Test

The manufacturer should carry out surface contamination test for each sealed source before supply. This test should be in accordance with the standard specified in AERB/SS-3 (Rev.1) or international standards (ISO 9978). 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.

3.2.5 Source Identification

The encapsulation of radioactive source should display a serial number, symbol of radionuclide, radiation trefoil sign, and manufacturer's name or logo and a legend 'RADIOACTIVE'. Marking of the capsule / source assembly should be done prior to the loading the sealed source. The marking should be legible and durable.

3.3 Source Housing

The source housing of a device containing a sealed radioactive source or of an X-ray source should incorporate adequate shielding such that the useful beam is defined and the dose rate outside the device does not exceed the leakage limits specified by AERB.

The design of source housing should meet the requirements given in this guide. Source housing should have appropriate marking and labelling. For radioactive source based systems, the shutter should get closed automatically after a pre-set time, when no object is present for scanning. Suitable mechanism is required to be provided to close the shutter manually if it does not close automatically. Suitable emergency mechanism should be provided with the equipment to block the primary radiation beam in case of an incident or an emergency.

Provisions should be made to close the shutter automatically in fail safe mode in case of collisional impact on the source housing by any object.

The primary beam opening should be fixed such that it does not extend beyond the object to be scanned.

3.3.1 Source Housing Integrity

The source housing should be so designed as to retain the integrity of the source and the shielding under all foreseeable conditions.

3.3.2 Security of Radioactive Source in Housing

The source housing should have a radiation symbol with a warning legend for deterrence and suitable locking mechanism to prevent unauthorized use or unauthorized servicing of the equipment. The radioactive source should be secured such that it should be possible to open the equipment only using special tools.

Specific user access control features such as password protection and/or key should be provided for operation of equipment/source housing operation.

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 container scanner. The trefoils 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 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-II.

3.4 Design of Radiation Equipment

Safety should be ensured during designing of the equipment itself. There should be multiple levels of safety systems in the container scanner equipment to prevent any undue exposure to workers and public. Container scanner equipment is required to meet the test requirements as stipulated in this guide. In addition, the design of the container scanner equipment should comply with conventional safety requirements (such as for fire, mechanical, electrical, transport) for the purpose of its intended use. The container scanner equipment should meet the requirements as stipulated by AERB (Appendix-III), as a part of type approval requirements. For radioactive source based container scanners, following stray radiation levels should not be exceeded:

Location	Maximum permitted stray radiation level
5 cm from the external surface of the source housing	1000 µSv/h
100 cm from the external surface of the source housing	20 µSv/h

In addition, manufacturer may follow the standards of the country of origin for the design of the scanner.

3.4.1 Fail-Safe Mechanism

A container scanner should be so designed that in the event of a breakdown of the equipment or malfunction of the operating system, or in the event of the occurrence of an unsafe condition, the equipment should attain safe condition and should continue to remain so, even after the desired condition is restored, until it is ensured that the equipment is operated from the control panel.

In the case of radioactive source-based equipment, the shutter of the equipment should automatically get closed if an incident or an emergency occurs and it should not be opened again unless and until the equipment is brought to a safe operating condition.

In case of X-ray based equipment, the beam should get switched OFF automatically if an incident or an emergency occurs and it should not get switched ON again unless and until the equipment is brought to a safe operating condition.

3.4.2 Safety Interlocks

A container scanner should be designed with suitable safety interlock systems. Container scanning equipment should have provision to attach any additional interlock in future. Such additional interlocks are to be installed with prior approval of AERB. Following are examples of typical interlocks for container scanning equipment.

Emergency Push Button: Provision of emergency push-button (mushroom switches) should be provided to the scanners. Emergency push buttons should be provided at various locations such as control panel, scanning bay, linear accelerator (LINAC) head and LINAC equipment room. In the case of mobile scanners, emergency push buttons should be provided at suitable locations of the vehicle carrying scanner, which should be easily accessible during emergency.

Door interlocks: For X-ray based scanner systems, door interlocks should be provided to all the doors to approach the LINAC equipment room. X-ray should not get energised whenever any of the interlock doors is open. When equipment is in use, upon opening of the door the X-ray should get automatically switch off. To restrict the entry of personnel or vehicles, entry and exit doors or similar arrangement should be provided in the container scanners operating at a fixed location. The accelerator equipment door should have interlock. Audio-visual light should be available near the accelerator equipment to alert any person who may be inadvertently trapped inside the scanning zone.

CCTV should be installed at specified location to give the complete view of the exposure area (for example, in case of gantry based container scanner, gantry obstructs major views during scanning) to ensure the safe exit of the driver. The entry door should be closed only after the exit door is closed.

Pull chord wires: In the case of fixed scanners operating inside enclosed installations or in the scan tunnel for drive through system, pull chord wires all along the wall of the scanning tunnel (room) should be available. Any person trapped inside the room can pull the wire to deactivate the system immediately. Pull chord wire should also provide audio/visual alarm to the operator, whenever activated.

3.4.3 Emergency Control Mechanism

For container scanner, whether it is controlled by electrical / mechanical / pneumatically operated control system, a readily identifiable and accessible means should be provided to control any emergency condition and to attain safe condition.

3.4.4 Control Console

All the scanning systems should be provided with a control console for safe operation of the equipment. The control console should not be located in the direction of primary beam. In the control console of X-ray based systems there should be a provision for display of operating photon energy (MV) & beam current, (μA) and time of beam generation (s/ms) for systems having provisions for operation at variable energy/current.

For X-ray based systems there should be an indication of beam status (ON/OFF) and for radioisotope-based systems, there should be an indication of shutter position (OPEN/CLOSED).

There should be key controlled / password protected operation of the equipment. Key can be removed only when X-ray beam is in OFF condition, or whenever the shutter is in CLOSED position (as applicable).

Appropriate radiation warning symbol(s) should be displayed on the control console.

3.4.5 Accelerator System/Source Housing

There should be a manufacturer's tag indicating the following particulars displayed on the accelerator system/ source housing:

(a) Appropriate radiation warning symbol
(b) Make of the unit
(c) Model number
(d) Serial number
(e) Year of manufacture
(f) Identity of the radioactive source (e.g. Cobalt-60) and its activity on a specified date, in the case of radioisotope-based systems.
(g) MV and mA, in case of X-ray based scanning system.

3.4.6 Operating parameters of X-ray based systems

Details of equipment parameters such as beam energy, beam current, head leakage, radiation output (dose rate) along with their variations should be provided by the manufacturer.

3.4.7 Leakage radiation from the equipment

Equipment should be designed to keep the leakage radiation as low as possible. In any case leakage radiation levels for X-ray based equipment should not be more than 0.5% of the primary output, when measured at 1 m from the target. For verification purpose leakage radiation levels should be measured at maximum beam energy and corresponding maximum beam current.

For radioisotope-based equipment, dose rates at 1m from the source housing in the shutter closed position should not exceed 20 µSv/h (2 mR/h).

3.4.8 Additional design requirements for scanners used on" Drive-Through" mode.

For scanning equipment used in drive through mode, additional in-built safety features should be provided to ensure that the driver does not receive a dose in excess of 0.25 µSv per scan. It is presumed that a given driver may not drive through more than 1000 scans per year with a dose constraint of 0.25 mSv per annum.

Equipment design should be such that in the drive through scanning mode, X-ray beam cannot be energised in the following cases:

(a) When driver cabin is within the scanning zone (primary beam area)

(b) Vehicle other than standard size container carrying vehicle having truck-trailor arrangement, passes through the system.

(c) When the gap between driver cabin and container is different from the standard specification for scanning.

(d) When a vehicle enters without container.

(e) When vehicle enters from wrong direction (through exit gate of scanning bay)

(f) When any person passes through the scanning zone.

(g) When vehicle carrying container is moving in the scanning zone with a speed beyond the pre-set speed limits.

Provisions should be provided to immediately and automatically switch OFF the X-rays in case of vehicle break down or stops moving during scanning.

3.4.9 Conventional safety

The design of the container scanner equipment should be in compliance with the conventional safety requirements, e.g., concerning high voltage power supply, as required by relevant authorities. All associated equipment/accessories required for operation of a container scanner including wiring, electrical equipment, lighting, etc. should be selected so as to minimise failure due to prolonged exposure to radiation.

3.5 Shielded Enclosure

3.5.1 Structural Shielding

(i) A shielded enclosure is required for a fixed type or relocatable type (such as drive-through and gantry based) Container Scanner (gamma and X-ray source). The enclosure should have sufficient structural shielding for walls/doors, ceiling and floor (if there is occupancy below the scanning zone) so that the dose rates outside the shielding do not exceed the prescribed dose limits or any other regulatory constraints for occupational workers and general public. The dose-rate at the operator's position should not exceed 10 µSv/h. For a fixed type or re-locatable type of accelerator-based container scanner, suitable shielded room (tunnel) should

be constructed. A beam stopper to attenuate primary radiation fan beam, structural shielding for walls, floor, ceiling, doors and control room should be available, so that the dose rates outside the shielding do not exceed the prescribed dose limits or any other regulatory constraints for occupational workers and general public.

In case of gantry-based High Energy X-ray (Accelerator) systems, the shielding provided at the beam stopper and around the accelerator head should be adequate, so as to limit the controlled area.

In the case of an open top installation with shed or mobile based system used in the open yard, sky-shine radiation around the installation should also be considered. Depending on the dose rate due to sky-shine, the controlled area should be extended beyond the shielding wall if found necessary.

(ii) The size of the enclosure should be so designed as to comfortably manage the intended task. The thickness of the shielding material should be such that the prescribed dose limits or other regulatory constraints are not exceeded. The workload, use factor and occupancy factor should be taken into account in the shielding calculations. The occupancy may be full, partial or occasional. There may be a need to establish a controlled area outside an enclosure. The amount of shielding needed can be reduced by restricting the number and area of internal surfaces that would be exposed to the primary radiation. High energy radiation would need primary protective barriers, which are either comparatively thicker or made using different materials. The size of the useful beam should be restricted so as to cover only the volume being scanned. The restriction can be achieved by collimating the primary beam that would reduce and shape the useful beam, as required. It is required to provide sufficient shielding for secondary radiation which is scattered by the scanned object and also the leakage radiation which has been transmitted through the housing which contains the radioactive source or the target (in the case of an X ray machine). This often dictates the thickness of secondary shielding required, which is then calculated in a manner similar to that used for calculating the primary barrier thickness.

3.5.2 Shielding material

Materials used for construction of shielded enclosure should be such that they provide sufficient shielding to ensure that the dose outside the enclosure does not exceed the prescribed limits given in Appendix-I. Normally concrete, brick, steel, lead etc. are used as

constructional shielding material for shielded enclosure. In case lead shielding is used (in door or in wall), the lead material should be sandwiched between steel plates to avoid sagging of the lead in prolonged 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.

3.5.3 Control Room

An enclosed installation should have a control room from where the operation of the container scanner within the shielded enclosure is remotely controlled. The control room should not be located in the directions of primary radiation. The shielding of the control room should be such that the limit on the effective dose for radiation workers is not exceeded.

3.5.4 Conduit / Opening

An underground conduit of should be provided in the wall to enable cables of the container scanner to pass through from the control console to the exposure room. . The conduit should be fixed in the specified wall(s) at an angle to avoid direct streaming of the radiation.

3.5.5 Door locks / interlocks

The shielded enclosure having a door for entry of materials or persons should have a provision for interlock. The door of the exposure room should be interlocked electrically or by any other reliable system so as to prevent operation of the radiation generating equipment when the door is open or improperly closed.

Boom Barrier Interlock: In the case of drive through scanning, the boom barrier and the entry and exit of the scan tunnel should be interlinked, wherever feasible. The boom barrier at the entry should not open until the boom barrier at exit is closed after completion of previous scanning and exit of the previous container.

Position Sensor: Interlock for sensing the exact position of the container and driver's cabin should be available. Command for switching 'ON' X-ray beam should take place only after pre-defined position sensing. The gap between the driver's cabin and container should also be sensed in the case of a drive through scanner.

Light Curtain: A light curtain (infra-red sensor) interlock should be provided, if there is no physical door available. The radiation beam should terminate in case any inadvertent entry or light path is breached.

Mechanical Interlocks: The mechanical interlocks should be of appropriate design to avoid injury to persons.

3.5.6 Audio-Visual Indicator

When the radiation equipment is in exposure 'ON' condition inside the enclosure, there should be an audio and/or visual indication. Arrangement for audio indicator should be made using an audio system directly connected to the radiation equipment or its control system. Similarly, a visual system such as red bulb/LED may also be activated. The audio system should be such that the sound is audible to the operator/controlled area. The visual system should be such that the exposure 'ON' indication is visible to operator from control console. Some examples of warning systems are given below:

Traffic Signal: Traffic signal such as red, amber and green colour signal should be available for the control of containers moving inside the tunnel (room) for scanning. Besides that, a marshal should be available to guide the vehicle before and after the scanning.

Time Delay: Time delay for beam generation should be incorporated in the safety system. The actual bream should be generated a few seconds (as per the pre-set delay) after the X-ray ON switch is activated. The beam should be generated after a hooter sound (alarm) is completed.

Audio Visual Alarm: An audio-visual alarm for the beam ON should be located at the entrance and exit gate of the enclosure/tunnel/scanning bay.

Fixed Radiation Zone Monitor

Based on the safety and security assessment of the facility, AERB may recommend additional measures such as installation of a fixed radiation zone monitor.

3.5.7 Radiation Symbol or Warning Sign at the Entry point

The radiation symbol specified in the safety directive issued by AERB should be conspicuously posted at the entrance and inside the enclosure. Specifications for the radiation symbol and the warning sign that are provided in the safety directive issued by AERB in Appendix-II. 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.

3.5.8 Ventilation systems

Special ventilation arrangement, if any, should be ensured as per the specifications of the manufacturer / supplier of the accelerator.

4. OPERATIONAL SAFETY

4.1 General

Radiation safety can be achieved broadly by incorporating design safety features and implementing operational controls. Operational safety plays an important role as it is not always possible to have engineering controls to address all the safety issues. For operational safety, qualified and trained manpower, proper operating procedures, adopting safety culture among the trained staff of the facility and compliance with the safe operating procedures and necessary infrastructure (protective accessories) are important. The basic principles of radiation safety, viz., time, distance and shielding should be adopted judiciously while operating container scanners.

The following factors should be taken into account for ensuring safety in the operation of container scanners:

(i) Operation of the equipment by trained person.

(ii) Availability of radiation monitoring instrument and radiation safety gadgets/tools (wherever applicable).

(iii) Monitoring of the radiation doses received by the workers.

(iv) Periodic maintenance of the container scanners by user/authorized suppliers.

(v) Operation of the container scanners as per standard operating procedures/manufacturers' manual.

(vi) Periodic training of the operating personnel and associated staff on radiation safety aspects.

(vii) Availability of radiation protection manual covering all the above aspects, its implementation and periodic review.

4.2 Manpower Requirement

The container scanner manufacturer, suppliers and user institutions should have competent professionals to ensure safe, effective and smooth operation of the unit.

No person under the age of 18 years should be employed as a radiation worker. While employing the workers, the licensee should ensure that the workers have appropriate training

and instructions in radiation safety, in addition to the qualification and training required for performing their intended tasks as prescribed by the relevant agency.

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 shall be designated as classified workers. Such employees shall be informed that they have been so designated.

Manpower involved in installation, testing, maintenance and operation of the container scanner are radiation workers and should have appropriate qualification and training.

The number of staff members and their qualifications should be in compliance with the requirements prescribed by the relevant authority. Guidance on manpower requirement for equipment under the scope of this guide are provided in the Appendix-IV. All persons involved in the use of a container scanner are not necessarily radiation workers. However, persons who do not operate such devices but involved in connection with the operation of the container scanner should have instructions on radiation safety.

4.3 Trainees

Persons undergoing training or apprenticeship in installation, testing and operation of container scanner are required to do so under direct supervision of certified radiation safety professional. Trainee/apprentice below 16 years of age should not be taken for training in radiation related work. Dose limits for trainees and apprentices should be as given in Appendix-I. In case of trainees/apprentice of 16-18 years of age, it should be ensured that their radiation dose does not exceed 6 mSv in a year. Dose limits for trainees and apprentices of above 18 years are same as those for occupational workers.

4.4 Monitoring, Protection and Safety Tools/Accessories

Operational safety may be effectively achieved by adherence to radiation protection procedures, monitoring of personnel involved in radiation work and workplace monitoring. Workplace monitoring is measurement of radiation exposure rate in controlled and supervised areas.

4.4.1 Personnel Monitoring

It should be ensured by the licensee and the organization providing service and maintenance that their personnel should avail Personnel Monitoring Services. Access to workers on information of their own dose records should be provided. Thermo Luminescent Dosimeters (TLD) should be used for personnel monitoring. The frequency of dose evaluation should be

quarterly. The licensee should ensure that the workers use the TLD badges properly. TLD badges should be returned at the beginning of subsequent quarter to the TLD service providing agency. The dose records of all the workers are required to be maintained and such records should be produced during regulatory inspections. The employer should furnish dose records to each worker in his employment annually and as and when requested by the worker. The dose received by servicing and maintenance personnel of container scanners should be evaluated using Direct Reading Dosimeters in addition to TLD.

The following guidelines should be followed for proper use of TLDs:

(i) TLDs should be worn by the personnel at all times when carrying out any work with radiation.

(ii) TLDs should be worn in accordance with recommendations from the personnel monitoring service provider.

(iii) The TLD card should be correctly positioned in the badge holder.

(iv) The dosimeter should be worn only by the person to whom it is issued.

(v) TLDs can be sensitive, and care should be taken to avoid damaging the measuring element of the dosimeter (e.g., dosimeters can be damaged by water, high temperature, high pressure and physical impact).

(vi) TLDs when not in use should be stored in locations where they are not likely to get exposed to radiation. TLDs should be sent for urgent processing by the dosimetry service in case there is suspected exposure in excess of the specified investigation level. (i.e. currently radiation dose in excess of 15 mSv in one monitoring period i.e. three months).

(vii) AERB and personnel monitoring service provider should be informed if the user agency suspects that the dosimeter has been damaged or has been exposed to radiation while not being worn.

(viii) While handling an incident or an emergency, DRD should be used in addition to TLD.

(ix) Detailed instructions for proper use of TLD are given in AERB website (https://aerb.gov.in/english/aerb-advertisement).

Investigation of reported dose in excess of investigation level:

In order to ensure that radiation dose to the workers do not exceed the dose limit, an investigation level of 15 mSv in a given monitoring period (3 months) 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 needs to submit an investigation report along with a statement from the personnel reported to be exposed in excess of investigation levels, to AERB. In case the reported dose is greater than 100 mSv, individual may have to undergo biological dosimetry i.e. chromosomal aberration (CA) test to determine the genuineness of the dose. CA test should be carried out at laboratories as directed by AERB.

4.4.2 Personnel Protective Equipment

Use of specific personnel protective equipment (PPE) such as lead-apron, thyroid shield, lead-equivalent spectacles etc. are not envisaged for normal operation/manufacturing of container scanners.

4.4.3 Radiation Monitoring Instrument

Radiation survey meters (RSM) are required for the purpose of :

(i) ensuring that the source is in safe position i.e. "OFF", after the scanning is over or X-rays are switched OFF.

(ii) ensuring that the dose rate outside the cordoning area/enclosure is within prescribed regulatory constraint.

(iii) measurement of surface dose rate and determination of Transport Index and the category of the package before transport. It is applicable for container scanners using Cobalt-60.

The range of an RSM used in a container scanner facility should be from 0.1μSv/h to 50 mSv/h. While handling incidents involving a radioactive source, a high range RSM (range up to 10 Sv/h (1000 R/h) should be used, in addition to the low range RSM. The drawback of some GM based RSM is that in a high radiation field, no reading will be seen due to the GM detector getting paralyzed. Therefore, user should be alert while entering a suspected high radiation field area.

Radiation monitors should be kept in a 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. Calibration of RSM should be carried out from authorized laboratories, at least once in two years or as recommended by the manufacturer of the RSM and immediately after the repair, and a certificate of calibration should be obtained.

4.4.4 Patient Dose Measuring Instrument

Not applicable for container scanner facilities.

4.4.5 Handling Tools

Generally special handling tools are not required for routine operation of container scanning systems. However, special handling tools, if any, as specified by the manufacturer should be available with facility. Tools required for servicing and maintenance should be available with the supplier/ the agency performing servicing and maintenance.

4.4.6 Mobile Shield / L-Bench

Not applicable for container scanner facilities.

4.5 Operation of Radiation equipment

Prior to operation of a container scanner, the operator is required to ensure that necessary arrangements are in place which provides protection to the workers and members of the public around the radiation installation. The operator should be familiar with all the safety features of the container scanner and to ensure that the dose received is as low as reasonably achievable. Periodically radiation monitoring should be carried out to have a check over dose rates and take measures if it exceeds the dose limits. The container scanner should only be used in the manner in which it was intended and for the purpose for which it was licensed. Only those trained in the use of the scanner should be allowed to operate it.

4.5.1 Gamma mobile container scanner

A gamma mobile container scanner uses Cobalt-60 source and is generally a vehicle mounted system. The following considerations should be taken during operation of such scanners:

(i) The cordoning off area should be done prior to actuation of the equipment. The cordoning distance should be such that the dose rate at cordon distance is not more than 1 µSv/h during the operation.

(ii) The warning sign should be displayed at the boundaries of the cordoning distance so that no person enters the radiation area.

(iii) All the warning lamps and audio signals provided in the equipment should be functional before scanning process is started.

(iv) A provision for gamma radiation source position indicator should be in place and should be clearly visible.

(v) All Emergency stop buttons should be functional.

(vi) Activation / deactivation of the system should be through key/password on control console.

4.5.2 Accelerator based (X-ray) container scanner

The X-ray container scanners are either fixed at a particular location or are moved along a fixed line to carry out scanning process. The container in a vehicle either stops at a particular position for scan or drives through at certain low speed for scan. The following precautions should be observed during operation of such scanners:

(i) The accelerator based fixed scanners are operated inside enclosed installation.

(ii) Warning signs should be displayed outside the enclosure to caution persons against approaching the radiation area.

(iii) All the warning lamps and audio signals provided in the equipment should be functional during the entire scanning process.

(iv) Speed of the vehicle carrying container should be within the specified limit and speed indication system should be functional and indicator should be installed in the control room.

(v) The CCTV should be functional and clear image should be visible in the control room.

(vi) All Emergency stop buttons at identified locations such as front and back side of equipment should be functional.

(vii) Activation / deactivation of the system should be through a key.

In addition to the above, in a drive through system it is essential that the X-ray equipment is energised only when the driver cabin has passed the region of primary beam and the container is facing the primary beam region, failing which the driver may receive a high dose. To achieve this functionality, appropriate safety systems should be provided. One of such safety systems is the laser gap profiler, which allows the actuation of X-rays, if and only if the vehicle carrying container having a gap between the driver's cabin and the container, passes through the scanning area. X-rays should be energised only after passing the driver cabin. X-rays should be switched off automatically in the event of vehicle break down or vehicle stops during scanning.

4.6 Source Location and Storage

4.6.1 Change of Premise / Location

The scanning of container should be carried out at the premise / location approved by AERB. In case a change of premise/location is contemplated, prior approval from AERB is required to be obtained.

4.6.2 Transfer of Radioactive Source / Equipment

The radiation source should not be lent, gifted, sold, supplied or otherwise transferred, decommissioned/disposed without the prior approval of AERB. The mobile unit used for scanning may be used only at such locations for which necessary approval from AERB has been obtained and in compliance with all safety requirements.

4.6.3 Safe and Secured Storage

In case the radioactive source(s) are not in use or to be temporarily stored, it should be stored in a safe and secure manner at the designated area, such as to restrict exposure of personnel to radiation to a minimum. Inventories of radioactive sources are required to be maintained and verified periodically. The source storage room should have all security provisions such as, locking arrangement at the door of the room, fencing with locking arrangement, CCTV and security guards.

4.6.4 Emergency Storage Container

The design of a container scanner using gamma source should be such that the radioactive source should not come out of the shielded container. In case the radioactive source comes out of the shielded container, efforts should be made to safely drive it back in the shielded container under the supervision of the RSO. The shielded container should be used as storage container in an emergency. If the shielded container is damaged and radioactive source cannot be driven back into it, then the supplier should arrange an alternate shielded container.

4.6.5 Source movement within the facility

Source movement, as permitted within the facility, should be carried out in a safe manner without exceeding the relevant dose limits.

4.6.6 Security of Radioactive Material

The employer should make necessary arrangements to ensure physical protection measures of the radioactive material 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 ensured that credible transporters are engaged for transport of radioactive source. For security during use and storage, AERB Safety 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-C for Category 3 sources) should be prepared and implemented at the container scanning facility. The security measures during transport of radioactive sources should be provided in accordance with AERB Safety Guide on 'Security of Radioactive Material during Transport" (AERB/NRF-TS/SG-10, 2008).

4.7 Safety Checks, Tests for Quality Assurance and Maintenance

4.7.1 Safety Check

For each safety system such as interlocks, audio alarm, visual alarms timers, couplings, emergency stop buttons, radiation monitoring systems and any other safety systems, the frequency of periodic checks should be established in consultation with the manufacturer/supplier and followed.

The safety systems should be checked periodically. The frequency of periodic checks is to be established, keeping in view the nature and probability of the failure of the safety systems. The frequency of checks of all safety systems may not be the same. A graded approach is to be followed in determining frequency of checks for safety systems. For safety systems, the functioning of which is more important to safety and the failure of which may give rise to radiation risk, the frequency of checks should be more than other safety systems. The licensee of the container scanning facility should specify all safety checks required for the radiation generating equipment and its frequency in the QA manual. It should mention the safety checks to be done by the operator and by the manufacturer/supplier or service providers. The records of all checks carried out should be maintained. If the container scanner develops a defect, it should not be used till it is repaired and found to be fit for use.

4.7.2 Tests for Quality Assurance

Quality Assurance(QA) is a set of planned and systematic actions necessary to provide the confidence that an item or service will satisfy the requirements for quality. The licensee should develop and adhere to the Manual on Quality Assurance Programme (QAP). Periodic Quality Assurance (QA) should be carried out as per manufacturer's instruction manual. In the event of detecting any defect in the equipment, it should not be used till it is repaired and confirmed to be suitable for operations.

4.7.3 Servicing and Maintenance

In order to maintain the reliability of equipment, periodic servicing should be done throughout the lifetime of the equipment. Because of the potential for radiation exposure involved in the service and maintenance of a container scanner, it should be carried out by trained personnel. The servicing of the equipment should be done by persons who have been authorised by the supplier/manufacturer and certified / recognised by AERB. In case, servicing and maintenance is not provided by manufacturer/supplier, it may be done by an authorised agency. The periodicity of servicing should be as prescribed by the manufacturer of the equipment. In container scanner equipment, use of spare parts and accessories meeting original specifications, is very important from radiation safety view point. The manufacturer or supplier is responsible for supply of original spare parts and accessories. Any replacement parts procured from the manufacturer / supplier or any other agency should satisfy the design requirements in order to meet the original safety specifications. The accessories and spare parts should meet the applicable standards such as International Standards Organization (ISO), Indian Standards(IS), International Electrotechnical Commission (IEC), Conformité Européenne) (CE). The routine checks of equipment should be carried out as prescribed by the manufacturer.

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

4.8.1 Management of disused sealed source

Safe management of disused radioisotopes used in isotope-based container scanners should be carried out after obtaining prior approval of AERB.

The disused/unused radioactive material should be disposed of, through the supplier/manufacturer. For sending the disused radioisotopes, to the supplier/manufacturer (local/country of origin) applicable transport regulations should be complied with. The safety and physical protection measures of the sources should be ensured by the licensee until it is sent back to the supplier/manufacturer.

4.8.2 Management of unsealed source (Radioactive waste)

This is not applicable for container scanner.

4.8.3 Decommissioning of Radiation Equipment/Facility

After the disposal of the radioactive material is done, the equipment should be formally decommissioned with the prior approval of AERB. However, when X-ray container scanner

is to be decommissioned then the key components such as voltage supply, wave guide, magnetron, electron gun etc. should be disengaged and ultimately the equipment should be dismantled such that no other person will be able to use it further.

4.8.4 Financial Provision for safe management / Decommissioning

The employer should make adequate financial arrangement for the decommissioning of the radioisotope based container scanner equipment and safe management of the disused radioactive source including any potential cost escalation, in the unlikely event of the facility becoming non-operational due to any reason 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.

The employer should make necessary legal provisions / agreement with the manufacturer / supplier so that disused radioactive source is returned to the country of origin or supplier.

4.9 Transport of Radioactive Material

The primary responsibility in achieving safety and security of the transport consignment lies with the consignor/licensee of the container scanner facility.

Approval from AERB is required before shipment of container scanner involving radioactive material. In addition, permission for carriage may be obtained as per applicable laws from relevant competent authority. Requirements for the safe transport of radioactive material are specified in AERB Safety Code on "Safe Transport of Radioactive Material" (AERB-NRF-TS/SC Rev.1), 2016.

Container scanner source should not be transported in public vehicles, shared taxis, motor cycles and other open vehicles. The source should always be booked as an item of cargo and it should be clearly declared in the documents that consignment contains Class 7 / Radioactive material.

The security aspects during transport of radioactive material are covered in the safety guide on "Security of Radioactive Material During Transport" AERB/NRF-TS/SG-10, 2008. Transport of radioactive material is governed as per Safety Code on "Safe Transport of Radioactive Material" (-AERB/NRF-TS/SC Rev.1), 2016.

5. MEDICAL EXPOSURES (Not Applicable)

The chapter on ‘Medical Exposure’ is kept intentionally blank since the same is not applicable to ‘Container Scanner’

6. HANDLING INCIDENTS / EMERGENCY SITUATION

6.1 General

Certain low probability incidents may occur during routine operation of isotope-based container scanning system. These events include failure of retraction of source shutter to its original position, fire/explosion involving radioactive source housing, extensive damage to the source, loss or theft of the source from the container scanner.

However, effects of emergency scenarios beyond the premises of radiation facility are generally not envisaged.

In case of an accelerator-based fixed or mobile installation, any inadvertent human entry, failure of interlocks or safety systems, or bypass of interlocks during maintenance (if any) may lead to an incident/higher exposure.

Standard procedures for management of incidents should be available in the institution to deal with any incident/emergency conditions and mitigate the consequences of an accident.

6.2 Emergency Preparedness and Response

Provisions in regard to radiological emergency are given in AERB Safety Code on 'Management of Nuclear and Radiation Emergencies' (AERB/NRF/SC/NRE (Draft)) and AERB Safety Guide on 'Management of Emergency arising from radiation sources, equipment and installations', AERB/RF/SG/NRE-2 (draft). The emergency response plan is required to be submitted to AERB prior to the commissioning of the installations. In case, any modification is to be carried out in the emergency plan, prior intimation for such modification should be submitted to AERB. The emergency preparedness plan for gamma container scanner and X-ray container scanner will be different. The emergency handling procedures should include the name and contact details of personnel to be contacted during an emergency, tools to be utilized and safety instructions. The procedure in brief is to be displayed conspicuously. All the concerned employees should be aware of the emergency response plan. Further, the equipment related to handling of incidents should be maintained in a usable condition and accessible so that they can be utilized during emergency. The plans should be made for each type of foreseeable incident. Few examples of such incidents are given below:

(i) Gamma container scanner:

(a) Radioactive source is unable to return to its safe position after use.
(b) The collimator shutter is unable to close completely.
(c) The radioactive source housing falls from a height.
(d) Theft of radioactive source or source together with source housing.
(e) The radioactive source housing hit by crane or heavy object.
(f) Incident during transport or movement of container scanner mounted on a vehicle.
(g) Unsafe work practices that could result in excessive exposure to radiation worker or members of the public.

(ii) For high energy accelerators, all foreseeable emergencies including the following contingencies should be considered:

(a) Failure of radiation generation to terminate even after the intended period of exposure.
(b) Malfunctioning of a safety system or warning system.
(c) Physical damage that affects the shielding or filtration.
(d) Unsafe work practices that could result in excessive exposure to radiation worker or members of the public.

6.3 Response to Incidents/Emergencies

The licensee, in consultation with the RSO, should ensure that incidents are handled in such a manner that the exposures to the personnel are minimized. AERB should be informed about any such incident and the remedial actions taken.

In the event of an accident involving a source, the employer is required to:

(i) make every effort to mitigate the consequences,
(ii) comply with the directives of AERB which may be issued to ensure safety including the immediate shutting down of the radiation installation.

Any unusual occurrences that may possibly lead to an unsafe condition may be recorded and remedying action taken indicated.

The response action should be as per the preparedness plan. However, depending upon the situation, the actions may vary. The protection action should be such that it does more good than harm. An example of response actions to be implemented in the case of an incident when a radioactive source cannot be driven back to its safe position is given in Appendix-V

6.3.1 Emergency Handling Tools

The following emergency handling tools (working and calibrated, as applicable) should be available with the institution for handling any incident / emergency involving a radioactive source:

(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; (only for radioactive source based container scanners)
(iv) Lead pot or temporary shielded source container. (only for radioactive source based container scanners)
(v) Equipment manual
(vi) Communication equipment (e.g., mobile phones)

6.3.2 Reporting an Emergency

After safe handling of emergency, a report giving the details of response action taken as per the available emergency procedures should be made. The root cause of the emergency situation and actions to prevent recurrence of such abnormal situation/ incidents in future should also be included in the report. The existing emergency procedures may also be revised based on the incident encountered in the facility.

The licensee 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 with the police, in case of loss or theft of radioactive source(s) within 24 hours of the event.
(iii) Investigate and inform AERB of any incident / radiological emergency involving radiation source and maintain record of investigations

7. PUBLIC SAFETY

7.1 General

AERB has prescribed dose limits for members of the public which are given in Appendix-I. 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 physical protection measures 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 RSO, should include the safety of the general public. Graded safety requirements should be established in the facility as per the level of radiation hazards expected to be encountered. Access to the facility by the general public should be controlled in accordance with zoning arrangement or classification of area (e.g. controlled area/supervised area). To ensure public safety, members of the public should not be allowed beyond Zone/ area designated for them. Access control system should be available to ensure entry of only authorised persons to higher zones. In addition regular radiation surveillance should be carried out to ensure that the dose rates in public access areas are acceptably low. The radiation exposure of the public from all sources including that due to operation of the container scanner facility in one week should not exceed 20µSv, considering the annual limit for public exposure is 1 mSv.

7.3 Protection of Foetus/Breast fed-infants

The foetus of a female radiation worker is considered as member of the public. A female worker, 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, if required, to ensure that the dose to the foetus well within the dose limit prescribed for general public.

There is no additional requirement for lactating radiation worker in the facility as chances of internal contamination in container scanner facility are very remote.

Appendix-I 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. 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/y 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-II 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 confirm 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.

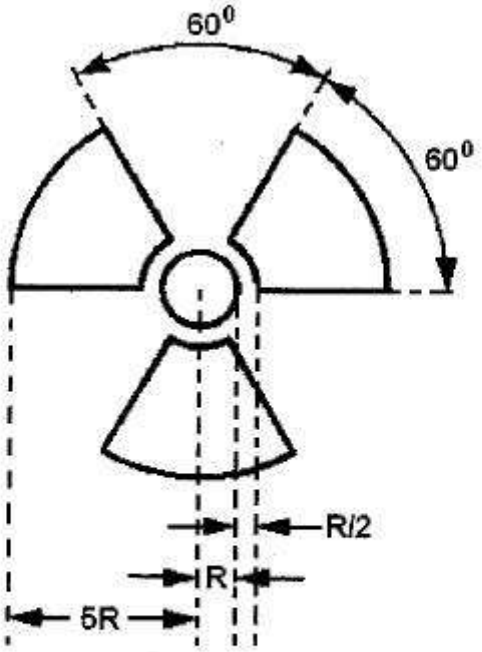

Fig. 1.
Radiation Symbol for Radioactive Sources

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

Appendix-III- Requirements for accelerator based container scanners

PART A: PERFORMANCE TESTS FOR CONTAINER SCANNER ACCELERATOR EQUIPMENT

Sr. No.	Parameters Tested	Tolerance	Remarks
1	Radiation Output measurement	Within tolerance value as provided by the manufacturer or within ± 5% of manufacturer's designed value, whichever is less	Measurements to be carried out at nominal beam energy

2	Consistency of radiation output	Cov$\leq$ 0.05	
3	Radiation leakage level at 1m from the target	$\leq$ 0.5% of radiation output	1.Measurements to be carried out at maximum beam energy and corresponding beam current 2. By shielding the primary beam with at least 3TVTs of shielding material

PART B: REQUIREMENTS FOR CONTAINER SCANNER ACCELERATOR EQUIPMENT

Sr. No.	Component	Requirements
1.	Control Console	(i) Provision for display of; (a) Operating photon energy (MV) & beam current, (μA) for systems having provisions for operation at variable energies/current (b) Beam status indicator (ON/OFF) (ii) Key controlled operation/ password protected operation of the equipment. Key can be removed only when X-rays are in OFF condition.

		(iii) Emergency stop switch (es) should be provided at the suitable locations at control console, on the equipment, equipment room, servicing work stations and other suitable locations as recommended by the manufacturer. (iv) Provision for attaching additional safety switches/devices. (v) Appropriate X-rays caution symbol(s) should be displayed.
2.	Accelerator system	a. Appropriate X-rays caution symbol(s) should be displayed. b. Display of manufacturer's tag indicating manufacturer's name and address, model number serial number.
3	Protection of crew member during scanning in drive through system	At least two independent mechanisms should be available to prevent any exposure of crew member (e.g. drivers) from the primary radiation beam.

Appendix-IV: Qualification Requirement

The qualifications of professionals are stipulated/ prescribed by the relevant authorities. Where such stipulations are not available, the qualifications suggested below should be considered.

1. Each radiation facility operating container scanners should have trained operator(s). The container scanner facility should have one operator per equipment per shift.
2. Each radiation facility operating container scanners, and each agency involved in the manufacture/supply/servicing and maintenance of container scanner should have a Radiological Safety Officer.

Radiological Safety Officer (RSO):

Minimum Qualification:

(i) Basic degree in Science or equivalent from a recognized University/Institution;

or;

Diploma in Engineering from recognized University/Institution;

(ii) Successfully completed the "RSO Certification for Scanning Facilities" or equivalent course conducted by AERB recognised agency.

Container Scanner Operator

Minimum Qualification:

(i) 10+2 Science or equivalent examination passed from a recognized Board/University.

(ii) Training and certification on radiation safety aspects (in addition to the training for operation of container scanners), by the original equipment manufacturer (OEM).

Appendix-V Typical case incident

Case: A mobile gamma container scanner was in scanning mode. After the scan time was over, the indicator for radioactive source return to its original position was still showing red.

The mechanism for exposure is by applying power to solenoid which pulls the source operating rod from the fully shielded position to the exposed position. The red indication is switched on when the rod is pulled out indicating the source is in exposed condition. It remains glowing till the source is in exposed condition. After scan is over, the solenoid is switched off, source returns to safe position through spring action and red light turns to green.

In the given case following response actions may be taken:

(i) Stop Scanning the container and carry out radiation monitoring from a distance from the radiation beam. If radiation monitoring readings are within the limits expected during source in shielded condition, it can be assumed that the source has returned back to safe (shielded) position and the problem is with the indicator system.

(ii) If the values are above the 'OFF' condition readings, it is to be concluded that the source has not returned to the safe position. Shutter closed partially or incompletely.

(iii) If the source assembly does not retract back into the shielding unit/head, If the Source fails to close and remains in the open position, a red warning light that is mounted on the Enclosure Box will stay lit.

(iv) Ensure that the cordoning is in place.

(v) Immediately after setting up the cordoning call the RSO

(vi) The RSO will take radiation exposure readings using a radiation survey meter around the enclosure box and the corresponding area.

(vii) The RSO will then make an assessment/determination about the cause of the problem

(viii) If the initial Radiation Exposure readings taken by the RSO are consistent with the readings of the Source being in a safe (shielded)position, then it is safe to assume that a malfunction has occurred of the Red Warning Lights System.

(ix) If the Radiation Exposure readings taken by the RSO confirm the failure of the Source Actuator, then the following steps must be taken:

a) Fix the emergency plug provided by the manufacturer in the exposure head, which provides shielding and thus reduces the dose rates to safe limits.

b) Open the side door of the enclosure box and attempt to install the transporting bolt.

(This bolt is mounted on the outside of the cylinder case).

c) After the transporting bolt is successfully installed, the RSO will take new radiation exposure readings to ensure that the Source is in the safe (shielded) position.

d) If the Radiation Exposure readings taken by the RSO are consistent with the Source being in a safe (shielded) position, then it is safe to assume that the surrounding areas of the source are safe.

e) After installing the transporting bolt, source container can be transported for further action.

(x) In case source is in safe position and problem is with the indicator, the same may be corrected by authorised service engineer.

Incidents in case of X-ray based container scanner, the response actions are usually simple because, in such case by switching off power the radiation exposure is terminated.

Appendix-VI: Responsibilities

1 General

There are various stakeholders involved in handling the radiation sources and equipment in the complete life cycle of the 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 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, Radiation Worker, Manufacturer and Suppliers of Container Scanner are provided in this Appendix-IV.

2 Responsibilities of Licensee (Employer)

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

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

(b) 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).

(c) ensure that persons handling container scanner equipment/radioactive source should abide by the provisions notifications/directives, the relevant Safety Code(s) and their further elaboration in the various safety guides, issued by the competent authority from time to time. Further, ensure that other measures of radiation safety stipulated by the competent authority are promptly implemented.

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

(e) ensure that no person under the age of 18 years is employed as a worker and no person under the age of 16 years is taken as trainee or employed as an apprentice for radiation work;

(f) provide adequate manpower for the functioning of the container scanner facilities and

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

(g) prior to employment of a worker, procure 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;

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

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

(j) furnish to each worker dose records and health surveillance reports of the worker in his/her employment annually, as and when requested by the worker and at the termination of service;

(k) inform AERB in case of any change(s) in licensee (employer)/Name of the Institute/Equipment and in case the RSO leaves employment;,

(l) 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;

(m) ensure that safety status report of the facility in the prescribed format is submitted to AERB periodically;

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

(o) 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;

(p) 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;

(q) ensure that adequate instruction/training is given to employees concerning any radiation hazards associated with their work, any precautionary measures necessary to limit radiation exposure of persons and to avoid radiation accidents and injuries;

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

(s) 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;

(t) 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;

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

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

(w) make financial arrangement for safe management of disused sources sufficiently in advance;

(x) be the custodian of radiation sources in his/her possession and ensure physical security of the sources at all times;

(y) ensure that procedures (SOP) are developed and implemented for radiation safety during operation of container scanner unit.

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

(aa) carry out physical verification of the radiation sources periodically and maintain inventory;

(bb) inform appropriate law enforcement agency (police authority) in the locality in case of any loss of source;

(cc) inform the Competent Authority in case of any loss of source;

(dd) 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 for safe management, with prior permission of AERB should be ensured;

(ee) ensure that the workers are familiarized with contents of the relevant surveillance procedures, safety standards, safety codes, safety guides and safety manuals issued by the competent authority and emergency response plans.

(ff) obtain prior permission of AERB in case of transfer of ownership of container scanner facility; and

(gg) obtain prior approval from AERB for any modifications in the layout of installation.

3 Responsibilities of Radiological Safety Officer

The role and responsibilities of RSO are elaborated below:

The Radiological Safety Officer should:

(a) advise and assist the employer/licensee for the implementation of the relevant provisions of Atomic Energy (Radiation Protection) Rules, 2004;

(b) 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;

(c) 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 location;

(d) advise licensee in establishing and maintaining an effective radiation protection programme to ensure safety of workers, members of the public and the environment;

(e) Advise and assist the licensee in providing training to the radiation workers on basic radiation safety, hazard potential and biological effects of radiation;

(f) 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);

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

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

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

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

(k) assist licensee to maintain inventory of sources including initial and present activity, operational logbook and associated QA records;

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

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

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

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

(p) ensure safe work practices during source replenishment, equipment repair/replacement and safe management of disused source ;

(q) 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;

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

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

4 Responsibilities of Workers (Operator/User)

Worker (Operator/user of Container Scanner) is the person who is directly involved in day-to-day operation/use of the unit. The worker has recognized rights and duties in achieving radiation safety while handling the radiation source, which call for awareness about the operational as well as safety requirements of the unit. Accordingly, the workers should get training in safe operation, preventive maintenance aspects of the unit from authorized manufacturer/supplier during installation of the unit at the site.

The worker (operator/user) of Container Scanner should:

(a) be familiar with the basic design, operation and preventive maintenance of the Container Scanner including procedures for routine operation and handling emergency situations;

(b) operate the Container Scanner unit as per the standard operating procedures (SOP) prepared by RSO from detailed instruction manual provided by the manufacturer/supplier of the Container Scanner unit;

(c) follow all applicable rules and regulations for safe operation of unit;

(d) maintain the logbook in respect of use and operation of the unit including users' details and of container under scanning.

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

(f) report to RSO/licensee of any issues related to safe operation of the Container Scanner unit, including the circumstances that could adversely affect safe operation of the unit;

(g) be familiar with area security safeguards such as locks, posting signs, warning lights and interlock systems;

(h) ensure that no person is present in the scanning area prior to starting the exposure; and

(i) in case of a female worker, on becoming aware that she is pregnant, notify the employer,

licencee and RSO in order that her working conditions may be modified, if necessary.

5 Responsibilities of Manufacturer and Supplier

The manufacturer/supplier should:

(a) ensure that only Type Approved Container Scanner units are supplied to the user and the terms and conditions of the Type approval are complied with;

(b) Adhere to the Terms and Conditions of the licence issued for manufacturing and authorization for supply of the Container Scanner.

(c) supply the unit only to the users authorized by AERB;

(d) install the unit only at premises authorized/approved by AERB;

(e) provide to the user instruction manual in understandable language (English/Hindi/Local language) for safe operation, periodic inspection, servicing, preventive maintenance including general description of the unit and detailed operating instructions and procedures;

(f) provide information to the user in respect of make, model, S. No. of the unit, details of radiation sources & activity with date, leak test certificate of sealed source, dose rate of the equipment;

(g) provide appropriate training to the personnel of user institution involved in operation, servicing and maintenance of Container Scanner unit.

(h) ensure the availability of essential spare parts of the unit till useful life of the supplied equipment ;

(i) provide servicing and maintenance of the unit whenever required;

(j) assure the supply of radiation sources/accelerator components as applicable in Container Scanner unit, when requested by user, in compliance with regulatory procedures;

(k) provide safety accessories, as required to the user for the normal operation of the Container Scanner unit and for handling emergency situations;

(l) provide written instructions to the user specifying procedures to be followed in an emergency situation that caused or may cause a radiation hazard to any individual;

(m) undertake the responsibility for providing technical support in disposal of disused sources and decommissioning of the unit;

(n) take back the disused sources supplied by them for disposal; and

(o) Provide support in handling any radiological emergency associated with the supplied Container Scanner.

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Dates of meeting: March 22, 2022, October 28, 2022

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