GUIDE NO. AERB/RF/SG/GXIC

GOVERNMENT OF INDIA

AERB SAFETY GUIDE

GAMMA AND X-RAY IRRADIATION CHAMBER

ATOMIC ENERGY REGULATORY BOARD

AERB SAFETY GUIDE: AERB/RF/SG/GXIC

GAMMA AND X-RAY IRRADIATION CHAMBER

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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 for all stages during the lifetime of nuclear and radiation facilities and transport of radioactive materials. These requirements and guidance are developed such that the radiation exposure of the public and the release of radioactive materials to the environment are controlled; the likelihood of events that might lead to a loss of control over a nuclear reactor core, nuclear chain reaction, radioactive source or any other source of radiation is limited, and the consequences of such events if they were to occur are mitigated.

The Regulatory Documents (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

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.

Gamma and X-ray Irradiation Chamber (GIC/XIC) facilities are required to obtain licence from AERB under Atomic Energy (Radiation Protection) Rules, 2004. GIC/XIC facilities should obtain regulatory consents at various stages such as layout approval of GIC/XIC installation, permission for procurement of equipment, operation of the facility, decommissioning of the equipment/facility and transfer of the radioactive sources for safe management after their useful life. This guide specifies the design safety aspects of sealed source, equipment and installation and describes the pre-requisites for operation of GIC/XIC facilities. This in effect, provides guidance on compliance with the regulatory requirements for GIC/XIC which 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 and supersedes Safety Guide on Gamma Irradiation Chambers, AERB/RF-RPF/SG-2, 2015.

Consistent with the accepted practice, 'should' and 'may' are used in the Guide to distinguish between a recommendation and a desirable option respectively. Appendix is an integral part of the document, whereas annexure and bibliography are included to provide 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.

(Dinesh Kumar Shukla)
Chairman, AERB

SPECIAL TERMS S AND INTERPRETATION[1]

(Specific for this Guide)

Capsule

Protective envelope used for prevention of leakage of radioactive material from a sealed source.

Category-I Irradiator

An irradiator in which the sealed source is completely contained in a dry container constructed of solid materials, the sealed source is shielded all the times, and human access to the sealed source and the volume undergoing irradiation is not physically possible in its designed configuration.

Encasement

A cover suitably designed to protect primary shielding material; this does not include cosmetic shells and cabinets.

Gamma Irradiation Chamber

The self-contained dry source storage gamma irradiator is also known by its commercial names, such as Gamma Irradiation Chamber [(GIC); also called as gamma chamber, gamma cell]. An irradiator in which the sealed sources are completely contained in a dry container constructed of solid materials, the sealed sources remain shielded at all times, and human access to the sealed sources and the volume containing a sample undergoing irradiation is not normally possible in its design configuration.

Primary Shielding

[1] Special definition may have different interpretation from definition in AERB Glossary on the same term.

The material integral to the design of the irradiator that has as its primary function the attenuation of radiation emitted by the sealed source(s) to acceptable levels.

Recommended Working Life

Recommended working life for sources is the period of time over which the source is expected to maintain its integrity

Safety Interlock

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

Unrestricted area

Any region to which human access is not controlled for radiation safety purposes.

X-ray Irradiation Chamber

An irradiator in which the X-ray generator is completely contained in a shielded enclosure constructed of solid materials, and human access to the volume(s) undergoing irradiation is not normally possible in its design configuration.

Note: Words and expressions used in this document and not defined, but defined in the Act, the Rules, and AERB Glossary shall have the meanings as assigned in the Act, Rules, and AERB Glossary.
Reader may also refer AERB Safety Code on 'Radiation Sources, Equipment and Installations' AERB/SC/RF, 2025 and AERB Safety Glossary, No. AERB/GLO, Rev.1 for Definitions of terms used in this Guide.

ABBREVIATIONS

AERB	Atomic Energy Regulatory Board
EPR	Emergency Preparedness and Response
NOC	No Objection Certificate
OEM	Original Equipment Manufacturer
RPP	Radiation Protection Programme
RSM	Radiation Survey Meter
RSO	Radiological Safety Officer
RWL	Recommended Working Life
GIC	Gamma Irradiation Chamber
XIC	X-ray Irradiation Chamber

Contents

1. INTRODUCTION

1.1 General

Basic and applied research studies based on radiation induced changes in materials are of high interest for harnessing known and potential applications in various fields, e.g. food and agriculture, medicine, material science, polymers, environmental protection, etc. Compact, self-shielded units of irradiation chambers (also known as laboratory irradiation chambers), containing a radioactive source (mostly ^{60}Co, ^{137}Cs) or X-ray generating equipment, are used for this purpose. The former is called Gamma Irradiation Chamber (GIC) and the latter is known as X-ray based Irradiation Chamber (XIC).

The GIC has been used in universities, academic and research institutions for research and development, such as mutation breeding of seed, radiobiological studies, and radiation effects on materials. It is also used in blood banks and medical centres for irradiation of blood and blood products to eliminate the risk of post-transfusion graft-versus-host disease (GVHD) in immuno-deficient recipients of blood transfusion.

Such gamma irradiation chamber falls under Category-I irradiator (to distinguish it from the other types of irradiators using high-intensity radioactive sources: They come under four categories of gamma irradiators, viz. Category I to IV.[2]). Category-I is self-contained dry source storage gamma irradiator in which the sample to be irradiated is moved close to the source for irradiation, and human access to the source is restricted / not feasible. GIC generally houses either ^{60}Co or ^{137}Cs source of typical activity ranging from few tens of TBq to few hundreds of TBq.

X-ray based irradiation chamber (XIC) is an effective alternative to GIC, with its typical operating parameters being 160 kV and 5 mA. The X-ray generator is housed in an enclosure of sufficient shielding so that dose rate outside the XIC is within the prescribed limit. Its use is increasing and becoming more popular now-a-days, (compared to GIC

[2] Category-II Irradiators are similar to Category-I but allow the source to be brought out for irradiation. Category-III and IV Irradiators, also known as wet source storage irradiators, involve either bringing the sample/material close to the source (Category III), or bringing the source out for irradiation (Category IV) of the samples/materials. The use of Category-II is almost obsolete. Category III and IV irradiators are in use and generally contain ^{60}Co sources of the order of thousands of TBq (i.e. PBq level) activity.

use), especially for irradiation of blood & blood products required in hospitals and blood banks. This is mainly due to its well-suited energy for irradiation of blood bags/components, as well as avoiding concerns and measures for physical protection of the radioactive sources. Also, there is no end-of-useful life management issues as in the case of the spent radioactive sources.

1.2 Objective

This safety guide provides guidance to meet the relevant regulatory requirements prescribed in AERB Safety Code on 'Radiation Sources, Equipment and Installations' AERB/RF/SC, 2025 , by specifying relevant procedures and elaborating radiation safety requirements for design, procurement, commissioning, operation and decommissioning of GIC/XIC in order to ensure :

(i) that exposure of the radiation workers and members of public are kept as low as reasonably achievable (ALARA) and within the dose limits prescribed by AERB (Appendix-I);
(ii) availability of appropriate instruments, tools and accessories, qualified and trained personnel for safe handling of equipment and sources; and
(iii) security, safe custody, transportation and safe management of sources during their operational life as well as after their useful life.

1.3 Scope

This safety guide provides guidance to the users, manufacturers and suppliers of GIC/XIC for ensuring radiological safety requirements while handling the radioactive sources or the radiation generating equipment, as the case may be. The radiation protection and safety requirements described in this safety guide apply to the design, manufacture, operation, maintenance and decommissioning of GIC/XIC and during safe transport of radioactive sources.

This safety guide does not deal with the radiological safety requirements of Category II, III and IV gamma irradiators which are covered in safety guide on ‘Gamma Radiation Processing Facilities’ (AERB/RF/SG/GRAPF). This guide does not deal with industrial accelerators for radiation processing which are covered in safety guide on ‘Industrial Accelerator Radiation Processing Facilities (AERB/RF/SG/IARPF).

Though this guide provides generic information on the need for appropriate physical security measures, it does not provide specific guidance on aspects of physical security measures required for GIC sources. For this purpose, the provisions of the 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) and such other regulatory documents as are published from time to time by the AERB in this regard should be adhered to.

2. RADIATION PROTECTION AND SAFETY

2.1 General

Radioactive source in GIC is stationary and inaccessible all the times. The sample/ product to be irradiated is loaded in a chamber, which is brought mechanically close to the source. The source is enclosed in a shielding of high density material such as lead, DU, tungsten etc. There is no possibility of excessive radiation to the user during routine operation. However, accidental conditions and breach of security measures may lead to safety implications.

Licensee[3] is responsible for the establishment and implementation of the radiation protection programme to ensure protection and safety in compliance with the regulatory requirements. The licensee has the overall responsibility for ensuring radiation safety and verifying that the radiation sources are handled safely in accordance with regulatory requirements. The licensee should ensure that procedures are developed for the protection of workers, the public and the environment, and for ensuring that radiation exposures are kept as low as reasonably achievable (ALARA) and within the dose limits prescribed by AERB.

2.2 Justification

The employer should ensure that no practice or activity involving exposure to radiation is performed unless it produces more benefit than harm. The use of GIC/XIC for blood irradiation and research purposes brings substantial benefits to immune suppressant patients and to know the effects of radiation on materials and biological samples respectively.

Licensee should ensure that the GIC/XIC is used only for the purpose it has been authorised by AERB.

2.3 Optimisation

The licensee should ensure that procedures are in place for the protection of workers, students and trainees handling the source. It should also be ensured that public and the

[3] Typically employer is the Licensee.

environment are protected from radiation exposure. Licensee should ensure that exposures to the above personnel due to the handling of GIC/XIC are kept as low as reasonably achievable (ALARA) and within the prescribed dose limits (Appendix-I). The optimization process should also consider minimizing the number of individuals exposed, magnitude of exposure and the likelihood of potential exposure.

Standard operating procedures (SOP) for operation of GIC/XIC, periodic maintenance to ensure effectiveness of safety interlocks, mechanical components, periodic operational and radiation safety training for users and establishment of emergency handling procedure should be in place for optimisation of the exposure.

2.4 Dose Limits

The licensee should ensure that the exposure of worker or public due to the use of GIC/XIC is so restricted that neither the effective dose nor the equivalent dose (to specified tissues or organs) exceeds the dose limits prescribed by AERB from time to time. It is to be ensured that radiation doses to personnel operating GIC/XIC are assessed on a regular basis (quarterly).

The dose received from natural background radiation and medical exposures due to diagnosis or treatment procedure incurred by a person are not part of the dose limits. The dose limits prescribed by AERB are reproduced in Appendix-I.

2.5 Management for Safety

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

Radiation Protection Programme (RPP) should be established and implemented in the GIC/XIC facility with the following objectives:

(i) the radiation exposure of both workers and the public is kept as low as reasonably

achievable (ALARA principle); and

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

The GIC/XIC facility should establish and implement technical and organizational measures to ensure protection and safety for operation of the facility. Organizational and technical measures should include the following:

(i) The employer/licensee should have a commitment towards safety and to continuously monitor and improve, the safety and security culture in the facility.

(ii) The employer/licensee should ensure reporting of the incidents/accidents and implement the lessons learnt to prevent their recurrence. Improvements arising from the findings of incident analysis should be incorporated as part of the organizational/ technical measures.

(iii) Building of safety culture should include assessment of organizational culture, communications/ interfaces, protocols/procedures/practices, adequacy of resources, human and technological factors, i.e., staff numbers, working hours, education and training.

(iv) Standard Operating Procedures (SOPs) should be developed and implemented. The SOPs should be subject to periodic review and update.

3. DESIGN OF RADIATION SOURCES, EQUIPMENT AND INSTALLATION

3.1 General

This chapter addresses the requirements for manufacturer, supplier and other entities who are involved in the design and manufacture of radioactive sources, GIC and XIC (radiation generating equipment) and installations. Further, this chapter is equally pertinent for the users in appreciating the design safety aspects of GIC/XIC.

Design requirements for radioactive sources and GIC/XIC play a major role in ensuring safety of sources and protection of users and public. Therefore, the design of radioactive sources, GIC/XIC and radiation installation should be such that undue exposures to personnel or public, and occurrence of incidents or emergency situations are prevented. Manufacturers/suppliers should obtain Type Approval from AERB upon satisfactory demonstration of compliance with the requirements provided in the relevant National/International Standards. GIC/XIC consists radioactive sealed source or X-ray sources enclosed within source housing of high density material, sample chamber, sample chamber movement mechanism for loading / unloading of sample for irradiation and control system. .

3.2 Sealed Source

The radioactive source is permanently sealed in a capsule or closely bonded and in a solid form. The capsule or material of a sealed source should be strong enough to maintain leak-tightness under the conditions of use and wear for which the source was designed, as also under foreseeable mishaps. GIC sources being sealed sources, they should be designed to meet the requirements as per the standards prescribed by the Competent Authority or equivalent international standards for design of sealed sources.

Sealed source manufacture should design sealed source to suit the GIC design and intent of application. Manufactures should provide recommended working life (RWL) / Rated Life for sealed source / special form sealed source. RWL is based on a number of factors

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Sealed Source: (1) Normally Co-60/Cs-137 in solid or vitrified form is used in GIC in suitable configuration. In case of XIC/X-ray is generator.

Source Housing: (2) It houses source and provide shielding to arrest leakage radiation to prescribed limit.

such as half-life of sealed source, fabrication of sealed source etc. Manufactures should clearly specify duration over which the sealed source assembly would retain its integrity.

The sources should not be used beyond the RWL. However, the licensee may use it further subject to certification by the original source manufacturer or other appropriate agency with prior approval from AERB. The manufacturers should carry out re-assessment for integrity of GIC sources that have completed RWL for continuation of use and recommend the exact period of extension of the use of the sources.

3.2.1 Encapsulation

The designer/manufacturer of the source should ensure that the design of the sealed source(s) used for GIC is in compliance with the Safety Standard on 'Testing and Classification of Sealed Radioactive Sources' [AERB/SS/3 (Rev.1)] issued by AERB or an equivalent International Standard (e.g. ISO 2919). This standard describes the test requirements that simulate operating conditions and accident conditions which might be encountered during the use of sealed sources.

The capsule material of a sealed source should be strong enough to maintain leak tightness under the conditions of use and wear for which the source was designed, as also under foreseeable mishaps. The encapsulation design of the sealed source(s) should meet the specifications as per national/ international standards in respect of containment integrity, mechanical strength, so as to prevent release of radioactive material during the useful life of the sealed source.

The sealed source used in a GIC should also meet the requirements of:

(i) 'special form radioactive material' ; and

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

The source(s) used in GIC should meet the minimum classification of performance requirement of the sealed source classification C/E 43323; and Bend Test# 4 as specified in AERB safety standard, AERB/SS/3 (Rev. 1).

The supplier of the source should demonstrate compliance with the test requirements as specified in AERB/SS/3 (Rev.1) if the sources are manufactured within India. For the imported sources, the supplier should submit the documents to AERB to demonstrate compliance as per requirements of AERB/SS/3(Rev.1) or equivalent international standard.

The source manufacturer or supplier should maintain records of sealed source(s) and provide relevant information to user to meet the requirements of licensing, transportation, etc.

3.2.2 Encapsulation Material

Material used for encapsulation should be physically and chemically compatible with the radioactive material and should remain unaffected by ionizing radiation and adverse environmental condition throughout its recommended working life. Generally Stainless Steel SS 316L grade is used as encapsulation material for sealed source used in GIC.

3.2.3 Contamination and Leak Test

The manufacturer/supplier should carry out surface contamination check for each sealed source before supply. This test should be conducted in accordance with the AERB/SS-3 (Rev.1) or ISO-9978. If the activity detected in the contamination check (i.e. leak test) conducted following the other prescribed tests is not in excess of 185 Bq (5 nCi), the sealed source is considered to be free from surface contamination. Leaky or contaminated sources should not be supplied/used.

3.2.4 Source Identification

All sealed sources used in GIC should have an identification mark. This information should be indelibly marked on the source encapsulation. The encapsulation of sealed sources should be durably and legibly marked with the information in the given order of priority: (a) the word ""“RADIOACTIVE” as feasible and the symbol for radioactivity (trefoil sign), (b) mass number and chemical symbol of the radionuclide; (c) serial number of the source and (d) manufacturer’s name or logo. Marking of the capsule /

source assembly should be done prior to loading the radioactive material in the sealed source capsule.

3.3 Source Housing

Source housing refers to the shielded container made of high density material in any device for housing sealed source or X-ray generator. This is to provide shielding and define the useful beam area and restrict the leakage radiation level outside the useful beam area to the limits prescribed by AERB.

3.3.1 Source Housing Design and Integrity

Source housing assembly of GIC/XIC should consist of sealed source, sample chamber and drive mechanism. It should facilitate housing of sealed sources generally in cylindrical configuration and can be loaded remotely in safe enclosure such as hot cell. Cylindrical configuration can be achieved by placing the sources in a source cage of circular geometry with appropriate distribution of actively in order to provide uniform dose to sample chamber which can be precisely positioned within the cavity of source cage during process of irradiation.

Manufacture should ensure that design of source housing and sample chamber movement system is such that transit dose to the sample is minimum and also loading/unloading is safe.

Source housing should be designed to comply with the applicable design requirements of the containment system for the safe transport of radioactive material. The shielding integrity (radiometry) of the Source housing and Transport package needs to be checked and the requirements of the same is specified in **Annexure-2.**

A sample quality assurance programme for manufacturing of GIC is given in **Annexure-3**. The maximum permissible leakage radiation levels from GIC/XIC unit with maximum designed source strength/rating (kVp, mA) for various modes of operation should not

exceed the limits in the restricted area (controlled area) as mentioned in the Table 3.1 given below:

Table 3.1: Limits on Leakage Radiation Levels of GIC/XIC

Mode of Operation	**Location**	**Limit on radiation level in a restricted area for GIC unit**	**Limit on radiation level in a restricted area for XIC unit**
Irradiate/Storage	5 cm from the accessible surface	200 µSv/h	1 µSv/h*[$]
	1 m from the accessible surface	20 µSv/h	NA
Sample Load/ Unload/Transient Mode	5 cm from the accessible surface	2000 µSv/h	NA
	1 m from the accessible surface	100 µSv/ h	NA

*Only during irradiation condition

[$] This value is above the background radiation

3.3.2 Securing of Radioactive Source in the Housing

Source should be removed / exposed only in safe enclosure such as hot cell by trained person.

3.3.3 Radiation Warning Sign and Radiation Symbol

The source housing should be clearly and permanently marked with radiation warning sign on the outer surface of the GIC/XIC. The radiation symbol for radioactive source is different from that for X-rays. Therefore, radiation symbol chosen should be appropriate to the source of radiation. The trefoil with central circle should be used as radiation symbol with 'CAUTION RADIOACTIVITY' as warning sign for radioactive sources. The equilateral triangle radiation symbol with 'CAUTION-X-RAY' as the warning sign should be used for X-ray sources. Specifications of radiation symbol and warning sign

are provided in the safety directive issued by AERB, which is reproduced in Appendix-II.

3.4 Design of Radiation Equipment

The manufacturer/supplier of GIC/XIC should ensure that design/type approval of the equipment is obtained from AERB prior to its supply. Applicant/user should ensure that GIC/XIC have necessary design/type approval from AERB prior to its procurement.

3.4.1 Design of GIC/XIC

Design of GIC should meet the requirements specified by National or equivalent International design standards. GIC containing sealed sources of high activity is completely enclosed in a shielded container (source housing) which is used as a transport package along with over pack. Design of the GIC container, therefore, should meet the performance requirements of Type B (U)/ (M) package, as specified in the National / International Regulation for the Safe Transport of Radioactive Material.

Usually, lead is used as shielding material for source housing, which is completely encased in a welded stainless steel shell. Depleted Uranium (DU) can also be used for primary shielding. In case of DU appropriate cladding should be provided over it to prevent degradation of the material due to oxidation and hydride formation. Any combination of these materials (Lead, Depleted Uranium, Steel, Tungsten) can also be used as primary shielding material for the construction of GIC.

Design of XIC should meet the mechanical, electrical, dosimetry and leakage radiation test parameters as per the national or relevant /international standard (e.g. IEC), as applicable. Conformity of the X-ray units with national or international standard on electro-mechanical compatibility should be established and authenticated document (such as Conformité Européenne (CE) certification, IEC or equivalent) in this regard, should be provided to AERB during design approval of the XIC as well as to the end user. Wherever feasible the CE or equivalent marking should be conspicuously displayed on the unit.

The parameters to be checked during type approval testing of GIC/XIC are specified in Annexure-4.

3.5 Electrical & Electronic Control System

3.5.1 Audio-Visual Indicators

GIC/XIC equipment should have the provision of visual indicators to indicate the operational status (Irradiation ON/OFF).

(a) Status Indicator Colors

Color indicators may be used to identify operational status on the GIC/XIC unit as given in the below table.

Condition	**Color**
Emergency (stop buttons or lights)	Red
Warning-Hazard	Red
Critical Information (source in use or malfunction)	Red
Caution (no emergency, but some function taking place to be aware)	Orange or Yellow
Normal (source not in use or function safe)	Green
Information	Blue

(b) Labeling of Controls

Each control should be clearly labeled indicating its function.

(i) **Master Control:** GIC/XIC should have a master control that should be used to prevent unauthorized operation. This control may be a key operated switch.

(ii) **Termination of Irradiation:** Means (emergency stop button/switch) should be provided to terminate an irradiation and return to its 'not in use' mode at any time.

3.5.2 Fail-Safe Mechanism

Fail-safe means the radioactive source remains secure in unexposed position. Since the GIC source is stationary, design should be such that in case of any unsafe circumstances, the interlocks are actuated immediately and the product under irradiation is automatically brought back to sample load/unload position.

In the case of an XIC which is controlled by electrical system, it should be so designed that in the event of a failure/breakdown or malfunction or undesirable conditions, the equipment automatically de-energises.

3.5.3 Safety Interlocks

Wherever GIC/XIC is controlled by electrical/mechanical/pneumatic system, it should be so designed that unsafe situations can be prevented by suitable safety interlock systems. The interlocks should be part of its design and interlock arrangements should have redundancy with defence in-depth mechanism. The safety interlock should be designed to prevent radiation levels in excess of the prescribed limits mentioned in Table 3.1. Interlocks should be provided to ensure sample chamber for irradiation attains precise location for irradiation / loading / unloading.

In the case of GIC, if the lid of the sample chamber or locking ring of removable lid is not properly placed, sample drawer movement should not be actuated.

In case of XIC, the X-ray generation should be interlocked with door or lid of the irradiation chamber. The X-ray should be de-energised if door/lid is opened during operation, and X-ray generator should not be energised unless door/lid is properly closed.

3.5.4 Emergency Control Mechanism

The control panel of the GIC/XIC should include emergency switch/push buttons to stop the irradiation or to bring back the sample chamber in sample loading/unloading position.

In case of power failure or machine breakdown of GIC, sample drawer should come back automatically to the safe sample loading/unloading position. Emergency control mechanisms should be made part of the fail-safe mechanism.

In case of XIC, the function of emergency stop button/switch is to de-energize the X-ray beam in case of an emergency situation. When radiation generation is stopped, either by an interlock or by actuation of emergency stop button, it should not be possible to restart the operation unless control panel of the equipment is reset manually.

3.5.6 Conventional Safety for installation requirement

In order to ensure the radiation safety during any fire incident, necessary fire protection measures as part of emergency response procedure need to be developed and the necessary fire-fighting systems should be provided in the GIC installation room. All regulatory requirements applicable to conventional safety should be duly met by the employer of the radiation facility operating the GIC/XIC.

3.6. Shielded Enclosure

3.6.1 Structural Shielding

The installation location for GIC should be preferably at the ground floor of the building or basement, with ease of accessibility for movement of GIC for installation and commissioning in view of the concentrated heavyweight of the unit, which is about 3 to 10 MT. The GIC/XIC should be located in an exclusive room having provisions for lock and key arrangement restricting access for unauthorized entry. The room for GIC/XIC installation is normally made of brick walls. The guidelines for installation of GIC/XIC are given in Annexure-1.

3.6.2 Control Room

GIC/XIC is operated from control panel provided on the unit itself and hence no separate control room is needed.

3.6.3 Conduit/Opening

Not Applicable

3.6.4 Door Interlock

Not Applicable

3.6.5 Audio-Visual Indicator

A visual indication of the XIC operational status (ON/OFF) should be provided at all times. A red warning light should be provided on the XIC unit and this light should be made 'ON' whenever the equipment is energized.

3.6.6 Radiation Zone Monitor

Not Applicable

3.6.7 Radiation Warning Sign and Radiation Symbol at Entry point

The GIC/XIC installation room should be clearly marked and labelled with a radiation warning symbol along with legend. Radiation symbol and warning sign as prescribed by AERB should be posted conspicuously and prominently at the entrance of the GIC/XIC installation room. The specifications for radiation symbol and warning sign are provided in the safety directive issued by AERB which is reproduced in **Appendix-II**.

3.6.8 Ventilation Systems

This section is not applicable for this guide on 'Gamma and X-ray Irradiation Chamber'

4. OPERATIONAL SAFETY

4.1 General

Achievement of radiation safety requires both incorporation of design safety features as well as implementation of operational controls. Operational safety plays a major role in ensuring radiation safety as it is not always possible to have engineering controls to address all safety issues. Operational safety depends on the availability of adequate manpower and their knowledge in radiation safety, standard operating procedures and their compliance, requisite infrastructure for safety and continuous fostering of safety culture.

The important elements of operational safety measures include: (i) type approved GIC/XIC and sources (ii) availability of qualified personnel trained in radiation safety (iii) appropriate monitoring instruments (iv) personnel monitoring (v) emergency preparedness plan (vi) Security plan (vii) Preventive maintenance of equipment (viii) Standard Operating Procedures for operation (ix) decommissioning and management of safety and security of radioactive sources.

4.2 Manpower Requirement

The GIC/XIC manufacturer and user institution should have competent professional/staff to ensure safe, effective and smooth operation of the unit. The number of staff members and their qualifications should be in compliance with the requirements prescribed by the relevant authority. In a facility handling a GIC/XIC, the licensee should designate a Radiological Safety Officer (RSO) for the facility with the approval of AERB.

4.2.1. Radiological Safety Officer (RSO)

For each GIC/XIC manufacturer/supplier and user institution, a Radiological Safety Officer (RSO) should be available to ensure compliance with the requirements specified in AERB Safety Code on ‘Radiation Sources, Equipment and Installations’ (AERB/RF/SC, 2025).

The qualifications of the RSO, should be in accordance with requirements prescribed by AERB. The suggested qualifications for the RSO are given in **Appendix-III**.

4.3 Trainees

Before actually using GIC/XIC, the RSO should inform the students about radiation, its benefits and risks, details about the equipment GIC/XIC, safe handling procedures, proper use of survey meters, probable emergency scenarios and response measures, etc. Operation of GIC/XIC should be done under the supervision of RSO. Trainee/students/apprentice below 16 years of age should not be taken for training in radiation related work. Dose limits for trainees and apprentices should be adhered to. In case of trainees/students/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 workers occupationally exposed to radiation.

4.4 Monitoring, Protection and Safety Tools/ Accessories

4.4.1 Personnel Monitoring

The RSO should estimate the dose that is likely to be received by the personnel involved in operation of GIC/XIC based on a radiation survey of the work place or assessment based on design parameters of the equipment, work profile and operating conditions. Based on estimation of the doses by RSO, the Employer/Licensee should provide the Personnel Monitoring service to the workers, in consultation with RSO. The details of the basis for providing personnel monitoring should be recorded. It is the responsibility of the licensee to ensure through periodic assessments that the work patterns of the concerned individuals continue to be in conformity with the assumptions made in the dose estimation. Only chest TLD badges are required to be provided for personnel monitoring. The TLD badges should be provided on a quarterly basis by accredited laboratories.

The licensee should ensure that radiation dose control measures are implemented effectively so as to keep doses as low as reasonably achievable and always within the prescribed dose limits. An assessment of the individual doses or collective dose could

also highlight good or bad working practices, faulty equipment, or the degradation of shielding or engineered safety systems.

The Employer should maintain the dose records which should include information on the general nature of the work involving occupational exposure, information on doses. The radiation workers should have access to his/her personnel monitoring records. TLDs when not in use should be stored in locations where they are not likely to get exposed to radiation other than natural background radiation. Detailed instructions for proper use of TLD are given in AERB website (https://aerb.gov.in/english/aerb-advertisement)

Investigation of Reported Excessive Exposure Cases

In order to ensure that radiation exposure to the workers does not exceed the dose limit, an investigation level of 15 mSv in a given monitoring period (i.e. quarterly for GIC/XIC practice) is recommended.

If the dose recorded by the personnel monitoring badge of the personnel exceeds the level mentioned above, the Licensee in consultation with RSO of the institution should submit an investigation report with a statement from the personnel (reported to be excessively exposed) to AERB. The investigation should focus on the causes of the exposure, and on any failures in standard operating procedures or safety systems. The investigation report should identify any improvements to facilities, equipment or procedures to optimize protection and safety, to reduce the likelihood of a similar event occurring and/or to mitigate the consequences. The investigation report would be reviewed and evaluated by AERB and the genuineness of the dose received by the personnel is decided based on various conditions such as the review of the report submitted, inspection at the site and interview with the individual exposed. In most of the cases, an attempt should be made to reconstruct the situation and assessment of dose is carried out based on the information gathered. In case the reported dose is greater than 100 mSv, biological dosimetry i.e. chromosomal aberration (CA) test of the exposed individual should be conducted if so directed by AERB to determine the genuineness of the dose.

4.4.3 Radiation Monitoring Instrument

Suitable radiation survey meters (RSM) should be available and the same should be maintained in a good working condition with valid calibration.

(i) The employer should ensure that duly calibrated portable radiation survey meters are available and used. The RSM should be appropriate for measuring the type of radiation emitted by the source (i.e. gamma/X rays).

(ii) The functionality of the RSM should be verified every time prior to its use.

(iii) The characteristics of radiation survey meters that may be used under different conditions are listed below:

  (a) Radiation survey meters of low to medium range are suitable for GIC/XIC unit.

  (b) GM/Scintillation detector based radiation survey meter (RSM) is preferable for GIC, whereas, ion chamber based survey meter is suitable for XIC unit. RSM with capability to measure X-rays may also be used.

  (c) Provision for visible and/or audible indication, when radiation levels exceed the maximum reading in any measurement range.

(iv) RSM should be calibrated in an accredited laboratory once in two years or on expiry of validity of calibration, or immediately after any repair, and a certificate of calibration should be obtained.

4.4.4 Measuring Instrument

The manufacturer of GIC/XIC should have proper dosimetric equipment for assessment of radiation output and dose to product during development of initial dose profile inside the sample chamber. Instruments having a valid calibration should be used for the dosimetry and the records of calibration should be maintained. It should be ensured that the instruments are re-calibrated prior to the expiry of the validity of the calibration certificate. The measuring instruments should be subject to period checks to verify the correctness of its measurements.

4.4.5 Handling Tools

The sample chamber of GIC should return automatically to non-irradiation position after irradiation is completed. However, in case of power failure, it does not come to non-irradiation position it would result in over irradiation of products. In such an event the sample chamber should be brought back to the non-irradiation position manually by using tool / hand crank (handle). No other special kinds of handling tools are required for normal operating conditions.

4.4.6 Mobile Shield/L-Bench

Not Applicable

4.5 Operation of Radiation Equipment

The person who operates the GIC/XIC should be familiar with all the safety features of the radiation equipment so as to ensure that the dose received remains as low as reasonably achievable. Prior to the use of the equipment, the licensee and RSO should ensure that necessary arrangements are in place to offer adequate protection to the worker, members of public and to the environment.

4.5.1 Layout of GIC/XIC installation

The layout plan for GIC/XIC should be submitted to AERB for its review from radiation safety view point and it should be ensured that approvals for the layout plan are in place before applying for permission to procure GIC/XIC.

4.5.2 Procurement of GIC/XIC equipment and installation

GIC/XIC should be procured only from authorized suppliers after obtaining the necessary permissions from AERB. The licensee should also ensure that certified trained person on radiation safety / RSO and appropriate radiation survey meters (compatible with type of radiation) are available before the procurement of the GIC/XIC. Further, the GIC/XIC equipment should be installed in the premises for which the institution has already obtained layout approval from radiation safety standpoint.

4.5.3 Licence for operation

No GIC/XIC should be operated for intended purpose without obtaining a licence for operation from AERB from radiation safety standpoint. For obtaining the licence for operation, application should be submitted with all the relevant reports such as radiation survey report, installation report, Radiation protection program and safety assessment report etc. Licence for operation is issued by AERB subject to the institution fulfilling the pre-requisites for obtaining licence. Reports/documents for submission should include particulars relating to availability of adequate qualified manpower, monitoring instruments, personnel monitoring, security plan for radioactive sources and such other documents as may be required at the time of application.

4.6 Source Location and Storage

4.6.1 Premises/Location for Source Handling

GIC/XIC should be used only in the authorized location. If it is required to relocate/transfer the GIC/XIC from one place to another, prior approval should be obtained by the licensee from AERB.

4.6.2 Transfer of GIC/XIC

An employer/licensee should not loan, lease, sell or otherwise transfer the GIC/XIC to another person/institution without obtaining prior permission from AERB.

4.6.3 Safe and Secure Storage

The GIC/XIC room should have proper access control such as lock and key and CCTV arrangement to avoid unauthorised (a) entry to the installation location (b) operation of the GIC/XIC. The facility should have all security provisions such as report, locking arrangement at the door of the room and CCTV (see para 4.6.6).

4.6.4 Emergency Storage Container

GIC units are self-shielded and contain heavy shielding, it is very unlikely that any emergency situation could require transfer of sources to an emergency source container.

However in case of such situations where transfer of source becomes necessary it should be done in a hot cell facility only.

Accident conditions such as fire, may cause damage to the shielding which may lead to elevated radiation levels on the surface of the exposure device. In such cases temporary shielding of suitable material (e.g. steel or a high density material) should be provided over the device. Manufacturer/supplier should have an emergency storage container of adequate capacity to hold maximum activity of the unit as per approved design.

In XIC, X-rays are not produced once the power is cut off hence such an emergency container is not required.

4.6.5 Source Movement within the Facility

GIC/XIC is not a portable device hence movement of source within the facility is not envisaged. However for changing location for installation within the facility shall be with the approval of AERB.

4.6.6 Security of Radioactive Material

As the GIC contains high activity radioactive sources, designated as Category-1 radioactive source, it requires effective physical protection measures to prevent unauthorized access to GIC.

For physical protection measures during use and storage, the requirements mentioned in safety guide viz. 'Security of Radioactive Sources in Radiation Facilities' [AERB/RF-RS/SG-1, (2011)] should be followed. As per this security guide, a security plan (Level-A for GIC sources) should be prepared and implemented at the radiation facility. The security measures during transport of GIC source should be provided in accordance with the safety guide on 'Security of Radioactive Material during Transport' [AERB/NRF-TS/SG-10 (2008)].

XIC does not use the radioactive sources and does not produce X-rays once de-energized hence security requirements are not applicable for XIC.

4.6.7 Source handling in other's Premise/Facility

GIC/XIC is not a portable device, hence it is installed and operated only at authorized location and handling in other's premises is not applicable

4.7 Safety Checks, Quality Assurance and Maintenance

4.7.1 Safety Check

The safety checks as per manufacturer's operational manual should be carried out and records should be maintained. In the event of observing any defect in GIC/XIC, it should not be used till it is repaired and confirmed to be suitable for operations.

4.7.2 Tests for Quality Assurance

Periodic Quality Assurance (QA) should be carried out as per manufacturer's instruction manual. In the event of detecting any defect in the GIC/XIC, it should not be used till it is repaired and confirmed to be suitable for operations.

4.7.3 Dose Rate Profile Verification of GIC/XIC

The initial dose profile inside the sample chamber is provided by manufacturer/supplier during installation of GIC/XIC unit to the user institution. If the licensee desires to verify the dose rate and dose profile of GIC/XIC in their possession, fresh dosimetry may be carried out either with the help of manufacturer/supplier of the GIC/XIC or through national/international standards laboratory or an accredited laboratory by using appropriate dosimetry methods.

4.7.4 Servicing and Maintenance

Servicing and maintenance of GIC/XIC has played an important role in achieving radiation safety. In order to maintain reliability of the GIC/XIC, periodic servicing

should be done throughout the lifetime of the equipment. The periodicity of servicing should be as prescribed by the manufacturer/supplier of the unit. The servicing of the equipment should be done by persons who have been trained by the original equipment manufacturer/supplier. Use of original spare parts and accessories in the unit is important from radiation safety view point. The manufacturer/supplier is responsible for supply of original spare parts and accessories. The accessories and spare parts should meet standards such as International Standards Organization (ISO), Indian Standards (IS), International Electrotechnical Commission (IEC), Conformité Européenne (CE).

Inspection and routine maintenance of unit should be done at intervals as stipulated by manufacturer/supplier. If equipment malfunctions, it should not be used until repaired and revalidated. Components which are used as replacement should meet design specifications of OEM or equivalent.

4.8 Management of Disused Source/Decommissioning of Equipment

4.8.1 Management of Disused Sealed Radioactive Source

Sources used in GIC, after completion of its useful life or when it is no longer required by the user, should be returned along with GIC to the original manufacturer / supplier with prior approval from AERB. There should not be undue delay (i.e. a delay in excess of 12 months) in returning these disused sources. In case of imported sources, the disused sources should be returned to the original supplier/ country of origin.

The licensee should obtain prior approval from AERB for the shipment of the radioactive material for its safe management. The transport/export of disused sources should be in accordance with the national/international transport regulations of radioactive material. It should be ensured by the licensee that the conditions specified by AERB for the safe disposal of the source are duly adhered to. The safe and secure custody of the disused source should be ensured till it is sent back to the supplier/manufacturer.

4.8.2 Disposal of Unsealed Source (Radioactive Waste)

Not Applicable

4.8.3 Decommissioning of Radiation Equipment/Facility

Decommissioning means discontinuation of the use of radiation equipment or installation on a permanent basis, with or without dismantling the equipment. Once the licensee declares that the GIC is of no use to the institution for its intended purpose the licensee should initiate decommissioning of the disused GIC unit and safe disposal of the radioactive sources by returning the GIC to the original supplier, with prior approval of AERB.

The facility where the GIC installation was operated can be released for other purposes only after decommissioning the GIC. The facility (employer/licensee) should not abandon a GIC containing radioactive source(s), even after the recommended working life is over. Such abandonment is a violation of the Atomic Energy Radiation Protection Rules, 2004, and would attract penal action.

When the XIC is no longer in use, the facility should decommission the XIC as per procedures laid down and with the approval of AERB. Decommissioning of XIC should be done such that the equipment can no longer be re-energized.

In case of XIC the unit should be dismantled/decommissioned following the supplier instruction ensuring that all components such as X-ray tube, the shielding material in the X-ray tube housing, electrical waste should be disposed-off in accordance with the procedure prescribed by the relevant authorities. It should also be ensured that before disposal radiation warning/caution symbol is defaced/removed.

4.8.4 Provision for Disposal / Decommissioning

The employer should make necessary financial arrangement for the decommissioning of the GIC sources once it has been decided to take them out of use. In order to provide against the unlikely event of bankruptcy or other constraints including any potential cost escalation, appropriate financial provision should be made by the facility to meet the cost of disposal of the radiation source. The financial provisions should include the cost of preparation of package, transport cost and charge for disposal of radiation source. The

Licensee / employer should at the time of procurement of the source, make necessary legal provisions / agreement with the manufacturer / supplier so that disused source(s) would be returned to the original supplier / country of origin.

4.9 Safe Transport of Radioactive Material

GIC sources should be transported only with prior approval of AERB and in accordance with the provisions of national/international Transport Regulations. The consignor should be responsible for safe and secure transport till the consignment is received by the consignee. In addition, permission for carriage as per applicable laws, should be obtained from relevant competent authority.

4.9.1 Safety Requirements for Transport of Radioactive Material

The primary responsibility in achieving safety and security during the transport of GIC lies with the consignor/Licensee of the institution, as applicable. The security aspects during transport of radioactive material are covered in AERB Safety Code on 'Safe Transport of Radioactive Material' [AERB-NRF-TS/SC-1 (Rev.1), 2016] and AERB safety guide on 'Security of Radioactive Material During Transport' [AERB/NRF-TS/SG-10, 2008] (for proper sequencing). Transport of GIC sources should be made in compliance with the requirements as specified in the Code.

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 facility and the supplier should ensure that a reliable transport agency is engaged for transport of source contained in the GIC.

5. MEDICAL EXPOSURE (Not Applicable)

The chapter on ‘Medical Exposure’ is kept intentionally blank since the same is not applicable to ‘Gamma and X-ray Irradiation Chamber’

6. HANDLING INCIDENTS/ EMERGENCY SITUATION

6.1 General

The emergency is a non-routine situation that necessitates prompt action, primarily to mitigate a hazard or adverse consequences for human health and environmental safety. Being the custodian of the radiation sources, the responsibility for handling the radiation emergency, mitigating consequences and making preventive measures to avoid any recurrence of such situation rests with the employer/licensee. Radiation sources used for GIC are always in shielded position. Though the probability of radiation emergency situations arising from GIC is very low, it is required to have an emergency preparedness and response plan for effectively dealing with such a situation.

6.2 Emergency Preparedness for Response

Licensee should prepare emergency preparedness and response (EPR) plan, as per Rule 33 of Atomic Energy (Radiation Protection) Rules, 2004, in consultation with RSO. The plan should be prepared envisaging various emergency scenarios/situations that may be encountered. A set of clear and concise written procedure should be developed and implemented to handle the emergency.

EPR plan should include indications of emergency situations requiring prompt action, communication with responsible persons and local response agencies which includes the name(s) and telephone number(s) of the person(s) to be notified, specific actions to be taken immediately for mitigating the consequences due to radiological emergency and to minimize exposure of persons in the vicinity of the GIC. The procedure should also list the contact details of important persons from outside agencies like, police, fire brigade, nearest hospital, AERB and DAE-ECR.

The EPR plan should include the followings:

(a) instructions on the immediate actions that need to be taken to protect workers, members of the public and the environment;

(b) instructions to employees who notices an incident should immediately report to RSO and the licensee;

(c) Instructions to cordon off an area as applicable around the source(s);

(d) implementation of any further action required to bring the incident under control;

(e) assessment as to whether any physical damage has occurred to the GIC/XIC;

A typical template for emergency preparedness and response plan is given in **Annexure-5.**

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 minimum.

During the emergency involving GIC, following should be done:

i. cordon-off the area, in case of external emergency situation.

ii. provide medical attention as priority, in case of injury to any individual.

iii. comply with the directions of AERB, which may be issued to ensure safety including immediate shutting down of the radiation installation.

For XIC the emergency procedures are different from those of GIC, as in most of the cases response to emergency in XIC is to use emergency stop switches/turn off power supply. Any unusual occurrences that may possibly lead to an unsafe condition should be noted and remedying action taken.

6.3.1 Display of Emergency Procedures

Instructions should be provided to follow approved emergency procedures during an emergency which has caused or may cause a radiation hazard to any person and the environment.

The procedures laid down for this purpose should be displayed in the GIC room. The name(s) and contact details of responsible personnel such as Employer/ Licensee, RSO, Security personnel of GIC institution, to be contacted in case of emergency should be displayed in GIC room of the facility. In addition, the contact details of important persons from outside agencies like, local Law Enforcement Authority (police), fire brigade, nearest hospital, source/Equipment supplier, AERB and Crisis Management Group (CMG), DAE should also be listed in the procedures.

6.3.2 Reporting of Radiation Emergency

After safe management of the emergency, a report should be prepared which should include a critical review of how well the procedures were implemented and what lessons can be learned to prevent similar emergencies and off-normal incidents in future and how response plans can be improved.

RSO should:

a. report to employer/licensee immediately on any emergency situation, initiate necessary remedial actions,
b. carry out investigation on causes of the emergency situation

Licensee/employer should:

a. report to AERB and CMG, DAE regarding the incident within 24 hours of its occurrence including date and time of occurrence and brief description of the incident, source, activity, action initiated, proposed measures, any support required, etc.
b. lodge a written complaint with the police in case of loss or theft of the radioactive sources and if not traceable within 24 hours.
c. submit to AERB a brief report within 5 days including status of the source and action taken etc. and weekly (or more frequently as directed by AERB) update till termination of emergency. Further, a complete detailed report of the incident including the preventive measures taken to avoid recurrence of such incidents should be submitted to AERB within 30 days of termination of emergency.

This report should include:

i. date and time of occurrence,
ii. detailed description of the incident,
iii. action taken,
iv. critical review to identify the causes of the incident,
v. personnel radiation exposure, if any,
vi. lessons learned to prevent similar incidents and accidents in the future; and
vii. improvement in the emergency plan and preparedness, if any.

7. PUBLIC SAFETY

7.1 General

GIC/XIC installations are located in research laboratories of the institution where access to general public is very limited. However, GIC/XIC installations in blood banks or hospitals, may be frequented by general public. Safety of the public is ensured by appropriate shielding of the unit and proper operational controls. AERB has prescribed dose limits for members of the public which is given in **Appendix-1**. To ensure public safety, the design and operation of the facility should be such that radiation exposure to the members of the public is kept at a minimum and well within the prescribed limits. The prime responsibility for safety always lies with the Employer/Licensee. It is the responsibility of the employer to ensure the public safety from the exposure resulting from GIC/XIC practice.

7.2 Measures for Public Safety

The Licensee, in consultation with RSO, should establish, implement and maintain radiation protection program for ensuring safety of the general public. In GIC/XIC safety of general public may be achieved by built-in-safety in designing of the unit, access control to installation location during operation.

During the design of the GIC/XIC facility, the places that will be occupied by the public should be taken in to account to ensure that due to operation of the facility, the annual dose limits are with the limits specified by AERB. It is also important to ensure that provisions of access control to avoid or restrict the approach of public near the GIC/XIC unit.

Public exposure is controlled by

(i) Proper design of GIC/XIC installation room by considering the presence of members of the public (non-occupational workers).

(ii) Restricting unauthorized access, through display of radiation symbol/warning signs on the entrance of GIC/XIC room.

(iii) Providing security arrangements for GIC so that unauthorized access is prevented

(iv) Periodic Radiological protection survey of the GIC/XIC installation. Safe management of Radiation equipment/radioactive sources at the end of their useful life/when they are no longer in use. Safe transportation of the radioactive sources meeting the national and international regulatory requirements.

7.3 Protection of Foetus and Breastfed Infants

The foetus of a female radiation worker is considered as member of the public for radiation protection purposes. Thus, the procedures should be incorporated in such a manner as to ensure that the dose to the foetus is within the prescribed limits. A female worker, on becoming aware that she is pregnant, should notify the employer, licensee and RSO so that her working conditions may be modified suitably, to ensure that the dose to the foetus is well within the dose limit prescribed for general public.

There is no additional requirement for lactating radiation worker as there is no internal contamination in GIC/XIC practice.

Appendix-I: The Dose Limits for Exposures from Ionising Radiations for Workers and the Members of the Public

(AERB Directive No. 01/2011)

[Under Rule 15 of the Atomic Energy (Radiation Protection) Rules 2004]

(Ref. No. CH/AERB/ITSD/125/2011/1507 dated April 27, 2011)

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

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 should be used for all prescribed dose limits.

Occupational Dose Limits

Occupational Workers

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

- an effective dose of 20 mSv/year 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/foetus should 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 should 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 should 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: The 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 should conform to the specifications given hereunder:

- The relative dimensions of the trefoils and the central circle should be as shown in Fig.1.
- The trefoils and the circle should be of magenta colour.
- The background of the above symbol should 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 should have a warning sign as illustrated in Fig. 2 and the warning sign should conform to the specifications given hereunder:

- The triangle should be equilateral.
- The ratio of the outer to the inner sides of the triangle should be 1.5.
- The area between the outer and inner triangle should be in yellow colour on white background.
- The printing on the area between the outer and inner triangle and figure inside the inner triangle should 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.

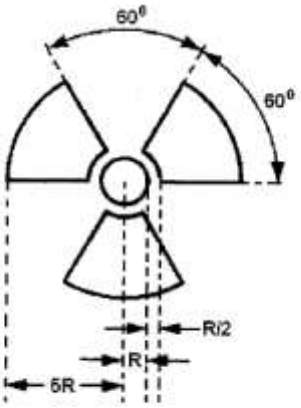

Fig. 1.
Radiation Symbol for Radioactive Sources

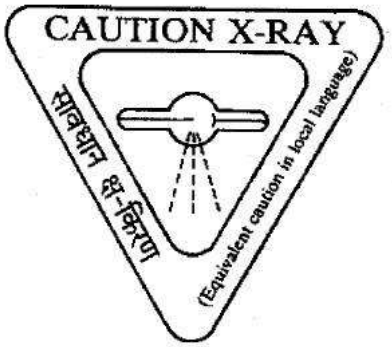

Fig. 2.
Radiation Symbol and Warning Sign for Radiation Generating Equipments

The X-ray symbol should be displayed on the cabinet/outer enclosure of X-ray generator also at entrances to the installation room in accordance with regulatory requirements.

Appendix-III: Minimum Qualification, Training and Adequacy for Personnel

Radiological Safety Officer (RSO):

The qualifications of the RSO are as follows:

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

or;

Diploma in Engineering from a recognized University/Institution;

and

(ii) Successful completion of Radiation Safety Certification i.e. 'RSO Certification for Gamma/X-ray Irradiation Chamber' from AERB recognized agency.

(ii) Adequacy of Personnel:

(a) Each GIC/XIC institution / plant should have a Radiological Safety Officer.

(b) Each manufacturer / supplier of GIC/XIC should have a trained & certified person on radiation safety aspects in Gamma/X-ray Irradiation Chamber (eligible to be designated as RSO).

Appendix-IV: Responsibilities

[This Annexure will be moved to Safety Guide AERB/RF/SG/G-3 on its revision]

2.1 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 GIC/XIC are provided.

2.2 Responsibilities of Licensee (Employer)

The person responsible for any facility or activity that gives rise to radiation risks should have the prime responsibility for safety. The prime responsibility of ensuring radiation safety in handling GIC/XIC 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 rules made thereunder, and stipulated requirements in regulatory documents/ conditions referred to or contained in the licences or Safety Directives/orders from AERB or otherwise applicable;

(b) designate, with the approval of AERB, a person having qualifications as specified in this guide, as Radiological Safety Officer (RSO).

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

(d) 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;

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

(f) 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;

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

(f) arrange for personnel monitoring of radiation workers, proper implementation and

also to maintain the individual dose records as prescribed by AERB;

(g) 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;

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

(i) 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;

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

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

(l) 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;

(m) 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;

(n) 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;

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

(p) 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;

(q) 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;

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

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

(t) make financial arrangement for disposal of disused sources;

(u) ensure that samples which are irradiated in GIC/XIC would not result in hazardous situations such as fire, explosion and corrosion to arise inside the chamber;

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

(w) ensure that Standard operating procedures (SOP) are developed and implemented during operation of GIC/XIC unit. This SOP should include specific Dos and Don'ts;

(x) ensure that no person is permitted to operate the GIC/XIC unit unless he/she has been adequately trained and is competent to operate the unit in accordance with the safety procedures;
(y) carry out physical verification of GIC periodically and maintain inventory;
(z) inform appropriate law enforcement agency in the locality, employer and AERB in case of any loss of source;
(aa) in case of permanent termination of the use of unit with radioactive source/radiation generator due to any reason, should decommission the unit and return the source to the supplier with prior permission of AERB;
(bb) should keep the documents/history of GIC/XIC in safe custody;
(cc) should obtain prior permission of AERB in case of transfer of ownership of GIC/XIC unit;
(dd) obtain prior approval from AERB for any modifications in location of installation; and
(ee) should identify the individuals for operation of GIC/XIC.

2.3 Responsibilities of Radiological Safety Officer

The role and responsibilities of RSO are elaborated as below:

The Radiological Safety Officer should:

(a) ensure that the provisions of Atomic Energy (Radiation Protection) Rules, 2004, are implemented;
(b) advice and assist the employer and 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 room where unit is installed and at appropriate location;
(d) implement continuous display of the radiation symbol, warning, marking and labelling on the unit;
(e) establish and maintain an effective radiation protection programme to ensure safety of workers, members of the public and the environment;
(f) train the users and associated servicing /maintenance personnel on basic radiation safety, hazard potential and biological effects of radiation;
(g) instruct all users on relevant safety measures, provide adequate training in radiation protection and safety methodologies, use of personnel monitoring devices (e.g. TLD badges);
(h) ensure that personnel monitoring devices are provided to radiation workers in the facility, as applicable, used as required and are securely stored in radiation-free zone;
(i) ensure that radiation monitoring instruments are kept in proper working condition and are periodically calibrated;
(j) assist the licensee in developing suitable emergency response plans to deal with emergencies and ensuring appropriate emergency preparedness;

(k) conduct periodic radiation protection surveys and maintain records;
(l) maintain inventory of sources including initial and present activity, operational logbook and associated QA records;
(m) furnish to the licensee and AERB periodic reports on safety status of the unit;
(n) investigate any situation that could lead to potential exposures and submit report to AERB;
(o) advice employer on physical security measures;
(p) maintain personnel monitoring records, analyze personnel exposure records to ensure that there are no abnormal exposure trends;
(q) prepare the standard operating procedures (SOP) in-line with the instruction manual provided by manufacturer/supplier of the unit;
(r) ensure periodic servicing and preventive maintenance of the unit as prescribed by manufacturer/supplier and maintain records;
(s) ensure safe work practices during source replenishment and safe disposal of disused sources;
(t) report on all hazardous situations along with details of any immediate remedial actions taken and are made available to the employer and licensee for reporting to the Competent Authority;
(u) advice the licensee on the modification in the working condition of female worker after her notification about pregnancy; and
(v) inform the competent authority when he/she leaves the employment.

2.4 Responsibilities of Workers

Worker 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 envisages 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 of GIC/XIC should:

(a) be familiar with the basic design, operation and preventive maintenance of the GIC/XIC including procedures for routine operation and handling emergency situations;
(b) operate the GIC/XIC unit as per the standard operating procedures (SOP) prepared by RSO from detailed instruction manual provided by manufacturer/supplier of the GIC/XIC unit;
(c) follow all applicable rules and regulations for safe operation of unit;
(d) ensure proper handling and placement of the sample/product inside the sample chamber based on the dose profile inside the sample chamber;
(e) maintain the logbook in respect of use and operation of the unit including personnel details and of samples/objects under irradiation, dose rate, dose delivered and time of irradiation;
(f) make proper use of protective equipment, radiation monitors and personnel monitoring devices as provided;
(g) report to RSO/licensee of any issues related to safe operation of the GIC/XIC unit,

including the circumstances that could adversely affect safe operation of the unit;

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

2.5 Responsibilities of Manufacturer and Supplier

The responsibilities mentioned below are in addition to the responsibilities mentioned in 2.2:

The manufacturer/supplier should:

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

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

(c) provide to the user instruction manual for safe operation, periodic inspection, servicing, preventive maintenance including general description of the unit and detailed operating instructions and procedures;

(d) provide information to the user in respect of make, model, serial number. of the unit, details of radiation sources & activity as on date, leak test certificate of sealed source, dose rate & dose profile inside irradiation chamber and dosimetry report;

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

(f) ensure the availability of essential spare parts of the unit for its useful life;

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

(h) assure the supply of radiation sources/generator as applicable in GIC / XIC unit, when requested by user, in compliance with regulatory procedures;

(i) provide safety accessories, as required to the user for the normal operation of the GIC/XIC unit and for handling emergency situations;

(j) provide written instructions to the user specifying procedures to be followed in an emergency situation that has caused or may cause a radiation hazard to any individual; (connected with and in the next item)

(k) undertake the responsibility for providing technical support in disposal of disused sources/X-ray tube and decommissioning of the unit; and

(l) take back the disused sources supplied by them for disposal.

Annexure-1: Installation of Gamma/X-Ray Irradiation Chamber

The design for the location of GIC/XIC, Category–I, should meet the following requirements:

GIC/XIC Room

It should be located inside an exclusive room having provisions of lock and key arrangement for preventing access of unauthorized entry. Since GIC unit is Category- I irradiator, there is no need for providing additional shielding for its installation. However it is preferable to have room with normal brick wall construction from safety and security viewpoint.

The GIC/XIC room should have following features:

(i) It should be preferably located on ground floor for ease of installation.
(ii) Approximate room size - 3.5 meters x 3.5 meter x 3.5 meter height.
(iii) Door size – Adequate for taking the unit (assembled) inside the room.
(iv) Floor loading capacity – as per the weight and base size of the unit(Ground floor or basement preferred)

Other requirements: Proper electrical power points as per the specification of the unit, window air conditioner / ventilation provisions, pit in the floor (if the unit has this requirement).
Restricted area should be constructed in consultation with manufacture / supply with the approval of AERB.

Installation Requirements

GIC/XIC unit is generally transported in almost assembled condition to the site by means of a truck. The unit therefore needs to be unloaded from the truck using proper material handling equipment and then taken to the exact site in the building/room for further installation and commissioning.
In view of the above, a typical requirement needed for the installation and commissioning is given below:

(i) Material handling Equipment:

A mobile crane of suitable capacity or a chain pulley block & tripod stand unit (for unloading from the truck) and a Fork lift / Pallet truck and steel rollers (for shifting to the exact site) along with skilled manpower/riggers for handling heavy weight of the GIC/XIC unit at the time of installation - depending upon the need at the site.

(ii) Platform:

A temporary platform / structure (made of concrete or steel) of required capacity and size at the floor level of the room / building for the convenience of unloading the unit from the truck and then shifting / rolling up to the exact location.

(iii) Technical Manpower for operation & maintenance:

At least one or two persons with electrical / mechanical engineering background from the user's institution, who would be subsequently associated with safe operation and preventive maintenance of the unit.

Annexure-2: Shielding Integrity (Radiometry) Test

Shielding integrity tests are very important because a void or low-density region will create a "hot spot" or elevated radiation region on the cask surface when in use. The shielding, as appropriate, should be tested for integrity. Before the initial use of the source container for transportation of radioactive source, the integrity of the shielding of the container/cask should be demonstrated. The container should be loaded with the type of radioactive source for which it is designed (or an equivalent), and the entire outer surface should be surveyed for ascertaining that the leakage radiation levels are within the permissible limits.
The shielding integrity should also be checked in case of XIC by operating the unit at maximum operating potential and current.

Gamma Scanning and Probing:

This test is a part of QA programme and often specified to increase the probability that the container will comply with the prescribed radiation leakage requirements when it is loaded with the radioactive material to be transported. When the test is included in the contract, the manufacturer should prepare a gamma scanning procedure, which should include following information:

i. Electronic equipment
ii. Radiation source and activity/strength
iii. Calibration standards for both scanning and probing
iv. Grid pattern
v. Type of radiation detector with its desired sensitivity
vi. Positioning equipment
vii. Method of reading and recording the radiation levels observed
viii. Measuring technique Acceptance requirements.

The manufacturer should ensure the shielding integrity/radiometry of GIC/XIC. The results of radiometry should be recorded.

Annexure-3: A Sample Quality Assurance Programme for Manufacturer of GIC

An effective Quality Assurance (QA) Program should be followed during the manufacturing process of GIC to ensure that a good quality product as per the drawings and specifications delivered for the safe operation and handling by the users.

The following QA aspects should be adhered to during manufacturing duly observing applicable industrial safety standards:

(i) It is to be ensured that all materials used for fabrication comply with the standards and specifications, are properly marked and correlated with the test reports or supported by test certificates from accredited laboratories. Copies of all approved test reports and certificates are to be documented.

(ii) Bought out components are inspected and approved /certified by the manufacturer and its compliance certificate is submitted.

(iii) All the welding and their NDT tests should comply with requirements of ASME Boiler and Pressure Vessel Code, Section IX.

(iv) Radiographic Tests (RT) of welding is carried out as specified in individual drawing as per the acceptance criteria in Section - V of ASME Boiler and Pressure Vessel Code.

(v) Inspection/verifications of dimensions and alignment of sub-assembly/ assembly should be carried out at various stages of fabrication, including tests like hydrostatic pressure and lead filling etc.

(vi) The fabricator should prepare a detailed lead pouring procedure with approval of manufacturer. Lead pouring should be done in a single, continuous operation ensuing that no high, local/ streaming radiation (hot spots) observed at the outer surface of the container.

(vii) Ascertain the integrity of casted lead by radiometric test by using suitable radioactive source.

(viii) Documentation and maintenance of records pertaining to various stages of fabrication and testing of the unit.

Annexure-4: List of Parameters to be checked during Type Approval Testing

S. No.	Name of Parameters	Results
1.	Model name of the X-ray/Gamma Irradiation Chamber	
2.	Make of X-ray/Gamma Irradiation Chamber	
3.	S. No. of X-ray/Gamma Irradiation Chamber	
4.	Manufacturer of the X-ray/Gamma Irradiation Chamber	
5.	Indian supplier of the X-ray/Gamma Irradiation Chamber	
6.	No. of X-ray tubes and its orientation with respect to the sample chamber/canister	
7.	Rating of X-ray tubes (max kV and max mA)	
8.	Maximum throughput X-ray/Gamma Irradiation Chamber	
9.	Estimated number of Bags per cycle X-ray/Gamma Irradiation Chamber	
10.	Product Irradiation time set per cycle X-ray/Gamma Irradiation Chamber	
11.	Central dose and central dose rate specified X-ray/ Gamma Irradiation Chamber	
12.	Dose Uniformity Ratio X-ray/Gamma Irradiation Chamber	
13.	Products Irradiated X-ray/ Gamma Irradiation Chamber	
14.	Canister details X-ray/ Gamma Irradiation Chamber	
15.	Useful Life of the X-ray/Gamma Irradiation Chamber	
16.	Availability of indicator to check the set irradiation time for irradiation cycle for X-ray/Gamma Irradiation Chamber	
17.	Provision of UPS with sufficient back up time to ensure the completion of irradiation cycle without interruption in case of power failure.	
18.	Central dose measured for the complete irradiation cycle using ion chamber positioned horizontally at different positions (Top, Middle and Bottom) of the solid phantom made of tissue equivalent material.	
19.	Peripheral dose measured using ion chambers positioned at	

	the periphery of the phantom.	
20.	Measurement data of kV, mA and central dose rate at the site (if possible) for the prescribed central dose.	
21.	Report on the measurement of kV , mA and central dose rate from the original manufacturer for the prescribed central dose	
22.	Availability of interlock (with fault indicator on the control panel) to ensure the operational availability of X-ray tubes to start the Irradiation cycle	
23.	Availability of interlock (with fault indicator on the control panel) to align the Irradiation program with the position of canister loading tray for X-ray/Gamma Irradiation Chamber	
24.	Radiation survey data around the machine in operation mode excluding the background for X-ray/Gamma Irradiation Chamber	
25.	Central dose measurement data collected for a period of 15 days to ensure consistency of the central dose delivered at the prescribed parameters of irradiation time, kV and mA for X-ray Irradiation Chamber	
26.	Availability of Cooling arrangement for the machine	
27.	Availability of emergency stop buttons on the control panel X-ray/Gamma Irradiation Chamber.	
28.	Availability of periodic QA programme prescribed by the original manufacturer for X-ray/Gamma Irradiation Chamber.	
29.	Availability of proper dosimetry system for X-ray/Gamma Irradiation Chamber	
30.	Availability of approval certificate in the case of imported equipment for X-ray/Gamma Irradiation Chamber	

Annexure-5: Measures to avoid Excessive Exposure cases

The following are some of the measures that should be implemented by the institutions to avoid excessive exposure cases:

(i) Standard operating procedure of GIC/XIC handling should be implemented during its use.

(ii) Awareness on proper use of Personnel Monitoring badge by the user should be provided by the RSO.

(iii) Servicing, repair or maintenance should be carried out by authorized/certified persons and under the surveillance of RSO.

(iv) Storage of personnel monitoring badge in an area with ambient background radiation level should be ensured by the RSO.

(v) Working and calibrated radiation monitoring instruments should be used.

Annexure-6: Template for Emergency Preparedness and Response Plan

Introduction

The action plans prescribed should be implemented in the event of occurrence of an emergency involving a Gamma Irradiation Chamber (GIC). The criteria for declaring and for terminating an emergency as stipulated in this Annexure should be adhered to. In case of any doubt, Licensee of the institution, Shri/Smt ……., (Designation, Affiliation) or RSO Shri ……., (Designation, Affiliation) should be contacted.

Emergency Situations

The following emergency scenario/situations may occur during transportation, installation, routine operation and decommissioning of GIC unit (as applicable).

(i) Loss or Theft of GIC unit containing radioactive material during transport
(ii) Damage to the GIC unit during transport
(iii) Fire incident, explosion or natural disaster at GIC installation location

Anyone noticing any of the above instances should immediately bring the matter to the notice of Licensee Shri ……., (Designation, Affiliation) or RSO of the facility Shri ……., (Designation, Affiliation).

Action plans that should be implemented for various emergency scenarios are as follows:

1. **Emergency Scenario:** Loss or Theft of GIC unit containing radioactive material during transport

Action Plan

Carrier:

a) Immediately inform Consignor and Crisis Management Group (CMG), DAE, about the incident
b) Follow the instruction stipulated in emergency preparedness procedures sheet and TREM CARD
c) Inform the nearest police station about the incident and seek help.

Consignor:

i. Upon receipt of information about an incident from transporter involving the GIC.
ii. The intimation should be sent immediately to Crisis Management Group (CMG), DAE and RSD, AERB
iii. Immediately establish contact with nearest police station and seek their help by sensitizing them regarding the seriousness of the incident in view of involvement of loss of radioactive material consignment
iv. Responsible officer from manufacturer and/or user institution should be deputed to

the location of the incident with emergency accessories (e.g. sensitive survey meter, direct reading pocket dosimeter, TLD etc.) to trace the consignment

v. In case, the consignment is not traceable,
   a. continue the efforts for locating the consignment
   b. inform all the concerned authorities and get updates regularly till consignment is located
   c. make public aware through media/news channels etc. in consultation with AERB, about the loss of radioactive material and its consequences if the lost consignment is damaged while lying in public domain.
   d. Also urge the public to immediately report to the nearest police station about such consignment if they come across.

vi. In case, the consignment is located,
   a. cordon off an area around the GIC unit;
   b. assess the extent of damage in terms of physical integrity and radiation leakage that has occurred to the GIC
   c. decision for its further transportation to manufacturers place or users place should be based on the assessment of severity of the damage.
   d. in case of significant damage to GIC and observation of excessive radiation level, adequate additional shielding should be provided for further transportation of GIC to manufacturer place for rectification and necessary action.
   e. Upon controlling of the emergency situation, intimate all the concerned authorities and recommend termination of the emergency

2. Emergency Scenario: Damage to the GIC unit during transport

Action Plan

Carrier:

a) Immediately inform the consigner and consignee
b) Cordon off an area within a radius around the unit
c) Inform to the nearest police station for help

Manufacturer/User institution

i. Upon receipt of information about a transport accident from transporter involving the GIC, the consigner should inform AERB; manufacturer and Employer/Licensee
ii. The intimation should be sent immediately to Crisis Management Group (CMG), DAE
iii. Responsible officer from manufacturer and/or user institution should be deputed to the site of accident with emergency accessories (e.g. survey meter, TLD etc.) to assess the extent of damage in terms of physical and radiation leakage occurred to the GIC consignment
iv. The decision for its further transportation to manufacturers place or users place should be based on the assessment of severity of the damage.
v. In case of significant damage to GIC and observation of excessive radiation level, adequate additional shielding should be provided for further

transportation of GIC to manufacturer's place for rectification and necessary action.

vi. Upon controlling the emergency situation, intimate Consigner, Consignee and AERB

3. **Emergency Scenario:** Fire incident, explosion or natural disaster at GIC installation location

Action Plan

Licensee/RSO should

i. In case of fire or explosion contact the fire department for help.
ii. As GIC is housed with a radioactive material, there is a possibility of loss of shielding integrity during fire or natural calamity (collapse of GIC room due to earthquake), may cause higher radiation levels around GIC, RSO should provide guidance to fire fighters about the safe handling of the fire incident
iii. After fire is controlled measure the radiation levels to verify the shielding loss. On confirmation of the same provide temporary additional shielding to reduce the radiation levels to permissible limit.
iv. check for radiation contamination, if any
v. In case of loss of shielding integrity during natural calamity (collapse of GIC room due to earthquake), may cause higher radiation levels around GIC. RSO should provide guidance to workers involved in debris removal.
vi. Inform the manufacturer/supplier and AERB for further course of action
vii. Investigate personnel exposure, if any, to the radiation workers involved in the remedial action.

Fire officer

i. Rescue the injured, if any
ii. Fight fire, keeping in mind the advice of the RSO

Medical Officer

If any person is injured or undergoes trauma, provide the necessary medical attention.

Manufacturer/Supplier

i. On receipt of information, responsible officer from manufacturer should be contacted to assess the extent of damage in terms of physical and radiation leakage occurred due to the fire accident.
ii. Repair of GIC for re-use or decommissioning can be taken up by the licensee/employer based on the assessment of the damage with prior approval from AERB

Table: Persons to be contacted in the Event of an Emergency

Name of Persons	Designation	Mobile number	Address		Telephone No	
			Office	Residence	Office	Residence
Employer						
Licensee						
RSO						
Security Officer						
Fire Brigade						
Local Police						
Local Hospital						
Manufacturer/Supplier						
AERB						
CMG, DAE						

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LIST OF PARTICIPANTS

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

Members in-house Working Group:

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Smt. Mahalakshmi, RSD, AERB	Member
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Shri J.V. K Sunil kumar, DRI	Member
Shri Pradip Kumar, DRI, AERB	Member
Shri Ashish Ramteke, RSD, AERB	Member
Shri Rajoo Kumar, RDS, RDD, AERB	Member-Secretary
Dr. P.K. Dash Sharma, Head, RSD, AERB	Co-opted

TASK FORCE

Dates of meeting: Reviewed through electronic communications, one meeting held on March 25, 2021

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Shri R.K.B.Yadav, RSSD, BARC	Member
Shri Rajoo Kumar, RDS, RDD, AERB	Member
Dr. Alok Pandey, RSD, AERB	Member
Shri Neeraj Dixit, RSD, AERB	Member-Secretary
Shri Pravin J. Patil, RDD, AERB	Member-Secretary
Shri Ganesh Bokam, IAS, RSD, AERB	Nodal Officer
Shri Meghraj Singh, IAS, RSD, AERB	Invitee

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Dates of meeting: August 16, 2022, September 15, 2023

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Dr. N. Ramamoorthy, Former CE, BRIT & AD, BARC	-	Member
Dr. A. N. Nandakumar, Former Head, RSD, AERB	-	Member
Shri Rajoo Kumar, RDD, AERB	-	Member-Secretary
Shri Ganesh Bokam, RASD	-	Co-opted
Dr. P.K. Dash Sharma, Head, RASD	-	Invitee
Shri R. K. Singh, RASD	-	Invitee
Shri Neeraj Dixit, RASD	-	Invitee

Advisory Committee on Nuclear and Radiation Safety (ACNRS)

Dates of Meeting: December 3, 2022, December 19, 2023, February 23, 2024

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Shri D.K.Shukla, Former Chairman, SARCOP, AERB	-	Member
Dr. M.R.Iyer, Former Head, RSSD, BARC	-	Member
Prof. C.V.R.Murty, Dept. of Civil Engg, IIT, Chennai	-	Member
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