STANDARD NO. AERB/RF-IRRAD/SS-6 (Rev-1)

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GOVERNMENT OF INDIA

AERB SAFETY STANDARD

LAND BASED STATIONARY GAMMA IRRADIATORS

ATOMIC ENERGY REGULATORY BOARD

AERB SAFETY STANDARD NO. AERB/RF-IRRAD/SS-6 (Rev-1)

LAND BASED STATIONARY GAMMA IRRADIATORS

Atomic Energy Regulatory Board
Mumbai-400 094
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Orders for this Standard should be addressed to:

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FOREWORD

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

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

Radiation processing technology using gamma ray sources is used on a commercial scale for sterilisation of medical products, preservation of food, vulcanization of rubber etc. Many new applications of this technology are being investigated. This technology involves the use of high intensity gamma ray emitting radioisotopes such as ^{60}Co to deliver a predetermined dose to a specific target under process conditions with access control systems to the irradiation cell. Widespread utilisation of ionising radiation for multifarious applications in medicine, industry, agriculture, research etc. has brought in its wake the need for exercising regulatory controls to ensure safety of users, members of public and the environment. The deployment of the intense gamma ray sources in the irradiators has a potential for radiation hazard for the plant personnel, public and environment in the event of any malfunction or failure of the safety systems. Therefore, the safety systems shall be designed to ensure their continued availability under all conditions to perform the intended function.

In view of the fact that regulatory standards and requirements, techniques of radiation safety engineering and type of equipment change with time, it becomes necessary to review and revise codes and standards from time to time to incorporate these changes. The first AERB Standard (Specification) titled ‘Radiological Safety for the Design and

Construction of Land-based Gamma Irradiators', AERB/SS-6 issued in 1993 has been useful to the manufacturers of land-based gamma irradiators. Although this Standard covered all the relevant requirements of design, tests for equipment, and installation procedures, further improvements in built-in safety, quality assurance during construction and safety in operation have been incorporated in this revision. The revised Standard, is effective from the date of issue and replaces the earlier Standard AERB/SS-6 of 1993.

Consistent with the accepted practice, 'shall' and 'should' are used in the standard to distinguish between a firm requirement and a desirable option respectively. Appendices are an integral part of the document, whereas bibliography and list of participants are included to provide further information on the subject that might be helpful to the user.

For aspects not covered in this standard, national and international standards and codes applicable and acceptable to Atomic Energy Regulatory Board (AERB) should be followed. Non-radiological aspects, such as industrial safety and environmental protection, are not explicitly considered. Industrial safety is to be ensured through compliance with the applicable provisions of the Factories Act, 1948 and the Atomic Energy (Factories) Rules, 1996 for the facilities belonging to Department of Atomic Energy.

Specialists in the field drawn from the Atomic Energy Regulatory Board, the Bhabha Atomic Research Centre and other consultants have prepared this guide. It has been reviewed by experts and the Standing Committee on Review of Radiation Safety Documents (SCRSD) and Advisory Committee on Radiological Safety (ACRS).

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

(S.K. Sharma)
Chairman, AERB

DEFINITIONS

Competent Authority

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

Construction

The process of manufacturing, testing and assembling the components of a nuclear or radiation facility, the erection of civil works and structures, the installation of components and equipment and the performance of associated tests.

Defence-in-Depth

Provision for multiple levels of protection for ensuring safety of the workers, the public and the environment.

Fail Safe Design

A concept in which, if a system or a component fails, then the plant/component/system will pass into a safe state without the requirement to initiate any operator action.

Fire Detector

Devices designed to automatically detect and indicate the presence of fire.

Irradiators

A facility that houses a particle accelerator, X-ray machine or large radioactive sources for imparting high radiation dose to materials.

Potential Exposure

Exposure that is not expected to be delivered with certainty but that may result from an accident at a source or owing to an event or sequence of events of a probabilistic nature, including equipment failures and operating errors.

Protective Barrier or Shielding (Radiation)

A barrier of appropriate thickness used to reduce radiation levels to specified values.

Quality Assurance

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

Responsible Organisation

The organisation having overall responsibility for siting, design, construction, commissioning, operation and decommissioning of a facility.

Sealed Source

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

CONTENTS

1. INTRODUCTION

1.1 General

Land-based stationary gamma irradiators (referred as irradiators in this standard) are used for preservation of food, vulcanisation of rubber, sterilisation of medical products, hygienisation of sewage sludge and many other applications involving the use of gamma irradiation. Radioactive material used in the irradiator is generally ^{60}Co. The amount of radioactivity in a large irradiator is typically about 10^{15}-10^{17} Bq. Due to very high activity, gamma irradiators produce large dose rates during irradiation. A person accidentally present in the irradiation cell with source in exposed condition can receive a lethal dose within minutes or seconds. In view of the severity of consequences that may arise from their malfunction leading to accidental situations, such irradiators shall be designed to be inherently safe and shall have means to prevent malfunction or mishap. The safety features provided in the design and installation of such irradiators shall ensure that the built-in safety systems perform their intended functions even under adverse conditions in order to protect plant personnel, property, environment and the public. Defence-in-depth concept shall be applied to all safety activities, whether organisational, behavioural or design-related, to ensure that they are covered by a series of provisions, so that, should a failure occur, it would be compensated for or corrected. Multiple levels of protection shall be incorporated in the design so that human intervention is minimized. Basic safety functions, such as access control, shielding and confinement of radioactivity shall be covered by multiple means of protection. Redundancy, diversity and independency principles shall be used in the control systems.

The standard has categorised irradiators in terms of their design with respect to configuration of the product irradiation position, accessibility and shielding of radioactive sources. The siting requirements for the installation of irradiators and design and performance are outlined in the standard.

1.2 Objective

This standard provides mandatory requirements for the designer and manufacturer of irradiator facilities to demonstrate the compliance with these requirements for obtaining approval of the competent authority for its design. This standard addresses the main design and performance requirements including quality assurance aspects for the land based stationary gamma irradiators.

1.3 Scope

The standard specifies the minimum requirements for the design and installation of irradiators to achieve built-in safety. These requirements are specific to radiation safety aspects of such facilities and are related to classification of irradiators, siting of irradiators, design and performance requirements and loading/unloading of sources. The scope covers the safety requirements in the design and installation of Category-II, Category-III and Category-IV irradiators, quality assurance and decommissioning aspects of these irradiators.

2. CATEGORISATION OF IRRADIATORS

The irradiators are categorised in terms of the design of the irradiator with respect to configuration of the product irradiation position, accessibility and shielding of radioactive source.

Category-I : **Self-contained, Dry source storage**

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

Category-II : **Panoramic, Dry source storage**

A controlled human access irradiator in which the sealed source is contained in a dry container constructed of solid materials, the sealed source is fully shielded when not in use; the sealed source is exposed within a radiation volume that is maintained inaccessible during use by an entry control system.

Category-III : **Self-contained, Wet source storage**

An irradiator in which the sealed source is contained in a storage pool (usually containing water), the sealed source is shielded at all times, and human access to the sealed source and the volume undergoing irradiation is physically restricted in its designed configuration and proper mode of use.

Category-IV : **Panoramic, Wet source storage**

A controlled human access irradiator in which the sealed source is contained in a storage pool (usually containing water), the sealed source is fully shielded when not in use; the sealed source is exposed within a radiation volume that is maintained inaccessible during use by an entry control system.

3. SITING REQUIREMENTS

The site for the location of the irradiators shall meet the following criteria:

3.1 A minimum distance from the boundary wall of the irradiator shall be maintained from:

a)	ammunition storage, explosive dumps and direction of runway of civilian/military airfields	:	2 km
b)	residential area and public places	:	30 m

3.2 Irradiation cell shall be engineered taking into account the maximum considered earthquake as specified in IS-1893 (Part-1), 2002. Strong motion accelerographs shall be provided to record ground motion (acceleration) at free field condition when irradiator is located in seismic zone-IV and above.

3.3 All the statutory requirements of central and state governments, as applicable, shall be complied with.

3.4 The structure of the irradiator shall be designed such that the soil and ground characteristics do not cause any deterioration in its strength and integrity during the useful life of the irradiator.

3.5 Geological and geotechnical requirements for design and construction of the irradiator shall take into account all provisions specified in Appendix-A.

3.6 The maximum level of ground water and design basis flood level considering the minimum return period of one hundred years shall be taken into account in the design of the irradiator.

3.7 Access road to the site shall be smooth and strong enough to take load of the transport container and other heavy parts of the irradiator.

3.8 There shall be a security compound wall around the irradiator facility.

4. DESIGN AND PERFORMANCE REQUIREMENTS

4.1 Sealed Sources

4.1.1 The sealed sources used in the irradiator shall be in a form that prevents dispersion of radioactivity under normal conditions and design basis accidents during use, storage, and transport. The radioactive material shall be solid and in metallic form.

4.1.2 Each sealed source shall have at least two encapsulations. The material of encapsulation shall be either AISI SS-316L grade or of equivalent metallurgical properties.

4.1.3 The encapsulation shall facilitate efficient transfer of decay heat to the outermost surface during storage and use.

4.1.4 The source may be either a single sealed source or several sealed sources forming an integral source unit.

4.1.5 The sealed sources shall be classified and tested in accordance with AERB/SS-3 (Rev-1), 2001.

4.2 Source Frame

4.2.1 The source pencils shall be firmly fixed at both ends in a rigid frame such that they do not get dislodged from the frame under normal use and accident conditions.

4.2.2 The material of the source frame shall be of AISI SS-304L or equivalent grade.

4.2.3 Tools and implements required for positioning and /or removing the sources shall be capable of being operated from outside the radiation shields.

4.2.4 Dissimilar metals shall not be used for the components of the sealed source and the source frame to avoid galvanic corrosion.

4.2.5 The source frame shall be balanced with respect to the hoisting system. This shall be done by proper arrangement of sources; if required by using dummy sources, which are distinguishable from the active sources.

4.2.6 The arrangement of the active and dummy sources in the source frame shall provide uniform radiation field at normal product irradiation position.

4.2.7 Design of the source raise system shall provide for firm and positive guide for the movement of the source frame in the intended direction.

4.2.8 The source movement system shall have fail-safe operation such that any malfunction in the system shall automatically retain/bring the source frame in its fully shielded position.

4.3 Source Storage (General Requirements)

4.3.1 The source frame shall remain in its shielded position except when moved to irradiation position by the operator following the procedure specified by the manufacturer in the operation manual in case of Category-II and Category-IV irradiators.

4.3.2 In case of Category-III irradiators, the source storage area shall remain inaccessible after the sources are loaded.

4.3.3 The radiation level on the external surface of the dry storage or wet storage facility for maximum design capacity of the sources shall not exceed 10 $\mu Sv.h^{-1}$.

4.3.4 The passage through which source transport container is moved and source storage area shall have adequate mechanical strength to support the source transport container.

4.3.5 Means shall be provided for continuous removal of decay heat from the radiation sources.

4.3.6 In case of wet storage, means shall be provided for continuous removal of decay heat from radiation sources when water temperature exceeds 55^0C, while the sources are stored.

4.4 Source Storage (Specific Requirements for Category-IV Irradiators)

4.4.1 The materials for construction of the water pool shall be resistant to corrosion. The inner surface of the pool shall be lined with stainless steel sheets of AISI 304L grade of at least 3 mm thickness.

4.4.2 There shall be no penetration (e.g. pipe or plugged holes) through the bottom of the pool.

4.4.3 The decrease in water level in the pool shall not exceed 15 mm per day.

4.4.4 Means shall be provided to monitor water level in the pool at three levels corresponding to maximum, normal, and abnormal low levels.

4.4.5 There shall be no penetration through the walls of the pool more than 30 cm below normal water level.

4.4.6 Means shall be provided to replenish water automatically when the level falls below the normal level. The replenishment of water shall be terminated automatically at the maximum level. Means shall be provided for periodic circulation of water from the bottom of the pool. The pool water make-up system shall have adequate capacity. This system shall be supplemented by a manual water make-up system in the event of failure of the automatic system to serve its purpose. Means shall also be provided to allow the drainage of water in case the water level exceeds the maximum level.

4.4.7 Adequate illumination shall be provided in the pool to carry out under-water operations.

4.4.8 Appropriate controls shall be provided to prevent entry of any person into the cell in the event of water level falling below the abnormal low level. An audio-visual alarm shall be activated and maintained until the pool water is restored to normal level.

4.4.9 A physical barrier shall be provided over the pool to prevent accidental fall of persons or objects into the pool. This arrangement shall be removable to facilitate source loading/unloading and other controlled servicing operations.

4.4.10 The pool water shall be demineralised, free from turbidity, fungus and any dissolved solid matter. The electrical conductivity of water shall not exceed 20 $\mu S.cm^{-1}$.

4.4.11 The pH of pool water shall be maintained between 7.5 and 8.

4.4.12 The quality of water shall be maintained by means of an on-line conditioning and clean-up system.

4.4.13 The floor of the source storage water pool shall be designed to support radiation source transport container used during source transfer operations without compromising the integrity of the pool.

4.4.14 On line radiation monitoring system shall be installed in the demineralised water plant to detect radioactive contamination of water in the pool and shall be interlocked with the source raise system.

4.5 Radiation Cell

4.5.1 The biological shield to be provided shall be such that the dose rate in full occupancy areas shall not exceed 1 $\mu Sv.h^{-1}$.

4.5.2 Penetrations in the walls shall not cause increase in radiation levels in occupied areas.

4.5.3 Concrete used for the construction of the irradiation cell shall have minimum density of 2.5 $g.cm^{-3}$. Adequate compaction shall be assured during pouring of concrete into the walls to avoid any void formation.

4.6 Personnel Access Door (PAD)

4.6.1 Entry into irradiation cell shall be through a personnel access door. The personnel access door shall be accessible only through control room.

4.6.2 Material and construction of the door shall be such that it can withstand fire for at least half an hour.

4.7 Cell Ventilation

4.7.1 Ventilation (induced draft type) in the cell shall be achieved by providing fresh air entry grills/louvers and exhaust fans (with standby provision).

4.7.2 There shall be adequate number of air changes per hour to prevent the concentration of O_3, NOx and other toxic gases exceeding three times their Threshold Limit Values (TLVs) during irradiation.

4.7.3 NOx detectors should be provided in installations where NOx concentrations are likely to be significant.

4.7.4 Outlet of exhaust fans shall be located at least 2.5 m above the tallest part of the irradiator building.

4.7.5 Time delay interlock shall be provided to prevent personnel entry into the cell immediately after the source returns to its fully shielded position in case of Category- II and Category-IV irradiators. The delay time should be adequate to bring the concentration of O_3 below TLV (i.e. below 0.1 ppm).

4.8 Fire Safety

4.8.1 Heat and smoke sensors shall be installed in the cell with audio-visual display in the control room.

4.8.2 Water sprinkler based fire extinguishing system shall be provided in the irradiation cell. The system shall be manually operable from outside the cell.

4.8.3 Chemicals and substances that could adversely affect the integrity of the source shall not be used in the fire extinguishing system.

4.8.4 Power supply to the cell and the cell ventilation system shall be cut off automatically in the event of fire alarm.

4.9 Operating Systems

4.9.1 Irradiation shall be carried out by either moving the source close to the product or by positioning the product close to a fixed source. In the first case, the source movement shall be either vertical or horizontal.

4.9.2 Motive power for the source movement and the product movement shall be either electrical, pneumatic, or hydraulic and this power shall be automatically disabled during any servicing or maintenance operation by means of a key control.

4.9.3 Construction of wire rope(s) used for moving the source frame shall conform to relevant standards.

4.9.4 Breaking strength of each of the wire ropes shall be at least five times the total weight of the fully loaded source frame.

4.9.5 The source frame shall be capable of being moved from its shielded position to the irradiation position by at least two wire ropes of identical specifications.

4.9.6 The material of the source hoist wire rope shall be of AISI SS 321 grade or equivalent for wet storage irradiators. Tensile strength of individual wire of the rope shall be in the range of 110 to 130 $kg.mm^{-2}$. (This range is given to ensure extended fatigue life). The construction of the wire rope shall be of type 7 x 19 (9/9/1).

4.9.7 The material of the guide rope for the source rack shall be of AISI SS 304 grade or equivalent.

4.9.8 For dry source storage irradiators, steel wire ropes of relevant standards, IS-2365 (1977) shall be used.

4.9.9 Ratio of the groove diameter of pulley to nominal diameter of the wire rope shall be of the order of 40 for ensuring longer fatigue life of the rope. The groove radius shall be designed as per the relevant standards.

4.9.10 The ends of the wire ropes shall be fastened by using appropriate end fittings conforming to the recommendations in IS standards.

4.9.11 Each rope shall be independently capable of supporting the full weight of the source frame. The mechanism shall be capable of returning the source frame to fully shielded position with one rope in the event of snapping of other wire rope.

4.9.12 Means shall be provided to adjust the tension on each rope and also to balance the tension on all the ropes.

4.9.13 It shall not be possible to move the source frame unless tensions on all the ropes are balanced.

4.10 Source Guard

4.10.1 The source frame shall be protected on all sides by metallic sheath/guard from damage by product carriers. The metallic sheath shall have adequate mechanical strength.

4.10.2 The protective sheath/guard shall not affect the smooth movement of the source frame or the product carriers.

4.11 Other Systems

4.11.1 The movement of the source frame from its shielded position shall be prevented in the event of anyone of the following:

(a) Failure of motive power

(b) Emergency stop from the control console

(c) Emergency stop inside the cell

(d) Personnel access door open

(e) Emergency trip wire pull

(f) Unequal tension in wire ropes

(g) Abnormal low pool water level

(h) Failure of cell ventilation

(i) Jamming of product carriers

(j) Actuation of thermal/smoke fire alarm

(k) Pool water contamination

(l) Actuation of product exit radiation monitor alarm

(m) Seismic event detection (for seismic zone-IV and above)

(n) Roof plug not in place

(o) Pressure plate alarm

(p) Service key engaged.

4.11.2 The source frame shall automatically return to its fully shielded position in the event of any one of the following:

(a) Failure of motive power

(b) Emergency stop from the control console

(c) Emergency stop inside the cell

(d) Emergency trip wire pull

(e) Disengagement of the personnel access door latch bar

(f) Actuation of entry control device at product entry/exit ports

(g) Snapping or loosening of wire rope(s)

(h) Failure of cell ventilation

(i) Jamming of product carriers

(j) Actuation of thermal/smoke alarm

(k) Pool water contamination

(l) Abnormal low pool water level

(m) Actuation of product exit radiation monitor alarm

(n) Seismic detection (for seismic zone-IV and above)

(o) Roof plug removed

(p) Actuation of pressure plate alarm

(q) Service key actuation.

4.11.3 Sequentially linked controls shall be provided for personnel access, irradiation cell lock-up sequence and source movement operations. The controls shall be designed such that any attempt to tamper with or deviate the sequence shall automatically abort the intended operation.

4.11.4 Any malfunction of the product movement system shall cause termination of irradiation. All components of this system shall be designed for fail-safe operation. Torque limiting device shall be incorporated in the conveyor drive system.

4.11.5 Means shall be provided at product entry/exit ports to prevent inadvertent entry of any person in the irradiation cell during operation.

4.11.6 Means shall be provided to terminate irradiator operation from inside the cell. The device shall be conspicuously labeled and prominently located. Actuation of this device shall cause an audio-visual alarm in the control room.

4.11.7 Emergency stop device shall be provided to terminate or interrupt irradiator operation at any time from control console. The device shall be conspicuously labeled and marked. Actuation of this device shall cause an audio-visual alarm in the control room.

4.11.8 The selection and status of critical equipments shall be displayed on the control panel. An on-demand display of other parameters should be provided.

4.11.9 Controls and displays for routine operations shall be physically separated and distinctly marked from the controls and displays for emergency operations as per the relevant standards.

4.11.10 There shall be clear and permanent display of the following process parameters on the control panel:

SOURCE POSITION: EXPOSED/SHIELDED/ IN TRANSIT
(in case of Category-II and Category-IV irradiators)

CELL VENTILATION: ON/OFF

PERSONNEL ACCESS DOOR: OPEN/CLOSED

PRODUCT CARRIER: CLEAR/JAMMED

WATER LEVEL: MAXIMUM/NORMAL/ABNORMAL LOW
(in case of Category-III and Category-IV irradiators)

Apart from normal parameters, emergency situations and abnormal conditions shall also be displayed on the console by means of audio-visual alarms.

4.11.11 Labels and markings for all controls shall be clear, permanent, durable and shall be in compliance with the relevant standards. Radiation warning symbol shall be conspicuously displayed on the personnel access door.

4.11.12 Every audio signal shall be distinct and clearly distinguishable from each other and from all other signals in the area.

4.11.13 The control console shall have a programmable logic circuit with provisions for auto-diagnosis and indication of an abnormal situation. Provision shall exist for obtaining event history.

4.11.14 The source position indicator shall also be displayed near the personnel access door at a prominent location.

4.11.15 Radiation monitoring devices shall be provided at the product exit port, resin bed of DM plant and in the cell through radiation interlock system.

4.12 Safety Interlocks for Personnel Access Door (PAD)

Safety Interlock is a device for precluding exposure of an individual to a hazard either by preventing entry to the hazardous area or by automatically removing the hazard. The PAD shall electrically, mechanically, hydraulically or pneumatically and in radiation mode, be interlocked with source movement system so as to interrupt/terminate the irradiation when any of these are actuated. The safety interlocks shall be of fail-safe design. PAD shall not open under the following conditions:

(a) Radiation level in the cell more than the preset safe level

(b) Water level abnormally low

(c) Source frame jam in hoisted mode

(d) Source in exposed condition

(e) Product exit monitor alarm

(f) Pool water contamination

(g) Seismic alarm (for seismic zone-IV and above)

4.13 Power Failure

Means shall be provided to ensure that, if an electric power failure occurs, the source will automatically be returned to the fully shielded position and the irradiator shuts down. An uninterrupted power supply (UPS) shall be incorporated in the control system for indication of source status. UPS shall function for minimum 30 minutes. Alternatively, diesel generator shall supply power.

4.14 Design Basis Accident Analysis

The designer and manufacturer shall assess the overall ability of the irradiator systems to achieve and maintain the desired level of safety. Abnormal events mentioned below shall be analysed and methods for achieving safety under these events shall be described.

(a) Breaking of source hoist cable

(b) Fraying of source hoist cable inside the cell roof tube

(c) Source frame jam in hoisted mode

(d) Failure of mooring of guide wire ropes of source frame

(e) Failure of PAD interlocks

(f) Fire in the irradiation cell

(g) Failure of ventilation system

(h) Damage to the sources

(i) Contamination of water pool

(j) Leakage of water from pool

(k) Earthquake at the irradiator site

(l) Flooding of irradiator cell with water.

The designer/manufacturer shall carry out such safety analysis to demonstrate the means provided to prevent and handle above situations safely.

5. LOADING AND UNLOADING OF SOURCES

5.1 Transport of Sources

Packaging and transport of radioactive sources shall be in accordance with the provisions of the regulations for the safe transport of radioactive material, AERB/SC/TR-1 (1986).

5.2 Installation of Sources in the Source Frame

5.2.1 The source loading and unloading operations shall be carried out either from inside the irradiation cell or from outside the cell through a loading port.

5.2.2 The source transport container shall be brought to the cell either through an opening on the cell roof or through product entry/personnel entry route.

5.2.3 When an opening is provided on the cell roof, the opening shall be kept closed by a shielded plug during operation of the irradiator. Operation of the irradiator shall be automatically prevented if the roof plug is not properly fixed in its place.

5.2.4 Loading of sources from outside the cell shall be through individual source channels clearly marked and identified from the loading port.

5.2.5 Tools and implements used for handling sources in case of Category-III and Category-IV irradiators during loading and unloading operation shall have openings to ensure effective water shield at all times.

5.2.6 Actual source transfer (either from the loading port or the transport flask) shall be possible only after ensuring selection and correct alignment of the relative channel positions and verified by trial operations.

5.2.7 Lifting devices used for in-plant handling of the source flask shall conform to relevant IS standards (IS-2365).

6. QUALITY ASSURANCE

6.1 An adequate quality assurance (QA), including appropriate quality control measures, shall be established for the design and manufacture, construction, operation and industrial safety of irradiators. Compliance with the ISO 9000 or IS 14000 series is desirable. Records of all QA procedures shall be maintained for the entire life of the irradiator.

6.2 Quality assurance during design and construction of the irradiator shall conform to the guidelines given in the Appendix-B.

APPENDIX-A

GEOLOGICAL AND GEOTECHNICAL INVESTIGATIONS FOR LAND BASED STATIONARY GAMMA IRRADIATORS

A1 Site investigations for Land-based Irradiators are necessary to determine the geotechnical characteristics of the site that affect the design, performance and safety of the irradiators. The investigations shall produce the information needed to define the overall site geology to a degree that is necessary for an understanding of the sub-surface conditions in order to ensure stability against natural hazards like earthquake and flood.

A1.1 Site investigations shall also provide information needed to define ground water conditions as well as the geotechnical parameters needed for analysis and design of different foundations. These include parameters to evaluate the sub-surface characteristics for safe engineering of irradiators, such as bearing capacity of foundation material, lateral earth pressure, the stability of cuts and slopes in rock and the effects of earthquake induced motions transmitted through underlying deposits on the response of soils and structure (including the potential for inducing liquefaction in soils) and those needed to estimate the expected settlement of the structure.

A1.2 Requirements of geotechnical investigations depend on the site-specific conditions. However, the following investigations are the minimum, which shall be carried out for the evaluation of parameters required for safe design:

(i) Field Work

- (a) Drilling of bore holes
- (b) Collection of disturbed/undisturbed soil and water samples
- (c) Standard penetration tests
- (d) Plate load tests
- (e) Electrical resistivity tests.

(ii) Laboratory Tests on Soil Samples

- (a) Grain size analysis (coarse and fine)
- (b) Consistency limit
- (c) Specific gravity of soil
- (d) Proctor density
- (e) Permeability
- (f) Consolidation

(g) Modulus of elasticity and Poisson's ratio

(h) Unconfined/confined compression

(i) Direct shear test (consolidated drained)

(j) Chemical test on soil.

(iii) Laboratory Tests on Rock Samples

(a) Petrographic

(b) Porosity

(c) Unconfined/confined compression test

(d) Modulus of elasticity and Poisson's ratio.

(iv) Test on Ground Water Samples

Chemical analysis of ground water samples.

A1.3 Geotechnical investigations:

A1.3.1 Requirements

The following geotechnical investigation shall be met.

(a) Minimum depth of boreholes shall be three times the larger dimension of the footing.

(b) Number of boreholes should be such that sub-surface profile of the plant area can be drawn with reasonable certainty in any direction. At least four data points shall be available, in any direction, for plotting of sub-surface profile.

(c) Geological mapping of the foundation pit shall be carried out after completion of excavation.

(d) Appropriate rectification/stabilisation measures shall be adopted if it is found necessary after excavation.

A1.3.2 Reports

The geotechnical report shall contain the following details:

(a) Geological status of the site based on available information

(b) Details of bore logs and trial pit logs

(c) Permeability test results

(d) Ground water observations

(e) Results of soil and rock tests

(f) Chemical test results of water

(g) Sub-surface profiles

(h) Electrical resistivity logging

(i) Petrographic study results

(j) Evaluation of design parameters.

APPENDIX-B

QUALITY ASSURANCE

B 1 Quality Assurance during Design for Land-Based Stationary Gamma Irradiators

B 1.1 Quality Assurance Programme

Licensee shall develop and implement a QA programme which describes the overall arrangements for the management, performance and assessment of the gamma irradiator facilities. This programme shall also provide the means to ensure that all work is suitably planned, correctly performed and properly assessed. Procedures shall be defined by the Licensee for control of design activities to ensure that the design of the gamma irradiator facility fulfills specified requirements.

B 1.2 Grading

A graded approach based on the relative importance to radiological safety of each item, service or process shall be used.

Design activities, which should be graded include:

(a) Level of detailed analysis of design

(b) Level of design review and approval

(c) Degree of verification of design

(d) Controls applied to design change

(e) Details of design records and their retention periods

(f) Need for alternative calculations to be carried out.

B 1.3 Organisation

The Responsible Organisation shall identify the principal designer who has the responsibility for specifying the design requirements and for approving the design output on its behalf.

B 1.4 Interfaces

Interface arrangements shall be agreed to between organizations involved in design activities. Interface that shall be addressed include:

(i) Interfaces between technical disciplines within the design organization

(ii) Principal designer with:

- (a) Siting organisation

(b) Construction organisation

(c) Commissioning organisation

(d) Operating organisation

(e) Decommissioning organisation

(f) Competent Authority.

B 1.5 Planning

Plans used in design shall include the following, as appropriate:

(a) Scope of work, including work carried out by other organizations

(b) Design methods

(c) Software requirements (software to be developed or software codes to be validated for use)

(d) Test requirements, including those for qualification tests, prototype and seismic

(e) Design review, verification and validation requirements

(f) Resource requirements

(g) Special training requirements

(h) Schedule of activities

(i) Points at which checks of the design process shall take place and the frequency of such checks; and

(j) Inputs from safety, reliability, maintainability, human factors, standardisation and other disciplines.

B 1.6 Non-conformance Control and Corrective Actions

A system for the control of non-conformances and their corrective actions shall be established.

B 1.7 Document Control and Records

Procedures for the preparation, review, approval, issue, modification and control of documents shall be established.

B 2 Quality Assurance during Construction of Civil Engineering Structures for Gamma Irradiators

B 2.1 Quality Assurance Programme

Licensee shall develop and implement a QA programme which describes the overall arrangements for the management, performance and assessment of civil engineering structures for gamma irradiators during construction. This programme shall specify the means to ensure that all work is suitably planned, correctly performed and properly assessed in order to implement design intent in the construction.

B 2.2 Grading

Work procedure shall be defined for control of construction activities at site and shall be reviewed and approved before use. A graded approach based on the relative importance to safety of each item, service or process shall be used. The construction activities, which shall be graded include:

(a) Qualification of special construction processes and the personnel to carry them out

(b) Details and need for inspection plans

(c) Level of traceability

(d) Level of in process controls and need for hold points

(e) Records and archived samples.

B 2.3 Organisation

The responsible organisation shall formally appoint a person on its staff to be responsible for construction activities. The person appointed shall have the necessary resources within the construction organisation to discharge the following responsibilities:

(a) Ensuring that construction and installation work is carried out in accordance with design specifications, drawings, procedures and instructions, including the implementation of specified QA requirements.

(b) Ensuring that construction and installation work undertaken, including work by suppliers, is coordinated, conducted and completed in accordance with planned programmes of work.

(c) Controlling access to the construction site.

B 2.4 Interfaces

The Responsible Organisation shall ensure that interface arrangements shall be agreed among the construction organisation, suppliers and other organisational units performing the work. They shall be defined in writing and shall be included in procurement documents.

B 2.5 Planning

All construction activities shall be planned. The plan shall define:

(a) The activities to be performed in manageable units

(b) The planned sequential order and duration of these activities

(c) The resource allocation for each activity.

B 2.6 Non-conformance Control and Corrective Actions

The non-conformances that are required to be reported to the construction organisation shall be identified. Suitable corrective action should also be recorded.

B 2.7 Document Control and Records

Procedures for the preparation, review, approval, issue, modification and control of documents should be established. The record system shall be established which includes the arrangements and responsibilities for the categorisation, receipt, indexing, storage, retrieval and disposal of construction records. Records shall include all those which record the as-built condition of structures, systems and components.

B 3 Industrial Safety during Construction of Civil Engineering Structures for Gamma Irradiators

A policy reflecting industrial safety regulations shall be established for all personnel, including suppliers and visitors. These shall be in line with the prevailing factory rules. The policy shall include arrangements for the effective planning, organisation, monitoring and review of the preventive and protective measures.

B 3.1 Management shall provide all necessary support to the contractor to ensure health and safety of the construction personnel.

B 3.2 Job hazard analysis shall be prepared before the start of construction.

B 3.3 Industrial safety at the construction site shall be enforced by a safety officer.

B 3.4 All construction equipment shall be tested prior to their use.

B 3.5 Construction personnel shall be given orientation program on industrial safety.

B 3.6 Accident statistics shall be maintained at the construction site.

B 3.7 Appropriate arrangements for fire safety and first aid shall be available.

CONVERSION TABLE

Curie (Ci)	**Becquerel (Bq)**
1 nCi	37 Bq
1 µCi	37 kBq
1 mCi	37 MBq
1 Ci	37 GBq
1000 Ci (1 kCi)	37 TBq
1000 kCi (1 MCi)	37 PBq
27 pCi	1 Bq
27 nCi	1 kBq
27 µCi	1 MBq
27 mCi	1 GBq
27 Ci	1 TBq

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COMMITTEE TO REVIEW / REVISE AERB STANDARD SPECIFIACATION FOR THE DESIGN AND INSTALLATION OF LAND BASED GAMMA IRRADIATORS, AERB/SS-6, 1993

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